BUILDING THE EVIDENCE BASE FOR THE DEVELOPMENT AND IMPLEMENTATION OF AN IRISH NATIONAL DIGITAL TYPE 2 DIABETES PREVENTION PROGRAMME

Luke Van Rhoon

BBus (Marketing), BHSc (Nutrition and Psychology)
BA (Psychological Sciences [Hons.]), MSc (Health Psychology)

Thesis submitted to the National University of Ireland, Galway in fulfilment of the requirements for the Degree of Doctor of Philosophy (Psychology)

School of Psychology, National University of Ireland, Galway

NUI Galway
OÉ Gaillimh

Supervisors:

Professor Molly Byrne
Health Behaviour Change Research Group
School of Psychology, National University of Ireland, Galway

Dr. Jenny McSharry
Health Behaviour Change Research Group
School of Psychology, National University of Ireland, Galway

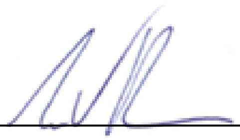
Submitted July 2022

Table of Contents

Declaration

I declare that this thesis has not been submitted as an exercise at this or any other university.

I declare that this thesis is entirely my own work.

Signed:  ______________________________

Luke Van Rhoon

Statement of Contribution

The candidate was responsible for the design, data collection, analysis, and write-up of each of the three studies conducted in this research. The supervisory team, Graduate Research Committee, manuscript co-authors, and local experts advised and/or provided support in conducting the research.

Requirements for an Article-Based PhD

This PhD was conducted in accordance with the requirements for an article-based PhD, as set by the School of Psychology, at the National University of Ireland, Galway (see Appendix A).

The requirements state that three articles should make up the core of the PhD, with two of these articles accepted for publication and the third submitted for review.

At the time of submission, two articles have been accepted for publication in the journals of *Digital Health* (published on March 24, 2020) and the *British Journal of Health Psychology* (published on October 31, 2021) respectively, and one article has been submitted to *Psychology & Health* for review. Therefore, the requirements for an article-based PhD have been met.

Funding

This research was funded between September 2019 and February 2022 by the Government of Ireland Postgraduate Scholarship from the Irish Research Council

IRISH RESEARCH COUNCIL
An Chomhairle um Thaighde in Éirinn

This research was also funded between September 2017 and September 2019 by the Hardiman Scholarship from the National University of Ireland, Galway

NUI Galway
OÉ Gaillimh

Acknowledgements

I would first like to thank my supervisory team and mentors. To my supervisors Professor Molly Byrne and Dr. Jenny McSharry, thank you both for your continuous support and encouragement. Your experience, knowledge, and expertise helped steady the ship that at times, threatened to sail off course once the pandemic took hold. Your unwavering trust in my ability to keep moving forward and take my work in new directions will always be remembered, and your sage advice has made me a better researcher, teacher, presenter, and writer. To Professor Jane Walsh, thank you for providing me with a wealth of opportunities to pursue an interest in digital health, and for setting a wonderful example on how to maintain a healthy work-life balance. To my Graduate Research Committee: Dr. Caroline Heary, Dr. Jennifer Holloway, Dr. Geraldine Leader, and Dr. Pádraig MacNeela, thank you all for your advice and support.

Next, I would like to thank others directly involved with this work. To the Irish Research Council and NUI Galway, thank you for providing me with the funds and resources to make this research possible. To Margaret Humphreys, your sound advice and assistance in the early stages of this research is most appreciated. To Declan Coogan, thank you for providing me with the tools and equipment needed to set up my workspace, and for pretending not to notice that I had moved my entire wardrobe into the office. I would also like to extend my gratitude to co-authors Eimear and Jane, members of the Health Behaviour Change Research Group, and every participant who donated their valuable time and energy. Thank you all for sharing your knowledge, views, and experiences.

I have made some awesome friends over the journey, and I wish to acknowledge their support. First and foremost, I would like to thank Christie: friend, colleague, co-author, and fellow expat. Centre of my Venn diagram of support. It has been a pleasure working with you (and walking with you) for these past five years. A book detailing our adventures and shenanigans would be much thicker than this thesis. I would also like to extend thanks to my remaining friends and colleagues in the School of Psychology at NUI Galway. To my friends at Camelot, thank you for being a great source of levity, and to Antony, thanks for the memories. I look forward to bumping into you one afternoon in Shibuya. Finally, to big Kev, thanks for the laughs. There is a big slice of coffee cake waiting here for you mate.

I would like to close by acknowledging the love and encouragement of my family, and my gratitude for their support. To my parents Rosa and Marty, thank you for providing me with the opportunity to carve my own path and for your help and understanding throughout my academic career. Thank you for believing in me, particularly in my junior years when nobody else would. To my brother Mat, thank you for keeping me up to speed with your work and setting me up for music production. It has been a welcome distraction. To Regina and Glenda, thank you for welcoming me into your home and family. I could not have imagined a more picturesque setting to complete this thesis, and the kindness you have extended to me will always be remembered fondly. Finally, to my amazing wife Sarah, I thank you for the love, kindness, support, and understanding you have given me from day one. I look forward to holding our son Leo for the very first time, and the many great moments we will share as a family in years to come.

Research Dissemination

Below is a list of publications, conference presentations, and workshops that have resulted from the work conducted within this thesis.

Publications

Van Rhoon, L., McSharry, J., & Byrne, M. (2021). Development and Testing of a Digital Health Acceptability Model to Explain the Intention to Use a Digital Diabetes Prevention Programme. *British Journal of Health Psychology*. 1-25. https://doi.org/10.1111/bjhp.12569

Van Rhoon, L., Byrne, M., Morrissey, E., Murphy, J., & McSharry, J. (2020). A Systematic Review of the Behaviour Change Techniques and Digital Features in Technology-Driven Type 2 Diabetes Prevention Interventions. *Digital Health*, *6*. 1-27. http://doi.org/10.1177/2055207620914427

Submitted for Review

Van Rhoon, L., Byrne, M., Tetreault, C., & McSharry, J. (2022). The Views and Experiences of Adults Living in Ireland Regarding the Acceptability of a Digital Diabetes Prevention Programme: A Qualitative Content Analysis. Submitted to *Psychology & Health*.

Conference and Seminar Presentations

Van Rhoon, L., McSharry, J., & Byrne, M. (2021). Development and Testing of a Digital Health Acceptability Model to Explain the Intention to Use a Digital Diabetes Prevention Programme. *UCL Centre for Behaviour Change 7th Annual Digital Health Conference*, online.

Van Rhoon, L., Byrne, M., & McSharry, J. (2021). Development and Testing of a Digital Health Acceptability Model to Explain the Intention to Use a Digital Diabetes Prevention Programme. *School of Psychology Research Day, National University of Ireland*, Galway.

Van Rhoon, L., Byrne, M., Morrissey, E., Murphy, J., & McSharry, J. (2021). A Systematic Review of the Behaviour Change Techniques and Digital Features in Technology-driven Type 2 Diabetes Prevention Interventions. *Health Promotion Conference, National University of Ireland,* Galway

Van Rhoon, L., Byrne, M., & McSharry, J. (2020). Building the Evidence Base for the Development and Implementation of an Irish National Digital Type 2 Diabetes Prevention Programme. *School of Psychology Research Day, National University of Ireland*, Galway.

Van Rhoon, L., Byrne, M., Morrissey, E., Murphy, J., & McSharry, J. (2020). A Systematic Review of the Behaviour Change Techniques and Digital Features in Technology-driven Type 2 Diabetes Prevention Interventions. *UCL Centre for Behaviour Change 6th Annual Digital Health Conference*, online.

Van Rhoon, L., Byrne, M., & McSharry, J. (2019). Building the Evidence Base for the Development and Implementation of an Irish National Digital Type 2 Diabetes Prevention Programme. *School of Psychology Research Day, National University of Ireland*, Galway.

Van Rhoon, L., & Byrne, M. (2018). Digital Type 2 Diabetes Prevention Programmes: An Evidence Base. *First annual meeting for the National Clinical Programme for Diabetes: Diabetes Prevention Subgroup*, Galway.

Van Rhoon, L., & Byrne, M. (2018). Behaviour Change in Diabetes Prevention. *First annual meeting for the National Clinical Programme for Diabetes: Diabetes Prevention Subgroup,* Galway.

Van Rhoon, L., & Byrne, M. (2018). Lifestyle Programmes to Prevent Type 2 Diabetes Mellitus: A Summary Literature Review of Recent Research to Inform the Development of an Irish Diabetes Prevention Programme. *First annual meeting for the National Clinical Programme for Diabetes: Diabetes Prevention Subgroup*, Galway.

Van Rhoon, L., Byrne, M., & McSharry, J. (2018). Building the Evidence Base for the Development and Implementation of an Irish National Digital Type 2 Diabetes Prevention Programme. *School of Psychology Research Day, National University of Ireland*, Galway.

Van Rhoon, L., Byrne, M., & McSharry, J. (2018). The Adaptation, Development, and Testing of an Irish Digital Type 2 Diabetes Prevention Programme. *15th Annual Psychology, Health and Medicine Conference, Ulster University,* Coleraine, N. Ireland.

Workshops Delivered

Van Rhoon, L. (2019, 2020, 2021). An introduction to conducting a systematic literature review for social scientists and health researchers. A three-hour workshop for postgraduate students and staff that uses the candidate's published systematic review as a guide. National University of Ireland, Galway.

Additional Works

Below is a list of additional publications, presentations, and submissions authored or co-authored by the candidate over the course of this PhD.

Additional Related Publications

Murphy, J., McSharry, J., Hynes, L., Matthews, S., **Van Rhoon, L.,** & Molloy, G.J. (2020). Prevalence and predictors of adherence to inhaled corticosteroids in young adults (15–30 years) with asthma: a systematic review and meta-analysis. *Journal of Asthma,* 1-28. https://doi.org/10.1080/02770903.2020.1711916

Hennessey, M., Heary, C., Laws, R., **Van Rhoon, L.,** Toomey, E., Wolstenholme, H., & Byrne, M. (2019). Health professional-delivered obesity prevention interventions during the first 1,000 days: A systematic review of external validity reporting. *HRB Open Research, 14*(2), 1-13. https://doi.org/10.12688/hrbopenres.12924.1

Hennessey, M., Heary, C., Laws, R., **Van Rhoon, L.,** Toomey, E., Wolstenholme, H., & Byrne, M. (2019). The effectiveness of health professional-delivered interventions during the first 1,000 days to prevent overweight/obesity in children: A systematic review. *Obesity Reviews, 20*(12), 1691-1707. https://doi.org/10.1111/obr.12924

Hennessey, M., Heary, C., Laws, R., **Van Rhoon, L.,** Toomey, E., & Byrne, M. (2018). Childhood obesity prevention: the effectiveness and active ingredients of interventions delivered by health professionals during the first 1,000 days. *International Journal of Behavioral Medicine, 25*(S1), S87-S88. https://doi.org/10.1007/s12529-018-9740-1

Additional Related Works Submitted for Review

Tetreault, C., **Van Rhoon, L.**, & Sarma, K. M. (2022). Cognitive Rigidity: A Predictive Model of Conspiratorial Endorsement. Submitted to *Applied Cognitive Psychology*.

Additional Related Conference Presentations

Van Rhoon, L. & Stewart, I. (2018). Testing an mHealth-based mindful eating intervention to improve students' eating behaviours: A randomised controlled trial. *32nd Annual Conference of the European Health Psychology Society, National University of Ireland*, Galway.

Abstract

Background: Type 2 Diabetes Mellitus (T2DM) represents a major public health concern. Over one million annual deaths worldwide are attributed to the disease, making it the ninth leading cause of mortality. In Ireland, the number of adults over 40 years of age with or at high risk of developing T2DM is estimated at 408,000 (17.4%) and could reach 717,000 by the year 2036. To reverse the escalating trend of T2DM, several countries have implemented a diabetes prevention programme (DPP) which empowers people at risk of T2DM to maintain a healthy weight and blood glucose levels through regular physical activity and heathy eating. Digital DPPs have also been developed to facilitate online participation via computer or smartphone. A national DPP is currently under consideration in Ireland; and, given the recent digital health boom, a digital programme could have significant impact. However, it is unknown which technology-driven T2DM prevention interventions are effective in producing clinically significant improvements in T2DM-related outcomes, and which intervention components have the greatest impact. Furthermore, the factors affecting the acceptability of a digital DPP among its target users remain unknown. Identifying these components and factors is essential for the development and implementation of an engaging and effective programme.

Aim: This research aimed to assess the effectiveness of, and active ingredients in, digital T2DM prevention interventions. It also aimed to identify and explore factors that influence the acceptability of a digital DPP among adults living in Ireland, particularly those at risk of T2DM. The findings of this research will form an evidence base for the development and implementation of an Irish digital DPP.

Methods: A mixed methods approach was adopted, informed by the UK Medical Research Council framework for developing and evaluating complex evaluations. The research comprises three studies. In study one, a systematic review was conducted to assess the effectiveness of technology-driven T2DM prevention interventions, and to identify the behaviour change techniques (BCTs) and digital features frequently used in effective interventions. In study two, a digital health acceptability model was developed and tested via cross-sectional questionnaire and structural equation modelling to identify the factors that influence the intention of adults living in Ireland to use a digital DPP. Study three used semi-structured interviews and qualitative content analysis to further refine the model developed in study two and to explore the views and experiences of adults at risk of T2DM regarding factors that affect the acceptability of a digital DPP, such as health status, social influence, health technology use, health behaviours, and perceptions of a smartphone based digital DPP.

Findings: According to the systematic review, in the short term (≤6 months), 63% of technology-driven T2DM prevention interventions achieved a clinically significant weight loss of at least 3%. However, only 33% of interventions achieved the 5% weight loss benchmark at ≥12 months. Of the interventions that reported glycaemic status, 77% and 38% reported a significant improvement in HbA1c and fasting glucose respectively. Interventions containing a larger number of BCTs and digital features were more effective. The BCTs: social support (unspecified), goal setting (outcome/behaviour), feedback on behaviour, and self-monitoring of outcome(s) of behaviour were most effective. Interventions containing digital features that facilitated health and lifestyle education, behaviour/outcome tracking, and/or online health coaching were most effective.

In study two, 316 eligible participants (M_{age} = 36) completed the questionnaire, of which 42% had a slightly elevated or higher risk of T2DM. The acceptability model developed in this study explained 65% of the variance in the intention to use a digital DPP. Twelve direct factor relationships were statistically significant. Subjective norm had a moderate-to-large impact on T2DM risk perceptions. Health status, perceived susceptibility to T2DM, eHealth readiness, communicative eHealth literacy and image had significant impacts on use intentions through mediators of perceived ease of use and perceived usefulness.

In study three, 17 adults (M_{age} = 50 years) at risk of T2DM participated in a semi-structured interview. Descriptive themes relating to personal health, social influence, eHealth literacy, healthy eating, physical activity, and perceived usefulness plus ease of use of a digital DPP were identified. Health technologies, programme features, and interactions with friends and health professionals regarding their health behaviours were viewed by participants as both favourable and unfavourable, potentially affecting digital DPP acceptability. However, the desire for a programme to be tailored at both the individual (e.g., personalised goals) and group (e.g., homogenous peer groups) levels was a common thread.

Conclusion: The findings of this research have advanced the evidence base regarding T2DM in Ireland, laying the foundation for the development and implementation of a national digital DPP. This research has also advanced the international knowledge base on what works in digital T2DM prevention interventions in three ways. First, it has extended the current understanding of health beliefs and eHealth literacy. Second, it identified the need for

policies that improve access to healthy foods and food skills training. Third, it recommends several further research and practice avenues, including the improved measurement and reporting of key programme outcomes, and consultation with healthcare professionals to facilitate programme buy-in. These avenues are vital in understanding a digital DPP's mechanisms of action, enhancing programme engagement and effectiveness, and ensuring significant and sustained impact on T2DM.

List of Tables

List of Figures

List of Appendices

List of Abbreviations

A1c	Glycated haemoglobin
AHEI	Alternative Healthy Eating Index
ANOVA	Analysis of Variance
ATT	Attitude towards the digital diabetes prevention programme
AVE	Average Variance Extracted
BCTs	Behaviour Change Techniques
BCTTv1	Behaviour Change Technique Taxonomy version 1
BMI	Body Mass Index
CDC	Centers for Disease Control and Prevention
CeL	Communicative eHealth Literacy
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CLF	Common Latent Factor
CMV	Common Method Variance
COREQ	Consolidated Criteria for Reporting Qualitative Research
COVID-19	Coronavirus Disease 2019
CT	Christie Tetreault
CVD	Cardiovascular Disease
DASH	Dietary Approaches to Stop Hypertension
DPI	Diabetes Prevention Intervention
DPS	Diabetes Prevention Study
eHEALS	eHealth Literacy Scale (Norman & Skinner)
eHLF	eHealth Literacy Framework

eHR	eHealth Readiness
eHRS	eHealth Readiness Scale
EM	Eimear Morrissey
FBG	Fasting Blood Glucose
FINDRISC	Finnish Diabetes Risk Score
FPG	Fasting Plasma Glucose
GDM	Gestational Diabetes Mellitus
GeL	General eHealth Literacy
GI	Glycaemic Index
GL	Glycaemic Load
GLB	Group Lifestyle Balance
GP	General Practitioner
HbA1c	Glycated haemoglobin
HBM	Health Belief Model
HCP	Healthcare Professional
HEI	Healthy Eating Index
HITAM	Health Information Technology Acceptance Model
HS	Health Status
HSE	Health Service Executive
IDPP	Indian Diabetes Prevention Programme
IFG	Impaired Fasting Glucose
IGT	Impaired Glucose Tolerance
IM	Image
IMAGE	Implementation of a European Guideline and Training Standards for Diabetes Prevention

INT	Intention to use the digital diabetes prevention programme
JDPP	Japan Diabetes Prevention Programme
JMc	Jenny McSharry
JMu	Jane Murphy
LV	Luke Van Rhoon
MB	Molly Byrne
MDPP	Medicare Diabetes Prevention Program
MET	Metabolic Equivalent of Task
ML-SEM	Maximum Likelihood Structural Equation Modelling
MRC	Medical Research Council
NCPD	National Clinical Programme for Diabetes
NDPP	National Diabetes Prevention Program
NHS	National Health Service
NHS-DPP	National Health Service Diabetes Prevention Programme
NICE	National Institute for Health and Care Excellence
PDM	Prediabetes Mellitus
PERQ	Patient eHealth Readiness Questionnaire
PEU	Perceived Ease of Use
PLS-PM	Partial Least Squares Path Modelling
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO	International Prospective Register of Systematic Reviews
PSe	Perceived Seriousness
PSu	Perceived Susceptibility
PU	Perceived Usefulness

QALY	Quality Adjusted Life Year
QCA	Qualitative Content Analysis
RCT	Randomised Controlled Trial
RMSEA	Root Mean Square Error of Approximation
RRSA	Research Readiness Self-Assessment
SEM	Structural Equation Modelling
SMART	Sequential Multiple Assignment Randomised Trial
SMS	Short Message Service
SN	Subjective Norm
SNAP	Supplemental Nutrition Assistance Program
SPSS	Statistical Package for the Social Sciences
SRMR	Square Root Mean Residual
T1DM (or T1D)	Type 1 Diabetes Mellitus
T2DM (or T2D)	Type 2 Diabetes Mellitus
TAM	Technology Acceptance Model
TAM2	Technology Acceptance Model 2
TAM3	Technology Acceptance Model 3
TLI	Tucker-Lewis Index
TMeHL	Transactional Model of eHealth Literacy
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
UK	United Kingdom
US	United States
US-DPP	United States Diabetes Prevention Program

UTAUT	Unified Theory of Acceptance and Use of Technology
UTAUT2	Unified Theory of Acceptance and Use of Technology 2
VIF	Variance Inflation Factor
WHO	Word Health Organization

1. Introduction

1.1. Chapter Overview

The opening chapter of this thesis will provide a background to this research. In the first half of the chapter, type 2 diabetes mellitus (T2DM) will be discussed. This will include summaries of the condition's characteristics, aetiology, and associations with other medical conditions. Additionally, several evidence-based strategies for the prevention of T2DM will be presented, including health screening, pharmacological therapy, nutritional support, physical activity interventions, and population-wide public health initiatives. Following this, several landmark diabetes prevention trials will be summarised, and a discussion of translational diabetes prevention programmes (DPPs) will outline the present state of pragmatic or 'real world' lifestyle intervention strategies. The second half of the chapter will introduce digital technologies, where discussion on digital health technologies (DHTs) will highlight the present application of technological innovations in healthcare, including their role in DPP delivery. This will be followed by a presentation of several technology acceptance theories and eHealth literacy frameworks, each relevant to the assessment and use of digital health interventions. The chapter will conclude with a summary of the rationale for this research, and its overall aim and objectives.

1.2. Type 2 Diabetes Mellitus

Type 2 diabetes mellitus is a complex chronic disease characterised by dysregulation of carbohydrate, lipid and protein metabolism, and is a result of impaired insulin secretion caused by pancreatic beta-cell dysfunction, insulin resistance or a combination of both (Chatterjee et al., 2017; DeFronzo et al., 2015). Insulin release and activity are essential processes for maintaining blood glucose balance, and the mechanisms involved in the synthesis and release of insulin are tightly regulated (Galicia-Garcia et al., 2020). Defects in any of the mechanisms involved in the synthesis, release, and detection of insulin can lead to a metabolic imbalance that results in elevated blood glucose levels or 'hyperglycaemia'. Over time, a consistent state of hyperglycaemia can damage the heart vasculature, eyes, kidneys, and nerves (Galicia-Garcia et al., 2020). Type 2 is one of two principal forms of diabetes mellitus. The other is type 1 diabetes mellitus (T1DM), a condition generally accepted to be precipitated by an immune-associated, if not directly immune-mediated, destruction of pancreatic beta cells (Atkinson et al., 2014). However, gestational diabetes mellitus (GDM), characterised by hyperglycaemia that develops during pregnancy and resolves following delivery, is another form of diabetes that has gained attention in recent years due to its rising prevalence, and implications for the health of current and future generations through genetic and environmental mechanisms (Johns et al., 2018; Lende & Rijhsinghani, 2020; McIntyre et al., 2019). While all forms of diabetes have serious health implications if not managed or treated appropriately, T2DM makes up 90-95% of all adult diabetes cases (Henning, 2018).

Several overt symptoms are typically experienced by people with T2DM. These include frequent urination, extreme thirst, hunger and/or fatigue, blurred vision, slow healing wounds, pain, and tingling and/or numbness in the feet (American Diabetes Association, 2020b). However, in some cases, symptoms can be so mild that they develop and persist unnoticed, and it has been estimated that almost 50% of people worldwide with T2DM are unaware of their condition, and may therefore remain undiagnosed (Beagley et al., 2014). Four diagnostic blood tests for T2DM are currently recognised by the World Health Organization (WHO). People with fasting plasma glucose (FPG) values of ≥7.0 mmol/L (126 mg/dl), 2-hour post-load plasma glucose of ≥11.1 mmol/L (200 mg/dl), glycated haemoglobin (HbA1c) of ≥6.5% (48 mmol/L), or random blood glucose values of ≥11.1 mmol/L (200 mg/dl) in the presence of signs or symptoms are considered to have T2DM (WHO, 2019a).

1.2.1. Prediabetes, Impaired Glucose Tolerance, and Impaired Fasting Glucose

Type 2 diabetes mellitus is preceded by a pre-clinical state that can be present for up to 9 to 12 years (Harris et al., 1992). This ‘pre-diabetic’ state has been described using various terms, including prediabetes mellitus (PDM), impaired glucose regulation, borderline diabetes, high risk of diabetes, or non-diabetic hyperglycaemia (Chatterjee et al., 2017). Both PDM and T2DM have the same risk factors, and are detected via the same blood tests, albeit with different diagnostic boundaries. The WHO (2006) recognises two distinct conditions under the umbrella term of ‘intermediate hyperglycaemia’, the WHO’s label for the pre-diabetic state. The first condition is impaired glucose tolerance (IGT), as indicated by FPG values of <7.0 mmol/L (<126 mg/dl), and 2-hour post-load plasma glucose of ≥7.8 and <11.1 mmol/L (≥140 and <200 mg/dl). The second is impaired fasting glucose (IFG), as indicated by FPG values of 6.1-6.9 mmol/L (110-125 mg/dl), and (if measured) 2-hour post-load plasma glucose of <7.8 mmol/L (<140 mg/dl). The WHO does not support the use of HbA1c to diagnose intermediate hyperglycaemia as quality-assured HbA1c measures are not globally available (WHO, 2011). While both IGT and IFG reflect insulin-resistant states, they differ in their site of insulin resistance. Individuals with isolated IGT have normal to slightly reduced hepatic (of the liver) insulin sensitivity and moderate to severe muscle insulin resistance, whereas people with isolated IFG predominantly have hepatic insulin resistance and normal muscle insulin sensitivity (Nathan et al., 2007). Despite its subclinical status, PDM (or intermediate hyperglycaemia) is still a high-risk condition which, if not averted, can lead to the development of T2DM (DeFronzo et al., 2015; WHO, 2006). It has been estimated that 25% of people with PDM will develop T2DM within a three-to-five year period, and as many as 70% of people with PDM will develop T2DM in their lifetime (Hostalek, 2019; Tabák et al., 2012).

There has been much debate regarding the use of the term 'prediabetes' as it can potentially disguise the differences between the two subcategories of the pre-diabetic state (Yudkin, 2016). However, there is currently no international consensus regarding appropriate diagnostic criteria for PDM, IGT, and IFG. Moreover, the term 'prediabetes' is currently recognised and actively used by Diabetes Ireland (2020c), Diabetes UK (2021b), and the American Diabetes Association (2021a). Given the ubiquitous use of the term 'prediabetes', the general subclinical or pre-diabetic state will be referred to hereafter as PDM. However, the terms IGT and IFG will be used where each condition is explicitly stated, or such distinction is warranted.

1.2.2. The Impact of Type 2 Diabetes

Due to its significant impact on the health and wellbeing of individuals, families and societies worldwide, T2DM has been labelled a major global public health concern; and, due to rapid economic development, urbanisation, and the ageing population, its incidence is rising steadily (Khan et al., 2020; Saeedi et al., 2019). In 2017, approximately 462 million individuals worldwide (or 6.28% of the global population) were affected by T2DM, and the current global prevalence rate is projected to increase from 6,059 cases per 100,000 people, to 7,079 cases per 100,000 by the year 2030 (Khan et al., 2020). Over one million deaths per year worldwide can be attributed to T2DM alone, making it the ninth leading cause of mortality, and it ranks seventh among the leading causes of disability and years of life lost (Khan et al., 2020). Serious complications of T2DM can include diabetic retinopathy, a microvascular disease and leading cause of visual loss in adults worldwide (Wang & Lo, 2018); diabetic kidney disease, a clinical syndrome that is experienced by 20 to 40% of adults with diabetes (Persson & Rossing, 2018); and diabetic foot disease, a condition experienced by 6% of people with diabetes, which manifests as infection, ulceration, or destruction of tissues within the foot (Mishra et al., 2017). In approximately 1 in 100 cases of diabetic foot disease, the severity of tissue damage warrants amputation (Lazzarini et al., 2015). A major comorbidity of T2DM is cardiovascular disease (CVD), which affects 32% of all people with diabetes (Einarson et al., 2018). In large prospective trials, T2DM was identified as a significant risk factor for CVD, including stroke, angina, heart failure, myocardial infarction, and atherosclerosis (Emerging Risk Factors Collaboration, 2010; Peters et al., 2014; Shah et al., 2015). Furthermore, meta-analytic studies have found that T2DM is associated with an increased risk of cognitive impairment and dementia (Pal et al., 2018; Xue et al., 2019), hepatocellular carcinoma (Xu et al., 2017), pancreatic cancer (Liao et al., 2015), periodontal disease (Chávarry et al., 2009), and tendinopathy (Ranger et al., 2016).

Recent research has assessed the relationship between T2DM and COVID-19, also known as novel coronavirus disease 2019, or by its viral label: severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Findings indicate that diabetes was associated with increased mortality, symptom severity, and acute respiratory distress syndrome in people who had contracted COVID-19 (Huang et al., 2020). In a meta-analysis of 87 studies–which included 35,486 patients, and 5,867 deaths–diabetes was found to be the strongest predictor of COVID-19 related mortality (Corona et al., 2021). The disproportionate severity of COVID-19 symptoms in those with T2DM is likely due to the pulmonary dysfunction observed in people with diabetes, and their increased susceptibility to infection due to lymphopenia, and exaggerated inflammatory response (Fuso et al., 2019).

The global economic burden of T2DM is substantial, growing rapidly in recent years (Seuring et al., 2015). The international average annual cost of treating patients with T2DM is estimated at US$3,418 (€3,120) per person. However, this figure rises to US$9,705 (€8,850) in patients with both T2DM and CVD (Einarson et al., 2018). It was also estimated that approximately 12% of overall global healthcare expenditures are on diabetes treatments alone, equating to approximately US$850 billion (Basu et al., 2019), though these figures encompass all forms of diabetes. In the context of Ireland, there is limited national data on the epidemiology of T2DM, particularly among middle-aged and younger adults (Buckley et al., 2013; Pierse et al., 2020; Tracey et al., 2015). However, recent estimates suggest that approximately 216,000 adults over the age of 40 have T2DM, and this figure is projected to reach 414,000 by the year 2036 (Pierse et al., 2021). Additionally, the current prevalence of T2DM and PDM among those over age 40 is estimated at approximately 9.2% and 8.2% respectively (Pierse et al., 2021). The economic burden of T2DM in Ireland is also cause for concern. According to an Irish study of healthcare utilisation among adults aged 50 years and over, diabetes was associated with an 87% increase in outpatient visits, a 52% increase in hospital admissions, and a 33% increase in accident and emergency department attendances, when compared against data from adults without diabetes (O'Neill et al., 2018). The incremental cost of this additional service use was estimated to be €89 million annually, with hospital admissions accounting for 67% of these costs.

1.2.3. Early-Onset Type 2 Diabetes

Type 2 Diabetes Mellitus is often framed as a disease that mostly affects middle-aged and older adults. However, the prevalence of T2DM is rising in younger adults aged 18 to 39 years (Lascar et al., 2018). It is estimated that individuals with 'early-onset' T2DM (most often defined as a diagnosis of T2DM in those under the age of 40), make up 15 to 20% of all adult T2DM cases worldwide (Centers for Disease Control and Prevention, 2020; Lascar et al., 2018; Yeung et al., 2014). Although the prevalence of T2DM among those under 40 years of age is lower than in those over 40, young adults with early-onset T2DM have a much higher risk of CVD when compared with age-matched individuals (Hillier & Pedula, 2003). This is mostly attributable to a longer duration of T2DM experienced by those who develop it earlier (Huo et al., 2016). Younger adults with early-onset T2DM experience more severe micro- and macrovascular complications (Chan et al., 2014; Lascar et al., 2018; Sattar et al., 2019; Song & Gray, 2011), and have a higher mortality rate (Gregg et al., 2018) than those who developed T2DM at an older age. Despite the disproportionate severity of the condition in younger adults, guidelines for early-onset T2DM are extrapolated predominantly from evidence in older individuals, and adults age 18 to 39 remain highly underrepresented in T2DM clinical research trials (Sargeant et al., 2020).

1.2.4. Risk Factors for Type 2 Diabetes

Genetic factors that predispose individuals to T2DM are considered essential to the disease's development. However, activation of these genetic predispositions requires the presence of several environmental and behavioural factors (Alberti et al., 2007). Risk factors for T2DM are usually characterised as either non-modifiable or modifiable.

1.2.4.1. Non-Modifiable Risk Factors. Commonly cited non-modifiable factors that increase one's risk of developing T2DM include: *family history*, such as having a first-degree relative with T2DM (Ali, 2013; Ekoe et al., 2018); *life stage*, where risk markedly increases as one advances in age (Cho et al., 2018; Ekoe et al., 2018); *sex or gender*, where the prevalence of early-onset T2DM tends to be higher among females, while mid-to-late life onset is most often higher among males (Huebschmann et al., 2019); *race or ethnicity*, where South Asian, Hispanic, Indigenous, and black African or Caribbean populations have a significantly higher probability of developing T2DM compared with white populations, due to both genetic factors and socio-economic disparities (Ekoe et al., 2018; Paul et al., 2017); and, *previous diagnosis of GDM,* as women with a history of the condition have an almost 10-fold higher risk of developing T2DM than those who experienced a normo-glycaemic pregnancy (Vounzoulaki et al., 2020).

1.2.4.2. Modifiable Risk Factors. The modifiable risk factors for T2DM are commonly known as 'lifestyle factors', as they represent behaviours that can be changed, or outcomes that can be prevented (Alberti et al., 2007). However, the term 'lifestyle factor' can imply that people engage in deleterious health behaviours solely by choice. In reality, a range of environmental factors such as global urbanisation and socio-economic disparities can limit the opportunities for certain individuals and groups to engage in behaviours that can reduce their risk of developing T2DM (Hill et al., 2013). Psychological stress for example, can increase the risk of T2DM by mobilising biological responses implicated in the disease, including the release of glucose and lipids into circulation, inflammatory cytokine expression, and increased blood pressure (Hackett & Steptoe, 2017). While one could take steps to reduce or modify their stress levels, this may be challenging if the stress derives from a factor that an individual cannot easily control, such as socio-economic status.

Notwithstanding the environmental antecedents, the most commonly cited modifiable risk factors for T2DM are excess body weight, physical inactivity, 'unhealthy' diet (e.g., a diet that is high in sugar and saturated fat, and low in fruit and vegetable intake), and smoking (Diabetes Ireland, 2020b; Diabetes UK, 2020a; Ekoe et al., 2018; Lindström et al., 2010; WHO, 2021). Obesity, characterised by a Body Mass Index (BMI) of $\geq$30 kg/m^2, is often associated with T2DM (Davies et al., 2018; International Diabetes Federation, 2019; Malone & Hansen, 2019), and is possibly the strongest modifiable risk factor for the development of the insulin resistance that ultimately leads to the development of the disease (Bastien et al., 2014). This is likely due to the accumulation of excess fat within adipose tissue, skeletal muscle and liver, and ectopic fat within and around major organs, including the heart, liver, pancreas, and kidneys, all commonly observed in people with high BMI levels (Carbone et al., 2019). While some have argued that visceral (or intra-abdominal) fat has the strongest causal relationship with insulin resistance (Lebovitz & Banerji, 2005), others suggest that subcutaneous (or peripheral) fat is the major causal factor (Miles &

Jensen, 2005). However, according to a recent meta-analysis, both are likely contributors. Lee et al. (2017) compared data on BMI, waist circumference, waist-hip ratio, and waist-height ratio against T2DM incidence. Each measure had a positive association with the incidence of the disease. A one standard deviation increase in each of the measures was associated with a 64 to 80% higher risk of developing T2DM. Regardless of its complex aetiology, obesity remains the outcome of an interplay between the non-modifiable and modifiable risk factors for T2DM. Furthermore, extensive international evidence suggests that an individual's dietary and physical activity practices represent the strongest behavioural predictors of both obesity and T2DM (American Diabetes Association, 2021b; National Institute for Health and Care Excellence, 2019; UK National Screening Committee, 2019).

1.3. Avenues for the Prevention of Type 2 Diabetes

A recent international consensus statement outlined the current global status of T2DM prevention and discussed several key forms of intervention that should be implemented to halt the disease's escalating trend (Ibrahim et al., 2018). First, people at risk of developing T2DM should be identified using validated non-invasive risk scores that are ethnically and culturally tailored. Second, lifestyle interventions should be prescribed with the aim of weight reduction and/or weight management to be achieved via nutritional education and the encouragement of regular physical activity. Third, diabetes medications can be considered for use in the highest risk individuals when lifestyle interventions are not successful. Finally, it was recognised that social and environmental factors have significant impact on the development of both obesity and T2DM. Disparities exist within global populations where individuals, despite having the desire to prevent T2DM, may have limited opportunity to do so. Therefore, population-wide policy measures should also be considered.

While the primary aim of the present research is to inform the development of a lifestyle programme, it is important to acknowledge other T2DM prevention strategies that could work alongside a digital DPP in Ireland, as implementation of these strategies are not necessarily mutually exclusive. Lifestyle interventions for the prevention of T2DM have attracted some criticism (e.g., Barry et al., 2015; Barry et al., 2017; Hawkes, 2018; Victor & Montori, 2016), seemingly fuelled by the belief that advocates for such interventions actively ignore the need to implement population-wide T2DM prevention policies, and thus fail to account for socio-economic disparities within and between countries and communities. However, preventing T2DM on both a national and global scale will likely require multiple avenues of intervention to be operating simultaneously at both the individual (or downstream), and population (upstream) levels. In view of this, the following sections will present several T2DM preventive strategies so that lifestyle intervention can be placed within a wider public health context.

1.3.1. Type 2 Diabetes Risk Screening

To determine one's overall risk of developing T2DM, several self-screening tools are available for people to complete online or in person through a health centre or clinic. These commonly take the form of brief questionnaires that, based on the responses given (e.g., age, race/ethnicity, BMI, waist circumference, family history, diet, and physical activity habits) generate a risk score that indicates one's level of T2DM risk. Such tools include the Finnish Diabetes Risk Score (FINDRISC; Lindström & Tuomilehto, 2003) and the Diabetes UK 'Know Your Risk Tool' (Diabetes UK, 2020b). The FINDRISC is one of the most widely applied and accepted risk assessment tools as it is non-invasive, inexpensive, and easy to perform with a good sensitivity and specificity (Gabriel et al., 2021). Moreover, it has been translated into several languages, and culturally adapted to suit various global populations. However, this and other questionnaire-based risk assessments are used to indicate potential risk only. They are not diagnostic tools, and therefore cannot confirm nor rule out the presence of either T2DM or PDM. However, they may be useful for encouraging people to attend a blood test screening for T2DM, or to make immediate lifestyle changes with the aim of preventing the disease's development.

1.3.2. Pharmacological Measures

In many cases, adults with T2DM take multiple medications for hyperglycaemia, diabetes-associated conditions, and other comorbidities (Kirkman et al., 2015). However, medications have also been prescribed for people at risk of T2DM, such as individuals with PDM (Yudkin & Montori, 2014). The American Association of Clinical Endocrinologists recommend that PDM should be managed through lifestyle change, with medication considered only for people with multiple pre-diabetic criteria such as IGT, IFG, and/or metabolic syndrome (Garber et al., 2017). In the United Kingdom (UK), the National Institute for Health and Care Excellence (NICE) have issued similar recommendations, suggesting that lifestyle changes should be encouraged before pharmaceutical options are prescribed (Chatterjee et al., 2018). Despite these guidelines, there remains a lack of international agreement regarding the specific eligibility criteria for the prescription of pharmacological therapy for T2DM prevention (Cefalu et al., 2016; Moin et al., 2018). Furthermore, among those who are eligible to receive such therapies, prescription rates are very low, presumably due to the perceived and/or observed side effects of the drugs, and reluctance of patients and providers to 'medicalise' sub-clinical T2DM (Moin et al., 2015). Currently in the UK, both Metformin (a plasma glucose-lowering drug) and Orlistat (an 'anti-obesity' drug that prevents fat absorption in the gastrointestinal tract) are recommended for the prevention of T2DM, but only in cases where patients are at particularly high risk, and if intensive lifestyle change is not possible, or was ineffective at reducing this risk (NICE, 2017). In the United States (US), the American Association of Clinical Endocrinologists also recommend Metformin, or additionally, Acarbose (another drug that assists in the control of blood glucose). However, if blood glucose levels do not normalise, Thiazolidinediones (which improve insulin sensitivity) or Glucagon-Like Peptide-1 Receptor Agonists (which increase the secretion of insulin from functioning beta cells, and decrease the release of glucagon, a peptide hormone that facilitates the release of glucose into the bloodstream) may be used with caution (Garber et al., 2017; Jiang & Zhang, 2003). A further range of pharmacological strategies have been used for the prevention of T2DM (Smith-Marsh, 2013), and while extended discussion of the strategies presented here is beyond the aims and scope of this thesis, a brief summary of the oral drug Metformin is warranted due to its popularity and consistent evaluation against lifestyle programmes, most of which will be discussed in forthcoming sections of this chapter.

Metformin has been established as the first-line pharmacological option for the management and treatment of T2DM for over 50 years, and is the most prescribed glucose-lowering agent in most countries (Foretz et al., 2019; Pernicova & Korbonits, 2014; Sanchez-Rangel & Inzucchi, 2017; Wang & Weinshilboum, 2014). It has also been linked with improved health outcomes such as BMI reduction and improved cholesterol profile (Bansal, 2015). In a recent review, Metformin was associated with reduced relative risk of incident T2DM, particularly in those at highest risk (e.g., age >60 years, BMI ≥35, and women with a history of GDM), and was deemed cost effective in 11 economic analyses (Moin et al., 2018). Despite having a good safety profile, commonly reported side effects include mild gastrointestinal effects (e.g., diarrhoea, nausea, abdominal pain) and vitamin B12 deficiency (Aroda et al., 2016; Foretz et al., 2019). However, these symptoms are generally transient, resolve spontaneously, and can be mitigated by gradually increasing the dosage (Diabetes Prevention Program Research Group, 2012). The drug has also been linked with lactic acidosis, a condition that can be fatal if left untreated (Lalau, 2010). However, a 2010 Cochrane review concluded that there is no evidence that Metformin is associated with an increased risk of lactic acidosis when compared to other anti-hyperglycaemic treatments (Salpeter et al., 2010).

1.3.3. Dietary Measures

Over the last decade, a range of systematic reviews and meta-analyses have assessed the effect of nutritional supplementation and dietary practices on: (a) the risk of T2DM and its incidence, and (b) T2DM indicators such as blood glucose levels. The focus of these studies can be grouped into separate categories, ranging from the smallest dietary elements such as micronutrients (e.g., vitamins and minerals) and macronutrients (e.g., fats, carbohydrates, and proteins), up to whole foods and beverages (e.g., potatoes, fruit juice, alcohol), food groups (e.g., dairy products), and complete diets (e.g., Mediterranean diet, vegetarian eating plans). As myriad reviews and meta-analyses exist in the literature, only those which found significant associations between the diets or dietary component(s) under study, and reductions in the risk and incidence of T2DM or related biomarkers will be presented here. Most studies assessed the dietary components on a dose-response relationship with T2DM or compared high versus low intakes of the components and adjusted for potential mediators or moderators such as age, sex, smoking, BMI, and physical activity. For the sake of brevity, extended details regarding each finding (dosage, frequency, form, mechanisms of action etc.) will in most instances, not be discussed.

1.3.3.1. Micro and Macronutrient Effects. Meta-analyses found that supplementation with the minerals magnesium (Fang et al., 2016) and calcium (Dong & Qin, 2012) may each independently reduce the incidence of T2DM; as can vitamin C (Hamer & Chida, 2007), vitamin E (Hamer & Chida, 2007), catechin, a natural plant phenol and antioxidant (Rienks et al., 2018), and common polyphenols in general (Rienks et al., 2018). Despite inconclusive results in previous studies, a recent meta-analysis by Zhang et al. (2020) found that vitamin D supplementation could reduce the risk of T2DM in people with PDM. Additionally, a recent meta-analysis on carnosine (a protein building-block) found that its supplementation may improve cardiometabolic risk factors pertinent to T2DM (De Courten et al., 2019). Other compounds with reported effects on reducing T2DM incidence are vegetable fats (Alhazmi et al., 2012), ruminant trans-palmitoleic acid (de Souza et al., 2015), cereal fibre and insoluble fibre (The InterAct Consortium, 2015), and sucrose, when compared against other sugars such as fructose (Tsilas et al., 2017).

1.3.3.2. Whole Food and Beverage Effects. Meta-analyses on beverage consumption found that light-to-moderate alcohol consumption (Li et al., 2016), moderate beer or wine consumption (Huang et al., 2017), total coffee (Carlström & Larsson, 2018), caffeinated coffee (Ding et al., 2014), decaffeinated coffee (Ding et al., 2014), and tea (Yang et al., 2014) were each independently associated with reduced incidence of T2DM. While the findings regarding alcohol consumption may seem unexpected given the links between its consumption (when in excess) and cirrhosis of the liver–which significantly increases the risk of T2DM (Garcia-Compean et al., 2009)–the link between light-to-moderate alcohol consumption and reduced T2DM incidence supports previous evidence indicating the presence of a U-shaped association between alcohol consumption and the incidence or risk of chronic disease (Higashiyama et al., 2013).

With regards to whole foods and food groups, meta-analyses found that the consumption of olive oil (Schwingshackl et al., 2017), oily fish (Zhang et al., 2013), yellow vegetables (Wang et al., 2016), whole grains (Schwingshackl et al., 2017), whole grain cereals (Aune et al., 2013), whole grain bread (Aune et al., 2013), wheat bran (Aune et al., 2013), brown rice (Aune et al., 2013), yoghurt (Gijsbers et al., 2016), and chocolate (Yuan et al., 2017) each independently reduced the risk or incidence of T2DM. Chocolate, which is often labelled an ‘unhealthy snack’ (Smith & Rogers, 2014), had a peak protective dose of two 30-gram servings per week. However, the benefit in risk reduction is lost when more than six weekly servings are consumed (Yuan et al., 2017). This suggests that chocolate is not inherently unhealthy, but like alcoholic beverages, may be detrimental to one’s health when consumed in larger amounts. Further to the above findings, a meta-analysis by Nowrouzi-Sohrabi et al. (2020) found that pistachio nut consumption may significantly reduce fasting blood glucose (FBG) in people at risk of T2DM. However, this effect was not present for HbA1c.

1.3.3.3. Complete Diet Strategies. One disadvantage of studying the effects of nutrients and foods in isolation is that such research may not capture the effects of one’s overall diet (Cespedes & Hu, 2015). In practice, the bioactivity of specific nutrients or foods can be nullified by other dietary compounds, while nutrients that have no health benefits in isolation could have synergistic effects when combined with other compounds (Jacobs & Tapsell, 2007). Acknowledging this, several meta-analyses have assessed a range of diets that in most cases were designed to prevent chronic disease. The Mediterranean diet–characterised by a high consumption of vegetables, olive oil, fruits, cereals and legumes, a low consumption of red or processed meat, and a low-to-moderate consumption of red wine during meals (Sofi, 2009)–was found by Koloverou et al. (2014) to reduce the risk and incidence of T2DM. Similar effects were found by Schwingshackl and Hoffmann (2015) regarding adherence to other diets and eating guides such as the DASH, or Dietary Approaches to Stop Hypertension eating guide (e.g., Chiuve et al., 2012; Sacks et al., 2001); the HEI, or Healthy Eating Index (Guenther et al., 2013; Kennedy et al., 1995); and the AHEI, or Alternate Healthy Eating Index (Chiuve et al., 2012; McCullough et al., 2002). Each guide recommends a high intake of fruits, vegetables, nuts and legumes, low-fat dairy products, and whole grains, in addition to low intakes of sodium, sugar-sweetened beverages, plus red and processed meats. A meta-analysis by Bhupathiraju et al. (2014) found that people who consumed a diet that was high on the glycaemic index (GI) or high in glycaemic load (GL), and low in cereal fibre had an approximately 50% higher risk of developing T2DM than people who consumed a low GI or GL diet. The GI is a ranking of carbohydrates according to their effect on postprandial (or post-meal) glycaemia, where a higher ranking indicates a stronger effect (Jenkins et al., 1981). The GL represents the amount of carbohydrate consumed (e.g., in grams) multiplied by its glycaemic index (Willett et al., 2002). In their meta-analysis, Lee and Park (2017) found an inverse relationship between adherence to a vegetarian diet and the risk of T2DM. This was supported by Qian et al. (2019) who found commensurate effects in their meta-analysis on plant-based diets. As no meat products are consumed in plant-based diets, these diets share commonalities with the Mediterranean, HEI, AHEI and DASH diets in that red or processed meats are eliminated.

1.3.3.4. Dietary Factors That Increase Type 2 Diabetes Risk. While the preceding sections outlined the nutrients, foods, and diets that may reduce the risk and incidence of T2DM, several meta-analyses found certain dietary components to increase one’s risk, suggesting that reducing the consumption of these components may protect against T2DM. These include total cholesterol (Tajima et al., 2014), sugar-sweetened beverages (Imamura et al., 2016), artificially-sweetened beverages (Imamura et al., 2016), sugar-sweetened fruit juice (Xi et al., 2014), potatoes (Schwingshackl et al., 2019), processed red meat (Pan et al., 2011), white rice (Aune et al., 2013), and bacon (Micha et al., 2010). Furthermore, routine breakfast skipping (Bi et al., 2015) and consuming a diet that is high in acidic load (Jayedi & Shab-Bidar, 2018) may also increase the risk of T2DM relative to those who do not skip breakfast, and have diets low in acidic load respectively.

1.3.4. Physical Activity

Physical activity is one of the most important factors for improving population health. However, it takes many forms, and there is little empirical agreement as to how it is best performed and measured, making it challenging to identify what works best (Bauman et al., 2009). However, several recent meta-analyses aimed to identify the links between physical activity (or lack thereof, commonly referred to as sedentary behaviour) and the risk of T2DM. In their meta-analysis of leisure time physical activity, Huai et al. (2016) found that high-level (e.g., >21 metabolic equivalent of task [MET] hours per week, or >1500 kilocalories per week) and moderate-level (e.g., 6-21 MET h/week, or 1000-1500 kcal/week) leisure time physical activity reduced the incidence of T2DM by 22-39% and 11-30% respectively. Aune et al. (2015) assessed various forms of physical activity in their meta-analysis and found that–when compared with low total physical activity–leisure-time activity; low, moderate and vigorous intensity activity; resistance exercise; occupational activity; walking; and cardiorespiratory fitness, were each associated with significant reductions in T2DM risk of between 15% (when linked with walking) and 55% (when linked with cardiorespiratory fitness). However, these risk reductions may be partly mediated by reductions in adiposity. The effectiveness of resistance training was assessed by Qadir et al. (2021) who found that, when performed two-to-four times per week, such training significantly improved HbA1c, FPG, and blood lipid levels (e.g., total cholesterol, high and low density lipoproteins, and triglycerides) when compared against a control condition. These results were independent of dietary intervention. Jadhav et al. (2017) recruited individuals with PDM, and found that participation in structured physical activity programmes, when compared against an active control group (e.g., general health advice, monitored walking), had significant effect on oral glucose tolerance and FBG, each indicating a reduction in the risk of progression to T2DM. A meta-analysis of cardiorespiratory fitness and muscular strength conducted by Tarp et al. (2019) found that, after controlling for adiposity and body size, each single unit MET increase in cardiorespiratory fitness was associated with an 8% lower relative risk of T2DM. Moreover, each single standard deviation increase in muscular strength was associated with a 13% lower relative risk of T2DM. Finally, sedentary behaviour, when operationalised as higher levels of total sitting as well as television viewing time, was found by Patterson et al. (2018) to increase the risk for all-cause and CVD mortality, and incidence of T2DM, independent of physical activity. This evidence collectively suggests that various forms of physical activity can be effective at reducing the risk of T2DM independent of dietary behaviours and reductions in body weight.

1.3.5. Population Measures

Research has demonstrated that T2DM disproportionately affects racial/ethnic minority and low-income adult populations, as evidenced by their elevated risk status, and higher rate of diabetes-related complications and mortality (Hill-Briggs et al., 2021). This has been attributed to uncertain or limited access to adequate safe foods, or a lack of living environments conducive to walking or other forms of physical activity (Essien et al., 2016; Haire-Joshu & Hill-Briggs, 2019). Given these disparities, national T2DM prevention policies may produce significant reductions in disease prevalence by affecting populations across the wider socio-economic spectrum, and by reducing the healthy eating and physical activity barriers experienced by individuals participating in lifestyle interventions such as a DPP (Gregg et al., 2013; Pierse et al., 2021). Population-based prevention strategies are those that focus on the whole population regardless of the level of risk, creating public health impact through policy implementation, campaigns, and other environmental strategies (Zhou et al., 2020). Such strategies were recommended by the WHO in its global status report where, it was suggested that to successfully prevent noncommunicable diseases such as T2DM, action from multiple sectors is required, such as those related to the production, distribution, and marketing of food, and those responsible for shaping an environment that facilitates and promotes physical activity (WHO, 2014).

Several international studies have assessed the cost-effectiveness of current or proposed population-wide strategies to prevent non-communicable diseases such as T2DM. These strategies include: (a) *the implementation of* a sugar-sweetened beverage *tax* as enacted in the US (Basu et al., 2013; Mekonnen et al., 2013), the UK (Breeze et al., 2017), and Australia (Cobiac et al., 2017; Veerman et al., 2016); (b) *the provision of fruit and vegetable subsidies,* as also implemented in the US (Basu et al., 2013; Choi et al., 2017) and Australia (Cobiac et al., 2017). For example, in the US, people of low-income households on the Supplemental Nutrition Assistance Program (SNAP) receive an extra 30-cent benefit for every $1 of SNAP benefits spent on fruit and vegetables (Choi et al., 2017); (c) *delivering public health education and promotion* where, in the US for example, community-wide interventions were developed to promote walking among sedentary individuals aged 50 to 65 years using paid media (e.g., television, radio, newspapers, websites, billboards), public relations, and public health activities at worksites, churches, and local organisations (Roux et al., 2008). In the UK, people residing in the most disadvantaged communities were offered diet education and cooking classes (Breeze et al., 2017). Additionally, in Australia, the

Travelsmart active transport program targeted households with tailored information (e.g., maps of local walking paths) and merchandise (e.g., water bottles, key rings) as incentives for reducing the use of cars for transport (Cobiac et al., 2009); and (d) *changing the built environment*, which involves the implementation of initiatives to facilitate an active lifestyle. In the US, this included: building bike paths, extending fitness facility hours, opening new fitness centres, and establishing cycling clubs, running courses, and organised athletic events (Roux et al., 2008). In the UK, this involved improving the food environment by opening new supermarkets in disadvantaged urban areas, and increasing healthy food options in workplace cafeterias (Breeze et al., 2017).

A recent systematic review of the cost-effectiveness of these population-wide measures in the context of T2DM prevention found that sugar-sweetened beverage taxes were cost-saving from both the health care system and governmental perspectives (Zhou et al., 2020). However, according to this same review, evaluations of these other population-based interventions showed inconsistent results. This supports a previous meta-analysis of population-wide diabetes and obesity prevention programs which found that–despite achieving small reductions in BMI–the implementation of sugar-sweetened beverage taxes, menu labelling, grocery store interventions, and multicomponent interventions had very little impact on the prevalence of overweight, obesity, or T2DM (Roberts et al., 2019). However, the authors concluded that the presence of 'some' effect still warrants the implementation of these measures in cases where they are both acceptable and affordable.

1.3.6. Lifestyle Interventions that Combine Diet and Physical Activity

Current international guidelines on the prevention of T2DM have been informed, in part, by research findings such as those regarding T2DM risk factors and risk screening, dietary practices, and physical activity. Examples of these guidelines include: the European evidence-based guidelines for the prevention of T2DM, or IMAGE toolkit for the prevention of T2DM in Europe (Lindström et al., 2010; Paulweber et al., 2010); Diabetes UK evidence-based guidelines for the prevention and management of T2DM (Dyson et al., 2018); the American Diabetes Association prevention or delay of T2DM standards of medical care (American Diabetes Association, 2020a); and the NICE guidelines for the prevention of T2DM in people who are at high risk (NICE, 2017). The common thread in these guidelines is the call for the implementation of evidence-based lifestyle interventions that focus on health behaviour change in the areas of both diet and physical activity, with the aim of facilitating weight loss, and where appropriate, smoking cessation. European guidelines further state that these interventions should contain a range of established behaviour change techniques (BCTs) such as goal setting, problem solving, social support, and action planning–each representing an observable, replicable, and irreducible intervention component that can be applied to assist people in changing their health behaviours (Michie et al., 2013; Paulweber et al., 2010). Such interventions have been deemed 'best practice' for individual-level preventive approaches, a distinction primarily based on findings from a series of international landmark diabetes prevention trials and seminal studies (Allende-Vigo, 2015; Gillett et al., 2012). These trials, which will be described in detail here, were of great significance, paving the way for current DPPs.

1.4. Landmark Diabetes Prevention Trials

Almost three decades ago, the burgeoning global incidence rate of T2DM and diabetes-related CVD prompted urgent preventive action in many countries, taking the form of large-scale clinical trials of lifestyle interventions and programmes. The aim of these programmes was to assist people at high risk of T2DM in achieving and maintaining a healthy body weight through improvements in dietary quality and physical activity levels (Alberti et al., 2007).

1.4.1. The Malmö Feasibility Study

In one of the first lifestyle intervention studies for T2DM prevention, men aged 47 to 49 in Malmö, Sweden (41 with early-stage T2DM, and 181 with IGT), identified through a screening programme conducted in the years 1975-79, were randomly assigned to either receive usual care or complete a lifestyle intervention (Eriksson & Lindgärde, 1990, 1991). Approximately 40% of individuals participating in the lifestyle intervention completed six months of supervised physical training, and six months of dietary treatment in a randomised cross-over design. Those who participated in the lifestyle intervention had a lower incidence of T2DM and a greater reversal of glucose intolerance compared with those who received usual care. Furthermore, mean body weight among intervention participants was reduced by 2.3 to 3.7%, whereas those who received usual care increased their body weight by 0.5 to 1.7%. At 12-year follow-up, the mortality rate among intervention participants with IGT was almost half that of those who received usual care, suggesting that a long-term programme which includes dietary counselling and physical exercise can reduce mortality among individuals at increased risk of developing T2DM (Eriksson & Lindgärde, 1998).

1.4.2. Da Qing Study

The Da Qing study in China which commenced in 1986, randomly assigned 577 men and women with IGT (mean age = 45 years) to a control group or one of three active treatment groups (diet only, exercise only, or diet and exercise combined) for a total intervention period of six years (Pan et al., 1997). Participants in the diet only group were encouraged to consume more vegetables and reduce their simple sugar and overall calorie intake, while those in the exercise only group were instructed to increase their leisure-time physical activity by one or two units of activity per day. Adjusting for differences in baseline BMI and fasting glucose, the diet, exercise, and diet-plus-exercise interventions were associated with T2DM risk reductions of 31%, 46%, and 42% respectively. At follow-up of 23 years, when comparing participants who received any of the interventions versus those in the control group respectively, the cumulative incidence of CVD mortality (11.9% versus 19.6%), all-cause mortality (28.1% versus 38.4%), and T2DM incidence (72.6% versus 89.9%) was each lower among intervention participants (Li et al., 2014). At 30-year follow-up, when compared with the control group, the combined intervention group had a median delay in T2DM onset of 3.96 years, fewer CVD events, lower incidence of microvascular complications, fewer CVD and all-cause deaths, and an increase in life expectancy of 1.44 years (Gong et al., 2019). All between-group differences were statistically significant, suggesting that a combined diet and exercise intervention can lead to sustained T2DM and CVD risk reductions.

1.4.3. Japan Diabetes Prevention Program

Commencing in 1990, the Japan Diabetes Prevention Programme (JDPP) randomly assigned 356 and 102 middle-aged males with IGT to a lifestyle intervention and active control group respectively (Kosaka et al., 2005). Participants in the intervention group were provided dietary education, and advised to increase their vegetable intake, decrease their meal portion sizes, limit their fat and alcohol intake, and were given individualised advice regarding snacks and fruit intake. Additionally, participants were advised to complete 30 to 40 minutes of moderate exercise each day through walking and bike riding, both for leisure, and/or as a part of their daily commute. At four-year follow-up, the cumulative incidence of T2DM in the intervention and control groups was 3.0% and 9.3% respectively, and body weight reductions were 2.18 kg and 0.39 kg respectively. Additionally, the risk reduction in the intervention group was a significant 67.4%. The intervention group’s relatively steep reduction in T2DM despite achieving only modest weight loss suggests that the success of the lifestyle intervention cannot be attributed to weight loss alone.

1.4.4. The Finnish Diabetes Prevention Study

The Finnish Diabetes Prevention Study (DPS), which commenced its recruitment in 1993, was the first randomised controlled trial (RCT) to specifically examine the effect of a structured lifestyle intervention on the prevention of T2DM (Eriksson et al., 1999; Lindstrom et al., 2003; Lindström et al., 2005; Tuomilehto et al., 2001). In this study, 522 adults aged 40 to 64 years were randomly assigned to a lifestyle intervention group or control group and followed for approximately three years. The lifestyle intervention provided participants with personalised counselling which focused on increasing physical activity and improving dietary behaviours (e.g., increasing fibre intake whilst reducing saturated fat intake) with the aim of maintaining a healthy body weight. At two-year follow-up, T2DM incidence in the intervention group was less than half of that observed in the control group, and at three years, weight reductions in the intervention and control groups were 3.5 kg and 0.9 kg respectively. Weight reduction was also associated with T2DM prevention in a linear fashion, with a 5% weight reduction from baseline resulting in a 66% risk reduction in T2DM incidence. Furthermore, this incidence was inversely proportional to the number and magnitude of lifestyle changes made. The DPS research group has since reported that the impact of lifestyle changes on body weight, fasting and 2-hour plasma glucose, and diet quality were sustained for 13 years after the original intervention had concluded (Lindström et al., 2013).

1.4.5. The United States Diabetes Prevention Program

The Diabetes Prevention Program implemented in the United States (US-DPP) was, at the time of commencement in 1996, one of the largest RCTs ever conducted. Furthermore, the trial included a large proportion of women (68%) and ethnic minorities (45%), making it the most demographically diverse diabetes prevention study to date (Diabetes Prevention Program Research Group, 1999, 2000, 2002). In this trial, 3,234 people with elevated fasting and post-load plasma glucose concentrations (mean age = 51 years) were randomly assigned to receive a placebo, a drug intervention (Metformin), or a lifestyle-modification intervention, each with the goals of at least 150 minutes of physical activity per week, and a 7% weight loss by programme’s end (Knowler et al., 2002). Participants who received the lifestyle intervention lost an average of between 5% and 7% of their baseline body weight after one year; and, after an average follow-up of 2.8 years, the incidence of diabetes was 11.0, 7.8, and 4.8 cases per 100 person-years in the placebo, Metformin, and lifestyle groups, respectively. The lifestyle intervention and Metformin reduced the incidence of T2DM by 58% and 31% respectively when compared with the placebo. Furthermore, the lifestyle intervention was significantly more effective than Metformin at preventing T2DM. At 15-year follow-up, T2DM incidence was reduced by 27% and 18% in the lifestyle and Metformin groups respectively, compared with the placebo group, suggesting that the effects of lifestyle intervention on T2DM can be sustained over an extended period (Diabetes Prevention Program Research Group, 2015). Overall, these results suggest that a diet plus physical activity lifestyle intervention can be more effective at reducing the long-term risk of developing T2DM than Metformin, the most prescribed drug for the management or prevention of the disease.

1.4.6. The Indian Diabetes Prevention Programme

The Indian Diabetes Prevention Programme (IDPP) was a prospective community-based study established in 2001 that tested whether the progression to T2DM could be reduced in a population of Asian Indians with IGT who were younger, leaner, and more insulin resistant than populations of the Da Qing, Finnish DPS and US-DPP trials (Ramachandran et al., 2006). In this study, 531 adults with IGT and a mean age of 45 years were randomised to four groups: control, lifestyle modification, Metformin, and lifestyle modification plus Metformin. The results showed that progression of IGT to T2DM was high in Asian Indians. At three years, both lifestyle modification and Metformin each significantly reduced T2DM incidence, but there was no added benefit from combining them. The relative risk reduction was 28.5% with lifestyle modification, 26.4% with Metformin and 28.2% with lifestyle modification plus metformin. However, unlike what was found in the Finnish DPS and US-DPP, body weight change was not significant between groups, suggesting that in some populations, T2DM risk can be reduced independent of weight loss, as was observed in the JDPP.

1.5. Type 2 Diabetes Prevention in the Real World

These landmark diabetes prevention trials demonstrated the efficacy of intensive lifestyle intervention across countries. However, the trials were resource-intensive in terms of staffing requirements and financial outlay. For example, the first-year cost alone of delivering the US-DPP was US$1,399 per participant (Diabetes Prevention Program Research Group, 2003a, 2003b). Additionally, the landmark trials contained selective samples that may have been highly motivated or had greater opportunity to commit to an intervention of this length and adhere to programme guidelines, when compared with the average individual at risk of developing T2DM, particularly those in disadvantaged settings (Cefalu et al., 2016; Johnson et al., 2013). Lifestyle and cultural patterns vary substantially across and within communities, necessitating the tailoring of interventions to align with regional and ethnic differences if they are to achieve effectiveness, acceptability, and sustainability (Brownson et al., 2009). For healthcare systems to effectively reduce the public health and economic burden of T2DM, these trials needed to be translated into practical, affordable interventions that are deliverable in diverse settings, yet still retain a reasonable degree of effectiveness (Schwarz et al., 2012). In view of this, national T2DM prevention efforts have since shifted from large-scale assessments of efficacy and effectiveness, to the implementation and transferability of DPPs into real-world settings (Aziz et al., 2015).

Implementation researchers seek to understand the factors, processes, and results that affect an intervention's practical application outside of controlled, clinical conditions to establish how and why these interventions may work in the real world (Peters et al., 2013). This concept of 'transferability' refers to the process of applying research results from one setting to other similar settings (Jensen, 2006). Healthcare networks in several countries have applied the evidence from landmark diabetes prevention trials to develop, implement, and assess their own real-world diabetes prevention interventions, targeting those at risk of T2DM based on BMI, blood glucose measures, and/or standardised risk assessment scores. These interventions provide education and support on healthy eating, physical activity, or a combination of both, and in many cases, were delivered to ethnic minority groups, and people in disadvantaged communities. Countries that have implemented a translational T2DM prevention intervention include Australia (Janus et al., 2012; Laatikainen et al., 2007; Payne et al., 2008; Reddy et al., 2011), Canada (Rowan et al., 2016), China (Yin et al., 2018), Finland (Absetz et al., 2009; Saaristo et al., 2010), France (Böhme et al., 2020), Germany (Kulzer et al., 2009; Zyriax et al., 2014), Greece (Makrilakis et al., 2010), India (Thankappan et al., 2018), Iran (Harati et al., 2010), Israel (Endevelt et al., 2015), Japan (Sakane et al., 2011), Malaysia (Ibrahim et al., 2016), the Netherlands (Mensink et al., 2003; Vermunt et al., 2012), New Zealand (Simmons et al., 2008), Norway (Nilsen et al., 2011), Poland (Gilis-Januszewska et al., 2011), Spain (Costa et al., 2012), Thailand (Oba et al., 2011), the UK (Bhopal et al., 2014; Penn et al., 2013; Penn et al., 2009; Yates et al., 2009), and the US (Ackermann et al., 2008; Boltri et al., 2008; Davis-Smith et al., 2007; Faridi et al., 2010; Kanaya et al., 2012; Katula et al., 2011; Kramer et al., 2009; Ockene et al., 2012; Parikh et al., 2010).

Several systematic reviews and meta-analyses have shown that these translational T2DM prevention interventions, when delivered in real-world settings, are effective for promoting weight loss and reductions in T2DM risk, performing significantly better than control conditions (Ali et al., 2012; Ashra et al., 2015; Cardona-Morrell et al., 2010; Dunkley et al., 2014; Galaviz et al., 2018; Mudaliar et al., 2016; Pronk, 2016; Shirinzadeh et al., 2019; Whittemore, 2011). Settings in which the interventions were delivered include outpatient clinical settings, workplaces, churches, and community centres, and results were most often similar whether the programme was delivered by a healthcare professional (HCP) or by non-medical (or lay) personnel, the latter resulting in comparable results at a reduced cost of delivery. Despite improvements in weight and T2DM risk, the effects on blood glucose outcomes were mixed, as some analyses found significant improvements in blood glucose measures, while others reported negligible change. Reviews that assessed the effect of T2DM prevention interventions on cardiometabolic risk factor markers (e.g., systolic and diastolic blood pressure, total cholesterol, low and high density lipoprotein cholesterol, and triglyceride levels) reported significant improvements in these factors, resulting in a reduced risk of CVD (Mudaliar et al., 2016; Pronk, 2016). However, according to a systematic review by Selph et al. (2015), the effect of these interventions on all-cause and cardiovascular mortality risk remains unclear. The reason for a lack of evidence regarding mortality risk after lifestyle intervention in real-world settings could be due to the lack of longitudinal data. According to Uusitupa (2019), findings of follow-up studies from the landmark diabetes prevention trials such as the Da Qing Study suggest that it can take up to 15 years before any beneficial intervention effects on morbidity or mortality can be found.

1.5.1. Translational National Diabetes Prevention Programmes

Most translational T2DM prevention interventions described in the literature were modelled after the US-DPP or Finnish DPS. However, many of the interventions implemented internationally are not part of a wide-reaching national DPP. In the years following the release of each landmark trial’s initial results, national real-world DPPs were developed and implemented in both the US and the UK. These programmes are: (1) the US National Diabetes Prevention Program (US NDPP; Centers for Disease Control and Prevention [CDC], 2021a); and (2) the NHS Diabetes Prevention Programme (NHS-DPP) in the UK (NHS England, 2019a). These programmes will be discussed in the following sections. However, as Ireland shares more similarities with the UK than the US regarding healthcare structure, geographical location and size, demographic profile, and population size, the NHS-DPP will be discussed in greater detail as it may be the more appropriate programme on which to model a national Irish DPP.

1.5.1.1. The US National Diabetes Prevention Program. The US NDPP (CDC, 2021a) was developed in 2010 to address the increasing burden of T2DM and PDM. This national programme, which was modelled after the US-DPP, created partnerships between public and private organisations to offer a CDC-recognised diabetes prevention lifestyle change programme which focused on healthy eating and physical activity. For an organisation to receive accreditation as a certified programme provider endorsed by the CDC, at least five participants must have completed the programme with an average weight loss of at least 5% of baseline (CDC, 2018). The programme runs for one year, where for the first six months (referred to as the 'core program'), participants meet in a group once per week, and in the second six months (the 'maintenance program'), they meet once or twice per month. The maintenance period is optional but highly recommended. To be eligible for the US NDPP, individuals must be aged 18 years or older with a BMI of ≥25; and have been either: (a) diagnosed with PDM via blood test, (b) previously diagnosed with GDM, or (c) classified as 'high risk' according to a recognised T2DM risk screening tool. To enrol, individuals either pay a proportion of the cost or may participate at no cost through their health insurance provider or employer. Adults aged 65 years or older who are registered with Medicare, can participate in the Medicare Diabetes Prevention Program (MDPP), a two-year version of the NDPP designed specifically for older adults (CDC, 2021c).

According to the CDC (2021e), key components of the NDPP and MDPP include: (a) a CDC-approved curriculum with lessons (delivered in a classroom format), handouts, and other resources to help participants make healthy changes (see CDC, 2021f); (b) support from a lifestyle coach (e.g., qualified dietitian, exercise physiologist, behavioural psychologist, health educator) to encourage participants to learn new skills, set and meet goals, and stay motivated. The coach also facilitates discussions to make the programme fun and engaging; and (c) a support group of people with similar goals and challenges. This is to share ideas, celebrate successes, and work to overcome obstacles. The primary goal of both programmes is a weight loss of 5% of baseline.

Several systematic reviews and meta-analyses have assessed the efficacy and cost-effectiveness of the US NDPP. The programme has achieved an average weight loss of 4%, where each additional lifestyle session attended was associated with a 0.26% point increase in the amount of weight lost (Ali et al., 2012). When compared against usual care, the programme achieved an additionally significant 2.2% weight loss, and a significant reduction in T2DM incidence at a risk ratio of 0.59 (Pronk, 2016). Furthermore, the goals of 5% weight loss and 150 minutes of physical activity per week were met by 35.5% and 41.8% of participants respectively (Ely et al., 2017). A more recent meta-analysis by Mudaliar et al., (2016) found, based on evidence from 44 studies, that the programme achieved clinically meaningful weight and cardiometabolic health improvements. This included an average weight loss of 3.77 kg and 5.43 kg by those who completed the core program and core-plus-maintenance programs respectively, and significant reductions in HbA1c and FBG. A cost-effectiveness analysis of the US NDPP when delivered to 847 low-income individuals reported the programme cost to be US$915 per participant (Gilmer et al., 2018). Additionally, the incremental cost-effectiveness ratio was estimated at US$14,011 per quality-adjusted life year (QALY). This collective evidence suggests that, although the US NDPP has not achieved the same level of weight loss as the US-DPP, with just over one third achieving the 5% weight loss goal, the results are still clinically meaningful. Furthermore, at a per-person running cost of approximately half that of the US-DPP (US$915 versus US$1,866), the US NDPP is comparable to its predecessor with regards to cost-effectiveness (Gilmer et al., 2018).

Despite its achievements, the US NDPP has experienced challenges with regards to participant engagement. According to the review by Mudaliar et al. (2016), 25.5% of eligible participants did not enrol, and of those who did, 23.8% dropped out of the programme prior to completion. A recent qualitative study by Ritchie et al. (2021) reported four main themes regarding barriers to participation as perceived by the programme’s participants. These were: (1) challenges with scheduling and planning (e.g., work, school, and caregiving responsibilities; and unspecified competing priorities), (2) challenges travelling to and from class (e.g., bad weather, lack of transport), (3) challenges with changing health behaviour (e.g., low motivation and/or self-efficacy, lack of support from family or friends, lack of knowledge and/or resources for health behaviour change), and (4) other miscellaneous health concerns.

1.5.1.2. The NHS Diabetes Prevention Programme. The UK’s NHS-DPP was originally announced in 2014 and remains the largest DPP in the world to achieve universal national coverage. The following sections will present a brief history of the programme, its service specifications, and a summary of findings from several studies that assessed the programme's performance to date.

1.5.1.2.1. Programme History. One of the first real-world DPPs to operate within the UK was assessed in a cluster RCT that commenced in 2009 (Gray et al., 2012). This programme would pave the way for the NHS-DPP. Labelled the 'Let's Prevent Diabetes' structured education programme (Davies et al., 2016), it was developed to meet the need for an evidence-based DPP, implemented within the NHS, which adheres to NICE recommendations. Let's Prevent Diabetes was based on 'DESMOND' (Diabetes Education and Self-Management for Ongoing and Newly Diagnosed), a programme for people with newly diagnosed T2DM (Davies et al., 2008). The Let's Prevent programme was a simple six-hour structured group education session, with three-hour refresher sessions at 12 and 24 months later. Additionally, participants received telephone calls every three months from nursing staff trained to offer ongoing support in behaviour change and encourage participants in achieving empowerment with regards to meeting their individual goals. In its cluster RCT of 44 general practices and 888 adult participants, Let's Prevent Diabetes achieved a 26% reduced risk of developing T2DM in the intervention arm compared to standard care at three-year follow-up (Davies et al., 2016). However, this result was not statistically significant. Despite this modest effect, the intervention was relatively inexpensive to run at a cost of just £168 per participant over three years (Leal et al., 2017). Further analysis found that the results of the trial were directly influenced by participant engagement, as 29% did not attend the initial session. Moreover, participants who attended one refresher session versus all refresher sessions were respectively 62% and 88% less likely to develop T2DM than those who received standard care (Gray et al., 2016), suggesting that engagement was a contributing factor to the intervention's effectiveness.

In a bid to increase and extend T2DM prevention efforts throughout the UK, the NHS-DPP, also known as the 'Healthier You: NHS Diabetes Prevention Programme', was jointly conceived by NHS England (2021b) and Diabetes UK (2021a). The programme identifies people at risk of developing T2DM and refers them onto a nine-month, evidence-based lifestyle change programme where they receive face-to-face personalised support to manage their weight, eat more healthily and be more physically active, all with the aim of reducing their risk status (Haste et al., 2016; NHS England, 2021b). The development, implementation, and evaluation of this programme was guided by the UK's Medical Research Council (MRC) framework for developing and evaluating complex interventions

(Craig et al., 2008; Penn et al., 2018), and informed by a systematic review and meta-analysis commissioned by Public Health England, which assessed the effectiveness of T2DM prevention interventions in routine practice (Ashra et al., 2015). This meta-analysis, which was an update of a 2012 meta-analysis conducted by Dunkley et al. (2014), included 36 studies of real-world T2DM prevention interventions from 11 different countries. The analysis found that the interventions reduced the progression of T2DM among those at risk by a significant 26% when compared with usual care. Furthermore, interventions modelled on either the US-DPP or Finnish DPS were more effective than those that used a different evidence-base. The authors also found a positive association between the number of NICE and IMAGE guidelines the interventions adhered to, and improvements in body weight and blood glucose measures (Ashra et al., 2015), suggesting that T2DM prevention interventions may be more effective when they adhere to international evidence-based guidelines.

1.5.1.2.2. Programme Design and Service Specifications. Health service providers selected to deliver the NHS-DPP are required to adhere to a set of programme design and service specifications (NHS England, 2019b). According to the specifications, the NHS-DPP is available for individuals aged 18 and over who have ‘non-diabetic hyperglycaemia’ (an alternative label for PDM) as confirmed via HbA1c or FPG test. Over nine months, 13 group-based sessions of between one and two hours in duration must be delivered by qualified health professionals (e.g., dietitian, health psychologist, or physical activity instructor) for an average total contact time of 16 hours. Consistent weight loss should be encouraged with a goal of at least 5% to be achieved by programme’s end. This will be supported through dietary education informed by the national Eatwell Guide (see NHS England, 2021a), and physical activity support in adherence with the national ‘Start Active, Stay Active’ guidelines (see Department of Health, 2011). Brief intervention on the benefits of smoking cessation should also be offered where appropriate. As a minimum, the provider should deliver all of the BCTs listed in the NICE public health recommendations (NICE, 2017).

1.5.1.2.3. Implementation Findings. Despite its relatively recent implementation, researchers involved in assessing the NHS-DPP have disseminated preliminary results which, from an efficacy perspective, are encouraging. In a recent cohort study of people who had enrolled in the programme between 2016 and 2019, participants lost an average of 3.2 kg (3.8% of baseline body weight) and 3.6 kg (4.2%) at six months and programme completion respectively (Marsden et al., 2022), and of those with non-diabetic hyperglycaemia at initial assessment, 60% and 68% had measures in the normal range at six months and completion respectively. With regards to the programme recommendation of 5% weight loss, a further study found that 37% of participants achieved this goal (Valabhji et al., 2020).

Despite these encouraging results, additional findings uncovered aspects of the programme that need improvement which, if addressed, could boost the programme's effectiveness. Engaging with individuals eligible to participate has been challenging, with less than half of those referred to the programme attending initial assessment, and even less signing on to participate (Barron et al., 2018; Frempong et al., 2021; Stokes et al., 2019). According to Marsden et al. (2022), of the 99,131 people who attended the initial assessment, only 36,614 (36.9%) remained in the programme for the first six months, and 22,697 remained in the programme until completion (or 22.9% of those initially assessed, and 62% of those who completed the first six months). Participants who remained in the programme for six months and to completion were, on average, slightly older and less socio-economically disadvantaged, more likely to be white, and more likely to be retired. This low rate of retention and completion was also found in an earlier NHS-DPP outcomes study by Valabhji et al. (2020) who reported that, of all people referred to the programme, 53% attended the initial assessment and 19% completed the programme, when completion was defined by a session attendance rate of >60%. A qualitative study by Begum et al. (2022) explored the reasons for this lack of engagement with the programme. Several participants reported accessibility issues, such as difficulties booking initial assessments, and lack of contact, organisation, and support from service providers. Participants also found it difficult to attend sessions due to scheduling conflicts, work/life commitments, and the distance required to travel. These findings supported those presented by Hawkes et al. (2020) who found that poor scheduling and lack of resources led to negative participant experiences. In this same study, interactive and visual activities delivered in small groups of 10-15 people with good rapport, were facilitators of positive participant experiences.

A further challenge to the successful implementation of the NHS-DPP was the lack of fidelity in the programme's delivery against the programme design and service specifications. Fidelity refers to the extent to which an intervention is delivered as intended, and is an important consideration when assessing an intervention's efficacy, as an absence of significant effects could be due to substandard delivery, rather than poor intervention quality (Carroll et al., 2007; Schinckus et al., 2021). French et al. (2021) found that only 37% of the mandatory 19 BCTs were being delivered, mostly due to poor translation between the specification document and programme manuals. Furthermore, BCTs designed to improve self-regulation of behaviour such as techniques involving problem solving and self-monitoring of behaviour, were substantially under-delivered, as was goal setting, a BCT which is considered vital for the prevention of T2DM (Begum et al., 2020; French et al., 2021; Hawkes et al., 2022). This represents a missed opportunity to facilitate participant engagement and retention, as a systematic review of 33 international T2DM prevention interventions conducted by Begum et al. (2020) found that problem solving was a key BCT used by programmes that reported high retention rates. This suggests that programme fidelity could be positively associated with engagement. It must be noted however, that despite only committing to the delivery of 74% of the specified BCTs, several NHS-DPP providers still delivered a large number of BCTs, in some cases exceeding the amount outlined in the specifications (Hawkes et al., 2020). This could be a result of individual providers lacking the training and/or knowledge to deliver certain BCTs, efforts made by providers to tailor the programme's delivery to suit their cohort, or the outcome of perceived pressure to meet other key performance indicators such as enrolment numbers, which can alter the group dynamic and affect service delivery (Hawkes et al., 2020).

Considering the challenges and limitations of face-to-face service delivery, alternative modes of delivery for DPPs such as those utilising digital technologies have been proposed, specifically to overcome the barriers to participant attendance in both the US NDPP and NHS-DPP. Globalisation and the rapid growth in digital technologies over the last two decades has revolutionised the way that organisations perform and interact internationally, and these technologies can address some of the challenges faced by health systems in terms of the availability, quality, and financing of health care (Sharmin et al., 2017). The following sections will outline the current state of digital technologies in Ireland and internationally, both in general and in relation to health care and T2DM prevention.

1.6. Digital Technologies

According to a global overview report released in January 2022 (Kemp, 2022b), 5.31 billion people or 67.1% of the global population currently use a mobile device (e.g., smartphone, electronic tablet), and 4.9 billion (62.5%) use the internet, with 92.1% of all users accessing the internet via their mobile device. Smartphones, laptop computers, and tablets are the most adopted digital devices worldwide, used by 90%, 83%, and 64% of respondents respectively, according to a recent global survey (Deloitte, 2020). Furthermore, smartphone penetration was highest among those aged 25 to 54 at an adoption rate of 93%, while the highest rate of growth over 12 months was among the 55 to 64-year age group, moving from 87% usership, up to 91%. Usership among the oldest surveyed age group (64 to 75 years) was also relatively high at 84% (Deloitte, 2020).

Recent Irish data indicates that 97.8% of the country's population currently use a mobile device, and 99% use the internet (Kemp, 2022a), with smartphones, computers (includes desktop and laptop), and tablets used by 95.4%, 77.4%, and 50.1% of the population respectively (Kemp, 2022c). People in Ireland spend, on average, six and a half hours per day using the internet across all devices, half of which is accessed via smartphone (Kemp, 2022c). While digital technology use is relatively high in Ireland, some disparities remain between demographic groups separated by age, area of residence, and socio-economic status. In a 2019 survey (ComReg, 2019), 85% to 86% of all phones owned by people residing in urban areas were smartphones, compared to 69% to 78% among rural residents. Among those aged 18 to 49 who own phones, approximately 94% were smartphones. Adoption figures were lower among those aged 50 to 64 (78% smartphone adoption) and 65 and over (47% adoption). However, adoption rates among these age groups are expected to rise rapidly, in line with global figures. With regards to socio-economic class, 92% of people in Ireland's class ABC1 (considered the upper-middle class) owed a smartphone, compared with those in class C2DE (considered the working class) at 79%. Finally, 34.5% of urban residents have experienced service issues (no signal, poor signal, or insufficient coverage) compared to 49.5% of rural residents. To improve service coverage across the country, the Irish government enacted the National Broadband Plan in 2020, which aims to grant 95% of Irish premises access to high-speed broadband by the year 2025 (Department of the Environment Climate and Communications, 2020). This plan, which will facilitate improvements to the digital infrastructure over the coming years, could greatly benefit the health technology sector in Ireland.

1.7. Digital Health Technologies

Digital health (also known as eHealth, electronic health or connected health) has been defined by Kostkova (2015) as 'the use of information and communications technologies to improve human health, healthcare services, and wellness for individuals and across populations' (p. 1). The digital health environment contains a range of digital health technology (DHT) categories such as mHealth (or mobile health), telehealth, telemedicine, internet-of-medical things, health information technology, and personalised medicine (Lupton, 2013, 2014; Omboni, 2019; US Food and Drug Administration, 2020). According to international surveys (Grand View Research, 2021) the global digital health market size was valued at US$96.5 billion in 2020 and is expected to grow at a compound rate of 15.1% every year, with a steeper upward swing from previous years due to the rapid rise in digital health development and application as a result of the COVID-19 pandemic. Mobile health has the largest market share of all digital health categories at 47%, maintaining this share through rapid widespread adoption of mobile and/or wireless devices (such as smartphones and smart watches), global positioning systems (GPS) and Bluetooth technologies, which are all used to facilitate the improvement of global health outcomes (Cameron et al., 2017; Grand View Research, 2021).

In Ireland, 41.1% of people use the internet to research health issues and products (Kemp, 2022c). For wearable technologies, 29% of Irish residents own a fitness band, and 16% own a smart watch (Deloitte, 2020). While there is a paucity of Irish data on the use of mobile health smartphone applications or ‘apps’, US studies found that almost 60% of smartphone users have downloaded a health app, most often with the aim of improving physical activity and fitness, increasing fruit and vegetable consumption, and facilitating weight loss (Carroll et al., 2017; Krebs & Duncan, 2015).

Digital health innovations are being used to support the needs of healthcare systems worldwide. Such innovations include interventions for the general public, patients, health care workers, health system managers, and data services, all of which involve interactions within the healthcare system, as well as the extended social, legal, political, and economic environments (Van Velthoven & Cordon, 2019; WHO, 2018). Although digital health services may be less accessible for certain populations, such as people with low incomes, education, and literacy; ethnic minorities; and residents of rural areas (Latulippe et al., 2017), digital health offers numerous benefits that may have farther reach as countries implement national policies to reduce disparities in digital health access.

1.7.1. Benefits of Digital Health Technologies

Digital health can help to identify health risks, and assist with the diagnosis, treatment, and monitoring of health and disease conditions. It can also provide novel ways to capture continuous data on individuals and populations that complement the episodic data obtained through traditional healthcare approaches (Coravos et al., 2019; Perakslis & Ginsburg, 2021). This continuous data recording is potentially lifesaving. For example, wearable sensors can monitor the cardiac activity of a person with T2DM in real time, alerting them, their physician, or a family member to a potentially significant arrhythmia

(Evangelista et al., 2019). Another benefit of digital health delivery is that it can save time and effort, offering cost-effective alternatives to traditional face-to-face interventions (Jandoo, 2020). Additionally, digital health technologies can facilitate on-the-spot testing for various diseases, eliminating the need to send samples to a laboratory and wait for the results (WHO, 2019b). Giving patients access to DHTs facilitates empowerment, providing them the opportunity to self-manage their condition and make personal choices regarding their care plan (Imison et al., 2016). This benefits the healthcare system as it encourages self-service, freeing up resources to prioritise individuals who require more urgent care, and/or those who are unable to access DHTs.

Another strength of DHTs is their potential to deliver health interventions at a high level of fidelity whilst allowing patients the flexibility to engage with the intervention on their own terms (Gan et al., 2021; Moller et al., 2017). Maintaining a high level of fidelity is important, as this fidelity has been identified as essential for intervention effectiveness (Hankonen, 2021). Despite the call for high fidelity interventions, allowing people flexibility in how they receive messages and interact with an intervention is highly valuable, as personalised or 'tailored' health care is often more engaging and effective than less flexible interventions (Lustria et al., 2013; Ryan et al., 2019). Digital health interventions have an advantage, as variability can be purposefully programmed into the intervention, allowing a single intervention to be delivered differently to each patient without compromising its fidelity.

1.7.2. Challenges for Digital Health Interventions

Despite the benefits of digital health, there are several key challenges to the successful implementation of digital health interventions. First, many widely-disseminated digital health interventions are not theory-based, and lack clear use of evidence-based BCTs and clinical guidelines, which may therefore limit their effectiveness (Nikolaou & Lean, 2017; Rivera et al., 2016). Second, interventions assessed via RCT often examine full intervention packages but do not test individual components, making it difficult to ascertain which components work best and in what context (Arigo et al., 2019). Third, the speed at which technologies evolve often exceeds the speed of evaluation, so by the time research evidence is disseminated, the technologies may be obsolete and no longer useful (Murray et al., 2016). Finally, while they may be viewed as more practical and convenient than face-to-face interventions, digital health interventions are still prone to engagement and retention issues (Arigo et al., 2019). For example, a recent meta-analysis of smartphone app-based interventions for chronic conditions reported a pooled dropout rate of 43% (Meyerowitz-Katz et al., 2020). Poor engagement can limit an intervention's effectiveness, as consistent usership is a prerequisite for the intervention to achieve positive health outcomes (Alkhaldi et al., 2017).

It has been stated that approximately 80% of digital health projects fail due to uncertainty, abandonment, and lack of willingness to adopt at both the individual and organisational level (Greenhalgh, 2018; Greenhalgh et al., 2017). Non-adoption and abandonment are particularly common at the service provider and end user levels. According to HCPs, barriers to DHT adoption include poor integration of the technologies within existing clinical workflows (Hanley et al., 2013), lack of available resources to support both digital and traditional health care services (Grant et al., 2012), scepticism regarding data accuracy and the efficacy of DHTs (DeAlleaume et al., 2015; Fagerlund et al., 2019), technical issues and steep learning curves required to use DHTs (Jung et al., 2021; Vedanthan et al., 2015), and lack of health care system support (Lennon et al., 2017). At the patient level, adoption barriers include: lack of perceived usefulness of the technologies (Slevin et al., 2019); low perceived usability of the technologies (Whitelaw et al., 2021); a preference for traditional health care and face-to-face consultations (Wilson et al., 2021); physical challenges, such as limited eyesight and hearing, or reductions in fine motor control (e.g., hand trembling), particularly among older adults (Mishuris et al., 2015; Nymberg et al., 2019); and information privacy concerns (Tieu et al., 2015).

In light of these and other challenges, the WHO (2019b) released a series of recommendations regarding the use of digital interventions within global health systems. Additionally, individual countries have developed their own national digital health action frameworks that outline plans and strategies to improve national health care through the use of DHTs (e.g., Australian Digital Health Agency, 2021; NHS England, 2018). In February 2022, the Government of Ireland released the 'Digital Ireland Framework', outlining strategies to assist Ireland in becoming a European and global leader in digital developments (Government of Ireland, 2022). This follows the 'eHealth strategy for Ireland' (Department of Health, 2013), and 'eHealth knowledge and information strategy' (Health Service Executive, 2015) published in 2013 and 2015 respectively. More recently, the Irish Department of Health published the Sláintecare implementation strategy, which included an action plan and progress reports outlining the step-by-step implementation of the national eHealth programme over a three year period, due to end in 2023 (Department of Health, 2021a, 2021b). Given the Irish government's support of a digital health ecosystem, and the country's partnership with enterprise–where, for example, 14 of the world's top 15 medical technology companies have operations in Ireland (Ardill, 2019)–the implementation of a national digital DPP in Ireland is eminently feasible. Furthermore, developers of this programme will have the benefit of hindsight, as other countries have already implemented their own independent technology-driven T2DM prevention interventions or national digital DPPs.

1.8. Digital Health Interventions for the Prevention of Type 2 Diabetes

Building on the success of the landmark diabetes prevention trials and encouraging results from the translational T2DM prevention interventions, digital versions of these interventions were developed as scalable and sustainable solutions for T2DM risk reduction. The remote, digital delivery of diabetes education and support sought to overcome the uptake and attendance barriers frequently reported in face-to-face programmes, while simultaneously minimising the cost of delivery (Grock et al., 2017). Digital T2DM prevention interventions can utilise a range of technologies such as smartphone apps, smartwatches, websites, videoconferencing, automated telephone calls, short message service (SMS) text messaging, and DVDs; and programmes can be wholly automated with no human contact, or contain online support from a health coach and other participants, much like that offered in the US NDPP and NHS-DPP (Joiner et al., 2017). These interventions can also be classified as either low-intensive, such as those using only simple text messages to educate and motivate; or high-intensive, such as those that use smartphone apps and websites to deliver educational multimedia content and facilitate diet plus physical activity tracking, support, and feedback.

In one example of a relatively low-intensity digital T2DM prevention intervention, Wong et al. (2013) delivered an SMS intervention to Chinese professional drivers with IGT. In this study, the researchers randomised 104 adults to either an intervention group, or a control group who received standard care from their general practitioner (GP). Over a period of two years, intervention participants received text messages at varying intervals (starting at three per week, tapering down to one per month), which included information about T2DM and PDM, information about lifestyle modification (e.g., healthy eating and physical activity), social norm statements on how others appreciate lifestyle modification, and self-efficacy enhancing messages. At 12 months, 5.56% of the intervention participants developed T2DM compared to 16% in the control group, and at 24 months, the intervention managed to reduce the onset of T2DM by 5.05%. However, this latter figure was not significant. Despite modest results, the intervention was inexpensive to sustain, incurring an average cost of only US$42 per participant over two years (Wong et al., 2016), and the money saved by treating less T2DM cases offset the cost of the intervention, resulting in an estimated US$118 saving per participant over two years. Furthermore, in a lifetime cost-effectiveness model, the additional QALYs gained through the intervention over the control condition equated to a saving of US$1,020 per person (Wong et al., 2016).

On the high end of the intervention intensity spectrum, a digital translation of the US NDPP was assessed by Sepah at al. (2014). In this single-arm study, 220 participants with a recent diagnosis of PDM underwent a core 16-week intensive lifestyle change intervention followed by a maintenance intervention which collectively totalled 12 months. During the core intervention, participants completed a series of online weekly lessons on topics such as healthy eating and physical activity. All participants received a wireless scale and a pedometer to track their weight and steps respectively. Participants also had access to an online social network that facilitated peer-to-peer interaction, and remote online support from a health coach. At 16 weeks and 12 months, participants had lost an average of 5.0-5.4% and 4.8-5.2% of their baseline body weight respectively. Moreover, 50% and 47% of participants achieved the 5% weight loss benchmark at 16 weeks and 12 months respectively, and weight loss was sustained at three-year follow-up. However, this figure had steadied at 3% (Sepah et al., 2017). An economic study of the same intervention delivered to 1,121 older adults estimated the programme cost to be US$1,300 per participant over three years (Chen et al., 2016). Using a Markov-based microsimulation model to simulate the impact of weight loss on future health states and medical expenditures, Chen et al. (2016) estimated the gross per capita medical expenditure savings over a cumulative 10 years to be US$11,550 in a partial weight regain scenario and US$14,200 in a sustained weight loss scenario.

While these two interventions represent opposite dimensions on both the intensity and operating cost spectrums, other programmes have been implemented internationally, many of which vary substantially with regards to their duration, mode of delivery, and level of human interaction and support. To date, two meta-analyses have assessed the effectiveness of digital T2DM prevention interventions. In the first meta-analysis, Bian et al. (2017) assessed 15 studies of technology-mediated diabetes prevention interventions for their effect on body weight. Based on data from 18 cohorts, the interventions were effective at decreasing body weight by an average of 3.67 kg. When the studies were categorised by evidence base, those based on the US NDPP achieved an average weight loss of 4.81 kg compared to the 2.44 kg achieved by those interventions not based on the programme. Although intervention duration across all studies ranged between 12 weeks to 24 months, the authors found no effect of intervention duration on weight loss outcomes. This was not consistent with a meta-analysis of face-to-face translational DPPs conducted by Ali et al. (2012) who found longer duration interventions to be more effective than those with shorter follow-ups. A limitation of this meta-analysis by Bian et al. (2017) was the use of absolute weight loss as its primary outcome, as it does not consider the baseline weight of participants. Therefore, it is unknown how successful the interventions were in meeting the 5% weight loss benchmark.

In a second meta-analysis, Joiner et al. (2017) assessed 26 eHealth-delivered lifestyle interventions based only on the US NDPP. The estimated overall effect across all interventions was a 3.98% reduction in baseline body weight at 15 months of follow-up. The authors also found that stand-alone interventions which did not include support from a health coach achieved less weight loss at 15 months (at 3.34%) than those interventions which included behavioural support from a health coach delivered either remotely (4.31% weight loss) or in-person (4.65% weight loss). However, this meta-analysis had the limitation of excluding interventions not based on the US NDPP. Moreover, the follow-up period of studies ranged from 3 to 15 months, and the authors did not report the effect of intervention duration on weight loss.

In both meta-analyses, average rates of attrition across interventions were relatively low, at 18% in the Joiner et al. (2017) study, and 20% in the Bian et al. (2017) study. However, these figures do not consider differences in the level of user engagement with each intervention, such the number of lessons attended, videos watched, phone calls completed, or steps logged. Therefore, despite ongoing participation in the intervention, engagement levels could have varied substantially, with several participants not using the programme to its full potential. In view of this, the authors of both studies conceded that future research is required to identify which intervention components are the most engaging and effective in achieving improved health outcomes (Bian et al., 2017; Joiner et al., 2017). A further limitation of these meta-analyses was the inclusion of interventions that were delivered in real time by a human coach either via phone or teleconference. Although these interventions did use ‘digital’ communication tools, such interventions are not ‘technology-driven’. Rather, the intervention protocols were identical to that of their face-to-face counterparts, and the technologies were non-essential facilitators of the intervention’s delivery. No review to date has exclusively assessed technology-driven T2DM prevention interventions nor identified the active ingredients of these interventions. This represents the first important research gap to consider.

1.8.1. The NHS Diabetes Prevention Programme Digital Stream

In 2017, NHS England launched a pilot digital DPP called the ‘Healthier You: NHS DPP digital stream’. This digital programme was developed to overcome the impact challenges of the face-to-face NHS-DPP such as acceptability problems due to the programme’s intensive nature, attendance barriers, and perceived stigma with regards to T2DM as a condition (Murray et al., 2019). It has been acknowledged that the digital stream will face several challenges, namely difficulties with engagement and adherence, plus limitations regarding the ‘digital divide’, which in this context refers to disparities in DHT access, usage, and favourable health outcomes among certain population groups (Lythreatis et al., 2021; Murray et al., 2019). One significant challenge is that of eHealth literacy (also known as digital health literacy) which, when defined succinctly, refers to the ability of people to use digital technologies to improve or enable health and health care (Neter & Brainin, 2012). Those with relatively low levels of eHealth literacy may not have the ability, confidence, or motivation to use the technologies and effectively engage with a digital DPP.

Notwithstanding these challenges, the NHS-DPP digital pilot is currently assessing five different digital DPPs or technology packages that focus on dietary intake, physical activity, and weight loss; the setting of personalised goals; and the provision of feedback on participants’ progress toward these goals (Murray et al., 2019). These programmes were chosen through a multistage selection process, culminating in a review by a committee of behaviour change theory experts, clinical safety officers, GPs, diabetologists, diabetes specialist nurses, and dietitians (Murray et al., 2019). The five programmes: Hitachi Diabetes Solution (Open Access Government, 2019; Zhang et al., 2017), Buddi Nujjer (Buddi Ltd., 2021; Langley, 2017), Liva Healthcare (Liva Healthcare, 2021; Rees, 2020), Oviva (Kanetkar, 2021; Oviva, 2021), and Second Nature (Know Diabetes, 2021; Second Nature, 2021) each contain a variety of key features, and use several tools to facilitate the prevention of T2DM, such as smartphone apps and wearable technologies. However, while some features are found in all programmes, other features are programme specific. For example, only Buddi Nujjer and Second Nature offer wearable technologies as part of their packages (to track physical activity for example), whereas the other programmes utilise the smartphone’s own internal trackers (Morrison, 2021). Each programme also contains unique selling points in the form of digital features or innovations offered by each developer to make their programme stand out. Furthermore, some programmes such as the Hitachi Diabetes Solution are accessed via smartphone, tablet, or standard computer, while others such as Second Nature are delivered exclusively via smartphone app.

The NHS-DPP digital stream pilot is a very large undertaking that may not be feasible to replicate in Ireland. Given the diversity of programmes, technologies, and features showcased in the NHS pilot, an opportunity exists for researchers to examine which of these programmes and/or features are most effective so that they may be combined into one complete package. While results of the pilot study are yet to be released, preliminary data across all programmes indicate a 68% uptake rate (characterised by conversion from referral to initial assessment), significantly higher than the 49% uptake rate observed in the face-to-face stream (McGough et al., 2019). These findings suggest that early-stage engagement is promising. However, for a digital DPP to have similar or greater levels of engagement in Ireland, it is important to assess the acceptability of such a programme and its DHTs among adults living in Ireland, particularly those at risk of developing T2DM who represent the programme's intended users.

1.9. Theories and Models of Technology Acceptance

Technology acceptability and technology acceptance are suggested to be distinct points on a temporal continuum of technology usership. Technology acceptability has been defined as one's perception of a system prior to its use (Distler et al., 2018; Martin et al., 2015), whereas technology acceptance represents one's perception of the system after initial use (Garces et al., 2016). In both cases, more favourable perceptions of the system would indicate greater acceptability and acceptance respectively. A recent review by Nadal et al. (2020) found that very few studies assessed the acceptability of a digital intervention in its pre-use stage, presumably because very few studies take end-user perceptions into consideration during the intervention's early design phase, and instead, only test its acceptance once the intervention is developed. However, this represents a missed opportunity, as proponents of person-based approaches to digital health intervention design highly recommend that target users are consulted early in the design process, as doing so may maximise user engagement once the intervention is implemented (Yardley et al., 2015). Several models and frameworks have been developed to explain the adoption of new technologies. However, more than one theoretical approach is often necessary to completely understand the acceptability of a unique or novel technology system (Taherdoost, 2018).

1.9.1. The Technology Acceptance Model

With its origins in the information technology sector, the Technology Acceptance Model (TAM) introduced in the 1980's by Fred Davis (1989) remains the most widely used model of technology acceptance (Marangunić & Granić, 2015). Derived from the psychology-based Theory of Reasoned Action (TRA; Fishbein & Ajzen, 1977), and Theory of Planned Behaviour (TPB; Ajzen, 1991), the TAM would suggest that one's intention to use a digital health intervention is determined by both its *perceived usefulness* and *perceived ease of use*, with one's general *attitude* regarding the intervention acting as a mediator between these two factors and *use intentions* (Davis, 1989). The TAM was later extended by Venkatesh and Davis (2000), who removed the attitude mediator but added *subjective norm* from the TPB and an additional generic intervention-specific variable, each as antecedents to perceived usefulness. Through the addition of subjective norm in this 'TAM2', it was suggested that social influence plays a key role in the acceptance of an intervention, as one would be more likely to use the intervention if they believed others would approve of its use. A further extension of the model by Venkatesh and Bala (2008), labelled the TAM3, added the additional social influence factor of *image*, or the perception that using the intervention's technologies would improve social status. The model also added key variables that tap into the technology competency aspects of eHealth literacy, namely *computer self-efficacy, computer anxiety,* and *computer playfulness*. However, the TAM3 was geared towards information technology usership in the context of job performance as it additionally included the factors of *job relevance,* and *output quality*, each irrelevant to consumer based DHTs.

1.9.2. Unified Theory of Acceptance and Use of Technology

The Unified Theory of Acceptance and Use of Technology (UTAUT) was developed by Venkatesh and colleagues (2003) in acknowledgement of the dilemma faced by researchers of whether to pick and choose constructs across technology acceptance models, or to use one large established model and apply it in an unmodified state. The authors examined the commonly used TRA, TPB and TAM, but also investigated other theories and models that had been used to study technology adoption, such as the Motivational Model (Davis et al., 1992), Model of PC Utilization (Thompson et al., 1991), Innovation Diffusion Theory (Moore & Benbasat, 1991), and Social Cognitive Theory (Compeau et al., 1999). In the UTAUT, factors of *performance expectancy* and *effort expectancy* (both commensurate with the TAM's perceived usefulness and perceived ease of use factors respectively), *social influence,* and *facilitating conditions* (objective environmental factors that an individual feels will make an act easy to accomplish) all directly influence one's intention to use an intervention. The UTAUT2 (Venkatesh et al., 2012), an extension of the UTAUT, added *hedonic motivation*, *price value*, and *habit* as direct predictors of intervention use intentions. The UTAUT models differ to the later iterations of the TAM as the UTAUT and UTAUT2 do not include factors that address eHealth literacy.

1.9.3. Health Information Technology Acceptance Model

While the TAM and UTAUT models were originally grounded in the information technology sector, they have also been used to assess the acceptability of health technologies. However, such use has required the models to be largely modified from their original forms. In 2012, Kim and Park (2012) developed the Health Information Technology Acceptance Model (HITAM), which augmented the TAM and its extensions by restoring the mediating *attitude* factor from the original TAM, maintaining the social influence factors, and adding *health information technology self-efficacy* as a proxy for eHealth literacy. Moreover, the HITAM added constructs from the Health Belief Model (HBM; Rosenstock, 1974), namely *perceived threat* which is a combination of *perceived susceptibility* and *perceived seriousness*, each referring to one's perception of the disease or condition under study. This includes: (a) how susceptible to the condition one feels they are, and (b) how serious they perceive the condition to be with regards to their own health and wellbeing. Kim and Park (2012) tested their model to assess the intention to use DHTs in general, and while it predicted a relatively large 83% of the variance in use intentions, the model has some limitations when taken in the context of digital DPPs. First, it combines both perceived susceptibility and perceived seriousness into a single construct (perceived threat). However, recent research has shown that the two are distinct, inversely related concepts when studied in the context of certain health conditions (El-Toukhy, 2015). Second, the health information technology self-efficacy factor was comprised of six items that focused on the use of technologies to access health information via one-way transaction. While Kim and Park (2012) found this factor to be a strong predictor within their model, it may not sufficiently represent the range of eHealth literacy skills required to navigate a complex digital health intervention that necessitates interaction with multiple technologies, such as wearable devices, smartphone apps, and online forums.

1.9.4. Applying Technology Acceptance to Digital Diabetes Prevention

Technology acceptance models have been used to test the acceptance of a computer-based chronic disease self-monitoring system for patients with T2DM (Yan & Or, 2019), the intention of older adults with T2DM to use wearable health technologies (Ahmad et al., 2020), and the factors influencing the sustained use of health and fitness smartphone apps (Cho et al., 2020). However, to date, no study has assessed the acceptability of a digital DPP, or any technology or platform specifically designed to facilitate the prevention of T2DM. Moreover, no study has explored the views and experiences of adults at risk of developing T2DM regarding the factors that could influence their decision to use a digital DPP. These represent the second and third important research gaps to consider, as an enhancement of acceptability in the early stages of digital DPP development may have a positive downstream effect on user engagement.

Given the ubiquitous application of these technology acceptance models, a recent meta-analysis was conducted by Tao et al. (2020) to assess the predictive utility of the various models, and identify the strongest predictors of the acceptance of consumer health technologies. The analysis found subjective norm, technology self-efficacy, perceived usefulness, perceived ease of use, and attitude to be the strongest predictors. The authors concluded that the TAM represents a good ground theory for examining DHT acceptance, but suggested future researchers incorporate additional factors that may moderate the model's existing relationships. After also reviewing technology acceptance models in the context of digital health, Rahimi et al. (2018) suggested that researchers modify these models to better fit their own research questions.

An opportunity exists to assess the engagement potential of a digital DPP in Ireland through the development and testing of an expanded health technology acceptance model. However, in addition to containing factors pertinent to T2DM, such a model could benefit greatly from the inclusion of factors that assess eHealth literacy, and the skills required to effectively engage with DHTs.

1.10. Theories and Models of eHealth Literacy

Selecting the most appropriate eHealth literacy factors to include in a digital health acceptability model in this context can be challenging, as digital DPPs contain a wide range of DHTs, each requiring a different skill set. The following sections will review the various theories, models, and measurement scales of eHealth literacy currently found in the literature. References to the appropriateness of each regarding the assessment of digital DPPs will be included.

1.10.1. The Lily Model and the eHEALS

The concept of eHealth literacy was first presented in 2006 by Norman and Skinner, who defined it as ‘the ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge gained to addressing or solving a health problem (Norman & Skinner, 2006b, p. 1).’ The authors developed the Lily Model, which separated eHealth literacy into six distinct components. First, *traditional literacy and numeracy* refers to one’s ability to understand numbers and text. Second, *health literacy* is the ability to process and understand health information. Third, *computer literacy* represents the ability to use computer hardware and software. Fourth, *science literacy* is the ability to understand scientific texts, facts, and correlations. Fifth, *media literacy* is the ability to process media content and assess its quality. Sixth, *information literacy* is the ability to process information, to know how knowledge is organised, and how to apply it. To assess eHealth literacy, Norman and Skinner (2006a) developed the eight-item eHealth Literacy Scale (eHEALS), which remains the most applied and cited measure of eHealth literacy (El Benny et al., 2021). It has been translated into many languages including Mandarin Chinese (Koo et al., 2012), Japanese (Mitsutake et al., 2011), Spanish (Almagro & Ji, 2015), Dutch (Van der Vaart et al., 2011), Korean (Chung et al., 2018), Swedish and Arabic (Wangdahl et al., 2019), Norwegian (Dale et al., 2020), and Italian (De Caro et al., 2016).

Despite its universal application, the eHEALS has attracted criticism in recent years as many have suggested that the scale does not capture the dynamic, evolving nature of eHealth. Cameron Norman, the scale’s co-developer, acknowledged the limitations of the eHEALS back in 2011, stating that the scale was developed for the first generation of health services (e.g., those that require one-way interaction, such as the seeking of health information online), and therefore does not include social media (Norman, 2011). Norman added that the confidence in expressing oneself clearly in online interactions should be included in future measures. Van der Vaart et al. (2013) seconded this notion after finding only a weak correlation between eHealth literacy via the eHEALS and actual internet use. The authors noted that this correlation was higher in earlier studies but has weakened over time. Despite its criticism, the eHEALS remains a reasonably valid and reliable tool, though this does not mean its use is valid in all cases. The eHEALS may be useful for assessing the skills it originally aimed to assess. However, while these skills would have been sufficient to navigate the digital realm at that time, such skills may now constitute only a small subset of the expanded skillset needed to effectively navigate modern digital environments. Therefore, when studying complex interventions such as a digital DPP, the eHEALS may provide a valid, but only partial assessment of the eHealth literacies required to effectively engage with the programme.

1.10.2. Newer Models and Measures of eHealth Literacy

Many researchers have since extended the body of knowledge on eHealth literacy to keep up with advancements in technology. Ivanitskaya et al. (2010) developed and tested the Research Readiness Self-Assessment for Health (RRSA-Health), a 56-item online assessment of eHealth literacy skills, specifically, those skills related to finding and evaluating health information from digital sources. While the assessment is comprehensive, its average completion time is a lengthy 37 minutes, making it less appropriate for use in studies that assess eHealth literacy as one construct within a larger research model. Moreover, the RRSA-Health is not relevant to the use of many DHTs such as smartphone apps and wearable devices. Hanik et al. (2011) subsequently created the shorter six-item RSSA-h, a more suitable scale for incorporation into a larger battery of measures. However, this scale is also limited to skills of information acquisition and evaluation, and not the use of DHTs.

Chan et al. (2009) developed a framework which combines the Lily Model and Blooms Taxonomy, which covers the increasing progression of the cognitive aspects of learning, skill acquisition, and performance (Chan & Kaufman, 2011). In their framework, Chan et al. (2009) assess eight eHealth literacies (computer, information, media, reading, writing, numeracy, science, and health) at six increasing levels of cognitive complexity (remembering, understanding, applying, analysing, evaluating, and creating). While the resulting matrix of 48 categories may not lend itself to a quantitative questionnaire, it may be useful in assessing the minimum skill level required to use a digital health intervention and its technologies.

To study the preparedness of patients to use the internet for health purposes, Jones (2013) developed the Patient eHealth Readiness Questionnaire (PERQ). This relatively new concept of ‘eHealth readiness’ moves beyond eHealth literacy in that it also assesses one’s opportunity to use the internet and smartphone apps for health purposes, but additionally captures eHealth inequalities. While this questionnaire contains several items on social support, these are framed in the context of technology support only (e.g., whether one feels comfortable asking for help using the internet), and not in seeking health advice from others online through social media groups or message boards. Furthermore, item response options consist primarily of ‘yes’, ‘no’, and ‘unsure’, which limits response variability. The PERQ is further limited by the absence of items relating to the use of smartphone health apps and wearable devices.

Norgaard et al. (2015) developed the eHealth Literacy Framework (eHLF) for evaluating one’s capacity to understand, use and benefit from technology to promote and maintain their health. The framework incorporates individual factors (e.g., one’s ability to process information and be engaged in their own health); system factors (e.g., one’s access to digital services that work and suit their needs); and interaction factors, where the individual and system factors intersect (e.g., one’s ability to actively engage in health services, feel safe and in control, and be motivated to engage with digital services). The 35-item eHealth Literacy Questionnaire by Kayser et al. (2018) is a multi-dimensional tool based on the eHLF. It was developed for the evaluation of digital health interventions, to assess the implementation and adoption of digital health services, and to conduct community and population surveys. Due to the questionnaire’s relatively high length and breadth, it may be best suited to assessments of interventions and systems that are already developed or established. Therefore, it may not be the ideal tool to assess eHealth literacy in a pre-use context.

More recently, several researchers heeded the advice of Norman (2011) and included a social connectivity component to their eHealth literacy scales or frameworks. The 19-item eHealth Literacy Scale by Seçkin et al. (2016) expands on previous eHealth Literacy measures by including a communication factor that involves one’s confidence in discussing health information with a health provider. However, there are no items regarding communications with non-health personnel. Acknowledging the lack of assessment on health communications and practical skills, van der Vaart and Drossaert (2017) developed the Digital Health Literacy Instrument which included self-report and performance-based items (such as how to assess the results of a Google search). The instrument contains seven three-item factors (operational skills, information searching, evaluating reliability, determining relevance, navigation skills, adding self-generated content, and protecting privacy) that assess one’s confidence in using technology; searching for, and applying health information; and interacting with others online. The limitation of this instrument is its lack of items assessing the use of smartphone apps or wearable devices.

Informed by the theory of self-efficacy, as well as the eHealth and eLearning literature, Bhalla et al. (2016) developed the seven-item eHealth Readiness Scale (eHRS) to assess one's readiness to engage with digital health interventions. This scale addresses gaps in previous measures as it is appropriate for predicting the use of smartphone health apps and wearable technologies. While the scale lacks the breadth of its predecessors, its specific focus on DHTs make it a valid inclusion within a larger eHealth literacy questionnaire designed to assess the acceptability of a digital DPP.

In the most recent addition to the literature on eHealth literacy, Paige et al. (2018) stated that, despite advancements in eHealth literacy theory, researchers were yet to capture the broader social elements of eHealth with theoretical underpinnings from the perspective of transactional communication. Based on a review of the eHealth literature, the authors developed the Transactional Model of eHealth Literacy (TMeHL). They posited that eHealth literacy through the transactional lens is a multi-dimensional, intrapersonal skillset that enables people to negotiate online transactions among diverse sources in the face of adversity (e.g., dexterity limitations, unique jargon, topic drift). Such transactional features are central to the use of technologies for health promotion, as these transactions describe how consumers access and engage with other users to exchange information (Paige et al., 2019). The operational skills outlined in the TMeHL correspond to four eHealth literacies that are each interdependent and serve as building blocks to one another. These are: *functional eHealth literacy*, which represents basic skills in reading and writing about health to effectively function on the internet; *communicative eHealth literacy*, which refers to one's ability to collaborate, adapt, and control communication about health with users in social online environments with multimedia; *critical eHealth literacy*, or one's ability to evaluate the credibility, relevance, and risks of sharing and receiving health information on the internet*;* and *translational eHealth literacy*, which represents one's ability to apply health knowledge gained from the internet across diverse ecological contexts. In addition to its focus on interpersonal communication, the TMeHL views these eHealth literacies as being influenced by dynamic contextual task-oriented factors (e.g., the source of information delivery such as a peer or health care provider, or the channel of communication such as instant message or smartphone app) and user-oriented factors (e.g., pre-existing knowledge of a health topic such as T2DM, or perceived social norms) which are central to the user, rather than the situation or task (Paige et al., 2018).

The authors later developed and validated an 18-item questionnaire which assesses the four eHealth literacies of the TMeHL (Paige et al., 2019). While the main strength of this questionnaire is its versatility, in that it collectively and parsimoniously assesses the factors of its predecessors, there are no items that assess the use or readiness to use wearable devices. Therefore, when assessing complex digital health interventions like a digital DPP, the TMeHL questionnaire could be combined with the eHRS to form a comprehensive but relatively brief 25-item eHealth literacy and readiness questionnaire.

1.11. Rationale for This Research

In summary, the escalating prevalence of T2DM represents an international public health concern, as the condition has serious impact on the health and wellbeing of individuals and societies worldwide. Furthermore, the economic burden faced by healthcare systems due to T2DM is substantial, so much so that the prevention of T2DM has been labelled a public health priority. In response to the T2DM threat, several countries have developed lifestyle interventions that aim to prevent the disease in those at risk. However, while the threat of T2DM is equally strong in Ireland, no such national programme is currently being delivered at scale. Informed by the findings of landmark diabetes prevention trials, national programmes such as the US NDPP and the NHS-DPP have been implemented in real-world settings to some success. However, as these programmes require face-to-face participation, it can be challenging for people to attend. Digital DPPs offer an alternative as they enable the same programmes to be delivered online with comparable results to their face-to-face counterparts. Even so, these technology-based programmes have their own challenges with regards to participant engagement. Notwithstanding these challenges, the relatively high usership of DHTs and burgeoning digital infrastructure in Ireland could see the country well-placed to develop and implement a digital DPP. For an Irish digital DPP to become a reality, a sound evidence base must first be developed. Through a review of the preceding literature, three key knowledge or research gaps were identified, and the prime function of the present research was to address these gaps by conducting three separate but interrelated studies.

1.11.1. Research Gap One

Technology-driven T2DM prevention interventions can vary substantially in terms of content, mode of delivery, and intensity, and it is currently not known which of these interventions are effective in achieving the recommended 5% weight loss. Uncovering this may help to identify the common characteristics of effective interventions so that they may be emulated in an Irish programme. Previous meta-analyses used either absolute weight loss or, when proportional weight loss was used, only US NDPP-based interventions were reviewed. Additionally, it is not known which BCTs or digital features are commonly used in effective interventions. Identifying these active ingredients may help developers of an Irish programme incorporate the most effective tools and techniques, potentially enhancing the programme's cost-effectiveness. It is also possible that these components are the most appealing to participants, and as such, their incorporation may help to maximise user engagement.

1.11.2. Research Gap Two

No research study to date has assessed the acceptability of a digital DPP. Furthermore, assessments of acceptability at the pre-use stage are rarely conducted. Identifying factors that influence people's intention to use a digital DPP could inform not only the content of an Irish programme, but also its communication strategies. That is, how the programme is presented to those eligible to participate with the aim of increasing uptake. Current theories and models used to assess digital health acceptability each have their limitations. An opportunity exists to develop and test a novel digital health acceptability model that incorporates aspects of technology acceptance, health behaviour, and composite measures of eHealth literacy, the latter of which are uniquely important as digital DPPs utilise multiple DHTs, each requiring several eHealth skills and competencies.

1.11.3. Research Gap Three

Given the evidence which suggests that tailored digital interventions may be more engaging and effective than those interventions that were not tailored, developers of an Irish digital DPP should consider the needs and capabilities of its target users. In addition to a lack of research on the pre-use acceptability of a digital DPP, no study to date has applied a theoretical framework to explore the views and experiences of adults at risk of developing T2DM towards the factors that may influence their decision to use a digital DPP. Once these factors are identified, liaising with the programme's intended user base may grant the insight needed to effectively tailor the programme with the goal of making it as engaging as possible.

1.12. Overall Aim

The overarching aim of this research was to build an evidence base for the development and implementation of a digital DPP in Ireland. This research had three key objectives, all to be achieved by conducting three separate but associated studies. These studies aimed to: (a) identify the evidence base regarding digital DPPs, (b) identify and develop an appropriate theory for the acceptability of digital DPPs, and (c) understand the perspectives of target users regarding the factors that determine a digital DPP's acceptability. These studies, including their individual aims are summarised below. A brief outline on how the research process will be presented in this thesis will follow.

1.12.1. Study One: Identify the Evidence Base

The aim of study one was to conduct a systematic review of technology-driven T2DM prevention interventions and identify the active ingredients or 'what works' in effective digital DPPs. The primary objectives of this review were to: (a) determine which technology-driven T2DM prevention interventions were effective in producing clinically significant weight loss and improvements in additional outcomes linked to the onset of T2DM; and (b) identify the BCTs and digital features most frequently used in effective interventions.

1.12.2. Study Two: Identify and Develop Appropriate Theory

The aim of study two was to develop a digital health acceptability model to explain the intention to use a digital DPP, and then test this model using a cross-sectional questionnaire. The primary objectives of this study were to: (a) develop an extended model of technology acceptance that incorporates theories of health behaviour and beliefs, and eHealth literacy frameworks; and (b) identify the factors that influence the intention of adults living in Ireland to use a digital DPP and determine the predictive strength of these factors.

1.12.3. Study Three: Understand Target User Perspectives

The aim of study three was to conduct a series of qualitative interviews to explore the views and experiences of adults living in Ireland who are at risk of developing T2DM on the factors affecting digital DPP acceptability. The study's primary objective was to gain a deeper understanding of the findings from study two by explaining how and why each factor may influence one's decision to use a digital DPP. This would be done by exploring participants' understanding of T2DM, their experiences with social influence in relation to their health behaviours, their views on health technologies, the perceived barriers and facilitators to healthy eating and physical activity, and opinions on a digital DPP that is currently available in other countries.

1.12.4. Research Presentation Structure

In the next chapter (Chapter Two), the methodology for the overall programme of research and each of the three studies will be presented in detail, including the ethical considerations pertaining to the research process. Chapters 3-5 will include the final manuscripts from each study. These manuscripts will be presented as originally submitted and/or published, and so the abbreviations and/or terminology used in these chapters may differ from that used in other chapters. A general discussion will constitute the sixth and final chapter of this thesis. In this concluding chapter, a summary of the findings of this research and its contribution to the areas of T2DM, digital health, health beliefs, and eHealth literacy will be presented, along with the project's strengths and limitations, and implications for research, policy, and practice.

2. Methodology

2.1. Chapter Overview

The following chapter will provide an outline of the overall methodological structure of this research. This will include a summary of the overall aims, objectives, and study design, and discussion on how each of the three research gaps was addressed. This will be followed by an in-depth discussion of the methods applied in all three studies; where, for each study, the aims, objectives, and overall approach will be outlined, and the research procedure described in detail. A rationale for the application of each study's methodological elements will also be discussed. The chapter will conclude with an overview of the various ethical considerations associated with this research, and a discussion on how each of these was addressed.

2.2. Aims and Objectives of This Research

The primary of aim of this research was to build an evidence base for the development and implementation of a digital DPP in Ireland for adults who are at risk of T2DM. The aim of digital DPPs is to educate and empower participants to modify their health behaviours, such as improving dietary practices, and increasing their level of regular physical activity, with the aim of maximising health and wellbeing, and preventing T2DM. Both quantitative and qualitative methods were used to develop this evidence. First, by systematically reviewing existing literature to discern whether digital DPPs are effective in achieving clinically significant weight loss in line with international guidelines, answering the question: 'do digital DPPs work?' Second, reviewing this same literature to identify the BCTs and digital features of digital DPPs that are most effective in achieving this outcome, answering the questions: 'how do they work, and what works best?' Third, developing and testing a novel digital health acceptability model to ascertain whether adults in Ireland would use a digital DPP once it is available, answering the question: 'what factors influence one's intention to use a digital DPP?' Finally, to explore the extended views and perceptions of adults at risk of T2DM regarding both: (a) a digital DPP that is currently available in other countries, and (b) people's experiences of factors that influence digital DPP use intentions, and how and why these factors affect a digital DPP's acceptability.

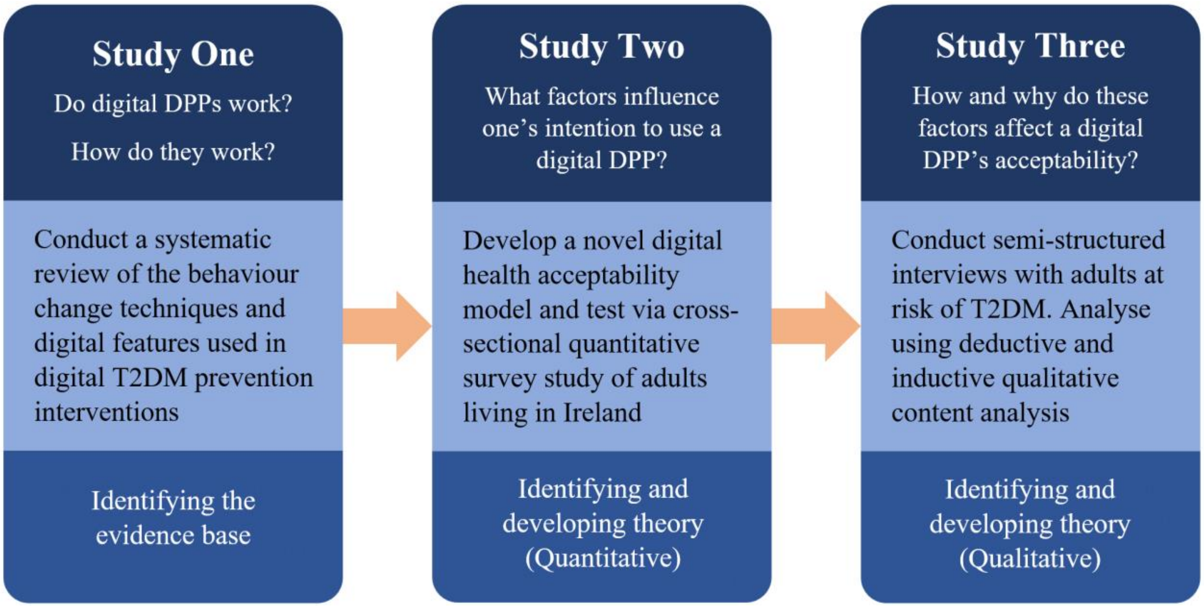
2.3. Overview of Study Design

In 2008, the MRC published a guidance framework to inform the development and evaluation of complex interventions (Craig et al., 2008). According to this framework, the first two steps toward developing a complex intervention are: (1) to identify the existing evidence base, and (2) identify or develop theory. The aim of this first step is to identify what is currently known about similar interventions to the one that is to be developed, and the methods that have been used to evaluate them. This is achieved by identifying high-quality systematic reviews of relevant evidence or conducting a review if no such evidence synthesis is available. The MRC guidance further suggests that, when evaluating interventions, the two key questions to ask are: (1) are these interventions effective in everyday practice? And (2) how do these interventions work? In other words, what are the active ingredients, and how are they exerting their effect? (Craig et al., 2008). While this form of quantitative exploration can grant insight into the intervention components that are potentially the most effective, it is also important to understand how to best implement these components in a particular context (Yardley et al., 2015). To gain this understanding, Yardley et al. (2015) suggest the use of qualitative research involving an intervention's intended users to gain insight into whether the intervention will be acceptable, interesting, persuasive, easy to use, and feasible for them to adhere to. The aim of the second step, according to the MRC framework, is to develop a theoretical understanding of the likely process of change by drawing on existing theory, or performing new primary research to supplement existing theory (Craig et al., 2008). For example, if one seeks to understand the acceptability of an intervention among its intended user base, it is important to identify the factors and processes that influence this acceptability.

To achieve these two overarching aims, this research adopted a mixed methods paradigm, defined by Johnson and Onwuegbuzie (2004) as 'the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study.' (p. 17). Various methodologies were employed to build an in-depth evidence base for the development and implementation of a digital DPP for adults in Ireland who are at risk of developing T2DM. As the studies were implemented sequentially, each building on or explaining the results from the study that preceded it, an 'exploratory sequential' approach (e.g., Creswell et al., 2011) was used to integrate the findings of each study. An overview of the research design is presented in Figure 2.1.

Figure 2.1

Research Design Overview



Three studies were conducted to achieve the aims and objectives of this research. First, a systematic review was conducted to identify whether digital DPPs were effective at achieving clinically significant weight loss, and to identify the active ingredients of those effective interventions. Second, a quantitative cross-sectional study was conducted to develop and test a digital health acceptability model, granting insight into the factors and processes that determine the digital DPP use intentions of adults living in Ireland. Third, a qualitative interview study was conducted involving a subset of participants from study two at risk of developing T2DM. In this study, participants' perceptions of a digital DPP were explored, as were their views and experiences regarding various factors relevant to the programme's acceptability.

2.4. Study One: Identify the Evidence Base

2.4.1. Aims and Objectives of Study One

Study one had three primary aims or research questions. First, to assess whether digital DPPs were effective at achieving clinically significant weight loss and improvements in outcomes linked to the onset of T2DM. Second, to determine which BCTs were frequently used in effective digital DPPs, and how BCT use differed between effective and non-effective DPPs (e.g., the number, and type of BCTs used). Third, to determine which digital intervention features were frequently used in effective digital DPPs, and how feature use differed between effective and non-effective DPPs (e.g., the number, and type of features used). The MRC recommends that, to identify the evidence base, a relevant high quality systematic review should be conducted if one does not currently exist (Craig et al., 2008). As no current review could answer all the above research questions, study one was conducted in the form of a systematic review. Furthermore, in line with MRC guidance, the first research question would determine whether the interventions are effective in everyday practice, while the second and third research questions would seek to determine how these interventions work.

2.4.2. Approach to Study One

2.4.2.1. Identifying the Effectiveness of Digital Diabetes Prevention Interventions. To assess whether digital T2DM prevention interventions are effective, body weight change from pre- to post-intervention was selected as the primary outcome of interest. Weight loss was chosen as the prime marker of effectiveness rather than glycaemic outcomes for two reasons. First, in approximately 50% of digital DPP studies, glycaemic changes (e.g., in HbA1c, fasting glucose) were not reported (Bian et al., 2017). Second, current T2DM prevention guidelines issued by the CDC in the USA, and NICE in the UK, suggest that to significantly reduce the risk of developing T2DM, a 12-month weight loss target of 5% of baseline weight should be set (CDC, 2018; NICE, 2019). This amount of weight loss is also considered clinically significant (Donnelly et al., 2009). In view of this, the 5% weight loss benchmark was used to identify effective versus non-effective interventions in this review.

Two systematic reviews and meta-analyses had already been conducted on digital T2DM prevention interventions with the aim of assessing their effectiveness at achieving weight loss. However, as highlighted previously, each had limitations regarding the choice of outcome measures (e.g., using absolute rather than proportional weight loss), the inclusion of interventions that were not technology-driven, and/or by limiting the inclusion of interventions to only those based on the US NDPP. Study one would address these research gaps and advance the literature by assessing all reported technology-driven interventions to date against internationally recognised standards of effectiveness.

2.4.2.2. Identifying How and Why the Interventions Are Effective. Understanding how and why an intervention works can be challenging, as behaviour change interventions are typically complex, containing many interacting components, making it difficult to identify the intervention's active and effective ingredients (Craig et al., 2008; Michie et al., 2013). The behaviour change technique taxonomy v1 (BCTTv1) was developed to identify BCTs or, the observable, replicable, and irreducible intervention components that elicit behaviour change (Michie et al., 2013). The BCTTv1 lists and defines 93 distinct BCTs, grouping them under 16 categories. Applying this taxonomy in the context of digital T2DM prevention interventions may help to identify the most effective behaviour change components in these interventions. Investigations into of the use of BCTs in lifestyle interventions are not new within the areas of T2DM management (Cradock et al., 2017; Hankonen et al., 2014), or prevention (Ashra et al., 2015). However, no study to date has explored the use of BCTs in digital T2DM prevention interventions.

In addition to identifying the BCTs that work best, it is also important to identify how they are delivered, as these modes of delivery can influence an intervention's effectiveness (Carey et al., 2017a). However, the term 'mode of delivery' carries multiple meanings in the digital health context, prompting efforts by researchers to standardise the terminology. For example, a recent prospective mode of delivery taxonomy reduced the broader concept of 'digital delivery' down to the more specific sub-category, such as 'smartphone app' (Carey et al., 2017b). However, smartphone health apps are diverse, with some containing a single feature or function (e.g., simple food checklist), while others house complex behaviour change interventions containing many features. For example, the Noom smartphone application is a weight loss programme that offers diet and activity tracking, online peer support, and personal coaching (Toro-Ramos et al., 2017). Each of these features could be effective or ineffective to varying degrees, so to understand how and why this intervention works, each individual feature should be identified, and its potential relationship to the intervention outcome(s) assessed.

Recent reviews have addressed this mode of delivery standardisation gap by reducing digital health interventions to their constituent features. However, there remains no consensus regarding the boundaries and definitions of these features (Donevant et al., 2018). Given the absence of a comprehensive digital feature taxonomy, researchers have used novel coding methods to identify individual intervention features, before assessing the impact of these features against relevant outcome measures. For their systematic review and meta-analysis, Webb et al. (2010) used their own coding scheme to identify a range of internet-driven features (e.g., automated follow-up messages, peer-to-peer access), and then linked these features to outcomes of behaviour change. More recently, Donevant et al. (2018) used thematic analysis to explore the features of mobile health apps used in studies of chronic respiratory diseases, diabetes, and hypertension. The authors found that interventions with statistically significant outcomes were more likely to contain interactive features (where participants respond to or modify content in real time) rather than passive features (where a response or feedback is not required or given). As is the case for BCTs, no study to date has explored the use of digital features in digital T2DM prevention interventions.

To complete an in-depth assessment of what works in these interventions, both top-down and bottom-up coding schemes were applied. First, the BCTTv1 (Michie et al., 2013) was used to code BCTs from each published intervention description. Each BCT was identified based on its definition as presented in the taxonomy. Second, a modified thematic analysis (e.g., Braun & Clarke, 2006) was used on these same intervention descriptions to: (a) code each irreducible digital intervention component, (b) organise all components into broader themes or ‘digital features’, and then (c) label these features and generate descriptive definitions.

2.4.3. Procedure

The following procedure was developed and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). These guidelines reflect an evidence-based minimum set of items aimed to assist in the sufficient reporting of key components within systematic reviews and meta-analyses, thus facilitating research transparency. The completed PRISMA checklist is presented in Appendix B. The protocol for this systematic review was pre-registered with PROSPERO, the International Prospective Register of Systematic Reviews (see Van Rhoon et al., 2018). This protocol was supported by input from members of the National Clinical Programme for Diabetes (NCPD) in Ireland. Members of the NCPD include a health researcher, dietitian, exercise therapist, health psychologist, general practitioner, and clinical endocrinologist. Furthermore, additional feedback was sought from several adults at risk of developing T2DM.

2.4.3.1. Search Methods for Identification of Studies. Five electronic databases, CINAHL Complete (EBSCO, 2018), EMBASE (Elsevier Limited, 2018), MEDLINE (National Library of Medicine, 2018a), PsycINFO (American Psychological Association, 2018), and PubMed (National Library of Medicine, 2018b), were searched from the date of each database’s inception up until September 3, 2018. These databases were selected due to their relevance to the research topic and frequent use in systematic reviews published in health and psychology journals. The search terms included key words, phrases, and Medical Subject Headings relevant to the conditions of T2DM and PDM; interventions or programmes to prevent T2DM; digital modes of delivery; and health outcomes including body weight, blood glucose, and the incidence or prevalence of T2DM. The search strategies for all databases (see Appendix C) were informed by previous reviews of both digital and non-digital T2DM prevention interventions (Ashra et al., 2015; Bian et al., 2017; Joiner et al., 2017). Multiple pilot searches were conducted across databases to test whether relevant papers already known to the researchers were identified (to perform assessments of coverage), and to keep the total number of papers identified in the search to a manageable number for later screening. Grey literature, which includes a range of documents not controlled by commercial publishing organisations (Adams et al., 2016) was not searched in this review. As studies with null results are less likely to be published, the inclusion of grey literature can potentially reduce publication bias in systematic reviews and meta-analyses (Hopewell et al., 2007). However, effectively identifying grey literature can be time consuming and resource intensive, requiring increasingly sophisticated methods of internet searching such as text analytics and data mining (Adams et al., 2016), which may have minimal influence on the results of most systematic reviews and meta-analyses (Schmucker et al., 2017).

2.4.3.2. Eligibility Criteria. All experimental and non-experimental studies published in English that assessed the effectiveness of a technology-driven diet and/or physical activity intervention for adults, aged 18 and over, who are at risk of developing T2DM, were eligible for inclusion. For an intervention to be ‘technology-driven’ it was required to be delivered using digital technologies (e.g., automated phone call or message, smartphone app, text, email, instant message, video, website, wearable device), where such technologies formed the basis for the intervention’s development and implementation. For example, if a face-to-face programme later included the option for consultations to be completed via video call, this intervention would not be defined as technology-driven, as the use of technology is a subsequent and/or optional add-on, and not an original function of the programme. Therefore, this intervention would not be included in this review. Conversely, an intervention developed specifically for remote online delivery would be defined as technology-driven, even if a face-to-face option is later added, and thus eligible for inclusion.

To warrant inclusion, the study must have recruited participants at risk of developing T2DM. This risk could be based on a previous diagnosis of PDM, IGT, or IFG; BMI; screening tool risk score; current blood test; or another valid risk marker. Studies that additionally recruited participants with T2DM were only included if the results of each group (those at risk versus those already diagnosed with T2DM) were analysed separately. Furthermore, studies of participants with a previous or current diagnosis of T1DM or GDM were not included. With regards to study design, observational studies, single-arm intervention studies, and randomised and non-randomised trials which assessed the intervention against a control group or alternative intervention were all eligible. Studies must have explicitly stated the aim of preventing T2DM or reducing the risk of T2DM. For example, diet and/or physical activity interventions for weight loss were not eligible for inclusion if T2DM prevention was not a stated intervention aim. However, studies that aimed to prevent both T2DM and CVD (or any condition in addition to T2DM) were eligible. For outcome measures, only studies that included one of the outcomes of body weight, glycaemic status (either HbA1c or fasting glucose), and T2DM incidence or prevalence were eligible for inclusion.

2.4.3.3. Study Selection. All records retrieved from the database searches were imported into an EndNote X5 database (Clarivate Analytics, 2011) where any duplicate records were removed. Following this, all unique records were exported to the Covidence systematic review management software (Veritas Health Innovation, 2019) and a two-stage screening process was conducted. First, all titles and abstracts were screened by one reviewer (LV) to determine potentially eligible full-text articles. Moreover, 20% of the same titles and abstracts (selected at random via online random number generator) were independently screened by a second reviewer (JMu). Based on title and abstract, articles were moved to the next stage of screening if they either met all inclusion criteria, or if their inclusion or exclusion could not be determined at that point. Second, full-text copies of all articles were obtained and assessed against the review's inclusion and exclusion criteria. In this stage, all full-text articles were assessed by LV and a randomly selected 20% of the articles were independently screened by JMu. Disagreements at both stages were resolved via discussion between the two reviewers. Forward and backward reference searches of the included articles were then conducted by LV to identify additional articles for inclusion.

At each screening stage, Cohen's Kappa (see Cohen, 1968) was calculated to determine the level of agreement between the two reviewers, or 'inter-rater agreement'. Such a measure is useful as it not only captures the observed agreement between reviewers, but accounts for situations in which agreement is reached purely by chance (Warrens, 2015). Informed by guidelines published by Landis and Koch (1977), the level of agreement at stage one (κ = .631) and stage two (κ = .617) was deemed substantial. The complete screening and selection process was completed in accordance with PRISMA guidelines (Moher et al., 2009) where the number of included and excluded articles was clearly presented and reasons for exclusion provided. This process was presented visually in a PRISMA flow diagram which can be found in Chapter Three, Figure 3.1.

2.4.3.4. Primary Outcomes. The primary outcomes in this review were body weight, glycaemic status (HbA1c or fasting blood glucose/fasting plasma glucose), and T2DM incidence or prevalence. Body weight was chosen to inform the review's primary definition of effectiveness as body weight is strongly associated with T2DM risk and is the most reported outcome in T2DM prevention studies (Bian et al., 2017; Dunkley et al., 2014; Yach et al., 2006). Intervention effectiveness was defined in relation to a mean weight loss of at least 5% of baseline body weight. In cases where a study only reported the amount of weight lost (e.g., in kg, lbs, st.), the proportion of weight lost was hand calculated by LV using available data. This 5% cut-off was chosen for two reasons. First, this figure is deemed clinically significant (Donnelly et al., 2009) and matches the weight loss benchmarks for 12-month DPPs in both the US (CDC, 2018) and the UK (NICE, 2019). Second, in the US, for an organisation to be accredited by the CDC as a certified DPP provider, at least five participants must have completed the year-long programme, and the average weight loss after 12 months must have been at least 5% (CDC, 2018). Achieving this 5% has important implications as it can result in insurance coverage for participants and reimbursement for the organisations that deliver the programme (Gruss et al., 2019).

Interventions of six months or less in duration were deemed effective if an average weight loss of at least 3% was achieved at six-month (or less) follow-up, while interventions of 12 months or greater in duration were deemed effective if an average weight loss of at least 5% was achieved at 12-month (or more) follow-up. Based on these criteria, interventions were labelled in four potential ways: (a) effective in the short term, (b) not effective in the short term, (c) effective in the long term, and (d) not effective in the long term. Interventions of 12 months or greater in duration received two labels if they included short- and long-term follow-ups. Relationships were explored between the number and type of BCTs and digital features identified in effective versus non-effective interventions. For this review, BCTs and digital features were considered effective if they were identified in at least 75% of effective interventions, both short and long term. A BCT or digital feature was considered most effective at each respective temporal period (short or long term) if it was identified at considerably greater frequency in effective interventions compared to non-effective interventions. The dichotomous classification of interventions as effective versus non-effective for the purpose of identifying effective BCTs has been used in a previous systematic review (Hennessy et al., 2019).

2.4.3.5. Data Extraction. A novel data extraction tool was developed for this review and piloted on five randomly selected papers then refined where necessary. All data was then transferred to a series of summary tables. Summary table one contained data pertaining to the overarching studies. This data included: author name(s), the country where the study was based, study design, comparison group(s) used (where applicable), study duration, enrolment or recruitment setting, T2DM risk inclusion criteria, sample characteristics (sample size, age, sex/gender, race/ethnicity, BMI), and attrition rate. Summary table two contained data pertaining to each intervention. This included: the intervention name or title, intervention duration, intervention type, primary mode(s) of delivery, level of human support, theoretical basis or evidence base, and message content and frequency (or dose). Summary table three contained data on the proportion of weight lost that was either provided in the article, or hand calculated. Weight loss was either categorised as short term (for follow-up periods of six months or less), or long term (for follow-ups of 12 months or more). Summary table four contained outcome measure data. This included: absolute weight loss and statistical comparisons either pre- and post-intervention and/or against a control group or other intervention; the proportion of the sample that achieved the target weight loss as stipulated in each study's intervention protocol; and changes in HbA1c and fasting glucose, each presented with relevant statistical comparisons.

The data extraction process was conducted by one reviewer (LV), and data from a randomly selected 20% of articles was checked for accuracy by a second reviewer (EM). Only the publicly available materials pertaining to the included studies were used for data extraction, BCT coding, and digital feature identification. Such materials included main study articles, follow-up study articles, intervention development articles, protocols, and supplementary materials. No further information or data was requested from the study authors as previous research has found that few authors respond to such requests, and when they do, the process of receiving the additional information can take many months (Black et al., 2018).

2.4.3.5.1. Behaviour Change Technique Coding. The BCTTv1 (Michie et al., 2013) was used by one reviewer (LV) to code BCTs from all included articles. A second reviewer (EM) independently double coded from a randomly selected 20% of all articles. Both LV and EM had previously completed the BCT-Taxonomy online training course provided by the Centre for Behaviour Change at University College London, available at http://www.bct-taxonomy.com (UCL Centre for Behaviour Change, 2019). All initial disagreements regarding the coded BCTs were resolved by the two reviewers via discussion. Based on previous reviews (Bian et al., 2017; Joiner et al., 2017), it was anticipated that in some cases the same digital intervention will be assessed in separate studies involving different populations. However, as the programmes are standardised, they would likely contain the same number and type of BCTs. It was also anticipated that these interventions may be described differently in each publication. For example, in journal articles with a small word or page allowance, BCTs that were used in the intervention may be less likely to be reported here than in longer articles. To account for this, an imputation process was applied to include those BCTs used in the interventions but missing from the articles. This imputation process consisted of two steps. First, when two identical interventions were described in the articles of two different studies (e.g., study A and study B), all BCTs from study A and study B were coded separately. Second, BCTs found in study A's articles but not Study B's articles were also coded to study B as imputed BCTs, and BCTs found in study B's articles but not in Study A were also coded to Study A as imputed BCTs. As a result, this review would consider each study to contain the exact same BCTs. However, to ensure transparency, it was clearly indicated which BCTs were coded directly from the articles, and which were coded via imputation. Furthermore, while the primary results of this review included the imputed BCTs, separate analyses were conducted using only the BCTs that were explicitly presented in the articles. A similar imputation process was used by Brown et al. (2019), who coded BCTs as 'definitely present' or 'probably present'. However, the authors analysed the entire pool of identified BCTs and did not conduct a separate analysis on only the BCTs that were identified as definitely present.

2.4.3.5.2. Digital Feature Identification. Digital features were identified using a modified three-phase thematic analysis (e.g., Braun & Clarke, 2006). First, one reviewer (LV) analysed all articles, coding each digital component (e.g., nutrition video) and its mode of delivery (e.g., website), plus each non-digital component (e.g., food diary) and its format (e.g., hard copy). The imputation process described above was also used to identify additional components. Second, each digital component was categorised according to the level of interactivity between the participant and the digital tool, and subsequently classified as either a passive or interactive intervention component. Passive components involve one-way communication between the technology and the user (e.g., a simple food log that offers no feedback), whereas interactive components involve two-way communication between the technology and the user, or between multiple users (e.g., online community forum). A second reviewer (EM) independently completed these first two phases on a randomly selected 20% of all articles to check for reliability. Third, all passive and interactive digital components were pooled together in their respective groups and analysed by LV and EM via discussion, where common themes among the passive and interactive components were identified. These component clusters or themes were subsequently classified as either passive or interactive digital features and assigned labels that best represent each feature. As was the case with BCTs, separate analyses were conducted using only the digital features explicitly presented in the articles.

2.4.3.6. Study Quality and Risk of Bias Assessment. The quality of included studies was assessed using the 27-item NICE quality appraisal checklist for quantitative intervention studies (NICE, 2012). The checklist assesses each study's internal and external validity where each item is rated ++, +, or – based on the degree to which the criteria was satisfied, with ++ indicating highest quality or lowest risk of bias. This assessment tool was chosen as it has been used in previous systematic reviews of DPPs (Ashra et al., 2015; Dunkley et al., 2014). Additionally, it is comprehensive, accommodates a range of study designs, and contains items that assess each study's adherence to real-world healthcare practice guidelines. One reviewer (LV) assessed all the included studies, and a randomly selected 20% of studies were independently assessed by a second reviewer (EM). Given that digital DPPs are designed to be implemented in routine practice where the programmes would fit seamlessly into the everyday lives of participants, it was not expected that the studies would adhere to the strict protocols of intensive RCTs. Therefore, the results of this quality assessment did not determine whether a study would be included in the analyses, and studies were not grouped by their assessment rating nor analysed separately.

2.4.3.7. Data Synthesis. The aim of this review was to investigate the associations between two types of intervention components (BCTs and digital features) and the percentage of baseline weight lost, assessing the effectiveness of interventions against international diabetes prevention benchmarks. In view of this, a narrative synthesis was used to organise and present the findings within the text, while all statistical data was presented in the summary tables.

When conducing this review, the prospect of including a meta-analysis was considered. While RCTs are often considered the ‘gold standard’ of scientific evidence, meta-analyses are thought to represent the ‘platinum standard’ (Stegenga, 2011). However, when synthesising research evidence, meta-analysis is not always appropriate, and in many cases, falls short of this proposed platinum status (Stegenga, 2011). There were two reasons why meta-analysis was not included in this systematic review. First, according to Haidich (2010), meta-analysis requires studies to be sufficiently homogeneous in terms of participants, interventions, and outcomes, as combining studies that differ substantially in multiple aspects can yield meaningless summary results. The studies included in this review varied not only in study design (e.g., RCT, observational study, feasibility study), but also mode of delivery (website, DVD, smartphone application, interactive voice response etc.), duration (3 to 24 months), level of support (self-contained with no human interaction versus regular interaction with a human health coach), and setting (wholly online, primary care, workplace, university etc.). Second, to conduct a meta-analysis, effect sizes or statistics that can be used to generate the effect sizes need to be extracted (Field & Gillett, 2010). As the reviewed studies examined within-group and between-group intervention effects, with researchers applying *t*-tests, ANOVA (Analysis of Variance) or similar statistical analyses, the appropriate effect size statistic to extract would be Cohen’s *d* (Thalheimer & Cook, 2002). Where Cohen’s *d* is not reported, it can be calculated using the reported means, standard deviations, *t* statistics (where *t*-tests were used), and/or *F* statistics (where ANOVA was used). As the outcome of interest was the proportion of baseline weight lost, this weight loss figure would need to be hand calculated from the included studies that only reported absolute weight loss. In these studies, all statistics that could be used to calculate Cohen’s *d* would pertain only to absolute weight loss and could therefore not be used to generate a pooled effect size estimate of proportional weight loss. While one option would be to contact the authors in an attempt to gain access to the original raw data, Field and Gillett (2010) state that these attempts are often unsuccessful. Furthermore, the authors may not have recorded raw data on proportional weight loss if it was not the outcome of interest. In view of these considerations, a narrative synthesis was deemed the most appropriate single form of evidence synthesis for this review.

2.5. Study Two: Identify and Develop Theory

2.5.1. Aims and Objectives of Study Two

Study one provided evidence that digital T2DM prevention interventions can be effective in achieving clinically significant weight loss plus reductions in blood glucose and can reduce the incidence of T2DM. Study one also found that interventions that used a larger number and specific combination of BCTs and digital features were most effective. This evidence can be used to develop a digital DPP for Ireland that contains only the most active ingredients. However, the review identified a large variation in rates of attrition between studies. The next step was to determine how to encourage people in Ireland at risk of T2DM to adopt this programme and interact with it on a regular basis. It has been stated that this continuous usership or 'engagement' with a digital health intervention is a necessary prerequisite for the intervention to achieve positive health outcomes (Alkhaldi et al., 2017). However, as an Irish digital DPP has yet to be developed, researchers can only ascertain the factors that determine one's intention to use the programme once it becomes available; or in other words, assess the 'acceptability' of an Irish digital DPP. In line with MRC guidelines, the next step after identifying the evidence base was to develop a theoretical understanding of digital DPP acceptability by drawing on or supplementing existing theory. While current theoretical models of technology acceptance have explained the use intentions of various digital health interventions and consumer health technologies (Or & Karsh, 2009; Rahimi et al., 2018; Tao et al., 2020), no study to date has assessed the acceptability of a digital T2DM prevention intervention or national digital DPP. When exploring technology acceptance in a new health-related context, it has been recommended that researchers additionally assess health behaviour constructs, and other factors specific to this new context (Rahimi et al., 2018; Sun et al., 2013). In view of this, the aim of study two was to develop and assess a digital health acceptability model–informed by technology acceptance models, health belief models, and eHealth literacy frameworks–to identify the factors that influence the intention of adults living in Ireland to use a digital DPP.

2.5.2. Approach to Study Two

To develop a research model that could explain the acceptability of a digital DPP, a review of technology acceptance, eHealth literacy, and health behaviour theories was first conducted to establish the most effective models and ascertain the factors most likely to predict peoples' intention to use the digital DPP. Once candidate factors were identified, the interrelationships of these factors were established to form the research model which contained several independent variables, dependent variables, and testable hypotheses. Next, an exemplar digital DPP was selected to be presented to participants. As there is currently no digital DPP available in Ireland, an existing offshore programme was required. The criteria for selecting this programme were as follows. First, based on the findings of the systematic review, the programme should contain a combination of BCTs and digital features comparable to those of the effective programmes. Second, the programme should previously have been assessed in some capacity (e.g., via observational study or RCT). Third, there should be evidence that it is, or may be successful in achieving clinically significant results (e.g., 5% weight loss, significant reductions in blood glucose). Finally, the programme should be one that could be implemented in Ireland if required. This could be evidenced through links between the intervention developer and the Irish Health Service Executive (HSE). Based on these criteria, the digital DPP created by Liva Healthcare (2020) was selected. Liva Healthcare (based in Copenhagen, London and Berlin) is the developer of one of the five smartphone-based digital DPPs featured in the NHS-DPP digital pilot (Murray et al., 2019). The programme had been tested in an observational study of 103 adults with T2DM, and achieved a mean weight loss of 4.3% and 6.3% at seven and nine months respectively (Komkova et al., 2019). The programme also contains the BCTs and digital features that the systematic review identified as the most effective, and representatives from Liva Healthcare had been in contact with members of the HSE and NCPD. In a meeting between LV and one of the co-founders of Liva Healthcare, a full colour brochure plus links to two online videos were offered, each showcasing the programme. Permission was granted by this Liva representative to present these materials to participants in studies two and three. However, no Liva representative had input into the research process.

To test the research model, a questionnaire was developed which included two or more items for each factor of the research model. Feedback on the questionnaire was provided by members of the NCPD and adults at risk of developing T2DM. The preliminary questionnaire (see Appendix D) was then pilot tested on 12 adults and subsequently refined (items rephrased or removed) to ensure readability and parsimony. Participants could access the final version of the questionnaire (see Appendix E) via the LimeSurvey online survey tool (Limesurvey GmbH, 2021), while hard copy questionnaires were issued upon request.

Structural Equation Modelling (SEM) was chosen to analyse the study data, as it allows a set of relationships between one or more independent variables and one or more dependent variables to be examined simultaneously (Ullman & Bentler, 2012). This analysis was conducted in multiple steps. First, to validate the questionnaire or ‘measurement model’, Confirmatory Factor Analysis (CFA) was conducted as there was already a strong empirical and conceptual foundation to guide the model’s specification, and the aim was to confirm the convergent validity (the condition where all questionnaire items pertaining to each single factor should be strongly interrelated) and discriminant validity (the condition where any two or more factors should not be highly intercorrelated) of each factor in the research model (Brown & Moore, 2012). Confirming both convergent and discriminant validity would indicate that the questionnaire is a valid and reliable tool, and that one should have greater confidence in the results of the hypothesis tests. Second, to test the factor interrelationships and hypotheses of the research or ‘structural model’, SEM with maximum likelihood estimation (ML-SEM) was used. Maximum likelihood estimation is a popular parameter estimation method best used in situations where prior theory is relatively strong and additional model testing and development are the goals (Barroso et al., 2010; Dolce & Lauro, 2015). This form of estimation was selected over the equally popular Partial Least Squares Path Modelling (PLS-PM) method, not only because ML-SEM suited the study aims and its use of prior theory, but because it is considered more robust and less vulnerable to parameter estimation bias than PLS-PM, provided the sample size is sufficient, and assumptions of normality are met (O'Loughlin & Coenders, 2004), as was expected in the present study.

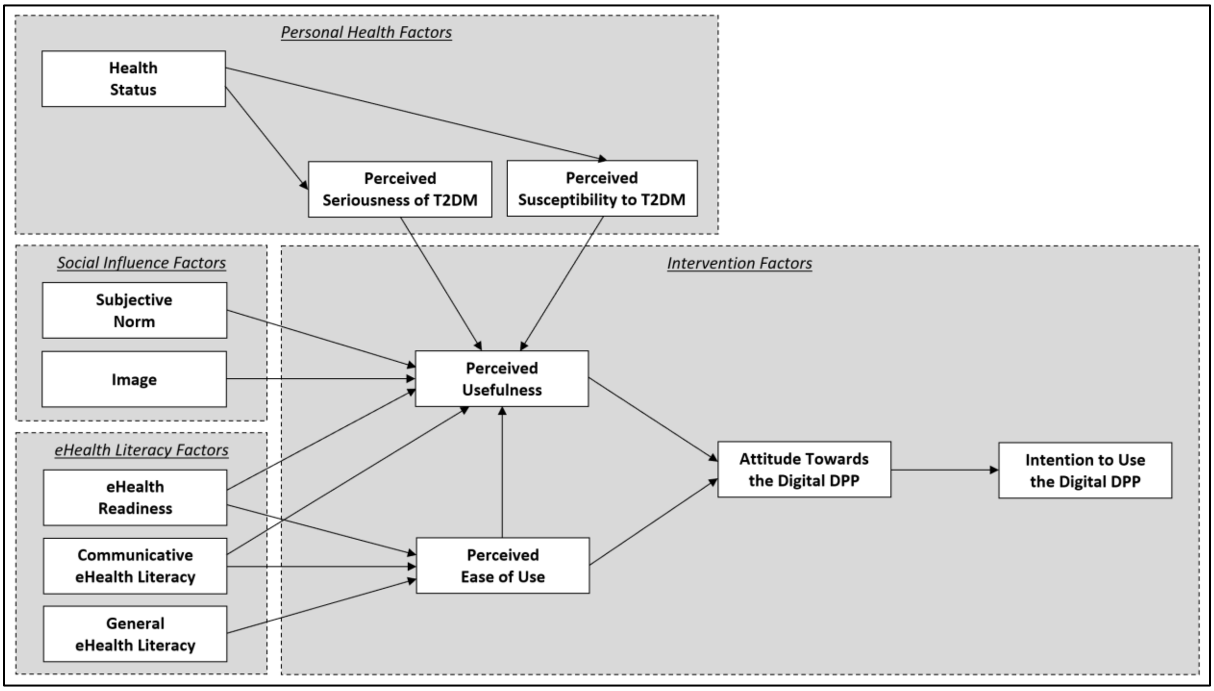
The study two sample size was projected to be sufficiently greater than the suggested *N* of 200 minimum when applying ML-SEM (Boomsma, 1983), and exceed the ‘5 observations per estimated parameter’ (Bentler & Chou, 1987) and ‘10 cases per variable’ (Nunnally, 1967) rules of thumb for applying SEM in general. As rule-of-thumb minimum sample size estimates can in some cases be insufficient, the application of a target sample size range has been suggested, as this accommodates interstudy differences in model characteristics, bias, errors, effect sizes, and missing data (Wolf et al., 2013). Given the relatively large effect sizes that were predicted based on previous research, and the application of a questionnaire that would avoid instances of missing data, it was estimated that a sample size of between 280 and 330 would be sufficient for this study. As no additional moderating variables were to be added to the model, and there was to be no between-group analysis–each representing a scenario which, when incorporated, would require a larger sample size–these figures were not projected to change.

2.5.3. Procedure

2.5.3.1. Research Model Development. Based on the literature review, a proposed research model was developed consisting of four sets of factors (see Figure 2.2). A summary table containing each factor, its evidence base, and descriptive definition can be found in Chapter Four, Table 4.1. Personal health factors included *health status* from the HITAM (Kim & Park, 2012), and both *perceived seriousness of T2DM* and *perceived susceptibility to T2DM* from the HBM (Rosenstock, 1974). Social influence factors included *subjective norm* from the TPB (Ajzen, 1991) and *image* from the TAM2 (Venkatesh & Davis, 2000). These two social influence factors were selected as they reflect social influence on one's health behaviours (e.g., eating, and physical activity) and DHT use respectively. The eHealth literacy factors included *general eHealth literacy* which represented the Lily Model by Norman and Skinner (2006b), *communicative eHealth literacy* as found in the TMeHL (Paige et al., 2018), and *eHealth readiness* as measured by the eHRS by Bhalla et al. (2016). These three respective eHealth literacy factors were included for the following reasons. First, as the eHEALS is the most frequently used eHealth literacy measure, its inclusion was justified to capture eHealth literacy in its general form. Second, the lack of a communicative component to eHealth literacy, a common criticism of the Lily Model, was addressed through the inclusion of the communicative eHealth literacy subscale of the TMeHL. Third, eHealth readiness was included to address the gap in both the Lily Model and TMeHL regarding the absence of a measure of one's readiness to engage with DHTs. Intervention factors included *perceived usefulness*, *perceived ease of use*, *attitude towards the digital DPP*, and *intention to use the digital DPP*, all from the TAM (Davis, 1989).

Figure 2.2

Proposed Model of the Factors Influencing the Acceptability of a Digital DPP



Note: Arrows represent the proposed direction of influence, where higher scores on one factor are expected to predict higher scores on the subsequent factor.

2.5.3.2. Research Model Testing

Ethical approval for this study's model testing procedure was granted by the National University of Ireland (NUI), Galway Research Ethics Committee. A copy of this approval notice can be found in Appendix F.

2.5.3.2.1. Participants. Participants were recruited through several avenues, each pursued online due to the COVID-19 pandemic and its restrictions to in-person contact and interaction. However, prospective participants were given the option of having a hard copy questionnaire mailed to them with free return postage. The recruitment avenues for this study were as follows. First, a press release was written by two researchers (LV and MB) and submitted to the university press office. The approved press release was then circulated to several local media organisations (e.g., print, radio) which published the release online. Various iterations of this press release can be found in Appendix G. Additionally, LV participated in live interviews for two local radio stations. The interviews focused on the importance of T2DM prevention, and details of the study were shared with listeners. Second, online print advertisements were posted through social media (e.g., Facebook, Twitter, LinkedIn). An example recruitment flyer can be found in Appendix H. Third, health and local council organisations were approached, and details of the study were posted online through their own social media accounts. Finally, the study details were circulated through the university's postgraduate student and staff mailing lists. In all forms of advertising, people were asked to 'have their say on digital health and type 2 diabetes prevention.' Adults living in Ireland were asked to complete a 15-minute online survey on their health behaviours, technology experiences, and perceptions regarding T2DM.

Inclusion criteria for this study were as follows: English-speaking adults aged 18 years or over, currently residing in the Republic of Ireland, with no previous diagnosis of T1DM or T2DM. Questionnaires were excluded from the analysis if a participant did not meet all these conditions. Questionnaires were also excluded if they were incomplete. This was for ethical reasons as it was assumed that the participant withdrew from the study. Data were collected between October 2020 and April 2021. Of the 333 completed questionnaires, 17 (5.1%) were excluded as participants did not meet all inclusion criteria. Of these 17, 12 were excluded as the participants had been diagnosed with T2DM, three were excluded as the participants were not residing in the Republic of Ireland, and two were excluded as the participants were under the age of 18. A final sample of 316 was analysed.

2.5.3.2.2. Questionnaire Design and Data Collection. Participants were asked to complete a questionnaire on digital health and T2DM prevention, either online via the LimeSurvey online survey tool (2021) or physical booklet. Before commencing the questionnaire, participants were presented with the information sheet (see Appendix I) and could provide informed consent by clicking the appropriate buttons (if online) or ticking boxes and signing (if hard copy) indicating that they have read and understood the information and choose to participate (see Appendix J). The questionnaire (see Appendix E) contained 61 mandatory items across four sections. The first section contained 14 items which obtained participant demographics and determined their T2DM risk score. Participants did not receive their score at this time. Section two contained 33 items assessing the personal health, social influence, and eHealth literacy factors. Section three contained a seven-page colour brochure (see Appendix K) for the Liva Healthcare smartphone-based digital DPP featured in the NHS-DPP digital pilot study (Murray et al., 2019). This brochure included images showcasing key programme features. Section four contained 14 items assessing participants' perceptions of this programme (intervention factors). Upon completing the questionnaire, participants were presented with three optional boxes to tick. Participants were asked: (1) if they wish to receive their T2DM risk score, (2) if they wanted to enter the draw to win one of two €100 Gift Cards, and (3) if they are interested in participating in a 30-minute phone or video follow-up interview for an upcoming study or would like more information about the study. Participants who ticked at least one of these boxes were prompted to enter their preferred contact details (e.g., email, phone number).

2.5.3.2.3. Measures. *Health status* was determined via the total score from eight FINDRISC items (see Lindström & Tuomilehto, 2003). These were age, BMI, waist circumference, eating and physical activity behaviours, medication and blood glucose history, and family history of diabetes. A higher health status score indicates a greater risk of developing T2DM. *Perceived seriousness of T2DM* and *perceived susceptibility to T2DM* were each assessed via four items, all adapted from questionnaires in previous studies assessing diabetes and CVD beliefs (Della et al., 2013; Tovar et al., 2010). Higher total scores represent greater perceived seriousness and susceptibility respectively. *Subjective Norm* was assessed using two items informed by published guidelines on the creation of TPB-based questionnaires (Ajzen, 2002). Higher total scores reflect a stronger perception that people important to the participant think they should eat healthier and be more physically active. *Image* was assessed using three items adapted from the TAM2 (Venkatesh & Davis, 2000), where higher total scores reflect a stronger belief that the use of DHTs are an indicator of higher social status. The factor of *eHealth readiness* was assessed using the seven-item eHRS developed by Bhalla et al. (2016), *communicative eHealth literacy* was assessed using the five-item communicative eHealth subscale of the TMeHL scale developed by Paige et al. (2019), and *general eHealth literacy* was assessed using the eight-item eHEALS developed by Norman and Skinner (2006a). For all eHealth measures, higher total scores reflect higher levels of eHealth readiness or literacy. *Perceived usefulness* and *perceived ease of use* were each assessed using four items, all adapted from the TAM2 (Venkatesh & Davis, 2000) and a previous T2DM digital health study which assessed these same factors (Yan & Or, 2019). Higher total scores suggest that participants perceive the intervention to be highly useful and very easy to use respectively. *Attitude towards the digital DPP* and *intention to use the digital DPP* were assessed using four and two items respectively, all adapted from the TAM (Davis, 1989), TPB (Ajzen, 2002), and the questionnaire used in a previous T2DM digital health study (Yan & Or, 2019). Higher total scores suggest that participants have a more positive attitude toward the programme, and more strongly intend to use the programme respectively.

2.5.3.2.4. Statistical Analysis. Descriptive analyses were conducted using IBM SPSS version 27.0 (IBM Corp., 2020). This included univariate and multi-variate outlier screening and normality assessments for each measurement item. Outliers and extreme values may need to be removed from a dataset as these could affect the research model fit and measurement quality (van Zyl & Ten Klooster, 2022). The data were screened for univariate outliers using *z*-scores, histograms, and boxplots (Field, 2017), and multivariate outliers were screened using Mahalanobis distance estimation (Hair, 2009). After the measurement model was validated, all factor scores were reviewed. Here normality was assessed, tolerance and variance inflation factors were inspected to identify issues of multi-collinearity, and bivariate correlations were analysed.

Using SEM, the specification and fit of both the measurement model and the research or causal model was assessed in IBM Amos version 27.0 (Arbuckle, 2020) with maximum likelihood estimation. For each model, chi-square values were identified, and model fit was deemed acceptable if all the following conditions (or model fit indices) were met: Comparative Fit Index (CFI) and Tucker Lewis Index (TLI) $\geq$.90, standardised root-mean-square residual (SRMR) $<$.09, and root-mean-square error of approximation (RMSEA) $<$.08 (Bentler, 1990; Hu & Bentler, 1999).

To evaluate the validity and reliability of the measurement model, CFA was used. All factors and their items were included in this CFA except for the *health status* factor. This factor was excluded due to its formative structure, whereas all other factors were reflective. For reflective factors, the items are manifested by the latent factor itself, and as such, items are expected to correlate strongly and are exchangeable with similar items. Furthermore, items can be removed without changing the nature of the factor (Hanafiah, 2020). However, a formative factor is considered a consequence of its items, whereby removing or exchanging an item alters the meaning of the factor (Hanafiah, 2020). For example, the reflective factor of *general eHealth literacy* contains eight items that each tap into the concept of eHealth literacy. Each item is expected to overlap significantly and if one or more items are removed to ensure model fit for the CFA, the remaining items still adequately represent eHealth literacy. Conversely, the formative factor of *health status* is represented by the FINDRISC, where each item is independent (e.g., age, BMI) with no clear overlap (or multicollinearity) expected. Removing one item or exchanging one item for another cannot be done as doing so would alter the scoring system and the factor would no longer represent the FINDRISC. Heath status was therefore excluded from the CFA as: (a) the Amos software and its maximum likelihood estimation cannot assess both reflective and formative factors within the same model, (b) the FINDRISC was already an internationally valid risk assessment tool, and (c) health status was the only formative factor in the research model.

When running the CFA, factor items were removed if: (a) the loading was <.50 (Hair, 2009) in cases where its factor contained three or more items, or <.70 in cases where its factor contained only two items (Worthington & Whittaker, 2006); or (b) the removal of such factors would improve model fit, as allowing error terms to correlate is not recommended when performing CFA as it may capitalise on chance occurrences and alter the research process from confirmatory or theory driven, back to exploratory or data driven (e.g., Hermida, 2015; Lance et al., 2010; MacCallum et al., 1992). Acceptable internal consistency of the measurement scales was established at Cronbach's alpha values of ≥.70 (Taber, 2018), and composite reliability was established at values of ≥.70 (Hair, 2009). Convergent validity was established with average variance extracted (AVE) values of ≥.50 (Hair, 2009), while values of <.50 were acceptable only if the factors' composite reliability value was ≥.70 (Malhotra & Dash, 2016). Discriminant validity was supported if: a) the square root of the AVE for each factor exceeded the correlation between it and each other factor (Fornell & Larcker, 1981), and b) a heterotrait-monotrait ratio of correlations (HTMT) test revealed all values to be <.85 (Henseler et al., 2015). As all data was obtained via self-report measures on a single questionnaire at a single time point, the data was subject to common method variance (CMV)–also known as common method bias–which could weaken the validity of the study's findings. As questionnaires are often used to simultaneously measure both independent and dependent variables, the estimated effect of one variable on another is at risk of being biased because of this CMV; that is, systematic variance shared among the variables which is introduced to the measures by the measurement method rather than the theoretical constructs the measures represent (Jakobsen & Jensen, 2015). To account for CMV, a common latent factor (CLF) test was used to compare the standardised regression weights of all items of the model with and without the inclusion of a CLF (Eichhorn, 2014). According to Gaskin (2021), if all regression weight differences are <.200, CMV is not a problem.

The direct, indirect, and total effects of the research or causal model were assessed using the bootstrapping method with 5,000 resamples at 95% confidence intervals as recommended by Preacher and Hayes (2008).

2.6. Study Three: Understand Target User Perspectives

2.6.1. Aims and Objectives of Study Three

The digital health acceptability model developed in study two was validated via CFA and subsequently tested, predicting 65% of the variance in the intentions of adults living in Ireland to use a digital DPP. The study found that people's personal health beliefs, social influence, and eHealth literacy levels were each significant predictors of the programme's acceptability. However, a large proportion of participants in this study were not at sizeable risk of developing T2DM. Furthermore, while the study design fulfilled its objectives, a deeper understanding was still needed as to how and why these factors affected programme acceptability. By undertaking qualitative research involving the intended users of the digital DPP, one could gain insight into all relevant perspectives, enabling the intervention to be tailored to the different types of people who might use it (Yardley et al., 2015). Tailored digital health interventions have performed significantly better than non-tailored interventions at improving health behaviours, and have reported greater user engagement (Lustria et al., 2013; Ryan et al., 2019). With these points considered, the aim of this third and final study was to explore the extended views and experiences of adults at risk of T2DM on the factors affecting digital DPP acceptability. This included their understanding of the condition, experiences with social influence on health behaviours, views on health technologies, barriers and facilitators to healthy eating and physical activity, and perceptions of a smartphone based digital DPP.

2.6.2. Approach to Study Three

2.6.2.1. Approach to Data Collection. One-to-one interviews were chosen to obtain data for the following reasons. First, the original data collection plan was to conduct one-hour focus groups where participants would interact with the digital DPP and its technologies in real time. However, due to time and resource constraints, and restrictions on face-to-face contact amidst the COVID-19 pandemic, such focus groups were no longer possible, and participants were instead exposed to the sample digital DPP via colour brochure and two short videos. Second, recent research has found that interviews are as effective if not more so than focus groups at generating a list of topics within a domain, and obtaining a larger breadth of information; while focus groups may be better at eliciting more personal disclosures (Guest et al., 2017). Given the limited exposure participants would now have to the digital DPP, breadth of information was most important, suggesting the suitability of one-to-one interviews. Third, focus groups can be challenging to schedule as they require all attendees to be available at one time (Dilshad & Latif, 2013; Wong, 2008), and such meetings are susceptible to non-attendance (McLafferty, 2004; Webb, 2002). Data was to be collected in February and March 2021 when COVID-19 restrictions were high, and it was therefore anticipated that people may be less willing to donate one hour of their time during this difficult period on a day that may not suit them best. It was decided that, given the challenges many were facing as they adjusted their routines, people would be more likely to commit to just 30 minutes at a date and time that suited them. Therefore, one-to-one interviews were undertaken.

Interviews were conducted in a semi-structured format as this format offers a balance between rigid and flexible styles of interviewing (Adams, 2015). As this study aimed to further explore the factors of the research model in study two, some structure would be required, such as asking all participants the same foundation questions to ensure that each topic was adequately addressed. However, open-ended follow-up questions or prompts would also be needed to gather a range of views and perspectives. A descriptive/interpretative form of semi-structured interview was therefore selected for this study as this style of interview allows researchers to discover the experiences of the participants within the boundaries of the research topics (McIntosh & Morse, 2015).

2.6.2.2. Approach to Data Analysis. The data was analysed using qualitative content analysis (QCA), a method which enables researchers to systematically and objectively describe research phenomena at the theoretical level (Kyngäs, 2020). Despite its roots in quantitative investigation, QCA is also used to describe human experiences and perspectives (Kyngäs, 2020). This form of analysis is often applied within the health sciences to answer practical questions, as it is most suitable for research where the informational content of one's experiences are most relevant, rather than a deeper interpretation and further investigation into how the individual derives meaning from these experiences (Forman & Damschroder, 2007). Qualitative content analysis has been used in previous studies of DHTs and online media in the field of diabetes. Such studies have explored the content of smartphone apps for the management of T2DM (Izahar et al., 2017), social media groups for people with diabetes (Stellefson et al., 2019), the use of Twitter to discuss the sharing of diabetes and diet-related information (Eriksson-Backa et al., 2016), the content of popular diabetes websites (Holtz, 2020), and the user challenges for first-time users of commercial diabetes smartphone apps (Fu et al., 2021).

In the field of qualitative research, there is much overlap between QCA and thematic analysis, another frequently used form of qualitative exploration, and although both forms of analysis can facilitate both data-driven and theory-driven approaches (Braun & Clarke, 2006; Fereday & Muir-Cochrane, 2006), QCA was used in the present study as it better facilitates data quantification if such quantification is required (Vaismoradi et al., 2013). Given the large number of topics or categories in this study, it was anticipated that some topics may not elicit discussion to the same level of detail as others, particularly as participants were no longer gaining hands-on experience with the digital DPP. While it is possible that topics such as *desired features for the digital DPP* could elicit in-depth discussion, the data regarding this topic could be quantified, with findings expressed through a feature list with associated frequencies regarding the number of times each feature was suggested.

Qualitative content analysis is often explained as a dichotomy of approaches: *inductive content analysis*, and *deductive content analysis.* While it has been argued that both approaches are applied dynamically in varying degrees within most studies (Armat et al., 2018), they are still regarded as separate forms of QCA. Inductive (also known as conventional) content analysis aims to describe a phenomenon when existing theory regarding the phenomenon is limited (Elo & Kyngäs, 2008). Researchers avoid using preconceived categories and allow the categories (or themes) and their labels to flow from the data (Hsieh & Shannon, 2005). In contrast, deductive (also known as directed) content analysis is used when existing theory about a phenomenon has been developed, or when existing theory would benefit from further description (Hsieh & Shannon, 2005). According to Hsieh and Shannon (2005), this directed approach to QCA can be used to validate or conceptually extend a theoretical framework or theory. As the aim for study three was to apply an augmented form of the research model used in study two and explore the extended views and experiences of participants with regards to the factors that influence the acceptability of a digital DPP, both deductive and inductive approaches were used as described by Elo and Kyngäs (2008) and Hsieh and Shannon (2005). This combined approach to QCA has been applied in previous health studies (Andersson et al., 2015; Fridberg et al., 2021; Sandström et al., 2015).

As a deductive-inductive approach was used, both manifest and latent content was analysed. Manifest content has been compared to the surface structure of the text (or explicit message) and can be recorded with a high degree of reliability with little interpretation needed; whereas latent content is implicit and embedded in the message, requiring the researcher to use cognitive deduction or even their own subjective feelings to interpret the text's meaning (Kim & Stepchenkova, 2015). In the present study, the manifest content (e.g., the participant may find it challenging to engage in physical activity) was prioritised during deductive analysis and coded to categories pertaining to the research framework; while latent content (e.g., reasons as to why the participant finds physical activity challenging) was identified through inductive analysis and used to generate themes. Given that the study aim was to explain the relationships between the factors of the framework (albeit in greater detail), *descriptive themes* (e.g., what the participants were trying to say) were used over *themes of meaning* (e.g., the underlying meaning of their stories). According to Graneheim et al. (2017), descriptive themes describe 'the red thread' that does not vary through the data. They give direction and nuance to the data, and the interpretation degree is usually moderate, though the abstraction level can vary. Conversely, themes of meaning illustrate a comprehensive interpretation of data. Like descriptive themes, they give direction and nuance to the data, but with a higher degree of interpretation on a more abstract level.

2.6.2.3. Epistemological Position. The epistemological approach adopted by this study was that of *subtle realism*, a position which understands that research involves subjective perception, but also believes that there is an underlying reality that can be studied (Mays & Pope, 2000). Martyn Hammersley, who coined the term, stated that we can only know this reality from our own perspective in it, and therefore one can only be *confident* in their interpretation of the data but cannot be *certain* of its validity (Hammersley, 1990, 1995). Despite this lack of certainty, Silverman (1993) views subtle realism as the only approach that allows us to develop any confidence in qualitative research. Silverman further states that validity can be enhanced through careful case selection, ongoing hypothesis testing, inductive analysis, and quantifying through counting. Each of these processes are well-suited to QCA, and so compatibility exists between study three's epistemological and analytical approaches.

2.6.2.4. Reflexivity. Reflexivity is defined as a critical approach to professional practice that questions how knowledge is generated, and how power relations influence the process of knowledge generation (D'cruz et al., 2007). It implies that researchers actively influence the data collection process, and the interpretation of the data, key findings, and conclusions. In the present study, it was important for the primary researcher to consider how aspirations, characters, values, philosophies, experiences, belief systems, and social identities have shaped the research; and ponder about how the research may have touched, affected, and possibly transformed the researcher as both a professional and a person (Palaganas et al., 2017).

Prior to working on this study, the primary researcher (LV)–who identifies as male (pronouns: he/him), and has a very low risk of developing T2DM according to the FINDRISC (Lindström & Tuomilehto, 2003)–had obtained a master's degree in health psychology and has 10 years of practical experience working with males and females at risk of developing T2DM as both a health and fitness trainer and nutritionist. However, as the researcher was not working in a professional capacity for this study and had not engaged in this line of work within the previous six years, this professional history was not disclosed to participants. The researcher aimed to remain aware of the uniqueness of each individual experience, but also acknowledge that it would be impossible to prevent previous professional experience from exerting influence over the interpretation of the participants' experiences. However, participants in this study were of a similar demographic to the researcher's previous clients, and many participants (like the researcher) had obtained a postgraduate degree. Therefore, these similarities may have cultivated rapport. This rapport, which is stated to involve harmonious interaction between parties, and describes the quality of any relationship between two people, has long been recognised as a central component of qualitative interviewing (Gremler & Gwinner, 2008; Prior, 2018). Despite being of a different gender to the researcher and having a higher T2DM risk profile, participants who had obtained their postgraduate degree may have been more willing to share their experiences due to a past or present affiliation with academia, or by empathising with the researcher regarding the research process and its potential challenges. According to Prior (2018) it is this *affiliation* and *empathy* that defines the concept of rapport.

To gain additional insight into the experiences of participants and to minimise researcher bias, a second researcher was involved with the review of each interview, and the data analysis plus reporting processes. This second researcher (CT) who identifies as female (pronouns: she/her), was of comparable age to the sample's mean age. She holds a master's degree in psychology and has extensive experience in cognitive psychology and decision making. Additionally, she shares a similar T2DM risk status to most of the participants, and therefore anticipated some overlap between the participants' experiences and her own. Furthermore, it was suggested that her personal experiences may facilitate the identification of additional latent content within the audio and transcripts, or a deeper interpretation of the participants' accounts (Hsieh & Shannon, 2005). While the focus of this study was to analyse latent content at the descriptive level rather than examine its underlying meaning, the researchers thought it remiss to ignore important underlying themes if identified, as these could represent important future research avenues or healthcare practice considerations.

Reflexivity was further facilitated through a reflexive journal which the primary researcher maintained throughout the interview and data analysis process. In this journal, the researcher routinely recorded his thoughts, feelings, and perceptions before each interview, during the first listening and transcription of each interview, and ad libitum throughout the deductive and inductive phases of QCA. Furthermore, categories, codes, and themes were discussed frequently between researchers both in the context of the data, and in relation to their own perspectives and potential biases.

2.6.3. Procedure

Ethical approval for this study was granted by the NUI Galway Research Ethics Committee. A copy of this approval can be found in Appendix F. The reporting of this study was guided by the consolidated criteria for reporting qualitative research (COREQ) checklist (Tong et al., 2007) which can be found in Appendix L.

2.6.3.1. Participants. The participants for this study were recruited from the pool of questionnaire completers in study two. These were English-speaking adults aged 18 and over living in Ireland (with no previous diagnosis of T1DM or T2DM) recruited online between October 2020 and April 2021 through press releases, social media, health and council organisations, and academic institutions, then asked to complete a 15-minute questionnaire on digital health and T2DM prevention. Upon completing the questionnaire, participants were shown a recruitment flyer for study three (see Appendix M) and given the option of providing their contact details to express interest in a follow-up interview to be conducted via phone or video. From the questionnaire responses, each participant's BMI and FINDRISC (Lindström & Tuomilehto, 2003) score was calculated to determine their eligibility to be interviewed. For the present study, those who completed the questionnaire in study two and opted in to being contacted about an interview, were eligible to participate if they registered: (a) a BMI of 25 or greater, placing them above the healthy weight range; and/or (b) a FINDRISC score of 15 or greater, placing them in the 'high risk' category for T2DM.

2.6.3.2. Sampling and Recruitment. Eligible participants were contacted by LV via email and invited to participate in a 30-minute phone or video interview to share their thoughts on the digital DPP they viewed in the questionnaire, in addition to their thoughts on

T2DM, eating behaviours, physical activity, and DHTs. A €20 One4All gift card was also offered as incentive to participate. All prospective participants received a study information sheet (see Appendix N) and consent form (see Appendix O) which could be signed digitally and returned via email. The recruitment flowchart can be found in Appendix P. Of those eligible to participate, 52 females and 11 males expressed interest in being interviewed. A stratified sampling approach was used to recruit a comparable number of participants between the characteristics of gender, age, BMI, and FINDRISC category. Twenty-six females and all 11 males were contacted on a rolling basis, with 17 females agreeing to an interview and providing informed consent. However, no males agreed to be interviewed.

2.6.3.2.1. Data Saturation. The concept of data saturation and its application as a marker of sampling adequacy has been described as a necessary and expected component of qualitative research (O'reilly & Parker, 2013). It has even been described as the 'gold standard' by which sample sizes are determined in health science research, where failure to reach saturation point may impact the quality of the research and hinder its validity (Fusch & Ness, 2015; Guest et al., 2006). Data saturation has been defined within the literature in various ways, raising several problematic conceptual and methodological issues. However, it is most often broadly and loosely defined as information redundancy, or the point at which no new information, codes, or themes can be extracted from the data (Braun & Clarke, 2021; Saunders et al., 2018). It has been argued that, because of external constraints such as funding deadlines and other time pressures, data saturation should not dictate sampling adequacy and study validity, particularly when used as a pre-meditated approach (Dey, 1999; Mason, 2010). Furthermore, as long as data continue to be collected, there will always be new theoretic insights (Low, 2019), suggesting that the pursuit of data saturation may be an exercise in futility. However, rather than discount it entirely, Low (2019) called for a more pragmatic definition of data saturation, and offered a set of questions–based on the seminal works of Corbin and Strauss (1990) and Strauss and Corbin (1998)–that qualitative researchers can answer, which provide a practical way of determining when pragmatic saturation has been reached.

According to Low's (2019) criteria, the opening set of questions assess whether the conceptual model is robust. First, does the model address process? Second, does the model address the core explanatory questions of 'how' and 'why', not merely descriptive accounts of 'what' questions? Third, does the model address deviant cases? The next set of questions assesses whether the conceptual model or theoretical explanation make sense given prior research. First, is the model or explanation informed by theoretical sampling including that of the relevant literature? Second, does the analysis rest on the assumption that the unit of analysis is the concept, not the person, the group, or the case? Third, does it generate 'categories' that is, general concepts that connect to form a conceptual model that is generalisable because it is contextualised in the broader social context?

Given that study three was guided by a research framework that was empirically tested in study two, several criteria offered by Low (2019) were satisfied the moment the present study was conceived. Therefore, applying this criteria as the sole measure of sampling adequacy and study validity would be tautological, even though these conditions are rooted in grounded theory (e.g., Glaser & Strauss, 1967), the very form of qualitative exploration that (perhaps inadvertently) engendered the modern interpretation of data saturation. An *information power* approach was therefore adopted to operate alongside Low's (2019) criteria. Information power, is a concept proposed by Malterud et al. (2016) as a pragmatic model for assessing adequate sample size in qualitative studies, where the larger information power the sample holds, the lower sample size is needed. The authors suggest that the size of a sample should depend on: (1) the aim of the study, (2) sample specificity, (3) the use of established theory, (4) quality of dialogue, and (5) the analysis strategy (Malterud et al., 2016).

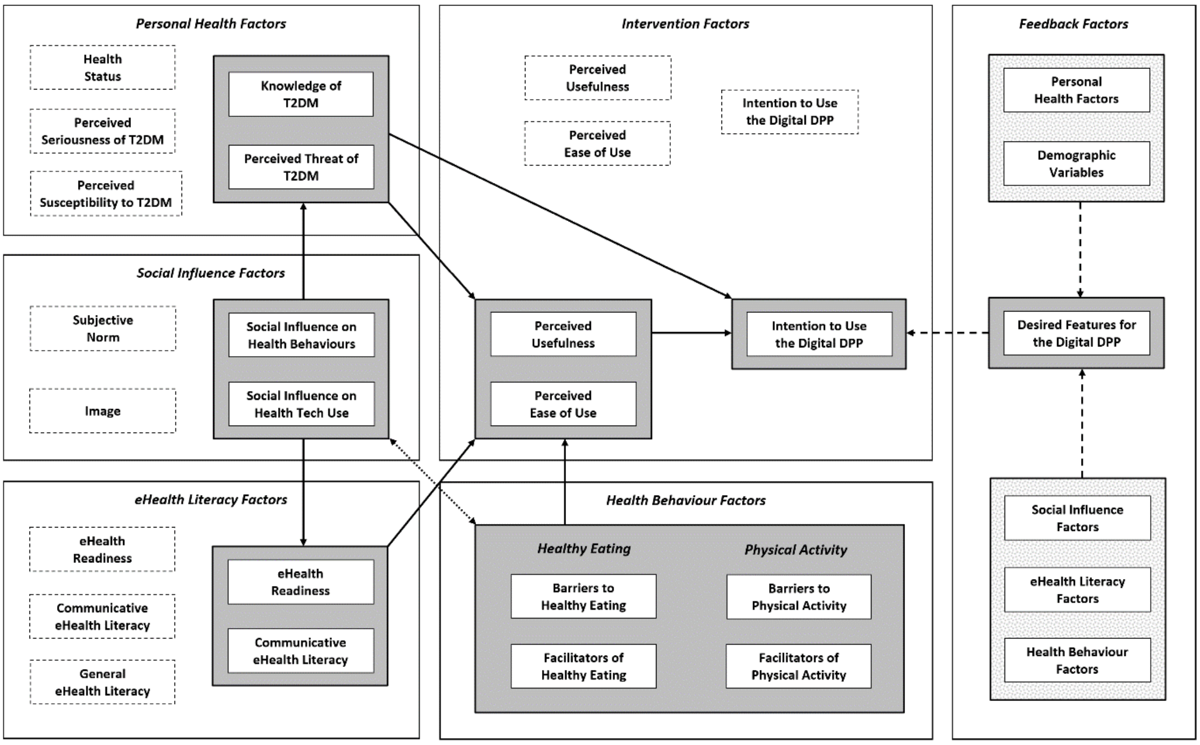
Each of these five criteria were discussed by the present researchers and assessed against the study aims and procedures to decide whether each criterion would require the study to have a lower, moderate, or higher sample size. For each criterion, the researchers rated the outcome as either *low, moderate,* or *high,* reflecting whether the study would need a low, moderate, or high sample size, based on that criterion. The final target sample range was generated using an average outcome across all five criteria. First, while the aim of the study was clearly defined, a broad range of topics were included (thus a rating of 'moderate' was given). Second, the recruitment criteria were relatively specific, as adults at risk of developing T2DM were recruited through a research study they had all previously completed; and, given the age range of participants, there was likely sufficient variation in the experiences to be explored (also moderate). Third, the study had a strong theoretical background as it was based on an empirically tested research model which itself was informed by multiple theories and models (thus rated 'low'). Fourth, the interview dialogue was expected to be strong, as the researcher has an extensive background and practical experience working and interacting with adults at risk of T2DM (also low). Fifth, QCA was used, with themes generated at the descriptive level (low). Based on this assessment it was agreed that a sample size of between 14 and 18 participants would achieve sufficient information power. After ten interviews were conducted, transcribed, and reviewed, the researchers performed an assessment of the sample's information power and appraised the data against Low's (2019) criteria. This process was repeated after each subsequent interview until it was decided that after 17 interviews, the information power was sufficient to answer the research questions, and that each of Low's criteria had been met.

2.6.3.3. Data Collection. After providing informed consent, participants were sent an email that contained a seven-page colour brochure (see Appendix K), and links to two, three-minute videos (see Appendix Q), all showcasing the digital DPP from study two, as featured in the NHS-DPP digital pilot (Murray et al., 2019). Participants viewed these materials before attending the interview. Semi-structured interviews were conducted by LV online via Zoom (Zoom Video Communications Inc, 2021) or Microsoft Teams (Microsoft, 2021) between the months of February and March, 2021. The researcher commenced each interview by introducing himself to the participant and providing a summary of the research aims and implications. Participants were then asked if they had familiarised themselves with the brochure and videos. The researcher then explained the format of the interview and how confidentiality would be maintained. The researcher closed the introduction by asking the participant if they wish to proceed and give consent for the interview to be audio recorded.

The interview guide (see Appendix R) was developed in line with an extension of the research model from study two. In this 'extended framework for digital DPP acceptability' (see Figure 2.3) *health behaviour factors* were included to address healthy eating and physical activity, the key health behaviours in the prevention of T2DM. *Feedback Factors* were also included as it was expected that any or all factors of the framework may influence participants' opinions regarding desired features for an Irish digital DPP, and that incorporating such features could improve programme acceptance after first use. Items of the interview guide were designed to elicit discussion regarding participants' understanding of T2DM and personal thoughts regarding the condition, the facilitators and barriers to physical activity and healthy eating, their experiences with social influence regarding their health behaviours and DHT use, their eHealth literacy skills and readiness to engage with DHTs, their perceptions of the Digital DPP, and the features they would like to see included in the programme. Before its application, the interview guide was reviewed by the extended research team who have substantial experience in qualitative research, and feedback was provided by members of the NCPD and adults at risk of developing T2DM. The guide was then pilot tested on the first participant. Following this, additional prompts were added to facilitate additional discussion on certain topics. In each interview, the guide was followed to ensure all topics were addressed. However, the discussion was led by the participant, with prompts only used when required, such as asking for elaboration. The duration of the 17 interviews ranged between 22 and 45 minutes with a mean duration of 33 minutes. Audio files were imported into QSR International's (2021) NVivo software (released in March 2020), anonymised, and then transcribed verbatim by LV for analysis. Transcripts were checked for accuracy by both LV and CT. However, the transcripts were not returned to participants for comment or correction.

Figure 2.3

Extended Framework for Digital DPP Acceptability



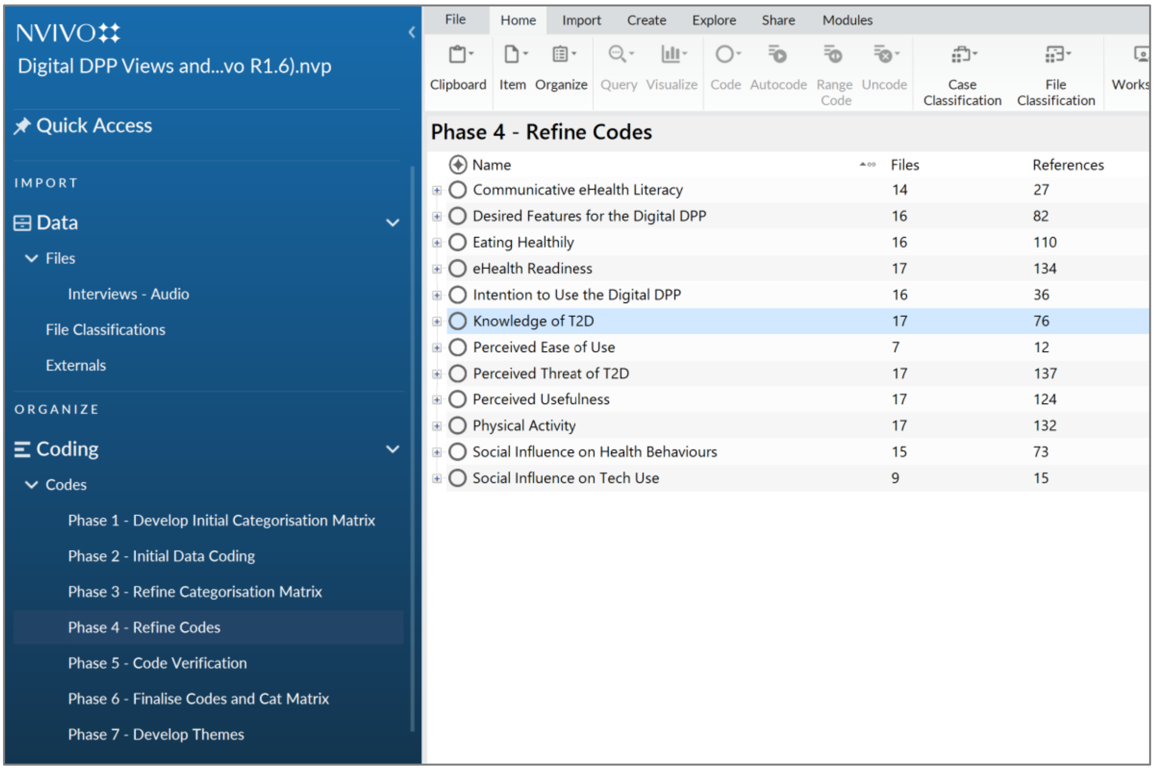
Note. Dark shaded boxes enclose the present study topics. Boxes with broken outlines represent precursor factors from the research model in study two. Arrows represent directions of influence.

2.6.3.4. Data Analysis. Both deductive and inductive QCA were used, each guided by the steps described by Elo and Kyngäs (2008) and Hsieh and Shannon (2005). Before the transcripts were deductively and inductively analysed, the primary researcher engaged in a data familiarisation process. After transcribing the data, preliminary notes were taken regarding contextual information and meaning obtained through both the interview process and upon hearing the audio. Audio was then reviewed a second time to verify the transcripts and to add additional notes regarding potential subcategories and themes.

2.6.3.4.1. Deductive Content Analysis. First, six structured categorisation matrices were developed to match the six factor clusters of the research framework. Each matrix contained one or more categories, with each category representing an interview topic (e.g., the *personal health factor* matrix contained the categories of: *knowledge of T2DM* and *perceived threat of T2DM*), while some also contained sub-categories (e.g., the *heathy eating* category contained the sub-categories: *barriers to healthy eating*, and *facilitators to healthy eating*). Second, initial coding was conducted by LV where each section of text was coded if it fit a category or sub-category based on its manifest or ‘face value’ content. Potentially relevant text that did not fit any sub-category was coded under prospective sub-categories. All coding was then reviewed by CT. This was followed by a discussion between LV and CT in which the coding structure was revised where necessary. Third, the categorisation matrices were revised through discussion between LV and CT based on the coding structure. During this process, new sub-categories were added, and existing categories were split into sub-categories if necessary. A snapshot of the coding process conducted in NVivo is presented in Figure 2.4.

Figure 2.4

Snapshot of the Coding Process Conducted in NVivo



2.6.3.4.2. Inductive Content Analysis. First, all codes were independently reviewed by LV and CT, then verified against the revised categorisation matrices. The final matrix structure can be found in Table 2.1. Second, codes under each category or sub-category were explored to identify frequent data patterns and commonly expressed thoughts or points that were pertinent to the research questions. Through this exploration, one or more themes were identified under each category or sub-category. Sub-themes were also created in cases where clear opposing views or experiences among participants were present under one single theme. While the qualitative content analysis literature (e.g., Elo & Kyngäs, 2008; Hsieh & Shannon, 2005) often refers to these 'code clusters' as categories or main categories, they were referred to as 'themes' in this study as the term 'category' here was used to describe the research topics. A visual representation of the distinction between categories and themes, and an overview of the combined deductive-inductive process is presented in Figure 2.5. Third, themes and sub-themes were independently reviewed against the codes by LV and CT. Both researchers then discussed the representativeness and distinctiveness of the themes, and how they align with the study aims and research questions. Fourth, quotes under each theme were reviewed by LV and CT to ensure they fit within the theme. Quotes that did not fit were removed or transferred to another theme. Themes were then labelled descriptively and discussed to ensure that all labels were a valid representation of the theme they describe. Fifth, all final themes were presented and reported via manuscript, where each theme was supported by quotes from various participants who were each identified by a participant number only.

Table 2.1

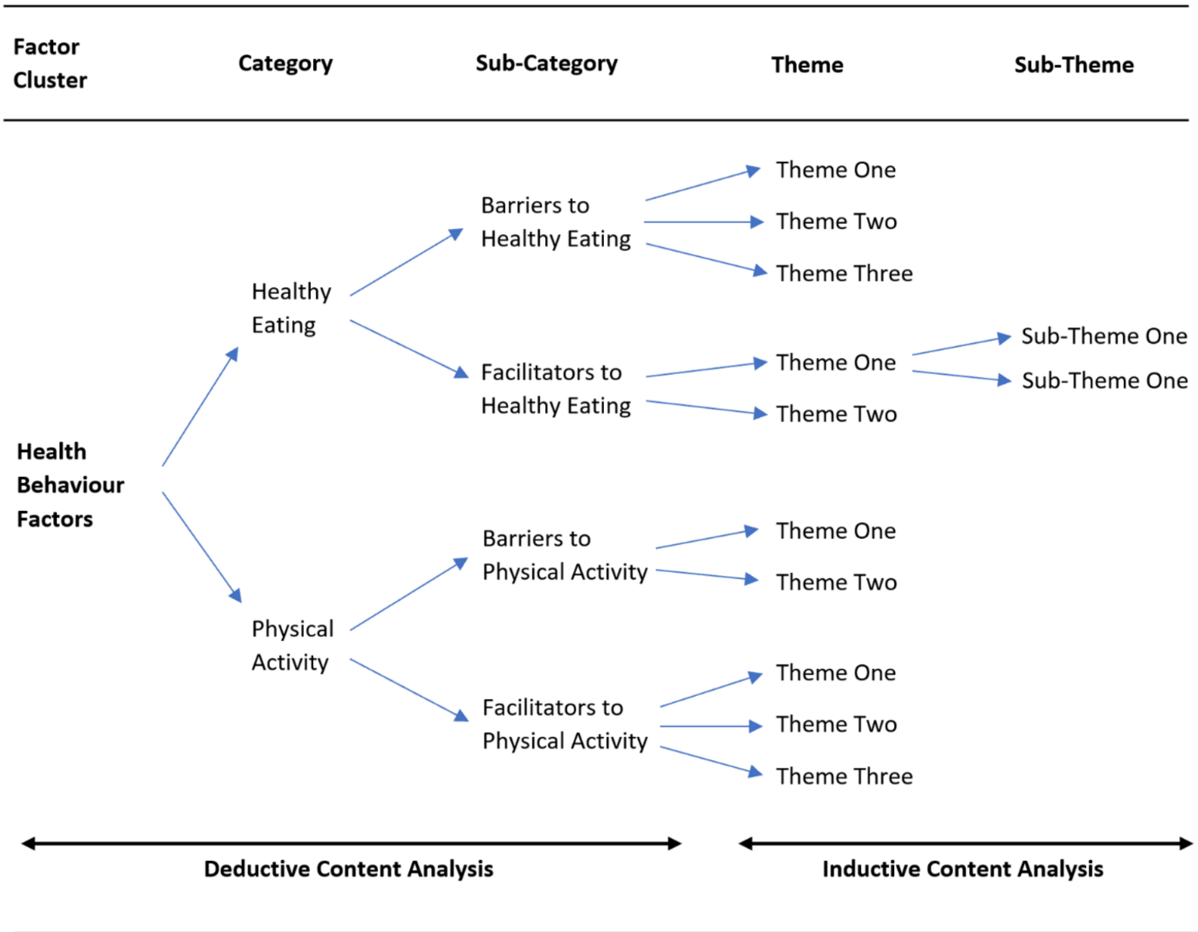
Categorisation Matrices Representing the Research Topics

Matrix	Category	Sub-category
Personal Health	Knowledge of T2D	
	Perceived threat of T2D	
Social Influence	Subjective norm	
	Image	
eHealth Literacy	eHealth readiness	
	Communicative eHealth literacy	
Health Behaviour	Eating healthily	Barriers to eating healthily
		Facilitators of eating healthily
	Physical activity	Barriers to physical activity
		Facilitators of physical activity
Intervention	Perceived usefulness	
	Perceived ease of use	
	Intention to use the digital DPP	Intend to use the digital DPP
		Do not intend to use the digital DPP
Feedback	Desired features for the digital DPP	

Note: All six matrices are combined here to form one table.

Figure 2.5

Overview of the Qualitative Content Analysis Process



Note: This image is for illustrative purposes only and does not reflect the final results. The categories and sub-categories presented here were labelled a priori as they were framework driven, reflecting the research topics. Theme and sub-theme labels were data-driven and were thus determined during the inductive analysis process.

2.7. Ethical Considerations

This research was guided by the framework for evaluating the ethics of clinical research studies. This framework, developed by Emanuel et al. (2000), lists seven requirements that determine whether research involving human participants is conducted ethically. These requirements are as follows:

1. The research must be of social or scientific value. For example, that it evaluates a diagnostic or therapeutic intervention that could lead to improvements in health or wellbeing.

2. It must be scientifically valid, that is, conducted in a methodologically rigorous manner.
3. It must include fair participant selection so that vulnerable individuals are not disproportionally targeted for risky research.
4. There must be a favourable risk-benefit ratio, where risks are minimised, and benefits maximised.
5. It must be subject to independent review, that is, the research design should be evaluated by individuals unaffiliated with the research.
6. Informed consent must be provided. Detailed information regarding the research purpose, procedure, benefits, and risks should be disclosed so that the individual understands this information and can volunteer whether they wish to enrol or continue to participate.
7. Respect for potential and enrolled participants should be present. For example, granting the right to withdraw at any time, maintaining privacy and confidentiality, and informing them of newly discovered risks or benefits.

As human participants were recruited for studies two and three, ethical approval was sought and obtained from the NUI Galway Research Ethics Committee. This approval notice can be found in Appendix F. The main ethical concerns for these studies were those of scientific validity, fair participant selection, informed consent, informing participants of risks and results, and confidentiality and anonymity. The following sections outline how each of these ethical concerns were addressed in both studies.

2.7.1. Scientific Validity

Several measures were taken to ensure that each study conformed to the relevant standards and recommendations. First, the systematic review for study one was conducted in accordance with PRISMA guidelines (Moher et al., 2009) to ensure that the reporting quality of this review met stringent standards. This included the presentation of the PRISMA flowchart (see Chapter Three, Figure 3.1), and PRISMA checklist (see Appendix B). Moreover, the review protocol was pre-published on PROSPERO (see Van Rhoon et al., 2018). Second, the self-report questionnaire used in study two was developed using measures that had been validated in previous studies. However, to ensure the construct validity of the factors in this new research context, CFA was conducted prior to testing the research model.

This CFA was important in establishing the convergent validity and discriminant validity of the measurement model (Harrington, 2009). To further validate the measurement model and test for CMV, a CLF test was applied (see Eichhorn, 2014). Third, the COREQ checklist (Tong et al., 2007) was used in study three to ensure that all key aspects of the qualitative research process were considered and reported where necessary. A copy of this checklist can be found in Appendix L.

2.7.2. Fair Participant Selection

The systematic review for study one excluded studies involving participants with previously diagnosed GDM. This exclusion criterion was set to minimise heterogeneity between interventions, as heterogeneity was already a common issue among digital T2DM prevention interventions (see Bian et al., 2017; Joiner et al., 2017). Moreover, as GDM affects 7 to 10% of pregnancies worldwide (Behboudi-Gandevani et al., 2019), and digital health interventions currently exist to help people manage or prevent GDM specifically (e.g., Mackillop et al., 2018; Mackillop et al., 2014; Sung et al., 2019), a stand-alone review of digital GDM interventions is warranted.

While the COVID-19 pandemic limited the recruitment avenues for studies two and three, the aim was to obtain a sample with as much diversity as possible. The GDM exclusion criterion was not applied in studies two and three as the aim of these studies was to identify those at risk of developing T2DM. It was important to include people with previous GDM as they are at a disproportionally high risk of developing T2DM (Clausen et al., 2009) and may therefore be in relatively greater need of a digital DPP. Stratified sampling was used, where eligible and interested prospective participants were divided into groups based on gender, age, BMI, and FINDRISC category. Individuals in each group or ‘stratum’ were assigned a random number via random.org (Haahr, 2020) an online random number generator, and then contacted in numerical order on a rolling basis. This process ensured that participants in each stratum had an equal chance of being contacted first, second, or third etc. before recruitment closed.

2.7.3. Informed Consent

To give informed consent, one should understand the purpose, process, risks, benefits, and alternatives to research (where available) and make a free, voluntary decision about whether to participate (Jefford & Moore, 2008). The information for each study was presented to participants in lay terms and included details on who was conducting the study, the purpose of the study, what the participant will be asked to do, what will happen to their data, what they must do to participate and give informed consent, and who they can contact for further details or issues. In study two, this information was presented to participants online or in hard copy (see Appendix I). In study three, this information (see Appendix N) was issued to participants via email once they expressed interest in participating, then issued again verbally at the beginning of the video interview period before the actual interview and audio recording could commence. In both studies, once the information was read by participants, they had to click the appropriate buttons (if online), or tick boxes and sign (if hard copy), stating that they: (a) have read the information, (b) understand the information and have had enough time to process the information, (c) are aware that they can withdraw from the study at any time without reason and penalty, and (d) agree to take part in the study and provide informed consent. The consent forms for studies two and three can be found in Appendices J and O respectively.

2.7.4. Informing Participants of Risks and Results

As the questionnaire issued to participants in study two contained items that would be used to determine their risk of developing T2DM and would subsequently determine their eligibility to be interviewed for study three, the researchers would have knowledge about each participant's risk that the participants themselves may not be privy too. This posed a slight ethical dilemma. However, while the researchers would know each participant's risk for potential harm (that is, developing T2DM), this harm was in no way influenced (or caused) by participation in either study. Additionally, although the calculation and identification of risk scores in study two were a 'result' of participation (as they may never know whether they are at risk if not for participating in this study), and pertain to a clinical condition (T2DM), this is likely not the scenario that was envisioned when the framework by Emanuel et al. (2000) was developed.

While blood tests are considered the 'gold standard' for T2DM risk screening (American Diabetes Association, 2018), it could be argued that all participants should be notified of their risk based on the FINDRISC score in study two; as, if one is informed that they are at greater risk, it may encourage them to see their GP and request an official screening. However, one could counter-argue that, as the FINDRISC is not a definitive screening tool, a false negative (e.g., the participant receives a low FINDRISC score, but would be in the PDM or T2DM range on a blood test), or false positive (e.g., the participant receives a high FINDRISC score, but a blood test would reveal 'normal' blood glucose levels) could occur. The false negative scenario could lead the participant to believe they are not at risk, potentially reducing their perceived need to attend a screening; while a false positive could generate stress in the participant, one that may not be present if not for this new information regarding their health status. A recent qualitative study found that once diagnosed with PDM (albeit via HbA1c test), participants experienced distress and fear regarding their future health, including physical symptoms, and the need to adapt their lifestyle (Strachan et al., 2018).

With these factors in mind, it was important to maintain respect for participant autonomy, and so participants were given the choice as to whether they received this score or not. The information sheet for study two informed participants that the questionnaire would contain items that will be used to assess their risk of developing T2DM and that they will be given the choice at the end of the questionnaire to either ‘opt in’ or ‘opt out’ of receiving this score via email. Participants who chose to receive this score were sent an email (see Appendix S) which presented their numerical FINDRISC score, their risk category (e.g., low, moderate, high), and weblinks to the relevant diabetes.ie (Diabetes Ireland, 2020a) and hse.ie (HSE, 2020b) websites where they could find out more about this risk and T2DM as a condition. Participants were also informed that this was not a definitive risk assessment or diagnosis and advised to contact their GP if they had any further questions or concerns.

2.7.5. Confidentiality and Anonymity

To ensure confidentiality in study two, participant contact details were removed from the questionnaire data file and exported to a separate document. Each document was then protected via password and stored on a password-protected computer. Emails containing participant T2DM risk scores were sent from a secure password-protected account that was established specifically for the purpose of issuing participants their scores once requested. In study three, the following steps were taken. First, each participant was granted a pseudonym in the form of a participant number. Second, the interview video files were deleted and only the audio files retained. Third, all audio files were transcribed to text and the audio files subsequently deleted. Fourth, during the transcription process, all potentially identifying details (e.g., people’s names, place names) were replaced with generic terms or phrases (e.g., ‘friend’ or ‘place of residence’). Fifth, a second researcher screened transcripts to ensure no potentially identifying details were included. All documents and project files were password protected and stored on a password-protected computer.

2.8. Summary of the Chapter

This chapter provided an outline of the overarching methodological structure of this research, including its aims, objectives, and study design. To build the evidence base for the development and implementation of a digital DPP for adults in Ireland who are at risk of developing T2DM, a series of three studies was conducted. These studies aimed to: (1) identify the evidence base of digital DPPs by establishing what works and how; (2) identify and develop theory to assess what factors influence one’s intention to use a digital DPP; and (c) explore the experiences of adults at risk of T2DM regarding these factors, and how and why these factors might affect a digital DPP’s acceptability. A description of each study’s methods and research procedure was presented, with appropriate rationale provided. The chapter concluded with a discussion of the ethical considerations of this research, namely those of scientific validity, fair participant selection, informed consent, informing participants of risks and results, and confidentiality and anonymity.

3. Study One: A Systematic Review of the Behaviour Change Techniques and Digital Features in Technology-Driven Type 2 Diabetes Prevention Interventions

Van Rhoon, L.[1], Byrne, M.[1], Morrissey, E.[1], Murphy, J.[2] & McSharry, J.[1]

[1]Health Behaviour Change Research Group, School of Psychology, National University of Ireland Galway, Ireland.

[2]Medication Adherence Across the Lifespan Research Group, School of Psychology, National University of Ireland Galway, Ireland.

3.1. Abstract

Objectives: Our aim was to conduct a systematic review to determine the effectiveness of technology-driven diabetes prevention interventions in producing clinically significant weight loss, and to identify the behaviour change techniques and digital features frequently used in effective interventions.

Methods: We searched five databases (CINAHL. EMBASE, MEDLINE, PsychINFO, and PubMed) from inception to September 2018 and reviewed 19 experimental and non-experimental studies of 21 technology-driven diet plus physical activity interventions for adults (≥18 years) at risk of developing type 2 diabetes. Behaviour change techniques were coded using the BCT taxonomy v1, and digital features were identified via thematic analysis of intervention descriptions.

Results: Sixty-three per cent of interventions were effective in the short term (achieving ≥3% weight loss at ≤6 months), using an average of 5.6 more behaviour change techniques than non-effective interventions; and 33% were effective in the long term (achieving ≥5% weight loss at ≥12 months), using 3.7 more behaviour change techniques than non-effective interventions. The techniques of social support (unspecified), goal setting (outcome/behaviour), feedback on behaviour, and self-monitoring of outcome(s) of behaviour were identified in over 90% of effective interventions. Interventions containing digital features that facilitated health and lifestyle education, behaviour/outcome tracking, and/or online health coaching were most effective.

Conclusion: The integration of specific behaviour change techniques and digital features may optimise digital diabetes prevention interventions to achieve clinically significant weight loss. Additional research is needed to identify the mechanisms in which behaviour change

techniques and digital features directly influence physical activity, dietary behaviours, and intervention engagement.

Keywords: Systematic review, type 2 diabetes, diabetes prevention, diet, physical activity, digital health, health behaviour change, weight loss.

3.2. Introduction

The global prevalence of diabetes represents a major public health concern. In 2015, the number of adults with diabetes was estimated at 415 million worldwide, with this figure projected to rise to 642 million by the year 2040 (Ogurtsova et al., 2017). Type 2 Diabetes (T2D) accounts for approximately 90% of all diabetes cases, and those with the condition face an additional two-to-fourfold risk of coronary heart disease (Alberti et al., 2007; American Diabetes Association, 2013). Overweight and obesity are the main drivers of T2D with 60% of diabetes cases directly attributed to weight gain (Yach et al., 2006). Based on international evidence from several landmark prevention studies (Knowler et al., 2002; Pan et al., 1997; Tuomilehto et al., 2001) the International Diabetes Federation concluded that modifications to diet and physical activity are key to diabetes prevention (Alberti et al., 2007). In the largest of these studies, the Diabetes Prevention Program included one-on-one health coaching and provided sixteen 30-60-minute educational sessions on diet, exercise, and behaviour modification. Participants lost an average of 5-7% of baseline body weight after one year, leading to a 58% study-wide reduction in T2D incidence over three years (Knowler et al., 2002). Current US and UK diabetes prevention guidelines therefore recommend a weight loss target of at least 5% (CDC, 2018; NICE, 2019).

Despite their effectiveness, the implementation of such large-scale, intensive programs may not be feasible in routine clinical practice where health care resources are limited (Dunkley et al., 2014; Greaves et al., 2011). In view of this, smaller-scale diabetes prevention interventions (DPIs) have been adapted from the original Diabetes Prevention Program for implementation in ‘real world’ community settings (Cardona-Morrell et al., 2010; Whittemore, 2011). Systematic reviews of these community based DPIs concluded that the interventions can promote clinically significant weight loss, as evidenced by an average 4-5% reduction in baseline body weight (Ali et al., 2012; Whittemore, 2011). However, despite offering greater accessibility and sustainability (Vojta et al., 2013) community-based DPIs still require face-to-face delivery, which present participation barriers such as transportation, family/work commitments, and cost (Johnson & Melton, 2016; Shawley-Brzoska & Misra, 2018).

Technology-driven DPIs have been developed to overcome the participation barriers of face-to-face DPIs by offering lifestyle education and support remotely or automatically via text messages, smartphone applications, or websites (Grock et al., 2017). Recent meta-analyses of DPIs delivered via digital technologies reported results comparable to the reviews of community based DPIs. Bian et al. (2017) reported a mean two-year weight loss of 4.81 kg across 15 studies; and Joiner et al. (2017) found an overall weight loss of 3.98% at 15 months across 22 studies. However, a number of the reviewed interventions were not necessarily technology-driven, with both meta-analyses including interventions that were delivered exclusively in real time by a human coach via phone or teleconference. Although these modes of delivery can be more accessible for participants, phone-based interventions require mutually convenient meeting times between participant and coach. Furthermore, these interventions may still incur substantial time and resource costs, as health coaches must drive the intervention by frequently interacting with participants in real time. This may be particularly resource-intensive if sessions are delivered one-on-one. Importantly, both meta-analyses also reported significant inter-study heterogeneity in the modes of delivery, materials used, and the amount of weight lost; and the most effective behavioural and digital components or ‘active ingredients’ of the interventions remain unclear.

Behaviour change techniques (BCTs) are the observable, replicable and irreducible intervention components, designed to modify the processes that regulate behaviour (Michie et al., 2013). A taxonomy of BCTs was developed to provide a standardised list of BCT labels and definitions, and evidence suggests that specific BCTs may be effective in improving dietary and physical activity behaviours (Michie et al., 2011; Michie et al., 2013). European diabetes prevention guidelines state that self-regulatory BCTs (e.g., goal setting, self-monitoring), action planning, problem solving, and social support should be present in all face-to-face DPIs (Greaves et al., 2011; Lindström et al., 2010). However, no review to date has assessed the use of BCTs in technology-driven DPIs.

Reviews of mobile health diabetes management studies have examined the links between technological features and intervention effectiveness. Donevant et al. (2018) found that interventions with statistically significant outcomes used a combination of interactive features (where participants respond to or modify content in real time) and passive features (where a response is not required), while interventions without significant outcomes were more likely to have used passive features only. Holcombe (2015) found that interactive two-way text messages were more effective than passive one-way text messages at improving glycated haemoglobin (A1c) and medication adherence in adults with T2D. However, as the reviewed interventions focused on the management of T2D, it is not yet known which digital features are most effective in diabetes prevention. Furthermore, these reviews excluded interventions that were delivered using non-mobile digital platforms such as desktop computers or websites.

As DPIs that incorporate technology vary in content and outcomes, identifying the most effective behavioural and digital components in technology-driven DPIs is important to delineate potential causal pathways between components and outcomes, and inform the cost and resource optimisation of future interventions. To achieve this, it must first be determined which technology-driven DPIs are effective in producing clinically significant weight loss, and following this, the most effective components can be identified. However, no review to date has either applied the BCT taxonomy to identify the techniques used in technology-driven DPIs or performed a digital feature assessment. In light of this, the present review has two primary aims:

1. To determine the effectiveness of technology-driven DPIs in producing clinically significant weight loss and improvements in additional outcomes linked to the onset of T2D; and
2. Identify the BCTs and digital features most frequently used in effective interventions.

3.3. Methods

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009) (see Appendix I). The protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) [CRD42018097195].

3.3.1. Study Eligibility Criteria

We included experimental and non-experimental studies, published in English, that assessed the effectiveness of technology-driven (e.g., automated phone calls or messages, smartphone application, text, email, instant message, video, website) diet and/or physical activity interventions for adults, age 18 and over, who are at risk of developing T2D (e.g., individuals with prediabetes, metabolic syndrome, overweight/obesity). This included observational studies, single-arm intervention studies, and randomised and non-randomised trials which assessed the intervention against a control group or alternative DPI. Studies must have had an explicit aim of preventing T2D or reducing the risk of developing T2D; and reported at least one of the following outcomes: body weight, glycaemic status (either A1c or fasting glucose), or T2D incidence. Studies were excluded if: participants had previously received a diagnosis of type 1, type 2, or gestational diabetes; the interventions were delivered exclusively in real-time via human coach (e.g., face-to-face, phone call, teleconferencing); or if technology was only used to supplement an unmodified face-to-face intervention.

3.3.2. Study Search and Selection

A systematic literature search of five databases (CINAHL, EMBASE, MEDLINE, PsycINFO, and PubMed) was conducted by the lead author (LV) to identify relevant studies published between database inception and September 3, 2018. Search terms (see Appendix C) included key words, phrases, and Medical Subject Headings relevant to T2D risk, prevention interventions, diabetes-relevant outcomes, and digital modes of delivery.

All records retrieved from the database search were imported into EndNote X5 (Clarivate Analytics, 2011) and duplicates removed. All unique records were then imported into the Covidence software (Veritas Health Innovation, 2019). Titles and abstracts were screened by one reviewer (LV) to determine potentially eligible full-text articles. The same reviewer screened all resulting full-text articles for inclusion. A second reviewer (JMu) independently screened a random 20% of the titles and abstracts, followed by a random 20% of the full-text articles. All initial disagreements were resolved via discussion between the two reviewers. Forward and backward reference searches of the included articles were then conducted by LV to identify additional articles.

3.3.3. Outcomes and Effectiveness Assessment

The primary outcomes of interest were body weight, glycaemic status (A1c or fasting glucose) and T2D incidence. Body weight was chosen to inform this review’s primary definition of effectiveness as body weight has a strong association with T2D incidence, and is reported more often in DPI studies than the other primary outcomes (Bian et al., 2017; Dunkley et al., 2014; Yach et al., 2006). Intervention effectiveness was defined in relation to a mean weight loss of at least 5% of baseline body weight for two reasons. First, this figure is considered clinically significant (Donnelly et al., 2009) and matches the US and UK weight loss benchmark for 12-month DPIs (CDC, 2018; NICE, 2019). Second, in the US, for an organisation to receive accreditation as a certified Diabetes Prevention Program provider endorsed by the Centers for Disease Control and Prevention (CDC), at least 5 participants must have completed the yearlong programme, and the average weight loss after 12 months must have been at least 5% (CDC, 2018). Achieving this 5% has important implications as it can result in insurance coverage for participants, and reimbursement for the organisations that deliver the programme (Gruss et al., 2019).

Interventions of ≤6 months were deemed effective if an average of ≥3% weight loss was achieved at ≤6-month follow-up, while interventions of ≥12-month duration were deemed effective if an average ≥5% weight loss was achieved at ≥12-month follow-up. Based on these criteria, interventions were labelled in four potential ways: (1) effective short term, (2) not effective short term, (3) effective long term, and (4) not effective long term. Interventions of ≥12 months duration received two labels as they included short- and long-term follow-ups. Relationships were explored between the number and type of BCTs and digital features identified in effective versus non-effective interventions.

For the purpose of this review, BCTs and digital features were considered effective if they were identified in at least 75% of effective interventions, both short and long term. A BCT or digital feature was considered most effective at each respective time period (short or long term) if it was identified at considerably greater frequency in effective interventions compared to non-effective interventions.

3.3.4. Data Extraction

A data extraction tool was developed for this review and piloted on five randomly selected papers then refined and finalised. The extracted information included participant, study, and intervention characteristics; and outcomes of absolute weight loss, percentage of baseline weight lost, A1c, fasting glucose, and T2D incidence–all of which were converted to standardised units where necessary. In cases where the average percentage of weight lost was not reported, this was hand calculated using the average baseline body weights, and the average body weights at post intervention and subsequent follow-up(s). Data were extracted by one reviewer (LV), with a random 20% checked for accuracy by a second independent reviewer (EM). As the process of obtaining more detailed information from authors can take many months in which only a percentage of authors respond to such requests (Black et al., 2018), only the publicly available materials (e.g. main study articles, follow-up study articles, intervention development articles, protocols, supplementary materials) pertaining to the included studies were used for data extraction, BCT coding, and digital feature identification.

3.3.4.1. Behaviour Change Technique Coding. The BCT taxonomy v1 (Michie et al., 2013) was used by one reviewer (LV) to code BCTs from all intervention descriptions, and a second independent reviewer (EM) double coded a random 20% of all descriptions to check for reliability. All initial disagreements were resolved via discussion between the two reviewers. Based on previous reviews (Bian et al., 2017; Joiner et al., 2017) it was anticipated that a number of different studies would describe the same standardised intervention such as those interventions based on the Diabetes Prevention Program. It was also anticipated that the interventions may be described differently in each study's published literature; where, for example, some BCTs clearly present in Study A's intervention description(s) would be absent from Study B's intervention description(s) and vice versa. To accommodate this, an imputation process was used to include the missing BCTs. First, intervention descriptions from each study were coded to identify the BCTs clearly present. Second, the BCTs coded as present in study A, but missing from study B, were also coded to Study B; and the BCTs present in study B, but missing from study A, were coded to study A.

3.3.4.2. Digital Feature Identification. A modified three-phase thematic analysis (Braun & Clarke, 2006) was performed on all intervention descriptions to identify digital features. First, one reviewer (LV) analysed the descriptions, coding each digital component (e.g., nutrition video) and its mode of delivery (e.g., website), plus each non-digital component (e.g., food diary) and its format (e.g., hard copy). The aforementioned imputation process was also used to identify additional components in cases where multiple studies assessed the same standardised intervention. Second, digital components were categorised according to the level of interactivity between the participant and the digital tool and classified as either passive (one-way interaction) or interactive (two-way interaction). A second reviewer (EM) independently completed these first two phases on a random 20% of all intervention descriptions to check for reliability. Third, all passive and interactive digital components were pooled together in their respective groups and analysed by LV and EM via discussion. Through this discussion, common themes among the passive and interactive components were generated. These component clusters or themes were subsequently classified as either passive or interactive digital features and assigned labels that best represent each theme.

3.3.5. Quality Assessment

Study quality was assessed using the NICE quality appraisal checklist for quantitative intervention studies (NICE, 2012). This 27-item checklist enables appraisal of a study's internal and external validity where each item is rated ++, +, or – based on the degree to which the criteria was satisfied, with ++ indicating highest quality or lowest risk of bias. One reviewer (LV) conducted the assessments and a random 20% were checked by a second reviewer (EM).

3.3.6. Data Synthesis

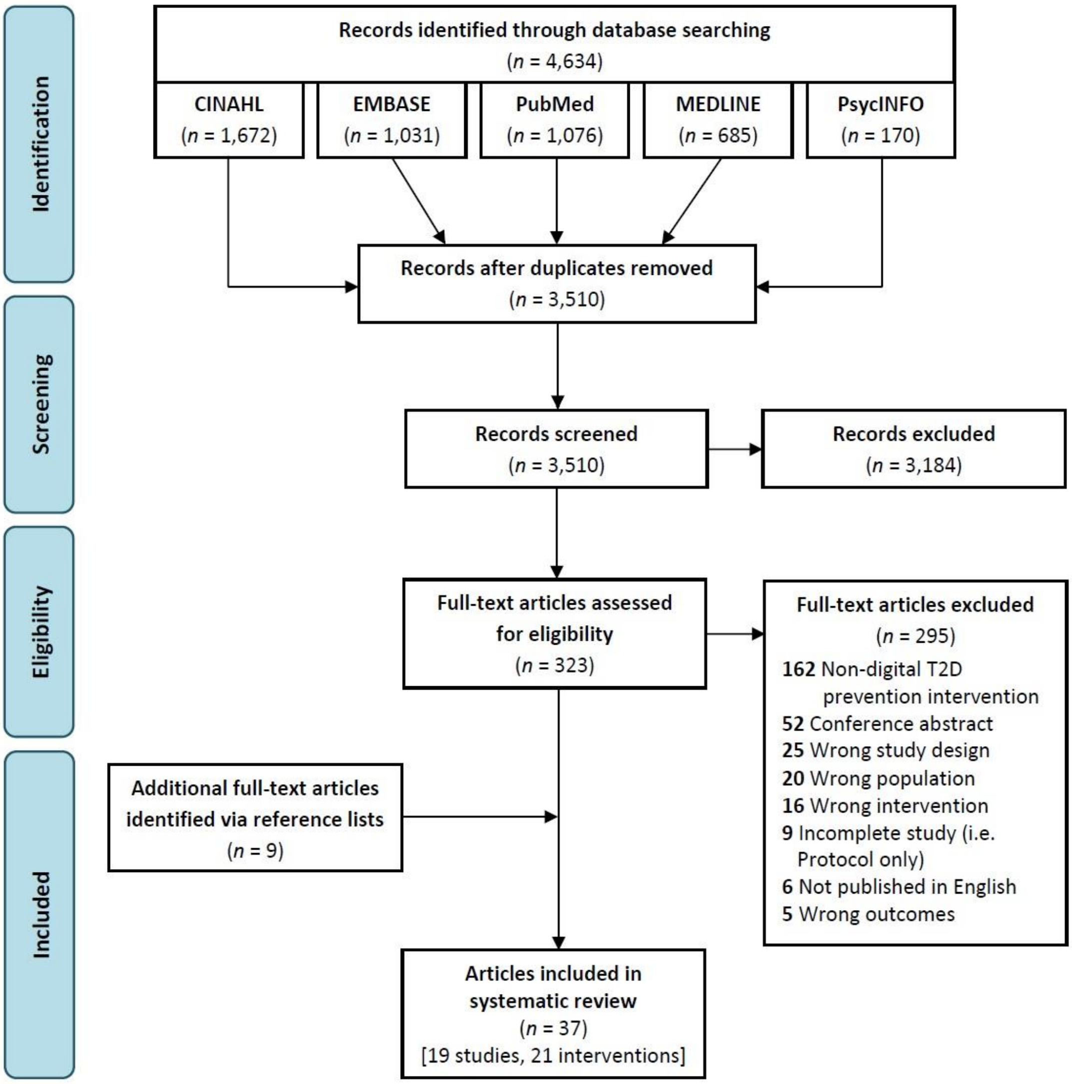
This review aimed to explore associations between two types of intervention components (BCTs and digital features) and the percentage of baseline weight lost, and assess the effectiveness of interventions using international diabetes prevention benchmarks and certification requirements. Therefore, a narrative synthesis was used to organise and present the data within the text, with statistical data presented in the summary tables. As the majority of studies featured in our primary effectiveness analysis did not report the percentage of weight lost, sufficient data was not available for meta-analysis.

3.4. Results

A total of 3,510 unique articles were identified via electronic database searches (see Figure 3.1) with 323 remaining for full-text review. Following full-text review, twenty-eight full-text articles were retained, and a forward and backward reference search identified nine additional articles. Thirty-seven articles (see Appendix T) representing 19 studies of 21 interventions (two studies each assessed two unique technology-driven DPIs) were ultimately included. For studies reported in multiple articles, only the main article reporting the primary outcome measure(s) at first follow-up is referenced in the text and tables.

Figure 3.1

PRISMA Flow Diagram



3.4.1. Study Characteristics

A summary of the characteristics of all 19 studies can be found in Table 3.1. Most studies (*N* = 14) were conducted in the USA (Block et al., 2015; Castro Sweet et al., 2018; Cha et al., 2014; Estabrooks & Smith-Ray, 2008; Everett et al., 2018; Fischer et al., 2016; Fukuoka et al., 2015; Kramer et al., 2010; Ma et al., 2013; Michaelides et al., 2016; Piatt et al., 2013; Sepah et al., 2014; Tate et al., 2003; Wilson et al., 2017) and the most common design (*N* = 10) was Randomised Controlled Trial (Aguiar et al., 2016; Block et al., 2015; Estabrooks & Smith-Ray, 2008; Fischer et al., 2016; Fukuoka et al., 2015; Limaye et al., 2017; Ma et al., 2013; Ramachandran et al., 2013; Tate et al., 2003; Wong et al., 2013). Study duration ranged between three months and five years, and enrolment was most often (N = 7) conducted in the primary care setting (Arens et al., 2018; Block et al., 2015; Estabrooks & Smith-Ray, 2008; Fischer et al., 2016; Fukuoka et al., 2015; Kramer et al., 2010; Ma et al., 2013). The total number of intervention arm participants in the analyses was 2,755 (65% female, age range 20-76 years). Two studies recruited males only (Aguiar et al., 2016; Ramachandran et al., 2013), while the remainder recruited both males and females. Across the ten studies which reported ethnicity in sufficient detail, 68% of participants were white. Across all intervention groups, short term attrition ranged between 9.4% and 43.4%, while the long-term attrition range was 7.4% to 79.8%.

Table 3.1

Study Characteristics

Author(s) (year) Country *Intervention*	Study design	Comparison group(s)	Study duration	Enrolment setting	Definition of high risk of T2D	Sample (intervention group)	Attrition (intervention group)
Aguiar et al. (2016) Australia	Randomised Controlled Trial	Waitlist control	6 months	University	Australian Diabetes Risk Tool (AUSDRISK) score of ≥12. BMI: 25-40 kg/m^2	*n* = 53 Age range: 20-65 years Mean age: 52.5 ± 9.5 years Male: 100% Ethnicity: not reported Mean BMI: 32.2 ± 3.5 kg/m^2	9.4% at 3 months 24.5% at 6 months
Arens et al. (2018) Germany	Prospective observational study	Usual care	12 months	Primary care	Presence of metabolic syndrome.	*n* = 109 Age range: 35-60 years Mean age: 49.6 ± 9.3 years Female: 60.6% Ethnicity: not reported Mean BMI: 32.2 ± 5.5 kg/m^2	19.3% at 3 months 32.1% at 6 months 49.5% at 9 months 79.8% at 12 months
Block et al. (2015) USA	Randomised Controlled Trial	Waitlist control	6 months	Primary care	Presence of prediabetes BMI: ≥27 kg/m^2 (≥25 kg/m^2 for Asian subgroups). Fasting glucose: 100-125 mg/dL A1c: 5.7-6.4%.	*n* = 163 Age range: 31-70 years Mean age: 55 ± 8.8 years Male: 68.1% White: 66.9% Mean BMI: 31.1 ± 4.5 kg/m^2	16.6% at 6 months
Castro Sweet et al. (2018) USA	Single-arm prospective study	NA	12 months	Online	Presence of prediabetes (A1c: 5.7-6.4%). Metabolic syndrome (Prediabetes, hypertension, dyslipidaemia, and obesity).	*n* = 501 Age range: not reported Mean age: 68.8 ± 2.6 years Female: 64% White: 60.3% Mean BMI: 33.6 ± 5.7 kg/m^2	4% of participants did not meet CDC DPRP criteria (as they completed ≤3 intensive phase lessons).

Author(s) (year) Country *Intervention*	Study design	Comparison group(s)	Study duration	Enrolment setting	Definition of high risk of T2D	Sample (intervention group)	Attrition (intervention group)
Cha et al. (2014) USA	Single-arm prospective pilot study	NA	12 weeks	University	Presence of prediabetes (impaired fasting glucose: 100-125 mg/dL; or A1c: 5.7-6.4%).	Intervention completers: *n* = 13 Age range: 21-28 years Mean age: 24.4 ± 2.2 years Female: 76.9% African American: 53.8% Mean BMI: not reported	13.3% at 12 weeks
Estabrooks and Smith-Ray (2008) USA	Randomised Controlled Trial	Usual Care	3 months	Primary care	Elevated blood glucose and/or clinical diagnosis of prediabetes.	*n* = 39 Age range: not reported Mean age: 57.8 ± 17 years Female: 71.8% White: 69% Mean BMI: not reported	28.2% at 3 months
Everett et al. (2018) USA	Single-arm prospective observational study	Calibration cohort	3 months	University hospital	Diagnosis of prediabetes (fasting glucose: 100-125 mg/dL; impaired glucose tolerance: 2-hour glucose of 140-199 mg/dL after 75g oral glucose tolerance test; or A1c: 5.7-6.4%). BMI: 24-40 kg/m^2 (22-40 kg/m^2 for Asian individuals).	Intervention completers only: *n* = 38 Age range: not reported Mean age: 57.2 ± 9.1 years Female: 63% White: 82% Mean BMI: not reported	11.6% at 3 months
Fischer et al. (2016) USA	Randomised Controlled Trial	Usual care	12 months	Primary care	A1c between 5.7% and 6.4%.	*n* = 78 Age range: not reported Mean age: 47.7 ± 12.4 Female: 70.5% Native Spanish speakers: 65% Mean BMI: not reported	7.7% at 12 months

Author(s) (year) Country *Intervention*	Study design	Comparison group(s)	Study duration	Enrolment setting	Definition of high risk of T2D	Sample (intervention group)	Attrition (intervention group)
Fukuoka et al. (2015) USA	Feasibility Randomised Controlled Trial	Pedometer only control	5 months	Primary care	BMI: ≥25 kg/m^2 (22 kg/m^2 if Asian-Pacific Islander). American Diabetes Association Diabetes Risk Test score of ≥5. Fasting plasma glucose: 100-125 mg/dL; A1c: 5.7-6.4%; Oral glucose tolerance test: 140-200 mg/dL.	*n* = 30 Age range: 36-76 years Mean age: 57.1 ± 9.1 years Female: 76.7% White: 43.3% Mean BMI: 32.2 ± 5.6 kg/m^2	10% of participants did not complete 3-month follow-up assessment. 6.6% of participants did not complete 5-month follow-up assessment.
Kramer et al. (2010) USA	Non-randomised Controlled Trial	Face-to-face intervention	3 months	Primary Care	BMI ≥25 kg/m^2 Prediabetes (FG: 100-125 mg/dL). Presence of metabolic syndrome.	*n* = 22 Age range: not reported Mean age: 57.3 years Sex/gender: not reported Ethnicity: not reported Mean BMI: 32.9 ± 6.1 kg/m^2	36.4% at 3 months
Limaye et al. (2017) India	Randomised Controlled Trial	Standard care	12 months	Worksite	Presence of ≥3 risk factors (family history of cardio-metabolic disease, overweight/obesity, high blood pressure, impaired fasting glucose, hypertriglyceridaemia, high LDL and low HDL cholesterol).	*n* = 133 Age range: not reported Mean age: 36.8 ± 7.2 years Male: 74.4% Ethnicity: not reported Mean BMI: 27 ± 3.2 kg/m^2	21.1% at 12 months
Ma et al. (2013) USA	Randomised Controlled Trial	Coach-led intervention; usual care control	15 months	Primary care	BMI: ≥25 kg/m^2 Prediabetes (fasting plasma glucose: 100-125 mg/dL) Metabolic syndrome (central obesity, dyslipidaemia, hypertension, prediabetes).	*n* = 81 Age range: not reported Mean age: 51.8 ± 9.9 years Male: 54.3% White: 79% Mean BMI: 31.7 ± 4.7 kg/m^2	7.4% at 15 months

Author(s) (year) Country *Intervention*	Study design	Comparison group(s)	Study duration	Enrolment setting	Definition of high risk of T2D	Sample (intervention group)	Attrition (intervention group)
Michaelides et al. (2016) USA	Single-arm prospective study	NA	24 weeks (plus 65-week follow-up)	Worksite	Hyperglycaemia (A1c: 5.7-6.4%).	Program starters: *n* = 43 Age range: not reported Mean Age: 51.5 ± 8.3 years Female: 86% Ethnicity: not reported Mean BMI: 35.5 ± 7.4 kg/m^2	16.3% of program starters (read > 1 article per week for ≥ 4 weeks) did not complete the core program.
Piatt et al. (2013) USA *GLB-DVD*	Prospective quasi-experimental study	Face-to-face, internet, self-selection interventions	6 months (plus 18-month follow-up)	University	BMI: ≥25 kg/m^2 Abdominally obese (waist circumference: >40 inches in males and >25 inches in females).	*n* = 113 Age range: not reported Mean age: 52.4 ± 10.9 years Female: 85% White: 93.8% Mean BMI: 36.2 ± 7.2 kg/m^2	43.4% at 6 months
Piatt et al. (2013) USA *GLB-Internet*	Prospective quasi-experimental study	Face-to-face, DVD, self-selection interventions	6 months (plus 18-month follow-up)	University	BMI: ≥25 kg/m^2 Abdominally obese (waist circumference: >40 inches in males and >25 inches in females).	*n* = 101 Age range: not reported Mean age: 48.7 ± 9.7 years Female: 88.1% White: 99.1% Mean BMI: 36.1 ± 6.4 kg/m^2	56.4% at 6 months
Ramachandran et al. (2013) India	Randomised Controlled Trial	Usual care	24 months (plus five-year follow-up)	Worksite	Positive family history of T2D. BMI: ≥23 kg/m^2	*n* = 271 Age range: not reported Mean age: 54.1 ± 6.1 years Male: 100% Ethnicity: not reported Mean BMI: 25.8 ± 3.3 kg/m^2	3.7% at 24 months

Author(s) (year) Country *Intervention*	Study design	Comparison group(s)	Study duration	Enrolment setting	Definition of high risk of T2D	Sample (intervention group)	Attrition (intervention group)
Sepah et al. (2014) USA	Quasi-experimental Single-arm prospective study	NA	12 months (plus 24- and 36-month follow-ups)	Online	BMI: ≥25 kg/m^2 (22 kg/m^2 if Asian).	Core group: *n* = 187 Age range: not reported Mean age: 43.9 ± 12.4 years Female: 85% White: 51% Mean BMI: 36.7 ± 7.6 kg/m^2	15% of participants did not meet CDC DPRP "core phase" criteria (as they only completed ≤3 core lessons). 34.5% did not meet "post-core phase" criteria (completed ≤3 core lessons and 0 post-core lessons)
Tate et al. (2003) USA *Basic Internet*	Randomised Controlled Trial	Internet and Behavioural e-Counselling Intervention	12 months	University hospital	BMI between 27-40 kg/m^2 ≥1 risk factors for T2D (e.g., family history of T2D, impaired glucose tolerance).	*n* = 46 Age range: not reported Mean age: 47.3 ± 9.5 years Female: 89% White: 89% Mean BMI: 33.7 ± 3.7 kg/m^2	15.2% at 12 months
Tate et al. (2003) USA *Internet and Behavioral e-Counseling*	Randomised Controlled Trial	Basic Internet Intervention	12 months	University hospital	BMI between 27-40 kg/m^2 ≥1 risk factors for T2D (e.g., family history of T2D, impaired glucose tolerance).	*n* = 46 Age range: not reported Mean age: 49.8 ± 9.3 years Female: 91% White: 89% Mean BMI: 32.5 ± 3.8 kg/m^2	17.4% at 12 months

Author(s) (year) Country *Intervention*	Study design	Comparison group(s)	Study duration	Enrolment setting	Definition of high risk of T2D	Sample (intervention group)	Attrition (intervention group)
Wilson et al. (2017) USA	Non-randomised controlled observational study	Matched control	2 years	Worksite	BMI: ≥24 kg/m^2 (22 kg/m^2 if Asian); Prediabetes (fasting blood glucose: 100-125 mg/dL, A1c: 5.7-6.4%, oral glucose tolerance test: 140-199 mg/dL).	*n* = 634 Age range: 23-68 years Median age: 46 years Female: 58.4% White: 68% Mean BMI: 34.5 kg/m^2	5.8% of participants did not meet CDC DPRP criteria (completed ≤3 intensive phase lessons). 76% of participants had sufficient data for analysis.
Wong et al. (2013) Hong Kong	Randomised Controlled Trial	Usual care	24 months	University Hospital	Diagnosis of prediabetes (fasting plasma glucose: 5.6-6.9 mmol/L; or, 2-hour postprandial glucose: 7.8-11.0 mmol/L after 75g glucose load).	*n* = 54 Age range: not reported Mean age: 54.1 ± 6.1 years Male: 90.7% Ethnicity: not reported Mean BMI: 25.6 ± 2.9 kg/m^2	16.7% at 12 months 24.1% at 24 months

Note: NA: Not Applicable, BMI: Body Mass Index

3.4.2. Intervention Characteristics

A summary of the characteristics from all 21 technology-driven DPIs can be found in Table 3.2. The intervention delivery period ranged between 3 and 24 months in duration, and all interventions targeted both diet and physical activity behaviours. Eleven interventions were independent (newly developed) (Aguiar et al., 2016; Arens et al., 2018; Block et al., 2015; Cha et al., 2014; Estabrooks & Smith-Ray, 2008; Everett et al., 2018; Limaye et al., 2017; Ramachandran et al., 2013; Tate et al., 2003; Wong et al., 2013) and ten were largely adapted from a previous face-to-face program. Of these ten, six (Castro Sweet et al., 2018; Fischer et al., 2016; Fukuoka et al., 2015; Michaelides et al., 2016; Sepah et al., 2014; Wilson et al., 2017) were adapted from the Diabetes Prevention Program (Diabetes Prevention Program Research Group, 2002), and four (Kramer et al., 2010; Ma et al., 2013; Piatt et al., 2013) were adapted from the Group Lifestyle Balance Program (Kramer et al., 2009). Sixteen interventions were informed by at least one theory or framework, with Social Cognitive Theory (N = 14) the most common. Digital modes of delivery included: website (Aguiar et al., 2016; Block et al., 2015; Castro Sweet et al., 2018; Cha et al., 2014; Piatt et al., 2013; Sepah et al., 2014; Tate et al., 2003; Wilson et al., 2017), smartphone app (Arens et al., 2018; Castro Sweet et al., 2018; Cha et al., 2014; Everett et al., 2018; Fukuoka et al., 2015; Michaelides et al., 2016; Sepah et al., 2014; Wilson et al., 2017), DVD (Aguiar et al., 2016; Kramer et al., 2010; Ma et al., 2013; Piatt et al., 2013), SMS (Fischer et al., 2016; Limaye et al., 2017; Ramachandran et al., 2013; Wong et al., 2013), email (Block et al., 2015; Limaye et al., 2017; Tate et al., 2003), and Interactive Voice Response (Block et al., 2015; Estabrooks & Smith-Ray, 2008). Eight interventions used multiple digital modes of delivery (Aguiar et al., 2016; Block et al., 2015; Castro Sweet et al., 2018; Cha et al., 2014; Limaye et al., 2017; Sepah et al., 2014; Tate et al., 2003; Wilson et al., 2017). Nine interventions were ‘stand-alone’ as they did not include human health coach support (Aguiar et al., 2016; Block et al., 2015; Estabrooks & Smith-Ray, 2008; Everett et al., 2018; Limaye et al., 2017; Ma et al., 2013; Ramachandran et al., 2013; Tate et al., 2003; Wong et al., 2013). Of the 12 interventions with health coach support, nine incorporated remote online or phone support (Castro Sweet et al., 2018; Cha et al., 2014; Kramer et al., 2010; Michaelides et al., 2016; Piatt et al., 2013; Sepah et al., 2014; Tate et al., 2003; Wilson et al., 2017), one incorporated face-to-face support (Fukuoka et al., 2015), and two included both remote and face-to-face support (Arens et al., 2018; Fischer et al., 2016).

Table 3.2

Intervention Characteristics

Author(s) (year)	Intervention name	Intervention duration	Intervention type	Primary mode(s) of delivery	Level of support	Theoretical basis	Message content and frequency
Aguiar et al. (2016)	PULSE	6 months	Independent	Website and DVD	Stand alone	Social Cognitive Theory	The PULSE Program was entirely self-paced and included the (also self-paced) Self-Help, Exercise and Diet Using Internet Technology (SHED-IT) weight loss program for men.
Arens et al. (2018)	NA	12 months	Independent	Smartphone application	Remote and face-to-face support via physician	NR	Participants were to regularly enter weight, abdominal girth, blood pressure, and blood glucose into the app. Participants were invited to attend up to 9 classes on nutrition and physical activity. Via a web-portal, physicians provided participants with regular feedback, messages, and goal modification.
Block et al. (2015)	Alive-PD	6 months	Independent	Website, Interactive Voice Response, and Email	Stand alone	Learning Theory, Social Cognitive Theory, Theory of Planned Behaviour	The Alive-PD was self-administered. Two weekly health notes provided health information. Participants engaged in weekly tailored goal setting and tracking. Individually tailored print materials were sent monthly. Automated individually tailored phone coaching was delivered every two weeks via Interactive Voice Response.
Castro Sweet et al. (2018)	Omada Health Program	12 months (16 week intensive + 36-week maintenance)	Diabetes Prevention Program	Website and smartphone application	Online support via health coach	Social Cognitive Theory, Transtheoretical model	For the initial 16-week intensive weight loss phase, participants completed one 1-hour online lesson each week. Less frequent lessons were completed in the subsequent 36-week weight maintenance phase. Participants engaged with their health coach and other participants online throughout the 12-month program.

Author(s) (year)	Intervention name	Intervention duration	Intervention type	Primary mode(s) of delivery	Level of support	Theoretical basis	Message content and frequency
Cha et al. (2014)	NA	12 weeks	Independent	Website and smartphone application	Remote phone support via undergraduate student	Social Cognitive Theory, AADE7 Self-Care Behaviors Framework	Participants submitted weekly dietary and exercise habits, and biweekly assignments. An undergraduate student on the research team provided weekly script-based phone counselling sessions.
Estabrooks and Smith-Ray (2008)	NA	3 months	Independent	Interactive Voice Response	Stand alone	NR	Automated calls delivered once per week for 12 weeks. Seven calls provided 5–10 minutes of counselling and the remaining five calls provided a tip of the week.
Everett et al. (2018)	Sweetch Mobile Intervention	3 months	Independent	Smartphone application	Stand alone	Just-in-time adaptive intervention design	The Sweetch app used machine learning to present users with content based on their own real-world life habits. Message content and frequency varied between users.
Fischer et al. (2016)	NA	12 months	Diabetes Prevention Program	Short Message Service (SMS)	Face-to-face and phone support via health coach, and nutritionist or nurse.	Social Cognitive Theory, Transtheoretical model	Participants received six text messages per week and were prompted to report their weight once per week. Participants were eligible for motivational interviewing phone appointments with a health coach, in addition to weight loss resources such as access to DPP classes and appointments with a nutritionist or nurse for diet support.
Fukuoka et al. (2015)	mDPP	5 months	Diabetes Prevention Program	Smartphone Application	Face-to-face support via non-medical research staff	Social Cognitive Theory, Transtheoretical model	The mobile app delivered daily messages, video clips, and quizzes. Participants attended six in-person sessions within a 4-month period.

Author(s) (year)	Intervention name	Intervention duration	Intervention type	Primary mode(s) of delivery	Level of support	Theoretical basis	Message content and frequency
Kramer et al. (2010)	GLB-DVD	3 months	Group Lifestyle Balance	DVD	Remote phone support via health care professional	Social Cognitive Theory, Transtheoretical model	Participants viewed one DVD per week. Participants contacted by health care professional once per week to review performance and voice questions/concerns.
Limaye et al. (2017)	LIMIT (Lifestyle modification in IT)	12 months	Independent	Short Message Service (SMS) and Email	Stand alone	NR	Participants received lifestyle modification information via mobile phone and e-mail for one year. Three mobile phone messages and two e-mails were sent per week. A total of 150 phone messages and 100 e-mails were sent to each participant during the intervention period.
Ma et al. (2013)	E-LITE	15 months (3-month intensive + 12-month maintenance)	Group Lifestyle Balance	DVD	Stand Alone	Social Cognitive Theory, Transtheoretical model	In the intensive treatment phase, participants were instructed to watch one DVD session per week for 12 weeks. In the maintenance phase, participants received an email reminder every two weeks to continue self-monitoring.
Michaelides et al. (2016)	Noom Coach	24 weeks (16-week core + 8-week post-core)	Diabetes Prevention Program	Smartphone Application	Remote app-based support via health coach	Social Cognitive Theory, Transtheoretical model	Participants received daily articles and interactive challenges, and log their weight, meals, and physical activity each week into the app. The health coach communicated with participants twice per month.

Author(s) (year)	Intervention name	Intervention duration	Intervention type	Primary mode(s) of delivery	Level of support	Theoretical basis	Message content and frequency
Piatt et al. (2013)	GLB-DVD	12-14 weeks	Group Lifestyle Balance	DVD	Phone support via registered nurse or dietician	Social Cognitive Theory, Transtheoretical model	Participants instructed to watch one DVD session per week for 12 weeks. Participants also met as a group at four time points within the 12-week period. Preventionists and lay health coaches called participants weekly to offer information and support.
Piatt et al. (2013)	GLB-Internet	12-14 weeks	Group Lifestyle Balance	Website	Online counselling via registered nurse or dietician	Social Cognitive Theory, Transtheoretical model	Participants were instructed to watch one video per week for 12 weeks. Participants also met as a group at baseline and again after completing the intervention. Preventionists and lay health coaches supported participants via online counselling.
Ramachandran et al. (2013)	NA	24 months	Independent	Short Message Service (SMS)	Stand alone	Transtheoretical Model	Participants received two-to-four text messages per week for 24 months. Messages contained <160 characters.
Sepah et al. (2014)	Prevent (Omada Health Program)	12 months (16-week core + 36-week post-core)	Diabetes Prevention Program	Website and smartphone application	Online support via health coach	Social Cognitive Theory, Transtheoretical model	Participants were matched into online groups of 10 to 15 people and communicated via online social network. In the 16-week core phase, participants completed 16 weekly online lessons. In the 12-month post-core phase, participants completed 9 monthly lessons.
Tate et al. (2003)	Basic Internet	12 months	Independent	Website	Stand alone	NR	Weekly weight loss tutorials and tips were delivered via website. Participants were sent weekly email reminders to submit weight.

Author(s) (year)	Intervention name	Intervention duration	Intervention type	Primary mode(s) of delivery	Level of support	Theoretical basis	Message content and frequency
Tate et al. (2003)	Internet and Behavioral e-Counseling	12 months	Independent	Website and Email	Remote e-mail support via counsellor	NR	Weekly weight-loss tutorials and tips were delivered via website. Participants were sent weekly email reminders to submit weight. The counsellor emailed participants five times during the first month and weekly for the remaining 11 months.
Wilson et al. (2017)	Omada Health Program	12 months (16-week core + 36-week post-core)	Diabetes Prevention Program	Website and smartphone application	Online support via health coach	Social Cognitive Theory, Transtheoretical model	For the initial 16-week intensive weight loss phase, participants completed one lesson each week. Participants completed additional weekly lessons during the subsequent 36-week weight maintenance phase. Participants engaged with their health coach and other participants online throughout the 12-month program.
Wong et al. (2013)	NA	24 months	Independent	Short Message Service (SMS)	Stand alone	Social Cognitive Theory, Theory of Planned Behaviour	Phase 1: three text messages per week (36 total) Phase 2: one text per week (12 total) Phase 3: one text per month (6 total) Phase 4: one text per month (12 total)

Note: NA: not applicable, NR: not reported.

3.4.3. Quality Assessment

A summary of the quality assessments for all 19 studies can be found in Appendix U. Fifteen studies (all 10 RCTs and 5 of the 9 non-RCTs) achieved a 'high quality' rating for internal validity through minimisation of bias across multiple criteria. Ten studies (7 of the 10 RCTs and 3 of the 9 non-RCTs) achieved a 'high quality' rating for external validity, with findings generalisable to the source population.

3.4.4. Intervention Effectiveness

Two studies were excluded from the primary effectiveness assessment. The study by Arens et al. (2018) was excluded as they implemented rolling follow-ups where a common intervention end point could not be determined. However, on average, participants remained in the intervention for 8.3 months, losing 2.4 kg (SD = 6.3, p < .0001). The study by Ramachandran et al. (2013) was excluded as body weight was not a key outcome and therefore not reported. The range of weight lost across the remaining 19 interventions was 0.69% to 8% in the short term and 0.93% to 7.5% in the long term (see Appendix V).

Based on this review's primary effectiveness criteria, 12 interventions were effective short term (Aguiar et al., 2016; Block et al., 2015; Castro Sweet et al., 2018; Fukuoka et al., 2015; Kramer et al., 2010; Ma et al., 2013; Michaelides et al., 2016; Piatt et al., 2013; Sepah et al., 2014; Tate et al., 2003; Wilson et al., 2017), which included both the GLB-DVD and GLB-Internet interventions by Piatt et al. (2013) and the Behavioural e-Counseling intervention by Tate et al. (2003). Seven interventions were not effective short term (Cha et al., 2014; Estabrooks & Smith-Ray, 2008; Everett et al., 2018; Fischer et al., 2016; Limaye et al., 2017; Tate et al., 2003; Wong et al., 2013), which included the Basic Internet intervention by Tate et al. (2003). Four interventions were effective long term (Castro Sweet et al., 2018; Ma et al., 2013; Michaelides et al., 2016; Piatt et al., 2013), which included the GLB-Internet intervention by Piatt et al. (2013). Eight interventions were not effective long term (Fischer et al., 2016; Limaye et al., 2017; Piatt et al., 2013; Sepah et al., 2014; Tate et al., 2003; Wilson et al., 2017; Wong et al., 2013), which included the GLB-DVD intervention by Piatt et al. (2013), and both the Behavioural e-Counselling and Basic Internet interventions by Tate et al. (2003).

Of the four interventions that included an active weight maintenance phase (8-12 months in duration) with sufficient outcome data, one achieved further weight loss (Michaelides et al., 2016) and three achieved weight maintenance (as indicated by <0.5%

change in body weight) during this period (Castro Sweet et al., 2018; Ma et al., 2013; Sepah et al., 2014). Four interventions included follow-ups that were conducted 12 or more months after the intervention was complete. Of these, both the GLB-DVD and GLB-Internet interventions by Piatt et al. (2013) achieved further weight loss at 12 months post-intervention; one achieved weight maintenance at 12 months (Michaelides et al., 2016), and one achieved weight maintenance at 12 months but reported a 39% regain of lost weight at 24 months (Sepah et al., 2014).

3.4.5. Secondary Measures

3.4.5.1. Change in Glycaemia. Complete results for changes in A1c and fasting glucose were reported for 9 and 13 interventions respectively (see Appendix W). Seven interventions achieved significant improvement in A1c (Aguiar et al., 2016; Block et al., 2015; Castro Sweet et al., 2018; Cha et al., 2014; Everett et al., 2018; Kramer et al., 2010; Sepah et al., 2014) and five interventions achieved significant improvement in fasting glucose (Block et al., 2015; Kramer et al., 2010; Limaye et al., 2017; Ma et al., 2013; Wilson et al., 2017).

3.4.5.2. Incidence of Type 2 Diabetes. Incidence rates for T2D were reported for two interventions. Wong et al. (2013) found a 24-month T2D incidence rate of 11.11% and 18% in the intervention and usual care groups respectively. However, this difference was not significant. Ramachandran et al. (2013) reported significantly lower T2D incidence, HR = 0.700, $p = .009$, 95% CI = (0.53, 0.93) among the intervention group (18%, and 33.9% at 24 and 60 months respectively) compared to the usual care group (27%, and 44.9% at 24 and 60 months respectively).

3.4.6. Behaviour Change Techniques

Thirty unique BCTs were coded from all 21 interventions (see Appendix X), with an average of nine BCTs per intervention (range: 1-14). A summary of the BCTs identified in effective and non-effective interventions can be found in Table 3.3. Seven BCTs were identified in at least 75% of effective interventions, both short and long term. These were: goal setting (behaviour) (identified in 92% and 100% of effective interventions in the short and long term respectively), problem solving (75% and 100%), goal setting (outcome) (92% and 100%), feedback on behaviour (92% and 100%), self-monitoring of behaviour (92% and 75%), self-monitoring of outcome(s) of behaviour (92% and 100%), and social support (unspecified) (100% and 100%).

Table 3.3

Summary of Behaviour Change Technique Use in Effective and Non-Effective Interventions

No.	Behaviour Change Technique	All interventions (*N* = 21)		Effective ST (*N* = 12)		Not Effective ST (*N* = 7)		Effective LT (*N* = 4)		Not-Effective LT (*N* = 8)	
		n	%	*n*	%	*n*	%	*n*	%	*n*	%
Cluster One: Goals and planning											
1.1	Goal setting (behaviour)	16	76.2	11	91.7	4	57.1	4	100	5	62.5
1.2	Problem solving	14	66.7	9	75	3	42.9	4	100	4	50
1.3	Goal setting (outcome)	15	71.4	11	91.7	3	42.9	4	100	5	62.5
1.4	Action planning	7	33.3	6	50	1	14.3	2	50	1	12.5
1.5	Review behaviour goals	5	23.8	4	33.3	1	14.3	2	50	1	12.5
1.7	Review outcome goals	4	19	4	33.3	0	0	2	50	1	12.5
Cluster Two: Feedback and monitoring											
2.2	Feedback on behaviour	15	71.4	11	91.7	3	42.9	4	100	5	62.5
2.3	Self-monitoring of behaviour	16	76.2	11	91.7	4	57.1	3	75	6	75
2.4	Self-monitoring of outcome(s) of behaviour	15	71.4	11	91.7	3	42.9	4	100	6	75
2.7	Feedback on outcome(s) of behaviour	1	4.8	0	0	0	0	0	0	0	0
Cluster Three: Social support											
3.1	Social support (unspecified)	14	66.7	12	100	2	28.6	4	100	6	75
3.2	Social support (practical)	1	4.8	0	0	1	14.3	0	0	1	12.5
3.3	Social support (emotional)	6	28.6	5	41.7	1	14.3	2	50	3	37.5

No.	Behaviour Change Technique	All interventions (*N* = 21)		Effective ST (*N* = 12)		Not Effective ST (*N* = 7)		Effective LT (*N* = 4)		Not-Effective LT (*N* = 8)	
		n	%	*n*	%	*n*	%	*n*	%	*n*	%
Cluster Four: Shaping knowledge											
4.1	Instruction on how to perform the behaviour	4	19	1	8.3	1	14.3	0	0	1	12.5
4.2	Information about antecedents	6	28.6	5	41.7	1	14.3	2	50	3	37.5
Cluster Five: Natural consequences											
5.1	Information about health consequences	5	23.8	2	16.7	2	28.6	0	0	2	25
Cluster Six: Comparison of behaviour											
6.1	Demonstration of the behaviour	2	9.5	1	8.3	1	14.3	0	0	0	0
6.2	Social comparison	7	33.3	6	50	1	14.3	2	50	3	37.5
Cluster Seven: Associations											
7.1	Prompts/cues	5	23.8	4	33.3	1	14.3	2	50	1	12.5
Cluster Eight: Repetition and substitution											
8.2	Behaviour substitution	3	14.3	1	8.3	1	14.3	0	0	1	12.5
8.3	Habit formation	2	9.5	2	16.7	0	0	0	0	0	0
8.4	Habit reversal	1	4.8	1	8.3	0	0	0	0	0	0
8.7	Graded tasks	1	4.8	1	8.3	0	0	0	0	0	0
Cluster Nine: Comparison of outcomes											
9.1	Credible source	7	33.3	5	41.7	1	14.3	2	50	2	25

No.	Behaviour Change Technique	All interventions (*N* = 21)		Effective ST (*N* = 12)		Not Effective ST (*N* = 7)		Effective LT (*N* = 4)		Not-Effective LT (*N* = 8)	
		n	%	*n*	%	*n*	%	*n*	%	*n*	%
Cluster Ten: Reward and threat											
10.1	Material incentive (behaviour)	1	4.8	1	8.3	0	0	0	0	0	0
10.2	Material reward (behaviour)	1	4.8	1	8.3	0	0	0	0	0	0
Cluster Eleven: Regulation											
11.2	Reduce negative emotions	3	14.3	1	8.3	1	14.3	0	0	1	12.5
Cluster Twelve: Antecedents											
12.3	Avoidance/reducing exposure to cues for the behaviour	1	4.8	0	0	1	14.3	0	0	1	12.5
12.5	Adding objects to the environment	9	42.9	8	66.7	0	0	3	75	3	37.5
Cluster Fourteen: Scheduled consequences											
14.4	Reward approximation	1	4.8	0	0	1	14.3	0	0	0	0
	Average number of BCTs per intervention	9		11.3		5.4		11.5		7.8	

Note: ST: short term (≤6 month) follow-up, LT: long term (≥12 month) follow-up, *N*: number of interventions, *n*: number of interventions in which the BCT was identified, %: proportion of interventions that used the BCT.

3.4.6.1. Short Term Effectiveness. Interventions that achieved short term effectiveness used an average of 11.3 BCTs (range: 4-14), compared to 5.4 (range: 1-10) among non-effective interventions. Two BCTs were identified at a considerably greater frequency in effective interventions versus non-effective interventions. These were social support (unspecified) (identified in 100% of effective interventions versus 29% of non-effective interventions) and adding objects to the environment–coded when participants were issued pedometers to count their steps (67% versus 0%).

3.4.6.2. Long Term Effectiveness. Interventions that achieved long term effectiveness used an average of 11.5 BCTs (range: 10-13), compared to 7.8 (range: 1-13) among non-effective interventions. One BCT, problem solving, was identified at a considerably greater frequency in effective interventions versus non-effective interventions (100% versus 50%).

3.4.7. Digital Features

The digital and non-digital components coded from all 21 interventions can be found in Appendix Y. Ten digital features–five passive and five interactive (see Appendix Z)–were identified via thematic analysis of intervention descriptions. Detailed descriptions of all ten digital features can be found in Appendix AA. The five passive features were: health and lifestyle information and advice, activity tracking, reminders and prompts, diet tracking, and weight and bio-measure tracking. The five interactive features were: interactive health and lifestyle lessons, social media and support, online health coaching, automated feedback, and gamification. Interventions used an average of 4.3 digital features (range: 1-9), including 2.9 passive features (range: 1-5), and 1.4 interactive features (range: 0-4).

A summary of the digital features identified in effective and non-effective interventions can be found in Table 3.4. Three digital features (all passive) were identified in at least 75% of effective interventions, both short and long term. These were: activity tracking (identified in 100% and 100% of effective interventions in the short and long term respectively), health and lifestyle information and advice (75% and 75%), and diet tracking (75% and 75%). It is noteworthy that the interactive social media and support feature was identified in only 50% of the effective interventions, yet the social support (unspecified) BCT was identified in 100% of effective interventions. Additionally, of the three interventions that only used paper based rather than digital tools to track diet and physical activity, two were not effective in the short term, and all three were not effective in the long term (data not shown).

Table 3.4

Summary of Digital Feature Use in Effective and Non-Effective Interventions

Digital features	All Interventions (*N* = 21)		Effective ST (*N* = 12)		Not effective ST (*N* = 7)		Effective LT (*N* = 4)		Not effective LT (*N* = 8)	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Passive Features										
Health and lifestyle information and advice	16	76.2	9	75	6	85.7	3	75	6	75
Activity tracking	15	71.4	12	100	2	28.6	4	100	4	50
Reminders and prompts	11	52.4	8	66.7	3	42.9	4	100	4	50
Diet tracking	10	47.6	9	75	1	14.3	3	75	3	37.5
Weight and biomeasure tracking	9	42.9	7	58.3	1	14.3	3	75	2	25
Average passive features per intervention	2.9 features		3.75 features		1.86 features		4.25 features		2.38 features	
Interactive Features										
Interactive health and lifestyle lessons	9	42.9	6	50	2	28.6	1	25	4	50
Social media and support	8	38.1	6	50	2	28.6	2	50	5	62.5
Online health coaching	8	38.1	7	58.3	0	0	4	100	3	37.5
Automated feedback	4	19	2	16.7	2	28.6	0	0	0	0
Gamification	1	4.8	1	8.3	0	0	0	0	0	0
Average interactive features per intervention	1.43 features		1.83 features		0.86 features		1.75 features		1.5 features	
Average total features per intervention	4.3		5.58		2.71		6		3.88	

Note: ST: short term (≤6 month) follow-up, LT: long term (≥12 month) follow-up. *N*: number of interventions, *n*: number of interventions in which the feature was identified, %: proportion of interventions that used the digital feature.

3.4.7.1. Short Term Effectiveness. Interventions that achieved short term effectiveness used an average of 5.6 total features (range: 3-9), including 3.8 passive features (range: 2-5), and 1.8 interactive features (range: 0-4). Non-effective interventions used an average of 2.7 total features (range: 1-5), including 1.9 passive features (range 1-4), and 0.9 interactive features (range: 0-2). Three digital features were identified at a considerably greater frequency in effective interventions versus non-effective interventions. These were the passive features of activity tracking (identified in 100% of effective interventions versus 29% of non-effective interventions) and diet tracking (75% versus 14%); and the interactive feature of online health coaching (58% versus 0%).

3.4.7.2. Long Term Effectiveness. Interventions that achieved long term effectiveness used an average of 6 total features (range: 4-7), including 4.3 passive features (range: 3-5), and 1.8 interactive features (range: 1-3). Non-effective interventions used an average of 3.9 total features (range: 1-7), including 2.4 passive features (range: 1-4), and 1.5 interactive features (range: 1-4). Four digital features were identified at a considerably greater frequency in effective interventions versus non-effective interventions. These were the passive features of activity tracking (100% versus 50%), reminders and prompts (100% versus 50%), and weight and bio-measure tracking (75% versus 25%); and the interactive feature of online health coaching (100% versus 38%).

3.4.8. Additional Analyses

As the imputation process used in this review is a novel means of coding BCTs and digital components, additional analyses were conducted using only those BCTs and digital components clearly present in each study's intervention description(s). Results of these analyses, which exclude any BCT or digital feature coded via imputation, can be found in Appendices AB through AF.

3.5. Discussion

This systematic review assessed 19 studies of 21 technology-driven DPIs, with the aims of determining if these interventions can produce clinically significant weight loss outcomes and identifying the most effective BCTs and digital features. This review found that a number of technology-driven DPIs successfully achieved clinically significant weight loss in adults at risk of developing T2D, particularly in the short term, with follow-up data indicating that weight loss was maintained for at least one year post-intervention. Additionally, seven and five interventions achieved significant improvements in A1c and fasting glucose respectively, and one study found a significantly lower 5-year incidence of T2D among participants who completed the intervention compared to those who received usual care–further evidence to support the effectiveness of technology-driven DPIs in diabetes prevention. However, there was wide heterogeneity in study populations, attrition rates, intervention duration, and mode of delivery; and many long-term interventions fell short of achieving the 5% weight loss benchmark. Comparable findings on the effectiveness of technology-driven DPIs and inter-study heterogeneity were reported in previous meta-analyses (Bian et al., 2017; Joiner et al., 2017).

3.5.1. Behaviour Change Techniques

Interventions which used a larger number of BCTs were more effective. This is consistent with reviews of face-to-face interventions for individuals with T2D (Avery et al., 2012; Cradock et al., 2017; Hankonen et al., 2014) or those at risk of developing T2D (Ashra et al., 2015). Seven unique BCTs were frequently identified in effective interventions. These were: social support (unspecified), goal setting (behaviour), goal setting (outcome), feedback on behaviour, self-monitoring of outcome(s) of behaviour, self-monitoring of behaviour, and problem solving. All of these BCTs correspond to the recommended behaviour change components for face-to-face DPIs as outlined in the IMAGE toolkit for the prevention of T2D in Europe (Lindström et al., 2010). Therefore, the present findings suggest these recommendations should extend to technology-driven DPIs. Of the recommended behaviour change components described in the toolkit, action planning was the only corresponding BCT that was not identified in at least 75% of effective interventions. Nevertheless, as action planning was identified more frequently in effective than non-effective interventions in both the short and long term, this technique may still be a valuable inclusion in technology-driven DPIs.

In the short term, effective interventions used, on average, 5.6 more BCTs than non-effective interventions, with social support (unspecified) and adding objects to the environment the most effective BCTs. A number of digital social support-based weight loss interventions have reported significant weight loss (Hales et al., 2016; Napolitano et al., 2013; Turner-McGrievy & Tate, 2013). However, the broad nature of the social support (unspecified) BCT may have increased the frequency in which it was coded in the present review relative to other BCTs. As this BCT accommodates a wide range of social support strategies, a rationale for the effectiveness of social support in the present review is difficult to discern, and weight loss may have occurred via interactions between social support and other intervention components. Furthermore, studies of online weight loss communities found weight loss or weight gain to depend on: the type(s) of social support available, how participants provided and received support, and the level in which participants engaged with the support opportunities (Ballantine & Stephenson, 2011; Hwang et al., 2014; Hwang et al., 2010; Yan, 2018). Therefore, for a nuanced understanding of the relationship between social support and weight loss in technology-driven DPIs, further assessment is needed to identify the perceptions and experiences of participants who engaged or disengaged with the social support tools and opportunities. Adding to the success of social support, all eight interventions that issued pedometers were effective–perhaps unsurprising given that pedometer-based walking interventions, even those lacking dietary intervention, have achieved modest weight loss (Richardson et al., 2008). However, weight loss may not be the product of pedometer use per se, as goal setting (e.g., daily step targets) could have motivated participants to increase their physical activity to the level required for weight reduction. Supporting this, a review of pedometer use among adult outpatients reported a 27% increase in physical activity and significant decrease in Body Mass Index (BMI), with goal setting the key outcome predictor (Bravata et al., 2007). It is also possible that participants perceived the self-contained pedometer to be a practical gift of value, providing an incentive to engage with the intervention in its early stages.

In the long term, effective interventions used, on average, 3.7 more BCTs than non-effective interventions. The most effective BCT was problem solving, a technique which encourages participants to generate potential strategies for health behaviour change (such as overcoming barriers, relapse prevention, and coping planning), and then select, apply and evaluate the most appropriate strategy (King et al., 2010; Lindström et al., 2010; Michie et al., 2013). Such strategies may have empowered participants to build the necessary skills to maintain healthier behaviours long term and prevent or overcome weight loss plateaus.

Collectively, the evidence suggests that technology-driven DPIs containing a larger number of BCTs were more likely to achieve clinically significant weight loss. Moreover, a specific set of seven BCTs were frequently identified in interventions that were effective in both the short and long term. Social support and adding objects to the environment (via pedometer use) were the most effective BCTs in the short term, and problem solving was the most effective BCT in the long term.

3.5.2. Digital Features

Much like the evidence for BCTs, interventions which used a larger number of passive and interactive digital features were more effective. Comparable results were reported by Donevant et al. (2018) and Holcombe et al. (2015) who found that mobile health interventions were more effective in improving diabetes-related outcomes when interactive features were included. However, in the present review, the influence of interactive features decreased over time. Three digital features, all passive (health and lifestyle information and advice, diet tracking, and activity tracking) were frequently identified in effective interventions–suggesting that these components may constitute an effective core set of features which future technology-driven DPIs should integrate as a base standard.

In the short term, effective interventions used, on average, 1.9 more passive features and 1 more interactive feature than non-effective interventions. The most effective were the passive features of activity tracking and diet tracking, and the interactive feature of online health coaching. In the long term, effective interventions used, on average, 1.9 more passive features and 0.25 more interactive features than non-effective interventions. The most effective were the passive features of activity tracking, reminders and prompts, and weight and biomeasure tracking; and the interactive feature of online health coaching. The comparatively high use of digital tracking and online health coaching across effective interventions at both time periods offers two conclusions. First, self-monitoring may be most effective when digital technologies are used to track behaviours and outcomes. This is further supported by the low rate of effectiveness among interventions that used paper-based tracking only. Paper-based diaries can be burdensome, and subject to delayed reporting and low adherence (Burke et al., 2005; Stone et al., 2003); limitations previously observed in diet plus physical activity interventions (Burke et al., 2011; Turner-McGrievy et al., 2013). However, paper-based reporting may have simply been less engaging for participants who chose to enrol in a technology-driven DPI through an interest in using digital tools. Second, feedback was most effective when delivered digitally, provided that it was given by a human coach. Online coaching predominantly involved two-way instant messaging and may have multiple advantages over automated feedback and real-time health coaching delivered in person or by phone. Online coaching grants participants the human interaction and detailed, tailored feedback that is lacking in automated feedback protocols; yet, unlike live coaching, instant messages are concise and accessible 24 hours a day. Furthermore, online coaching eliminates the need to set mutually convenient meeting times, arrange transport, or seek privacy to accept or make a phone call. Although self-monitoring and health coaching were most effective when delivered digitally, the same was not found for social support. The social support (unspecified) BCT used in 100% of effective interventions, captured online, face-to-face, and phone support, yet the digitally exclusive social media and support feature was found in only 50% of effective interventions, together suggesting that online support (e.g., via other participants) and face-to-face or phone support (e.g., via family, friends, and support staff) were equally effective.

Technology-driven DPIs have been developed to overcome the accessibility barriers of face-to-face interventions; and, as the present findings collectively suggest that interventions which use more BCTs and digital features are more effective, websites and smartphones may be the most suitable modes of delivery due to their increasingly high adoption rates and breadth of functionality. In 2018, internet use and smartphone ownership rates among adults in advanced economies were 90% and 76% respectively, with sharp, steady growth reported among the 50-and-older age group (Taylor & Silver, 2019). Moreover, these multimedia platforms have the capacity to incorporate a large variety of passive and interactive features, and deliver a comprehensive, evidence-based curriculum such as that used in the Diabetes Prevention Program.

3.5.3. Strengths and Limitations

This was the first review of technology-driven DPIs to identify the BCTs and digital features frequently associated with clinically significant weight loss. We used two separate approaches to identify intervention components, enabling a detailed assessment of the interventions' active ingredients. Behaviour Change Technique coding represented a top-down approach in which intervention descriptions were reduced to their smallest behaviour change components as informed by existing labels and definitions. Conversely, digital feature identification was a bottom-up approach through which the features were informed by the intervention descriptions themselves–working from the narrowly defined digital components, up to the broadly defined digital features. Future reviews of interventions containing both digital and non-digital components may benefit from this dual approach, as in addition to identifying the interventions' most effective behavioural components, this approach can also identify a component's most effective mode of delivery.

This review has some limitations. First, identification of BCTs and digital components was dependent on the detail in which the interventions were described–a common limitation of reviews that examine BCTs and digital features (Cradock et al., 2017; Donevant et al., 2018; Joiner et al., 2017). While the imputation process mitigated this to some degree, imputation was only used to extrapolate BCTs from other studies within this review that applied the same standardised intervention. For all independent interventions, a BCT was only marked as present if its inclusion was explicitly clear in the intervention description(s). Second, although this review found BCTs and digital features to be identified more frequently in effective interventions, the long-term assessment contained fewer interventions than the short-term assessment. Therefore, greater confidence may be placed in the short-term findings. Third, as a meta-analysis was not feasible, an overall intervention effect could not be established; and, as there was wide heterogeneity in sample size between studies, an intervention's effectiveness may have been influenced by the study's statistical power. However, to establish the effectiveness of individual interventions, we used international benchmarks and certification criteria that are applied, in practice, to assess interventions on a case-by-case basis. For example, the CDC can certify an individual cite regardless of sample size (at a minimum of 5 participants) provided the 5% weight loss benchmark was achieved (CDC, 2018) Finally, we reviewed studies with varying designs, including RCTs and non-experimental (observational) studies, which may have introduced various biases. However, technology-driven DPIs are designed for real world implementation, and RCT conditions are unlikely to match those in which the intervention is routinely completed. Furthermore, observational data can offer insight into the outcomes of participants often unrepresented in RCTs, such as older adults or individuals with comorbid conditions (Booth & Tannock, 2014). These population groups are particularly important, with recent US reports citing that nearly half of adults aged 65 and over have prediabetes; and, of all adults with prediabetes, rates of comorbid hypertension and dyslipidaemia were 51% and 24% respectively (Ali et al., 2018; Kirkman et al., 2012).

3.5.4. Future Directions

Although this review described the associations between specific BCTs, digital features, and effectiveness–causality cannot be inferred, and further research is needed to determine the most effective intervention components for population sub-groups such as those defined by age, gender, ethnicity, geographic location, and socio-economic status. As some technology-driven DPIs have standardisation requirements, precluding the post-hoc testing of individual components (Albright & Gregg, 2013; Castro Sweet et al., 2018), developers of future interventions could trial individual components during the development phase. For example, the Multiphase Optimization Strategy (MOST; Collins et al., 2007) facilitates the identification and testing of candidate components before a complete prototype is developed and ultimately tested via RCT. However, this process is subject to relatively high resource and time commitments, and care is needed to ensure that methodological rigour does not impede the assessment of real-world effectiveness. Further research is also needed to identify the implementation and sustainability costs for the digital features by mode of delivery so that cost-effectiveness can be established. The ‘non-effective’ interventions in this review do not necessarily lack utility in T2D prevention, as for every kilogram of weight lost in the original Diabetes Prevention Program, T2D risk was still reduced by 16% (Hamman et al., 2006). Interventions that achieve modest weight loss but are inexpensive to sustain, may still be viable T2D prevention tools. Finally, each of the reviewed interventions targeted physical activity and dietary behaviours, yet only 11 and 9 studies reported changes in these respective behaviours, each measured in a variety of ways. Standardised physical activity and dietary measures should be used in future interventions to enable researchers to identify the behaviours that most strongly influence weight loss. Additionally, as attrition varied widely between studies, further research is also required to assess participant adherence and engagement, and its subsequent impact on behaviour change and the outcomes associated with T2D.

3.6. Conclusion

Technology-driven DPIs achieved clinically significant weight loss in adults at risk of developing T2D, particularly in the short term, which, along with reports of improved glycaemia and lower T2D incidence, supports the utility of these interventions for preventing diabetes. However, a number of interventions fell short of reaching the 5% weight loss benchmark. Effective interventions contained a larger number of BCTs and digital features. Interventions that encouraged participants to set goals; self-monitor their diet, physical activity, and body weight; seek social support; and develop problem solving strategies were most successful. Technology-driven DPIs can be optimised by integrating digital-only tools that provide health and lifestyle information and advice, track behaviours and outcomes, and facilitate online behavioural support from a health coach. Websites and smartphone applications are appropriate modes of delivery as these multimedia platforms are widely accessible and have the capacity to incorporate a large variety of features. Additional research is needed to determine the cost-effectiveness of technology-driven DPIs and identify the mechanisms in which BCTs and digital features directly influence physical activity, dietary behaviours, and engagement among different population groups.

3.7. Declaration of Conflicting Interests

The authors declare no financial interest, benefit, or other conflict of interest.

3.8. Funding Details

This work was supported by the National University of Ireland, Galway under the Hardiman Scholarship, and the Irish Research Council under the Government of Ireland Postgraduate Scholarship [GOIPG/2019/1355]. The funders had no role in study design, data coding and analysis, the decision to publish, or preparation of the manuscript.

3.9. Author Contributions

LV was the review lead and was responsible for drafting the review protocol, conducting searches, screening articles, extracting data, conducting quality assessments, coding BCTs and digital components, identifying digital features, analysing and synthesising the data, and writing the manuscript. EM independently double-coded the BCTs and digital components, identified digital features, and performed consistency checks on the data and quality assessments. MB and JMc provided independent advice for the duration of the review process. JMu independently double-screened the full-text articles. All authors contributed to the review protocol and critically reviewed each manuscript draft and approved the final manuscript.

4. Study Two: Development and Testing of a Digital Health Acceptability Model to Explain the Intention to Use a Digital Diabetes Prevention Programme

Van Rhoon, L.[1], McSharry, J.[1] & Byrne, M.[1]

[1]Health Behaviour Change Research Group, School of Psychology, National University of Ireland Galway, Ireland.

4.1. Abstract

Objectives: Digitally-delivered diabetes prevention programmes (DPPs) may improve population health by reversing the escalating trend of type 2 diabetes (T2D) incidence. Understanding the factors which determine digital health acceptability is critical to developing effective interventions. This study aimed to develop and test a digital health acceptability model of the factors influencing the intention of adults living in Ireland to use a digital DPP.

Design: A 61-item cross-sectional survey was issued online or in hard copy to a sample of adults.

Methods: Participants viewed a brochure for a smartphone-based digital DPP. The FINDRISC assessed their risk of developing T2D, and Likert scale items assessed the personal health, social influence, eHealth literacy, and intervention factors of the model. Structural equation modelling was used to assess the relationships between these factors.

Results: Three-hundred-and-sixteen eligible participants (M_{age} = 36) completed the survey, 42% of which had a slightly elevated T2D risk or higher. Twelve direct factor relationships were statistically significant. Subjective norm had a moderate-to-large impact on T2D risk perceptions. Health status, perceived susceptibility to T2D, eHealth readiness, communicative eHealth literacy, and image had significant impacts on use intentions through mediators of perceived ease of use and perceived usefulness. The model explained 65% of the variance in digital DPP use intentions.

Conclusions: Personal health beliefs, social influence, and eHealth literacy collectively influence a digital DPP's acceptability. These findings may inform the development of future digital DPPs and other digital health interventions. Future research should test the model with adults that have a higher T2D risk status.

Keywords: Type 2 diabetes, diabetes prevention, digital health, behaviour change, health beliefs, technology acceptance, eHealth literacy.

Data availability statement: The data that support the findings of this study are openly available in Open Science Network at https://osf.io/tzjby

Acknowledgements: This work was supported by the Irish Research Council under the Government of Ireland Postgraduate Scholarship, and the National University of Ireland, Galway under the Hardiman Scholarship.

4.2. Background

Diabetes is a serious health condition that, in 2019, affected approximately 9.3% or 463 million people worldwide (Saeedi et al., 2019). People with diabetes are at greater risk of cardiovascular disease, and complications such as nephropathy, retinopathy, and neuropathy (Murray et al., 2019). Type 2 diabetes (T2D) represents approximately 90% of all diabetes cases, which can often be attributed to modifiable, preventive factors associated with weight gain such as physical inactivity, unhealthy dietary practices, and related environmental factors (Saeedi et al., 2019; Yach et al., 2006). In Ireland, T2D represents a significant health threat, as 216,000 people over age 40 are estimated to have the condition, with incidence expected to reach 414,000 by the year 2036 (Pierse et al., 2021). It has therefore been suggested that a national public health strategy should include the implementation of a diabetes prevention programme (DPP) for at-risk individuals (Pierse et al., 2021).

Informed by landmark diabetes prevention studies (Knowler et al., 2002; Pan et al., 1997; Tuomilehto et al., 2001), countries such as the United States and England have implemented national community based DPPs. In these programmes, people at risk of developing T2D are identified via Body Mass Index (BMI), blood glucose tests, and/or self-report risk score (Barron et al., 2018; Ely et al., 2017) and offered educational materials and in-person group counselling sessions to support the lifestyle changes (e.g., healthier eating, increased physical activity) needed to achieve and maintain a healthy weight (Valabhji et al., 2020). Reviews of these DPPs reported significant average weight reductions of 2.3 kg (Dunkley et al., 2014), and 4% of baseline values (Ali et al., 2012) at 12 months; and, significant reductions in fasting glucose and HbA1c (two blood sugar markers that can indicate T2D risk), and T2D incidence at 12-18 months (Ashra et al., 2015).

Despite the success of DPPs, barriers such as transportation difficulties, lack of community spaces, and work/family commitments can make attendance difficult (Halley et al., 2020; Harrison et al., 2020). Digital DPPs can potentially overcome these barriers, delivering content (e.g., exercise and diet tracking, goal setting) through computers or smartphones whilst facilitating remote communication with a health coach and other participants via video calls and online social forums (Grock et al., 2017; Van Rhoon et al., 2020). Digital DPPs have achieved results comparable to their in-person counterparts and are potentially more cost-effective (Bian et al., 2017; Castro Sweet et al., 2020). This, when combined with the burgeoning need for digital health solutions highlighted during the COVID-19 pandemic (Robbins et al., 2020), suggests that the implementation of a digitally-delivered DPP could be an important diabetes prevention solution for Ireland and other countries that are yet to adopt such a programme.

Although digital interventions can facilitate health behaviour change, many show low rates of initial uptake, limiting their impact (Murray et al., 2019). However, uptake may be maximised by consulting potential users in the development or ‘pre-use’ stage, where findings can inform the intervention’s design (Nadal et al., 2020). This pre-use ‘acceptability’ represents a person’s intention to adopt the intervention once it becomes available. A number of existing theories, such as those that follow, aim to explain digital health acceptability, and the application of theory in the current study provides an evidence-based foundation for examining factors that influence this acceptability in the context of diabetes prevention.

4.3. Theoretical Framework

The Technology Acceptance Model (TAM; Davis, 1989) and subsequent revisions are the primary models used for investigating digital health acceptability (Rahimi et al., 2018). The TAM posits that an intervention’s perceived usefulness and ease of use determine one’s attitude towards the intervention and subsequent adoption (Davis, 1989). However, as the TAM is technology-focused, researchers have suggested that health behaviour factors should be included in such models when assessing digital health (Sun et al., 2013).

The Health Information Technology Acceptance Model (HITAM), developed by Kim and Park (2012), expanded the TAM, incorporating personal health factors (e.g., perceived susceptibility) from the Health Belief Model (HBM; Rosenstock, 1974), and social influence factors (e.g., subjective norm) from the Theory of Planned Behaviour (TPB; Ajzen, 1991). The HITAM suggests that people will perceive a digital health intervention as useful if there is a perceived threat of illness, and if the people they trust recommend its use (Kim & Park, 2012). The HITAM also includes two antecedents to both perceived usefulness and ease of use, in the factors of health information technology reliability and self-efficacy. These capture one's previous experiences with technology, and confidence in using technology respectively (Kim & Park, 2012). This 'eHealth literacy' has been identified as a key determinant of one's engagement with digital health interventions (Paige et al., 2018).

A recent meta-analysis of technology acceptance models found that subjective norm, technology self-efficacy, perceived usefulness, perceived ease of use, and attitude were the strongest predictors of consumers' intentions to use health technologies (Tao et al., 2020). To further improve the predictive power of these models, researchers recommend the addition of context-specific (in this case, digital DPP-related) constructs (Rahimi et al., 2018).

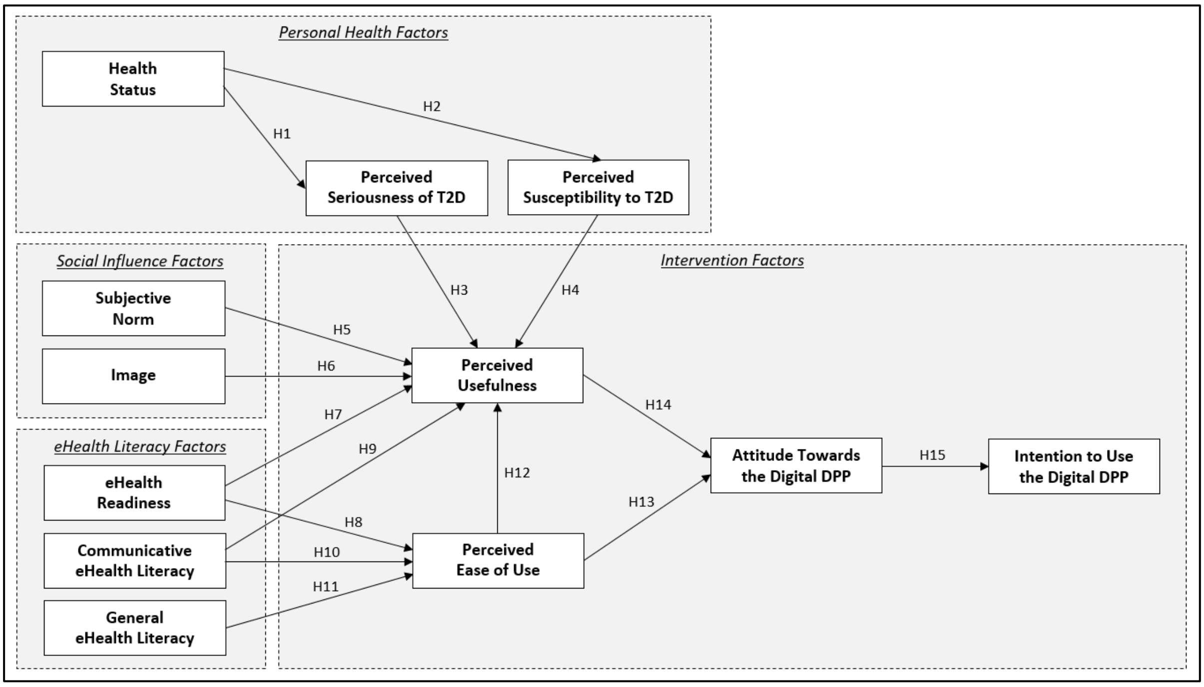
There is limited research exploring digital health acceptance at the pre-use stage (Nadal et al., 2020); and to date, no study has applied a health technology acceptance model to assess digital DPP acceptability. The present study aimed to develop and assess a digital health acceptability model to identify the factors that influence the intention of adults living in Ireland to use a digital DPP. Establishing each factor's predictive strength may facilitate an understanding as to why people may or may not use a digital DPP. Furthermore, identification of the most important, modifiable determinants of programme acceptability may assist developers in tailoring the programme's content and communication strategies to make the programme more appealing to people at risk of developing T2D, potentially maximising uptake.

4.4. The Hypothesised Research Model

The hypothesised model for the current study was informed by the HITAM and its predecessors (HBM, TAM, and TPB), and included digital DPP-specific factors. There are four types of factors included in the model: personal health factors, social influence factors, eHealth literacy factors, and intervention factors. These are detailed below along with the model diagram (Figure 4.1) and factor descriptions (Table 4.1).

Figure 4.1

Hypothesised Model of the Factors Influencing the Acceptability of a Digital DPP



Note. H1-H15 indicates all hypothesised direct positive relationships in the model.

Table 4.1

The Factors Included in the Hypothesised Model, Theories/Models of Origin, and Factor Definitions

Factor (abbreviation)	Theory/model	Definition
Health status (HS)	HITAM	The individual's objective risk of developing T2D within the next 10 years.
Perceived seriousness (PSe)	HITAM, HBM	The individual's belief as to the seriousness of T2D as a health condition. This includes their emotional feelings about T2D and perceived difficulties they may face if it develops.
Perceived susceptibility (PSu)	HITAM, HBM	The individual's belief as to how susceptible they are to developing T2D, and their level of concern regarding these beliefs.
Subjective norm (SN)	HITAM, TAM3, TPB	The degree to which an individual perceives that most people who are important to them think they should eat healthier and be more physically active.
Image (IM)	TAM2	The degree to which an individual believes that using a digital health programme's technological innovations are an indicator of higher social status.
eHealth readiness (eHR)	-	The degree to which an individual feels ready to engage with a digital health intervention and its devices via website, online application, and/or through the use of wearable technologies.
Communicative eHealth literacy (CeL)	TMeHL	The individual's perceived level of ability to collaborate, adapt, and control communication about health with others online, using multimedia devices.
General eHealth literacy (GeL)	Lily model	The individual's perceived level of knowledge, comfort, and skills at finding, evaluating, and applying electronic health information to health problems.
Perceived usefulness (PU)	HITAM, TAM, TAM2	The extent to which an individual believes that the programme will help them to become more physically fit, improve their diet, manage their weight, and prevent T2D.
Perceived ease of use (PEU)	HITAM, TAM, TAM2	The individual's perception as to how easy the programme would be to use, and how effortless it would be to navigate.
Attitude towards the programme (ATT)	HITAM, TAM	The individual's level of positive perception of the programme, including how satisfying and enjoyable they would find it to use.
Intention to use the programme (INT)	HITAM, TAM, TAM2	The level of intent the individual has toward using the programme.

Note: HITAM = Health Information Technology acceptance Model (Kim & Park, 2012), FINDRISC = Finnish Diabetes Risk Score (Lindström & Tuomilehto, 2003), HBM = Health Belief Model (Rosenstock, 1974), TPB = Theory of Planned Behaviour (Ajzen, 1991), TAM3 = Technology Acceptance Model 3 (Venkatesh & Bala, 2008), TMeHL = Transactional Model of eHealth Literacy (Paige et al., 2018), TAM = Technology Acceptance Model (Davis, 1989), TAM2 = Technology Acceptance Model 2 (Venkatesh & Davis, 2000). Lily Model = model of six literacies (Norman & Skinner, 2006b).

4.4.1. Personal Health Factors

These factors represent the individual's objective and subjective health status and beliefs pertaining to T2D. Health status represents one's objective risk of developing T2D within the next 10 years. The HITAM (Kim & Park, 2012) suggests that a greater T2D risk would increase one's perceived seriousness of T2D, and perceived susceptibility to developing T2D. This 'perceived threat' has positively influenced the perceived usefulness of a chronic disease management smartphone intervention (Dou et al., 2017).

4.4.2. Social Influence Factors

These capture the influence that trusted others (e.g., friends, family, healthcare professionals) have over one's motivation to improve their health behaviours and use health technologies. Social influence has predicted telemedicine use (Harst et al., 2019). Subjective norms suggest that one is more likely to adhere to dietary and physical activity recommendations if trusted others advise them to do so (Traina et al., 2016). A programme that facilitates these actions may be perceived as more useful. Image reflects one's belief that using health technologies will enhance their social status, thus increasing the programme's perceived usefulness. Status enhancement has been identified as a motivating factor for the use of health technologies and data sharing (Brinson & Rutherford, 2020; Rosales et al., 2017).

4.4.3. eHealth Literacy Factors

Digital DPPs incorporate many technology-driven devices and features (e.g., smartphone apps, wearables, social networks) requiring an extended repertoire of eHealth competencies (Van Rhoon et al., 2020). In view of this, and Bautista's (2015) conceptual definition, eHealth literacy factors capture one's aptitude towards, and confidence in using digital health technologies; and the interplay of individual and social factors in the use of a digital intervention. Three eHealth literacy factors are included here. Based on the HITAM (Kim & Park, 2012), *eHealth readiness* and *communicative eHealth literacy* were predicted to influence perceived usefulness and perceived ease of use. *General eHealth literacy* is not feature-specific and was therefore only predicted to influence perceived ease of use.

4.4.4. Intervention Factors

Intervention factors capture one's perceptions of the digital DPP, including its acceptability. In a study of patients with T2D, Yan and Or (2019) found that a digital health system's perceived usefulness and perceived ease of use were positively associated with more favourable attitudes toward, and intention to use the system, with perceived ease of use also directly influencing perceived usefulness.

4.4.5. Research Hypotheses

Fifteen significant positive associations were hypothesised (see Table 4.2).

Table 4.2

List of Hypotheses

Label	Hypothesis
H1	Health status is positively associated with perceived seriousness of T2D.
H2	Health status is positively associated with perceived susceptibility to T2D.
H3	Perceived seriousness is positively associated with perceived usefulness.
H4	Perceived susceptibility is positively associated with perceived usefulness.
H5	Subjective norm is positively associated with perceived usefulness.
H6	Image is positively associated with perceived usefulness.
H7	eHealth readiness is positively associated with perceived usefulness.
H8	eHealth readiness is positively associated with perceived ease of use.
H9	Communicative eHealth literacy is positively associated with perceived usefulness.
H10	Communicative eHealth literacy is positively associated with perceived ease of use.
H11	General eHealth literacy is positively associated with perceived ease of use.
H12	Perceived ease of use is positively associated with perceived usefulness.
H13	Perceived ease of use is positively associated with attitude towards the digital DPP.
H14	Perceived usefulness is positively associated with attitude towards the digital DPP.
H15	Attitude towards the digital DPP is positively associated with intention to use the digital DPP.

4.5. Methods

4.5.1. Participants

Participants were recruited online through press releases, social media, health and council organisations, and postgraduate student and academic staff mailing lists. Inclusion criteria was as follows: English-speaking adults aged ≥18 years, residing in the Republic of Ireland, and no previous diagnosis of type 1 or T2D. Data were collected between October 2020 and April 2021. Of the 333 completed surveys, 17 (5.1%) were excluded as participants did not meet all inclusion criteria. A final sample of 316 was analysed.

4.5.2. Design and Procedure

This study was approved by the NUI Galway Research Ethics Committee (see Appendix F). To test the model, participants were asked to complete a survey on digital health and T2D prevention, either online via the LimeSurvey online survey tool (Limesurvey GmbH, 2021) or physical booklet. Consent was obtained before the survey commenced. The survey contained 61 mandatory items across four sections, from which the study measures were obtained. The first section obtained participant demographics and determined their T2D risk score. Participants did not receive this score until after the study. Section two contained items assessing the personal health, social influence, and eHealth literacy factors. Section three contained a seven-page colour brochure (see Appendix K) for an established smartphone-based digital DPP featured in the National Health Service (NHS) England digital DPP pilot study (Murray et al., 2019). This brochure included images showcasing key programme features. Section four contained items assessing participants' perceptions of this programme (intervention factors). Upon completing the survey, participants could enter a draw to win a €100 gift card.

4.5.3. Measures

4.5.3.1 Health Status. Health status was determined via the total score from eight Finnish Diabetes Risk Score (FINDRISC) items (see Lindström & Tuomilehto, 2003). These were age, BMI, waist circumference, eating and physical activity behaviours, medication and blood glucose history, and family history of diabetes. A higher health status score indicated a greater risk of developing T2D.

4.5.3.2. Research Model Measures. The following measures assessed the remaining 11 factors (see Appendix AG). All items were answered using a five-point Likert scale (strongly disagree to strongly agree) unless otherwise indicated.

4.5.3.2.1. Personal Health Factors. Measures of perceived seriousness and perceived susceptibility (four items each) were adapted from previous studies assessing diabetes and cardiovascular disease beliefs (Della et al., 2013; Tovar et al., 2010).

4.5.3.2.2. Social Influence Factors. Subjective norm was assessed using two items adapted from the TPB (Ajzen, 2002). Image was assessed using three items adapted from the Technology Acceptance Model 2 (TAM2; Venkatesh & Davis, 2000).

4.5.3.2.3. eHealth Literacy Factors. eHealth readiness was assessed using the seven-item eHealth Readiness Scale (Bhalla et al., 2016). Communicative eHealth literacy was assessed using the five-item communicative eHealth subscale of the Transactional Model of eHealth Literacy scale (Paige et al., 2019). General eHealth literacy was assessed using the eight-item eHealth Literacy Scale (eHEALS; Norman & Skinner, 2006a).

4.5.3.2.4. Intervention Factors. Perceived usefulness and perceived ease of use were each assessed using four items, all adapted from the TAM2 (Venkatesh & Davis, 2000) and previous T2D research (Yan & Or, 2019). Attitudes and intentions were assessed using four and two items respectively, all adapted from the TAM (Davis, 1989), TPB (Ajzen, 2002), and previous T2D research (Yan & Or, 2019).

4.5.4. Statistical Analysis

Descriptive analyses were conducted using IBM SPSS version 27.0 (IBM Corp., 2020). This included multi-variate outlier screening and normality assessments for each measurement item. For all factors, after measurement model validation, normality was assessed, tolerance and variance inflation factors were inspected to identify issues of multi-collinearity, and bivariate correlations were analysed.

Using structural equation modelling (SEM), the specification and fit of both the measurement and hypothesised models was assessed in IBM Amos version 27.0 (Arbuckle, 2020) with maximum likelihood estimation. For each model, chi-square values were identified, and model fit deemed acceptable if all of the following conditions were met: Comparative Fit Index (CFI) and Tucker Lewis Index (TLI) ≥.90, standardised root-mean-square residual (SRMR) <.09, and root-mean-square error of approximation (RMSEA) <.08 (Bentler, 1990; Hu & Bentler, 1999). Data from which all analyses were conducted are available at https://osf.io/tzjby/.

Confirmatory Factor Analysis (CFA) evaluated the validity and reliability of the measurement model, which included all factors except for the single-item heath status factor. Factor items were deemed questionable, warranting removal if: (a) their loading was <.50 (Hair, 2009), or <.70 in the case of two-item factors (Worthington & Whittaker, 2006); or, (b) their removal would improve model fit, as allowing error terms to correlate is not recommended when performing CFA (Hermida, 2015). Acceptable internal consistency of the measurement scales was established at Cronbach's alpha values of ≥.70 (Taber, 2018). Composite reliability was established at values of ≥.70 (Hair, 2009). Convergent validity was established with average variance extracted (AVE) values of ≥.50 (Hair, 2009), while values of <.50 were acceptable only if the factors' composite reliability value was ≥.70 (Malhotra & Dash, 2016). Discriminant validity was supported if: a) the square root of the AVE for each factor exceeded the correlation between it and each other factor (Fornell & Larcker, 1981), and b) a heterotrait-monotrait ratio of correlations (HTMT) test revealed all values to be <.85 (Henseler et al., 2015). To account for common method variance generated by the use of a single survey, a common latent factor (CLF) test compared the standardised regression weights of all items of the model with and without the CLF (Eichhorn, 2014). If all regression weight differences are <.200, common method variance is not a problem (Gaskin, 2021).

The direct, indirect, and total effects of the hypothesised model were assessed using the bootstrapping method with 5000 resamples at 95% confidence intervals.

4.6. Results

4.6.1. Participant Characteristics

Characteristics of the 316 participants can be found in Table 4.3. Participants' mean age was 36.25 years old (*SD* = 13.99). The sample was 77% female, 93% white, and 90% held an undergraduate degree or higher. Additionally, 40% had a slightly elevated risk or higher of developing T2D, and 48% reported a family history of type 1 or T2D. For reference, 48% of participants had a BMI of ≥25, a criterion used in the Unites States to determine potential eligibility for enrolment in the Centers for Disease Control and Prevention (CDC) DPP (CDC, 2021d).

Table 4.3

Summary of Sample Characteristics (N = 316)

Characteristic and Category	*n* (%)	*M*	*SD*
Form of survey completed			
Online	313 (99.05)		
Hard copy[a]	3 (0.95%)		
Age in years		36.25	13.99
18-29	145 (45.89)		
30-39	53 (16.77)		
40-49	62 (19.62)		
50-59	31 (9.81)		
60+	25 (7.91)		
Gender			
Female	242 (76.58)		
Male	71 (22.47)		
Other	3 (0.95)		
Ethnicity			
White Irish	252 (79.75)		
Any other white background	43 (13.61)		
Asian or Asian Irish	12 (3.80)		
Other	6 (1.90)		
Black or Black Irish	3 (0.95)		
Irish Traveller	3 (0.95)		
Highest education obtained			
Postgraduate degree	143 (45.25)		
Undergraduate degree	141 (44.62)		
Technical or vocational	12 (3.80)		
Upper secondary	11 (3.48)		
Lower secondary	8 (2.53)		
Primary	1 (0.32)		
Body Mass Index (BMI)		26.09	5.98
Underweight (<18.5)	6 (1.90)		
Healthy weight (18.5-24.9)	160 (50.63)		
Overweight (25-29.9)	88 (27.85)		
Obese (≥30)	62 (19.62)		
FINDRISC score		6.14	4.82
Low risk (0-6)	189 (57.81)		
Slightly elevated risk (7-11)	79 (25.00)		
Moderate risk (12-14)	29 (9.18)		
High risk (15-20)	17 (5.38)		
Very high risk (≥20)	2 (0.63)		
Familial T2D risk[b]			
No	165 (52.22)		
Yes: grandparent, aunt, uncle, or first cousin	91 (28.80)		
Yes: mother, father, brother, sister, or own child	60 (18.99)		

[a] Effective distribution of hard copy surveys was not possible due to COVID-19 restrictions.

[b] An immediate family member or other relative had been previously diagnosed with type 1 or 2 diabetes.

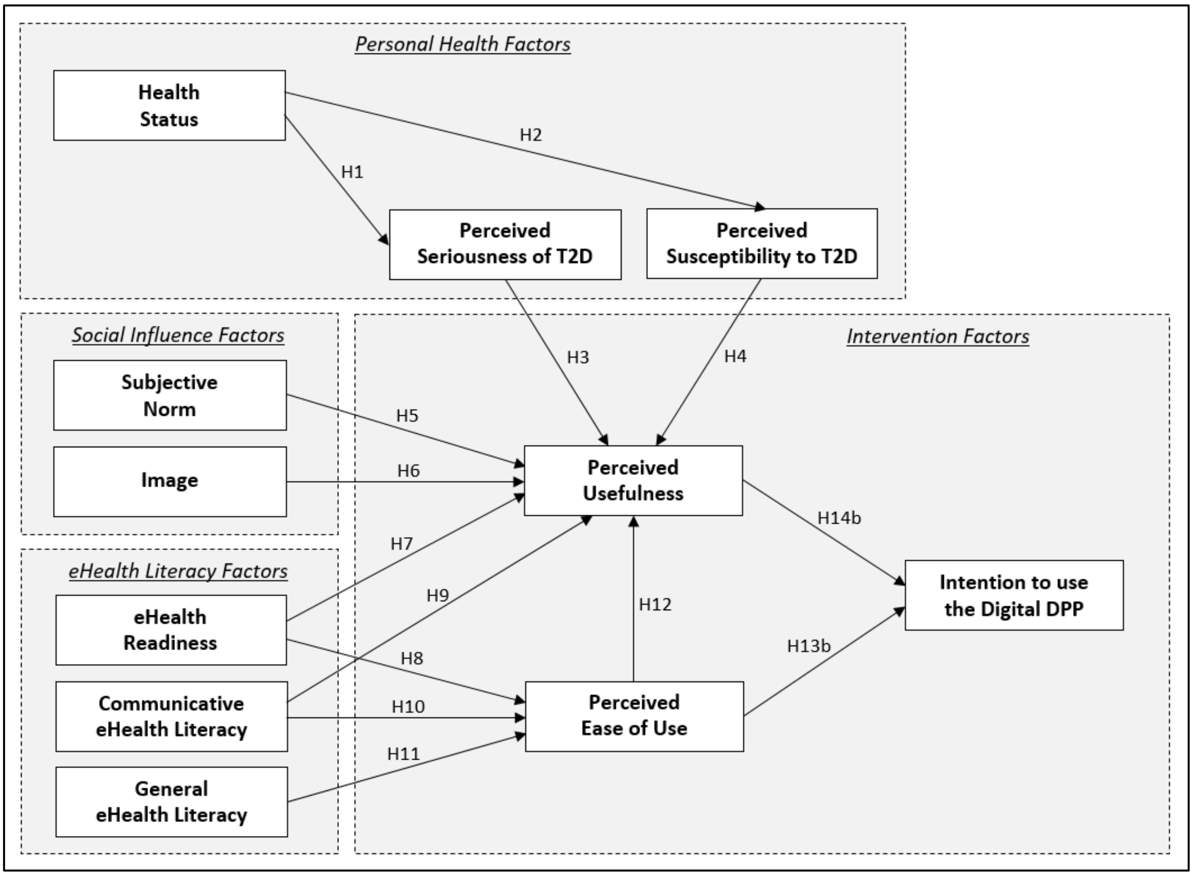
4.6.2. Confirmatory Factor Analysis

The initial CFA revealed that the perceived usefulness and attitude factors were in-discriminant, with an HTMT test value of .89. As the removal of two attitude items did not sufficiently improve this, the conservative approach was to remove the attitude factor from further analysis and, in accordance with TAM2 (Venkatesh & Davis, 2000) and TAM3 (Venkatesh & Bala, 2008), draw relationships from perceived usefulness and perceived ease of use to intention directly. This revised structural model can be found in Figure 4.2. Two eHealth readiness items were removed: item eHR1 was removed to improve model fit, and eHR7 had a factor loading of .46. Three general eHealth literacy items (GeL6-8) were removed to improve model fit.

The final measurement model achieved acceptable fit: [$\chi^2_{(620)} = 1095.022$, $p < .001$, CFI = .916, TLI = .905, SRMR = .062, RMSEA = .049]. Skewness, kurtosis, and factor loadings of all items can be found in Table 4.4. The CLF test revealed the largest regression difference to be .036, suggesting that common method variance was not an issue, and all HTMT test values were <.85, confirming the discriminant validity of all factors. Values of internal consistency, composite reliability, AVE, and the Fornell-Larcker test can be found in Table 4.5, and descriptive statistics of the summed factor scores in Table 4.6. All values were within the required ranges, supporting the validity and reliability of the final measurement model.

Figure 4.2

Revised Structural Model of the Factors Influencing the Acceptability of a Digital DPP



Note. Hypotheses 13 and 14 are now denoted as "b" hypotheses as these relationships theoretically remained despite removal of the mediating attitude factor. Hypothesis 15 (attitude predicts intention) was no longer applicable and thus removed.

Table 4.4

Skewness, Kurtosis and Factor Loadings of All Items of the Final Measurement Model

Item	Skewness	Kurtosis	Factor loading
PSe1: If I get diabetes it will not affect my relationships with others that much. (Item reverse-scored).	0.45	-0.11	.77
PSe2: Getting diabetes will slow down my daily life.	-0.57	-0.53	.66
PSe3: Diabetes is a sickness that can be very painful.	-0.21	-0.62	.62
PSe4: The costs of living with diabetes are so bad that I really want to avoid them if I can.	-0.45	-0.37	.52
PSu1: My chances of developing diabetes in the next few years are great.	0.54	-0.62	.77
PSu2: I am concerned about the likelihood of developing diabetes in the near future.	0.17	-1.18	.90
PSu3: Because there are so many things that could happen to me, I think it is foolish to worry about diabetes. (Item reverse-scored)	0.47	0.22	.51
PSu4: The older I get, the more I think about getting diabetes.	-0.14	-1.17	.72
SN1: Most people who are important to me think that I should get more exercise.	0.45	-0.86	.84
SN2: Most people who are important to me think that I should have a healthier diet.	0.34	-1.02	.79
IM1: People who use digital wearable devices/or smartphone apps have more prestige than those who don’t.	0.80	0.63	.77
IM2: People who use digital wearable devices or smartphone apps have a high profile.	0.60	0.14	.86
IM3: Between the people I know, the use of digital wearable devices and smartphone apps are a status symbol.	0.50	-0.43	.64
eHR2: I feel that my previous experiences with online technologies are important to my success with using a lifestyle intervention.	-0.48	-0.61	.55
eHR3: Using internet technologies makes me more efficient in my daily functioning.	-0.69	-0.15	.79
eHR4: I believe that I am able to make good use of internet websites and web applications.	-1.05	2.31	.57
eHR5: Using internet technologies provide me with a feeling of independence.	-0.80	0.11	.75
eHR6: I enjoy the challenge of figuring out the different functions of websites and web applications.	-0.20	-0.87	.54
CeL1: I can achieve my health information goals on the internet while helping other users achieve theirs.	-0.02	-0.50	.62
CeL2: I have the skills I need to talk about health topics on the Internet with multiple users at the same time.	0.07	-0.84	.80
CeL3: I can identify the emotional tone of a health conversation on the internet.	-0.29	-0.66	.53
CeL4: I have the skills I need to contribute to health conversations on the internet.	-0.13	-0.92	.86
CeL5: I have the skills I need to build personal connections with other internet users who share health information.	-0.20	-0.74	.78

Table 4.4 Continued

Item	Skewness	Kurtosis	Factor loading
GeL1: I know how to find helpful resources on the internet.	-0.93	2.18	.62
GeL2: I know how to use the internet to answer my health questions.	-1.07	1.54	.79
GeL3: I know what health resources are available on the internet.	-0.81	0.56	.80
GeL4: I know where to find helpful resources on the internet.	-1.13	2.67	.82
GeL5: I know how to use the health information I find on the internet to help me.	-0.87	1.05	.80
PU1: Using the intervention would help me to improve my fitness.	-1.23	1.89	.87
PU2: Using the intervention would help me to improve my diet.	-1.17	1.29	.90
PU3: Using the intervention would help me to manage my weight.	-1.12	1.35	.83
PU4: Using the intervention would help me to prevent diabetes.	-1.03	1.64	.64
PEU1: Learning how to use the intervention would be clear and understandable.	-0.78	2.35	.74
PEU2: Using the intervention would not require a lot of mental effort.	-0.42	-0.60	.53
PEU3: The intervention tools seem to be easy to use.	-0.73	2.50	.82
PEU4: I would it find it easy to get the tools to do what I want them to do.	-0.49	1.16	.78
INT1: Assuming the intervention is available, I intend to use it.	-0.17	-0.77	.93
INT2: Given that the intervention is available, I predict I would use it.	-0.26	-0.87	.95

Note: PSe: perceived seriousness, PSu: perceived susceptibility, SN: subjective norm, IM: image, eHR: eHealth readiness, CeL: communicative eHealth literacy, GeL: general eHealth literacy, PU: perceived usefulness, PEU: perceived ease of use, INT: intention to use the digital DPP. Skewness values of >2, or kurtosis values of >7 indicate non-normality (Cohen et al., 2013).

Table 4.5

Cronbach's Alpha, Composite Reliability, AVE, and the Fornell-Larcker Test of All Factors in the CFA

Factor	CA	CR	AVE	PSe	PSu	SN	IM	eHR	CeL	GeL	PU	PEU	INT
PSe	0.73	0.74	0.42	**0.65**									
PSu	0.82	0.82	0.55	0.10	**0.74**								
SN	0.80	0.80	0.67	0.61	0.18	**0.82**							
IM	0.79	0.80	0.58	0.09	0.19	0.14	**0.76**						
eHR	0.76	0.78	0.42	0.09	0.13	0.11	0.22	**0.65**					
CeL	0.84	0.85	0.53	0.02	0.02	-0.03	-0.05	0.27	**0.73**				
GeL	0.88	0.88	0.60	-0.05	-0.01	-0.08	-0.10	0.14	0.44	**0.77**			
PU	0.89	0.89	0.67	0.23	0.26	0.30	0.25	0.39	-0.03	-0.17	**0.82**		
PEU	0.79	0.81	0.55	0.03	0.25	0.16	-0.02	0.24	0.23	0.14	0.43	**0.73**	
INT	0.97	0.94	0.89	0.42	0.20	0.39	0.15	0.21	0.03	-0.15	0.70	0.35	**0.94**

Note: PSe: perceived seriousness, PSu: perceived susceptibility, SN: subjective norm, IM: image, eHR: eHealth readiness, CeL: communicative eHealth literacy, GeL: general eHealth literacy, PU: perceived usefulness, PEU: perceived ease of use, INT: intention to use the digital DPP, CA: Cronbach's alpha, CR: composite reliability, AVE: average variance extracted. For discriminant validity to be supported, all factor values below and to the left of each value (excluding CA, CR and AVE values) in bold must be lower than the bolded value itself.

Table 4.6

Descriptive Statistics of the Total Factor Scores

Factor	Mean	SD	Min	Max	Skewness	Kurtosis	Tolerance	VIF
HS	6.14	4.82	0	23	0.71	-0.04	0.66	1.52
PSe	13.09	2.94	4	20	-0.90	0.16	0.85	1.18
PSu	10.50	3.61	4	20	0.44	-0.44	0.59	1.71
SN	5.07	2.17	2	10	0.36	-0.83	0.70	1.43
IM	6.53	2.39	3	15	0.57	0.31	0.89	1.13
eHR	21.13	4.39	6	30	-0.37	-0.01	0.76	1.33
CeL	15.10	4.21	5	25	0.01	-0.29	0.75	1.33
GeL	19.82	3.21	5	25	-0.83	2.26	0.81	1.24
PU	14.57	3.13	4	20	-1.31	2.44	0.68	1.47
PEU	15.42	2.32	4	20	-0.47	1.98	0.7	1.28
INT	6.24	2.25	2	10	-0.22	-0.80	-	-

Note: HS: health status, PSe: perceived seriousness, PSu: perceived susceptibility, SN: subjective norm, IM: image, eHR: eHealth readiness, CeL: communicative eHealth literacy, GeL: general eHealth literacy, PU: perceived usefulness, PEU: perceived ease of use, INT: intention to use the digital DPP, VIF: variance inflation factor. Skewness values of >2, or kurtosis values of >7 indicate non-normality (Cohen et al., 2013). Tolerance values of <0.2 or VIF values of >4 indicate multicollinearity problems (Hair, 2009).

4.6.3. Correlation Analysis

Before analysing the revised model, bivariate correlations were conducted using the summed factor scores (Table 4.7). Of the relationships of interest not explored in the model, significant positive relationships were found within the social influence and eHealth literacy clusters. Subjective norm and image were positively associated (r = .13, p < .05), and eHealth readiness was positively associated with both communicative eHealth literacy (r = .30, p < .01) and general eHealth literacy (r = .16, p < .05).

Table 4.7

Pearson's Correlation Matrix of All Factors of the Revised Structural Model

Factor	1	2	3	4	5	6	7	8	9	10	11
1. HS	1										
2. PSe	-.21**	1									
3. PSu	.51**	.08	1								
4. SN	.30**	.13**	.50**	1							
5. IM	-.03	.17**	.07	.13*	1						
6. eHR	.04	.11*	.11*	.09	.21**	1					
7. CeL	.03	.03	.01	-.03	-.05	.30**	1				
8. GeL	-.02	.01	-.04	-.08	-.08	.16**	.40**	1			
9. PU	.02	.24**	.22**	.27**	.24**	.36**	.02	-.12*	1		
10. PEU	-.12*	.19**	.02	.14**	-.01	.21**	.22**	.10*	.35**	1	
11. INT	.21**	.14**	.37**	.35**	.14**	.21**	.02	-.14**	.65**	.29**	1

Note: HS: health status, PSe: perceived seriousness, PSu: perceived susceptibility, SN: subjective norm, IM: image, eHR: eHealth readiness, CeL: communicative eHealth literacy, GeL: General eHealth literacy, PU: perceived usefulness, PEU: perceived ease of use, INT: intention to use the digital DPP.

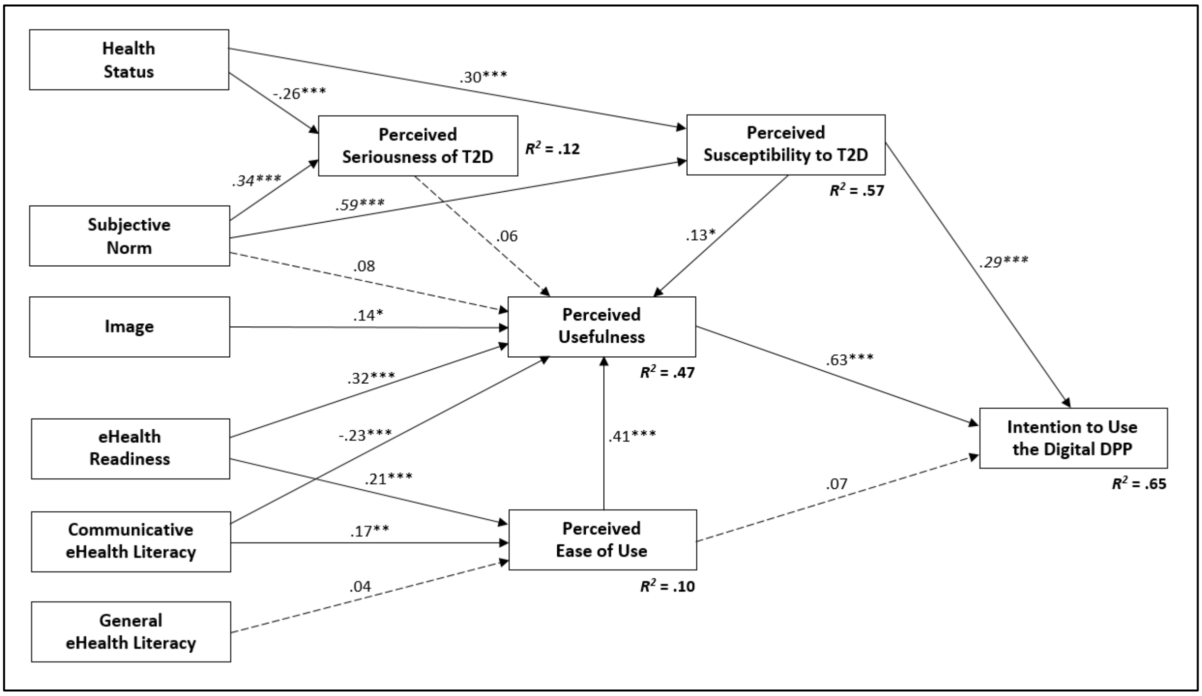
**p* < .05, two-tailed. ***p* < .01, two-tailed.

4.6.4. Revised Structural Model Analysis

Index values from the initial analysis suggested that model fit was not acceptable. Informed by the largest modification indices, three direct positive relationships were added, all of which supported by existing theory. These were: (a) subjective norm to perceived seriousness, (b) subjective norm to perceived susceptibility, and (c) perceived susceptibility to intention. With these relationships included, model fit was acceptable [$\chi^2_{(20)} = 52.625$, $p < .001$, CFI = .971, TLI = .920, SRMR = .047, RMSEA = .072]. Standardised regression weights of all paths and squared multiple correlations for all endogenous variables can be found in Figure 4.3.

Figure 4.3

The Revised Structural Model of the Relationships of the Factors Influencing the Acceptability of a Digital DPP



Note. Co-variances and shaded boxes removed for illustrative parsimony. Figures in italics represent the standardised regression weights for paths that were added to the hypothesised model to achieve acceptable model fit. Broken lines indicate associations that were not statistically significant.

**p* < .05, ***p* < .01, ****p* < .001

As shown in Table 4.8, eight of the fourteen hypotheses were supported, with the following significant direct positive relationships found: health status to perceived susceptibility (β = .30, $p < .001$); perceived susceptibility (β = .13, $p = .021$), image (β = .14, $p <.001$), eHealth readiness (β = .32, $p < .001$), and perceived ease of use (β = .41, $p < .001$) to perceived usefulness; eHealth readiness (β = .21, $p < .001$) and communicative eHealth literacy (β = .17, $p = .007$) to perceived ease of use; and perceived usefulness to intention (β = .30, $p < .001$). Two hypotheses were not supported as their significant direct relationships were negative. These were health status to perceived seriousness (β = -.27, $p < .001$), and communicative eHealth literacy to perceived usefulness (β = -.23, $p < .001$). Four hypothesised direct positive associations (perceived seriousness to perceived usefulness, subjective norm to perceived usefulness, general eHealth literacy to perceived ease of use, and perceived ease of use to intention) were found, but not significant. However, two of these were indirectly significant (see Appendix AH). The first was subjective norm, through perceived susceptibility, to perceived usefulness (standardised indirect effect = .08, $p = .048$); and the second was perceived ease of use, through perceived usefulness, to intention (standardised indirect effect = .26, $p < .001$). All indirect and total effects can be found in Appendix AI.

Table 4.8

Hypothesis Tests of the Direct Effects of the Revised Structural Model

Hyp.	EnV		ExV	Regression weight (SE)	S Est. (*β*)	95% CI	CR (*t*)	*p* value	Hyp. Test	SMC
H1	PSe	←	HS	-.03 (.01)	-.27	-.35, -.17	-4.71	< .001	NS[a]	.12
-		←	SN	.21 (.04)	.34	.24, .43	5.93	< .001	- [b]	
H2	PSu	←	HS	.05 (.01)	.30	.23, .36	7.35	< .001	Supp.	.57
-		←	SN	.55 (.04)	.59	.52, .65	14.75	< .001	- [b]	
H3	PU	←	PSe	.08 (.06)	.06	-.00, .13	1.42	.155	NS	.47
H4		←	PSu	.11 (.05)	.13	.01, .25	2.31	.021	Supp.	
H5		←	SN	.07 (.05)	.08	-.03, .20	1.38	.166	NS	
H6		←	IM	.16 (.05)	.14	.08, .20	3.29	< .001	Supp.	
H7		←	eHR	.36 (.05)	.32	.25, .40	6.95	< .001	Supp.	
H9		←	CeL	-.29 (.06)	-.23	-.31, -.16	-5.13	< .001	NS[a]	
H12		←	PEU	.67 (.07)	.41	.30, .49	9.00	< .001	Supp.	
H8	PEU	←	eHR	.14 (.04)	.21	.11, .31	3.74	< .001	Supp.	.10
H10		←	CeL	.13 (.05)	.17	.05, .29	2.69	.007	Supp.	
H11		←	GeL	.04 (.07)	.04	-.08, .16	0.64	.525	NS	
-	INT	←	PSu	.36 (.04)	.29	.23, .35	8.26	< .001	- [b]	.65
H13b		←	PU	.89 (.06)	.63	.56, .68	15.77	< .001	Supp.	
H14b		←	PEU	.16 (.09)	.07	.01, .13	1.74	.083	NS	

Note: Hyp: hypothesis, EnV: endogenous variable, ExV: exogenous variable, SE: standard error, S Est: standardised estimate, 95% CI: confidence interval for the standardised estimate, CR: critical ratio, SMC: squared multiple correlation for the endogenous variable, HS: health status, PSe: perceived seriousness, PSu: perceived susceptibility, SN: subjective Norm, IM: image, eHR: eHealth readiness, CeL: communicative eHealth literacy, GeL: general eHealth literacy, PU: perceived usefulness, PEU: perceived ease of use, INT: intention to use the digital DPP, NS: hypothesis not supported, Supp: hypothesis supported.

[a] Despite achieving statistical significance, these hypotheses were not supported as the associations between these factors were hypothesised to be positive.

[b] These relationships were added to achieve acceptable model fit, and therefore not originally hypothesised.

This revised structural model (referred to hereafter as the present model) accounted for: 65% of the variance in intention, 57% of perceived susceptibility, 47% and 10% of perceived usefulness and ease of use respectively, and 12% of perceived seriousness.

4.7. Discussion

This study developed and assessed a digital health acceptability model to identify the factors that influence the intention of adults living in Ireland to use a digital DPP. Using SEM, the analysis found the present model to explain 65% of the variance in the intention to use the programme. This is lower than the 74% found by Yan and Orr (2019) when assessing the acceptance of an eHealth system for patients with T2D, but higher than the median 54% found in a meta-analysis of health technology acceptance studies (Tao et al., 2020). The personal health factors of health status (T2D risk) and perceived susceptibility to T2D, social influence factors of subjective norm and image, eHealth literacy factors of eHealth readiness and communicative eHealth literacy, and intervention factors of perceived usefulness and perceived ease of use were all significant predictors, directly and/or indirectly influencing programme use intentions to a relatively large degree. For a digital DPP to have significant impact on reducing T2D incidence, uptake must be substantial and may be maximised if these factors are considered in the programme's development or pre-use phase.

4.7.1. Personal Health and Social Influence

Sizable relationships between the personal health and social influence factors were found. Kim and Park (2012) found a significant positive relationship between health status and the perceived threat of ill health. The present study supported this, finding a significant positive relationship between health status and perceived susceptibility, suggesting that people held accurate perceptions about their own personal risk of T2D. However, a significant negative relationship was found between health status and perceived seriousness, suggesting that people at greater risk underestimated the seriousness of T2D. Antwi et al. (2020) also reported an underestimation of perceived seriousness among college students with a family history of T2D, while Kowall et al. (2017) found that people at risk strongly underestimated the probability of developing diabetes. This could be due to optimistic bias, which can occur when people perceive their risk to be controllable (Weinstein, 1982). The relatively young, educated participants in the present study may have believed that they, despite being susceptible to T2D, can avoid its deleterious effects. Educating people on the risk factors and outcomes for T2D, and encouraging regular health checks with T2D risk screening, may generate greater T2D awareness.

Although not hypothesised, subjective norm was a significant positive predictor of both perceived seriousness and perceived susceptibility, outperforming health status as a predictor of these two factors. In the HBM (Rosenstock, 1974), peer and reference group pressure are linked with perceived seriousness and perceived susceptibility. As subjective norms reflected the advice from trusted others to eat healthier and be more physically active, its association with perceived seriousness and perceived susceptibility is understandable if this advice was given in the context of T2D prevention. Given the predictive strength of subjective norms, further qualitative exploration could unpack this factor to determine the source (e.g., friend, family, or healthcare professional) and content of the advice received. This knowledge could inform future communication strategies to improve the public's understanding of T2D.

4.7.2. Predicting Perceived Usefulness

Seven factors were hypothesised to have positive associations with perceived usefulness. Four were supported, with perceived ease of use, eHealth readiness, perceived susceptibility, and image (perceived social status enhancement through technology use) each significant predictors. This suggests that people may perceive a digital DPP to be useful if they feel susceptible to developing T2D, are ready to use digital health technologies whilst believing they enhance status, and/or view the programme as simple to navigate.

These findings support those of previous studies. First, Yan and Or (2019) found a significant positive association between the perceived usefulness and ease of use of a self-monitoring system for patients with T2D. Second, Both Kim and Park (2012) and Tao et al. (2020) found significant positive associations between technology self-efficacy and the perceived usefulness of health technologies. Third, Kim and Park (2012) found a significant positive association between perceived threat and the perceived usefulness of health technologies. Finally, Rosales et al. (2017) found social status enhancement to be a motivating factor for older adults to use health technologies.

Contrary to expectations, perceived seriousness did not directly influence perceived usefulness. However, if participants downplayed the seriousness of T2D, it is reasonable to suggest they would not view the programme as useful. Also unexpected was the lack of influence of subjective norm over perceived usefulness. This opposes the finding of Yan and Or (2019) who found subjective norm to significantly predict the perceived usefulness of a self-monitoring system for patients with T2D. However, the present study did find a significant indirect positive relationship between subjective norm and perceived usefulness when mediated by perceived susceptibility, suggesting that, if advised to improve their health behaviours, one may not perceive a digital DPP as useful unless they feel susceptible to developing T2D.

An unexpected significant negative association was found between communicative eHealth literacy and perceived usefulness, suggesting that people with greater confidence discussing health issues with others online actually perceived the digital DPP as less useful. This could be due to privacy and security concerns as people with greater communicative eHealth literacy may be hyper-vigilant to the potential risks of sharing health information online. Through qualitative interviews, Lee at al. (2019) found that participants of a T2D management intervention had concerns about sharing health information online. The brochure in the current survey was succinct, lacking the privacy statements participants would receive upon referral to the programme. Additionally, some people may happily communicate with friends and family online, but do not wish to engage with other participants. A digital DPP may be more appealing if privacy measures are clear, or if participants can choose to opt out of peer-to-peer communication. Further qualitative research could investigate people's extended views of the programme's online social networks.

4.7.3. Predicting Perceived Ease of Use

All three eHealth literacy factors were hypothesised to positively predict perceived ease of use. As expected, significant positive associations were found between both eHealth readiness, communicative eHealth literacy, and perceived ease of use. This suggests that those who were ready to engage with health technologies and confident in discussing health issues online were more likely to perceive the digital DPP as easy to use. Both Kim and Park (2012) and Tao et al. (2020) found significant positive associations between health technology self-efficacy and the perceived ease of use of health technologies. In the present study, the hypothesised relationship between general eHealth literacy and perceived ease of use was not significant. This implies that one's ability to find, evaluate, and apply electronic health information did not influence the programme's perceived usability. This study used the eHEALS (Norman & Skinner, 2006a) to measure general eHealth literacy as it is the most widely used eHealth literacy scale. However, it has been criticised for not capturing the dynamic, social nature of eHealth (Paige et al., 2018). As digital DPPs contain many interactive features (Van Rhoon et al., 2020), general eHealth literacy may not sufficiently boost one's confidence in navigating complex digital health interventions.

4.7.4. Predicting Intention

As expected, a significant positive association was found between perceived usefulness and intention. Moreover, it was the strongest direct predictor of intention, suggesting that acceptability may be maximised if the programme's usefulness is well established. Contrary to expectations, the positive association between perceived ease of use and intention was not significant. However, when mediated by perceived usefulness, perceived ease of use and intention had a significant indirect positive relationship, suggesting that people may not intend to use the programme on ease of use alone. Rather, they must first believe that ease of use is a prerequisite for usefulness. A meta-analysis of the acceptance of consumer-oriented health technologies found perceived usefulness and ease of use to be significant predictors of intention, and perceived usefulness was the stronger predictor (β = .41 vs. .21; Tao et al., 2020).

Although not hypothesised, a direct significant positive relationship was found between perceived susceptibility and intention, suggesting that if people believe themselves susceptible to developing T2D, they may intend to use the programme without evaluating it beforehand. Sun et al. (2013) also found a significant direct relationship between perceived vulnerability to ill health and the intention to use mobile health services. Based on these findings, T2D screening should be widely facilitated as it could encourage more individuals to learn of their susceptibility, potentially increasing the number of at-risk individuals who intend to use a digital DPP.

4.7.5. Strengths and Limitations

To our knowledge, this is the first study to test an extended health technology acceptance model to assess digital DPP acceptability. The present model included objective and subjective health factors, social influence factors that captured health behaviours and technology beliefs, and multiple eHealth literacy measures–all relevant to T2D and the skills required to navigate modern digital health interventions. Future studies could extend the model to assess actual uptake or test the acceptability of other digital health interventions.

The present study has some limitations. First, the sample contained a large proportion of low-risk individuals and were relatively young, with an average age of 36 years–lower than the 45 years at which, according to the FINDRISC (Lindström & Tuomilehto, 2003), T2D risk significantly increases. As the sample was self-selecting, people interested in digital health may have been more motivated to participate. This could have contributed to the sample's relatively low average age. Despite this limitation, early-onset adult T2D is increasingly prevalent, with adults age 18 to 39 alone representing up to 20% of all global adult T2D cases (Sargeant et al., 2020). Furthermore, a study found that over five-year follow-up, people diagnosed with T2D under the age of 40 had the highest excess relative risk of mortality and adverse cardiovascular outcomes compared with people over 40 (Sattar et al., 2019). Therefore, T2D prevention is also very important for younger adults. Second, while the FINDRISC is widely used, laboratory blood tests remain the gold standard in T2D risk assessment (American Diabetes Association, 2018). Some national programmes such as the NHS DPP require blood glucose tests to determine one's eligibility to enrol (Hawkes et al., 2020). As blood tests were not feasible for the current study, the number of participants eligible for a DPP using the same criteria is unknown. Finally, recruitment avenues were limited due to the COVID-19 pandemic. Online-only recruitment obtained a well-educated, predominantly white, female sample, so results may not be generalisable to other populations. Future studies should examine socio-economically diverse groups.

4.7.6. Conclusion

This study developed and tested a digital health acceptability model to predict the intention of adults living in Ireland to use a digital DPP. Collectively, the personal health, social influence, eHealth literacy, and intervention factors predicted programme use intentions to a relatively large degree. Providing education on T2D risk factors and outcomes may improve the public's understanding of the condition, and widespread screening practices may increase risk awareness, potentially increasing the number of willing programme users. To further assess the model's reliability, future studies could test it with other digital DPPs and people at higher risk of developing T2D, including older adults. Additionally, qualitative research may uncover perceptions of online social networking, and facilitate a deeper understanding of the nature of social influence. Such knowledge would assist developers in tailoring the programme's content and communication strategies to broaden the programme's appeal. Offering eHealth readiness training and support, such as how to use apps and wearables, could improve digital health uptake nationally. Digital DPPs can be cost effective interventions that encourage healthy lifestyle behaviours, potentially improving population health by reducing the risk and incidence of T2D. The present findings may not only inform strategies to maximise uptake of a digital DPP but inform the development of digital health solutions in general.

4.8. Acknowledgements

This work was supported by the Irish Research Council under the Government of Ireland Postgraduate Scholarship, and the National University of Ireland, Galway under the Hardiman Scholarship. Open access funding enabled and organised by IRel.

4.9. Conflicts of Interest

All authors declare no conflict of interest.

4.10. Author Contribution

Luke Van Rhoon: conceptualisation (equal), data curation (equal), formal analysis (equal), funding acquisition (equal), investigation (equal), methodology (equal), project administration (equal), validation (equal), visualisation (equal), writing – original draft (equal), writing – review & editing (equal). Jenny McSharry: supervision (equal), writing – review & editing (equal). Molly Byrne: supervision (equal), writing – review & editing (equal).

5. Study Three: The Views and Experiences of Adults Living in Ireland Regarding the Acceptability of a Digital Diabetes Prevention Programme: A Qualitative Content Analysis

Luke Van Rhoon*[1], Molly Byrne[1], Christie Tetreault[2] & Jenny McSharry[1]

[1]Health Behaviour Change Research Group, School of Psychology, National University of Ireland, Galway.

[2]School of Psychology, National University of Ireland, Galway.

5.1. Abstract

Objective: Digital diabetes prevention programmes (DPPs) may slow the escalating trend of type 2 diabetes mellitus (T2DM) incidence by empowering people to improve their dietary and physical activity behaviours. However, generating user engagement can be challenging. This study explored the views and experiences of adults at risk of T2DM regarding factors impacting the acceptability of a digital DPP, including their health status, social influence, health technology use, health behaviours, and perceptions of a smartphone based digital DPP.

Design: Semi-structured interviews of 17 adults (M_{age} = 50 years) were analysed using deductive and inductive qualitative content analysis.

Results: Descriptive themes regarding personal health, social influence, eHealth literacy, healthy eating, physical activity, and perceived usefulness plus ease of use of a digital DPP were identified. Health technologies, programme features, and interactions with friends and health professionals concerning their health behaviours were viewed by participants as both favourable and unfavourable, potentially affecting digital DPP acceptability. However, the desire for a tailored programme was a common thread.

Conclusion: Peoples' experiences, needs, and motivations that affect digital DPP acceptability are diverse. Digital DPPs or similar digital health interventions should be tailored in both content and communication strategies to maximise user engagement and potential effectiveness.

5.2. Introduction

Diabetes is a chronic health condition that can significantly impact the health and wellbeing of individuals and societies worldwide, and is among the top 10 causes of death in adults (Saeedi et al., 2019). In Ireland, Type 2 diabetes mellitus (T2DM), which represents

90% of all diabetes cases, affected approximately 216,000, or 9.2% of people over 40 years of age in 2020, and is projected to affect 414,000 people over age 40 by the year 2036 (Pierse et al., 2021; Saeedi et al., 2019). Landmark diabetes prevention trials have demonstrated that the condition can be prevented, and systematic reviews and meta-analyses found that T2DM prevention interventions, when delivered in routine practice, achieved relative risk reductions in T2DM incidence of almost 30% (Cefalu et al., 2016; Valabhji et al., 2020).

There are plans to develop a pilot diabetes prevention programme (DPP) in Ireland (Pierse et al., 2021), and evidence from established programmes could shape its development. In 2016, National Health Service (NHS) England launched the NHS-DPP, a lifestyle intervention for adults at risk of developing T2DM (Hawkes et al., 2020). The programme delivers 13 face-to-face group-based sessions over nine months by trained educators, aiming to reduce T2DM risk by empowering participants to improve their diet and increase physical activity whilst promoting weight loss, weight maintenance, and/or reductions in blood glucose (Valabhji et al., 2020). Results are encouraging, but attendance has been low (Barron et al., 2018; Valabhji et al., 2020). This limited engagement was also observed in the United States National Diabetes Prevention Program (US NDPP; Ali et al., 2019). Barriers to participant attendance in both programmes included inflexible scheduling, geographical distance, and under-equipped venues (Halley et al., 2020; Hawkes et al., 2020).

Following a move by the US NDPP to offer remote participation via computer or smartphone (Castro Sweet et al., 2018), NHS England launched a digital stream of the NHS-DPP to overcome the challenges of face-to-face delivery, and improve cost-effectiveness (Murray et al., 2019). Such digital adaptations are timely as the COVID-19 pandemic has generated a surge in digital health adoption within healthcare systems worldwide (Petracca et al., 2020). As Ireland considers its own face-to-face DPP, the parallel implementation of a digital programme could reach more people at risk of T2DM. Recent evidence supports a digital programme's success potential, as digital DPP participants have achieved clinically significant weight loss and reductions in blood glucose through online health coaching, peer support, and diet plus physical activity self-monitoring (Bian et al., 2017; Van Rhoon et al., 2020). However, while online delivery addresses the attendance barriers of face-to-face programmes, digital health interventions have unique user engagement challenges that could limit the impact of a digital DPP (Murray et al., 2019). By consulting intended users in the early development phase, researchers could assess a digital health programme's acceptability, and engagement potential (Nadal et al., 2020). This could facilitate the user-centred design process, leading to the creation of more engaging and effective interventions (Perski & Short, 2021).

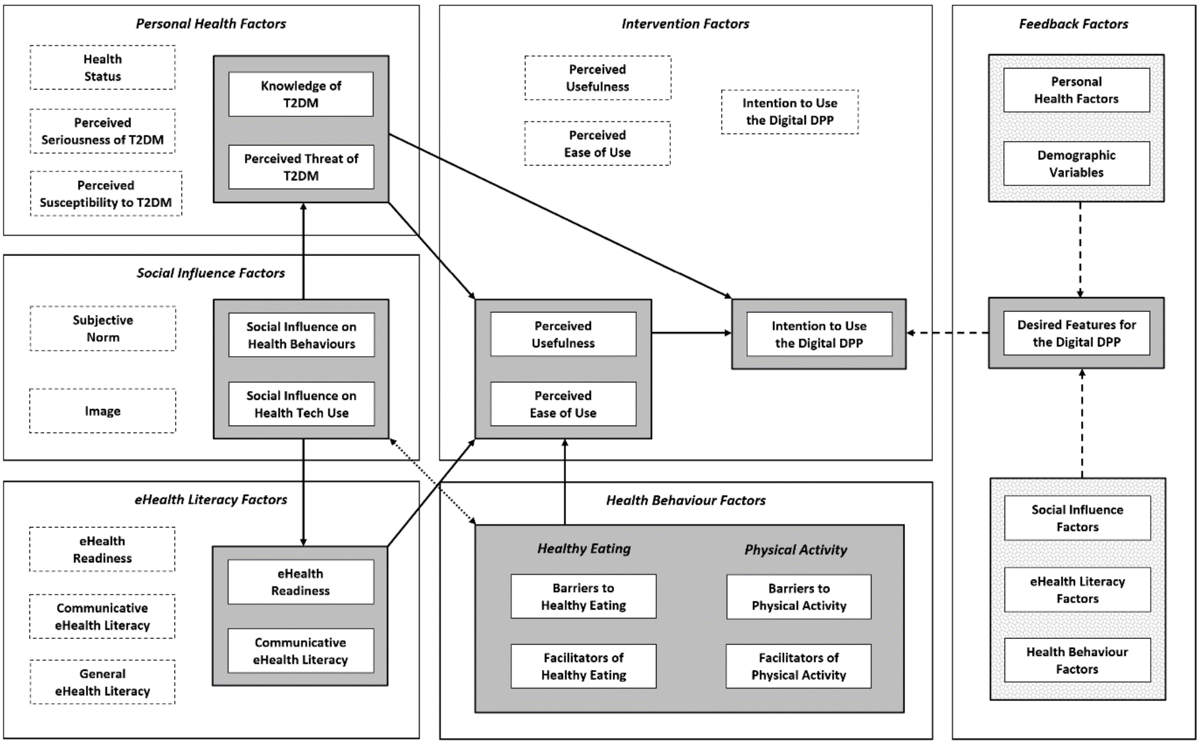
In a recent study, we developed and tested a digital health acceptability model to explain the intention of adults living in Ireland to use a digital DPP (Van Rhoon et al., 2021). This model, which was based on models of technology acceptance, eHealth literacy and health beliefs, explained 65% of the variance in participants' intention to use the digital DPP. Furthermore, factors pertaining to personal health, social influence, and eHealth literacy each had significant impact on digital DPP use intentions. However, the quantitative study design precluded a deeper understanding as to how and why these factors affected programme acceptability. To elaborate on this acceptability model, the present study aimed to explore the extended views and experiences of adults at risk of T2DM on the factors affecting digital DPP acceptability. This included their understanding of the condition, experiences with social influence on health behaviours, views on health technologies, and barriers and facilitators to healthy eating and physical activity. These findings could inform the development of future digital DPPs or other digital health interventions by providing guidance on how these programmes can be tailored to suit intended users. Tailored digital health interventions often perform significantly better than non-tailored interventions at improving health behaviours, and promoting user engagement (Lustria et al., 2013; Ryan et al., 2019).

5.2.1. Extended Framework for Digital DPP Acceptability

Building on our model of digital health acceptability (see Van Rhoon et al., 2021), an extended framework (see Figure 5.1) was developed to facilitate qualitative exploration. For example, barriers and facilitators to healthy eating and physical activity were included in the framework as these behaviours are the cornerstones of T2DM prevention (Alberti et al., 2007). The framework contains six clusters of factors relevant to digital DPP acceptability (see Table 5.1). *Personal health factors* represent participants' knowledge and understanding of T2DM, and how they view the condition in relation to their own health and wellbeing. *Social influence factors* capture situations where participants experience social influence (e.g., from family, friends, health professionals) over their eating behaviours, physical activity, and health technology use. *eHealth literacy factors* represent participants' self-perceived aptitude towards, and confidence in using health technologies (e.g., smartphone applications, wearable devices) and captures their user experiences. *Health behaviour factors* represent conditions where participants find it both challenging and simple to engage in healthy eating and regular physical activity. *Intervention factors* capture participants' views and perceptions of a digital DPP's usefulness, ease of use, and their intention to use it. *Feedback factors* suggest that all aforementioned factors influence participants' opinions regarding the features they would like to see in a digital DPP, and that incorporating such features could increase their intention of using the programme.

Figure 5.1

Extended Framework for Digital DPP Acceptability



Note. Dark shaded boxes enclose the present study topics. Boxes with broken outlines represent precursor factors from (Van Rhoon et al., 2021). Arrows represent directions of influence. Adapted from "Development and testing of a digital health acceptability model to explain the intention to use a digital diabetes prevention programme," by Van Rhoon et al., 2021, *British Journal of Health Psychology*, page 11, Figure 2 (https://doi.org/ 10.1111/bjhp.12569). CC BY 4.0.

Table 5.1

Factors of the Extended Framework for Digital DPP Acceptability

Factor cluster Factor	Descriptive definition
Personal health factors	
Knowledge of T2DM	Participants' knowledge and understanding of T2DM as a condition.
Perceived threat of T2DM	Participants' perceptions regarding the seriousness of T2DM and their susceptibility to developing it.
Social influence factors	
Social influence on health behaviours	Participants' experiences with social influence, advice, or pressure to change their health behaviours.
Social influence on health technology use	Participants' experiences with social influence over their views of, and desire to use health technologies.
eHealth literacy factors	
eHealth readiness	Participants' views and experiences regarding their own use of health technologies.
Communicative eHealth literacy	Participants' views and experiences regarding the use of technology to communicate with others on health-related matters.
Health behaviour factors	
Barriers to healthy eating	Factors that participants' feel make it harder to eat healthily.
Facilitators to healthy eating	Factors that participants' feel make it easier to eat healthily.
Barriers to physical activity	Factors that participants' feel make it harder for them to remain physically active.
Facilitators to physical activity	Factors that participants' feel make it easier for them to remain physically active
Intervention factors	
Perceived usefulness	Participants' views of the usefulness of the digital DPP in preventing T2DM, and/or improving diet and physical activity.
Perceived ease of use	Participants' views of the ease to which the programme and its technologies are to navigate.
Intention to use the digital DPP	Participants' discussion on why they would or would not use the digital DPP.
Feedback factors	
Desired features for the digital DPP	Features participants would like to see included in a digital DPP.

5.3. Materials and Methods

This study was guided by the consolidated criteria for reporting qualitative research (COREQ) checklist (Tong et al., 2007; Appendix L), and was approved by the National University of Ireland, Galway Research Ethics Committee (reference number: 20-Apr-15).

5.3.1. Participants

Participants were recruited through our previous study (Van Rhoon et al., 2021), where English-speaking adults aged ≥18 years living in Ireland (with no previous type 1 or T2DM diagnosis) were recruited online between October 2020 and April 2021 through press releases, social media, health and council organisations, and academic institutions, and asked to complete a 15-minute questionnaire on digital health and T2DM prevention. Upon completing the questionnaire, participants could express interest in participating in a 30-minute follow-up interview. From the questionnaire responses, each participant's Body Mass Index (BMI) and Finnish Diabetes Risk Score (FINDRISC; Lindström & Tuomilehto, 2003) was calculated to determine their eligibility to be interviewed.

For the present study, questionnaire completers were eligible to participate if they registered either: (a) a BMI of ≥25, exceeding the healthy weight range; and/or (b) a FINDRISC score of ≥15, indicating 'high risk' for T2DM. The recruitment flowchart is presented in Appendix P. Fifty-two females and 11 males expressed interest in being interviewed. A stratified sampling approach was used to recruit a comparable number of participants by gender, age, BMI, and FINDRISC category. Twenty-six females and all 11 males were contacted on a rolling basis, with 17 females and no males agreeing to an interview.

5.3.2. Interviews

After providing informed consent, participants were emailed a colour brochure (see Appendix K), and links to two videos of three-minutes in length, all showcasing one of the smartphone-based digital DPPs featured in the NHS digital DPP pilot (Murray et al., 2019). Participants were asked to view these materials before attending the interview. Interviews ran between February and March 2021 in Ireland when COVID-19 'lockdown' restrictions were in effect. All interviews were conducted via video call in a semi-structured format by LV and audio recorded. The interview guide (see Appendix R) was developed to facilitate discussion on each factor of the extended framework for digital DPP acceptability. Interviews ran for 22 to 45 minutes (mean duration = 33 minutes), and each participant received a €20 gift card.

Audio files were imported into QSR International's (2021) NVivo software (released in March 2020), and transcribed by LV for analysis. Field notes were taken by LV throughout the interview and analysis process to record context-sensitive information and facilitate reflexivity, a process in which the researcher reflects on their values, preconceptions, or behaviours that could affect data interpretation (Parahoo, 2006).

5.3.3. Data Analysis

Data were analysed using deductive and inductive qualitative content analysis as described by Elo and Kyngäs (2008) and, Hsieh and Shannon (2005). The analyses were performed by two researchers. First, LV, is a male with a master's degree in health psychology and has extensive experience developing and delivering nutrition and physical activity interventions. Second, CT, is a female with a master's degree in psychology and has extensive experience in cognitive psychology and decision making.

5.3.3.1. Deductive Content Analysis. First, LV and CT reviewed all audio recordings and transcripts to ensure data familiarity. Next, transcribed interviews were deductively analysed in line with the extended framework. Six structured categorisation matrices (see Elo & Kyngäs, 2008) were developed to match the framework's six factor clusters. Each matrix contained one or more categories, with each category representing a factor of the framework (e.g., the *personal health factor* matrix contained the categories of *knowledge of T2DM* and *perceived threat of T2DM*), while some also contained sub-categories (e.g., the *heathy eating* category contained the sub-categories *barriers to healthy eating*, and *facilitators to healthy eating*). Coding was conducted by LV where each section of text was coded to a category or sub-category. Finally, all coding was reviewed by CT, and the categorisation matrices revised by both researchers through discussion. A summary of the deductive content analysis process, including final categorisation matrices and example codes, is presented in Appendix AJ.

5.3.3.2. Inductive Content Analysis. The aim of this inductive process (conducted independently by LV and CT) was to develop themes to elaborate on patterns of experiences and views within the categories identified during deductive analysis. First, all codes were reviewed and verified. Second, the coded text was used to guide the development of themes and sub-themes under each category or sub-category. Finally, all themes were reviewed independently against the coded text and, after discussion between researchers, refined where necessary. While the QCA literature often refers to these 'code clusters' as categories (Elo & Kyngäs, 2008; Hsieh & Shannon, 2005), they were called 'themes' here as the term ‘category’ was already used to represent factors of the extended framework. As the aim of this study was to explore the many factors of the extended framework at limited depth, descriptive themes (what participants were trying to say) were generated rather than themes of meaning (the underlying meaning of their stories).

5.4. Results

The final sample consisted of 17 females (Table 5.2) with an average age of 50 years (range = 23-71 years). Of the 17 participants, 76% (*n* = 13) had a BMI of ≥25, and 71% (*n* = 12) were at a high-to-very high risk of developing T2DM based on their FINDRISC score.

Table 5.2

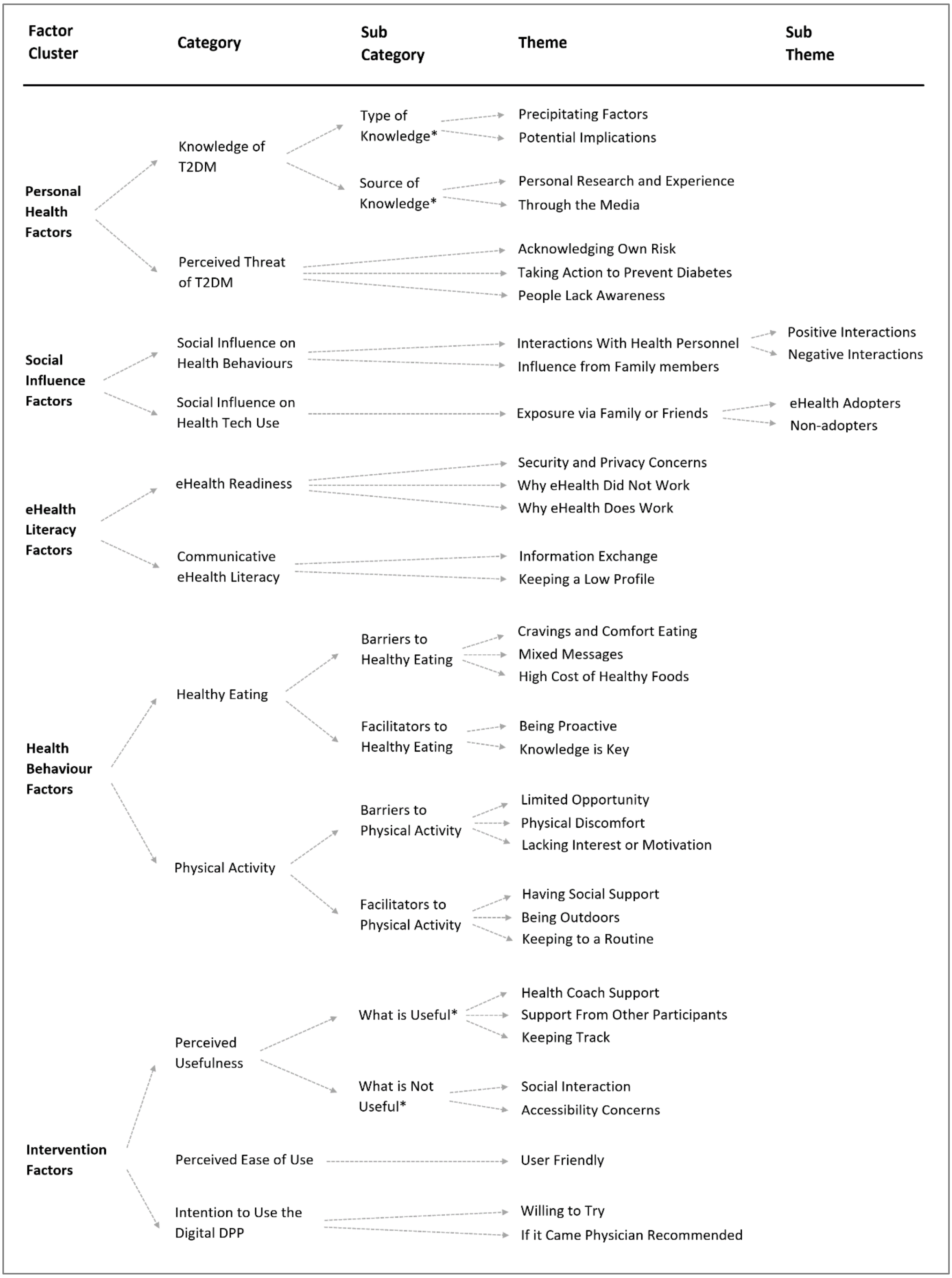
Participant Characteristics

Characteristic and Category	*n*	%
Age in years		
18-29	1	5.88
30-39	3	17.65
40-49	4	23.53
50-59	3	17.65
60+	6	35.29
Ethnicity		
White Irish	15	88.24
Any other white background	1	5.88
Asian or Asian Irish	1	5.88
Highest education obtained		
Postgraduate degree	8	47.06
Undergraduate degree	7	41.18
Technical or vocational	2	11.76

Four additional sub-categories were identified via deductive analysis. *Type of knowledge* and *source of knowledge* were added under *knowledge of T2DM. What is useful* and *what is not useful* were added under *perceived usefulness.* Through inductive analysis, one-to-three themes were developed to elaborate on each factor. These themes (denoted by ‘T’), each supported by one or more participant quotes, are presented below by category and sub-category. Additional quotes are presented in Appendix AK. Themes were not generated for the category *desired features for a digital DPP* as a large range of features were outlined that varied across participants. Several of the most requested features are listed under the category heading below, and an exhaustive feature list is presented in Appendix AL. Figure 5.2 presents an overview of the combined deductive/inductive analysis.

Figure 5.2

Overview of the Categories and Themes Identified via Qualitative Content Analysis



Note: Categories/sub-categories represent factors of the extended framework.

*Denotes sub-categories generated during deductive content analysis.

5.4.1. Knowledge of T2DM

5.4.1.1. Type of Knowledge

5.4.1.1.1. T1: Precipitating Factors. Participants referenced many 'lifestyle-related' potential causes of T2DM, such as stress, limited physical activity, unhealthy food choice, alcohol consumption, and body weight. One participant questioned the term 'lifestyle disease' when used to describe T2DM, due to its potential to assign blame.

> It seems to be accepted that it is a lifestyle disease. That it can be managed by diet, by exercise, I suppose by reduction in stress. But…I do think we're missing out on something. I think there's something there that hasn't been investigated enough because a 'lifestyle disease' is a very easy label. I think there could be something genetic. (P3)

5.4.1.1.2. T2: Potential Implications. Several participants described the negative physical effects of T2DM (e.g., eye, kidney damage), while some cited negative emotions such as guilt.

> You would feel guilty if you have it in the sense that you could have prevented it. It does lead to um, major problems with circulation, eyesight, different things. (P12)

5.4.1.2. Source of Knowledge

5.4.1.2.1. T1: Personal Research and Experience. Some participants learned of T2DM through their work in the health sector, while others conducted their own research through books, or online.

> Yeah, I've probably bought some books on it…there's diabetes.co.uk website with a very good forum, so I would've been looking at that. (P13)

5.4.1.2.2. T2: Through the Media. Others received T2DM information through the media, namely newspaper articles, online news, and radio.

> There's a radio presenter. He has type 2 diabetes, so I've been listening to him over the last couple of years since he got his diagnosis, talking about it. (P14)

5.4.2. Perceived Threat of T2DM

5.4.2.1. T1: Acknowledging Own Risk. Most participants understood their own risk of developing T2DM. Some were informed by a health professional, while others noted a family history of T2DM. Several participants also discussed a previous diagnosis of gestational diabetes.

> I know I'm a prime candidate for type 2 diabetes. Based on my lifestyle, weight, the fact I had it in pregnancy already so, it's in the family. It's a worry, yeah. (P7)

5.4.2.2. T2: Taking Action to Prevent Diabetes. Some had taken steps to prevent T2DM by improving their health behaviours, in some cases, to avoid medication.

> I think it's a good thing that we can at least change our lifestyle, and we can adopt things. I know better. I am taking very little sugar intake. I try to watch carbohydrates. (P4)

> I really am not interested in taking medication so I just said to him [the GP]: 'give me three months to see what I can do about reversing it'. And I reversed it back about three points. (P15)

5.4.2.3. T3: People Lack Awareness. Participants noted a lack of awareness of the seriousness of T2DM, particularly among older adults.

> In Ireland it's something that's definitely not treated as a chronic disease…they don't believe diabetes to be the same extent to be as severe as say cancer… it's crazy basically…the way people understand diabetes, and they just don't seem to think that it's as debilitating as it can be…I feel like the younger people are more aware, whereas the older, they're more stuck in their ways. (P10)

5.4.3. Social Influence on Health Behaviours

5.4.3.1. T1: Interactions with Health Personnel. Participants had been advised by GPs, dietitians, and other health personnel to make dietary and physical activity improvements and/or lose weight. Some were happy with these interactions.

> I was sent to a dietitian, and she said, 'you work hard…we will educate your stomach so that you will never have a difficulty with weight again'. So, she taught me so beautifully. It was so humane to reduce what I was eating and improve the quality of what I was leaving on my plate. (P3)

However, many described a lack of support and understanding, and in some cases, weight stigma.

> But no other information [on T2DM] anywhere really…we get like a health screening maybe once a year or something, and then they give about your weight…well, that's it. That's all, they just give out to you for it. (P7)

> I think you're kind of on your own you know…'cause they [GPs] don't even want to see you…you're not going to be annoying them by going in and saying oh, you know, 'can you weigh me?' (P12)

One participant felt GPs would be opposed to receiving digital DPP data.

> Share it with your doctor? Ha! To get lacerated? And it thrown in your face? I'd love to meet the doctor who would welcome you using something like that [a digital DPP]. They're very far back with it. (P3)

5.4.3.2. T2: Influence from Family Members. Several participants were given unsolicited and/or unwanted advice by family members to improve their diet and physical activity levels.

> They wouldn't comment on my weight…but it's more like if you really want to be healthy you shouldn't be working so much or you should go out or, it's yeah, the specifics would be, 'you should take more exercise.' (P8)

5.4.4. Social Influence on eHealth Use

5.4.4.1. T1: Exposure via Family or Friends. Most participants received information about health technologies from family and friends. Some adopted these technologies. . .

> All of my family have them now, they're all going on about them…people like to have something else to focus on and be like: 'oh look I did 12,000 steps today'…I have the health app that Samsung have on the phone, so I'd use that every now and again. (P14)

. . .while others had no interest in using them.

> I do have a friend and to me she became obsessive [counting steps] and, no I wouldn't definitely like to do that. (P17)

5.4.5. eHealth Readiness

5.4.5.1. T1: Security and Privacy Concerns. Regardless of whether participants endorsed health technologies, data protection was a concern for some.

> I'm very cagey. I will not sign into any health app on my phone that monitors my health because I do not trust the health insurance companies…I have no doubt they would either pay so well, they would get the information, or they would hack so well. (P3)

5.4.5.2. T2: Why eHealth Did Not Work. Some initial adopters stopped using health technologies (e.g., smartwatch) due to lack of interest in learning the device's full capability, or after experiencing discomfort.

> I had a Fitbit, I gave it away. I was using just the bare minimum. It had a lot more capability, but I didn't give myself enough time to educate myself how to use it. (P1)

> The watch actually doesn't suit me at the minute, I'm allergic to the strap. (P7)

Others felt these technologies generated negative 'obsessions'.

> I had a Fitbit there a couple of years ago, but I stopped wearing it 'cause I got obsessed with looking at how much sleep I was getting, and I nearly felt tired if I didn't. (P6)

5.4.5.3. T3: Why eHealth Does Work. Participants who stated they often used health technologies praised the benefits. Self-monitoring of eating and exercise behaviours facilitated motivation and accountability, while online classes and consultations enabled social support.

> I used MyFitnessPal the most and yeah, I found it very good 'cause you were able to track your food according to the brand and everything and right down to the small details. Things like that open up your eyes to what you're actually eating…it was very motivating to be able to just see where you're at in your day and what you're allowed and what you're not allowed more or less. (P10)

> She's a Slimming World consultant. She runs the Zoom call and then the rest of the participants during the week, and they talk to you then about how you got on that week…But the Zoom calls, they are good, it's nearly like a shared community. (P7)

5.4.6. Communicative eHealth Literacy

5.4.6.1. T1: Information Exchange. When communicating with others online regarding health-related matters, participants shared advice through video calls or online discussion groups.

> There was a Keto group…I joined that group also, so because of these two groups on Facebook I got a lot of ideas for making food like, what can be in my lunch, what can be in my dinner. (P4)

5.4.6.2. T2: Keeping a Low Profile. However, some preferred not to interact online, using these forums as a learning platform only, to avoid social judgement.

> Very seldom I would ever ask a question…or they're going to think, 'oh she knows it all, so like she's had one child, and all of a sudden she's like, quite extraordinary'…That would be good, to be able to view the information but not necessarily be under pressure to post. (P16)

5.4.7. Healthy Eating

5.4.7.1. Barriers to Healthy Eating

5.4.7.1.1. T1: Cravings and Comfort Eating. Participants cited cravings, or 'addiction' to chocolate and/or sugar as challenges. Some consumed these foods to achieve comfort.

> That's just…the snacking and treats and chocolate and stuff…it's comfort eating and I don't, I haven't managed to grapple with that yet. (P8)

5.4.7.1.2. T2: Mixed Messages. Others felt bewildered by contradictory nutritional advice and were unsure of what they should be eating.

> Trying to follow the pyramid, and I was eating more potatoes so I wouldn't be looking for biscuits afterwards and then somebody said to me, 'well potatoes are actually quite high in carbs', so I stopped eating potatoes. (P2)

5.4.7.1.3. T3: High Cost of Healthy Foods. A few were unhappy that healthy foods were relatively more expensive than less healthy options, and thus less accessible.

> Well, the cost of food…it's extortionate. I've made a conscious decision to try and eat what's in season, and I'd just buy the veg that is on special offer…I stopped buying strawberries and raspberries. (P16)

5.4.7.2. Facilitators to Healthy Eating

5.4.7.2.1. T1: Being Proactive. Participants felt that diet planning, pre-preparing meals, and organising shopping trips around healthy eating helped them to maintain a balanced diet.

> I've been trying to kind of batch cook things and have things constantly on standby as opposed to reaching out for whatever's there or ordering a takeaway. (P10)

> I've been trying to do a shop once a week…and then there's a local fruit and vegetable guy, so instead of going into the supermarket again, just having plenty of fruit and vegetables. (P14)

5.4.7.2.2. T2: Knowledge is Key. Some suggested that possessing good nutritional knowledge was the key to healthy eating.

> My background, I'm actually a dairy scientist…so I have a good understanding of the composition of foods, and we eat a reasonably healthy diet. (P2)

5.4.8. Physical Activity

5.4.8.1. Barriers to Physical Activity

5.4.8.1.1. T1: Limited Opportunity. Some participants felt they had little opportunity to be physically active, due to work and family commitments, poor weather, and/or ‘lockdown’ restrictions.

> I'm home schooling at the moment. I'm working, running a house. I try and get out at least two or three times a week for about an hour, but then the weather's bad…so it's not good. (P7)

> I am trying to adopt healthy lifestyle but it's very hard with this lockdown, and it's affected a lot because we are unable to do gym anymore. (P4)

5.4.8.1.2. T2: Physical Discomfort. Some wanted to be more active, but experienced pain or discomfort during or after exercise.

> I have really bad arthritis in both my knees, and it's quite painful sometimes to walk as I used to get gel injections. (P15)

5.4.8.1.3. T3: Lacking Interest or Motivation. A number or participants felt they lacked interest in, or motivation to complete physical activity despite having the opportunity.

> I did start walking more over the spring and the summer even a bit into the autumn, but that has stopped recently, 'cause it's, I don't want to be part of that world [walking for leisure]. (P9)

5.4.8.2. Facilitators to Physical Activity

5.4.8.2.1. T1: Having Social Support. Participants found it easier to exercise with friends as it facilitated social interaction, particularly with social opportunities restricted.

> I've a close-knit group of friends around me, so we meet up and go for walks because that seems to be the only thing we can do at the moment…It became the new coffee, the new night out…where you'd be walking, and chatting, and catching up. (P6)

5.4.8.2.2. T2: Being Outdoors. Some participants liked to be active outside, particularly after being indoors for long periods due to lockdown.

> I like the fresh air…it's easier to go out on a fine day rather than when it's a cold day…I suppose one thing with this pandemic is that you're dying to get out for your walk in a day. (P6)

5.4.8.2.3. T3: Keeping to a Routine. Participants who felt challenged by the lockdown and loss of routine found that establishing a new routine with regular scheduled exercise kept them active.

> I spent most of the pandemic trying to get into a routine of doing yoga, so probably what made the difference there was fixing a time of day where nothing else was going to happen. (P13)

5.4.9. Perceived Usefulness

5.4.9.1. What is useful

5.4.9.1.1. T1: Health Coach Support. Participants liked the idea of having regular contact with a health coach who would offer credible information and personalised guidance.

> I thought the coaching side of it is good…I suppose if you had questions on different things. Like instead of googling and guessing, that you could actually put it out there and ask someone who's going to give you an answer back that's evidence-based, and it's accurate. (P6)

5.4.9.1.2. T2: Support from Other Participants. Some liked the idea of an online social network, viewing this as a platform to organise social walks and share advice.

> There seems to be a lot of support from different sides. If there was people in your area that also had the app, that you could link in with people you can go for a walk with. (P14)

> Accountability…and there's a chat room and there's sharing, you're actually not alone and don't feel it's just me. Or just to chat with somebody having the same problems and talk through with you. (P17)

5.4.9.1.3. T3: Keeping Track. The self-monitoring aspect was praised as it encourages accountability and offers visual progress reports.

> Tracking the food I think is a good idea actually…I think it's a reminder, it's your conscience almost, so I think that I've never done it, but I actually think that could be a very good idea. (P17)

5.4.9.2. What is Not Useful

5.4.9.2.1. T1: Social Interaction. Some participants had a negative view of the online social network, mostly due to the desire for privacy.

> I would hate the part of meeting other people to talk about it. It just reminds me of an AA meeting. That for me that wouldn't work at all, I'd hate it. I'd feel uncomfortable about it and talking to people I don't know about my health. (P8)

5.4.9.2.2. T2: Accessibility Concerns. Others questioned the programme's accessibility, due to insufficient broadband coverage, or the perception that older adults would have difficulty accessing and using the technologies.

> I definitely think accessibility would be a major issue for rural parts of the country and the older generation. Yeah, so even just having a smartphone, but definitely broadband connections. (P10)

> I think older generations…my parents they, well I suppose they wouldn't be very tech savvy. I don't think an app like that would be good for them because they just wouldn't manage it. (P6)

5.4.10. Perceived Ease of Use

5.4.10.1. T1: User Friendly. Participants generally perceived the programme to be easy to use or learn. However, without hands-on experience, there was little elaboration on this.

> I thought it looked to be laid out very well and very clear and quite user friendly…it did look like it was really user friendly and really easy to use. (P16)

5.4.11. Intention to Use the Digital DPP

5.4.11.1. T1: Willing to Try. Participants would not unequivocally endorse the programme without hands-on experience, but some would be happy to try it.

> I think so, I'd have to give it a go and see but from looking at it initially, yeah it's inviting…something I'd try, but again I'd have to see as I said I might lose interest after a while, but initially yeah it looks good. (P7)

5.4.11.2. T2: If it Came Physician Recommended. Others would likely use it if it was recommended by a GP.

> I think if it was something a doctor was recommending to me then I probably would. I would probably take it on face value that it was a legitimate thing. (P11)

5.4.12. Desired Features of the Digital DPP

Participants discussed a unique range of desired features, including blood glucose monitoring, sound evidence base, medical record compatibility, online exercise classes, reminders and prompts, and gamification. However, the most common request was for the programme to be tailored to their needs, at the individual level (e.g., personalised goals), and/or group level (e.g., meeting participants with similar interests).

> I'm always caught between whether you should be very prescriptive in these things, or should be tailored to suit the person's need, and I think it has to be tailored. I don't think something very prescriptive would work for me. (P8)

> That it’s enjoyable I suppose that, you know, it's not about what you can't have or can't do or whatever, that it's you're linking in with people who have the same motivation as you. (P14)

5.5. Discussion

This study investigated factors relevant to the acceptability of a digital DPP through the lens of 17 women living in Ireland at risk of developing T2DM. Through semi-structured interviews we explored their experiences with social influence regarding health behaviours and technology use, barriers and facilitators to healthy eating and physical activity, and perceptions regarding the usefulness and usability of a digital DPP, plus its most desired features. These perspectives could shape the content and communication strategies of future digital DPPs, potentially maximising user engagement. After deductively organising coded text from the interview transcripts, we used inductive content analysis to develop themes for each factor within the six factor clusters (personal health, social influence, eHealth literacy, health behaviour, intervention, and feedback) of the extended framework.

5.5.1 Personal Health Factors

Participants understood their risk of developing T2DM and were knowledgeable regarding the condition's aetiology and implications. Such knowledge may increase one's capability or motivation to engage in preventive health measures (Pelullo et al., 2019), which could increase the acceptability of a digital DPP as the programme facilitates such efforts. Most participants felt that T2DM can be prevented by improving diet and physical activity, and some had already made such changes. However, the term 'lifestyle disease' was criticised for its potential to assign blame to those who develop the condition. There were also concerns that developing T2DM would elicit guilt for not taking preventive action sooner. Such guilt is not uncommon in those who develop preventable conditions that manifest through deleterious health behaviours (Lindqvist & Hallberg, 2010). When promoting a digital DPP, care should be taken with communication strategies so that prospective users perceive the intervention as empowering, rather than judgemental. Participants cited a lack of awareness regarding the seriousness of T2DM, particularly among older adults. Our previous study found an unexpected negative association between objective risk for developing T2DM, and perceived seriousness of the condition (Van Rhoon et al., 2021). As FINDRISC scores automatically increase with age, this negative association could be due to the age-awareness link suggested by participants. Supporting this, previous research suggests that health literacy levels of older adults (from age 55) is generally lower than that of younger adults (Manafo & Wong, 2012).

5.5.2. Social Influence Factors

Participants were exposed to health technologies through family and/or friends. Some subsequently adopted a device, but for others, this exposure had the opposite effect (e.g., after witnessing a friend's self-tracking 'obsession'). It is possible that socially driven health technology exposure may deter adoption if the prospective user perceives the technology to produce undesired behaviours. The diet and physical activity advice participants received from family members was often unsolicited and seemingly unwelcome. However, participants did seek advice online through social media groups such as Facebook, and video coaching sessions, suggesting that some were already engaging in the types of services that are offered through a digital DPP. Discussions with health professionals regarding T2DM focused on improving eating and exercise behaviours, which could explain the strong positive association between perceived social influence on these behaviours and the perceived threat of T2DM in our previous study (Van Rhoon et al., 2021). However, many participants were unhappy with the lack of knowledge and support from health professionals, citing a lack of empathy and understanding regarding their body weight and physical limitations. This supports a recent study which found an international prevalence in weight stigma by doctors. Patients who perceived this stigma reported less frequent listening and understanding from health professionals (Puhl et al., 2021).

5.5.3. eHealth Literacy Factors

All participants were familiar with technology, using multiple devices to communicate with friends, family, or colleagues, and to access the internet. Regular health technology users praised the benefits of these technologies. Activity and diet self-monitoring via wearable devices or smartphone applications was deemed positive and motivating, enabling participants to set activity or macronutrient targets whilst tracking their progress. Some participants engaged with pre-recorded and live exercise classes via YouTube or Zoom respectively. Participants who abandoned health technologies did so for various reasons. These included lack of interest in utilising the technology's full potential or developing contact dermatitis from a wearable device. Furthermore, several participants experienced unsettling 'obsessions' with self-monitoring. As was the case here, digital self-monitoring has been found to produce both positive and negative emotions (Orji et al., 2018). Although self-monitoring is a key digital DPP feature (Van Rhoon et al., 2020), alternative behaviour change strategies could be prioritised when engaging with individuals averse to self-monitoring. The concern for information privacy was a common thread, and although this did not necessarily deter participants from using health technologies, there was concern over the data they were sharing, how it was obtained, and its intended use, such as the fear of insurance companies accessing private information without consent. It is therefore important that digital health interventions offer clear and concise data privacy statements, and/or allow users to opt out of sharing certain data.

5.5.4. Health Behaviour Factors

Participants were more likely to engage in healthy eating behaviours when they were proactive with meal planning and shopping trips, possess the knowledge to select health-promoting foods, and could ascertain a meal's nutritional content. This 'nutrition literacy' has been positively associated with diet quality in previous research (Gibbs et al., 2018). Barriers to healthy eating included cravings and comfort eating, inconsistencies in nutritional recommendations, and the high cost of healthy foods. While these first two are addressed in digital DPPs, the latter represents a population-level issue outside the scope of individual intervention. It has therefore been recommended that population-wide strategies for diabetes prevention are implemented in tandem with individual-level approaches (Pierse et al., 2021).

COVID-19 restrictions featured prominently when discussing physical activity. A desire to be outside facilitated physical activity, while those who had adjusted to an exercise routine found it easier to exercise regularly. Furthermore, participants preferred exercising socially with friends. A systematic review found a positive association between social support specific to physical activity and adult physical activity levels (Smith et al., 2017). Barriers to physical activity included physical pain/discomfort, limited opportunity (e.g., poor weather, gym closures), and lack of interest or motivation. These three themes map to the components of the COM-B model developed by Michie and colleagues (2011), which suggests that, to remain physically active, one must possess the capability, opportunity, and motivation to perform regular physical activity. Online exercise classes could be a valuable addition to a digital DPP. However, given recent reports of limited uptake, particularly among less active individuals, future research is needed to determine how to tailor these classes for those who experience physical and/or motivational barriers (Füzéki et al., 2021).

5.5.5. Intervention Factors

When asked their thoughts on the digital DPP, participants described the health coaching (which facilitated education and motivation), peer support (which promoted social interaction, shared activities, and advice), and self-monitoring (progress tracking and accountability) as the most useful features. A recent systematic review of digital DPPs found that health coaching, social support, and activity tracking were the most effective features for promoting weight loss (Van Rhoon et al., 2020). These features could therefore be effective because they generate greater user engagement. When asked about undesirable aspects of the programme, peer support was also discussed, as some participants wished to remain private, autonomous, and avoid social judgement. This could explain the unexpected negative association between communicative eHealth literacy (or the confidence and ability to communicate with others online regarding health matters), and the perceived usefulness of a digital DPP found in our previous study (Van Rhoon et al., 2021). Some may happily discuss health matters with close friends, family, or health professionals, but not with unfamiliar people. Together, this suggests, as was the case for self-monitoring, that key digital DPP features or 'selling points' may not be appealing for some, and it is therefore recommended that other features or benefits are prioritised when promoting or tailoring a digital DPP to these individuals. Some participants had concerns regarding digital DPP accessibility for older adults and those in rural areas, due to limitations in broadband internet coverage, and lack of smartphone ownership and technology literacy among older adults. According to recent Irish survey data, 93% of households have internet access (Central Statistics Office, 2021). However, smartphone usage among people aged 60-74 was only 37% compared with 96% and 77% for those aged 30-44 and 45-59 respectively (Gibney & McCarthy, 2020). Therefore, while geographical reach may be sufficient, smartphone based digital DPPs may be less accessible for older adults than would face-to-face DPPs.

5.5.6. Feedback Factors

When asked about features they would like included in a digital DPP, participants offered many suggestions. These were diverse, and in most cases, a feature suggested by one participant was not suggested by another. However, the most common request was for a programme to be tailored to meet their needs. Offering this flexibility may improve the uptake of a digital DPP, as tailored digital behaviour change interventions have achieved higher levels of user engagement and effectiveness (Lustria et al., 2013; Ryan et al., 2019).

5.5.7. Limitations and Future Directions

This study has some limitations. First, all participants who expressed an interest in taking part were female. As males are traditionally less likely than females to engage in preventive health services (Davis et al., 2012), this discrepancy is not unusual. Participants were also predominantly white, with high levels of formal education, limiting the generalisability of our findings. Further studies involving other populations (e.g., males/non-binary, culturally/educationally diverse) is needed to ensure that future programmes are accessible for hard-to-reach groups. Second, in our initial study design, we intended to conduct focus groups, and share sample digital DPP content with participants in person to facilitate group discussion. However, given COVID-19 restrictions at the time of the study, face-to-face data collection was not possible, and participants could only experience the digital DPP via brochure and video presentations. Finally, participants' experiences regarding certain topics (e.g., physical activity) may be limited to a 'lockdown' context, and their perceptions may have changed once restrictions eased.

5.5.8. Conclusion

This study explored factors relevant to the acceptability of a digital DPP from the perspective of women living in Ireland at risk of developing T2DM. We found that participants understood the aetiology and implications of T2DM, and wish avoid the condition. Participants experienced both favourable and unfavourable social influence with regards to their eating and exercise behaviours, and health technology use; and experienced several facilitators and barriers to healthy eating and physical activity, particularly amid COVID-19 restrictions. All participants were familiar with and/or capable of using health technologies. However, views on these technologies were diverse, and in some instances, oppositional (e.g., self-monitoring viewed both positively and negatively). When discussing the digital DPP, participants endorsed the personalised health coaching, peer support, and self-monitoring as it facilitated education, motivation, and accountability. However, peer support was also viewed negatively by some, and others questioned the programme's accessibility for older adults and/or those in rural areas. Given the diversity of experiences, needs, and motivations within a relatively homogenous sample, we emphasise the importance of tailored digital health solutions and offer recommendations for their implementation. Our findings could inform the content and communication strategies of future digital DPPs or other digital health interventions, potentially maximising user engagement and effectiveness.

5.6. Acknowledgements

The authors wish to extend their gratitude to the volunteers who kindly donated their time to participate in the online interviews and share their thoughts and experiences.

5.7. Disclosure Statement

No potential conflict of interest was reported by the authors.

5.8. Funding

This work was supported by the Irish Research Council under the Government of Ireland Postgraduate Scholarship [Project ID number: GOIPG/2019/1355]; and the National University of Ireland, Galway under the Hardiman Scholarship.

5.9. Data Availability Statement

The authors confirm that the data supporting the findings of this study can be found in the article and supplemental online materials.

6. General Discussion

6.1. Discussion Overview

In this final chapter, a summary of the research findings from all three studies will be presented, followed by a discussion on how this research has extended the evidence base. Next, the strengths and limitations of this research will be highlighted, and recommendations for future studies to overcome these limitations will be offered. The implications of this research will also be discussed, with reference to future research, policy, and practice. The chapter will close with a set of concluding statements.

6.2. Summary of the Research Findings

The overarching aim of this research was to conduct three separate but interrelated studies to build the evidence base for the development and implementation of an Irish digital DPP for adults at risk of developing T2DM. This aim was achieved by following the MRC framework for developing and evaluating complex interventions (Craig et al., 2008) and: (a) identifying the evidence base regarding digital DPPs, (b) identifying and developing appropriate theory for the acceptability of digital DPPs, and (c) understanding the perspectives of target users regarding the factors that determine a digital DPP's acceptability.

The aim of study one was to conduct a systematic review of technology-driven T2DM prevention interventions to determine their effectiveness in achieving clinically significant weight loss and improvements in additional outcomes linked to the onset of T2DM; and to identify the BCTs and digital features most frequently used in effective interventions. The aim of study two was to develop a new model of digital health acceptability that incorporates theories of health behaviour, health beliefs, and eHealth literacy, and then test this model to identify the factors that influence the intention of adults living in Ireland to use a digital DPP. To further understand the acceptability of a digital DPP among its target users, study three aimed to explore the extended views and experiences of adults at risk of T2DM on the factors affecting digital DPP acceptability. This included their understanding of T2DM, experiences with social influence on health behaviours, views on health technologies, barriers and facilitators to healthy eating and physical activity, and perceptions regarding the usefulness, usability, and desired features of a digital DPP.

6.2.1. Study One

The systematic review assessed 19 studies of 21 technology-driven T2DM prevention interventions. A majority of the interventions achieved clinically significant short-term weight loss in adults at risk of developing T2DM. However, many interventions fell short of reaching the 12-month 5% weight loss target as set by the CDC (2018) and NICE (2019). Of the 21 interventions, 19 and 12 were assessed on their effectiveness in achieving short-term and long-term proportional weight loss respectively. In the short term (≤6 months), 63% or 12 of 19 interventions achieved a clinically significant weight loss of at least 3%. However, only 33% or 4 of 12 interventions achieved the 5% weight loss benchmark for clinical significance at ≥12 months. Of the 9 and 13 interventions that reported HbA1c and fasting glucose respectively, 77% reported a significant improvement in HbA1c, and 38% reported a significant improvement in fasting glucose. In the two interventions that reported rates of T2DM incidence, these rates at 24 months were 11% and 18% respectively, each lower than those rates found in the usual care groups at 18% and 27% respectively. Rates of attrition varied substantially between interventions in both the short term (9.4% to 43.4%) and long term (7.4% to 79.8%). Very few studies reported outcomes pertaining to dietary intake, physical activity, cost-effectiveness, and user engagement.

Interventions which used a larger number of BCTs were more effective. Seven unique BCTs were frequently identified in effective interventions. These were: social support (unspecified), goal setting (behaviour), goal setting (outcome), feedback on behaviour, self-monitoring of outcome(s) of behaviour, self-monitoring of behaviour, and problem solving. In the short term, effective interventions used, on average, 5.6 more BCTs than non-effective interventions, with social support (unspecified) and adding objects to the environment the most effective BCTs. In the long term, effective interventions used, on average, 3.7 more BCTs than non-effective interventions, with problem solving identified as the most effective. Interventions which used a larger number of passive and interactive digital features were more effective. Three digital features, all passive, were frequently identified in effective interventions. These were health and lifestyle information and advice, diet tracking, and activity tracking. In the short term, effective interventions used, on average, 1.9 more passive features and one more interactive feature than non-effective interventions. The most effective were the passive features of activity tracking and diet tracking, and the interactive feature of online health coaching. In the long term, effective interventions used, on average, 1.9 more passive features and 0.25 more interactive features than non-effective interventions. The most effective were the passive features of activity tracking, reminders and prompts, weight and biomeasure tracking, and the interactive feature of online health coaching.

6.2.2. Study Two

Study one confirmed that technology-driven T2DM prevention interventions can achieve clinically significant weight loss, and it was established which BCTs and digital features were likely most effective. However, rates of participant drop-out in several interventions were very high. While the findings suggest that these interventions can work, low levels of participant engagement could prevent the interventions from reaching their full potential. Study two extended the findings of study one by investigating the acceptability of a digital DPP among adults living in Ireland, to identify potential avenues for maximising user engagement. An 11-factor digital health acceptability model was developed and subsequently tested using SEM. The analysis found the model to explain 65% of the variance in the intention to use a digital DPP.

Most factor associations were statistically significant. Health status (one's level of T2DM risk) was positively associated with perceived susceptibility to T2DM but negatively associated with perceived seriousness of T2DM. Subjective norm was positively associated with both perceived susceptibility to T2DM and perceived seriousness of T2DM. Image was positively associated with perceived usefulness. eHealth readiness was positively associated with both perceived usefulness and perceived ease of use. Communicative eHealth literacy was positively associated with perceived ease of use but negatively associated with perceived usefulness. Perceived susceptibility to T2DM was positively associated with both perceived usefulness and intention to use the digital DPP. Perceived ease of use was positively associated with perceived usefulness, which in turn was positively associated with intention to use the digital DPP. General eHealth literacy, which was assessed using the eHEALS, was not a significant predictor of the programme's perceived ease of use.

6.2.3. Study Three

Study three extended the work of study two through the development of an extended framework for digital DPP acceptability. While study two identified the factors that influence the intention of adults living in Ireland to use a digital DPP, study three explored how and why these factors affected programme acceptability among a group of adults at risk of T2DM. Through semi-structured video interviews and QCA, several themes were identified under each category of the extended research framework.

Participants understood the aetiology of T2DM and the disease's implications. This knowledge was mostly obtained through personal research and experience, and via the media.

Participants also acknowledged their high-risk status, and some had already taken steps to try and reduce this risk. However, some participants felt there was a lack of awareness of the disease in Ireland, particularly among older adults. On the topic of social influence, participants mostly received health behaviour advice from HCPs and/or family members. Such advice was perceived as either positive or negative, with several participants discussing negative interactions with HCPs, describing a lack of support, understanding, and knowledge regarding T2DM, in addition to stigma about their weight. Participants described their family and friends as a source of influence over their adoption of DHTs. When discussing their readiness to engage with DHTs, participants were concerned about the security and privacy of their data, and the threat of insurance companies obtaining this data without permission. Frequent users of DHTs felt that self-monitoring their eating and exercise behaviours facilitated motivation and accountability, while online classes enabled social support. However, some users stopped using DHTs due to lack of interest in learning the device's full capability, or after experiencing discomfort from a wearable device.

On the topic of healthy eating, barriers included cravings and comfort eating, mixed messages regarding nutritional advice, and the high cost of healthy foods. Facilitators to healthy eating included being proactive and possessing sufficient nutritional knowledge. When discussing physical activity, the COVID-19 lockdown restrictions were mentioned frequently. Barriers to physical activity included: limited opportunity due to work/family commitments and gym closures, physical discomfort during and after exercise, and a lack of interest in or motivation to engage in physical activity. Facilitators included having social support, the desire to be outdoors, and keeping to a set routine.

When discussing the digital DPP, the programme was viewed as user friendly. Participants described the health coach support, peer support, and self-monitoring of diet and physical activity as the most useful aspects of the programme. However, several participants described the social interaction component as a turn-off, preferring to remain private and avoid possible social judgement. There were also programme accessibility concerns, particularly for older adults due to perceptions of lower eHealth literacy, and for those who reside in remote areas with limited broadband connectivity. When asked about their intention to use the programme, several were willing to try it, while others felt they would be more likely to use it if it came recommended by their GP.

6.3. Contribution of This Research

This research has extended the knowledge base within multiple fields of research, both within Ireland, and internationally. First, this research has advanced the area of T2DM prevention in Ireland by producing an evidence base to inform the development and implementation of a programme that could counter what has recently been called a 'dramatic rise' in the country's T2DM incidence rate (Pierse et al., 2021). Second, this research determined which digital T2DM prevention interventions are most effective, and it was discerned which BCTs and digital features could have the strongest impact. This information could help to improve the effectiveness of future DPPs or other digital health interventions. Third, a new digital health acceptability model and extended framework was developed using both quantitative and qualitative methodologies, advancing the areas of T2DM prevention, technology acceptance, health behaviour, health beliefs, and eHealth literacy. Finally, by identifying and exploring the factors that influence digital DPP acceptability among adults, including those at risk of T2DM, this research has identified knowledge gaps regarding T2DM, and avenues through which a digital DPP may be tailored to maximise uptake among its target users. Furthermore, this research extends the global evidence base on digital health as very few studies had assessed technology acceptance at the pre-use stage (Nadal et al., 2020), and no study to date had conducted qualitative exploration into the acceptability of a digital DPP.

6.3.1. Supports Type 2 Diabetes Prevention in Ireland

In Ireland, T2DM and PDM collectively affect approximately 408,000 or 17.4% of adults over 40 years of age, and this figure is expected to reach 717,000 by the year 2036, prompting the HSE to consider the development of a national DPP (Pierse et al., 2021). In view of this, Pierse et al. (2021), using the face-to-face NHS-DPP as a benchmark, conducted a simulation study to assess the potential economic and health impact of a face-to-face Irish DPP. According to findings, the DPP would be cost saving under two scenarios. In the first scenario, excess health care and intervention costs will be reduced by €13.5 million over a 15-year period if the programme matches the NHS-DPP on outcomes of T2DM incidence reduction (at 26%), duration of effectiveness (4 years), and attendance rates (4% of people with PDM per year). In the second scenario, where the yearly attendance rate is set to 12% with all else equal, the 15-year cost savings would reach €39.4 million. In these two scenarios, QALYs would increase by 10,471 and 31,915 respectively, while deaths attributed to T2DM would decrease by 408 and 1247 respectively. However, if effectiveness or attendance falls significantly short of NHS-DPP projections, the programme would be cost increasing at a figure of up to €46.8 million (Pierse et al., 2021). Based on this study, the success or healthcare cost-saving potential of an Irish DPP appears contingent on three key outcomes. These are: (1) programme effectiveness, (2) user engagement, and (3) implementation costs. The present research considered all three aspects, and findings suggest that a digital DPP, when implemented in Ireland could potentially be effective, engaging, and cost-saving.

First, study one confirmed that real-world digital T2DM prevention interventions can achieve clinically significant improvements in weight loss and outcomes linked to the onset of T2DM at levels comparable to face-to-face interventions. A recent study of the NHS-DPP digital pilot reported similar findings, as the digital programme achieved significant improvements in body weight and blood glucose at levels on par with the face-to-face NHS-DPP (Ross et al., 2022). However, longitudinal data on T2DM incidence is not yet available.

Second, as internet use and smartphone adoption in Ireland is relatively high and rising steadily (Kemp, 2022a, 2022c), a digital DPP would be accessible for a sizeable proportion of those risk of T2DM. However, in acknowledgement of the user engagement challenges experienced by DPPs abroad, studies two and three explored factors that affect the acceptability of an Irish programme. The findings of these studies may be used to develop and tailor a digital DPP and its communication strategies to engage adults living in Ireland and maximise uptake. Recent studies of the US NDPP and NHS-DPP indicate that digital DPPs can achieve higher uptakes than their face-to-face counterparts, even among older adults. When assessing the US NDPP, Cannon et al. (2022) found that, between the years of 2012 and 2019, the number of people enrolled in the face-to-face and digital programmes was 166,191 and 269,001 respectively. However, the annual enrolment gap between the two programme streams is proportionally larger, further favouring the digital programme as it was first implemented three years after the in-person programme had commenced. Moreover, this gap may have since widened as data were collected prior to the COVID-19 digital health boom. In the NHS-DPP, the conversion rate for the face-to-face programme (the proportion of referred individuals who attended initial assessment) over a 12-month period was 56%, or 55,275 out of the 99,473 referred (Howarth et al., 2020). Although the NHS-DPP digital pilot had a much smaller sample size, 74% of the 2,424 referred individuals registered with the programme (Ross et al., 2022). Additionally, there was no digital divide for older participants, as adults in the age categories of 55-64 and 65+ represented a respective 30%

and 32% of all registered participants, and each group achieved greater weight loss than participants aged 18 to 55. This relatively high uptake and effectiveness among older adults is promising, as several participants in study three felt that older adults could have difficulty using DHTs and engaging with a digital DPP.

Third, one challenge when assessing whole interventions is that the effects of an individual component often cannot be discerned. Identifying the most effective components of an intervention is important, as one can take the cost of each component and assess whether the effect of the component justifies its inclusion within the intervention (Collins et al., 2016). Although the present research could not identify the cost of implementing each BCT and digital feature, the systematic review did identify the components most frequently used in effective interventions. Therefore, developers of an Irish DPP could minimise implementation costs and maximise cost-effectiveness by including fewer components that individually or collectively have a larger effect, both on engagement and T2DM-related outcomes.

These three points suggest, based on the conditions outlined by Pierse et al. (2021), that a digital DPP could indeed be cost-saving when introduced to Ireland. While longitudinal data is not yet available from the NHS-DPP digital pilot to ascertain a reduction in T2DM incidence, this stream has matched the in-person programme on improvements in key outcome measures and has surpassed its level of engagement. Furthermore, developers of an Irish digital DPP could use the results of all three present studies to tailor the programme and its communication strategies to maximise acceptability, and to apply only the most effective intervention components to increase cost-effectiveness.

6.3.2. Established What Works in Digital Diabetes Prevention Interventions

Informed by evidence from the landmark diabetes trials, the IMAGE toolkit for the prevention of T2DM in Europe (Lindström et al., 2010), and the NICE recommendations for preventing T2DM in people at high risk (NICE, 2017) listed several BCTs that should be included in T2DM prevention interventions to maximise effectiveness. A meta-analysis by Ashra et al. (2015) supported the application of these guidelines, as greater adherence by the interventions to both IMAGE and NICE recommendations was associated with greater improvements in body weight and blood glucose. However, these guidelines and findings pertain to the delivery of face-to-face interventions only, and it was unknown whether these BCTs were equally effective in digital interventions. According to study one, the most effective BCTs were social support (unspecified), goal setting (behaviour), goal setting (outcome), feedback on behaviour, self-monitoring of outcome(s) of behaviour, self-monitoring of behaviour, and problem solving. Each of these are listed in the IMAGE and NICE guidelines, suggesting that these techniques translate well to digital delivery and should therefore be used in all future digital DPPs. Recent studies have supported the digital application of several of these BCTs in the context of T2DM prevention and management. In the NHS-DPP digital pilot, peer support had the strongest effect on both HbA1c and body weight reduction, while the use of wearable devices to self-monitor one's behaviour also influenced weight loss (Ross et al., 2022). Furthermore, a meta-analysis of mHealth T2DM management interventions found digital self-monitoring to be the most effective feature in HbA1c reduction (El-Gayar et al., 2021). This effectiveness by way of digital self-monitoring also supports the findings of study one regarding digital feature use, as the features of diet, activity, weight, and biomeasure tracking were all frequently identified in effective interventions.

It is possible that the effectiveness of the BCTs and digital features identified in study one was influenced by each component's capacity to engage its users. In study three, participants praised the self-monitoring capabilities of DHTs as this facilitated motivation, such as the drive to meet daily step goals; and accountability, where for example, participants would record their food intake and report this to their health consultant. Several participants also valued the social support they received from peers in online health classes, and face-to-face through friends who would help to make routine exercise more enjoyable. The effectiveness of the goal setting and feedback BCTs identified in study one may have been due to the usefulness of online health coaching. Health coaches in digital DPPs deliver these BCTs by offering personalised feedback, and assisting participants in setting their own goals (CDC, 2021b). Such personalisation or tailoring was considered desirable by participants in study three and it has been linked to intervention effectiveness and engagement in previous studies (Lustria et al., 2013; Ryan et al., 2019). The effectiveness of remote health coaching was also confirmed in a meta-analysis by Joiner et al. (2017), as digital T2DM prevention interventions that included remote health coaching achieved 29% more weight loss than stand-alone interventions.

While it is clear that behaviour change interventions such as digital DPPs can successfully encourage participants to modify their health behaviours, there is limited evidence to suggest that such changes are sustainable long term, ether due to the paucity of studies that assess long-term effects, or because intervention effects typically diminish over time (Kwasnicka et al., 2016). In study one, 63% of interventions were effective in the short term. However, in the long term, only 33% of interventions were effective. While the study's effectiveness criteria for the two periods differed at 3% and 5% respectively, the weight loss figures across studies indicate that short-term weight loss most often exceeded the amount lost in the long term. According to the analysis in study one, the most effective BCT and digital feature for long term effectiveness was problem solving and online health coaching respectively. Problem solving is a technique that encourages participants to generate several health behaviour change strategies (such as overcoming barriers, relapse prevention, and coping planning), and then to select, apply, and evaluate the most appropriate strategy (King et al., 2010; Lindström et al., 2010; Michie et al., 2013). Such strategies may have enabled participants to develop the skills needed for sustained behaviour change. However, as study one found that all the effective long-term interventions included online health coaching, it is difficult to discern whether problem solving could be effective as a stand-alone technique in the absence of health coaching, or if the two components have a synergistic effect. The latter notion is supported through a recent qualitative study of the face-to-face NHS-DPP conducted by Miles et al. (2021). According to the authors, several participants could not recall engaging in problem solving activities, or they simply misunderstood the term itself. However, participants who did recall problem solving and found it useful in supporting their behaviour change, stated that it was the group exercises and discussions around problem solving, facilitated by the health coach, that was most effective. Miles et al. (2021) concluded that problem solving is a cognitively demanding technique, and so the development of complex problem solving strategies may be too challenging for participants to do in isolation. Considering these findings, to enable long-term behaviour-change and ensure sustained improvements in T2DM-related health outcomes, future digital DPPs should include problem solving activities that are facilitated by an online health coach.

6.3.3. Advanced the Evidence on Health Beliefs and eHealth Literacy

The digital health acceptability model developed and tested in study two and extended in study three, explained a relatively large proportion of the variance in the intention of participants to use a digital DPP, warranting the model's application in future studies. These studies therefore extended the evidence base on T2DM prevention, technology acceptance, and digital health. Further to this, these studies advanced the current understanding of health beliefs, risk perceptions, and eHealth literacy in several ways.

The HBM (Rosenstock, 1974) is one of the most highly recognised and widely used conceptual frameworks of health behaviour (Green et al., 2020). However, its application is lacking in studies of T2DM prevention. In one rare study, Herman et al. (2018) assessed the uptake of a face-to-face DPP against the factors of perceived susceptibility to T2DM and perceived seriousness of T2DM. Programme enrolees reported higher levels of perceived susceptibility than non-enrolees, while both enrolees and non-enrolees perceived the disease to be serious. However, the authors did not assess these factors against actual risk of T2DM. Study two built on this by assessing each HBM factor against both the actual risk of developing T2DM and the acceptability of a digital DPP.

To accommodate the complexity of health behaviours involved in DHT adoption, Kim and Park's (2012) HITAM included the factors of perceived susceptibility and perceived seriousness from the HBM. However, these factors were combined to form the composite factor of perceived threat. When testing the HITAM, the authors found perceived threat to have a significant positive association with health status (as operationalised by the presence or absence of disease), but perceived threat did not significantly predict perceived usefulness. Risk or threat perceptions are often conceptualised as an additive or multiplicative index of susceptibility to and severity of a health risk or disease. However, according to El-Toukhy (2015), who assessed data on 50 health conditions, susceptibility and severity (or seriousness) are two distinct and often inversely related concepts. Given the limited predictive utility of perceived threat in the HITAM, study two tested perceived susceptibility to T2DM and perceived seriousness of T2DM as two separate factors, and three key findings confirmed the factors' discrete nature. First, the factors did not correlate. Second, actual risk of developing T2DM was negatively associated with perceived seriousness but positively associated with perceived susceptibility. Third, perceived seriousness was not a significant predictor of the digital DPP's perceived usefulness, yet perceived susceptibility significantly predicted both the perceived usefulness of, and intention to use the digital DPP. These findings thereby advance the evidence base on health beliefs by confirming emerging evidence of the complex, contradictory nature of disease risk perceptions.

The concept of eHealth literacy is another complex subject that researchers have attempted to assess using simple measures, despite suggestions that such measures are insufficient to assess eHealth as it exists today. As eHealth literacy represents a relatively new area of research, the evidence base is still growing as it aims to keep up with the rapid development and evolution of new technologies. The eHEALS (Norman & Skinner, 2006a) remains the most commonly applied assessment of eHealth literacy. However, the Lily model from which the eHEALS was based had been developed for the first generation of eHealth services (Norman, 2011). Second-generation instruments were thus created to overcome the limitations of the eHEALS.

With multiple knowledge gaps in the eHealth literature under consideration, the present research advanced the evidence base in several ways. First, the eHEALS was applied in study two to measure general eHealth literacy, a factor hypothesised to predict the perceived ease of use of the digital DPP. However, there was no association between the two factors, suggesting that first generation eHealth literacy skills may not be sufficient to increase one's perceived aptitude and confidence in using a complex digital health intervention. It is also possible that the eHEALS itself is not a comprehensive enough measure to assess the range of skills required to navigate second-generation DHTs. In their recent systematic review of eHealth literacy measures, Lee et al. (2021) confirmed the eHEALS to be insufficient to measure the dynamic and social nature of eHealth. While many researchers may use the eHEALS based on its ubiquitous application–or to pre-emptively appease journal editors by applying a longstanding, frequently cited measure of eHealth literacy–its future application when studying current digital health interventions should be approached with caution, and alternative or at least additional second-generation measures considered. Second, to tap into the evolving social nature of eHealth, the communicative eHealth literacy sub-scale of the TMeHL questionnaire (Paige et al., 2019) was used in study two to assess the sub-scale's namesake factor. Study two was the first to apply this questionnaire after its original validation studies. Upon reviewing all second-generation eHealth literacy measures developed to date, Lee et al. (2021) stated that the TMeHL questionnaire is psychometrically better than the other measures, and the authors support its further use. Third, the eHRS (Bhalla et al., 2016) was used in study two to fill the gap present in most eHealth literacy measures. That is, the lack of items assessing DHT use. Despite the scale's rare application, its latent factor of eHealth readiness in study two was the strongest eHealth predictor in the model, confirming its suitability for assessing current digital health interventions.

6.3.4. Provided an Understanding of the Factors that Influence Digital DPP Acceptability

The identification and exploration of the factors that influence a digital DPP's acceptability contribute to both the national and international evidence base in two ways. First, discrepancies in T2DM risk perceptions were found in study two, indicating a lack of understanding of the disease which should be addressed if prevention efforts are to succeed. Second, through qualitative interviews, study three identified a range of avenues through which a digital DPP could be tailored to suit the diverse needs of those at risk of T2DM.

6.3.4.1. Type 2 Diabetes Risk Perceptions. According to findings from study two, the perceived susceptibility to T2DM was positively associated with health status, suggesting that participants at higher risk of T2DM were cognizant of this risk. This supports previous studies that found significant associations between participants' general risk perceptions and actual risk status on single factors such as family history, BMI, and diet (Fukuoka et al., 2015; Yang et al., 2018); or, their overall score on a validated risk assessment tool (Godino et al., 2014). Study three also confirmed that participants were aware of their risk status, learning of this via discussion with a HCP, a family member with T2DM, or through a previous GDM diagnosis. However, contrary to what was hypothesised in study two, the perceived seriousness of T2DM was inversely associated with health status. Therefore, those at greater risk of T2DM perceived the disease to be less serious. Participants in study three felt there was a lack of awareness in Ireland regarding the seriousness of T2DM compared with other diseases such as cancer, particularly among older adults. It is possible that people at greater risk may be aware of their T2DM risk status but worry only about what they perceive to be a more serious health condition. As T2DM risk automatically increases with age when applying the FINDRISC, those with higher scores in study two could have been older adults who, according to participants in study three, have less knowledge about the seriousness of T2DM. Alternatively, this inverse relationship could be linked to the study's younger adults through the presence of optimistic bias and greater perceived control. These often-associated factors represent instances where an individual feels they are less likely than the average person to experience adverse events, such as T2DM and its complications, and/or have greater control over these events if they occur (Klein & Helweg-Larsen, 2002). A meta-analytic review by Klein and Helweg-Larsen (2002) found that the control-optimistic bias association was stronger among younger adults than older adults. As 46% of participants in study two were aged 18 to 29, and the overall sample's mean age was a relatively low 36 years, the inverse relationship between T2DM risk and perceived seriousness could have been due to the high levels of perceived control and/or optimistic bias that would be expected in a sample containing many younger adults.

These overall findings on risk perceptions suggest that, although T2DM risk screening is necessary and highly encouraged, more education of the public is needed with regards to the seriousness of T2DM. While being optimistic about one's health and level of control over the disease could empower participants in a digital DPP to achieve better outcomes, these biases could also lead to the avoidance of such interventions as individuals may not view T2DM as serious enough to warrant engagement with the programme or to change their health behaviours. This was evident in study two as perceived seriousness had no influence over the perceived usefulness of the digital DPP, whereas perceived susceptibility was a direct predictor of both perceived usefulness, and the intention to use the programme.

6.3.4.2. Tailoring the Digital Diabetes Prevention Programme. Study three found that most participants would like a digital DPP to be tailored to their needs. This was explicitly expressed by several participants where, for example, they suggested the need for personalised goals, or for the programme to match them with other people who share similar interests. Participants also saw the programme as an opportunity to share advice and organise social walks. In a study of peer support in digital health interventions, Fortuna et al. (2019) discussed the concept of 'reciprocal accountability', where participants (or participants and group leaders) mutually help and learn from each other. It is this accountability, when combined with common goals, shared life experiences, and the forming of bonds, that is suggested by the authors to enhance user engagement with digital health interventions. This indicates the importance for effective matchmaking when facilitating social support within a digital DPP, as participants may only engage with others they can relate to. In study three, those averse to peer-to-peer interaction viewed the programme's social support feature as a threat to their privacy or autonomy because they do not know the other participants personally and were worried about negative social judgement. In view of this, future digital DPPs should be adaptable by allowing participants to opt out of this function entirely or by offering flexibility into how the feature is implemented. For example, participants could complete a questionnaire that captures information on their demographics, cultural norms, geographic location, likes, and hobbies etc. that may be used to create groups of likeminded participants. Alternatively, as some participants may feel overwhelmed by large groups, a buddy system could be employed that would pair two individual participants who share similar goals and interests, with the aim of facilitating mutual support and accountability. Buddy systems that use text message, phone call, or face-to-face meetings have been successfully implemented in digital T2DM management interventions (Ojo et al., 2015; Rotheram-Borus et al., 2012; Sylvetsky et al., 2015) and could therefore be effective in a digital DPP.

In addition to identifying potential avenues for tailoring the digital DPP, communication strategies could also be tailored to increase uptake. First, several participants in study three were concerned about the privacy and security of their personal information and feared that insurance companies could obtain this information through unscrupulous means such as hacking. These privacy concerns were also identified in a systematic review of digital health qualitative studies (O'Connor et al., 2016). It is therefore important for a digital DPP to clearly communicate its data collection, storage, and usage policies to prospective participants, and/or allow individuals to opt out of sharing certain information. Second, participants in study three stated they often received advice on their diet, physical activity, and use of DHTs from family members. Additionally, many participants were aware of their risk status due to a family history of T2DM. Based on these findings, digital DPP promotional materials could be issued to patients with T2DM so they may pass these on to family members who may be at risk. Furthermore, if more than one family member is at risk, this could encourage family members to join a digital DPP together. According to evidence from the US NDPP, co-participation from a partner or family member can increase attendance and lead to greater health outcomes. Ritchie et al. (2019) found that diverse (e.g., non-white) individuals who joined the programme along with household members showed greater engagement. Additionally, men who joined the programme as a dyad were four times more likely to achieve the 5% weight loss target than men who enrolled individually. However, this effect was not observed for women. Given the traditionally low levels of engagement by men in health interventions, further supported by the comparatively low number of male participants in studies two and three, offering joint enrolment in a digital DPP could encourage more males to actively engage with the programme.

6.4. Strengths and Limitations

There are several strengths and limitations of this research, at both the individual study level, and of the project overall. As a large proportion of this research was conducted during the COVID-19 pandemic, the methods applied in studies two and three were modified, resulting in several unavoidable limitations. The pandemic has been a challenging period for researchers, particularly those undergoing a doctoral degree, and most have experienced a negative impact on their data collection and analysis process (Byrom, 2020; Paula, 2020). However, the methodological alterations implemented to overcome the challenges to this research did not affect the overarching aims. Furthermore, such modifications offered novel ways of conducting research at a time when resources were limited, which in some cases, resulted in findings that may not have been obtained had the original methodologies been employed. In the sections that follow, the strengths and limitations of each individual study and overall project will be presented, with specific focus on the methodologies used, accommodations made, and how the research process deviated from its original plan. The following sections will also include discussion on the steps taken to attenuate these limitations, and proposals for future research.

6.4.1. Strengths and Limitations of the Individual Studies

6.4.1.1. Study One. The main strength of the systematic review was that it was the first in digital T2DM prevention to identify the BCTs and digital features frequently associated with clinically significant weight loss. The review was conducted in accordance with established best-practice guidelines and maintained a commitment to research transparency with regards to its methods, collected data, and presentation of results. First, the review process adhered to a pre-registered protocol (Van Rhoon et al., 2018) and was reported in line with PRISMA guidelines (Moher et al., 2009). Second, a comprehensive search strategy was developed and pilot tested before its implementation across five databases. These searches were supplemented by forward and backward reference searches to locate additional articles. Finally, the article screening, quality assessment, BCT coding, digital feature coding, and thematic analysis were all independently conducted by two researchers. While the level of agreement was only statistically assessed for article screening, all disagreements arising from the coding process were efficiently resolved through discussion between the researchers. One limitation of the review was the absence of a grey literature search which, if conducted, could have identified relevant unpublished articles. However, such searches are often time consuming and may have little influence on the results of most reviews and meta-analyses (Adams et al., 2016; Schmucker et al., 2017).

Another strength of this review was its use of both top-down and bottom-up approaches to data collection. An existing, internationally-recognised taxonomy, the BCTTv1 (Michie et al., 2013), was used to code BCTs from all available intervention descriptions, and a modified thematic analysis was used to identify digital components which were then grouped to generate a list of passive and interactive digital features. As a complete list of digital components identified in this review were published online with the manuscript, researchers could use this information to develop a digital feature taxonomy for categorising digital DPPs and then use this to assess future programmes. For example, Almalki and

Giannicchi (2021) recently developed a taxonomy of the digital features found in COVID-19 health apps. This taxonomy was then used as a guidance tool for categorising COVID-19 apps, assessing their functionalities, and evaluating their acceptability and effectiveness.

Study one's coding process had several limitations. First, the number of BCTs (and digital components) identified in each digital DPP was influenced by the detail in which the programmes were described in the articles. Noting this limitation, other reviewers have either coded only those BCTs that were clearly present (e.g., Hailey et al., 2022), or coded all BCTs regardless of whether they were clearly present or possibly present (e.g., Hansen et al., 2018). However, such approaches can lead to under and over-coding respectively. The imputation process applied in study one combined these approaches, enabling two separate analyses. The results of the inclusive coding approach were presented in the main manuscript, while the results of the conservative approach (with imputed components excluded) were made available in the manuscript's supporting materials. Second, the applied 'dose' of each BCT was not discussed in the articles. Therefore, the frequency at which each technique was applied could not be discerned. Assessments of BCT dosage have been conducted previously. For example, in a study of Australian physiotherapists, Kunstler et al. (2019) asked practitioners about the types of BCTs they used to promote physical activity, and how frequently each BCT was applied. However, as the level of interactivity in digital DPPs is largely participant-driven, the frequency of BCT utilisation within a single programme may differ substantially between users. To account for this, developers could integrate BCT tracking into their platforms. This could enable researchers to determine a programme's mean usage level for each BCT. However, this may only be feasible for BCTs that involve simple, rapid user input and quantifiable data such as the self-monitoring of behavioural outcomes (e.g., recording how often a user enters their weight), rather than more complex BCTs such as problem solving, which requires extended thought, planning, and collaboration.

A meta-analysis could not be conducted with this review as several included studies did not report data pertaining to proportional weight loss. While the review of eHealth DPPs conducted by Joiner et al. (2017) did include a meta-analysis on proportional weight loss, the authors only included interventions based on the US NDPP. These interventions are required to report proportional weight loss data as per CDC standards and operating procedures (CDC, 2018), and therefore, such data was available. However, in the present review, more than half of the interventions were independent, and in most cases, only absolute weight loss was reported. Absolute weight loss is a less-robust indicator of effectiveness as it does not account for baseline body weight. As meta-analysis was not possible in the present review, the 5% weight loss benchmark as recommended by the CDC (2018) and NICE (2019) was applied to assess intervention effectiveness as a dichotomy (effective versus non-effective). This enabled the assessment of all technology-driven interventions regardless of evidence base, against the clinically relevant outcome of proportional weight loss.

Studies of all designs were included in this review, such as RCTs that compared a digital DPP against a control group or another intervention, and non-experimental studies such as single-arm observational studies. Randomised controlled trials are considered the 'gold standard' for establishing an intervention's effectiveness, as they are less subject to bias, and can establish a cause and effect relationship between the intervention components and the outcomes of interest (Hariton & Locascio, 2018). However, only 10 of the 19 studies included in this review used this design. The inclusion of less rigorous observational studies may have introduced various biases into the analyses. One key disadvantage to observational studies when compared to RCTs is the presence of confounding factors, that is, any factor that is related not only to the intervention but also to the outcome, and could affect both (Mariani & Pego-Fernandes, 2014; McNamee, 2003). Examples of confounding factors in the context of digital DPPs could be the use of additional interventions, such as structured physical activity regimes completed by participants outside the scope of the programme, or the use of diet supplements. Such confounding factors were controlled for in the Finnish DPS (Hu et al., 2007). However, controlling for factors that occur naturally in the real world does not necessarily represent best practice. The goal of lifestyle intervention is to improve one's quality of life, both from a physical and emotional standpoint (Daundasekara et al., 2020). If, for example, a participant using a digital DPP chooses to join their local gym and participate in a structured exercise programme, such steps would be encouraged in the real world as it could facilitate social support and regular exercise. However, in an RCT, this additional activity would represent an undesirable confounder as it would be difficult to determine whether changes in the participant's health status were due to the DPP, the additional exercise classes, or a combination of both. Critics of RCTs have argued that such trials were designed for testing drugs and not for the assessment of complex interventions delivered to diverse populations (Harvey, 2015). Randomised controlled trials often have stringent inclusion and exclusion criteria when selecting participants, and while this may enable researchers to reduce sampling bias, the selection criteria can be highly dissimilar to the characteristics of the real-world target population (Grapow et al., 2006; Yang et al., 2010).

6.4.1.2. Study Two. This cross-sectional study, which involved the development and testing of a digital health acceptability model to explain the intention to use a digital DPP, was the first to apply an extended health technology acceptance model within the field of T2DM prevention. The research model included: objective and subjective health factors, social influence factors that captured health behaviours and beliefs regarding the use of health technologies, and multiple eHealth literacy measures–each relevant to T2DM and the diverse skillset required to effectively navigate modern digital health interventions. However, despite advancing the digital DPP literature, this study had several limitations, most of which were a product of the recruitment strategy modifications necessitated by the COVID-19 pandemic.

Shortly after this study was originally approved by the NUI Galway Research Ethics Committee on March 19, 2020, the Government of Ireland issued the first 'stay at home' instructions in response to the emerging pandemic. In the original protocol, adults at an elevated-to-very high risk of developing T2DM would be recruited for this study. According to the FINDRISC (Lindström & Tuomilehto, 2003), those at elevated risk have a 1 in 25 chance of developing T2DM within the next ten years, while those at highest risk have a 1 in 2 chance. By including only these individuals, the study's sample would more closely match the target population for a digital DPP. Face-to-face recruitment was also to feature prominently. This would have involved the researcher engaging with general practice, health centres, community groups (e.g., women's groups, Men's Sheds, older adult groups, Parkrun groups, Irish Traveller groups), and recreation centres. During these interactions, the researcher would present talks on health behaviours, share advice, and issue hard copies of the study questionnaire. The aims of the original combined online and in-person recruitment strategy were fourfold. First, to recruit individuals who would be candidates for a DPP based on their elevated risk status. Second, obtain an accurate picture of Ireland's eHealth literacy levels as online-only recruitment channels may skew the sample towards a higher level of eHealth literacy. Disparities in technology access and eHealth literacy can impact vulnerable populations by denying them the opportunity to engage in services that could improve their health (Smith & Magnani, 2019). Third, reduce under-coverage and self-selection bias. According to Bethlehem (2010), online recruitment is subject to: (a) under-coverage, as the target population usually includes people who do not have internet access, and therefore individuals who are eligible to participate may not have the means of doing so; and (b) self-selection bias, as individuals can select themselves for the study by finding and completing the questionnaire. In this scenario, the researcher has little control over the selection process.

Fourth, to collect a very large number of completed questionnaires so once those at low risk of T2DM were excluded, the study would still have sufficient statistical power.

In response to the COVID-19 social and physical distancing measures, a revised study protocol was submitted and approved by the NUI Galway Research Ethics Committee (see Appendix F). The key changes to this protocol were: (a) all recruitment would now be conducted online, and (b) all participants regardless of T2DM risk status would enter the analysis. The inclusion criteria were relaxed to accommodate the forecasted decrease in sample size. Conducting online recruitment during the height of the pandemic was challenging for various reasons. Community meetings were no longer held, and there were few replies to the almost 250 personalised emails that were sent to community groups and representatives. Follow-up phone calls confirmed that nationwide community collectives such as Men's Shed, National Women's Council, Parkrun, and the many older adult groups were on hiatus, while those that were still meeting were self-sustaining; that is, any contact between members was at the discretion of the members themselves through their own private social networks. Furthermore, organisations such as Parkrun were no longer authorising the use of their Facebook groups and networks for research assistance until further notice. Given these challenges, the recruitment period was extended by several months to ensure the study would obtain an adequate sample size.

As a result of the inclusion criteria modifications and recruitment challenges, the study had several limitations. First, only 40% of participants had at least a slightly elevated risk or greater of developing T2DM. Therefore, a large proportion of participants were considered low risk. However, as FINDRISC scores increase automatically with age, the relatively large number of participants under 40 years of age (62% of the total sample) could have been a contributing factor to the sample's relatively low risk of T2DM. The mean age of the sample in this study (at 36 years) was lower than the sample means of studies that assessed the effectiveness of digital DPPs. For example, of the 21 interventions included in the systematic review for study one, 18 interventions had a mean participant age of over 45 years. However, given that early-onset T2DM (defined as a diagnosis of T2DM in individuals under 40 years of age) is linked with a higher risk of CVD, more severe micro- and macrovascular complications, and a higher mortality rate when compared to late-onset T2DM (Chan et al., 2014; Hillier & Pedula, 2003; Lascar et al., 2018; Sattar et al., 2019; Song & Gray, 2011), the inclusion of younger adults in study two was desirable, particularly as this demographic is underrepresented in T2DM studies (Sargeant et al., 2020).

Second, as online-only recruitment was used, this study was subject to self-selection bias. People who use the internet routinely and have an interest in digital health may have been more motivated to participate than members of the general population. Furthermore, frequent internet users may have a relatively higher level of eHealth literacy or familiarity with online questionnaires, each making it comparatively easy for them to participate. However, self-selection based on an interest in and ability to use DHTs could be desirable when attempting to maximise digital DPP uptake. For example, the NHS-DPP includes both a face-to-face and digital stream, and those who are eligible but decline the offer from face-to-face providers are offered referral to the digital programme (McGough et al., 2019). By leveraging the appeal of using DHTs, a DPP could reach people that may otherwise be disinterested in participating in the programme.

Third, the use of online-only recruitment channels resulted in a sample with relatively high levels of education; and was predominantly white, and female. Therefore, the results of this study may not be generalisable to the overall adult population residing in Ireland, or the population of adults at risk of developing T2DM. Future studies should recruit socio-economically diverse groups. Doing so would obtain a more accurate snapshot of the current state of eHealth literacy in Ireland and assess the level of digital DPP acceptability among disadvantaged populations.

6.4.1.3. Study Three. Study three explored the views and perceptions of adults living in Ireland towards a digital DPP and the factors that influenced the programme's acceptability and was the first of its kind in T2DM prevention. It extended the findings from study two, using two complementary forms of qualitative analysis to offer insight into how and why the factors of the research model were significant. This study also built upon study two by including the health behaviour factors of healthy eating and physical activity to form an extended research framework. This new framework facilitated discussion on the wide range of behaviours that participants of a digital DPP would engage in. That is, the use of DHTs, social interactivity (be it with a health coach and/or other participants), and both dietary and physical activity behaviour change.

Despite the strengths of this study, there were several limitations that warrant discussion. As participants were recruited from the pool of participants who completed the questionnaire in study two, this study experienced the same limitations. Furthermore, the extended recruitment period of study two delayed the commencement of this study, reducing the recruitment window. As a sizeable portion of participants in study two were at low risk of developing T2DM, the number of participants eligible to participate in this study was relatively low, and of those eligible, only a small proportion expressed interest in participating in a follow-up interview. This figure consisted of 52 females and 11 males, and of the 26 females and 11 males contacted, 17 females and no males ultimately agreed to participate. Therefore, while this study aimed to recruit a gender-balanced sample (including non-binary individuals) all participants were female. Men have traditionally been reluctant to participate in health promotion programmes as they are often averse to disclosing vulnerability or may be dissatisfied with the way in which health service are delivered (Anderson et al., 2016; Gast & Peak, 2011; Verdonk et al., 2010). Organisations such as Men's Sheds were established in Ireland to encourage men to openly discuss matters regarding their own health and wellbeing, and be more actively engaged in formal health services (Lefkowich & Richardson, 2018). However, due to the COVID-19 pandemic, such groups were on hiatus, limiting the proportion of males in study two to just 22% of the overall sample. This in-turn led to the gender imbalance observed in study three. Given the delays to both studies, there was no opportunity to run a second wave of recruitment to exclusively target males and non-binary individuals. When COVID-related restrictions ease and community groups resume normal operations, researchers should engage with these groups to obtain a broader picture of digital DPP acceptability in Ireland.

A further limitation was the means through which participants were exposed to the digital DPP. That is, by viewing a colour brochure and watching two short videos. The original plan for this third study was to conduct one-hour focus groups where participants would view an extended multimedia presentation on the digital DPP and then experience the smartphone application first hand on either their own smartphone or a demonstration smartphone. In these focus groups, a think-aloud protocol would be used, which involves asking users to vocalise their reactions and thinking processes while, or immediately after, they use the application (Yardley et al., 2010). This form of qualitative research design has been used in studies of T2DM illness perceptions (Anderson-Lister & Treharne, 2014; McCorry et al., 2013), and digital T2DM management interventions and systems (Georgsson & Staggers, 2016; Hsieh et al., 2019). The original aim for study three was to obtain rich, detailed accounts of participants' perceptions of, and experiences with the digital DPP. However, due to time and resource constraints that included restrictions regarding face-to-face contact, focus groups were switched to online interviews, and the protocol was altered significantly. This included formulating a new topic guide to address a much wider range of topics, and switching the data analysis strategy from thematic analysis in line with guidelines expressed by Braun and Clarke (2006), to a combined deductive and inductive content analysis (Elo & Kyngäs, 2008; Hsieh & Shannon, 2005). Despite this limitation, by shifting the primary focus from the digital DPP itself, over to the factors that determined its acceptability in study two, this research gained insight into the broader contextual factors that influence one's decision to use a digital DPP. However, future research could use focus groups to explore people's views of the programme during or after its use.

Another limitation to this study was that the sample (all-female, predominantly white, with a relatively high level of education) does not reflect the overall target population for a digital DPP. However, all participants would still be eligible for referral to a DPP based on CDC standards (CDC, 2021d). For referral into the NHS-DPP, a blood test conducted within the previous 12 months must indicate the presence of non-diabetic hyperglycaemia (Valabhji et al., 2020), but as blood tests were not feasible for this study, the FINDRISC (Lindström & Tuomilehto, 2003) was used instead.

Finally, as this study was conducted at a time when COVID-19 restrictions in Ireland were relatively strict, the views and perceptions of participants during this period may change once restrictions ease. However, with the prospect of emerging COVID-19 variants and concerns about the ability of the current vaccines to protect against these variants (Ciotti et al., 2022; Haque & Pant, 2022), future restrictions cannot be ruled out entirely. Therefore, understanding peoples' experiences during periods of lockdown that act as barriers to successful behaviour change could help researchers to develop interventions that can adapt to, and accommodate these restrictions. For example, as participants in study three felt that their physical activity opportunities were limited due to the COVID-19 restrictions, the addition of online exercise classes to a digital DPP could encourage people to remain active if lockdowns are reinstated.

6.4.2. Strengths and Limitations of the Overall Research

6.4.2.1. Mixed Methods Research Design. This programme of research adopted a mixed methods research paradigm, which can produce scientifically sound and transferable results by integrating qualitative stakeholder engagement with quantitative outcomes to inform the development, implementation, evaluation, and monitoring of interventions (Ivankova & Wingo, 2018). Quantitative methodologies were adopted in study one to identify digital DPPs that were effective in achieving clinically significant weight loss, and to determine the frequency of BCT and digital feature use in effective versus non-effective interventions. However, there was some overlap with the qualitative paradigm in this study as a modified thematic analysis (e.g., Braun & Clarke, 2006) was used to identify the digital features. In study two, quantitative methods were applied to collect and analyse questionnaire data which was subsequently used to assess the digital health acceptability model. Qualitative methods were then used in study three to provide a better understanding of the factors that influence peoples' intention to use a digital DPP. These methods facilitated a deeper explanation as to how and why several factors in study two were such strong predictors of digital DPP acceptability, and to explain the unexpected results. According to mixed methods research leaders, obtaining this 'deeper understanding' is a key reason why mixed methods approaches are used and recommended (Johnson et al., 2007).

A main strength of this research was the connectedness of all three studies. The identification of digital features in study one and the need to develop a greater understanding of participant engagement, informed the rationale, aims, and methods employed in study two. For example, the integration of modern measures of eHealth literacy into the research model was informed by the diversity of the digital features identified in study one. That is, study two sought to assess whether participants possessed the degree of eHealth literacy and readiness required to use a digital DPP effectively. Furthermore, the assessment of digital DPP acceptability aimed to ascertain ways through which researchers and developers could tailor a digital DPP and its communication strategies to make the programme more appealing and engaging for its target users. The research model in study two was then used to inform the extended research framework and interview guide in study three. In this final study, a subset of participants from study two were interviewed to explore their extended views and perceptions of the digital DPP and explain the factors predicting its intended use. This overarching 'explanatory sequential' study design adopted by this programme of research is a popular approach within the health sciences (Creswell et al., 2011). Each of the three studies was disseminated as independent manuscripts. However, in the introduction section of the latter two manuscripts, the findings of the study that preceded it were cited as rationales for that current study, thereby maintaining a flowing narrative.

6.4.2.2. Use of Interdisciplinary Theories, Models, and Approaches. Another key strength of this research was its use of internationally recognised tools and approaches, and the application of interdisciplinary theories and models. In study one, the BCTTv1 was applied to identify the active ingredients of effective digital DPPs. This taxonomy is predominantly used to retrospectively unpack complex behaviour change interventions plus identify potential correlates of successful behaviour change (Armitage et al., 2021), and was therefore the appropriate tool. Moreover, the transparent imputation process mitigated a key limitation of this taxonomy's application; that is, the inadequate description of intervention content in published reports which makes BCT identification difficult (Lorencatto et al., 2013). The complementary approach involving the identification and assessment of digital features addressed a second limitation of the BCTTv1, in that it was not originally designed to unpack DHTs. Moreover, as there is a lack of consensus on categories and definitions of digital features in the extended literature (Donevant et al., 2018), and no published digital feature taxonomy, a bespoke approach to digital feature identification was warranted.

The research model and extended framework applied in studies two and three were informed by various theories and models from multiple fields of research. According to the MRC, the second step to developing a complex intervention is to develop a theoretical understanding of the likely process of change by drawing on existing theory, or performing new primary research to supplement existing theory (Craig et al., 2008). The intervention factors were based on constructs of the TAM (Davis, 1989), a model which originated in the field of information technology and is the most referenced and applied model of technology acceptance to date (Khan & Woosley, 2011; Marangunić & Granić, 2015). However, the TAM itself is informed by the psychological theories of Reasoned Action (Fishbein & Ajzen, 1977), and Planned Behaviour (Ajzen, 1991). The Health Belief Model (Rosenstock, 1974), which is often applied in a health psychology context, informed the present model's personal health factors, while the Lily Model (Norman & Skinner, 2006b) and TMeHL (Paige et al., 2018) informed the eHealth literacy factors. The overall structure of the present model and extended framework, including the relationships between factors, were informed by the HITAM (Kim & Park, 2012), another composite model that has been used assess the acceptance of health information technologies.

Overall, the present research model and extended framework represents a merging of multiple research fields. As a result of this evidence-based integration, the model was able to predict digital DPP use intentions to a relatively large degree. However, such level of model customisation could also represent a limitation when attempting to apply this model outside the context of digital T2DM prevention, as certain factors may not be relevant to other digital health interventions. For example, *health status* was operationalised by FINDRISC scores.

However, studies of other conditions would require different measures to assess health status. Additionally, the *image* factor–which reflects the belief that using DHTs, such as smartwatches or health apps, are a sign of prestige or social status–may not be relevant to other DHTs. For example, a recent study on smartwatch use found that aesthetics were a stronger predictor of continuous use than was perceived usefulness (Bölen, 2020). This suggests that smartwatches (which can be used by participants in digital DPPs to self-monitor their physical activity) may be perceived as fashionable, tapping into the concept of image as found in the present research. However, other DHTs such as digital blood glucose monitors that are used in the management of both T1DM and T2DM, may not be perceived as image-enhancing as they are medical devices. Moreover, the use of such devices may be perceived by people with T2DM as negative because it could indicate to others the presence of a medical condition. According to the 2017 DiaTribe survey, which was issued to 12,000 people with diabetes in the US, 76% and 52% of people with T1DM and T2DM respectively reported feeling stigmatised due to their condition (Barnard & Breton, 2018).

6.4.2.3. Population Diversity. A clear limitation of this research was the limited diversity of its participants, particularly in studies two and three. While a sizeable proportion of participants in study two and all in study three represent a digital DPP's target population, each sample is likely not representative of the overall population of adults at risk of developing T2DM currently residing in Ireland. While the exact demographics of Irish residents at risk of T2DM is unknown, the 2016 Irish Census found that 82% of all people in Ireland identified as white Irish, and 51% were female (Central Statistics Office, 2017a).

In study one, of the 2,655 participants that were included in the systematic review, 65% were female and 68% were white. Moreover, 5 of the 21 interventions targeted ethnic minorities, people of low socio-economic status, and/or non-white populations. Therefore, while those who were white and/or female constituted most of the pooled sample, there was still sizeable representation from non-females and people of non-white ethnic groups. This relatively high representation of ethnic minorities in the review could be due to the inclusion of smaller studies and/or those conducted within disadvantaged community settings.

In study two, a comparatively large 76% of the sample was female. However, 80% were white Irish, which matched the proportion of those residing in Ireland. Additionally, 0.95% of the sample were members of the Irish Traveller community, a figure also reflective of the national population according to the 2016 Irish Census (Central Statistics Office, 2017a). In addition to the proportionally high number of females, the study two sample had achieved a relatively high level of formal education, with 45% and 44% completing a postgraduate or undergraduate degree respectively. This indicates that 89% had obtained a third-level degree, more than double the national figure of 42% as reported through the 2016 Irish Census (Central Statistics Office, 2017b). Further research involving individuals with less formal education is needed as these individuals may be at a disproportionally greater risk of developing T2DM. Many studies have identified a positive association between the level of education and health status, an association that is evident in men and women, and among all race/ethnic groups (Zajacova & Lawrence, 2018). Adults with less education have reported worse general health (Mirowsky & Ross, 2008; Zajacova et al., 2012), more chronic health conditions (Johnson-Lawrence et al., 2017), and more functional limitations and disabilities (Bruusgaard et al., 2010; Tsai, 2017). Lower levels of education are also associated with lower levels of health literacy (Vamos et al., 2020) which, according to a recent systematic review of reviews conducted by Caruso et al. (2018) is further associated with low T2DM knowledge.

The sample in study three was less diverse than study two, as it consisted only of women, of which 88% were white Irish. However, the level of education was almost identical to study two with 88% in possession of postgraduate and/or undergraduate degree. No member of the Irish Traveller community was included in this study as this group were difficult to reach. Only three members of this community participated in study two, limiting the pool of eligible participants for study three. It is important that future T2DM prevention studies engage with members of the Irish Traveller community as they experience significantly lower healthy life expectancy and disability-free life expectancy compared with the general population, according to the All-Ireland Traveller Health Study (Abdalla et al., 2013). Additionally, Irish Travellers experience 16 to 17 more years of poorer health and are more likely to be categorised as disabled. Members of Travelling communities face challenges in accessing adequate and appropriate health care due to collective health beliefs (e.g., that health should be addressed within the family circle), or perceived discrimination from HCPs (Matthews, 2008). In view of this, there is the potential for a digital DPP to reach members of the Irish Traveller community. However further research is needed in the following areas. First, there is a lack of data on technology use among Irish Travellers. Comparable data on Gypsy and Traveller communities in the UK collected in 2018 suggests that more than half do not feel confident using digital technologies, only 38% had a household internet connection, and only 40% use the internet daily (Scadding & Sweeney, 2018). Second, members of the Traveller community may be less receptive to engaging with others online through a digital DPP if these other participants are not part of the same community. An opportunity could exist to tailor a digital DPP to facilitate connection between members of the Traveller community. However, future studies that exclusively recruit members of this community are needed to determine the most culturally appropriate avenues for T2DM prevention.

6.4.2.4. Stakeholder Involvement. Successful integration of DHTs within the healthcare sector can be challenging, as the field contains an extended variety of stakeholders, each with their own needs, views, and resources. These stakeholders include end users (e.g., patients), health care staff and managers, project managers, information technology departments, technology innovators, and government officials. Effective collaboration between stakeholders can better facilitate the implementation of digital health interventions (Nilsen et al., 2020).

Increasingly in healthcare, patients and members of the general public are specifically sought as partners in research design and operation (Maccarthy et al., 2019). This concept of public and patient involvement (PPI)–defined as research carried out *with* or *by* patients and those who have experience of a condition, rather than *for*, *to*, or *about* them–is now an expected component of health-related research activity in the UK (Holmes et al., 2019; Maccarthy et al., 2019). Engaging with patients is important as they usually understand their disease and lifestyle needs better than many HCPs, and patients can offer valuable insight into the types of research that would be most beneficial to them, especially on how to manage symptoms in a way that improves daily quality of life (Mader et al., 2018). In Ireland, the Health Research Board with support from the Irish Research Council, launched a joint initiative in 2017 entitled PPI Ignite, to support the efforts of higher education institutions to embed PPI into their organisational structures (Murphy et al., 2020). However, for many doctoral researchers, there continues to be strict time and financial constraints that make it challenging to implement PPI within their research projects, particularly if their programme is not set up to facilitate formal PPI support and training (Tomlinson et al., 2019). Further to this, reports have indicated significant disruption and reductions in PPI since the early phases of the COVID-19 pandemic due to lack of patient access, and the redundancy of previous methods of engaging with people throughout the research process (Carson et al., 2020; Chew-Graham, 2020; Leese et al., 2022).

Despite these barriers which resulted in the lack of formal PPI implementation within the present research, key stakeholders were consulted for each of the three studies. However, as participants in these studies were at risk of T2DM and not currently under care or receiving support for T2DM, they were referred to as members of the public rather than patients. First, the systematic review protocol for study one was informed by feedback received from members of the NCPD in Ireland. Members included a health researcher, dietitian, exercise therapist, health psychologist, general practitioner, and clinical endocrinologist. Additional feedback was sought from several adults at risk of developing T2DM. Second, the design of studies two and three, specifically, the inclusion/exclusion criteria, choice of screening tool, data collection methods, questionnaire design, interview guide content, and recruitment avenues, were all developed via discussion with members of the NCPD and adults at risk of developing T2DM. Third, those at risk of developing T2DM (the target users of a digital DPP) were identified in study two and subsequently interviewed in study three to explore their views and experiences. Although these points demonstrate consistent collaboration with key stakeholders, future research could benefit from a more formal implementation of PPI, particularly as COVID-19 restrictions ease and multi-modal access (e.g., both face-to-face and virtual) to patients and members of the public becomes available again.

Further qualitative research on digital DPP acceptability should also include other key stakeholders as participants. In the UK, individuals who are identified as being at risk of T2DM via HbA1c blood glucose test are referred to the NHS-DPP by their GP (Frempong et al., 2021). However, it is up to the individual whether they wish to participate in the programme. Healthcare professionals such as GPs should also be considered target users of a digital DPP as, in addition to referring patients to the programme, they may need to assist patients in how to use DHTs (Ehn et al., 2019). Additionally, as digital DPPs enable participants to share data with their GP, system use and data interpretation may be required of these professionals if they are to provide the most up-to-date healthcare services (Fagherazzi & Ravaud, 2019).

6.5. Implications for Research

This research has identified the need for a digital DPP in Ireland, and the findings have developed an evidence base to support the programme's development and implementation. Through this research process, several additional research avenues were identified that if explored, could further advance the national and international evidence base for T2DM prevention. First, additional research involving the use of key outcome measures in digital DPPs should be conducted. Additionally, digital DPP developers should identify ways to assess and integrate the most cost-effective intervention components. Finally, researchers, developers, and other key stakeholders in Ireland should incorporate the evidence from this research into a larger development, implementation, and evaluation plan that will facilitate the rollout of a national digital DPP, ether as a stand-alone programme, or in combination with a face-to-face stream.

6.5.1. Extending the Evidence for and Use of Key Outcome Measures and Assessments

6.5.1.1. Diet and Physical Activity Assessments. All interventions assessed in the systematic review targeted diet and physical activity behaviours. However, only half of the studies reported data pertaining to these behaviours, making it impossible to determine which behaviours had the strongest effect on weight loss or other outcomes linked to the onset of T2DM such as blood glucose. Reviews of interventions for the management of T2DM have found that combined diet and physical activity interventions have performed better (Cradock et al., 2017; Umpierre et al., 2011) than interventions that target diet alone (Ajala et al., 2013) or physical activity alone (Avery et al., 2012) at improving blood glucose, body weight and BMI. As the evidence for a combined approach is strong, there is perhaps a reduced need to assess each approach in isolation in the context of a digital DPP. Notwithstanding this need, such comparison could be made in future digital DPP studies. For example, if a DPP achieves significant improvements in its outcome measures and reports high adherence to physical activity protocols but low adherence to dietary guidelines, this could indicate that physical activity has the stronger effect. While this method of assessment is less rigorous than comparing a diet-only against a physical activity-only group, it is still important to assess whether a behaviour change intervention was successful in changing its target behaviours, particularly if different approaches to diet or physical activity are used, as certain approaches may work better for certain groups in certain contexts. For example, in their recent assessment of a digital intervention based on the US NDPP, Painter et al. (2020) found that food logging had the largest impact on weight loss, followed by lesson engagement, and physical activity.

6.5.1.2. Cost-Effectiveness Assessments. Very few studies assessed the cost-effectiveness of the reviewed digital DPPs, highlighting a notable research gap in the digital DPP literature. With growing and ageing populations and an ever-expanding range of healthcare interventions, decision-makers are under increased pressure to effectively distribute scarce resources (Shields & Elvidge, 2020). For example, health institutions such as NICE in the UK consider cost-effectiveness analyses in conjunction with effectiveness assessments to determine their recommendations for the provision of treatments and healthcare services (McCabe et al., 2008). As noted in study one, there was wide heterogeneity between studies with regards to intervention intensity and the number of features employed. For example, the SMS-based intervention implemented by Wong et al. (2013) achieved modest reductions in T2DM incidence that were not statistically significant long term. However, this intervention contained only one digital feature and incurred a very small annual per-participant cost of US$21, resulting in a healthcare cost saving of US$1,020 per participant (Wong et al., 2016). In comparison, the more intensive and effective US NDPP-based intervention assessed by Sepah et al. (2014) contained seven digital features at an annual cost of US$433, resulting in a saving of at least US$11,550 per participant (Chen et al., 2016). While these results suggest the latter intervention should be selected due to its greater effectiveness and cost savings, the former is also cost saving and could be more feasible to implement in healthcare systems that lack sufficient resources to finance a more intensive intervention.

6.5.1.3. Data on Type 2 Diabetes Incidence. A further knowledge gap identified by this research was the lack of data on the incidence rates of T2DM. Such data was used to provide evidence for the effectiveness of both the landmark US-DPP and Finnish DPS trials. However, although many of the interventions reviewed in study one achieved clinically significant weight loss or significant improvements in blood glucose measures, it is unknown if these improvements led to the prevention of T2DM. A recent study of the digital stream of the US NDPP reported 22% fewer cases of T2DM among the intervention group at one year when compared with a matched control group (Castro Sweet et al., 2020). However, the authors recommend the use of longer follow-up periods for a more accurate assessment of the intervention's effect on T2DM incidence. In a longitudinal study of 10,796 patents with PDM, 404 (3.7%) had progressed to T2DM at one year, and 1,845 (17.1%) had progressed at five years (DeJesus et al., 2016). This suggests that it could take up to five years for conclusive evidence on T2DM incidence to be established, as digital DPP studies tend to have relatively low sample sizes, and the incidence rate would need to be high enough for there to be sufficient case numbers to confidently assess the intervention's performance against a comparator. The outcome of T2DM incidence is important, as the landmark JDPP and IDPP trials found that incidence could be significantly reduced despite relatively modest weight loss. This has wider implications as potentially effective interventions could be discontinued prematurely if they do not meet the 5% weight loss target.

6.5.1.4. The Need for Detailed User Engagement Assessments. Only a small number of the studies included in the systematic review reported data on participant engagement, and in nearly all cases, this data was not linked to the intervention outcome measures, making it difficult to determine the effect of engagement on weight loss or blood glucose. For example, Castro Sweet et al. (2018) assessed programme assessment by obtaining data for website logins, weigh-ins, meals tracked, exercise tracked, lesson completion, heath coach interactions, and group discussions; and reported a mean weekly score for each. However, this data alone does not indicate which features had the strongest impact on behaviour change or the primary outcome of proportional weight loss. Sepah et al. (2017) did assess the effect of engagement on weight loss by conducting a regression analysis which found the number of participant logins and group interactions to be a significant predictor. However, lesson attendance and tracking consistency did not predict weight loss. The limitation of this analysis was the combining of multiple features into these two predictors, but this was largely a statistical decision as the authors obtained data on seven engagement metrics and identified the two key predictors via factor analysis.

Even in cases where measures of engagement are linked with intervention outcomes, the measures themselves may be inadequate if they cannot assess whether participants were actively engaged with the programme, or simply completing assigned tasks in a cursory manner. The concept of engagement is relatively complex, and exists, according to Yardley et al. (2016), at both the micro- and macro- levels. The microlevel involves moment-to-moment engagement with the intervention, whereas the macrolevel consists of deep involvement with the behaviour change process and is closely tied to the intervention's behaviour change goals. The measures of engagement used by Castro Sweet et al. (2018) were limited to the microlevel. While the authors did provide data on feature usage, this does not indicate the participants' depth of involvement, and therefore only a surface-level assessment of participant engagement can be obtained. For example, the authors assessed engagement using the number of group discussions to which participants contributed. However, study three found that several participants frequented online discussion groups only to absorb the information and not contribute to the discussion themselves. One digital DPP participant may post frequently on social topics outside the scope of the programme and its goals. A second participant may never post, but instead, read every other post before using the information gained to make lifestyle changes that enable them to achieve their goals. If engagement here was assessed by post count or one's level of contribution to the discussion, participant one would appear highly engaged, and participant two would appear disengaged. However, if engagement were assessed on a macro level, participant two could be considered more engaged as they are using a key programme feature in a goal-driven manner to directly facilitate behaviour change.

Considering these points, future studies of digital DPPs should not only assess the impact of participant engagement on key outcome measures, but also assess engagement at both the micro- and macrolevels. According to Short et al. (2018) the best measurement approach for assessing engagement in digital health interventions will likely depend on the stage of research and the specific research context, although there are benefits from using multiple methods and combining the data. For example, semi-structured interviews or focus groups could be combined with self-report questionnaires to offer a mixed methods approach, assessing engagement at the micro- and macrolevels. This would then be combined with the feature or service usage data.

6.5.2. Identification and Integration of Cost-Effective Intervention Components

The identification of effective BCTs and digital features in study one represents a positive step toward the development of an effective digital DPP. However, while the systematic review identified components that were commonly found in effective interventions, it could not assess the strength of each component's individual effect, or the combined effect of multiple components. Evidence suggests that intervention components can interact and have cumulative or potentially synergistic effects (van Genugten et al., 2016). Statistical techniques such as meta-regression have been used to ascertain the effect sizes of individual BCTs (Samdal et al., 2017), while meta-CART analysis has been used to measure the synergistic effect sizes of various combinations of BCTs (Dusseldorp et al., 2014). However, such analyses were not possible in study one as there was insufficient data on proportional weight loss to obtain the effect size estimates required to conduct either analysis. Rather than conducting additional post hoc intervention component assessments, developers of future digital DPPs could assess the effectiveness of each component before the intervention is assessed as a complete package.

Approaches such as the Multiphase Optimization Strategy (MOST; Collins et al., 2007) could be used in the development and evaluation of a digital DPP. In this three-phase approach, the most effective components identified in study one could be used to create a 'first draft' of the intervention. Next, the draft intervention can be 'refined', a process through which optimal doses of each technique or feature are identified and varied based on the individual or group characteristics. This dosage could either be informed by the findings from study three, additional studies of digital DPPs, or through experimentation. Finally, the optimised intervention can be evaluated via standard RCT. As study three identified the need for an adaptable programme, a Sequential Multiple Assignment Randomised Trial (SMART) approach could be used to confirm the effectiveness of the intervention, as it could test a range of different strategies within the same programme (Collins et al., 2007). For example, in a digital DPP, alternative strategies could be tested in cases where a participant either: (a) engages with the social support feature, or (b) disengages from this feature. Under each condition, one or more alternative strategies could be tested. The SMART approach could be used to identify intervention strategies that could still be effective in cases where participants choose to opt out of peer support entirely. Recent weight loss and physical activity studies have applied SMART designs to identify the most effective adaptive interventions and to inform the development of effective individualised treatment approaches (Buchholz et al., 2020; Sherwood et al., 2022).

6.5.3. Next Steps for the Rollout of an Irish Digital Diabetes Prevention Programme

This research has laid the foundation for the development and implementation of an Irish digital DPP. However, as a face-to-face pilot DPP has been proposed for Ireland (Pierse et al., 2021), the development and implementation of a digital DPP will likely fall under a wider national DPP strategy that incorporates both online and face-to-face delivery to maximise the programme's coverage and minimise access disparities. It should then be decided if the digital and face-to-face programmes will be developed, assessed, and rolled out simultaneously, or if the digital programme will roll out only after the face-to-face programme has been running for several years, as was the approach adopted by the US NDPP and NHS-DPP. In either case, further research, collaboration, and evaluation is needed before a digital DPP can be implemented in routine practice. Based on the updated MRC framework for developing and evaluating complex interventions (Skivington et al., 2021), further digital DPP research and design should be undertaken through four dynamic phases. First, the programme should be developed as a new intervention, or adapted from an existing intervention. Second, this intervention should undergo feasibility and acceptability testing. Third, the intervention should be evaluated using appropriate methods. Finally, the intervention will be implemented, with efforts made to increase uptake and impact.

6.5.3.1. Phase One: Develop or Identify a Complex Intervention. The systematic review identified effective interventions and their active ingredients. The developers of the Irish digital DPP could adapt one of the reviewed interventions, or design one from scratch using the BCTs and digital features associated with intervention effectiveness. Regardless of the approach selected, the programme can be tailored to best fit the Irish context by using the findings from studies two and three. As Ireland is now recognised as a top five global hub for digital health and medical technologies (Ibec, 2020), its digital health ecosystem is well-placed to develop a 'home grown' DPP. Through the 'Stay Left, Shift Left' digital innovation strategy, the HSE has already collaborated with Irish start-ups and small- to mid-size enterprises to develop digital solutions to prevent chronic disease (HSE, 2020a). An alternative approach would be to partner with one of the offshore developers currently involved with the NHS-DPP digital pilot, as the lessons learned from this pilot could inform the feasibility of the digital DPP in Ireland.

6.5.3.2. Phase Two: Feasibility and Acceptability Assessment. In this phase, the MRC (Skivington et al., 2021) recommends a feasibility study to assess predefined progression criteria that relate to the evaluation design (e.g., recruitment, data collection, retention, outcomes, and analysis) or the intervention itself (e.g., optimal content and delivery, acceptability, adherence, cost-effectiveness, or capacity of providers to deliver the intervention). Feasibility and/or acceptability studies of this type have been conducted on Digital DPPs in both the US and the UK. In the US, Fontil et al. (2016) conducted an adaptation and feasibility study of a digital DPP for low-income patients. This programme, adapted from the US NDPP, was a collaboration between an academic research team and Omada Health, a digital health developer. The team used a four-phase user-centred approach to design a programme prototype. First, focus groups were conducted to understand the needs and perspectives of end users. Second, based on this feedback, the US NDPP sign-up process and curriculum were adapted. Third, a feasibility study was conducted to test the modified programme on 23 participants. Finally, the team provided and adopted recommendations for an updated programme to be assessed in a larger RCT. In the UK, Cassidy et al. (2019) designed a pilot study to assess the feasibility of a digital programme (smartphone app plus remote tele-coaching) for adults with PDM. The objectives of this study were to: (1) assess the feasibility of participant recruitment, (2) assess the intervention's acceptability among target users, (3) assess adherence to and completion of the intervention, (4) assess intervention fidelity, and (5) conduct a qualitative process evaluation with participants to identify enablers and barriers to programme completion.

6.5.3.3. Phase Three: Intervention Evaluation. In this phase, an evaluation is used to not only determine whether the intervention works in achieving its outcomes, but to identify additional impact, theorise how it works, understand how it interacts within the context in which it is implemented, how it contributes to system change, and how the findings can be used to support real-world decision making (Skivington et al., 2021). According to the MRC, a crucial aspect of evaluation design is the choice of outcome measures or evidence of change (Skivington et al., 2021). When evaluating the Irish digital DPP, appropriate measures of dietary intake, physical activity and engagement should be used, as these outcomes will help to determine the programme's mechanisms of action, or how target outcomes such as weight loss and reductions on T2DM incidence were achieved. The evaluation could take the form of a rigorous RCT such as the aforementioned SMART trial (Collins et al., 2007). Additionally, a process evaluation can be used to assess the programme's fidelity and implementation quality (Moore et al., 2015). A recent document analysis study by Hawkes et al. (2022) assessed the fidelity of the BCT content in the NHS-DPP digital pilot, and found the fidelity in the digital programme to be higher than that of the face-to-face programme. Such an assessment will be important for the Irish digital DPP, as interventions that maintain a high level of fidelity are more likely to be effective (Hankonen, 2021).

6.5.3.4. Phase Four: Programme Implementation. In this final phase, the Irish DPP is implemented in the real world, and its uptake and sustainability evaluated. Highly pragmatic effectiveness trials or specific hybrid effectiveness implementation designs can be used to combine effectiveness and implementation outcomes in one study to reduce the time needed to translate what works into routine practice (Skivington et al., 2021). During its implementation, the digital DPP can be altered to suit different contexts. For example, digital programmes based on the US NDPP were delivered to diverse populations including young adults (Cha et al., 2014), older adults (Barthold et al., 2020), and individuals residing in disadvantaged areas (Auster-Gussman et al., 2022). In each case, adaptations to the programme's delivery were required to suit each context. Although fidelity is an important precursor to intervention effectiveness, an Irish DPP can be altered if it is to be implemented and evaluated in different settings. However, it is important that the key functions of the programme are maintained, and that any adaptations or alterations to the programme's delivery are well documented and clearly understood (Moore et al., 2021). To determine the real-world impact of the programme in Ireland, it is important to obtain extended follow-up data regarding the estimated number of prevented cases of T2DM, and how this translates to reductions in national healthcare expenditure.

6.6. Implications for Policy

Two key policy implications were identified through this research. First, the accessibility of healthy foods in Ireland, particularly with regards to its affordability, should be examined prior the implementation of a digital DPP. In study three, the high cost of healthy food was identified as a main barrier to healthy eating. This limited affordability is a common perceived barrier in many high income countries, and is most prevalent among individuals of low socio-economic status (Zorbas et al., 2018). However, data on food affordability and accessibility in Ireland tells two contrasting stories. According to a 2021 report conducted by Safefood (2021), low-income households in Ireland spend up to 35% on their take-home income to buy a healthy minimum essential food basket that is both realistic, acceptable, and nutritionally adequate. As food is a flexible part of a family's budget, and more controllable than other costs such as rent and utilities, the unavoidable priority for many limited income families is to reduce food expenses by consuming cheaper foods that often have lower nutritional quality (Irish Heart Foundation, 2019). However, according to the 2021 Global Food Security Index report published by Economist Impact (2021), Ireland is ranked number one in the world on overall food security (out of 113 index countries, 26 in Europe), ranking 2nd on food affordability, and 8th on food availability. Although this index represents the affordability of all foods and not just those considered healthy, it highlights the equity potential for the Irish food environment. Therefore, T2DM prevention efforts should be supported through population-wide policies and initiatives that improve nationwide access to healthy food. As healthy food consumption is encouraged in a digital DPP, all participants must have sufficient access to nutritious foods if the programme is to be effective, particularly among lower income groups. An additional strategy could involve the distribution of vitamin and mineral supplements to individuals and groups who are at risk of T2DM and have limited access to adequate healthy food, specifically those nutrients with confirmed links with T2DM risk reduction. However, this may only solve issues of undernourishment regarding certain nutrients and may not affect the problematic consumption of calorie-dense, nutritionally poor foods.

The second policy implication is closely linked to the first as it also involves healthy eating practices. In study three, the two prominent facilitators for healthy eating were *being proactive* and *knowledge is key*. Through these themes, participants stated that batch cooking, pre-planning meals, organising shopping trips around healthy eating, and simply having the appropriate nutritional knowledge were the key factors that enabled them to eat healthily. Evidence supports this relationship between food literacy–defined as the range of knowledge and skills needed to use food–and the food choices people make (Safefood, 2016). In an Irish Safefood (2016) study, a sample of over 1,000 adults were assessed on their cooking skills confidence and food skills confidence via questionnaires of 14 and 19 items respectively. Items were rated on a scale of 1 (very poor) to 7 (very good). The mean cooking skills confidence score was 47.8 of a possible 98, and the mean food skills confidence score was 45.8 of a possible 133. This suggests that many Irish adults have low confidence in both preparing and planning their meals. Supporting the findings of study three, scores for cooking and food skills confidence were each positively associated with scores on the Eating Choice Index, suggesting that confidence levels predict healthier eating choices. Sub-group analysis revealed that younger adults (age 20 to 39), males, and those with no secondary education or higher were each significantly less confident than their respective comparison groups of older adults (age 40 to 60), females, and those with secondary or greater education. However, there were no significant differences in either cooking or food skills confidence between those of high and low socio-economic status.

The Community Food Initiative programme developed by Safefood (2022) was implemented to help families with children in low-income communities to develop various skills and knowledge on healthy eating, healthier shopping, and cooking. However, given that cooking and food skills confidence in Ireland is low across the socio-economic spectrum, additional initiatives may be required to improve these skills and aid in the prevention of T2DM. For example, an Irish digital DPP could include the delivery of food and cooking skills training remotely, either live via webinar, or through pre-recorded content. At the population level, upstream initiatives should also be considered, such as the delivery of food and cooking skills classes in primary and/or secondary schools. While cooking skills interventions tend to target all age groups, an Irish cross-sectional study found that the optimal period for learning these skills is in early childhood (under 12 years of age) and the teenage years, as these learners had significantly greater numbers of, and confidence in, their cooking and food skills, cooking practices, cooking attitudes, diet quality and health status when assessed against adult learners (Lavelle et al., 2016). One disadvantage regarding the prioritisation of nutrition education in early childhood, is that it could take many years for its impact to be reflected in reduced rates of adult T2DM incidence.

6.7. Implications for Practice

Multiple referral pathways exist for digital DPPs in the US and the UK. In the US, the main source of referral is through primary care where eligible participants are identified through their primary physician or electronic health record and then referred to the programme through their respective health centres (Almeida et al., 2020; Katula et al., 2022; Kim et al., 2018). In the UK, the most common referral pathway is through primary care and general practice, or at NHS health checks which are offered at no cost to adults aged 40 to 74 every five years to determine their risk of developing heart disease, stroke, kidney disease, or T2DM (NHS England, 2022; Ross et al., 2022). Given the reliance on primary care in the referral process, there must be a high degree of buy-in from GPs and other HCPs in Ireland to maximise referrals and programme uptake within a digital DPP. The results of study three support this as participants stated they would be more likely to try the programme if it was recommended by their GP.

According to a qualitative study of the face-to-face NHS-DPP, one key barrier to programme participation at the point of referral was the inconsistency of information provided by GPs and other HCPs on what the programme actually involved, causing apprehension among prospective participants (Rodrigues et al., 2020). In this same study, key stakeholders which included service users, referrers, and programme delivery personnel, identified the point of referral as a window of opportunity to offer brief advice, promote behaviour change, and to provide an understanding of T2DM risk and details of the programme. In Ireland, the HSE have implemented the ‘Making Every Contact Count’ programme which enables and encourages HCPs to apply brief behavioural interventions in routine healthcare consultations to support patients in making health behaviour changes (HSE, 2016; Meade et al., 2022). In the context of T2DM prevention, this would involve a discussion on physical activity and nutrition with patients or clients that are at risk. However, research has indicated that the majority of medical students, doctors, and nurses in the UK, Ireland, and abroad–despite recognising the importance of nutrition in preventive healthcare–are not confident in their nutrition knowledge, frequently citing a lack of confidence and time as barriers to providing nutritional advice to patients (Crowley et al., 2019; Macaninch et al., 2020; Ní Chonaill et al., 2022; O′ Connell et al., 2018). This suggests that HCPs may not be well-equipped to advise patients or clients on the health behaviour changes they can make to prevent T2DM. In study three, several participants felt they received little support and understanding from their GP or other HCPs regarding T2DM. This included the perception that HCPs lacked the time or knowledge to assist, and in some cases, participants felt dismissed and judged negatively because of their body weight.

For a digital DPP to have sizeable impact through primary care or general practice, several research avenues, initiatives, and communication strategies should be considered. First, the research model and extended framework for digital DPP acceptability should be modified and applied in a study that assesses the programme's acceptability among GPs and other HCPs in Ireland. One participant in study three suggested that their GP would be vehemently against the use of DHTs in healthcare. This supports the findings of O'Connor et al. (2015) who found that many healthcare staff responsible for recruiting digital health users held traditional perceptions of care and did not see the need for DHTs, and did not view them as beneficial. This resulted in fewer referrals. It is therefore important to obtain a broader picture of DHT acceptability among HCPs in Ireland to identify the facilitators and barriers to their endorsement of a digital DPP. Second, initiatives to stimulate primary care buy-in should be implemented so that individuals eligible to enrol in the programme are learning of the programme through their GP and are offered a place. According to Stokes et al. (2019), who reported the 'lessons learned' from the implementation of the face-to-face NHS-DPP, the programme needs to be well promoted in primary care to generate awareness. It was found that after the programme had been implemented, many GPs still did not know what it was outside of knowing that it was a lifestyle programme. Whether this limited understanding was due to a lack of education regarding the programme or a lack of interest, the authors found that the provision of education and financial incentives to general practices could be used to encourage buy-in and increase referrals. Third, the way in which HCPs address issues of body weight and T2DM risk with their patients should be assessed further. Without using the word 'blame' explicitly, several participants in study three alluded to the stigmatisation of their body weight by HCPs. One participant stated they were 'given out to' or scolded about their weight; another stated that they received no advice except to hire a personal trainer; and a third participant who suffered from serious foot pain stated that their dietician did not believe the pain existed, or that it could be serious enough to prevent exercise. Weight stigma has been associated with adverse physiological and psychological outcomes such as obesity, depression, anxiety, and low self-esteem; and can increase the risk of T2DM (Pearl et al., 2020; Wu & Berry, 2018). This stigma is often informed by stereotypes that describe people wither higher body weights as lazy and lacking self-control, along with the perception that body weight is controllable, which places blame directly on the individual if they are unable to control their weight (Pearl, 2020).

While it is important to encourage GPs to refer people at risk of T2DM to the digital DPP, a patient or client may develop a negative view of the programme if the referral is associated with perceived weight stigma or personal judgement. Both the US NDPP and NHS-DPP are promoted by their respective facilitators as 'lifestyle programmes'. However, this term can be interpreted in different ways. On one hand, the term could suggest that T2DM is solely reflective of one's lifestyle choices. Choice could imply responsibility, which can incite blame or lead to personal feelings of guilt, such as that described by a participant in study three. When referred under this condition, the programme could be perceived negatively. On the other hand, the true aim of the programme is to encourage the types of sustainable health behaviour change that can fit seamlessly into one's existing lifestyle. That is, becoming more active and energetic, but not exhausting oneself through laborious exercise. It is also about eating a balanced and nutritious diet, rather than restricting or 'dieting'. For a digital DPP to be successful through general practice, it could best be expressed as a programme that can improve one's day-to-day energy and augment one's quality of life, rather than as a programme that corrects obesity, prevents disease, and decreases mortality. In the context of massage framing (see Rothman et al., 2006), this would suggest a recommendation for the use of gain-framed messages, which emphasise the benefits of performing a behaviour (e.g., more energy and vitality), as opposed to loss-framed messages which emphasise the costs of not performing a behaviour (e.g., becoming ill). However, studies assessing the effectiveness of gain-framed versus loss-framed messages in T2DM prevention and management have reported mixed results (e.g., Goh et al., 2021; Grady et al., 2011; Lee & Gu, 2009; Park et al., 2020; van't Riet et al., 2010). Therefore, future research should examine the use of gain-framed and loss-framed messages in the context of a digital DPP and assess the effect of these messages on programme acceptability and subsequent adoption.

6.8. Conclusion

Type 2 diabetes mellitus represents a significant global public health concern and economic burden. In efforts to slow the escalating trend of T2DM incidence, several countries have implemented a national DPP that empowers people at risk of the disease to improve their eating behaviours, increase their level of physical activity, and maintain a healthy weight. These programmes have since been adapted for digital delivery, enabling users to engage with the programme online via computer or smartphone. This research has built an evidence base for the development and implementation of a digital DPP in Ireland, where its findings have identified ways through which the programme can maximise its effectiveness and engagement. Avenues to further extend the global evidence base regarding digital DPPs, and to support the prevention of T2DM in Ireland at both the practice and policy levels were also identified through this research.

The research found that technology-driven T2DM prevention interventions can achieve clinically significant weight loss, improvements in blood glucose, and reductions in T2DM incidence. However, this effectiveness was mostly limited to the short-term, with the evidence for long-term effectiveness unclear. To maximise effectiveness and potential engagement, the Irish digital DPP should include, at minimum, BCTs and digital features pertaining to social support, goal setting, feedback, self-monitoring, problem solving, health and lifestyle information and advice, and online health coaching. Problem solving exercises facilitated by an online health coach are particularly important for long term effectiveness. To further extend the evidence base regarding digital DPPs, key outcomes pertaining to dietary intake, physical activity, T2DM incidence, cost-effectiveness, and user engagement should be assessed, as these outcomes are often understudied and/or underreported. Such measures may provide a complete picture of a programme's impact by identifying its mechanisms of action, its effect on the nation's T2DM incidence rate, and whether this effect translates into reductions in national healthcare expenditures.

To enhance the acceptability and engagement potential of an Irish programme, further public education regarding the seriousness of T2DM is required, particularly for those at higher risk. The programme and its communication strategies should also be tailored to suit the diverse needs and interests of its target users, particularly in the areas of goal setting social support, and information plus data sharing. Further research is needed to identify appropriate avenues for programme tailoring to engage populations in Ireland that were underrepresented in this research, such as socio-economically diverse groups, members of the

Irish Traveller community, and men and non-binary individuals. Additional research involving HCPs in Ireland regarding the acceptability of a digital DPP is also required, as buy-in from these professionals is important to maximise programme referrals. To further support the efforts of a digital DPP, policies that ensure population-wide access to and affordability of heathy foods should be implemented, as should the provision of cooking and food skills education and training. Such population-level initiatives, when combined with a national digital DPP, could facilitate an equitable and impactful approach to T2DM prevention in Ireland.

References

Abdalla, S., Kelleher, C., Quirke, B., Daly, L., Cronin, F., Drummond, A., Fitzpatrick, P., Frazier, K., Hamid, N. A., Kelly, C., Kilroe, J., Lotya, J., McGorrian, C., Moore, R. G., Murnane, S., Carthaigh, R. N., O'Mahony, D., O'Shea, B., Staines, A., . . . Whelan, J. (2013). Social inequalities in health expectancy and the contribution of mortality and morbidity: the case of Irish Travellers. *Journal of Public Health*, *35*(4), 533-540. https://doi.org/10.1093/pubmed/fds106

Absetz, P., Oldenburg, B., Hankonen, N., Valve, R., Heinonen, H., Nissinen, A., Fogelholm, M., Talja, M., & Uutela, A. (2009). Type 2 diabetes prevention in the real world: three-year results of the GOAL lifestyle implementation trial. *Diabetes Care*, *32*(8), 1418-1420. https://doi.org/10.2337/dc09-0039

Ackermann, R. T., Finch, E. A., Brizendine, E., Zhou, H., & Marrero, D. G. (2008). Translating the Diabetes Prevention Program into the community: the DEPLOY pilot study. *American Journal of Preventive Medicine*, *35*(4), 357-363. https://doi.org/10.1016/j.amepre.2008.06.035

Adams, J., Hillier-Brown, F. C., Moore, H. J., Lake, A. A., Araujo-Soares, V., White, M., & Summerbell, C. (2016). Searching and synthesising ‘grey literature’ and ‘grey information’ in public health: critical reflections on three case studies. *Systematic Reviews*, *5*(1), 1-11. https://doi.org/10.1186/s13643-016-0337-y

Adams, W. C. (2015). Conducting semi-structured interviews. In J. S. Wholey, H. P. Hatry, & K. E. Newcomer (Eds.), *Handbook of Practical Program Evaluation* (3rd ed., pp. 492-505). Jossey-Bass.

Aguiar, E. J., Morgan, P. J., Collins, C. E., Plotnikoff, R. C., Young, M. D., & Callister, R. (2016). Efficacy of the type 2 diabetes prevention using lifestyle education program RCT. *American Journal of Preventive Medicine*, *50*(3), 353-364. https://doi.org/10.1016/j.amepre.2015.08.020

Ahmad, A., Rasul, T., Yousaf, A., & Zaman, U. (2020). Understanding factors influencing elderly diabetic patients' continuance intention to use digital health wearables: extending the Technology Acceptance Model (TAM). *Journal of Open Innovation: Technology, Market, and Complexity*, *6*(3), 1-15. https://doi.org/10.3390/joitmc6030081

Ajala, O., English, P., & Pinkney, J. (2013). Systematic review and meta-analysis of different dietary approaches to the management of type 2 diabetes. *The American Journal of Clinical Nutrition*, *97*(3), 505-516. https://doi.org/10.3945/ajcn.112.042457

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179-211. https://doi.org/10.1016/0749-5978(91)90020-T

Ajzen, I. (2002). Constructing a TPB questionnaire: Conceptual and methodological considerations. Retrieved March 3, 2020, from http://chuang.epage.au.edu.tw/ezfiles/168/1168/attach/20/pta_41176_7688352_57138.pdf

Alberti, K. G. M. M., Zimmet, P., & Shaw, J. (2007). International Diabetes Federation: a consensus on Type 2 diabetes prevention. *Diabetic Medicine*, *24*(5), 451-463. https://doi.org/10.1111/j.1464-5491.2007.02157.x

Albright, A. L., & Gregg, E. W. (2013). Preventing type 2 diabetes in communities across the US: the National Diabetes Prevention Program. *American Journal of Preventive Medicine*, *44*(4), S346-S351. https://doi.org/10.1016/j.amepre.2012.12.009

Alhazmi, A., Stojanovski, E., McEvoy, M., & Garg, M. L. (2012). Macronutrient Intakes and Development of Type 2 Diabetes: A Systematic Review and Meta-Analysis of Cohort Studies. *Journal of the American College of Nutrition*, *31*(4), 243-258. https://doi.org/10.1080/07315724.2012.10720425

Ali, M. K., Bullard, K. M., Saydah, S., Imperatore, G., & Gregg, E. W. (2018). Cardiovascular and renal burdens of prediabetes in the USA: analysis of data from serial cross-sectional surveys, 1988–2014. *The Lancet Diabetes & Endocrinology*, *6*(5), 392-403. https://doi.org/10.1016/S2213-8587(18)30027-5

Ali, M. K., Echouffo-Tcheugui, J., & Williamson, D. F. (2012). How effective were lifestyle interventions in real-world settings that were modeled on the Diabetes Prevention Program? *Health Affairs*, *31*(1), 67-75. https://doi.org/10.1377/hlthaff.2011.1009

Ali, M. K., McKeever Bullard, K., Imperatore, G., Benoit, S. R., Rolka, D. B., Albright, A. L., & Gregg, E. W. (2019). Reach and Use of Diabetes Prevention Services in the United States, 2016-2017. *JAMA Network Open*, *2*(5), 1-14. https://doi.org/10.1001/jamanetworkopen.2019.3160

Ali, O. (2013). Genetics of type 2 diabetes. *World Journal of Diabetes*, *4*(4), 114-123. https://doi.org/10.4239/wjd.v4.i4.114

Alkhaldi, G., Modrow, K., Hamilton, F., Pal, K., Ross, J., & Murray, E. (2017). Promoting engagement with a digital health intervention (HeLP-Diabetes) using email and text message prompts: mixed-methods study. *Interactive Journal of Medical Research*, *6*(2), 1-14. https://doi.org/10.2196/ijmr.6952

Allende-Vigo, M. Z. (2015). Diabetes mellitus prevention. *American Journal of Therapeutics*, *22*(1), 68-72. https://doi.org/10.1097/MJT.0b013e3182211bae

Almagro, B., & Ji, A. G. (2015). Validation of the eHealth literacy scale (eHEALS) in Spanish university students. *Revista Espanola de Salud Publica*, *89*(3), 329-338. https://doi.org/10.4321/s1135-57272015000300010

Almalki, M., & Giannicchi, A. (2021). Health apps for combating COVID-19: descriptive review and taxonomy. *JMIR mHealth and uHealth*, *9*(3), 1-15. https://doi.org/10.2196/24322

Almeida, F. A., Michaud, T. L., Wilson, K. E., Schwab, R. J., Goessl, C., Porter, G. C., Brito, F. A., Evans, G., Dressler, E. V., Boggs, A. E., Katula, J. A., Sweet, C. C., & Estabrooks, P. A. (2020). Preventing diabetes with digital health and coaching for translation and scalability (PREDICTS): A type 1 hybrid effectiveness-implementation trial protocol. *Contemporary Clinical Trials*, *88*, 1-9. https://doi.org/10.1016/j.cct.2019.105877

American Diabetes Association. (2013). Diagnosis and classification of diabetes mellitus. *Diabetes Care*, *36*(Supplement 1), S67-S74. https://doi.org/10.2337/dc13-S067

American Diabetes Association. (2018). 2. Classification and diagnosis of diabetes: standards of medical care in diabetes—2018. *Diabetes Care*, *41*(Supplement 1), S13-S27. https://doi.org/10.2337/dc18-S002

American Diabetes Association. (2020a). 3. Prevention or Delay of Type 2 Diabetes: Standards of Medical Care in Diabetes—2021. *Diabetes Care*, *44*(Supplement 1), S34-S39. https://doi.org/10.2337/dc21-S003

American Diabetes Association. (2020b). *Type 2 Overview: Diabetes Symptoms*. American Diabetes Association. Retrieved May 14, 2020 from https://www.diabetes.org/diabetes/type-2/symptoms

American Diabetes Association. (2021a). *Prediabetes: With prediabetes, action is the best medicine*. American Diabetes Association. Retrieved December 2, 2021 from https://diabetes.org/diabetes/prediabetes

American Diabetes Association. (2021b). Standards of medical care in diabetes—2021 abridged for primary care providers. *Clinical Diabetes*, *39*(1), 14-43. https://doi.org/10.2337/cd21-as01

American Psychological Association. (2018). *APA PsycInfo.* https://www.apa.org/pubs/databases/psycinfo/

Anderson-Lister, G., & Treharne, G. J. (2014). 'Healthy'individuals' perceptions of type 1 and type 2 diabetes cause and management: A 'think-aloud', mixed-methods study using video-based vignettes. *Journal of Health Psychology*, *19*(11), 1371-1381. https://doi.org/10.1177/1359105313490315

Anderson, C., Seff, L. R., Batra, A., Bhatt, C., & Palmer, R. C. (2016). Recruiting and Engaging Older Men in Evidence-Based Health Promotion Programs: Perspectives on Barriers and Strategies. *Journal of Aging Research*, *2016*, 1-9. https://doi.org/10.1155/2016/8981435

Andersson, E. K., Sjöström-Strand, A., Willman, A., & Borglin, G. (2015). Registered nurses views of caring in coronary care – a deductive and inductive content analysis. *Journal of Clinical Nursing*, *24*(23-24), 3481-3493. https://doi.org/10.1111/jocn.12975

Antwi, J., Lavin, R., Sullivan, S., & Bellavia, M. (2020). Perception of and risk factors for type 2 diabetes among students attending an upstate New York college: a pilot study. *Diabetology & Metabolic Syndrome*, *12,* 1-8. https://doi.org/10.1186/s13098-020-00535-1

Arbuckle, J. L. (2020). *Amos (Version 27.0)*. In IBM SPSS.

Ardill, L. (2019). Why healthcare is undergoing a digital revolution in Ireland. Retrieved January 5, 2022, from https://www.siliconrepublic.com/innovation/digital-health-ireland-infographic

Arens, J. H., Hauth, W., & Weissmann, J. (2018). Novel App- and Web-Supported Diabetes Prevention Program to Promote Weight Reduction, Physical Activity, and a Healthier Lifestyle: Observation of the Clinical Application. *Journal of Diabetes Science and Technology*, *12*(4), 831-838. https://doi.org/10.1177/1932296818768621

Arigo, D., Jake-Schoffman, D. E., Wolin, K., Beckjord, E., Hekler, E. B., & Pagoto, S. L. (2019). The history and future of digital health in the field of behavioral medicine. *Journal of Behavioral Medicine*, *42*(1), 67-83. https://doi.org/10.1007/s10865-018-9966-z

Armat, M. R., Assarroudi, A., Rad, M., Sharifi, H., & Heydari, A. (2018). Inductive and deductive: Ambiguous labels in qualitative content analysis. *The Qualitative Report*, *23*(1), 219-221. https://link.gale.com/apps/doc/A528960568/AONE?u=anon~40b2f0ae&sid=googleScholar&xid=07b08a7d

Armitage, C. J., Conner, M., Prestwich, A., de Bruin, M., Johnston, M., Sniehotta, F., & Epton, T. (2021). Investigating which behaviour change techniques work for whom in which contexts delivered by what means: Proposal for an international collaboratory of Centres for Understanding Behaviour Change (CUBiC). *British Journal of Health Psychology*, *26*(1), 1-14. https://doi.org/10.1111/bjhp.12479

Aroda, V. R., Edelstein, S. L., Goldberg, R. B., Knowler, W. C., Marcovina, S. M., Orchard, T. J., Bray, G. A., Schade, D. S., Temprosa, M. G., White, N. H., Crandall, J. P., & Group, t. D. P. P. R. (2016). Long-term Metformin Use and Vitamin B12 Deficiency in the Diabetes Prevention Program Outcomes Study. *The Journal of Clinical Endocrinology & Metabolism*, *101*(4), 1754-1761. https://doi.org/10.1210/jc.2015-3754

Ashra, N. B., Spong, R., Carter, P., Davies, M. J., Dunkley, A., Gillies, C., Greaves, C., Khunti, K., Sutton, S., & Yates, T. (2015). *A systematic review and meta-analysis assessing the effectiveness of pragmatic lifestyle interventions for the prevention of type 2 diabetes mellitus in routine practice*. Public Health England. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/733053/PHE_Evidence_Review_of_diabetes_prevention_programmes-_FINAL.pdf

Atkinson, M. A., Eisenbarth, G. S., & Michels, A. W. (2014). Type 1 diabetes. *The Lancet*, *383*(9911), 69-82. https://doi.org/10.1016/S0140-6736(13)60591-7

Aune, D., Norat, T., Leitzmann, M., Tonstad, S., & Vatten, L. J. (2015). Physical activity and the risk of type 2 diabetes: A systematic review and dose-response meta-analysis. *European Journal of Epidemiology*, *30*(7), 529-542. https://doi.org/10.1007/s10654-015-0056-z

Aune, D., Norat, T., Romundstad, P., & Vatten, L. J. (2013). Whole grain and refined grain consumption and the risk of type 2 diabetes: a systematic review and dose-response meta-analysis of cohort studies. *European Journal of Epidemiology, 28*(11), 845-858. http://www.jstor.org.nuigalway.idm.oclc.org/stable/43774908

Auster-Gussman, L. A., Lockwood, K. G., Graham, S. A., Stein, N., & Branch, O. H. (2022). Reach of a Fully Digital Diabetes Prevention Program in Health Professional Shortage Areas. *Population Health Management*, 1-8. https://doi.org/10.1089/pop.2021.0283

Australian Digital Health Agency. (2021). *National Digital Health Strategy and Framework for Action*. Retrieved January 17, 2022 from https://www.digitalhealth.gov.au/about-us/strategies-and-plans/national-digital-health-strategy-and-framework-for-action

Avery, L., Flynn, D., Van Wersch, A., Sniehotta, F. F., & Trenell, M. I. (2012). Changing physical activity behavior in type 2 diabetes: a systematic review and meta-analysis of behavioral interventions. *Diabetes Care, 35*(12), 2681-2689. https://doi.org/10.2337/dc11-2452

Aziz, Z., Absetz, P., Oldroyd, J., Pronk, N. P., & Oldenburg, B. (2015). A systematic review of real-world diabetes prevention programs: learnings from the last 15 years. *Implementation Science*, *10*(1), 1-17. https://doi.org/10.1186/s13012-015-0354-6

Ballantine, P. W., & Stephenson, R. J. (2011). Help me, I'm fat! Social support in online weight loss networks. *Journal of Consumer Behaviour*, *10*(6), 332-337. https://doi.org/10.1002/cb.374

Bansal, N. (2015). Prediabetes diagnosis and treatment: A review. *World Journal of Diabetes*, *6*(2), 296-303. https://doi.org/10.4239/wjd.v6.i2.296

Barnard, K. D., & Breton, M. D. (2018). Diabetes Technological Revolution: Winners and Losers? *Journal of Diabetes Science and Technology*, *12*(6), 1227-1230. https://doi.org/10.1177/1932296818788872

Barron, E., Clark, R., Hewings, R., Smith, J., & Valabhji, J. (2018). Progress of the Healthier You: NHS Diabetes Prevention Programme: referrals, uptake and participant characteristics. *Diabetic Medicine*, *35*(4), 513-518. https://doi.org/10.1111/dme.1356

Barroso, C., Carrión, G. C., & Roldán, J. L. (2010). Applying maximum likelihood and PLS on different sample sizes: studies on SERVQUAL model and employee behavior model. In *Handbook of partial least squares* (pp. 427-447). Springer. https://doi.org/10.1111/dme.135610.1007/978-3-540-32827-8_20

Barry, E., Roberts, S., Finer, S., Vijayaraghavan, S., & Greenhalgh, T. (2015). Time to question the NHS diabetes prevention programme. *BMJ*, *351*, 1-2. https://doi.org/10.1136/bmj.h4717

Barry, E., Roberts, S., Oke, J., Vijayaraghavan, S., Normansell, R., & Greenhalgh, T. (2017). Efficacy and effectiveness of screen and treat policies in prevention of type 2 diabetes: systematic review and meta-analysis of screening tests and interventions. *BMJ*, *356*, 1-16. https://doi.org/10.1136/bmj.i6538

Barthold, D., Chiguluri, V., Gumpina, R., Castro Sweet, C., Pieratt, J., Cordier, T., Matanich, R., Rogstad, T. L., & Prewitt, T. (2020). Health Care Utilization and Medical Cost Outcomes from a Digital Diabetes Prevention Program in a Medicare Advantage Population. *Population Health Management, 23*(6), 414-421. https://doi.org/10.1089/pop.2019.0184

Bastien, M., Poirier, P., Lemieux, I., & Després, J.-P. (2014). Overview of epidemiology and contribution of obesity to cardiovascular disease. *Progress in Cardiovascular Diseases*, *56*(4), 369-381. https://doi.org/10.1016/j.pcad.2013.10.016

Basu, S., Seligman, H., & Bhattacharya, J. (2013). Nutritional policy changes in the supplemental nutrition assistance program: a microsimulation and cost-effectiveness analysis. *Medical Decision Making*, *33*(7), 937-948. https://doi.org/10.1177/0272989X13493971

Basu, S., Yudkin, J. S., Kehlenbrink, S., Davies, J. I., Wild, S. H., Lipska, K. J., Sussman, J. B., & Beran, D. (2019). Estimation of global insulin use for type 2 diabetes, 2018–30: a microsimulation analysis. *The Lancet Diabetes & Endocrinology*, *7*(1), 25-33. https://doi.org/10.1016/S2213-8587(18)30303-6

Bauman, A., Bull, F., Chey, T., Craig, C. L., Ainsworth, B. E., Sallis, J. F., Bowles, H. R., Hagstromer, M., Sjostrom, M., Pratt, M., & The, I. P. S. G. (2009). The International Prevalence Study on Physical Activity: results from 20 countries. *International Journal of Behavioral Nutrition and Physical Activity*, *6*(1), 21. https://doi.org/10.1186/1479-5868-6-21

Bautista, J. R. (2015). From solving a health problem to achieving quality of life: redefining eHealth literacy. *Journal of Literacy and Technology*, *16*(2), 33-54. http://www.literacyandtechnology.org/uploads/1/3/6/8/136889/jlt_v16_2_bautista.pdf

Beagley, J., Guariguata, L., Weil, C., & Motala, A. A. (2014). Global estimates of undiagnosed diabetes in adults. *Diabetes Research and Clinical Practice*, *103*(2), 150-160. https://doi.org/10.1016/j.diabres.2013.11.001

Begum, S., Povey, R., Ellis, N., & Gidlow, C. (2020). A systematic review of recruitment strategies and behaviour change techniques in group-based diabetes prevention programmes focusing on uptake and retention. *Diabetes Research and Clinical Practice*, *166*, 1-13. https://doi.org/10.1016/j.diabres.2020.108273

Begum, S., Povey, R., Ellis, N., Gidlow, C., & Chadwick, P. (2022). Influences of decisions to attend a national diabetes prevention programme from people living in a socioeconomically deprived area. *Diabetic Medicine*, 1-9. https://doi.org/10.1111/dme.14804

Behboudi-Gandevani, S., Amiri, M., Bidhendi Yarandi, R., & Ramezani Tehrani, F. (2019). The impact of diagnostic criteria for gestational diabetes on its prevalence: a systematic review and meta-analysis. *Diabetology & Metabolic Syndrome*, *11*(1), 1-18. https://doi.org/10.1186/s13098-019-0406-1

Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin*, *107*(2), 238-246. https://doi.org/10.1037/0033-2909.107.2.238

Bentler, P. M., & Chou, C.-P. (1987). Practical issues in structural modeling. *Sociological Methods & Research*, *16*(1), 78-117. https://doi.org/10.1177/0049124187016001004

Bethlehem, J. (2010). Selection bias in web surveys. *International Statistical Review*, *78*(2), 161-188. https://doi.org/10.1111/j.1751-5823.2010.00112.x

Bhalla, A., Durham, R. L., Al-Tabaa, N., & Yeager, C. (2016). The development and initial psychometric validation of the eHealth readiness scale. *Computers in Human Behavior*, *65*, 460-467. https://doi.org/10.1016/j.chb.2016.09.015

Bhopal, R. S., Douglas, A., Wallia, S., Forbes, J. F., Lean, M. E., Gill, J. M., McKnight, J. A., Sattar, N., Sheikh, A., & Wild, S. H. (2014). Effect of a lifestyle intervention on weight change in south Asian individuals in the UK at high risk of type 2 diabetes: a family-cluster randomised controlled trial. *The Lancet Diabetes & Endocrinology*, *2*(3), 218-227. https://doi.org/10.1016/S2213-8587(13)70204-3

Bhupathiraju, S. N., Tobias, D. K., Malik, V. S., Pan, A., Hruby, A., Manson, J. E., Willett, W. C., & Hu, F. B. (2014). Glycemic index, glycemic load, and risk of type 2 diabetes: results from 3 large US cohorts and an updated meta-analysis. *The American Journal of Clinical Nutrition*, *100*(1), 218-232. https://doi.org/10.3945/ajcn.113.079533

Bi, H., Gan, Y., Yang, C., Chen, Y., Tong, X., & Lu, Z. (2015). Breakfast skipping and the risk of type 2 diabetes: a meta-analysis of observational studies. *Public Health Nutrition*, *18*(16), 3013-3019. https://doi.org/10.1017/S1368980015000257

Bian, R. R., Piatt, G. A., Sen, A., Plegue, M. A., De Michele, M. L., Hafez, D., Czuhajewski, C. M., Buis, L. R., Kaufman, N., & Richardson, C. R. (2017). The Effect of Technology-Mediated Diabetes Prevention Interventions on Weight: A Meta-Analysis. *Journal of Medical Internet Research*, *19*(3), 1-12. https://doi.org/10.2196/jmir.4709

Black, N., Williams, A. J., Javornik, N., Scott, C., Johnston, M., Eisma, M. C., Michie, S., Hartmann-Boyce, J., West, R., & Viechtbauer, W. (2018). Enhancing Behavior Change Technique Coding Methods: Identifying Behavioral Targets and Delivery Styles in Smoking Cessation Trials. *Annals of Behavioral Medicine*, *53*(6), 583-591. https://doi.org/10.1093/abm/kay068

Block, G., Azar, K. M. J., Romanelli, R. J., Block, T. J., Hopkins, D., Carpenter, H. A., Dolginsky, M. S., Hudes, M. L., Palaniappan, L. P., & Block, C. H. (2015). Diabetes prevention and weight loss with a fully automated behavioral intervention by email, Web, and mobile phone: A randomized controlled trial among persons with prediabetes. *Journal of Medical Internet Research*, *17*(10), 1-14. https://doi.org/10.2196/jmir.4897

Böhme, P., Luc, A., Gillet, P., & Thilly, N. (2020). Effectiveness of a type 2 diabetes prevention program combining FINDRISC scoring and telephone-based coaching in the French population of bakery/pastry employees. *European Journal of Clinical Nutrition*, *74*(3), 409-418. https://doi.org/10.1038/s41430-019-0472-3

Bölen, M. C. (2020). Exploring the determinants of users' continuance intention in smartwatches. *Technology in Society*, *60*, 1-12. https://doi.org/10.1016/j.techsoc.2019.101209

Boltri, J. M., Davis-Smith, Y. M., Seale, J. P., Shellenberger, S., Okosun, I. S., & Cornelius, M. E. (2008). Diabetes prevention in a faith-based setting: results of translational research. *Journal of Public Health Management and Practice*, *14*(1), 29-32. https://doi.org/10.1097/01.PHH.0000303410.66485.91

Boomsma, A. (1983). *On the robustness of LISREL (maximum likelihood estimation) against small sample size and non-normality*. University of Groningen. https://pure.rug.nl/ws/portalfiles/portal/14418735/04_c4.pdf

Booth, C., & Tannock, I. (2014). Randomised controlled trials and population-based observational research: partners in the evolution of medical evidence. *British Journal of Cancer*, *110*(3), 551-555. https://doi.org/10.1038/bjc.2013.72

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Braun, V., & Clarke, V. (2021). To saturate or not to saturate? Questioning data saturation as a useful concept for thematic analysis and sample-size rationales. *Qualitative Research in Sport, Exercise and Health*, *13*(2), 201-216. https://doi.org/10.1080/2159676X.2019.1704846

Bravata, D. M., Smith-Spangler, C., Sundaram, V., Gienger, A. L., Lin, N., Lewis, R., Stave, C. D., Olkin, I., & Sirard, J. R. (2007). Using pedometers to increase physical activity and improve health: a systematic review. *Journal of the American Medical Association*, *298*(19), 2296-2304. https://doi.org/10.1001/jama.298.19.2296

Breeze, P., Thomas, C., Squires, H., Brennan, A., Greaves, C., Diggle, P., Brunner, E., Tabak, A., Preston, L., & Chilcott, J. (2017). Cost-effectiveness of population-based, community, workplace and individual policies for diabetes prevention in the UK. *Diabetic Medicine*, *34*(8), 1136-1144. https://doi.org/10.1111/dme.13349

Brinson, N. H., & Rutherford, D. N. (2020). Privacy and the quantified self: A review of US health information policy limitations related to wearable technologies. *Journal of Consumer Affairs, 54*(4), 1355-1374. https://doi.org/10.1111/joca.12320

Brown, T. A., & Moore, M. T. (2012). Confirmatory factor analysis. In R. H. Hoyle (Ed.), *Handbook of Structural Equation Modeling* (Vol. 361, pp. 361-379). https://www.researchgate.net/profile/Michael-Moore-75/publication/251573889_Hoyle_CFA_Chapter_-_Final/links/0deec51f14d2070566000000/Hoyle-CFA-Chapter-Final.pdf

Brown, T. J., Hardeman, W., Bauld, L., Holland, R., Maskrey, V., Naughton, F., Orton, S., Ussher, M., & Notley, C. (2019). A systematic review of behaviour change techniques within interventions to prevent return to smoking postpartum. *Addictive Behaviors, 92*, 236-243. https://doi.org/10.1016/j.addbeh.2018.12.031

Brownson, R. C., Chriqui, J. F., & Stamatakis, K. A. (2009). Understanding evidence-based public health policy. *American Journal of Public Health*, *99*(9), 1576-1583. https://doi.org/10.2105/AJPH.2008.156224

Bruusgaard, D., Smeby, L., & Claussen, B. (2010). Education and disability pension: a stronger association than previously found. *Scandinavian Journal of Public Health*, *38*(7), 686-690. https://doi.org/10.1177/1403494810378916

Buchholz, S. W., Wilbur, J., Halloway, S., Schoeny, M., Johnson, T., Vispute, S., & Kitsiou, S. (2020). Study protocol for a sequential multiple assignment randomized trial (SMART) to improve physical activity in employed women. *Contemporary Clinical Trials, 89*, 1-25. https://doi.org/10.1016/j.cct.2019.105921

Buckley, C., Madden, J., Balanda, K., Barron, S., Fahy, L., Harrington, J., Perry, I., & M. Kearney, P. (2013). Pre-diabetes in adults 45 years and over in Ireland: the Survey of Lifestyle, Attitudes and Nutrition in Ireland 2007. *Diabetic Medicine*, *30*(10), 1198-1203. https://doi.org/10.1111/dme.12226

Buddi Ltd. (2021). *Nujjer is your personal solution to help you improve your lifestyle and prevent type 2 diabetes*. Retrieved November 8, 2021 from http://nujjer.com/

Burke, L. E., Conroy, M. B., Sereika, S. M., Elci, O. U., Styn, M. A., Acharya, S. D., Sevick, M. A., Ewing, L. J., & Glanz, K. (2011). The effect of electronic self-monitoring on weight loss and dietary intake: a randomized behavioral weight loss trial. *Obesity*, *19*(2), 338-344. https://doi.org/10.1038/oby.2010.208

Burke, L. E., Warziski, M., Starrett, T., Choo, J., Music, E., Sereika, S., Stark, S., & Sevick, M. A. (2005). Self-monitoring dietary intake: current and future practices. *Journal of Renal Nutrition*, *15*(3), 281-290. https://doi.org/10.1016/j.jrn.2005.04.002

Byrom, N. (2020). COVID-19 and the research community: The challenges of lockdown for early-career researchers. *Elife*, *9*, 1-3. https://doi.org/10.7554/eLife.59634

Cameron, J. D., Ramaprasad, A., & Syn, T. (2017). An ontology of and roadmap for mHealth research. *International Journal of Medical Informatics*, *100*, 16-25. https://doi.org/10.1016/j.ijmedinf.2017.01.007

Cannon, M. J., Ng, B. P., Lloyd, K., Reynolds, J., & Ely, E. K. (2022). Delivering the National Diabetes Prevention Program: Assessment of Enrollment in In-Person and Virtual Organizations. *Journal of Diabetes Research*, *2022*, 1-9. https://doi.org/10.1155/2022/2942918

Carbone, S., Del Buono, M. G., Ozemek, C., & Lavie, C. J. (2019). Obesity, risk of diabetes and role of physical activity, exercise training and cardiorespiratory fitness. *Progress in Cardiovascular Diseases*, *62*(4), 327-333. https://doi.org/10.1016/j.pcad.2019.08.004

Cardona-Morrell, M., Rychetnik, L., Morrell, S. L., Espinel, P. T., & Bauman, A. (2010). Reduction of diabetes risk in routine clinical practice: are physical activity and nutrition interventions feasible and are the outcomes from reference trials replicable? A systematic review and meta-analysis. *BMC Public Health*, *10*(1), 653-669. https://doi.org/10.1186/1471-2458-10-653

Carey, R., Jenkins, E., Williams, P., Evans, F., Horan, M., Johnston, M., West, R., & Michie, S. (2017a). *A taxonomy of modes of delivery of behaviour change interventions: development and evaluation*. The European Health Psychologist. Retrieved February 10, 2019 from https://www.ehps.net/ehp/index.php/contents/article/view/2687

Carey, R., Jenkins, E., Williams, P., Evans, F., Horan, M., Johnston, M., West, R., & Michie, S. (2017b). *A taxonomy of modes of delivery of behaviour change interventions: development and evaluation* European Health Psychology Society Conference, Padova, Italy. https://osf.io/d4qyk/#!

Carlström, M., & Larsson, S. C. (2018). Coffee consumption and reduced risk of developing type 2 diabetes: a systematic review with meta-analysis. *Nutrition Reviews*, *76*(6), 395-417. https://doi.org/10.1093/nutrit/nuy014

Carroll, C., Patterson, M., Wood, S., Booth, A., Rick, J., & Balain, S. (2007). A conceptual framework for implementation fidelity. *Implementation Science*, *2*(1), 1-9. https://doi.org/10.1186/1748-5908-2-40

Carroll, J. K., Moorhead, A., Bond, R., LeBlanc, W. G., Petrella, R. J., & Fiscella, K. (2017). Who Uses Mobile Phone Health Apps and Does Use Matter? A Secondary Data Analytics Approach. *Journal of Medical Internet Research*, *19*(4), 1-9. https://doi.org/10.2196/jmir.5604

Carson, S. L., Gonzalez, C., Lopez, S., Morris, D. A., Mtume, N., Lucas-Wright, A., Vassar, S. D., Norris, K. C., & Brown, A. F. (2020). Reflections on the importance of community-partnered research strategies for health equity in the era of COVID-19. *Journal of Health Care for the Poor and Underserved*, *31*(4), 1-5. https://doi.org/10.1353/hpu.2020.0112.

Caruso, R., Magon, A., Baroni, I., Dellafiore, F., Arrigoni, C., Pittella, F., & Ausili, D. (2018). Health literacy in type 2 diabetes patients: a systematic review of systematic reviews. *Acta Diabetologica*, *55*(1), 1-12. https://doi.org/10.1007/s00592-017-1071-1

Cassidy, S., Okwose, N., Scragg, J., Houghton, D., Ashley, K., Trenell, M. I., Jakovljevic, D. G., Hallsworth, K., & Avery, L. (2019). Assessing the feasibility and acceptability of Changing Health for the management of prediabetes: protocol for a pilot study of a digital behavioural intervention. *Pilot and Feasibility Studies*, *5*(1), 1-9. https://doi.org/10.1186/s40814-019-0519-1

Castro Sweet, C., Jasik, C. B., Diebold, A., DuPuis, A., & Jendretzke, B. (2020). Cost savings and reduced health care utilization associated with participation in a digital diabetes prevention program in an adult workforce population. *Journal of Health Economics and Outcomes Research*, *7*(2), 1-9. https://doi.org/10.36469/jheor.2020.14529

Castro Sweet, C. M., Chiguluri, V., Gumpina, R., Abbott, P., Madero, E. N., Payne, M., Happe, L., Matanich, R., Renda, A., & Prewitt, T. (2018). Outcomes of a Digital Health Program With Human Coaching for Diabetes Risk Reduction in a Medicare Population. *Journal of Aging & Health*, *30*(5), 692-710. https://doi.org/10.1177/0898264316688791

Cefalu, W. T., Buse, J. B., Tuomilehto, J., Fleming, G. A., Ferrannini, E., Gerstein, H. C., Bennett, P. H., Ramachandran, A., Raz, I., & Rosenstock, J. (2016). Update and next steps for real-world translation of interventions for type 2 diabetes prevention: reflections from a diabetes care editors' expert forum. *Diabetes Care*, *39*(7), 1186-1201. https://doi.org/10.2337/dc16-0873

Centers for Disease Control and Prevention. (2018). *Centers for Disease Control and Prevention Diabetes Prevention Recognition Program Standards and Operating Procedures*. Centers for Disease Control and Prevention. https://www.cdc.gov/diabetes/prevention/pdf/dprp-standards.pdf

Centers for Disease Control and Prevention. (2020). *National diabetes statistics report 2020. Estimates of diabetes and its burden in the United States.* Centers for Disease Control and Prevention. www.cdc.gov/diabetes/pdfs/data/statistics/national-diabetes-statistics-report.pdf

Centers for Disease Control and Prevention. (2021a). *About the National DPP*. Retrieved January 10, 2022 from https://www.cdc.gov/diabetes/prevention/about.htm

Centers for Disease Control and Prevention. (2021b). *Lifestyle Change Program Details*. Centers for Disease Control and Prevention. Retrieved November 30, 2021 from https://www.cdc.gov/diabetes/prevention/lcp-details.html

Centers for Disease Control and Prevention. (2021c). *Medicare Can Help You Prevent Type 2 Diabetes*. Retrieved November 30, 2021 from https://www.cdc.gov/diabetes/prevention/lcp-details/mdpp.html

Centers for Disease Control and Prevention. (2021d). *National Diabetes Prevention Program Eligibility*. Centers for Disease Control and Prevention. Retrieved June 25, 2021 from https://www.cdc.gov/diabetes/prevention/program-eligibility.html

Centers for Disease Control and Prevention. (2021e). *National Diabetes Prevention Program: Change Program Details*. Retrieved November 29, 2021 from https://www.cdc.gov/diabetes/prevention/lcp-details.html

Centers for Disease Control and Prevention. (2021f). *National Diabetes Prevention Program: Curricula and Handouts*. Retrieved November 27, 2021 from https://www.cdc.gov/diabetes/prevention/resources/curriculum.html

Central Statistics Office (Ed.). (2017a). *Census 2016 Summary Results - Part 1*. Central Statistics Office. https://www.cso.ie/en/media/csoie/newsevents/documents/census2016summaryresultspart1/Census2016SummaryPart1.pdf.

Central Statistics Office. (2017b). *Census of Population 2016 – Profile 10 Education, Skills and the Irish Language*. Central Statistics Office. https://www.cso.ie/en/releasesandpublications/ep/p-cp10esil/p10esil/

Central Statistics Office. (2021). *Internet Coverage and Usage in Ireland 2021.* Central Statistics Office. Retrieved March 4, 2022 from https://www.cso.ie/en/releasesandpublications/ep/p-isshict/internetcoverageandusageinireland2021/

Cespedes, E. M., & Hu, F. B. (2015). Dietary patterns: from nutritional epidemiologic analysis to national guidelines. *The American Journal of Clinical Nutrition, 101*(5), 899-900. https://doi.org/10.3945/ajcn.115.110213

Cha, E., Kim, K. H., Umpierrez, G., Dawkins, C. R., Bello, M. K., Lerner, H. M., Narayan, K. M., & Dunbar, S. B. (2014). A feasibility study to develop a diabetes prevention program for young adults with prediabetes by using digital platforms and a handheld device. *The Diabetes Educator*, *40*(5), 626-637. https://doi.org/10.1177/0145721714539736

Chan, C. V., & Kaufman, D. R. (2011). A framework for characterizing eHealth literacy demands and barriers. *Journal of Medical Internet Research*, *13*(4), 1-16. https://doi.org/10.2196/jmir.1750

Chan, C. V., Matthews, L. A., & Kaufman, D. R. (2009). A taxonomy characterizing complexity of consumer eHealth literacy. *AMIA Annual Symposium proceedings.*, *2009*, 86. https://pubmed.ncbi.nlm.nih.gov/20351828/

Chan, J. C., Lau, E. S., Luk, A. O., Cheung, K. K., Kong, A. P., Linda, W., Choi, K.-C., Chow, F. C., Ozaki, R., & Brown, N. (2014). Premature mortality and comorbidities in young-onset diabetes: a 7-year prospective analysis. *The American Journal of Medicine*, *127*(7), 616-624. https://doi.org/10.1016/j.amjmed.2014.03.018

Chatterjee, S., Davies, M., & Khunti, K. (2018). Pharmaceutical Interventions for Diabetes Prevention in Patients at Risk. *American Journal of Cardiovascular Drugs*, *18*(1), 13-24. https://doi.org/10.1007/s40256-017-0239-y

Chatterjee, S., Khunti, K., & Davies, M. J. (2017). Type 2 diabetes. *The Lancet*, *389*(10085), 2239-2251. https://doi.org/10.1016/S0140-6736(17)30058-2

Chávarry, N. G. M., Vettore, M. V., Sansone, C., & Sheiham, A. (2009). The relationship between diabetes mellitus and destructive periodontal disease: a meta-analysis. *Oral Health & Preventive Dentistry*, *7*(2), 107-127. http://www.quintpub.com/userhome/ohpd/ohpd_2009_02_s0107.pdf

Chen, F., Su, W., Becker, S. H., Payne, M., Castro Sweet, C. M., Peters, A. L., & Dall, T. M. (2016). Clinical and Economic Impact of a Digital, Remotely-Delivered Intensive Behavioral Counseling Program on Medicare Beneficiaries at Risk for Diabetes and Cardiovascular Disease. *PloS One*, *11*(10), 1-14. https://doi.org/10.1371/journal.pone.0163627

Chew-Graham, C. A. (2020). Involving patients in research during a pandemic. *Health Expectations*, *23*(3), 1-2. https://doi.org/10.1111/hex.13079

Chiuve, S. E., Fung, T. T., Rimm, E. B., Hu, F. B., McCullough, M. L., Wang, M., Stampfer, M. J., & Willett, W. C. (2012). Alternative dietary indices both strongly predict risk of chronic disease. *The Journal of Nutrition*, *142*(6), 1009-1018. https://doi.org/10.3945/jn.111.157222

Cho, H., Chi, C., & Chiu, W. (2020). Understanding sustained usage of health and fitness apps: Incorporating the technology acceptance model with the investment model. *Technology in Society*, *63*, 1-10. https://doi.org/10.1016/j.techsoc.2020.101429

Cho, N., Shaw, J., Karuranga, S., Huang, Y., da Rocha Fernandes, J., Ohlrogge, A., & Malanda, B. (2018). IDF Diabetes Atlas: Global estimates of diabetes prevalence for 2017 and projections for 2045. *Diabetes Research and Clinical Practice*, *138*, 271-281. https://doi.org/10.1016/j.diabres.2018.02.023

Choi, S. E., Seligman, H., & Basu, S. (2017). Cost effectiveness of subsidizing fruit and vegetable purchases through the Supplemental Nutrition Assistance Program. *American Journal of Preventive Medicine*, *52*(5), 147-155. https://doi.org/10.1016/j.amepre.2016.12.013

Chung, S., Park, B. K., & Nahm, E.-S. (2018). The Korean eHealth Literacy Scale (K-eHEALS): reliability and validity testing in younger adults recruited online. *Journal of Medical Internet Research*, *20*(4), 1-11. https://doi.org/10.2196/jmir.8759

Ciotti, M., Ciccozzi, M., Pieri, M., & Bernardini, S. (2022). The COVID-19 pandemic: viral variants and vaccine efficacy. *Critical Reviews in Clinical Laboratory Sciences*, *59*(1), 66-75. https://doi.org/10.1080/10408363.2021.1979462

Clarivate Analytics. (2011). *EndNote X5 Reference Managament Software*. In Clarivate Analytics. https://endnote.com/

Clausen, T. D., Mathiesen, E. R., Hansen, T., Pedersen, O., Jensen, D. M., Lauenborg, J., Schmidt, L., & Damm, P. (2009). Overweight and the metabolic syndrome in adult offspring of women with diet-treated gestational diabetes mellitus or type 1 diabetes. *The Journal of Clinical Endocrinology & Metabolism*, *94*(7), 2464-2470. https://doi.org/10.1210/jc.2009-0305

Cobiac, L. J., Tam, K., Veerman, L., & Blakely, T. (2017). Taxes and subsidies for improving diet and population health in Australia: a cost-effectiveness modelling study. *PLoS Medicine*, *14*(2), 1-18. https://doi.org/10.1371/journal.pmed.1002232

Cobiac, L. J., Vos, T., & Barendregt, J. J. (2009). Cost-effectiveness of interventions to promote physical activity: a modelling study. *PLoS Medicine*, *6*(7), 1-11. https://doi.org/10.1371/journal.pmed.1000110

Cohen, J. (1968). Weighted kappa: nominal scale agreement provision for scaled disagreement or partial credit. *Psychological Bulletin*, *70*(4), 213. https://doi.org/10.1037/h0026256

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2013). *Applied multiple regression/correlation analysis for the behavioral sciences*. Routledge.

Collins, L. M., Kugler, K. C., & Gwadz, M. V. (2016). Optimization of multicomponent behavioral and biobehavioral interventions for the prevention and treatment of HIV/AIDS. *AIDS and Behavior*, *20*(1), 197-214. https://doi.org/10.1007/s10461-015-1145-4

Collins, L. M., Murphy, S. A., & Strecher, V. (2007). The multiphase optimization strategy (MOST) and the sequential multiple assignment randomized trial (SMART): new methods for more potent eHealth interventions. *American Journal of Preventive Medicine*, *32*(5), S112-S118. https://doi.org/10.1016/j.amepre.2007.01.022

Compeau, D., Higgins, C. A., & Huff, S. (1999). Social cognitive theory and individual reactions to computing technology: A longitudinal study. *MIS Quarterly*, 145-158. https://doi.org/10.2307/249749

ComReg. (2019). Mobile Consumer Experience Survey 2019. Retrieved February 16, 2020, from https://www.comreg.ie/publication/mobile-consumer-experience-survey-2019

Coravos, A., Goldsack, J. C., Karlin, D. R., Nebeker, C., Perakslis, E., Zimmerman, N., & Erb, M. K. (2019). Digital medicine: a primer on measurement. *Digital Biomarkers*, *3*(2), 31-71. https://doi.org/10.1159/000500413

Corbin, J. M., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative Sociology*, *13*(1), 3-21. https://doi.org/10.1007/BF00988593

Corona, G., Pizzocaro, A., Vena, W., Rastrelli, G., Semeraro, F., Isidori, A. M., Pivonello, R., Salonia, A., Sforza, A., & Maggi, M. (2021). Diabetes is most important cause for mortality in COVID-19 hospitalized patients: Systematic review and meta-analysis. *Reviews in Endocrine and Metabolic Disorders*, *22*(2), 275-296. https://doi.org/10.1007/s11154-021-09630-8

Costa, B., Barrio, F., Cabré, J.-J., Piñol, J.-L., Cos, X., Solé, C., Bolíbar, B., Basora, J., Castell, C., & Solà-Morales, O. (2012). Delaying progression to type 2 diabetes among high-risk Spanish individuals is feasible in real-life primary healthcare settings using intensive lifestyle intervention. *Diabetologia*, *55*(5), 1319-1328. https://doi.org/10.1007/s00125-012-2492-6

Cradock, K. A., ÓLaighin, G., Finucane, F. M., Gainforth, H. L., Quinlan, L. R., & Ginis, K. A. M. (2017). Behaviour change techniques targeting both diet and physical activity in type 2 diabetes: A systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity*, *14*(1), 1-17. https://doi.org/10.1186/s12966-016-0436-0

Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I., & Petticrew, M. (2008). Developing and evaluating complex interventions: the new Medical Research Council guidance. *BMJ*, *337*, 1-6. https://doi.org/10.1136/bmj.a1655

Creswell, J. W., Klassen, A. C., Plano Clark, V. L., & Smith, K. C. (2011). Best practices for mixed methods research in the health sciences. *Bethesda (Maryland): National Institutes of Health*, *2013*, 541-545. https://www.csun.edu/sites/default/files/best_prac_mixed_methods.pdf

Crowley, J., Ball, L., & Hiddink, G. J. (2019). Nutrition in medical education: a systematic review. *The Lancet Planetary Health*, *3*(9), e379-e389. https://doi.org/10.1016/S2542-5196(19)30171-8

D'cruz, H., Gillingham, P., & Melendez, S. (2007). Reflexivity, its meanings and relevance for social work: A critical review of the literature. *The British Journal of Social Work*, *37*(1), 73-90. https://doi.org/10.1093/bjsw/bcl001

Dale, J. G., Lüthi, A., Skaraas, B. F., Rundereim, T., & Dale, B. (2020). Testing measurement properties of the Norwegian version of electronic health literacy scale (eHEALS) in a group of day surgery patients. *Journal of Multidisciplinary Healthcare*, *13*, 241-247. https://doi.org/10.2147/jmdh.s242985

Daundasekara, S. S., Arlinghaus, K. R., & Johnston, C. A. (2020). Quality of Life: The Primary Goal of Lifestyle Intervention. *American Journal of Lifestyle Medicine*, *14*(3), 267-270. https://doi.org/10.1177/1559827620907309

Davies, M. J., D'Alessio, D. A., Fradkin, J., Kernan, W. N., Mathieu, C., Mingrone, G., Rossing, P., Tsapas, A., Wexler, D. J., & Buse, J. B. (2018). Management of hyperglycaemia in type 2 diabetes, 2018. A consensus report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). *Diabetologia*, *61*(12), 2461-2498. https://doi.org/10.2337/dci18-0033

Davies, M. J., Gray, L. J., Troughton, J., Gray, A., Tuomilehto, J., Farooqi, A., Khunti, K., & Yates, T. (2016). A community based primary prevention programme for type 2 diabetes integrating identification and lifestyle intervention for prevention: the Let's Prevent Diabetes cluster randomised controlled trial. *Preventive Medicine*, *84*, 48-56. https://doi.org/10.1016/j.ypmed.2015.12.012

Davies, M. J., Heller, S., Skinner, T., Campbell, M., Carey, M., Cradock, S., Dallosso, H., Daly, H., Doherty, Y., & Eaton, S. (2008). Effectiveness of the diabetes education and self management for ongoing and newly diagnosed (DESMOND) programme for people with newly diagnosed type 2 diabetes: cluster randomised controlled trial. *BMJ*, *336*(7642), 491-495. https://doi.org/10.1136/bmj.39474.922025.BE

Davis-Smith, Y. M., Davis-Smith, M., Boltri, J. M., Seale, J. P., Shellenberger, S., Blalock, T., & Tobin, B. (2007). Implementing a diabetes prevention program in a rural African-American church. *Journal of the National Medical Association*, *99*(4), 440-446. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2569663/

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 319-340. https://doi.org/10.2307/249008

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1992). Extrinsic and intrinsic motivation to use computers in the workplace. *Journal of Applied Social Psychology*, *22*(14), 1111-1132. https://doi.org/10.1111/j.1559-1816.1992.tb00945.x

Davis, J. L., Buchanan, K. L., Katz, R. V., & Green, B. L. (2012). Gender differences in cancer screening beliefs, behaviors, and willingness to participate: implications for health promotion. *American Journal of Men's Health*, *6*(3), 211-217. https://doi.org/10.1177/1557988311425853

De Caro, W., Corvo, E., Marucci, A., Mitello, L., Lancia, L., & Sansoni, J. (2016). eHealth Literacy Scale: An Nursing Analisys and Italian Validation. *Studies in Health Technology and Informatics*, *225*, 949-949. https://europepmc.org/article/med/27332425

De Courten, B., Mousa, A., & Menon, K. (2019). Effect of carnosine supplementation on cardiometabolic risk factors in obesity, prediabetes, and diabetes: a meta-analysis of randomized controlled trials. *Obesity Research and Clinical Practice*, *13*(3), 306. https://doi.org/10.1016/j.orcp.2018.11.197

de Souza, R. J., Mente, A., Maroleanu, A., Cozma, A. I., Ha, V., Kishibe, T., Uleryk, E., Budylowski, P., Schünemann, H., Beyene, J., & Anand, S. S. (2015). Intake of saturated and trans unsaturated fatty acids and risk of all cause mortality, cardiovascular disease, and type 2 diabetes: systematic review and meta-analysis of observational studies. *BMJ, 351*, 1-16. https://doi.org/10.1136/bmj.h3978

DeAlleaume, L., Parnes, B., Zittleman, L., Sutter, C., Chavez, R., Bernstein, J., LeBlanc, W., Dickinson, M., & Westfall, J. M. (2015). Success in the Achieving CARdiovascular Excellence in Colorado (A CARE) home blood pressure monitoring program: a report from the Shared Networks of Colorado Ambulatory Practices and Partners (SNOCAP). *The Journal of the American Board of Family Medicine*, *28*(5), 548-555. https://doi.org/10.3122/jabfm.2015.05.150024

DeFronzo, R. A., Ferrannini, E., Groop, L., Henry, R. R., Herman, W. H., Holst, J. J., Hu, F. B., Kahn, C. R., Raz, I., & Shulman, G. I. (2015). Type 2 diabetes mellitus. *Nature Reviews Disease Primers*, *1*(1), 1-22. https://doi.org/10.1038/nrdp.2015.19

DeJesus, R. S., Breitkopf, C. R., Rutten, L. J., Jacobson, D. J., Wilson, P. M., & Sauver, J. S. (2016). Incidence Rate of Prediabetes Progression to Diabetes: Modeling an Optimum Target Group for Intervention. *Population Health Management*, *20*(3), 216-223. https://doi.org/10.1089/pop.2016.0067

Della, L. J., King, K. M., & Ha, J.-P. (2013). Psychometric properties of a prediabetes instrument to assess perceived susceptibility and perceived severity in Appalachians. *Journal of Nursing Measurement*, *21*(2), 210-223. https://doi.org/10.1891/1061-3749.21.2.210

Deloitte. (2020). Digital usage & COVID-19: Digital Consumer Trends 2020. Retrieved 14 October, 2020, from https://www2.deloitte.com/ie/en/pages/technology-media-and-telecommunications/articles/digital-consumer-trends/digital-consumer-trends-digitalusage.htm

Department of Health. (2011). *Start Active, Stay Active: A report on physical activity for health from the four home countries' Chief Medical Officers.* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/830943/withdrawn_dh_128210.pdf

Department of Health. (2013). *eHealth Strategy for Ireland*. Department of Health. https://www.ehealthireland.ie/knowledge-information-plan/ehealth-strategy-for-ireland.pdf

Department of Health. (2021a). *Sláintecare Implementation Strategy and Action Plan 2021-2023*. Department of Health. https://assets.gov.ie/134746/9b3b6ae9-2d64-4f87-8748-cda27d3193f3.pdf

Department of Health. (2021b). *Sláintecare Progress Report 2021*. Department of Health. https://assets.gov.ie/134746/9b3b6ae9-2d64-4f87-8748-cda27d3193f3.pdf

Department of the Environment Climate and Communications. (2020). *National Broadband Plan*. Retrieved January 28, 2021 from https://www.gov.ie/en/publication/c1b0c9-national-broadband-plan/

Dey, I. (1999). *Grounding Grounded Theory.* Emerald Group Publishing Ltd.

Diabetes Ireland. (2020a). *Are you at risk of type 2 diabetes test.* Retrieved March 11, 2020 from https://www.diabetes.ie/living-with-diabetes/are-you-at-risk-of-type-2-diabetes/

Diabetes Ireland. (2020b). *Diabetes Risk Factors*. Diabetes Ireland. Retrieved December 10, 2020 from https://www.diabetes.ie/about-us/diabetes-risk-factors/

Diabetes Ireland. (2020c). *What is Prediabetes*. Diabetes Ireland. Retrieved February 19, 2021 from https://www.diabetes.ie/what-is-prediabetes/

Diabetes Prevention Program Research Group. (1999). The Diabetes Prevention Program: Design and methods for a clinical trial in the prevention of type 2 diabetes. *Diabetes Care*, *22*(4), 623-634. https://doi.org/10.2337/diacare.22.4.623

Diabetes Prevention Program Research Group. (2000). The Diabetes Prevention Program: baseline characteristics of the randomized cohort. *Diabetes Care, 23*(11), 1619–1629. https://doi.org/10.2337/diacare.23.11.1619

Diabetes Prevention Program Research Group. (2002). The Diabetes Prevention Program (DPP): description of lifestyle intervention. *Diabetes Care*, *25*(12), 2165-2171. https://doi.org/10.2337/diacare.25.12.2165

Diabetes Prevention Program Research Group. (2003a). Costs associated with the primary prevention of type 2 diabetes mellitus in the diabetes prevention program. *Diabetes Care*, *26*(1), 36-47. https://doi.org/10.2337/diacare.26.1.36

Diabetes Prevention Program Research Group. (2003b). Within-trial cost-effectiveness of lifestyle intervention or metformin for the primary prevention of type 2 diabetes. *Diabetes Care*, *26*(9), 2518-2523. https://doi.org/10.2337/diacare.26.9.2518

Diabetes Prevention Program Research Group. (2012). Long-term safety, tolerability, and weight loss associated with metformin in the Diabetes Prevention Program Outcomes Study. *Diabetes Care*, *35*(4), 731-737. https://doi.org/10.2337/dc11-1299

Diabetes Prevention Program Research Group. (2015). Long-term effects of lifestyle intervention or metformin on diabetes development and microvascular complications over 15-year follow-up: the Diabetes Prevention Program Outcomes Study. *The Lancet Diabetes & Endocrinology*, *3*(11), 866-875. https://doi.org/10.1016/S2213-8587(15)00291-0

Diabetes UK. (2020a). *Diabetes Risk Factors*. Diabetes UK. Retrieved December 10, 2020 from https://www.diabetes.org.uk/preventing-type-2-diabetes/diabetes-risk-factors

Diabetes UK. (2020b). *Type 2 Diabetes: Know Your Risk*. Diabetes UK. Retrieved December 10, 2020 from https://riskscore.diabetes.org.uk/start

Diabetes UK. (2021a). *NHS diabetes prevention programme*. Diabetes UK. Retrieved December 10, 2021 from https://www.diabetes.org.uk/professionals/resources/shared-practice/nhs-diabetes-prevention-programme

Diabetes UK. (2021b). *Prediabetes*. Diabetes UK. Retrieved December 10, 2021 from https://www.diabetes.org.uk/preventing-type-2-diabetes/prediabetes

Dilshad, R. M., & Latif, M. I. (2013). Focus group interview as a tool for qualitative research: An analysis. *Pakistan Journal of Social Sciences*, *33*(1), 191-198. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.704.3482&rep=rep1&type=pdf

Ding, M., Bhupathiraju, S. N., Chen, M., van Dam, R. M., & Hu, F. B. (2014). Caffeinated and Decaffeinated Coffee Consumption and Risk of Type 2 Diabetes: A Systematic Review and a Dose-Response Meta-analysis. *Diabetes Care*, *37*(2), 569-586. https://doi.org/10.2337/dc13-1203

Distler, V., Lallemand, C., & Bellet, T. (2018). Acceptability and acceptance of autonomous mobility on demand: The impact of an immersive experience. *Proceedings of the 2018 CHI conference on human factors in computing systems*, 1-10. https://doi.org/10.1145/3173574.3174186

Dolce, P., & Lauro, N. C. (2015). Comparing maximum likelihood and PLS estimates for structural equation modeling with formative blocks. *Quality & Quantity*, *49*(3), 891-902. https://doi.org/10.1007/s11135-014-0106-8

Donevant, S. B., Estrada, R. D., Culley, J. M., Habing, B., & Adams, S. A. (2018). Exploring app features with outcomes in mHealth studies involving chronic respiratory diseases, diabetes, and hypertension: a targeted exploration of the literature. *Journal of the American Medical Informatics Association*, *25*(10), 1407-1418. https://doi.org/10.1093/jamia/ocy104

Dong, J. Y., & Qin, L. Q. (2012). Dietary calcium intake and risk of type 2 diabetes: possible confounding by magnesium. *European Journal of Clinical Nutrition*, *66*(3), 408-410. https://doi.org/10.1038/ejcn.2012.5

Donnelly, J. E., Blair, S. N., Jakicic, J. M., Manore, M. M., Rankin, J. W., Smith, B. K., & American College of Sports, M. (2009). American College of Sports Medicine Position Stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. *Medicine and Science in Sports and Exercise*, *41*(2), 459-471. https://doi.org/10.1249/mss.0b013e3181949333

Dou, K., Yu, P., Deng, N., Liu, F., Guan, Y., Li, Z., Ji, Y., Du, N., Lu, X., & Duan, H. (2017). Patients' acceptance of smartphone health technology for chronic disease management: a theoretical model and empirical test. *JMIR mHealth and uHealth*, *5*(12), 1-15. https://doi.org/10.2196/mhealth.7886

Dunkley, A. J., Bodicoat, D. H., Greaves, C. J., Russell, C., Yates, T., Davies, M. J., & Khunti, K. (2014). Diabetes Prevention in the Real World: Effectiveness of Pragmatic Lifestyle Interventions for the Prevention of Type 2 Diabetes and of the Impact of Adherence to Guideline Recommendations: A Systematic Review and Meta-analysis. *Diabetes Care*, *37*(4), 922-933. https://doi.org/10.2337/dc13-2195

Dusseldorp, E., van Genugten, L., van Buuren, S., Verheijden, M. W., & van Empelen, P. (2014). Combinations of techniques that effectively change health behavior: Evidence from Meta-CART analysis. *Health Psychology*, *33*(12), 1-11. https://doi.org/10.1037/hea0000018

Dyson, P. A., Twenefour, D., Breen, C., Duncan, A., Elvin, E., Goff, L., Hill, A., Kalsi, P., Marsland, N., McArdle, P., Mellor, D., Oliver, L., & Watson, K. (2018). Diabetes UK evidence-based nutrition guidelines for the prevention and management of diabetes. *Diabetic Medicine*, *35*(5), 541-547. https://doi.org/10.1111/dme.13603

EBSCO. (2018). *CINAHL Complete*. https://www.ebsco.com/products/research-databases/cinahl-complete

Economist Impact. (2021). *Global Food Security Index: Ireland*. Economist Impact. Retrieved April 17, 2022 from https://impact.economist.com/sustainability/project/food-security-index/Country/Details#Ireland

Ehn, M., Johansson, A.-C., & Revenäs, Å. (2019). Technology-based motivation support for seniors' physical activity—A qualitative study on seniors' and health care professionals' views. *International Journal of Environmental Research and Public Health*, *16*(13), 1-20. https://doi.org/10.3390/ijerph16132418

Eichhorn, B. R. (2014). Common method variance techniques. 1-11. Retrieved August 20, 2020, from https://www.lexjansen.com/mwsug/2014/AA/MWSUG-2014-AA11.pdf

Einarson, T. R., Acs, A., Ludwig, C., & Panton, U. H. (2018). Economic burden of cardiovascular disease in type 2 diabetes: a systematic review. *Value in Health*, *21*(7), 881-890. https://doi.org/10.1016/j.jval.2017.12.019

Ekoe, J.-M., Goldenberg, R., & Katz, P. (2018). Screening for diabetes in adults. *Canadian Journal of Diabetes*, *42*, S16-S19. https://doi.org/10.1016/j.jcjd.2017.10.004

El-Gayar, O., Ofori, M., & Nawar, N. (2021). On the efficacy of behavior change techniques in mHealth for self-management of diabetes: A meta-analysis. *Journal of Biomedical Informatics*, *119*, 1-12. https://doi.org/10.1016/j.jbi.2021.103839

El-Toukhy, S. (2015). Parsing Susceptibility and Severity Dimensions of Health Risk Perceptions. *Journal of Health Communication*, *20*(5), 499-511. https://doi.org/10.1080/10810730.2014.989342

El Benny, M., Kabakian-Khasholian, T., El-Jardali, F., & Bardus, M. (2021). Application of the eHealth Literacy Model in Digital Health Interventions: Scoping Review. *Journal of Medical Internet Research*, *23*(6), 1-15. https://doi.org/10.2196/23473

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, *62*(1), 107-115. https://doi.org/10.1111/j.1365-2648.2007.04569.x

Elsevier Limited. (2018). *EMBASE.* https://www.embase.com/landing?status=grey

Ely, E. K., Gruss, S. M., Luman, E. T., Gregg, E. W., Ali, M. K., Nhim, K., Rolka, D. B., & Albright, A. L. (2017). A national effort to prevent type 2 diabetes: participant-level evaluation of CDC's National Diabetes Prevention Program. *Diabetes Care*, *40*(10), 1331-1341. https://doi.org/10.2337/dc16-2099

Emanuel, E. J., Wendler, D., & Grady, C. (2000). What makes clinical research ethical? *Journal of the American Medical Association*, *283*(20), 2701-2711. https://doi.org/10.1001/jama.283.20.2701

Emerging Risk Factors Collaboration. (2010). Diabetes mellitus, fasting blood glucose concentration, and risk of vascular disease: a collaborative meta-analysis of 102 prospective studies. *The Lancet*, *375*(9733), 2215-2222. https://doi.org/10.1016/S0140-6736(10)60484-9

Endevelt, R., Peled, R., Azrad, A., Kowen, G., Valinsky, L., & Heymann, A. (2015). Diabetes prevention program in a Mediterranean environment: individual or group therapy? An effectiveness evaluation. *Primary Care Diabetes*, *9*(2), 89-95. https://doi.org/10.1016/j.pcd.2014.07.005

Eriksson-Backa, K., Holmberg, K., & Ek, S. (2016). Communicating diabetes and diets on Twitter-a semantic content analysis. *International Journal of Networking and Virtual Organisations*, *16*(1), 8-24. https://doi.org/10.1504/IJNVO.2016.075133

Eriksson, J., Lindström, J., Valle, T., Aunola, S., Hämäläinen, H., Ilanne-Parikka, P., Keinänen-Kiukaanniemi, S., Laakso, M., Lauhkonen, M., & Lehto, P. (1999). Prevention of Type II diabetes in subjects with impaired glucose tolerance: the Diabetes Prevention Study (DPS) in Finland Study design and 1-year interim report on the feasibility of the lifestyle intervention programme. *Diabetologia*, *42*(7), 793-801. https://doi.org/10.1007/s001250051229

Eriksson, K.-F., & Lindgärde, F. (1990). Impaired glucose tolerance in a middle-aged male urban population: a new approach for identifying high-risk cases. *Diabetologia*, *33*(9), 526-531. https://doi.org/10.1007/BF00404139

Eriksson, K.-F., & Lindgärde, F. (1991). Prevention of Type 2 (non-insulin-dependent) diabetes mellitus by diet and physical exercise The 6-year Malmö feasibility study. *Diabetologia*, *34*(12), 891-898. https://doi.org/10.1007/BF00400196

Eriksson, K.-F., & Lindgärde, F. (1998). No excess 12-year mortality in men with impaired glucose tolerance who participated in the Malmö Preventive Trial with diet and exercise. *Diabetologia*, *41*(9), 1010-1016. https://doi.org/10.1007/s001250051024

Essien, U. R., Shahid, N. N., & Berkowitz, S. A. (2016). Food Insecurity and Diabetes in Developed Societies. *Current Diabetes Reports*, *16*(9), 1-8. https://doi.org/10.1007/s11892-016-0774-y

Estabrooks, P. A., & Smith-Ray, R. L. (2008). Piloting a behavioral intervention delivered through interactive voice response telephone messages to promote weight loss in a pre-diabetic population. *Patient Education and Counseling*, *72*(1), 34-41. https://doi.org/10.1016/j.pec.2008.01.007

Evangelista, L., Steinhubl, S. R., & Topol, E. J. (2019). Digital health care for older adults. *The Lancet*, *393*(10180), 1493-1493. https://doi.org/10.1016/S0140-6736(19)30800-1

Everett, E., Kane, B., Yoo, A., Dobs, A., & Mathioudakis, N. (2018). A novel approach for fully automated, personalized health coaching for adults with prediabetes: pilot clinical trial. *Journal of Medical Internet Research*, *20*(2), 1-15. https://doi.org/10.2196/jmir.9723

Fagerlund, A. J., Holm, I. M., & Zanaboni, P. (2019). General practitioners' perceptions towards the use of digital health services for citizens in primary care: a qualitative interview study. *BMJ Open*, *9*(5), 1-7. https://doi.org/10.1136/bmjopen-2018-028251

Fagherazzi, G., & Ravaud, P. (2019). Digital diabetes: Perspectives for diabetes prevention, management and research. *Diabetes and Metabolism*, *45*(4), 322-329. https://doi.org/10.1016/j.diabet.2018.08.012

Fang, X., Han, H., Li, M., Liang, C., Fan, Z., Aaseth, J., He, J., Montgomery, S., & Cao, Y. (2016). Dose-Response Relationship between Dietary Magnesium Intake and Risk of Type 2 Diabetes Mellitus: A Systematic Review and Meta-Regression Analysis of Prospective Cohort Studies. *Nutrients*, *8*(11), 1-18. https://doi.org/10.3390/nu8110739

Faridi, Z., Shuval, K., Njike, V. Y., Katz, J. A., Jennings, G., Williams, M., Katz, D. L., & Group, P. P. W. (2010). Partners reducing effects of diabetes (PREDICT): a diabetes prevention physical activity and dietary intervention through African-American churches. *Health Education Research*, *25*(2), 306-315. https://doi.org/10.1093/her/cyp005

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods*, *5*(1), 80-92. https://doi.org/10.1177/160940690600500107

Field, A. (2017). *Discovering Statistics Using IBM SPSS Statistics* (5th ed.). SAGE Publications Ltd.

Field, A. P., & Gillett, R. (2010). How to do a meta-analysis. *British Journal of Mathematical and Statistical Psychology*, *63*(3), 665-694. https://doi.org/10.1348/000711010X502733

Fischer, H. H., Fischer, I. P., Pereira, R. I., Furniss, A. L., Rozwadowski, J. M., Moore, S. L., Durfee, M. J., Raghunath, S. G., Tsai, A. G., & Havranek, E. P. (2016). Text Message Support for Weight Loss in Patients With Prediabetes: A Randomized Clinical Trial. *Diabetes Care*, *39*(8), 1364-1370. https://doi.org/10.2337/dc15-2137

Fishbein, M., & Ajzen, I. (1977). Belief, attitude, intention, and behavior: An introduction to theory and research. *Philosophy and Rhetoric*, *10*(2), 177-188. https://philpapers.org/archive/FISBAI.pdf

Fontil, V., McDermott, K., Tieu, L., Rios, C., Gibson, E., Sweet, C. C., Payne, M., & Lyles, C. R. (2016). Adaptation and feasibility study of a digital health program to prevent diabetes among low-income patients: results from a partnership between a digital health company and an academic research team. *Journal of Diabetes Research*, *2016*, 1-11. https://doi.org/10.1155/2016/8472391

Foretz, M., Guigas, B., & Viollet, B. (2019). Understanding the glucoregulatory mechanisms of metformin in type 2 diabetes mellitus. *Nature Reviews Endocrinology*, *15*(10), 569-589. https://doi.org/10.1038/s41574-019-0242-2

Forman, J., & Damschroder, L. (2007). Qualitative content analysis. In *Empirical methods for bioethics: A primer*. Emerald Group Publishing Limited.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, *18*(1), 39-50. https://doi.org/10.1177/002224378101800104

Fortuna, K. L., Brooks, J. M., Umucu, E., Walker, R., & Chow, P. I. (2019). Peer Support: a Human Factor to Enhance Engagement in Digital Health Behavior Change Interventions. *Journal of Technology in Behavioral Science*, *4*(2), 152-161. https://doi.org/10.1007/s41347-019-00105-x

Frempong, S. N., Shinkins, B., Howdon, D., Messenger, M., Neal, R. D., & Sagoo, G. S. (2021). Early economic evaluation of an intervention to improve uptake of the NHS England Diabetes Prevention Programme. *Expert Review of Pharmacoeconomics and Outcomes Research*, *22*(3), 417-427. https://doi.org/10.1080/14737167.2021.1895755

French, D. P., Hawkes, R. E., Bower, P., & Cameron, E. (2021). Is the NHS Diabetes Prevention Programme Intervention Delivered as Planned? An Observational Study of Fidelity of Intervention Delivery. *Annals of Behavioral Medicine*, *55*(11), 1104-1115. https://doi.org/10.1093/abm/kaaa108

Fridberg, H., Wallin, L., & Tistad, M. (2021). The innovation characteristics of person-centred care as perceived by healthcare professionals: an interview study employing a deductive-inductive content analysis guided by the consolidated framework for implementation research. *BMC Health Services Research*, *21*(1), 13-13. https://doi.org/10.1186/s12913-021-06942-y

Fu, H. N., Jin, D., & Adam, T. J. (2021). Content Analysis: First-Time Patient User Challenges with Top-Rated Commercial Diabetes Apps. *Telemedicine and e-Health*, *27*(6), 663-669. https://doi.org/10.1089/tmj.2020.0128

Fukuoka, Y., Choi, J., Bender, M. S., Gonzalez, P., & Arai, S. (2015). Family history and body mass index predict perceived risks of diabetes and heart attack among community-dwelling Caucasian, Filipino, Korean, and Latino Americans—DiLH Survey. *Diabetes Research and Clinical Practice*, *109*(1), 157-163. https://doi.org/10.1016/j.diabres.2015.04.015

Fukuoka, Y., Gay, C. L., Joiner, K. L., & Vittinghoff, E. (2015). A Novel Diabetes Prevention Intervention Using a Mobile App. *American Journal of Preventive Medicine*, *49*(2), 223-237. https://doi.org/10.1016/j.amepre.2015.01.003

Fusch, P. I., & Ness, L. R. (2015). Are we there yet? Data saturation in qualitative research. *The Qualitative Report*, *20*(9), 1408-1416. https://doi.org/10.46743/2160-3715/2015.2281

Fuso, L., Pitocco, D., & Antonelli-Incalzi, R. (2019). Diabetic lung, an underrated complication from restrictive functional pattern to pulmonary hypertension. *Diabetes/Metabolism Research and Reviews*, *35*(6), 1-4. https://doi.org/10.1002/dmrr.3159

Füzéki, E., Schröder, J., Groneberg, D. A., & Banzer, W. (2021). Online exercise classes during the COVID-19 related lockdown in Germany: use and attitudes. *Sustainability*, *13*(14), 14-14. https://doi.org/10.3390/su13147677

Gabriel, R., Acosta, T., Florez, K., Anillo, L., Navarro, E., Boukichou, N., Acosta-Reyes, J., Barengo, N. C., Lindström, J., Tuomilehto, J. O., & Aschner, P. (2021). Validation of the Finnish Type 2 Diabetes Risk Score (FINDRISC) with the OGTT in Health Care Practices in Europe. *Diabetes Research and Clinical Practice*, *178*, 1-7. https://doi.org/10.1016/j.diabres.2021.108976

Galaviz, K. I., Weber, M. B., Straus, A., Haw, J. S., Narayan, K. V., & Ali, M. K. (2018). Global diabetes prevention interventions: a systematic review and network meta-analysis of the real-world impact on incidence, weight, and glucose. *Diabetes Care*, *41*(7), 1526-1534. https://doi.org/10.2337/dc17-2222

Galicia-Garcia, U., Benito-Vicente, A., Jebari, S., Larrea-Sebal, A., Siddiqi, H., Uribe, K. B., Ostolaza, H., & Martín, C. (2020). Pathophysiology of type 2 diabetes mellitus. *International Journal of Molecular Sciences*, *21*(17), 1-34. https://doi.org/10.3390/ijms21176275

Gan, D. Z. Q., McGillivray, L., Han, J., Christensen, H., & Torok, M. (2021). Effect of Engagement With Digital Interventions on Mental Health Outcomes: A Systematic Review and Meta-Analysis. *Frontiers in Digital Health*, *3*, 1-14. https://doi.org/10.3389/fdgth.2021.764079

Garber, A. J., Abrahamson, M. J., Barzilay, J. I., Blonde, L., Bloomgarden, Z. T., Bush, M. A., Dagogo-Jack, S., DeFronzo, R. A., Einhorn, D., Fonseca, V. A., Garber, J. R., Garvey, W. T., Grunberger, G., Handelsman, Y., Hirsch, I. B., Jellinger, P. S., McGill, J. B., Mechanick, J. I., Rosenblit, P. D., & Umpierrez, G. E. (2017). Consensus Statement by the American Association of Clinical Endocrinologists and American College of Endocrinology on the Comprehensive type 2 Diabetes Management Algorithm – 2017 Executive Summary. *Endocrine Practice*, *23*(2), 207-238. https://doi.org/10.4158/EP161682.CS

Garces, G. A., Rakotondranaivo, A., & Bonjour, E. (2016). An acceptability estimation and analysis methodology based on Bayesian networks. *International Journal of Industrial Ergonomics*, *53*, 245-256. https://doi.org/10.1016/j.ergon.2016.02.005

Garcia-Compean, D., Jaquez-Quintana, J. O., Gonzalez-Gonzalez, J. A., & Maldonado-Garza, H. (2009). Liver cirrhosis and diabetes: risk factors, pathophysiology, clinical implications and management. *World Journal of Gastroenterology, 15*(3), 280-288. https://doi.org/10.3748/wjg.15.280

Gaskin, J. (2021). *Common Latent Factor: Confirmatory Factor Analysis*. Retrieved May 1, 2021 from http://statwiki.gaskination.com/index.php?title=Main_Page

Gast, J., & Peak, T. (2011). "It used to be that if it weren't broken and bleeding profusely, I would never go to the doctor": men, masculinity, and health. *American Journal of Men's Health*, *5*(4), 318-331. https://doi.org/10.1177/1557988310377926

Georgsson, M., & Staggers, N. (2016). An evaluation of patients' experienced usability of a diabetes mHealth system using a multi-method approach. *Journal of Biomedical Informatics*, *59*, 115-129. https://doi.org/10.1016/j.jbi.2015.11.008

Gibbs, H. D., Ellerbeck, E. F., Gajewski, B., Zhang, C., & Sullivan, D. K. (2018). The nutrition literacy assessment instrument is a valid and reliable measure of nutrition literacy in adults with chronic disease. *Journal of Nutrition Education and Behavior*, *50*(3), 247-257. https://doi.org/10.1016/j.jneb.2017.10.008

Gibney, S., & McCarthy, T. (2020). *Profile of Smartphone Ownership and Use in Ireland.* Department of Health. https://igees.gov.ie/wp-content/uploads/2020/07/Research-Brief-Profile-of-Smartphone-ownership-and-use-May-2020.pdf

Gijsbers, L., Ding, E. L., Malik, V. S., de Goede, J., Geleijnse, J. M., & Soedamah-Muthu, S. S. (2016). Consumption of dairy foods and diabetes incidence: a dose-response meta-analysis of observational studies. *The American Journal of Clinical Nutrition*, *103*(4), 1111-1124. https://doi.org/10.3945/ajcn.115.123216

Gilis-Januszewska, A., Szybinski, Z., Kissimova-Skarbek, K., Piwonska-Solska, B., Pach, D., Topor-Madry, R., Tuomilehto, J., Lindström, J., Peltonen, M., & Schwarz, P. E. (2011). Prevention of type 2 diabetes by lifestyle intervention in primary health care setting in Poland: Diabetes in Europe Prevention using Lifestyle, physical Activity and Nutritional intervention (DE-PLAN) project. *The British Journal of Diabetes & Vascular Disease*, *11*(4), 198-203. https://doi.org/10.1177/1474651411412429

Gillett, M., Royle, P., Snaith, A., Scotland, G., Poobalan, A., Imamura, M., Black, C., Boroujerdi, M., Jick, S., Wyness, L., McNamee, P., Brennan, A., & Waugh, N. (2012). Non-pharmacological interventions to reduce the risk of diabetes in people with impaired glucose regulation: a systematic review and economic evaluation. *Health Technology Assessment 16*, 1-254. https://doi.org/10.3310/hta16330

Gilmer, T., O'Connor, P. J., Schiff, J. S., Taylor, G., Vazquez-Benitez, G., Garrett, J. E., Vue-Her, H., Rinn, S., Anderson, J., & Desai, J. (2018). Cost-Effectiveness of a Community-Based Diabetes Prevention Program with Participation Incentives for Medicaid Beneficiaries. *Health Services Research*, *53*(6), 4704-4724. https://doi.org/10.1111/1475-6773.12973

Glaser, B. G., & Strauss, A. L. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research.* Aldine.

Godino, J. G., van Sluijs, E. M., Sutton, S., & Griffin, S. J. (2014). Understanding perceived risk of type 2 diabetes in healthy middle-aged adults: a cross-sectional study of associations with modelled risk, clinical risk factors, and psychological factors. *Diabetes Research and Clinical Practice*, *106*(3), 412-419. https://doi.org/10.1016/j.diabres.2014.10.004

Goh, M. C. W., Kelly, P. J., & Deane, F. P. (2021). Enhancing Type 2 diabetes risk communication with message framing and tailored risk feedback: an online randomised controlled trial. *Australian Journal of Psychology*, *73*(4), 499-511. https://doi.org/10.1080/00049530.2021.1997554

Gong, Q., Zhang, P., Wang, J., Ma, J., An, Y., Chen, Y., Zhang, B., Feng, X., Li, H., & Chen, X. (2019). Morbidity and mortality after lifestyle intervention for people with impaired glucose tolerance: 30-year results of the Da Qing Diabetes Prevention Outcome Study. *The Lancet Diabetes & Endocrinology*, *7*(6), 452-461. https://doi.org/10.1016/S2213-8587(19)30093-2

Government of Ireland. (2022). *Harnessing Digital: The Digital Ireland Framework*. Government of Ireland. https://assets.gov.ie/214584/fa3161da-aa9d-4b11-b160-9cac3a6f6148.pdf

Grady, J. L., Entin, E. B., Entin, E. E., & Brunyé, T. T. (2011). Using message framing to achieve long-term behavioral changes in persons with diabetes. *Applied Nursing Research*, *24*(1), 22-28. https://doi.org/10.1016/j.apnr.2009.03.007

Grand View Research. (2021). *Digital Health Market Size, Share & Trends Analysis Report By Technology (Healthcare Analytics, mHealth), By Component (Software, Services), By Region, And Segment Forecasts, 2021 - 2028*. Retrieved October 10, 2021 from https://www.globenewswire.com/news-release/2021/02/18/2178393/0/en/Digital-Health-Market-Size-Share-Trends-Analysis-Report-By-Technology-By-Component-By-Region-And-Segment-Forecasts-2021-2028.html

Graneheim, U. H., Lindgren, B.-M., & Lundman, B. (2017). Methodological challenges in qualitative content analysis: A discussion paper. *Nurse Education Today*, *56*, 29-34. https://doi.org/10.1016/j.nedt.2017.06.002

Grant, R. W., Pandiscio, J. C., Pajolek, H., Woulfe, A., Pelletier, A., Kvedar, J., & Park, E. R. (2012). Implementation of a web-based tool for patient medication self-management: the Medication Self-titration Evaluation Programme (Med-STEP) for blood pressure control. *Informatics in Primary Care*, *20*(1), 57-67. https://doi.org/10.14236/jhi.v20i1.48

Grapow, M. T. R., von Wattenwyl, R., Guller, U., Beyersdorf, F., & Zerkowski, H.-R. (2006). Randomized controlled trials do not reflect reality: Real-world analyses are critical for treatment guidelines! *The Journal of Thoracic and Cardiovascular Surgery*, *132*(1), 5-7. https://doi.org/10.1016/j.jtcvs.2006.03.035

Gray, L. J., Khunti, K., Williams, S., Goldby, S., Troughton, J., Yates, T., Gray, A., & Davies, M. J. (2012). Let's prevent diabetes: study protocol for a cluster randomised controlled trial of an educational intervention in a multi-ethnic UK population with screen detected impaired glucose regulation. *Cardiovascular Diabetology*, *11*, 1-10. https://doi.org/10.1186/1475-2840-11-56

Gray, L. J., Yates, T., Troughton, J., Khunti, K., Davies, M. J., & Team, L. s. P. D. (2016). Engagement, retention, and progression to type 2 diabetes: a retrospective analysis of the cluster-randomised" Let's Prevent Diabetes" trial. *PLoS Medicine*, *13*(7), 1-14. https://doi.org/10.1371/journal.pmed.1002078

Greaves, C. J., Sheppard, K. E., Abraham, C., Hardeman, W., Roden, M., Evans, P. H., Schwarz, P., & Group, T. I. S. (2011). Systematic review of reviews of intervention components associated with increased effectiveness in dietary and physical activity interventions. *BMC Public Health*, *11*(1), 1-12. https://doi.org/10.1186/1471-2458-11-119

Green, E. C., Murphy, E. M., & Gryboski, K. (2020). The health belief model. In K. Sweeny, M. L. Robbins, & L. M. Cohen (Eds.), *The Wiley Encyclopedia of Health Psychology* (pp. 211-214). John Wiley & Sons Ltd.

Greenhalgh, T. (2018). Why do so many technology projects in healthcare fail? A new framework for studying the non-adoption, abandonment and failure of scale-up, spread and sustainability (NASSS) of health and care technologies. Retrieved March 29, 2020, from https://new.talks.ox.ac.uk/talks/id/4e41675d-317c-467f-8c70-96918ca171eb/

Greenhalgh, T., Wherton, J., Papoutsi, C., Lynch, J., Hughes, G., Hinder, S., Fahy, N., Procter, R., & Shaw, S. (2017). Beyond adoption: a new framework for theorizing and evaluating nonadoption, abandonment, and challenges to the scale-up, spread, and sustainability of health and care technologies. *Journal of Medical Internet Research*, *19*(11), 1-21. https://doi.org/10.2196/jmir.8775

Gregg, E. W., Boyle, J. P., Thompson, T. J., Barker, L. E., Albright, A. L., & Williamson, D. F. (2013). Modeling the impact of prevention policies on future diabetes prevalence in the United States: 2010–2030. *Population Health Metrics*, *11*(1), 1-9. https://doi.org/10.1186/1478-7954-11-18

Gregg, E. W., Cheng, Y. J., Srinivasan, M., Lin, J., Geiss, L. S., Albright, A. L., & Imperatore, G. (2018). Trends in cause-specific mortality among adults with and without diagnosed diabetes in the USA: an epidemiological analysis of linked national survey and vital statistics data. *The Lancet*, *391*(10138), 2430-2440. https://doi.org/10.1016/S0140-6736(18)30314-3

Gremler, D. D., & Gwinner, K. P. (2008). Rapport-building behaviors used by retail employees. *Journal of Retailing*, *84*(3), 308-324. https://doi.org/10.1016/j.jretai.2008.07.001

Grock, S., Ku, J.-h., Kim, J., & Moin, T. (2017). A Review of Technology-Assisted Interventions for Diabetes Prevention. *Current Diabetes Reports*, *17*(11), 1-12. https://doi.org/10.1007/s11892-017-0948-2

Gruss, S. M., Nhim, K., Gregg, E., Bell, M., Luman, E., & Albright, A. (2019). Public health approaches to type 2 diabetes prevention: the US National Diabetes Prevention Program and Beyond. *Current Diabetes Reports*, *19*(9), 1-11. https://doi.org/0.1007/s11892-019-1200-z

Guenther, P. M., Casavale, K. O., Reedy, J., Kirkpatrick, S. I., Hiza, H. A., Kuczynski, K. J., Kahle, L. L., & Krebs-Smith, S. M. (2013). Update of the healthy eating index: HEI-2010. *Journal of the Academy of Nutrition and Dietetics*, *113*(4), 569-580. https://doi.org/10.1016/j.jand.2012.12.016

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods*, *18*(1), 59-82. https://doi.org/10.1177/1525822X05279903

Guest, G., Namey, E., Taylor, J., Eley, N., & McKenna, K. (2017). Comparing focus groups and individual interviews: findings from a randomized study. *International Journal of Social Research Methodology*, *20*(6), 693-708. https://doi.org/10.1080/13645579.2017.1281601

Haahr, M. (2020). *RANDOM.ORG: True Random Number Service.* Retrieved January 30, 2020 from https://www.random.org

Hackett, R. A., & Steptoe, A. (2017). Type 2 diabetes mellitus and psychological stress — a modifiable risk factor. *Nature Reviews Endocrinology*, *13*(9), 547-560. https://doi.org/10.1038/nrendo.2017.64

Haidich, A.-B. (2010). Meta-analysis in medical research. *Hippokratia*, *14*(Suppl 1), 29-37. https://www.ncbi.nlm.nih.gov/pubmed/21487488

Hailey, V., Rojas-Garcia, A., & Kassianos, A. P. (2022). A systematic review of behaviour change techniques used in interventions to increase physical activity among breast cancer survivors. *Breast Cancer*, 1-16. https://doi.org/10.1007/s12282-021-01323-z

Hair, J. F. (2009). *Multivariate data analysis* (7th ed.). Prentice-Hall Inc.

Haire-Joshu, D., & Hill-Briggs, F. (2019). The next generation of diabetes translation: a path to health equity. *Annual Review of Public Health*, *40*, 391-410. https://doi.org/10.1146/annurev-publhealth-040218-044158

Hales, S., Turner-McGrievy, G. M., Wilcox, S., Fahim, A., Davis, R. E., Huhns, M., & Valafar, H. (2016). Social networks for improving healthy weight loss behaviors for overweight and obese adults: a randomized clinical trial of the social pounds off digitally (Social POD) mobile app. *International Journal of Medical Informatics*, *94*, 81-90. https://doi.org/10.1016/j.ijmedinf.2016.07.003

Halley, M. C., Petersen, J., Nasrallah, C., Szwerinski, N., Romanelli, R., & Azar, K. M. (2020). Barriers and Facilitators to Real-world Implementation of the Diabetes Prevention Program in Large Healthcare Systems: Lifestyle Coach Perspectives. *Journal of General Internal Medicine*, *35*(6), 1684-1692. https://doi.org/10.1007/s11606-020-05744-y

Hamer, M., & Chida, Y. (2007). Intake of fruit, vegetables, and antioxidants and risk of type 2 diabetes: systematic review and meta-analysis. *Journal of Hypertension*, *25*(12), 2361-2369. https://doi.org/10.1097/HJH.0b013e3282efc214

Hamman, R. F., Wing, R. R., Edelstein, S. L., Lachin, J. M., Bray, G. A., Delahanty, L., Hoskin, M., Kriska, A. M., Mayer-Davis, E. J., & Pi-Sunyer, X. (2006). Effect of weight loss with lifestyle intervention on risk of diabetes. *Diabetes Care*, *29*(9), 2102-2107. https://doi.org/10.2337/dc06-0560

Hammersley, M. (1990). What's wrong with ethnography? The myth of theoretical description. *Sociology*, *24*(4), 597-615. https://doi.org/10.1177/0038038590024004003

Hammersley, M. (1995). Theory and evidence in qualitative research. *Quality and Quantity*, *29*(1), 55-66. https://doi.org/10.1007/BF01107983

Hanafiah, M. H. (2020). Formative vs. reflective measurement model: Guidelines for structural equation modeling research. *International Journal of Analysis and Applications*, *18*(5), 876-889. https://pdfs.semanticscholar.org/d156/8a44bb34fa1861bed906f9ed8358a7fdab96.pdf

Hanik, B., & Stellefson, M. (2011). E-Health Literacy Competencies among Undergraduate Health Education Students: A Preliminary Study. *International Electronic Journal of Health Education*, *14*, 46-58. https://www.fahefoundation.org/wp-content/uploads/2020/04/4203-14149-1-CE.pdf

Hankonen, N. (2021). Participants' enactment of behavior change techniques: a call for increased focus on what people do to manage their motivation and behavior. *Health Psychology Review*, *15*(2), 185-194. https://doi.org/10.1080/17437199.2020.1814836

Hankonen, N., Sutton, S., Prevost, A. T., Simmons, R. K., Griffin, S. J., Kinmonth, A. L., & Hardeman, W. (2014). Which behavior change techniques are associated with changes in physical activity, diet and body mass index in people with recently diagnosed diabetes? *Annals of Behavioral Medicine*, *49*(1), 7-17. https://doi.org/10.1007/s12160-014-9624-9

Hanley, J., Ure, J., Pagliari, C., Sheikh, A., & McKinstry, B. (2013). Experiences of patients and professionals participating in the HITS home blood pressure telemonitoring trial: a qualitative study. *BMJ Open*, *3*(5), 1-10. https://doi.org/10.1136/bmjopen-2013-002671

Hansen, C. R., O'Mahony, D., Kearney, P. M., Sahm, L. J., Cullinan, S., Huibers, C., Thevelin, S., Rutjes, A. W., Knol, W., & Streit, S. (2018). Identification of behaviour change techniques in deprescribing interventions: a systematic review and meta-analysis. *British Journal of Clinical Pharmacology*, *84*(12), 2716-2728. https://doi.org/10.1111/bcp.13742

Haque, A., & Pant, A. B. (2022). Mitigating Covid-19 in the face of emerging virus variants, breakthrough infections and vaccine hesitancy. *Journal of Autoimmunity*, 1-6. https://doi.org/10.1016/j.jaut.2021.102792

Harati, H., Hadaegh, F., Momenan, A. A., Ghanei, L., Bozorgmanesh, M. R., Ghanbarian, A., Mirmiran, P., & Azizi, F. (2010). Reduction in incidence of type 2 diabetes by lifestyle intervention in a middle eastern community. *American Journal of Preventive Medicine*, *38*(6), 628-636. https://doi.org/10.1016/j.amepre.2010.03.003

Hariton, E., & Locascio, J. J. (2018). Randomised controlled trials - the gold standard for effectiveness research: Study design: randomised controlled trials. *BJOG: An International Journal of Obstetrics and Gynaecology*, *125*(13), 1-4. https://doi.org/10.1111/1471-0528.15199

Harrington, D. (2009). *Confirmatory factor analysis*. Oxford university press.

Harris, M. I., Klein, R., Welborn, T. A., & Knuiman, M. W. (1992). Onset of NIDDM occurs at least 4–7 yr before clinical diagnosis. *Diabetes Care*, *15*(7), 815-819. https://doi.org/10.2337/diacare.15.7.815

Harrison, C. R., Phimphasone-Brady, P., DiOrio, B., Raghuanath, S. G., Bright, R., Ritchie, N. D., & Sauder, K. A. (2020). Barriers and facilitators of National Diabetes Prevention Program engagement among women of childbearing age: a qualitative study. *The Diabetes Educator*, *46*(3), 279-288. https://doi.org/10.1177/0145721720920252

Harst, L., Lantzsch, H., & Scheibe, M. (2019). Theories predicting end-user acceptance of telemedicine use: systematic review. *Journal of Medical Internet Research*, *21*(5), 1-19. https://doi.org/10.2196/13117

Harvey, L. A. (2015). Randomised controlled trials do not always give the results we want but that doesn't mean we should abandon randomised controlled trials. *Spinal Cord*, *53*(4), 251-251. https://doi.org/10.1038/sc.2015.59

Haste, A., Rodrigues, A. M., Penn, L., Bell, R., Summerbell, C. D., White, M., Adamson, A. J., & Sniehotta, F. F. (2016). The NHS Diabetes Prevention Programme in England: Lessons learnt from process evaluation of the demonstrator site phase. *Endocrine Practice*, *22*, 12-13. https://www.proquest.com/openview/c02a9e7428d4e0fdc6e30d52378c70e2/1?pq-origsite=gscholar&cbl=1896353

Hawkes, N. (2018). Sixty seconds on... diabetes. *BMJ*, *360*, 1-2. https://doi.org/10.1136/bmj.k1264

Hawkes, R. E., Cameron, E., Cotterill, S., Bower, P., & French, D. P. (2020). The NHS Diabetes Prevention Programme: an observational study of service delivery and patient experience. *BMC Health Services Research*, *20*(1), 1-12. https://doi.org/10.1186/s12913-020-05951

Hawkes, R. E., Miles, L. M., & French, D. P. (2022). Fidelity to Program Specification of the National Health Service Digital Diabetes Prevention Program Behavior Change Technique Content and Underpinning Theory: Document Analysis. *Journal of Medical Internet Research*, *24*(4), 1-16. https://doi.org/10.2196/34253

Hawkes, R. E., Warren, L., Cameron, E., & French, D. P. (2022). An evaluation of goal setting in the NHS England diabetes prevention programme. *Psychology & Health*, *37*(2), 131-150. https://doi.org/10.1080/08870446.2021.1872790

Health Service Executive. (2015). *Knowledge & Information Strategy: Delivering the Benefits of eHealth in Ireland*. Health Service Executive. https://assets.gov.ie/215972/8c94a67f-a432-4cb4-8ebb-7c890d6279cd.pdf

Health Service Executive. (2016). *Making every contact count: A health behaviour change framework and implementation plan for health professionals in the Irish health service.* Health Service Executive. https://www.hse.ie/eng/health/hl/selfmanagement/donegal/health-social-care-professionals/making-every-contact-count-framework.pdf

Health Service Executive. (2020a). *HSE wins award for public sector innovation and start-ups collaboration*. Health Service Executive. Retrieved October 21, 2021 from https://www.hse.ie/eng/services/news/media/pressrel/hse-wins-award-for-public-sector-innovation-and-start-ups-collaboration.html

Health Service Executive. (2020b). *Type 2 Diabetes*. Retrieved October 30, 2020 from https://www2.hse.ie/type-2-diabetes/

Hennessy, M., Heary, C., Laws, R., Van Rhoon, L., Toomey, E., Wolstenholme, H., & Byrne, M. (2019). The effectiveness of health professional-delivered interventions during the first 1000 days to prevent overweight/obesity in children: A systematic review. *Obesity Reviews*, *20*(12), 1691-1707. https://doi.org/10.1111/obr.12924

Henning, R. J. (2018). Type-2 diabetes mellitus and cardiovascular disease. *Future Cardiology*, *14*(6), 491-509. https://doi.org/10.2217/fca-2018-0045

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science, 43*(1), 115-135. https://doi.org/10.1007/s11747-014-0403-8

Herman, W. H., Joiner, K. L., Stites, M. B., & McEwen, L. N. (2018). Factors predicting participation in the Diabetes Prevention Program (DPP) among people with prediabetes. *Diabetologia*, *61*, S162. https://doi.org/10.1007/s00125-018-4693-0

Hermida, R. (2015). The problem of allowing correlated errors in structural equation modeling: concerns and considerations. *Computational Methods in Social Sciences*, *3*(1), 5-17. http://cmss.univnt.ro/wp-content/uploads/vol/split/vol_III_issue_1/CMSS_vol_III_issue_1_art.001.pdf

Higashiyama, A., Okamura, T., Watanabe, M., Kokubo, Y., Wakabayashi, I., Okayama, A., & Miyamoto, Y. (2013). Alcohol consumption and cardiovascular disease incidence in men with and without hypertension: the Suita study. *Hypertension Research*, *36*(1), 58-64. https://doi.org/10.1038/hr.2012.133

Hill-Briggs, F., Adler, N. E., Berkowitz, S. A., Chin, M. H., Gary-Webb, T. L., Navas-Acien, A., Thornton, P. L., & Haire-Joshu, D. (2021). Social determinants of health and diabetes: A scientific review. *Diabetes Care*, *44*(1), 258-279. https://doi.org/10.2337/dci20-0053

Hill, J. O., Galloway, J. M., Goley, A., Marrero, D. G., Minners, R., Montgomery, B., Peterson, G. E., Ratner, R. E., Sanchez, E., & Aroda, V. R. (2013). Scientific statement: socioecological determinants of prediabetes and type 2 diabetes. *Diabetes Care*, *36*(8), 2430-2439. https://doi.org/10.2337/dc13-1161

Hillier, T. A., & Pedula, K. L. (2003). Complications in young adults with early-onset type 2 diabetes: losing the relative protection of youth. *Diabetes Care*, *26*(11), 2999-3005. https://doi.org/10.2337/diacare.26.11.2999

Holcomb, L. S. (2015). A Taxonomic Integrative Review of Short Message Service (SMS) Methodology:A Framework for Improved Diabetic Outcomes. *Journal of Diabetes Science and Technology*, *9*(6), 1321-1326. https://doi.org/10.1177/1932296815585132

Holmes, L., Cresswell, K., Williams, S., Parsons, S., Keane, A., Wilson, C., Islam, S., Joseph, O., Miah, J., Robinson, E., & Starling, B. (2019). Innovating public engagement and patient involvement through strategic collaboration and practice. *Research Involvement and Engagement*, *5*(1), 1-12. https://doi.org/10.1186/s40900-019-0160-4

Holtz, B. E. (2020). Evaluating the most popular diabetes websites in the USA: a content analysis. *Health Promotion International*, *35*(6), 1394-1405. https://doi.org/10.1093/heapro/daaa008

Hopewell, S., McDonald, S., Clarke, M. J., & Egger, M. (2007). Grey literature in meta-analyses of randomized trials of health care interventions. *Cochrane Database of Systematic Reviews,* (2), 1-15. https://doi.org/10.1002/14651858.MR000010.pub3

Hostalek, U. (2019). Global epidemiology of prediabetes-present and future perspectives. *Clinical Diabetes and Endocrinology*, *5*(1), 1-5. https://doi.org/10.1186/s40842-019-0080-0

Howarth, E., Bower, P. J., Kontopantelis, E., Soiland-Reyes, C., Meacock, R., Whittaker, W., & Cotterill, S. (2020). 'Going the distance': an independent cohort study of engagement and dropout among the first 100 000 referrals into a large-scale diabetes prevention program. *BMJ Open Diabetes Research & Care*, *8*(2), 1-12. https://doi.org/10.1136/bmjdrc-2020-001835

Hsieh, H.-F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, *15*(9), 1277-1288. https://doi.org/10.1177/1049732305276687

Hsieh, M.-H., Chen, Y.-C., & Ho, C.-H. (2019). A Usability Evaluation of Diabetes Mobile Applications. *International Conference on Human-Computer Interaction*, 3-15. https://doi.org/10.1007/978-3-030-22636-7_1

Hu, G., Lakka, T. A., Kilpeläinen, T. O., & Tuomilehto, J. (2007). Epidemiological studies of exercise in diabetes prevention. *Applied Physiology, Nutrition, and Metabolism*, *32*(3), 583-595. https://doi.org/10.1139/H07-030

Hu, L. t., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: a Multidisciplinary Journal*, *6*(1), 1-55. https://doi.org/10.1080/10705519909540118

Huai, P., Han, H., Reilly, K. H., Guo, X., Zhang, J., & Xu, A. (2016). Leisure-time physical activity and risk of type 2 diabetes: a meta-analysis of prospective cohort studies. *Endocrine*, *52*(2), 226-230. https://doi.org/10.1007/s12020-015-0769-5

Huang, I., Lim, M. A., & Pranata, R. (2020). Diabetes mellitus is associated with increased mortality and severity of disease in COVID-19 pneumonia–a systematic review, meta-analysis, and meta-regression. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(4), 395-403. https://doi.org/10.1016/j.dsx.2020.04.018

Huang, J., Wang, X., & Zhang, Y. (2017). Specific types of alcoholic beverage consumption and risk of type 2 diabetes: A systematic review and meta-analysis. *Journal of Diabetes Investigation*, *8*(1), 56-68. https://doi.org/10.1111/jdi.12537

Huebschmann, A. G., Huxley, R. R., Kohrt, W. M., Zeitler, P., Regensteiner, J. G., & Reusch, J. E. (2019). Sex differences in the burden of type 2 diabetes and cardiovascular risk across the life course. *Diabetologia*, *62*(10), 1761-1772. https://doi.org/10.1007/s00125-019-4939-5

Huo, X., Gao, L., Guo, L., Xu, W., Wang, W., Zhi, X., Li, L., Ren, Y., Qi, X., & Sun, Z. (2016). Risk of non-fatal cardiovascular diseases in early-onset versus late-onset type 2 diabetes in China: a cross-sectional study. *The Lancet Diabetes & Endocrinology*, *4*(2), 115-124. https://doi.org/10.1016/S2213-8587(15)00508-2

Hwang, K. O., Etchegaray, J. M., Sciamanna, C. N., Bernstam, E. V., & Thomas, E. J. (2014). Structural social support predicts functional social support in an online weight loss programme. *Health Expectations*, *17*(3), 345-352. https://doi.org/10.1111/j.1369-7625.2011.00759.x

Hwang, K. O., Ottenbacher, A. J., Green, A. P., Cannon-Diehl, M. R., Richardson, O., Bernstam, E. V., & Thomas, E. J. (2010). Social support in an Internet weight loss community. *International Journal of Medical Informatics*, *79*(1), 5-13. https://doi.org/10.1016/j.ijmedinf.2009.10.003

Ibec. (2020). *Ireland: Where Digital Health Thrives*. Ibec. https://www.ibec.ie/-/media/documents/media-press-release/where-digital-health-thrives.pdf

IBM Corp. (2020). *IBM SPSS Statistics for Windows*. In (Version 27.0) IBM Corp.

Ibrahim, M., Tuomilehto, J., Aschner, P., Beseler, L., Cahn, A., Eckel, R. H., Fischl, A. H., Guthrie, G., Hill, J. O., Kumwenda, M., Leslie, R. D., Olson, D. E., Pozzilli, P., Weber, S. L., & Umpierrez, G. E. (2018). Global status of diabetes prevention and prospects for action: A consensus statement. *Diabetes/Metabolism Research and Reviews*, *34*(6), 1-10. https://doi.org/10.1002/dmrr.3021

Ibrahim, N., Ming Moy, F., Awalludin, I. A. N., Mohd Ali, Z., & Ismail, I. S. (2016). Effects of a community-based healthy lifestyle intervention program (Co-HELP) among adults with prediabetes in a developing country: a quasi-experimental study. *PloS One*, *11*(12), 1-21. https://doi.org/10.1371/journal.pone.0167123

Imamura, F., O'Connor, L., Ye, Z., Mursu, J., Hayashino, Y., Bhupathiraju, S. N., & Forouhi, N. G. (2016). Consumption of sugar sweetened beverages, artificially sweetened beverages, and fruit juice and incidence of type 2 diabetes: systematic review, meta-analysis, and estimation of population attributable fraction. *British Journal of Sports Medicine*, *50*(8), 496-504. https://doi.org/10.1136/bjsports-2016-h3576rep

Imison, C., Castle-Clarke, S., Watson, R., & Edwards, N. (2016). *Delivering the benefits of digital health care*. Nuffield Trust. https://www.atmedics.com/wp-content/uploads/2016/02/nuffield-trust-delivering-the-benefits-of-digital-care-17-02-2016.pdf

International Diabetes Federation. (2019). *IDF Diabetes Atlas* (9th ed.). International Diabetes Federation. https://diabetesatlas.org/idfawp/resource-files/2019/07/IDF_diabetes_atlas_ninth_edition_en.pdf

Irish Heart Foundation. (2019). *Many low-income families struggle to afford healthy diet*. Retrieved April 20, 2022 from https://irishheart.ie/news/many-low-income-families-struggle-to-afford-healthy-diet/

Ivanitskaya, L., Brookins-Fisher, J., O'Boyle, I., Vibbert, D., Erofeev, D., & Fulton, L. (2010). Dirt cheap and without prescription: how susceptible are young US consumers to purchasing drugs from rogue internet pharmacies? *Journal of Medical Internet Research*, *12*(2), 1-15. https://doi.org/10.2196/jmir.1520

Ivankova, N., & Wingo, N. (2018). Applying mixed methods in action research: Methodological potentials and advantages. *American Behavioral Scientist*, *62*(7), 978-997. https://doi.org/10.1177/0002764218772673

Izahar, S., Lean, Q. Y., Hameed, M. A., Murugiah, M. K., Patel, R. P., Al-Worafi, Y. M., Wong, T. W., & Ming, L. C. (2017). Content analysis of mobile health applications on diabetes mellitus. *Frontiers in Endocrinology*, *8*, 1-8. https://doi.org/10.3389/fendo.2017.00318

Jacobs, D. R., & Tapsell, L. C. (2007). Food, Not Nutrients, Is the Fundamental Unit in Nutrition. *Nutrition Reviews, 65*(10), 439-450. https://doi.org/10.1111/j.1753-4887.2007.tb00269.x

Jadhav, R. A., Hazari, A., Monterio, A., Kumar, S., & Maiya, A. G. (2017). Effect of Physical Activity Intervention in Prediabetes: A Systematic Review With Meta-analysis. *Journal of Physical Activity & Health*, *14*(9), 745-755. https://doi.org/10.1123/jpah.2016-0632

Jakobsen, M., & Jensen, R. (2015). Common method bias in public management studies. *International Public Management Journal*, *18*(1), 3-30. https://doi.org/10.1080/10967494.2014.997906

Jandoo, T. (2020). WHO guidance for digital health: What it means for researchers. *Digital Health*, *6*, 1-4. https://doi.org/10.1177/2055207619898984

Janus, E. D., Best, J. D., Davis-Lameloise, N., Philpot, B., Hernan, A., Bennett, C. M., O'Reilly, S., Carter, R., Vartiainen, E., & Dunbar, J. A. (2012). Scaling-up from an implementation trial to state-wide coverage: results from the preliminary Melbourne Diabetes Prevention Study. *Trials*, *13*(1), 1-6. https://doi.org/10.1186/1745-6215-13-152

Jayedi, A., & Shab-Bidar, S. (2018). Dietary acid load and risk of type 2 diabetes: A systematic review and dose–response meta-analysis of prospective observational studies. *Clinical Nutrition ESPEN*, *23*, 10-18. https://doi.org/10.1016/j.clnesp.2017.12.005

Jefford, M., & Moore, R. (2008). Improvement of informed consent and the quality of consent documents. *The Lancet Oncology*, *9*(5), 485-493. https://doi.org/10.1016/S1470-2045(08)70128-1

Jenkins, D. J., Wolever, T., Taylor, R. H., Barker, H., Fielden, H., Baldwin, J. M., Bowling, A. C., Newman, H. C., Jenkins, A. L., & Goff, D. V. (1981). Glycemic index of foods: a physiological basis for carbohydrate exchange. *The American Journal of Clinical Nutrition*, *34*(3), 362-366. https://doi.org/10.1093/ajcn/34.3.362

Jensen, D. (2006). Transerability. In L. Given (Ed.), *The Sage encyclopedia of qualitative research methods* (pp. 887). Thousand Oaks: SAGE Publications, Inc.

Jiang, G., & Zhang, B. B. (2003). Glucagon and regulation of glucose metabolism. *American Journal of Physiology-Endocrinology and Metabolism*, *284*(4), E671-E678. https://doi.org/10.1152/ajpendo.00492.2002

Johns, E. C., Denison, F. C., Norman, J. E., & Reynolds, R. M. (2018). Gestational Diabetes Mellitus: Mechanisms, Treatment, and Complications. *Trends in Endocrinology & Metabolism*, *29*(11), 743-754. https://doi.org/10.1016/j.tem.2018.09.004

Johnson-Lawrence, V., Zajacova, A., & Sneed, R. (2017). Education, race/ethnicity, and multimorbidity among adults aged 30–64 in the National Health Interview Survey. *SSM-Population Health*, *3*, 366-372. https://doi.org/10.1016/j.ssmph.2017.03.007

Johnson, L. N., & Melton, S. T. (2016). Perceived benefits and barriers to the diabetes prevention program. *PLAID: People Living with And Inspired by Diabetes*, *2*(1), 15-24. https://doi.org/10.17125/plaid.2016.65

Johnson, M., Jones, R., Freeman, C., Woods, H. B., Gillett, M., Goyder, E., & Payne, N. (2013). Can diabetes prevention programmes be translated effectively into real-world settings and still deliver improved outcomes? A synthesis of evidence. *Diabetic Medicine*, *30*(1), 3-15. https://doi.org/10.1111/dme.12018

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, *33*(7), 14-26. https://doi.org/10.3102/0013189X033007014

Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2007). Toward a definition of mixed methods research. *Journal of Mixed Methods Research*, *1*(2), 112-133. https://doi.org/10.1177/1558689806298224

Joiner, K. L., Nam, S., & Whittemore, R. (2017). Lifestyle interventions based on the diabetes prevention program delivered via eHealth: A systematic review and meta-analysis. *Preventive Medicine*, *100*, 194-207. https://doi.org/10.1016/j.ypmed.2017.04.033

Jones, R. (2013). Development of a questionnaire and cross-sectional survey of patient ehealth readiness and ehealth inequalities. *Medicine 2.0*, *2*(2), 1-20. https://doi.org/10.2196/med20.2559

Jung, S. Y., Hwang, H., Lee, K., Lee, D., Yoo, S., Lim, K., Lee, H.-Y., & Kim, E. (2021). User Perspectives on Barriers and Facilitators to the Implementation of Electronic Health Records in Behavioral Hospitals: Qualitative Study. *JMIR Formative Research*, *5*(4), 1-16. https://doi.org/10.2196/18764

Kanaya, A. M., Santoyo-Olsson, J., Gregorich, S., Grossman, M., Moore, T., & Stewart, A. L. (2012). The live well, be well study: a community-based, translational lifestyle program to lower diabetes risk factors in ethnic minority and lower–socioeconomic status adults. *American Journal of Public Health*, *102*(8), 1551-1558. https://doi.org/10.2105/AJPH.2011.300456

Kanetkar, R. (2021). Europe's healthtech boom continues with Oviva's $80m raise. Retrieved December 17, 2021, from https://sifted.eu/articles/healthtech-oviva-80m-raise/

Katula, J. A., Dressler, E. V., Kittel, C. A., Harvin, L. N., Almeida, F. A., Wilson, K. E., Michaud, T. L., Porter, G. C., Brito, F. A., Goessl, C. L., Jasik, C. B., Sweet, C. M. C., Schwab, R., & Estabrooks, P. A. (2022). Effects of a Digital Diabetes Prevention Program: An RCT. *American Journal of Preventive Medicine*, *62*(4), 567-577. https://doi.org/10.1016/j.amepre.2021.10.023

Katula, J. A., Vitolins, M. Z., Rosenberger, E. L., Blackwell, C. S., Morgan, T. M., Lawlor, M. S., & Goff Jr, D. C. (2011). One-year results of a community-based translation of the Diabetes Prevention Program: Healthy-Living Partnerships to Prevent Diabetes (HELP PD) Project. *Diabetes Care*, *34*(7), 1451-1457. https://doi.org/10.2337/dc10-2115

Kayser, L., Karnoe, A., Furstrand, D., Batterham, R., Christensen, K. B., Elsworth, G., & Osborne, R. H. (2018). A Multidimensional Tool Based on the eHealth Literacy Framework: Development and Initial Validity Testing of the eHealth Literacy Questionnaire (eHLQ). *Journal of Medical Internet Research*, *20*(2), 1-11. https://doi.org/10.2196/jmir.8371

Kemp, S. (2022a). *Digital 2022: Country Headlines Report*. Retrieved February 18, 2022 from https://datareportal.com/reports/digital-2022-local-country-headlines

Kemp, S. (2022b). *Digital 2022: Global Overview Report*. Retrieved February 18, 2022 from https://datareportal.com/reports/digital-2022-global-overview-report

Kemp, S. (2022c). *Digital 2022: Ireland*. Retrieved February 18, 2022 from https://datareportal.com/reports/digital-2022-ireland

Kennedy, E., Ohls, J., Carlson, S., & Fleming, K. (1995). The healthy eating index: design and applications. *Journal of the American Dietetic Association*, *95*(10), 1103-1108. https://doi.org/0.1016/S0002-8223(95)00300-2

Khan, A., & Woosley, J. M. (2011). Comparison of contemporary technology acceptance models and evaluation of the best fit for health industry organizations. *IJCSET*, *1*(11), 709-717. http://www.ijcset.net/docs/Volumes/volume1issue11/ijcset2011011106.pdf

Khan, M. A. B., Hashim, M. J., King, J. K., Govender, R. D., Mustafa, H., & Al Kaabi, J. (2020). Epidemiology of type 2 diabetes–global burden of disease and forecasted trends. *Journal of Epidemiology and Global Health*, *10*(1), 107-111. https://doi.org/10.2991/jegh.k.191028.001

Kim, H., & Stepchenkova, S. (2015). Effect of tourist photographs on attitudes towards destination: Manifest and latent content. *Tourism Management*, *49*, 29-41. https://doi.org/10.1016/j.tourman.2015.02.004

Kim, J., & Park, H.-A. (2012). Development of a health information technology acceptance model using consumers' health behavior intention. *Journal of Medical Internet Research*, *14*(5), 1-14. https://doi.org/10.2196/jmir.2143

Kim, S. E., Castro Sweet, C. M., Gibson, E., Madero, E. N., Rubino, B., Morrison, J., Rosen, D., Imberg, W., & Cousineau, M. R. (2018). Evaluation of a digital diabetes prevention program adapted for the Medicaid population: Study design and methods for a non-randomized, controlled trial. *Contemporary Clinical Trials Communications*, *10*, 161-168. https://doi.org/10.1016/j.conctc.2018.05.007

King, D. K., Glasgow, R. E., Toobert, D. J., Strycker, L. A., Estabrooks, P. A., Osuna, D., & Faber, A. J. (2010). Self-efficacy, problem solving, and social-environmental support are associated with diabetes self-management behaviors. *Diabetes Care*, *33*(4), 751-753. https://doi.org/10.2337/dc09-1746

Kirkman, M. S., Briscoe, V. J., Clark, N., Florez, H., Haas, L. B., Halter, J. B., Huang, E. S., Korytkowski, M. T., Munshi, M. N., & Odegard, P. S. (2012). Diabetes in older adults. *Diabetes Care*, *35*(12), 2650-2664. https://doi.org/10.2337/dc12-1801

Kirkman, M. S., Rowan-Martin, M. T., Levin, R., Fonseca, V. A., Schmittdiel, J. A., Herman, W. H., & Aubert, R. E. (2015). Determinants of Adherence to Diabetes Medications: Findings From a Large Pharmacy Claims Database. *Diabetes Care*, *38*(4), 604-609. https://doi.org/10.2337/dc14-2098

Klein, C. T., & Helweg-Larsen, M. (2002). Perceived control and the optimistic bias: A meta-analytic review. *Psychology & Health*, *17*(4), 437-446. https://doi.org/10.1080/0887044022000004920

Know Diabetes. (2021). Second Nature. Retrieved Februay 19, 2022, from https://www.knowdiabetes.org.uk/for-you/programmes/type-2/second-nature/

Knowler, W. C., Barrett-Connor, E., Fowler, S. E., Hamman, R. F., Lachin, J. M., Walker, E. A., Nathan, D. M., Watson, P., Mendoza, J., & Smith, K. (2002). Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *New England Journal of Medicine*, *346*(6), 393-403. https://doi.org/10.1056/NEJMoa012512

Koloverou, E., Esposito, K., Giugliano, D., & Panagiotakos, D. (2014). The effect of Mediterranean diet on the development of type 2 diabetes mellitus: A meta-analysis of 10 prospective studies and 136,846 participants. *Metabolism*, *63*(7), 903-911. https://doi.org/10.1016/j.metabol.2014.04.010

Komkova, A., Brandt, C. J., Pedersen, D. H., Emneus, M., & Sortsø, C. (2019). Electronic health lifestyle coaching among diabetes patients in a real-life municipality setting: observational study. *JMIR Diabetes*, *4*(1), 1-11. https://doi.org/10.2196/12140

Koo, M., Norman, C. D., & Hsiao-Mei, C. (2012). Psychometric evaluation of a Chinese version of the eHealth literacy scale (eHEALS) in school age children. *Global Journal of Health Education and Promotion*, *15*(1), 29-36. https://fahefoundation.org/wp-content/uploads/2020/04/4219-14188-1-CE.pdf

Kosaka, K., Noda, M., & Kuzuya, T. (2005). Prevention of type 2 diabetes by lifestyle intervention: a Japanese trial in IGT males. *Diabetes Research and Clinical Practice*, *67*(2), 152-162. https://doi.org/10.1016/j.diabres.2004.06.010

Kostkova, P. (2015). Grand challenges in digital health. *Frontiers in Public Health*, *3*, 1-5. https://doi.org/10.3389/fpubh.2015.00134

Kowall, B., Rathmann, W., Stang, A., Bongaerts, B., Kuss, O., Herder, C., Roden, M., Quante, A., Holle, R., & Huth, C. (2017). Perceived risk of diabetes seriously underestimates actual diabetes risk: the KORA FF4 study. *PloS One*, *12*(1), 1-13. https://doi.org/10.1371/journal.pone.0171152

Kramer, M. K., Kriska, A. M., Venditti, E. M., Miller, R. G., Brooks, M. M., Burke, L. E., Siminerio, L. M., Solano, F. X., & Orchard, T. J. (2009). Translating the Diabetes Prevention Program: a comprehensive model for prevention training and program delivery. *American Journal of Preventive Medicine*, *37*(6), 505-511. https://doi.org/10.1016/j.amepre.2009.07.020

Kramer, M. K., Kriska, A. M., Venditti, E. M., Semler, L. N., Miller, R. G., McDonald, T., Siminerio, L. M., & Orchard, T. J. (2010). A novel approach to diabetes prevention: Evaluation of the Group Lifestyle Balance program delivered via DVD. *Diabetes Research & Clinical Practice*, *90*(3), 60-63. https://doi.org/10.1016/j.diabres.2010.08.013

Krebs, P., & Duncan, D. T. (2015). Health App Use Among US Mobile Phone Owners: A National Survey. *JMIR mHealth and uHealth*, *3*(4), 1-12. https://doi.org/10.2196/mhealth.4924

Kulzer, B., Hermanns, N., Gorges, D., Schwarz, P., & Haak, T. (2009). Prevention of diabetes self-management program (PREDIAS): effects on weight, metabolic risk factors, and behavioral outcomes. *Diabetes Care*, *32*(7), 1143-1146. https://doi.org/10.2337/dc08-2141

Kunstler, B. E., Cook, J. L., Kemp, J. L., O'Halloran, P. D., & Finch, C. F. (2019). The behaviour change techniques used by Australian physiotherapists to promote non-treatment physical activity to patients with musculoskeletal conditions. *Journal of Science and Medicine in Sport*, *22*(1), 2-10. https://doi.org/10.1016/j.jsams.2018.06.002

Kwasnicka, D., Dombrowski, S. U., White, M., & Sniehotta, F. (2016). Theoretical explanations for maintenance of behaviour change: a systematic review of behaviour theories. *Health Psychology Review*, *10*(3), 277-296. https://doi.org/10.1080/17437199.2016.1151372

Kyngäs, H. (2020). Inductive content analysis. In *The application of content analysis in nursing science research* (pp. 13-21). Springer.

Laatikainen, T., Dunbar, J. A., Chapman, A., Kilkkinen, A., Vartiainen, E., Heistaro, S., Philpot, B., Absetz, P., Bunker, S., & O'Neil, A. (2007). Prevention of type 2 diabetes by lifestyle intervention in an Australian primary health care setting: Greater Green Triangle (GGT) Diabetes Prevention Project. *BMC Public Health, 7*(1), 1-7. https://doi.org/10.1186/1471-2458-7-249

Lalau, J.-D. (2010). Lactic Acidosis Induced by Metformin. *Drug Safety*, *33*(9), 727-740. https://doi.org/10.2165/11536790-000000000-00000

Lance, C. E., Lance, C. E., & Vandenberg, R. J. (2010). On the practice of allowing correlated residuals among indicators in structural equation models. In *Statistical and methodological myths and urban legends* (pp. 213-236). Routledge.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*(1), 159-174. https://doi.org/10.2307/2529310

Langley, H. (2017). UK's NHS is handing out trackers designed to prevent diabetes. Retrieved December 10, 2021, from https://www.wareable.com/health-and-wellbeing/nhs-buddi-nujjer-diabetes-tracker-339

Lascar, N., Brown, J., Pattison, H., Barnett, A. H., Bailey, C. J., & Bellary, S. (2018). Type 2 diabetes in adolescents and young adults. *The Lancet Diabetes & Endocrinology*, *6*(1), 69-80. https://doi.org/10.1016/S2213-8587(17)30186-9

Latulippe, K., Hamel, C., & Giroux, D. (2017). Social health inequalities and eHealth: a literature review with qualitative synthesis of theoretical and empirical studies. *Journal of Medical Internet Research*, *19*(4), 1-14. https://doi.org/10.2196/jmir.6731

Lavelle, F., Spence, M., Hollywood, L., McGowan, L., Surgenor, D., McCloat, A., Mooney, E., Caraher, M., Raats, M., & Dean, M. (2016). Learning cooking skills at different ages: a cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity*, *13*(1), 1-11. https://doi.org/10.1186/s12966-016-0446-y

Lazzarini, P. A., Hurn, S. E., Fernando, M. E., Jen, S. D., Kuys, S. S., Kamp, M. C., & Reed, L. F. (2015). Prevalence of foot disease and risk factors in general inpatient populations: a systematic review and meta-analysis. *BMJ Open*, *5*(11), 1-15. https://doi.org/10.1136/bmjopen-2015-008544

Leal, J., Ahrabian, D., Davies, M., Gray, L., Khunti, K., Yates, T., & Gray, A. (2017). Cost-effectiveness of a pragmatic structured education intervention for the prevention of type 2 diabetes: economic evaluation of data from the Let's Prevent Diabetes cluster-randomised controlled trial. *BMJ Open*, *7*(1), 1-9. https://doi.org/10.1136/bmjopen-2016-013592

Lebovitz, H. E., & Banerji, M. A. (2005). Point: visceral adiposity is causally related to insulin resistance. *Diabetes Care*, *28*(9), 2322-2325. https://doi.org/10.2337/diacare.28.9.2322

Lee, B. J., & Gu, M. O. (2009). Comparison of the Effects between Positive Message and Negative Message in Diabetes Mellitus Education. *Korean Diabetes Journal*, *33*(4), 344-352. https://doi.org/10.4093/kdj.2009.33.4.344

Lee, C. M. Y., Woodward, M., Pandeya, N., Adams, R., Barrett-Connor, E., Boyko, E. J., Eliasson, M., Franco, L. J., Fujimoto, W. Y., Gonzalez, C., Howard, B. V., Jacobs, D. R., Keinanen-Kiukaanniemi, S., Magliano, D., Schreiner, P., Shaw, J. E., Stevens, J., Taylor, A., Tuomilehto, J., . . . Huxley, R. R. (2017). Comparison of relationships between four common anthropometric measures and incident diabetes. *Diabetes Research and Clinical Practice*, *132*, 36-44. https://doi.org/10.1016/j.diabres.2017.07.022

Lee, J., Lee, E.-H., & Chae, D. (2021). eHealth Literacy Instruments: Systematic Review of Measurement Properties. *Journal of Medical Internet Research*, *23*(11), 1-16. https://doi.org/10.2196/30644

Lee, J. Y., Chan, C. K. Y., Chua, S. S., Paraidathathu, T., Lee, K. K.-C., San San Tan, C., Nasir, N., & Lee, S. W. H. (2019). Using telemedicine to support care for people with type 2 diabetes mellitus: a qualitative analysis of patients' perspectives. *BMJ Open*, *9*(10), 1-7. https://doi.org/10.1136/bmjopen-2018-026575

Lee, Y., & Park, K. (2017). Adherence to a Vegetarian Diet and Diabetes Risk: A Systematic Review and Meta-Analysis of Observational Studies. *Nutrients*, *9*(6), 1-11. https://doi.org/10.3390/nu9060603

Leese, J., Garraway, L., Li, L., Oelke, N., & MacLeod, M. (2022). Adapting patient and public involvement in patient-oriented methods research: Reflections in a Canadian setting during COVID-19. *Health Expectations, 25*(2), 477-481. https://doi.org/10.1111/hex.13387

Lefkowich, M., & Richardson, N. (2018). Men's health in alternative spaces: exploring men's sheds in Ireland. *Health Promotion International*, *33*(3), 525-535. https://doi.org/10.1093/heapro/daw091

Lende, M., & Rijhsinghani, A. (2020). Gestational diabetes: overview with emphasis on medical management. *International Journal of Environmental Research and Public Health*, *17*(24), 1-12. https://doi.org/10.3390/ijerph17249573

Lennon, M. R., Bouamrane, M.-M., Devlin, A. M., O'connor, S., O'donnell, C., Chetty, U., Agbakoba, R., Bikker, A., Grieve, E., & Finch, T. (2017). Readiness for delivering digital health at scale: lessons from a longitudinal qualitative evaluation of a national digital health innovation program in the United Kingdom. *Journal of Medical Internet Research, 19*(2), 1-18. https://doi.org/10.2196/jmir.6900

Li, G., Zhang, P., Wang, J., An, Y., Gong, Q., Gregg, E. W., Yang, W., Zhang, B., Shuai, Y., & Hong, J. (2014). Cardiovascular mortality, all-cause mortality, and diabetes incidence after lifestyle intervention for people with impaired glucose tolerance in the Da Qing Diabetes Prevention Study: a 23-year follow-up study. *The Lancet Diabetes & Endocrinology, 2*(6), 474-480. https://doi.org/10.1016/S2213-8587(14)70057-9

Li, X.-H., Yu, F.-f., Zhou, Y.-H., & He, J. (2016). Association between alcohol consumption and the risk of incident type 2 diabetes: a systematic review and dose-response meta-analysis. *The American Journal of Clinical Nutrition, 103*(3), 818-829. https://doi.org/10.3945/ajcn.115.114389

Liao, W. C., Tu, Y. K., Wu, M. S., Lin, J. T., Wang, H. P., & Chien, K. L. (2015). Blood glucose concentration and risk of pancreatic cancer: Systematic review and dose-response meta-analysis. *BMJ, 349,* 1-11. https://doi.org/10.1136/bmj.g7371

Limaye, T., Kumaran, K., Joglekar, C., Bhat, D., Kulkarni, R., Nanivadekar, A., & Yajnik, C. (2017). Efficacy of a virtual assistance-based lifestyle intervention in reducing risk factors for Type 2 diabetes in young employees in the information technology industry in India: LIMIT, a randomized controlled trial. *Diabetic Medicine*, *34*(4), 563-568. https://doi.org/10.1111/dme.13258

Limesurvey GmbH. (2021). *Limesurvey: An Open Source Survey Tool*. Limesurvey GmbH, Hamburg, Germany. http://www.limesurvey.org

Lindqvist, G., & Hallberg, L. R. (2010). 'Feelings of Guilt due to Self-inflicted Disease' A Grounded Theory of Suffering from Chronic Obstructive Pulmonary Disease (COPD). *Journal of Health Psychology*, *15*(3), 456-466. https://doi.org/10.1177/1359105309353646

Lindsay Smith, G., Banting, L., Eime, R., O'Sullivan, G., & Van Uffelen, J. G. (2017). The association between social support and physical activity in older adults: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, *14*(1), 1-21. https://doi.org/10.1186/s12966-017-0509-8

Lindstrom, J., Louheranta, A., Mannelin, M., Rastas, M., Salminen, V., Eriksson, J., Uusitupa, M., Tuomilehto, J., & Group, F. D. P. S. (2003). The Finnish Diabetes Prevention Study (DPS) Lifestyle intervention and 3-year results on diet and physical activity. *Diabetes Care*, *26*(12), 3230-3236. https://doi.org/10.2337/diacare.26.12.3230

Lindström, J., Neumann, A., Sheppard, K. E., Gilis-Januszewska, A., Greaves, C. J., Handke, U., Pajunen, P., Puhl, S., Pölönen, A., Rissanen, A., Roden, M., Stemper, T., Telle-Hjellset, V., Tuomilehto, J., Velickiene, D., Schwarz, P. E., Acosta, T., Adler, M., AlKerwi, A., . . . Yilmaz, T. (2010). Take Action to Prevent Diabetes – The IMAGE Toolkit for the Prevention of Type 2 Diabetes in Europe. *Hormone and Metabolic Research*, *42*(S 01), S37-S55. https://doi.org/10.1055/s-0029-1240975

Lindström, J., Peltonen, M., Eriksson, J., Ilanne-Parikka, P., Aunola, S., Keinänen-Kiukaanniemi, S., Uusitupa, M., & Tuomilehto, J. (2013). Improved lifestyle and decreased diabetes risk over 13 years: long-term follow-up of the randomised Finnish Diabetes Prevention Study (DPS). *Diabetologia*, *56*(2), 284-293. https://doi.org/10.1007/s00125-012-2752-5

Lindström, J., Peltonen, M., Tuomilehto, J., & Group, F. D. P. S. (2005). Lifestyle strategies for weight control: experience from the Finnish Diabetes Prevention Study. *Proceedings of the Nutrition Society*, *64*(1), 81-88. https://doi.org/10.1079/pns2004412

Lindström, J., & Tuomilehto, J. (2003). The diabetes risk score: a practical tool to predict type 2 diabetes risk. *Diabetes Care*, *26*(3), 725-731. https://doi.org/10.2337/diacare.26.3.725

Liva Healthcare. (2020). *Liva Healthcare - Improving Lives Through Digital Health Coaching*. Liva Healthcare. Retrieved March 10, 2020 from https://livahealthcare.com/

Liva Healthcare. (2021). *NHS Diabetes Prevention Programme*. Liva Healthcare. Retrieved March 10, 2020 from https://livahealthcare.com/nhs-diabetes-prevention-programme/

Lorencatto, F., West, R., Stavri, Z., & Michie, S. (2013). How well is intervention content described in published reports of smoking cessation interventions? *Nicotine & Tobacco Research*, *15*(7), 1273-1282. https://doi.org/10.1093/ntr/nts266

Low, J. (2019). A Pragmatic Definition of the Concept of Theoretical Saturation. *Sociological Focus*, *52*(2), 131-139. https://doi.org/10.1080/00380237.2018.1544514

Lupton, D. (2013). The digitally engaged patient: Self-monitoring and self-care in the digital health era. *Social Theory & Health*, *11*(3), 256-270. https://doi.org/10.1057/sth.2013.10

Lupton, D. (2014). Beyond techno-utopia: Critical approaches to digital health technologies. *Societies*, *4*(4), 706-711. https://doi.org/10.3390/soc4040706

Lustria, M. L. A., Noar, S. M., Cortese, J., Van Stee, S. K., Glueckauf, R. L., & Lee, J. (2013). A meta-analysis of web-delivered tailored health behavior change interventions. *Journal of Health Communication*, *18*(9), 1039-1069. https://doi.org/10.1080/10810730.2013.768727

Lythreatis, S., Singh, S. K., & El-Kassar, A.-N. (2021). The digital divide: A review and future research agenda. *Technological Forecasting and Social Change*, 1-11. https://doi.org/10.1016/j.techfore.2021.121359

Ma, J., Yank, V., Xiao, L., Lavori, P. W., Wilson, S. R., Rosas, L. G., & Stafford, R. S. (2013). Translating the diabetes prevention program lifestyle intervention for weight loss into primary care: A randomized trial. *JAMA Internal Medicine*, *173*(2), 113-121. https://doi.org/10.1001/2013.jamainternmed.987

Macaninch, E., Buckner, L., Amin, P., Broadley, I., Crocombe, D., Herath, D., Jaffee, A., Carter, H., Golubric, R., Rajput-Ray, M., Martyn, K., & Ray, S. (2020). Time for nutrition in medical education. *BMJ Nutrition, Prevention & Health*, 1-9. https://doi.org/10.1136/bmjnph-2019-000049

MacCallum, R. C., Roznowski, M., & Necowitz, L. B. (1992). Model modifications in covariance structure analysis: the problem of capitalization on chance. *Psychological Bulletin*, *111*(3), 490-504. https://doi.org/10.1037/0033-2909.111.3.490

Maccarthy, J., Guerin, S., Wilson, A. G., & Dorris, E. R. (2019). Facilitating public and patient involvement in basic and preclinical health research. *PloS One, 14*(5), 1-16. https://doi.org/10.1371/journal.pone.0216600

Mackillop, L., Hirst, J. E., Bartlett, K. J., Birks, J. S., Clifton, L., Farmer, A. J., Gibson, O., Kenworthy, Y., Levy, J. C., & Loerup, L. (2018). Comparing the efficacy of a mobile phone-based blood glucose management system with standard clinic care in women with gestational diabetes: randomized controlled trial. *JMIR mHealth and uHealth*, *6*(3), 1-11. https://doi.org/10.2196/mhealth.9512

Mackillop, L., Loerup, L., Bartlett, K., Farmer, A., Gibson, O. J., Hirst, J. E., Kenworthy, Y., Kevat, D. A., Levy, J. C., & Tarassenko, L. (2014). Development of a real-time smartphone solution for the management of women with or at high risk of gestational diabetes. *Journal of Diabetes Science and Technology*, *8*(6), 1105-1114. https://doi.org/10.1177/1932296814542271

Mader, L. B., Harris, T., Kläger, S., Wilkinson, I. B., & Hiemstra, T. F. (2018). Inverting the patient involvement paradigm: defining patient led research. *Research Involvement and Engagement*, *4*(1), 1-7. https://doi.org/10.1186/s40900-018-0104-4

Makrilakis, K., Liatis, S., Grammatikou, S., Perrea, D., & Katsilambros, N. (2010). Implementation and effectiveness of the first community lifestyle intervention programme to prevent type 2 diabetes in Greece. The DE-PLAN study. *Diabetic Medicine*, *27*(4), 459-465. https://doi.org/10.1111/j.1464-5491.2010.02918.x

Malhotra, N. K., & Dash, S. (2016). *Marketing research: An applied orientation*. Pearson.

Malone, J. I., & Hansen, B. C. (2019). Does obesity cause type 2 diabetes mellitus (T2DM)? Or is it the opposite? *Pediatric Diabetes*, *20*(1), 5-9. https://doi.org/10.1111/pedi.12787

Malterud, K., Siersma, V. D., & Guassora, A. D. (2016). Sample size in qualitative interview studies: guided by information power. *Qualitative Health Research*, *26*(13), 1753-1760. https://doi.org/10.1177/1049732315617444

Manafo, E., & Wong, S. (2012). Health literacy programs for older adults: a systematic literature review. *Health Education Research*, *27*(6), 947-960. https://doi.org/10.1093/her/cys067

Marangunić, N., & Granić, A. (2015). Technology acceptance model: a literature review from 1986 to 2013. *Universal Access in the Information Society, 14*(1), 81-95. https://doi.org/10.1007/s10209-014-0348-1

Mariani, A. W., & Pego-Fernandes, P. M. (2014). Observational studies: why are they so important? *Sao Paolo Medical Journal*, *132*(1), 1-2. https://doi.org/10.1590/1516-3180.2014.1321784

Marsden, A. M., Bower, P., Howarth, E., Soiland-Reyes, C., Sutton, M., & Cotterill, S. (2022). ‘Finishing the race’–a cohort study of weight and blood glucose change among the first 36,000 patients in a large-scale diabetes prevention programme. *International Journal of Behavioral Nutrition and Physical Activity*, *19*(1), 1-10. https://doi.org/10.1186/s12966-022-01249-5

Martin, N., Erhel, S., Jamet, É., & Rouxel, G. (2015). What links between user experience and acceptability? *Proceedings of the 27th Conference on l'Interaction Homme-Machine*, 1-6. https://doi.org/10.1145/2820619.2825015

Mason, M. (2010). Sample size and saturation in PhD studies using qualitative interviews. *Forum: Qualitative Social Research*, *11*(3), 1-19. https://research.phoenix.edu/sites/default/files/files-content/data%20saturation.pdf

Matthews, Z. (2008). *Better Health Briefing 12: The Health of Gypsies and Travellers in the UK*. Race Equality Foundation. http://www.gypsy-traveller.org/wp-content/uploads/health-brief.pdf

Mays, N., & Pope, C. (2000). Assessing quality in qualitative research. *BMJ*, *320*(7226), 50-52. https://doi.org/10.1136/bmj.320.7226.50

McCabe, C., Claxton, K., & Culyer, A. J. (2008). The NICE cost-effectiveness threshold. *Pharmacoeconomics*, *26*(9), 733-744. https://doi.org/10.2165/00019053-200826090-00004

McCorry, N. K., Scullion, L., McMurray, C. M., Houghton, R., & Dempster, M. (2013). Content validity of the illness perceptions questionnaire–revised among people with type 2 diabetes: A think-aloud study. *Psychology & Health*, *28*(6), 675-685. https://doi.org/10.1080/08870446.2012.746690

McCullough, M. L., Feskanich, D., Stampfer, M. J., Giovannucci, E. L., Rimm, E. B., Hu, F. B., Spiegelman, D., Hunter, D. J., Colditz, G. A., & Willett, W. C. (2002). Diet quality and major chronic disease risk in men and women: moving toward improved dietary guidance. *The American Journal of Clinical Nutrition*, *76*(6), 1261-1271. https://doi.org/10.1093/ajcn/76.6.1261

McGough, B., Murray, E., Brownlee, L., Barron, E., Smith, J., & Valabhji, J. (2019). The Healthier You: NHS Diabetes Prevention Programme: digital modes of delivery engage younger people. *Diabetic Medicine*, *36*(11), 1510-1511. https://doi.org/10.1111/dme.14083

McIntosh, M. J., & Morse, J. M. (2015). Situating and constructing diversity in semi-structured interviews. *Global Qualitative Nursing Research*, *2*, 1-12. https://doi.org/10.1177/2333393615597674

McIntyre, H. D., Catalano, P., Zhang, C., Desoye, G., Mathiesen, E. R., & Damm, P. (2019). Gestational diabetes mellitus. *Nature Reviews Disease Primers*, *5*(1), 1-19. https://doi.org/10.1038/s41572-019-0098-8

McLafferty, I. (2004). Focus group interviews as a data collecting strategy. *Journal of Advanced Nursing*, *48*(2), 187-194. https://doi.org/10.1111/j.1365-2648.2004.03186.x

McNamee, R. (2003). Confounding and confounders. *Occupational and Environmental Medicine*, *60*(3), 227-234. https://doi.org/10.1136/oem.60.3.227

Meade, O., O'Brien, M., Mc Sharry, J., Lawless, A., Coughlan, S., Hart, J., Hayes, C., Keyworth, C., Lavoie, K. L., & Murphy, A. W. (2022). Enhancing the implementation of the Making Every Contact Count brief behavioural intervention programme in Ireland: protocol for the Making MECC Work research programme. *HRB Open Research*, *5*, 1-16. https://doi.org/10.12688/hrbopenres.13481.1

Mekonnen, T. A., Odden, M. C., Coxson, P. G., Guzman, D., Lightwood, J., Wang, Y. C., & Bibbins-Domingo, K. (2013). Health benefits of reducing sugar-sweetened beverage intake in high risk populations of California: results from the cardiovascular disease (CVD) policy model. *PloS One*, *8*(12), 1-9. https://doi.org/10.1371/journal.pone.0081723

Mensink, M., Feskens, E., Saris, W., De Bruin, T., & Blaak, E. (2003). Study on Lifestyle Intervention and Impaired Glucose Tolerance Maastricht (SLIM): preliminary results after one year. *International Journal of Obesity*, *27*(3), 377-384. https://doi.org/10.1038/sj.ijo.0802249

Meyerowitz-Katz, G., Ravi, S., Arnolda, L., Feng, X., Maberly, G., & Astell-Burt, T. (2020). Rates of attrition and dropout in app-based interventions for chronic disease: systematic review and meta-analysis. *Journal of Medical Internet Research*, *22*(9), 1-10. https://doi.org/10.2196/20283

Micha, R., Wallace, S. K., & Mozaffarian, D. (2010). Red and Processed Meat Consumption and Risk of Incident Coronary Heart Disease, Stroke, and Diabetes Mellitus. *Circulation*, *121*(21), 2271-2283. https://doi.org/10.1161/CIRCULATIONAHA.109.924977

Michaelides, A., Raby, C., Wood, M., Farr, K., & Toro-Ramos, T. (2016). Weight loss efficacy of a novel mobile diabetes prevention program delivery platform with human coaching. *BMJ Open Diabetes Research and Care*, *4*(1), 1-5. https://doi.org/10.1136/bmjdrc-2016-000264

Michie, S., Ashford, S., Sniehotta, F. F., Dombrowski, S. U., Bishop, A., & French, D. P. (2011). A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: The CALO-RE taxonomy. *Psychology & Health*, *26*(11), 1479-1498. https://doi.org/10.1080/08870446.2010.540664

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., Eccles, M. P., Cane, J., & Wood, C. E. (2013). The Behavior Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques: Building an International Consensus for the Reporting of Behavior Change Interventions. *Annals of Behavioral Medicine*, *46*(1), 81-95. https://doi.org/10.1007/s12160-013-9486-6

Michie, S., Van Stralen, M. M., & West, R. (2011). The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implementation Science*, *6*(1), 1-12. https://doi.org/10.1186/1748-5908-6-42

Microsoft. (2021). *Microsoft Teams Group Chat Software*. Retrieved February 27, 2021 from https://www.microsoft.com/en-us/microsoft-teams/group-chat-software

Miles, J. M., & Jensen, M. D. (2005). Counterpoint: visceral adiposity is not causally related to insulin resistance. *Diabetes Care*, *28*(9), 2326-2328. https://doi.org/10.2337/diacare.28.9.2326

Miles, L. M., Hawkes, R. E., & French, D. P. (2021). How is the Behavior Change Technique Content of the NHS Diabetes Prevention Program Understood by Participants? A Qualitative Study of Fidelity, With a Focus on Receipt. *Annals of Behavioral Medicine*, 1-11. https://doi.org/10.1093/abm/kaab093

Mirowsky, J., & Ross, C. E. (2008). Education and self-rated health: Cumulative advantage and its rising importance. *Research on Aging*, *30*(1), 93-122. https://doi.org/10.1177/0164027507309649

Mishra, S. C., Chhatbar, K. C., Kashikar, A., & Mehndiratta, A. (2017). Diabetic foot. *BMJ*, *359*, 1-7. https://doi.org/10.1136/bmj.j5064

Mishuris, R. G., Stewart, M., Fix, G. M., Marcello, T., McInnes, D. K., Hogan, T. P., Boardman, J. B., & Simon, S. R. (2015). Barriers to patient portal access among veterans receiving home-based primary care: a qualitative study. *Health Expectations*, *18*(6), 2296-2305. https://doi.org/10.1111/hex.12199

Mitsutake, S., Shibata, A., Ishii, K., Okazaki, K., & Oka, K. (2011). Developing Japanese version of the eHealth literacy scale (eHEALS). *[Nihon Koshu Eisei Zasshi] Japanese Journal of Public Health*, *58*(5), 361-371. https://pubmed.ncbi.nlm.nih.gov/21905612/

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Group, a. t. P. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA StatementThe PRISMA Statement. *Annals of Internal Medicine*, *151*(4), 264-269. https://doi.org/10.7326/0003-4819-151-4-200908180-00135

Moin, T., Li, J., Duru, O. K., Ettner, S., Turk, N., Keckhafer, A., Ho, S., & Mangione, C. M. (2015). Metformin Prescription for Insured Adults With Prediabetes From 2010 to 2012. *Annals of Internal Medicine*, *162*(8), 542-548. https://doi.org/10.7326/M14-1773

Moin, T., Schmittdiel, J. A., Flory, J. H., Yeh, J., Karter, A. J., Kruge, L. E., Schillinger, D., Mangione, C. M., Herman, W. H., & Walker, E. A. (2018). Review of Metformin Use for Type 2 Diabetes Prevention. *American Journal of Preventive Medicine*, *55*(4), 565-574. https://doi.org/10.1016/j.amepre.2018.04.038

Moller, A. C., Merchant, G., Conroy, D. E., West, R., Hekler, E., Kugler, K. C., & Michie, S. (2017). Applying and advancing behavior change theories and techniques in the context of a digital health revolution: proposals for more effectively realizing untapped potential. *Journal of Behavioral Medicine, 40*(1), 85-98. https://doi.org/10.1007/s10865-016-9818-7

Moore, G., Campbell, M., Copeland, L., Craig, P., Movsisyan, A., Hoddinott, P., Littlecott, H., O'Cathain, A., Pfadenhauer, L., & Rehfuess, E. (2021). Adapting interventions to new contexts—the ADAPT guidance. *BMJ, 374*, 1-10. https://doi.org/10.1136/bmj.n1679

Moore, G. C., & Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information Systems Research, 2*(3), 192-222. https://doi.org/10.1287/isre.2.3.192

Moore, G. F., Audrey, S., Barker, M., Bond, L., Bonell, C., Hardeman, W., Moore, L., O'Cathain, A., Tinati, T., & Wight, D. (2015). Process evaluation of complex interventions: Medical Research Council guidance. *BMJ*, *350*, 1-7. https://doi.org/10.1136/bmj.h1258

Morrison, C. (2021). *Digital Solutions Supporting Healthy Weight Management and the Type 2 Diabetes Prevention Framework*. Digital Health & Care Innovation Centre. https://strathprints.strath.ac.uk/76805/7/Morrison_DHI_2021_Digital_solutions_supporting_healthy_weight_management.pdf

Mudaliar, U., Zabetian, A., Goodman, M., Echouffo-Tcheugui, J. B., Albright, A. L., Gregg, E. W., & Ali, M. K. (2016). Cardiometabolic risk factor changes observed in diabetes prevention programs in US settings: a systematic review and meta-analysis. *PLoS Medicine*, *13*(7), 1-19. https://doi.org/10.1371/journal.pmed.1002095

Murphy, E., Tierney, E., Ní Shé, É., Killilea, M., Donaghey, C., Daly, A., Roche, M., Mac Loughlin, D., P. P. I. Ignite @ NUI Galway Public Advisory Panel, & Dinneen, S. (2020). COVID-19: Public and patient involvement, now more than ever. *HRB Open Research*, *3*, 1-9. https://doi.org/10.12688/hrbopenres.13067.1

Murray, E., Daff, K., Lavida, A., Henley, W., Irwin, J., & Valabhji, J. (2019). Evaluation of the digital diabetes prevention programme pilot: uncontrolled mixed-methods study protocol. *BMJ Open*, *9*(5), 1-9. https://doi.org/10.1136/bmjopen-2018-025903

Murray, E., Hekler, E. B., Andersson, G., Collins, L. M., Doherty, A., Hollis, C., Rivera, D. E., West, R., & Wyatt, J. C. (2016). Evaluating digital health interventions: key questions and approaches. *American Journal of Preventive Medicine*, *51*(5), 843-851. https://doi.org/10.1016/j.amepre.2016.06.008

Nadal, C., Sas, C., & Doherty, G. (2020). Technology acceptance in mobile health: scoping review of definitions, models, and measurement. *Journal of Medical Internet Research*, *22*(7), 1-17. https://doi.org/10.2196/17256

Napolitano, M. A., Hayes, S., Bennett, G. G., Ives, A. K., & Foster, G. D. (2013). Using Facebook and text messaging to deliver a weight loss program to college students. *Obesity*, *21*(1), 25-31. https://doi.org/10.1002/oby.20232

Nathan, D. M., Davidson, M. B., DeFronzo, R. A., Heine, R. J., Henry, R. R., Pratley, R., & Zinman, B. (2007). Impaired Fasting Glucose and Impaired Glucose Tolerance: Implications for care. *Diabetes Care*, *30*(3), 753-759. https://doi.org/10.2337/dc07-9920

National Institute for Health and Care Excellence. (2012). *Methods for the development of NICE public health guidance (third edition)*. NICE. https://www.nice.org.uk/process/pmg4/resources/methods-for-the-development-of-nice-public-health-guidance-third-edition-pdf-2007967445701

National Institute for Health and Care Excellence. (2017). *Type 2 diabetes: prevention in people at high risk*. National Institute for Health and Care Excellence. Retrieved July 6, 2019 from https://www.nice.org.uk/guidance/PH38

National Institute for Health and Care Excellence. (2019). Preventing type 2 diabetes overview. Retrieved May 31, 2019, from https://pathways.nice.org.uk/pathways/preventing-type-2-diabetes

National Library of Medicine. (2018a). *MEDLINE*. https://www.nlm.nih.gov/medline/index.html

National Library of Medicine. (2018b). *PubMed*. https://pubmed.ncbi.nlm.nih.gov/

Neter, E., & Brainin, E. (2012). eHealth literacy: extending the digital divide to the realm of health information. *Journal of Medical Internet Research, 14*(1), 1-10. https://doi.org/10.2196/jmir.1619

NHS England. (2018). *A Health and Care Digital Capabilities Framework*. NHS England. https://www.hee.nhs.uk/sites/default/files/documents/Digital%20Literacy%20Capability%20Framework%202018.pdf

NHS England. (2019a). *Diabetes Prevention Programme: Information Governance and Data Flows Framework*. NHS England. https://www.england.nhs.uk/wp-content/uploads/2019/09/diabetes-prevention-programme-information-governance-and-data-flows-framework.pdf

NHS England. (2019b). *NHS Diabetes Prevention Programme National Service Specification*. NHS England. https://www.england.nhs.uk/wp-content/uploads/2016/08/nhs-dpp-service-specification-aug-2019.pdf

NHS England. (2021a). *The Eatwell Guide*. NHS England. Retrieved October 20, 2021 from https://www.nhs.uk/live-well/eat-well/food-guidelines-and-food-labels/the-eatwell-guide/

NHS England. (2021b). *NHS Diabetes Prevention Programme (NHS DPP)*. NHS England. Retrieved December 2, 2021 from https://www.england.nhs.uk/diabetes/diabetes-prevention/

NHS England. (2022). *NHS Health Check*. NHS England. Retrieved April 23, 2022 from https://www.nhs.uk/conditions/nhs-health-check/

Ní Chonaill, D., Deane Huggins, M., McHugh, C. M., & Keaver, L. (2022). Nutrition knowledge related to chronic disease of Irish medical and nursing students. *International Journal of Health Promotion and Education*, 1-13. https://doi.org/10.1080/14635240.2022.2041066

Nikolaou, C. K., & Lean, M. E. (2017). Mobile applications for obesity and weight management: current market characteristics. *International Journal of Obesity*, *41*(1), 200-202. https://doi.org/10.1038/ijo.2016.186

Nilsen, E. R., Stendal, K., & Gullslett, M. K. (2020). Implementation of eHealth Technology in Community Health Care: the complexity of stakeholder involvement. *BMC Health Services Research*, *20*(1), 1-13. https://doi.org/10.1186/s12913-020-05287-2

Nilsen, V., Bakke, P. S., & Gallefoss, F. (2011). Effects of lifestyle intervention in persons at risk for type 2 diabetes mellitus-results from a randomised, controlled trial. *BMC Public Health*, *11*(1), 1-9. https://doi.org/10.1186/1471-2458-11-893

Norgaard, O., Furstrand, D., Klokker, L., Karnoe, A., Batterham, R., Kayser, L., & Osborne, R. H. (2015). The e-health literacy framework: a conceptual framework for characterizing e-health users and their interaction with e-health systems. *Knowledge Management & E-Learning: An International Journal*, *7*(4), 522-540. https://doi.org/10.34105/j.kmel.2015.07.035

Norman, C. (2011). eHealth literacy 2.0: problems and opportunities with an evolving concept. *Journal of Medical Internet Research*, *13*(4), 1-4. https://doi.org/10.2196/jmir.2035

Norman, C. D., & Skinner, H. A. (2006a). eHEALS: the eHealth literacy scale. *Journal of Medical Internet Research*, *8*(4), 1-7. https://doi.org/10.2196/jmir.8.4.e27

Norman, C. D., & Skinner, H. A. (2006b). eHealth literacy: essential skills for consumer health in a networked world. *Journal of Medical Internet Research*, *8*(2), 1-10. https://doi.org/10.2196/jmir.8.2.e9

Nowrouzi-Sohrabi, P., Hassanipour, S., Sisakht, M., Daryabeygi-Khotbehsara, R., Savardashtaki, A., & Fathalipour, M. (2020). The effectiveness of pistachio on glycemic control and insulin sensitivity in patients with type 2 diabetes, prediabetes and metabolic syndrome: A systematic review and meta-analysis. *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, *14*(5), 1589-1595. https://doi.org/10.1016/j.dsx.2020.07.052

Nunnally, J. C. (1967). *Psychometric theory*. McGraw Hill.

Nymberg, V. M., Bolmsjö, B. B., Wolff, M., Calling, S., Gerward, S., & Sandberg, M. (2019). 'Having to learn this so late in our lives…'Swedish elderly patients' beliefs, experiences, attitudes and expectations of e-health in primary health care. *Scandinavian Journal of Primary Health Care*, *37*(1), 41-52. https://doi.org/10.1080/02813432.2019.1570612

O'Connor, S., Hanlon, P., O'Donnell, C. A., Garcia, S., Glanville, J., & Mair, F. S. (2016). Understanding factors affecting patient and public engagement and recruitment to digital health interventions: a systematic review of qualitative studies. *BMC Medical Informatics and Decision Making*, *16*(1), 120. https://doi.org/10.1186/s12911-016-0359-3

O'Connor, S., Mair, F. S., McGee-Lennon, M. R., Bouamrane, M.-M., & O'Donnell, K. (2015). Engaging in large-scale digital health technologies and services. What factors hinder recruitment? *Studies in Health Technology and Informatics*, *210*, 306-310. https://www.research.manchester.ac.uk/portal/files/48218500/FULL_TEXT.PDF

O'Loughlin, C., & Coenders, G. (2004). Estimation of the European customer satisfaction index: maximum likelihood versus partial least squares. Application to postal services. *Total Quality Management & Business Excellence*, *15*(9-10), 1231-1255. https://doi.org/10.1080/1478336042000255604

O'Neill, K. N., McHugh, S. M., Tracey, M. L., Fitzgerald, A. P., & Kearney, P. M. (2018). Health service utilization and related costs attributable to diabetes. *Diabetic Medicine*, *35*(12), 1727-1734. https://doi.org/10.1111/dme.13806

O'reilly, M., & Parker, N. (2013). 'Unsatisfactory Saturation': a critical exploration of the notion of saturated sample sizes in qualitative research. *Qualitative Research*, *13*(2), 190-197. https://doi.org/10.1177/1468794112446106

O′ Connell, M. B., Jensen, P. S., Andersen, S. L., Fernbrant, C., Nørholm, V., & Petersen, H. V. (2018). Stuck in tradition-A qualitative study on barriers for implementation of evidence-based nutritional care perceived by nursing staff. *Journal of Clinical Nursing*, *27*(3-4), 705-714. https://doi.org/10.1111/jocn.14020

Oba, N., McCaffrey, R., Choonhapran, P., Chutug, P., & Rueangram, S. (2011). Development of a community participation program for diabetes mellitus prevention in a primary care unit, Thailand. *Nursing & Health Sciences*, *13*(3), 352-359. https://doi.org/10.1111/j.1442-2018.2011.00627.x

Ockene, I. S., Tellez, T. L., Rosal, M. C., Reed, G. W., Mordes, J., Merriam, P. A., Olendzki, B. C., Handelman, G., Nicolosi, R., & Ma, Y. (2012). Outcomes of a Latino community-based intervention for the prevention of diabetes: the Lawrence Latino Diabetes Prevention Project. *American Journal of Public Health*, *102*(2), 336-342. https://doi.org/10.2105/AJPH.2011.300357

Ogurtsova, K., da Rocha Fernandes, J., Huang, Y., Linnenkamp, U., Guariguata, L., Cho, N. H., Cavan, D., Shaw, J., & Makaroff, L. (2017). IDF Diabetes Atlas: Global estimates for the prevalence of diabetes for 2015 and 2040. *Diabetes Research & Clinical Practice*, *128*, 40-50. https://doi.org/10.1016/j.diabres.2017.03.024

Ojo, A., Chatterjee, S., Neighbors, H. W., Piatt, G. A., Moulik, S., Neighbors, B. D., Abelson, J., Krenz, C., & Jones, D. (2015). *OH-BUDDY: mobile phone texting based intervention for diabetes and oral health management* 2015 48th Hawaii International Conference on System Sciences, Hawaii. https://doi.org/10.1109/HICSS.2015.102

Omboni, S. (2019). Connected health in hypertension management. *Frontiers in Cardiovascular Medicine*, *6*, 76. https://doi.org/10.3389/fcvm.2019.00076

Open Access Government. (2019). From diabetes prevention 1.0 to Prevention 3.0. Retrieved February 4, 2020, from https://www.openaccessgovernment.org/diabetes-prevention-3-0/52965/

Or, C. K., & Karsh, B.-T. (2009). A systematic review of patient acceptance of consumer health information technology. *Journal of the American Medical Informatics Association*, *16*(4), 550-560. https://doi.org/10.1197/jamia.M2888

Orji, R., Lomotey, R., Oyibo, K., Orji, F., Blustein, J., & Shahid, S. (2018). Tracking feels oppressive and 'punishy': Exploring the costs and benefits of self-monitoring for health and wellness. *Digital Health*, *4*, 1-10. https://doi.org/10.1177/2055207618797554

Oviva. (2021). *Diabetes Prevent: For People at Risk of Diabetes*. Oviva. Retrieved December 1, 2021 from https://oviva.com/uk/en/programmes/diabetes-prevent/

Paige, S. R., Stellefson, M., Krieger, J. L., Anderson-Lewis, C., Cheong, J., & Stopka, C. (2018). Proposing a transactional model of eHealth literacy: concept analysis. *Journal of Medical Internet Research*, *20*(10), 1-16. https://doi.org/10.2196/10175

Paige, S. R., Stellefson, M., Krieger, J. L., Miller, M. D., Cheong, J., & Anderson-Lewis, C. (2019). Transactional eHealth literacy: Developing and testing a multi-dimensional instrument. *Journal of Health Communication*, *24*(10), 737-748. https://doi.org/10.1080/10810730.2019.1666940

Painter, S. L., Lu, W., Schneider, J., James, R., & Shah, B. (2020). Drivers of weight loss in a CDC-recognized digital diabetes prevention program. *BMJ Open Diabetes Research and Care*, *8*(1), 1-9. https://doi.org/10.1136/bmjdrc-2019-001132

Pal, K., Mukadam, N., Petersen, I., & Cooper, C. (2018). Mild cognitive impairment and progression to dementia in people with diabetes, prediabetes and metabolic syndrome: a systematic review and meta-analysis. *Social Psychiatry and Psychiatric Epidemiology*, *53*(11), 1149-1160. https://doi.org/10.1007/s00127-018-1581-3

Palaganas, E. C., Sanchez, M. C., Molintas, V. P., & Caricativo, R. D. (2017). Reflexivity in qualitative research: A journey of learning. *Qualitative Report*, *22*(2), 426-438. http://nsuworks.nova.edu/tqr/vol22/iss2/5

Pan, A., Sun, Q., Bernstein, A. M., Schulze, M. B., Manson, J. E., Willett, W. C., & Hu, F. B. (2011). Red meat consumption and risk of type 2 diabetes: 3 cohorts of US adults and an updated meta-analysis. *The American Journal of Clinical Nutrition*, *94*(4), 1088-1096. https://doi.org/10.3945/ajcn.111.018978

Pan, X.-R., Li, G.-W., Hu, Y.-H., Wang, J.-X., Yang, W.-Y., An, Z.-X., Hu, Z.-X., Juan-Lin, Xiao, J.-Z., Cao, H.-B., Liu, P.-A., Jiang, X.-G., Jiang, Y.-Y., Wang, J.-P., Zheng, H., Zhang, H., Bennett, P. H., & Howard, B. V. (1997). Effects of Diet and Exercise in Preventing NIDDM in People With Impaired Glucose Tolerance: The Da Qing IGT and Diabetes Study. *Diabetes Care*, *20*(4), 537-544. https://doi.org/10.2337/diacare.20.4.537

Parahoo, K. (2006). *Nursing Research: Principles, processes and issues* (2nd ed.). Palgrave Macmillan.

Parikh, P., Simon, E. P., Fei, K., Looker, H., Goytia, C., & Horowitz, C. R. (2010). Results of a pilot diabetes prevention intervention in East Harlem, New York City: Project HEED. *American Journal of Public Health*, *100*(S1), S232-S239. https://doi.org/10.2105/AJPH.2009.170910

Park, J., Kim, S. H., & Kim, J. G. (2020). Effects of message framing and health literacy on intention to perform diabetes self-care: A randomized controlled trial. *Diabetes Research and Clinical Practice*, *161*, 1-7. https://doi.org/10.1016/j.diabres.2020.108043

Patterson, R., McNamara, E., Tainio, M., de Sá, T. H., Smith, A. D., Sharp, S. J., Edwards, P., Woodcock, J., Brage, S., & Wijndaele, K. (2018). Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. *European Journal of Epidemiology*, *33*(9), 811-829. https://doi.org/10.1007/s10654-018-0380-1

Paul, S. K., Owusu Adjah, E. S., Samanta, M., Patel, K., Bellary, S., Hanif, W., & Khunti, K. (2017). Comparison of body mass index at diagnosis of diabetes in a multi-ethnic population: a case-control study with matched non-diabetic controls. *Diabetes, Obesity and Metabolism*, *19*(7), 1014-1023. https://doi.org/10.1111/dom.12915

Paula, J. R. (2020). Lockdowns due to COVID-19 threaten PhD students' and early-career researchers' careers. *Nature Ecology & Evolution*, *4*(8), 999. https://doi.org/10.1038/s41559-020-1231-5

Paulweber, B., Valensi, P., Lindström, J., Lalic, N., Greaves, C., McKee, M., Kissimova-Skarbek, K., Liatis, S., Cosson, E., & Szendroedi, J. (2010). A European evidence-based guideline for the prevention of type 2 diabetes. *Hormone and Metabolic Research*, *42*(S 01), S3-S36. https://doi.org/10.1055/s-0029-1240928

Payne, W. R., Walsh, K. J., Harvey, J. T., Livy, M. F., McKenzie, K. J., Donaldson, A., Atkinson, M. G., Keogh, J. B., Moss, R. S., & Dunstan, D. W. (2008). Effect of a low–resource-intensive lifestyle modification program incorporating gymnasium-based and home-based resistance training on type 2 diabetes risk in Australian adults. *Diabetes Care, 31*(12), 2244-2250. https://doi.org/10.2337/dc08-0152

Pearl, R. L. (2020). Weight stigma and the "Quarantine-15". *Obesity*, *28*(7), 1-3. https://doi.org/:10.1002/oby.22850

Pearl, R. L., Puhl, R. M., Himmelstein, M. S., Pinto, A. M., & Foster, G. D. (2020). Weight Stigma and Weight-Related Health: Associations of Self-Report Measures Among Adults in Weight Management. *Annals of Behavioral Medicine*, *54*(11), 904-914. https://doi.org/10.1093/abm/kaaa026

Pelullo, C. P., Rossiello, R., Nappi, R., Napolitano, F., & Di Giuseppe, G. (2019). Diabetes prevention: knowledge and perception of risk among Italian population. *BioMed Research International*, *2019*, 1-7. https://doi.org/10.1155/2019/2753131

Penn, L., Rodrigues, A., Haste, A., Marques, M. M., Budig, K., Sainsbury, K., Bell, R., Araújo-Soares, V., White, M., Summerbell, C., Goyder, E., Brennan, A., Adamson, A. J., & Sniehotta, F. F. (2018). NHS Diabetes Prevention Programme in England: Formative evaluation of the programme in early phase implementation. *BMJ Open*, *8*(2), 1-11. https://doi.org/10.1136/bmjopen-2017-019467

Penn, L., Ryan, V., & White, M. (2013). Feasibility, acceptability and outcomes at a 12-month follow-up of a novel community-based intervention to prevent type 2 diabetes in adults at high risk: mixed methods pilot study. *BMJ Open, 3*(11), 1-12. https://doi.org/10.1136/bmjopen-2013-003585

Penn, L., White, M., Oldroyd, J., Walker, M., Alberti, K. G. M., & Mathers, J. C. (2009). Prevention of type 2 diabetes in adults with impaired glucose tolerance: the European Diabetes Prevention RCT in Newcastle upon Tyne, UK. *BMC Public Health*, *9*(1), 1-14. https://doi.org/10.1186/1471-2458-9-342

Perakslis, E., & Ginsburg, G. S. (2021). Digital Health—The Need to Assess Benefits, Risks, and Value. *Journal of the American Medical Association*, *325*(2), 127-128. https://doi.org/10.1001/jama.2020.22919

Pernicova, I., & Korbonits, M. (2014). Metformin—mode of action and clinical implications for diabetes and cancer. *Nature Reviews Endocrinology*, *10*(3), 143-156. https://doi.org/10.1038/nrendo.2013.256

Perski, O., & Short, C. E. (2021). Acceptability of digital health interventions: embracing the complexity. *Translational Behavioral Medicine, 11*(7), 1473-1480. https://doi.org/10.1093/tbm/ibab048

Persson, F., & Rossing, P. (2018). Diagnosis of diabetic kidney disease: state of the art and future perspective. *Kidney International Supplements*, *8*(1), 2-7. https://doi.org/10.1016/j.kisu.2017.10.003

Peters, D. H., Adam, T., Alonge, O., Agyepong, I. A., & Tran, N. (2013). Implementation research: what it is and how to do it. *BMJ, 347*, 1-7. https://doi.org/10.1136/bmj.f6753

Peters, S. A., Huxley, R. R., & Woodward, M. (2014). Diabetes as risk factor for incident coronary heart disease in women compared with men: a systematic review and meta-analysis of 64 cohorts including 858,507 individuals and 28,203 coronary events. *Diabetologia*, *57*(8), 1542-1551. https://doi.org/10.1007/s00125-014-3260-6

Petracca, F., Ciani, O., Cucciniello, M., & Tarricone, R. (2020). Harnessing digital health technologies during and after the COVID-19 pandemic: context matters. *Journal of Medical Internet Research*, *22*(12), 1-7. https://doi.org/10.2196/21815

Piatt, G. A., Seidel, M. C., Powell, R. O., & Zgibor, J. C. (2013). Comparative effectiveness of lifestyle intervention efforts in the community: results of the Rethinking Eating and ACTivity (REACT) study. *Diabetes Care*, *36*(2), 202-209. https://doi.org/10.2337/dc12-0824

Pierse, T., Barry, L., Glynn, L., Murphy, A. W., Cruise, S., & O'Neill, C. (2020). A comparison, for older people with diabetes, of health and health care utilisation in two different health systems on the island of Ireland. *BMC Public Health*, *20*(1), 1-8. https://doi.org/10.1186/s12889-020-09529-0

Pierse, T., O'Neill, S., Dinneen, S. F., & O'Neill, C. (2021). A simulation study of the economic and health impact of a diabetes prevention programme in Ireland. *Diabetic Medicine*, 1-8. https://doi.org/10.1111/dme.14540

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, *40*(3), 879-891. https://doi.org/10.3758/BRM.40.3.879

Prior, M. T. (2018). Accomplishing "rapport" in qualitative research interviews: Empathic moments in interaction. *Applied Linguistics Review*, *9*(4), 487-511. https://doi.org/10.1515/applirev-2017-0029

Pronk, N. P. (2016). Structured diet and physical activity programmes provide strong evidence of effectiveness for type 2 diabetes prevention and improvement of cardiometabolic health. *BMJ Evidence-Based Medicine*, *21*(1), 18-18. https://doi.org/10.1136/ebmed-2015-110292

Puhl, R. M., Lessard, L. M., Himmelstein, M. S., & Foster, G. D. (2021). The roles of experienced and internalized weight stigma in healthcare experiences: Perspectives of adults engaged in weight management across six countries. *PloS One*, *16*(6), 1-20. https://doi.org/10.1371/journal.pone.0251566

Qadir, R., Sculthorpe, N. F., Todd, T., & Brown, E. C. (2021). Effectiveness of Resistance Training and Associated Program Characteristics in Patients at Risk for Type 2 Diabetes: a Systematic Review and Meta-analysis. *Sports Medicine - Open*, *7*(1), 1-15. https://doi.org/10.1186/s40798-021-00321-x

Qian, F., Liu, G., Hu, F. B., Bhupathiraju, S. N., & Sun, Q. (2019). Association Between Plant-Based Dietary Patterns and Risk of Type 2 Diabetes: A Systematic Review and Meta-analysis. *JAMA Internal Medicine*, *179*(10), 1335-1344. https://doi.org/10.1001/jamainternmed.2019.2195

QSR International Pty Ltd. (2021). *NVivo (released in March 2020).* In QSR International Pty Ltd. https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home

Rahimi, B., Nadri, H., Afshar, H. L., & Timpka, T. (2018). A systematic review of the technology acceptance model in health informatics. *Applied Clinical Informatics*, *9*(3), 604-634. https://doi.org/10.1055/s-0038-1668091

Ramachandran, A., Snehalatha, C., Mary, S., Mukesh, B., Bhaskar, A., & Vijay, V. (2006). The Indian Diabetes Prevention Programme shows that lifestyle modification and metformin prevent type 2 diabetes in Asian Indian subjects with impaired glucose tolerance (IDPP-1). *Diabetologia*, *49*(2), 289-297. https://doi.org/10.1007/s00125-005-0097-z

Ramachandran, A., Snehalatha, C., Ram, J., Selvam, S., Simon, M., Nanditha, A., Shetty, A. S., Godsland, I. F., Chaturvedi, N., Majeed, A., Oliver, N., Toumazou, C., Alberti, K. G., & Johnston, D. G. (2013). Effectiveness of mobile phone messaging in prevention of type 2 diabetes by lifestyle modification in men in India: A prospective, parallel-group, randomised controlled trial. *The Lancet Diabetes and Endocrinology*, *1*(3), 191-198. https://doi.org/10.1016/s2213-8587(13)70067-6

Ranger, T. A., Wong, A. M. Y., Cook, J. L., & Gaida, J. E. (2016). Is there an association between tendinopathy and diabetes mellitus? A systematic review with meta-analysis. *British Journal of Sports Medicine, 50*(16), 982-989. https://doi.org/10.1136/bjsports-2015-094735

Reddy, P., Rankins, D., Timoshanko, A., & Dunbar, J. A. (2011). Life! in Australia: translating prevention research into a large-scale intervention. *The British Journal of Diabetes & Vascular Disease*, *11*(4), 193-197. https://doi.org/10.1177/1474651411410724

Rees, K. (2020). Liva Healthcare signs contracts to improve diabetes prevention. Retrieved March 31, 2020, from https://www.laingbuissonnews.com/healthcare-markets-content/news-healthcare-markets-content/liva-healthcare-signs-contracts-to-improve-diabetes-prevention/

Richardson, C. R., Newton, T. L., Abraham, J. J., Sen, A., Jimbo, M., & Swartz, A. M. (2008). A meta-analysis of pedometer-based walking interventions and weight loss. *The Annals of Family Medicine, 6*(1), 69-77. https://doi.org/10.1370/afm.761

Rienks, J., Barbaresko, J., Oluwagbemigun, K., Schmid, M., & Nöthlings, U. (2018). Polyphenol exposure and risk of type 2 diabetes: dose-response meta-analyses and systematic review of prospective cohort studies. *American Journal of Clinical Nutrition*, *108*(1), 49-61. https://doi.org/10.1093/ajcn/nqy083

Ritchie, N. D., Baucom, K. J. W., & Sauder, K. A. (2019). Benefits of Participating With a Partner in the National Diabetes Prevention Program. *Diabetes Care*, *43*(2), 20-21. https://doi.org/10.2337/dc19-1489

Ritchie, N. D., Phimphasone-Brady, P., Sauder, K. A., & Amura, C. R. (2021). Perceived Barriers and Potential Solutions to Engagement in the National Diabetes Prevention Program. *ADCES in Practice*, *9*(1), 16-20. https://doi.org/10.1177/2633559X20966275

Rivera, J., McPherson, A., Hamilton, J., Birken, C., Coons, M., Iyer, S., Agarwal, A., Lalloo, C., & Stinson, J. (2016). Mobile apps for weight management: a scoping review. *JMIR mHealth and uHealth*, *4*(3), 1-9. https://doi.org/10.2196/mhealth.5115

Robbins, T., Hudson, S., Ray, P., Sankar, S., Patel, K., Randeva, H., & Arvanitis, T. N. (2020). COVID-19: A new digital dawn? *Digital Health*, *6*, 1-3. https://doi.org/10.1177/2055207620920083

Roberts, S., Pilard, L., Chen, J., Hirst, J., Rutter, H., & Greenhalgh, T. (2019). Efficacy of population-wide diabetes and obesity prevention programs: an overview of systematic reviews on proximal, intermediate, and distal outcomes and a meta-analysis of impact on BMI. *Obesity Reviews*, *20*(7), 947-963. https://doi.org/10.1111/obr.12821

Rodrigues, A. M., Haste, A., Penn, L., Bell, R., Summerbell, C., White, M., Adamson, A. J., & Sniehotta, F. F. (2020). Stakeholders' perceptions and experiences of the National Health Service diabetes prevention programme in England: qualitative study with service users, intervention providers and deliverers, commissioners and referrers. *BMC Health Services Research*, *20*(1), 1-13. https://doi.org/10.1186/s12913-020-05160-2

Rosales, A., Fernández-Ardèvol, M., Comunello, F., Mulargia, S., & Ferran-Ferrer, N. (2017). Older people and smartwatches, initial experiences. *El Profesional de la Información*, *26*(3), 457-463. https://doi.org/10.3145/EPI

Rosenstock, I. M. (1974). Historical origins of the health belief model. *Health Education Monographs*, *2*(4), 328-335. https://doi.org/10.1177/109019817400200403

Ross, J. A. D., Barron, E., McGough, B., Valabhji, J., Daff, K., Irwin, J., Henley, W. E., & Murray, E. (2022). Uptake and impact of the English National Health Service digital diabetes prevention programme: observational study. *BMJ Open Diabetes Research and Care*, *10*(3), 1-10. https://doi.org/10.1136/bmjdrc-2021-002736

Rotheram-Borus, M. J., Tomlinson, M., Gwegwe, M., Comulada, W. S., Kaufman, N., & Keim, M. (2012). Diabetes Buddies: Peer Support Through a Mobile Phone Buddy System. *The Diabetes Educator*, *38*(3), 357-365. https://doi.org/10.1177/0145721712444617

Rothman, A. J., Bartels, R. D., Wlaschin, J., & Salovey, P. (2006). The strategic use of gain- and loss-framed messages to promote healthy behavior: How theory can inform practice. *Journal of Communication*, *56*(suppl_1), S202-S220. https://doi.org/10.1177/0146167299259003

Roux, L., Pratt, M., Tengs, T. O., Yore, M. M., Yanagawa, T. L., Van Den Bos, J., Rutt, C., Brownson, R. C., Powell, K. E., & Heath, G. (2008). Cost effectiveness of community-based physical activity interventions. *American Journal of Preventive Medicine*, *35*(6), 578-588. https://doi.org/10.1016/j.amepre.2008.06.040

Rowan, C. P., Riddell, M. C., Gledhill, N., & Jamnik, V. K. (2016). Community-based culturally preferred physical activity intervention targeting populations at high risk for type 2 diabetes: results and implications. *Canadian Journal of Diabetes*, *40*(6), 561-569. https://doi.org/10.1016/j.jcjd.2016.05.011

Ryan, K., Dockray, S., & Linehan, C. (2019). A systematic review of tailored eHealth interventions for weight loss. *Digital Health*, *5*, 1-23. https://doi.org/10.1177/2055207619826685

Saaristo, T., Moilanen, L., Korpi-Hyövälti, E., Vanhala, M., Saltevo, J., Niskanen, L., Jokelainen, J., Peltonen, M., Oksa, H., & Tuomilehto, J. (2010). Lifestyle intervention for prevention of type 2 diabetes in primary health care: one-year follow-up of the Finnish National Diabetes Prevention Program (FIN-D2D). *Diabetes Care*, *33*(10), 2146-2151. https://doi.org/10.2337/dc10-0410

Sacks, F. M., Svetkey, L. P., Vollmer, W. M., Appel, L. J., Bray, G. A., Harsha, D., Obarzanek, E., Conlin, P. R., Miller, E. R., & Simons-Morton, D. G. (2001). Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. *New England Journal of Medicine*, *344*(1), 3-10. https://doi.org/10.1056/NEJM200101043440101

Saeedi, P., Petersohn, I., Salpea, P., Malanda, B., Karuranga, S., Unwin, N., Colagiuri, S., Guariguata, L., Motala, A. A., & Ogurtsova, K. (2019). Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas. *Diabetes Research and Clinical Practice*, *157*, 1-10. https://doi.org/10.1016/j.diabres.2019.107843

Safefood. (2016). *Cooking and food skills - the current picture*. Safefood. https://www.safefood.net/getattachment/66d42e61-7b87-491a-9ceb-d6dad1b81fe4/Cooking-skills.pdf

Safefood. (2021). *What is the cost of a healthy food basket in Ireland in 2020?* Safefood. https://www.safefood.net/getattachment/3bce7bc6-86db-4480-8c2a-719fb223dc5b/safefood-Cost-of-a-healthy-food-basket-2020-Report-ROI.pdf

Safefood. (2022). *Community Food Initiatives*. Safefood. Retrieved April 20, 2022 from https://www.safefood.net/community-food-initiatives

Sakane, N., Sato, J., Tsushita, K., Tsujii, S., Kotani, K., Tsuzaki, K., Tominaga, M., Kawazu, S., Sato, Y., & Usui, T. (2011). Prevention of type 2 diabetes in a primary healthcare setting: three-year results of lifestyle intervention in Japanese subjects with impaired glucose tolerance. *BMC Public Health*, *11*(1), 1-8. https://doi.org/10.1186/1471-2458-11-40

Salpeter, S. R., Greyber, E., Pasternak, G. A., & Salpeter, E. E. (2010). Risk of fatal and nonfatal lactic acidosis with metformin use in type 2 diabetes mellitus. *Cochrane Database of Systematic Reviews,* (4), 1-233. https://doi.org/10.1002/14651858.CD002967.pub4

Samdal, G. B., Eide, G. E., Barth, T., Williams, G., & Meland, E. (2017). Effective behaviour change techniques for physical activity and healthy eating in overweight and obese adults; systematic review and meta-regression analyses. *International Journal of Behavioral Nutrition and Physical Activity*, *14*(1), 1-14. https://doi.org/10.1186/s12966-017-0494-y

Sanchez-Rangel, E., & Inzucchi, S. E. (2017). Metformin: clinical use in type 2 diabetes. *Diabetologia*, *60*(9), 1586-1593. https://doi.org/10.1007/s00125-017-4336-x

Sandström, B., Willman, A., Svensson, B., & Borglin, G. (2015). Perceptions of national guidelines and their (non) implementation in mental healthcare: a deductive and inductive content analysis. *Implementation Science*, *10*(1), 1-13. https://doi.org/10.1186/s13012-015-0234-0

Sargeant, J. A., Brady, E. M., Zaccardi, F., Tippins, F., Webb, D. R., Aroda, V. R., Gregg, E. W., Khunti, K., & Davies, M. J. (2020). Adults with early-onset type 2 diabetes (aged 18–39 years) are severely underrepresented in diabetes clinical research trials. *Diabetologia*, *63*, 1516-1520. https://doi.org/10.1007/s00125-020-05174-9

Sattar, N., Rawshani, A., Franzén, S., Rawshani, A., Svensson, A.-M., Rosengren, A., McGuire, D. K., Eliasson, B., & Gudbjörnsdottir, S. (2019). Age at diagnosis of type 2 diabetes mellitus and associations with cardiovascular and mortality risks: findings from the Swedish National Diabetes Registry. *Circulation*, *139*(19), 2228-2237. https://doi.org/10.1161/CIRCULATIONAHA.118.037885

Saunders, B., Sim, J., Kingstone, T., Baker, S., Waterfield, J., Bartlam, B., Burroughs, H., & Jinks, C. (2018). Saturation in qualitative research: exploring its conceptualization and operationalization. *Quality & Quantity*, *52*(4), 1893-1907. https://doi.org/10.1007/s11135-017-0574-8

Scadding, J., & Sweeney, S. (2018). *Digital Exclusion in Gypsy and Traveller communities in the United Kingdom* Friends Families and Travellers. https://www.gypsy-traveller.org/wp-content/uploads/2018/09/Digital-Inclusion-in-Gypsy-and-Traveller-communities-FINAL-1.pdf

Schinckus, L., Van den Broucke, S., van der Zanden, G., Levin-Zamir, D., Mueller, G., Riemenschneider, H., Hayter, V., Yardley, L., Schillinger, D., Doyle, G., Ganahl, K., Pelikan, J., & Chang, P. (2021). To Adapt or Not to Adapt: The Association between Implementation Fidelity and the Effectiveness of Diabetes Self-Management Education. *International Journal of Environmental Research and Public Health*, *18*(8), 1-15. https://doi.org/10.3390/ijerph18084095

Schmucker, C. M., Blümle, A., Schell, L. K., Schwarzer, G., Oeller, P., Cabrera, L., von Elm, E., Briel, M., Meerpohl, J. J., & consortium, O. (2017). Systematic review finds that study data not published in full text articles have unclear impact on meta-analyses results in medical research. *PloS One*, *12*(4), 1-16. https://doi.org/10.1371/journal.pone.0176210

Schwarz, P. E., Greaves, C. J., Lindström, J., Yates, T., & Davies, M. J. (2012). Nonpharmacological interventions for the prevention of type 2 diabetes mellitus. *Nature Reviews Endocrinology*, *8*(6), 363-373. https://doi.org/10.1038/nrendo.2011.232

Schwingshackl, L., & Hoffmann, G. (2015). Diet Quality as Assessed by the Healthy Eating Index, the Alternate Healthy Eating Index, the Dietary Approaches to Stop Hypertension Score, and Health Outcomes: A Systematic Review and Meta-Analysis of Cohort Studies. *Journal of the Academy of Nutrition and Dietetics, 115*(5), 780-800. https://doi.org/10.1016/j.jand.2014.12.009

Schwingshackl, L., Hoffmann, G., Lampousi, A.-M., Knüppel, S., Iqbal, K., Schwedhelm, C., Bechthold, A., Schlesinger, S., & Boeing, H. (2017). Food groups and risk of type 2 diabetes mellitus: a systematic review and meta-analysis of prospective studies. *European Journal of Epidemiology*, *32*(5), 363-375. https://doi.org/10.1007/s10654-017-0246-y

Schwingshackl, L., Lampousi, A. M., Portillo, M. P., Romaguera, D., Hoffmann, G., & Boeing, H. (2017). Olive oil in the prevention and management of type 2 diabetes mellitus: a systematic review and meta-analysis of cohort studies and intervention trials. *Nutrition & Diabetes*, *7*(4), 1-6. https://doi.org/10.1038/nutd.2017.12

Schwingshackl, L., Schwedhelm, C., Hoffmann, G., & Boeing, H. (2019). Potatoes and risk of chronic disease: a systematic review and dose–response meta-analysis. *European Journal of Nutrition*, *58*(6), 2243-2251. https://doi.org/10.1007/s00394-018-1774-2

Seçkin, G., Yeatts, D., Hughes, S., Hudson, C., & Bell, V. (2016). Being an Informed Consumer of Health Information and Assessment of Electronic Health Literacy in a National Sample of Internet Users: Validity and Reliability of the e-HLS Instrument. *Journal of Medical Internet Research*, *18*(7), 1-19. https://doi.org/10.2196/jmir.5496

Second Nature. (2021). *Lose weight without losing out*. Second Nature,. Retrieved December 1, 2021 from https://www.secondnature.io/

Selph, S., Dana, T., Blazina, I., Bougatsos, C., Patel, H., & Chou, R. (2015). Screening for type 2 diabetes mellitus: a systematic review for the US Preventive Services Task Force. *Annals of Internal Medicine*, *162*(11), 765-776. https://doi.org/10.7326/M14-2221

Sepah, S. C., Jiang, L., Ellis, R. J., McDermott, K., & Peters, A. L. (2017). Engagement and outcomes in a digital Diabetes Prevention Program: 3-year update. *BMJ Open Diabetes Research and Care*, *5*(1), 1-9. https://doi.org/10.1136/bmjdrc-2017-000422

Sepah, S. C., Jiang, L., & Peters, A. L. (2014). Translating the diabetes prevention program into an online social network: Validation against CDC standards. *The Diabetes Educator*, *40*(4), 435-443. https://doi.org/10.1177/0145721714531339

Seuring, T., Archangelidi, O., & Suhrcke, M. (2015). The economic costs of type 2 diabetes: a global systematic review. *Pharmacoeconomics*, *33*(8), 811-831. https://doi.org/10.1007/s40273-015-0268-9

Shah, A. D., Langenberg, C., Rapsomaniki, E., Denaxas, S., Pujades-Rodriguez, M., Gale, C. P., Deanfield, J., Smeeth, L., Timmis, A., & Hemingway, H. (2015). Type 2 diabetes and incidence of a wide range of cardiovascular diseases: a cohort study in 1· 9 million people. *The Lancet*, *385*, S86. https://doi.org/10.1016/S0140-6736(15)60401-9

Sharmin, S., Faith, B., Prieto Martín, P., & Ramalingam, B. (2017). *The contribution of digital technologies to service delivery: an evidence review*. Institute of Development Studies. https://opendocs.ids.ac.uk/opendocs/bitstream/handle/20.500.12413/12862/ER221_TheContributionofDigitalTechnologiestoServiceDelivery.pdf

Shawley-Brzoska, S., & Misra, R. (2018). Perceived Benefits and Barriers of a Community-Based Diabetes Prevention and Management Program. *Journal of Clinical Medicine*, *7*(3), 1-10. https://doi.org/10.3390/jcm7030058

Sherwood, N. E., Crain, A. L., Seburg, E. M., Butryn, M. L., Forman, E. M., Crane, M. M., Levy, R. L., Kunin-Batson, A. S., & Jeffery, R. W. (2022). BestFIT sequential multiple assignment randomized trial results: a SMART approach to developing individualized weight loss treatment sequences. *Annals of Behavioral Medicine*, *56*(3), 291-304. https://doi.org/10.1093/abm/kaab061

Shields, G. E., & Elvidge, J. (2020). Challenges in synthesising cost-effectiveness estimates. *Systematic Reviews*, *9*(1), 1-7. https://doi.org/10.1186/s13643-020-01536-x

Shirinzadeh, M., Afshin-Pour, B., Angeles, R., Gaber, J., & Agarwal, G. (2019). The effect of community-based programs on diabetes prevention in low- and middle-income countries: a systematic review and meta-analysis. *Globalization and Health*, *15*(1), 1-13. https://doi.org/10.1186/s12992-019-0451-4

Short, C. E., DeSmet, A., Woods, C., Williams, S. L., Maher, C., Middelweerd, A., Müller, A. M., Wark, P. A., Vandelanotte, C., Poppe, L., Hingle, M. D., & Crutzen, R. (2018). Measuring Engagement in eHealth and mHealth Behavior Change Interventions: Viewpoint of Methodologies. *Journal of Medical Internet Research*, *20*(11), 1-18. https://doi.org/10.2196/jmir.9397

Silverman, D. (1993). *Interpreting qualitative data: Methods for analyzing talk, text and interaction.* SAGE.

Simmons, D., Rush, E., Crook, N., & Team, T. W. o. R. D. P. S. (2008). Development and piloting of a community health worker-based intervention for the prevention of diabetes among New Zealand Maori in Te Wai o Rona: Diabetes Prevention Strategy. *Public Health Nutrition*, *11*(12), 1318-1325. https://doi.org/10.1017/S1368980008002711

Skivington, K., Matthews, L., Simpson, S. A., Craig, P., Baird, J., Blazeby, J. M., Boyd, K. A., Craig, N., French, D. P., & McIntosh, E. (2021). A new framework for developing and evaluating complex interventions: update of Medical Research Council guidance. *BMJ, 374,* 1-11. https://doi.org/10.1136/bmj.n2061

Slevin, P., Kessie, T., Cullen, J., Butler, M. W., Donnelly, S. C., & Caulfield, B. (2019). A qualitative study of chronic obstructive pulmonary disease patient perceptions of the barriers and facilitators to adopting digital health technology. *Digital Health, 5*, 1-10. https://doi.org/10.1177/2055207619871729

Smith-Marsh, D. (2013). Pharmacological strategies for preventing type 2 diabetes in patients with impaired glucose tolerance. *Drugs of Today*, *49*(8), 499-507. https://doi.org/10.1358/dot.2013.49.8.2002839

Smith, A. P., & Rogers, R. (2014). Positive Effects of a Healthy Snack (Fruit) Versus an Unhealthy Snack (Chocolate/Crisps) on Subjective Reports of Mental and Physical Health: A Preliminary Intervention Study. *Frontiers in Nutrition, 1*, 1-5. https://doi.org/10.3389/fnut.2014.00010

Smith, B., & Magnani, J. W. (2019). New technologies, new disparities: the intersection of electronic health and digital health literacy. *International Journal of Cardiology*, *292*, 280-282. https://doi.org/10.1016/j.ijcard.2019.05.066

Sofi, F. (2009). The Mediterranean diet revisited: evidence of its effectiveness grows. *Current Opinion in Cardiology*, *24*(5), 442-446. https://doi.org/10.1097/HCO.0b013e32832f056e

Song, S. H., & Gray, T. A. (2011). Early-onset type 2 diabetes: high risk for premature diabetic retinopathy. *Diabetes Research and Clinical Practice*, *94*(2), 207-211. https://doi.org/10.1016/j.diabres.2011.07.030

Stegenga, J. (2011). Is meta-analysis the platinum standard of evidence? *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences*, *42*(4), 497-507. https://doi.org/10.1016/j.shpsc.2011.07.003

Stellefson, M., Paige, S., Apperson, A., & Spratt, S. (2019). Social media content analysis of public diabetes Facebook groups. *Journal of Diabetes Science and Technology*, *13*(3), 428-438. https://doi.org/10.1177/1932296819839099

Stokes, J., Gellatly, J., Bower, P., Meacock, R., Cotterill, S., Sutton, M., & Wilson, P. (2019). Implementing a national diabetes prevention programme in England: lessons learned. *BMC Health Services Research*, *19*(1), 1-12. https://doi.org/10.1186/s12913-019-4809-3

Stone, A. A., Shiffman, S., Schwartz, J. E., Broderick, J. E., & Hufford, M. R. (2003). Patient compliance with paper and electronic diaries. *Controlled Clinical Trials*, *24*(2), 182-199. https://doi.org/10.1016/S0197-2456(02)00320-3

Strachan, S. M., Bean, C., & Jung, M. E. (2018). 'I'm on the train and I can't stop it': Western Canadians' reactions to prediabetes and the role of self-compassion. *Health & Social Care in the Community*, *26*(6), 979-987. https://doi.org/10.1111/hsc.12628

Strauss, A., & Corbin, J. (1998). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory.* SAGE Publications.

Sun, Y., Wang, N., Guo, X., & Peng, Z. (2013). Understanding the acceptance of mobile health services: a comparison and integration of alternative models. *Journal of Electronic Commerce Research*, *14*(2), 183-200. https://ir.nsfc.gov.cn/paperDownload/1000006533286.pdf

Sung, J.-H., Min, K. P., & Park, C.-Y. (2019). Peripartum management of gestational diabetes using a digital health care service: a pilot, randomized controlled study. *Clinical Therapeutics*, *41*(11), 2426-2434. https://doi.org/10.1016/j.clinthera.2019.09.005

Sylvetsky, A. C., Nandagopal, R., Nguyen, T. T., Abegg, M. R., Nagarur, M., Kaplowitz, P., & Rother, K. I. (2015). Buddy Study: Partners for better health in adolescents with type 2 diabetes. *World Journal of Diabetes*, *6*(18), 1355. https://doi.org/10.4239/wjd.v6.i18.1355

Tabák, A. G., Herder, C., Rathmann, W., Brunner, E. J., & Kivimäki, M. (2012). Prediabetes: a high-risk state for diabetes development. *The Lancet*, *379*(9833), 2279-2290. https://doi.org/10.1016/S0140-6736(12)60283-9

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education*, *48*(6), 1273-1296. https://doi.org/10.1007/s11165-016-9602-2

Taherdoost, H. (2018). A review of technology acceptance and adoption models and theories. *Procedia Manufacturing*, *22*, 960-967. https://doi.org/10.1016/j.promfg.2018.03.137

Tajima, R., Kodama, S., Hirata, M., Horikawa, C., Fujihara, K., Yachi, Y., Yoshizawa, S., Iida, K. T., & Sone, H. (2014). High cholesterol intake is associated with elevated risk of type 2 diabetes mellitus – A meta-analysis. *Clinical Nutrition*, *33*(6), 946-950. https://doi.org/10.1016/j.clnu.2014.03.001

Tao, D., Shao, F., Wang, H., Yan, M., & Qu, X. (2020). Integrating usability and social cognitive theories with the technology acceptance model to understand young users' acceptance of a health information portal. *Health Informatics Journal*, *26*(2), 1347-1362. https://doi.org/10.1177/1460458219879337

Tao, D., Wang, T., Wang, T., Zhang, T., Zhang, X., & Qu, X. (2020). A systematic review and meta-analysis of user acceptance of consumer-oriented health information technologies. *Computers in Human Behavior*, *104*, 1-15. https://doi.org/10.1016/j.chb.2019.09.023

Tarp, J., Støle, A. P., Blond, K., & Grøntved, A. (2019). Cardiorespiratory fitness, muscular strength and risk of type 2 diabetes: a systematic review and meta-analysis. *Diabetologia*, *62*(7), 1129-1142. https://doi.org/10.1007/s00125-019-4867-4

Tate, D. F., Jackvony, E. H., & Wing, R. R. (2003). Effects of Internet behavioral counseling on weight loss in adults at risk for type 2 diabetes: a randomized trial. *Journal of the American Medical Association*, *289*(14), 1833-1836. https://doi.org/10.1001/jama.289.14.1833

Taylor, K., & Silver, L. (2019). *Smartphone Ownership Is Growing Rapidly Around the World, but Not Always Equally*. Pew Research Center. https://www.pewresearch.org/global/wp-content/uploads/sites/2/2019/02/Pew-Research-Center_Global-Technology-Use-2018_2019-02-05.pdf

Thalheimer, W., & Cook, S. (2002). *How to calculate effect sizes from published research: A simplified methodology* (Vol. 1). Work-Learning Research. https://www.academia.edu/download/55240204/Effect_Sizes_pdf5.pdf

Thankappan, K. R., Sathish, T., Tapp, R. J., Shaw, J. E., Lotfaliany, M., Wolfe, R., Absetz, P., Mathews, E., Aziz, Z., & Williams, E. D. (2018). A peer-support lifestyle intervention for preventing type 2 diabetes in India: A cluster-randomized controlled trial of the Kerala Diabetes Prevention Program. *PLoS Medicine, 15*(6), 1-23. https://doi.org/10.1371/journal.pmed.1002575

The InterAct Consortium. (2015). Dietary fibre and incidence of type 2 diabetes in eight European countries: the EPIC-InterAct Study and a meta-analysis of prospective studies. *Diabetologia*, *58*(7), 1394-1408. https://doi.org/10.1007/s00125-015-3585-9

Thompson, R. L., Higgins, C. A., & Howell, J. M. (1991). Personal computing: Toward a conceptual model of utilization. *MIS Quarterly*, 125-143. https://doi.org/10.2307/249443

Tieu, L., Sarkar, U., Schillinger, D., Ralston, J. D., Ratanawongsa, N., Pasick, R., & Lyles, C. R. (2015). Barriers and facilitators to online portal use among patients and caregivers in a safety net health care system: a qualitative study. *Journal of Medical Internet Research*, *17*(12), 1-11. https://doi.org/10.2196/jmir.4847

Tomlinson, J., Medlinskiene, K., Cheong, V. L., Khan, S., & Fylan, B. (2019). Patient and public involvement in designing and conducting doctoral research: the whys and the hows. *Research Involvement and Engagement*, *5*(1), 1-12. https://doi.org/10.1186/s40900-019-0155-1

Tong, A., Sainsbury, P., & Craig, J. (2007). Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*, *19*(6), 349-357. https://doi.org/10.1093/intqhc/mzm042

Toro-Ramos, T., Lee, D.-H., Kim, Y., Michaelides, A., Oh, T. J., Kim, K. M., Jang, H. C., & Lim, S. (2017). Effectiveness of a smartphone application for the management of metabolic syndrome components focusing on weight loss: a preliminary study. *Metabolic Syndrome and Related Disorders*, *15*(9), 465-473. https://doi.org/10.1089/met.2017.0062

Tovar, E. G., Rayens, M. K., Clark, M., & Nguyen, H. (2010). Development and psychometric testing of the Health Beliefs Related to Cardiovascular Disease Scale: preliminary findings. *Journal of Advanced Nursing*, *66*(12), 2772-2784. https://doi.org/10.1111/j.1365-2648.2010.05443.x

Tracey, M. L., Gilmartin, M., O'Neill, K., Fitzgerald, A. P., McHugh, S. M., Buckley, C. M., Canavan, R. J., & Kearney, P. M. (2015). Epidemiology of diabetes and complications among adults in the Republic of Ireland 1998-2015: a systematic review and meta-analysis. *BMC Public Health*, *16*(1), 1-13. https://doi.org/10.1186/s12889-016-2818-2

Traina, S. B., Mathias, S. D., Colwell, H. H., Crosby, R. D., & Abraham, C. (2016). The diabetes intention, attitude, and behavior questionnaire: evaluation of a brief questionnaire to measure physical activity, dietary control, maintenance of a healthy weight, and psychological antecedents. *Patient Preference and Adherence, 10*, 213–222. https://doi.org/10.2147/PPA.S94878

Tsai, Y. (2017). Education and disability trends of older Americans, 2000–2014. *Journal of Public Health*, *39*(3), 447-454. https://doi.org/10.1093/pubmed/fdw082

Tsilas, C. S., de Souza, R. J., Mejia, S. B., Mirrahimi, A., Cozma, A. I., Jayalath, V. H., Ha, V., Tawfik, R., Di Buono, M., Jenkins, A. L., Leiter, L. A., Wolever, T. M. S., Beyene, J., Khan, T., Kendall, C. W. C., Jenkins, D. J. A., & Sievenpiper, J. L. (2017). Relation of total sugars, fructose and sucrose with incident type 2 diabetes: a systematic review and meta-analysis of prospective cohort studies. *Canadian Medical Association Journal*, *189*(20), 711-720. https://doi.org/10.1503/cmaj.160706

Tuomilehto, J., Lindström, J., Eriksson, J. G., Valle, T. T., Hämäläinen, H., Ilanne-Parikka, P., Keinänen-Kiukaanniemi, S., Laakso, M., Louheranta, A., Rastas, M., Salminen, V., Aunola, S., Cepaitis, Z., Moltchanov, V., Hakumäki, M., Mannelin, M., Martikkala, V., Sundvall, J., & Uusitupa, M. (2001). Prevention of Type 2 Diabetes Mellitus by Changes in Lifestyle among Subjects with Impaired Glucose Tolerance. *New England Journal of Medicine*, *344*(18), 1343-1350. https://doi.org/10.1056/nejm200105033441801

Turner-McGrievy, G. M., Beets, M. W., Moore, J. B., Kaczynski, A. T., Barr-Anderson, D. J., & Tate, D. F. (2013). Comparison of traditional versus mobile app self-monitoring of physical activity and dietary intake among overweight adults participating in an mHealth weight loss program. *Journal of the American Medical Informatics Association*, *20*(3), 513-518. https://doi.org/10.1136/amiajnl-2012-001510

Turner-McGrievy, G. M., & Tate, D. F. (2013). Weight loss social support in 140 characters or less: use of an online social network in a remotely delivered weight loss intervention. *Translational Behavioral Medicine, 3*(3), 287-294. https://doi.org/10.1007/s13142-012-0183-y

UCL Centre for Behaviour Change. (2019). *BCT Taxonomy v1 Online Training*. Retrieved February 12, 2019 from http://www.bct-taxonomy.com/

UK National Screening Committee. (2019). *Screening for Type 2 Diabetes in adults: External review against programme appraisal criteria for the UK National Screening Committee*. UK National Screening Committee. https://view-health-screening-recommendations.service.gov.uk/document/343/download

Ullman, J. B., & Bentler, P. M. (2012). Structural equation modeling. In I. B. Weiner (Ed.), *Handbook of Psychology, Second Edition* (Vol. 2). Wiley Online Library.

Umpierre, D., Ribeiro, P. A., Kramer, C. K., LeitŃo, C. B., Zucatti, A. T., Azevedo, M. J., Gross, J. L., Ribeiro, J. P., & Schaan, B. D. (2011). Physical activity advice only or structured exercise training and association with HbA1c levels in type 2 diabetes: a systematic review and meta-analysis. *Journal of the American Medical Association, 305*(17), 1790-1799. https://doi.org/10.1001/jama.2011.576

US Food and Drug Administration. (2020). *What is Digital Health?* Retrieved February 28, 2021 from https://www.fda.gov/medical-devices/digital-health-center-excellence/what-digital-health

Uusitupa, M. (2019). Good news from the Da Qing Diabetes Prevention Outcome Study—healthy lifestyles result in long-term cardiovascular benefits. *Annals of Translational Medicine*, 1-4. https://doi.org/10.21037/atm.2019.08.123

Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing & Health Sciences, 15*(3), 398-405. https://doi.org/10.1111/nhs.12048

Valabhji, J., Bakhai, C., Martin, L., & Newbound, T. (2020). Healthier you: Preventing type 2 diabetes and optimising engagement with the NHS Diabetes Prevention Programme. *Diabetic Medicine, 37*(SUPPL 1), 89. https://doi.org/10.1111/dme.14245

Valabhji, J., Barron, E., Bradley, D., Bakhai, C., Fagg, J., O'Neill, S., Young, B., Wareham, N., Khunti, K., & Jebb, S. (2020). Early outcomes from the English National health service diabetes prevention programme. *Diabetes Care*, *43*(1), 152-160. https://doi.org/10.2337/dc19-1425

Vamos, S., Okan, O., Sentell, T., & Rootman, I. (2020). Making a Case for "Education for Health Literacy": An International Perspective. *International Journal of Environmental Research and Public Health*, *17*(4), 1-18. https://doi.org/10.3390/ijerph17041436

van't Riet, J., Ruiter, R. A. C., Werrij, M. Q., & de Vries, H. (2010). Investigating message-framing effects in the context of a tailored intervention promoting physical activity. *Health Education Research*, *25*(2), 343-354. https://doi.org/10.1093/her/cyp061

Van Der Vaart, R., & Drossaert, C. (2017). Development of the digital health literacy instrument: measuring a broad spectrum of health 1.0 and health 2.0 skills. *Journal of Medical Internet Research*, *19*(1), 1-13. https://doi.org/10.2196/jmir.6709

Van der Vaart, R., Drossaert, C. H., de Heus, M., Taal, E., & van de Laar, M. A. (2013). Measuring actual eHealth literacy among patients with rheumatic diseases: a qualitative analysis of problems encountered using Health 1.0 and Health 2.0 applications. *Journal of Medical Internet Research*, *15*(2), 1-17. https://doi.org/10.2196/jmir.2428

Van der Vaart, R., Van Deursen, A. J., Drossaert, C. H., Taal, E., van Dijk, J. A., & van de Laar, M. A. (2011). Does the eHealth Literacy Scale (eHEALS) measure what it intends to measure? Validation of a Dutch version of the eHEALS in two adult populations. *Journal of Medical Internet Research*, *13*(4), e1840. https://doi.org/10.2196/jmir.1840

van Genugten, L., Dusseldorp, E., Webb, T. L., & van Empelen, P. (2016). Which Combinations of Techniques and Modes of Delivery in Internet-Based Interventions Effectively Change Health Behavior? A Meta-Analysis. *Jourman of Medical Internet Research*, *18*(6), 1-14. https://doi.org/10.2196/jmir.4218

Van Rhoon, L., Byrne, M., Morrissey, E., Murphy, J., & McSharry, J. (2020). A systematic review of the behaviour change techniques and digital features in technology-driven type 2 diabetes prevention interventions. *Digital Health, 6,* 1-27. https://doi.org/10.1177/2055207620914427

Van Rhoon, L., Byrne, M., Murphy, J., & McSharry, J. (2018). A systematic review of the behaviour change techniques and digital components found within digital lifestyle interventions for the prevention of type 2 diabetes in adults. PROSPERO: International prospective register of systematic reviews. https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42018097195

Van Rhoon, L., McSharry, J., & Byrne, M. (2021). Development and testing of a digital health acceptability model to explain the intention to use a digital diabetes prevention programme. *British Journal of Health Psychology*, 1-25. https://doi.org/10.1111/bjhp.12569

Van Velthoven, M. H., & Cordon, C. (2019). Sustainable Adoption of Digital Health Innovations: Perspectives From a Stakeholder Workshop. *Journal of Medical Internet Research, 21*(3), 1-8. https://doi.org/10.2196/11922

van Zyl, L. E., & Ten Klooster, P. M. (2022). Exploratory Structural Equation Modeling: Practical Guidelines and Tutorial With a Convenient Online Tool for Mplus. *Frontiers in Psychiatry*, *12*, 1-28. https://doi.org/10.3389/fpsyt.2021.795672

Vedanthan, R., Blank, E., Tuikong, N., Kamano, J., Misoi, L., Tulienge, D., Hutchinson, C., Ascheim, D. D., Kimaiyo, S., & Fuster, V. (2015). Usability and feasibility of a tablet-based Decision-Support and Integrated Record-keeping (DESIRE) tool in the nurse management of hypertension in rural western Kenya. *International Journal of Medical Informatics*, *84*(3), 207-219. https://doi.org/10.1016/j.ijmedinf.2014.12.005

Veerman, J. L., Sacks, G., Antonopoulos, N., & Martin, J. (2016). The impact of a tax on sugar-sweetened beverages on health and health care costs: a modelling study. *PloS One, 11*(4), 1-10. https://doi.org/10.1371/journal.pone.0151460

Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences*, *39*(2), 273-315. https://doi.org/10.1111/j.1540-5915.2008.00192.x

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, *46*(2), 186-204. https://doi.org/10.1287/mnsc.46.2.186.11926

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*, *27*(3), 425-478. https://doi.org/10.2307/30036540

Venkatesh, V., Thong, J. Y. L., & Xu, X. (2012). Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. *MIS Quarterly*, *36*(1), 157-178. https://doi.org/10.2307/41410412

Verdonk, P., Seesing, H., & De Rijk, A. (2010). Doing masculinity, not doing health? A qualitative study among Dutch male employees about health beliefs and workplace physical activity. *BMC Public Health*, *10*(1), 1-14. https://doi.org/10.1186/1471-2458-10-712

Veritas Health Innovation. (2019). *Covidence systematic review software*. In Veritas Health Innovation. www.covidence.org

Vermunt, P., Milder, I., Wielaard, F., De Vries, J., Baan, C., Van Oers, J., & Westert, G. (2012). A lifestyle intervention to reduce Type 2 diabetes risk in Dutch primary care: 2.5-year results of a randomized controlled trial. *Diabetic Medicine*, *29*(8), 223-231. https://doi.org/10.1111/j.1464-5491.2012.03648.x

Victor, M., & Montori, M. (2016). What We Don't Talk About When We Talk About Preventing Type 2 Diabetes—Addressing Socioeconomic Disadvantage. *JAMA Internal Medicine*, *176*(8), 1053-1054. https://doi.org/10.1001/jamainternmed.2016.2952

Vojta, D., Koehler, T. B., Longjohn, M., Lever, J. A., & Caputo, N. F. (2013). A Coordinated National Model for Diabetes Prevention: Linking Health Systems to an Evidence-Based Community Program. *American Journal of Preventive Medicine*, *44*(4, Supplement 4), S301-S306. https://doi.org/10.1016/j.amepre.2012.12.018

Vounzoulaki, E., Khunti, K., Abner, S. C., Tan, B. K., Davies, M. J., & Gillies, C. L. (2020). Progression to type 2 diabetes in women with a known history of gestational diabetes: systematic review and meta-analysis. *BMJ*, *369*, 1-11. https://doi.org/10.1136/bmj.m1361

Wang, L., & Weinshilboum, R. (2014). Metformin Pharmacogenomics: Biomarkers to Mechanisms. *Diabetes*, *63*(8), 2609-2610. https://doi.org/10.2337/db14-0609

Wang, P.-Y., Fang, J.-C., Gao, Z.-H., Zhang, C., & Xie, S.-Y. (2016). Higher intake of fruits, vegetables or their fiber reduces the risk of type 2 diabetes: A meta-analysis. *Journal of Diabetes Investigation*, *7*(1), 56-69. https://doi.org/10.1111/jdi.12376

Wang, W., & Lo, A. C. (2018). Diabetic retinopathy: pathophysiology and treatments. *International Journal of Molecular Sciences*, *19*(6), 1-14. https://doi.org/10.3390/ijms19061816

Wangdahl, J. M., Dahlberg, K., Jaensson, M., & Nilsson, U. (2019). Psychometric validation of Swedish and Arabic versions of two health literacy questionnaires, eHEALS and HLS-EU-Q16, for use in a Swedish context: a study protocol. *BMJ Open*, *9*(9), 1-7. https://doi.org/10.1136/bmjopen-2019-029668

Warrens, M. J. (2015). Five ways to look at Cohen's kappa. *Journal of Psychology & Psychotherapy*, *5*(4), 1-4. https://doi.org/10.4172/2161-0487.1000197

Webb, B. (2002). Using focus groups as a research method: a personal experience. *Journal of Nursing Management*, *10*(1), 27-35. https://doi.org/10.1046/j.0966-0429.2001.00273.x

Webb, T., Joseph, J., Yardley, L., & Michie, S. (2010). Using the internet to promote health behavior change: a systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy. *Journal of Medical Internet Research*, *12*(1), 1-18. https://doi.org/10.2196/jmir.1376

Weinstein, N. D. (1982). Unrealistic optimism about susceptibility to health problems. *Journal of Behavioral Medicine*, *5*(4), 441-460. https://doi.org/10.1007/BF00845372

Whitelaw, S., Pellegrini, D. M., Mamas, M. A., Cowie, M., & Van Spall, H. G. (2021). Barriers and facilitators of the uptake of digital health technology in cardiovascular care: a systematic scoping review. *European Heart Journal - Digital Health*, *2*(1), 62-74. https://doi.org/10.1093/ehjdh/ztab005

Whittemore, R. (2011). A systematic review of the translational research on the Diabetes Prevention Program. *Translational Behavioral Medicine*, *1*(3), 480-491. https://doi.org/10.1007/s13142-011-0062-y

Willett, W., Manson, J., & Liu, S. (2002). Glycemic index, glycemic load, and risk of type 2 diabetes. *The American Journal of Clinical Nutrition*, *76*(1), 274S-280S. https://doi.org/10.1093/ajcn/76/1.274S

Wilson, J., Heinsch, M., Betts, D., Booth, D., & Kay-Lambkin, F. (2021). Barriers and facilitators to the use of e-health by older adults: a scoping review. *BMC Public Health*, *21*(1), 1-12. https://doi.org/10.1186/s12889-021-11623-w

Wilson, M. G., Castro Sweet, C. M., Edge, M. D., Madero, E. N., McGuire, M., Pilsmaker, M., Carpenter, D., & Kirschner, S. (2017). Evaluation of a Digital Behavioral Counseling Program for Reducing Risk Factors for Chronic Disease in a Workforce. *Journal of Occupational and Environmental Medicine*, *59*(8), 150-155. https://doi.org/10.1097/jom.0000000000001091

Wolf, E. J., Harrington, K. M., Clark, S. L., & Miller, M. W. (2013). Sample size requirements for structural equation models: An evaluation of power, bias, and solution propriety. *Educational and Psychological Measurement*, *73*(6), 913-934. https://doi.org/10.1177/0013164413495237

Wong, C. K. H., Fung, C. S. C., Siu, S. C., Lo, Y. Y. C., Wong, K. W., Fong, D. Y. T., & Lam, C. L. K. (2013). A short message service (SMS) intervention to prevent diabetes in Chinese professional drivers with pre-diabetes: A pilot single-blinded randomized controlled trial. *Diabetes Research and Clinical Practice*, *102*(3), 158-166. https://doi.org/10.1016/j.diabres.2013.10.002

Wong, C. K. H., Jiao, F.-F., Siu, S.-C., Fung, C. S. C., Fong, D. Y. T., Wong, K.-W., Yu, E. Y. T., Lo, Y. Y. C., & Lam, C. L. K. (2016). Cost-Effectiveness of a Short Message Service Intervention to Prevent Type 2 Diabetes from Impaired Glucose Tolerance. *Journal of Diabetes Research*, *2016*(101605237), 1-8. https://doi.org/10.1155/2016/1219581

Wong, L. P. (2008). Focus group discussion: a tool for health and medical research. *Singapore Medical Journal*, *49*(3), 256-260. http://www.smj.org.sg/sites/default/files/4903/4903me1.pdf

World Health Organization. (2006). *Definition and diagnosis of diabetes mellitus and intermediate hyperglycemia*. World Health Organization. https://www.who.int/diabetes/publications/Definition%20and%20diagnosis%20of%20diabetes_new.pdf

World Health Organization. (2011). *Use of glycated haemoglobin (HbA1c) in diagnosis of diabetes mellitus: abbreviated report of a WHO consultation*. World Health Organization. https://www.who.int/diabetes/publications/report-hba1c_2011.pdf

World Health Organization. (2014). *Global status report on noncommunicable diseases 2014*. World Health Organization. Retrieved March 10, 2019 from https://www.who.int/nmh/publications/ncd-status-report-2014/en/

World Health Organization. (2018). *Classification of digital health interventions v1.0: A shared language to describe the uses of digital technology for health*. World Health Organization. http://apps.who.int/iris/bitstream/10665/260480/1/WHO-RHR-18.06-eng.pdf

World Health Organization. (2019a). *Classification of diabetes mellitus*. World Health Organization. https://apps.who.int/iris/bitstream/handle/10665/325182/9789241515702-eng.pdf

World Health Organization. (2019b). *WHO Guideline: recommendations on digital interventions for health system strengthening*. World Health Organization. https://apps.who.int/iris/bitstream/handle/10665/311941/9789241550505-eng.pdf

World Health Organization. (2021). *Diabetes*. World Health Organization. Retrieved December 2, 2021 from https://www.who.int/news-room/fact-sheets/detail/diabetes

Worthington, R. L., & Whittaker, T. A. (2006). Scale development research: A content analysis and recommendations for best practices. *The Counseling Psychologist*, *34*(6), 806-838. https://doi.org/10.1177/0011000006288127

Wu, Y.-K., & Berry, D. C. (2018). Impact of weight stigma on physiological and psychological health outcomes for overweight and obese adults: A systematic review. *Journal of Advanced Nursing*, *74*(5), 1030-1042. https://doi.org/10.1111/jan.13511

Xi, B., Li, S., Liu, Z., Tian, H., Yin, X., Huai, P., Tang, W., Zhou, D., & Steffen, L. M. (2014). Intake of Fruit Juice and Incidence of Type 2 Diabetes: A Systematic Review and Meta-Analysis. *PloS One*, *9*(3), 1-6. https://doi.org/10.1371/journal.pone.0093471

Xu, W. G., Qian, Y. F., & Wu, J. (2017). The effect of prediabetes on hepatocellular carcinoma risk: A systematic review and meta-Analysis. *Minerva Medica*, *108*(2), 185-190. https://doi.org/10.23736/S0026-4806.16.04601-2s

Xue, M., Xu, W., Ou, Y. N., Cao, X. P., Tan, M. S., Tan, L., & Yu, J. T. (2019). Diabetes mellitus and risks of cognitive impairment and dementia: A systematic review and meta-analysis of 144 prospective studies. *Ageing Research Reviews*, *55*, 1-9. https://doi.org/10.1016/j.arr.2019.100944

Yach, D., Stuckler, D., & Brownell, K. D. (2006). Epidemiologic and economic consequences of the global epidemics of obesity and diabetes. *Nature Medicine*, *12*(1), 62-66. https://doi.org/10.1038/nm0106-62

Yan, L. (2018). Good intentions, bad outcomes: The effects of mismatches between social support and health outcomes in an online weight loss community. *Production and Operations Management*, *27*(1), 9-27. https://doi.org/10.1111/poms.12793

Yan, M., & Or, C. (2019). A 12-week pilot study of acceptance of a computer-based chronic disease self-monitoring system among patients with type 2 diabetes mellitus and/or hypertension. *Health Informatics Journal*, *25*(3), 828-843. https://doi.org/10.1177/1460458217724580

Yang, K., Baniak, L. M., Imes, C. C., Choi, J., & Chasens, E. R. (2018). Perceived Versus Actual Risk of Type 2 Diabetes by Race and Ethnicity. *The Diabetes Educator*, *44*(3), 269-277. https://doi.org/10.1177/0145721718770983

Yang, W.-S., Wang, W.-Y., Fan, W.-Y., Deng, Q., & Wang, X. (2014). Tea consumption and risk of type 2 diabetes: a dose–response meta-analysis of cohort studies. *British Journal of Nutrition*, *111*(8), 1329-1339. https://doi.org/10.1017/S0007114513003887

Yang, W., Zilov, A., Soewondo, P., Bech, O. M., Sekkal, F., & Home, P. D. (2010). Observational studies: going beyond the boundaries of randomized controlled trials. *Diabetes Research and Clinical Practice*, *88*, S3-S9. https://doi.org/10.1016/S0168-8227(10)70002-4

Yardley, L., Morrison, L., Bradbury, K., & Muller, I. (2015). The person-based approach to intervention development: application to digital health-related behavior change interventions. *Journal of Medical Internet Research*, *17*(1), 1-15. https://doi.org/10.2196/jmir.4055

Yardley, L., Morrison, L. G., Andreou, P., Joseph, J., & Little, P. (2010). Understanding reactions to an internet-delivered health-care intervention: accommodating user preferences for information provision. *BMC Medical Informatics and Decision Making*, *10*(1), 1-10. https://doi.org/10.1186/1472-6947-10-52

Yardley, L., Spring, B. J., Riper, H., Morrison, L. G., Crane, D. H., Curtis, K., Merchant, G. C., Naughton, F., & Blandford, A. (2016). Understanding and Promoting Effective Engagement With Digital Behavior Change Interventions. *American Journal of Preventive Medicine*, *51*(5), 833-842. https://doi.org/10.1016/j.amepre.2016.06.015

Yates, T., Davies, M., Gorely, T., Bull, F., & Khunti, K. (2009). Effectiveness of a pragmatic education program designed to promote walking activity in individuals with impaired glucose tolerance: a randomized controlled trial. *Diabetes Care*, *32*(8), 1404-1410. https://doi.org/10.2337/dc09-0130

Yeung, R. O., Zhang, Y., Luk, A., Yang, W., Sobrepena, L., Yoon, K.-H., Aravind, S., Sheu, W., Nguyen, T. K., & Ozaki, R. (2014). Metabolic profiles and treatment gaps in young-onset type 2 diabetes in Asia (the JADE programme): a cross-sectional study of a prospective cohort. *The Lancet Diabetes & Endocrinology*, *2*(12), 935-943. https://doi.org/10.1016/S2213-8587(14)70137-8

Yin, Z., Perry, J., Duan, X., He, M., Johnson, R., Feng, Y., & Strand, M. (2018). Cultural adaptation of an evidence-based lifestyle intervention for diabetes prevention in Chinese women at risk for diabetes: results of a randomized trial. *International Health*, *10*(5), 391-400. https://doi.org/10.1093/inthealth/ihx072

Yuan, S., Li, X., Jin, Y., & Lu, J. (2017). Chocolate Consumption and Risk of Coronary Heart Disease, Stroke, and Diabetes: A Meta-Analysis of Prospective Studies. *Nutrients*, *9*(7), 1-10. https://doi.org/10.3390/nu9070688

Yudkin, J. S. (2016). “Prediabetes”: are there problems with this label? Yes, the label creates further problems! *Diabetes Care*, *39*(8), 1468-1471. https://doi.org/10.2337/dc15-2113

Yudkin, J. S., & Montori, V. M. (2014). The epidemic of pre-diabetes: the medicine and the politics. *BMJ*, *349*, 1-6. https://doi.org/10.1136/bmj.g4485

Zajacova, A., Hummer, R. A., & Rogers, R. G. (2012). Education and health among US working-age adults: A detailed portrait across the full educational attainment spectrum. *Biodemography and Social Biology*, *58*(1), 40-61. https://doi.org/10.1080/19485565.2012.666122

Zajacova, A., & Lawrence, E. M. (2018). The relationship between education and health: reducing disparities through a contextual approach. *Annual Review of Public Health*, *39*, 273-289. https://doi.org/10.1146/annurev-publhealth-031816-044628

Zhang, M., Picard-Deland, E., & Marette, A. (2013). Fish and Marine Omega-3 Polyunsatured Fatty Acid Consumption and Incidence of Type 2 Diabetes: A Systematic Review and Meta-Analysis. *International Journal of Endocrinology*, *2013*, 1-11. https://doi.org/10.1155/2013/501015

Zhang, S., Shuntaro Yui, E., Akashi, T., Araki, K., Stedman, J., Paisley, A., Jarvis, P., & Grady, K. (2017). *Proof of Concept Project for a Diabetes Prevention Service in Greater Manchester, United Kingdom*. Hitachi Consulting. https://www.hitachivantara.com/en-us/pdfd/hcc/point-of-view/proof-of-concept-for-a-diabetes-prevention-service-in-greater-manchester-united-kingdom.pdf

Zhang, Y., Tan, H., Tang, J., Li, J., Chong, W., Hai, Y., Feng, Y., Lunsford, L. D., Xu, P., Jia, D., & Fang, F. (2020). Effects of Vitamin D Supplementation on Prevention of Type 2 Diabetes in Patients With Prediabetes: A Systematic Review and Meta-analysis. *Diabetes Care*, *43*(7), 1650-1658. https://doi.org/10.2337/dc19-1708

Zhou, X., Siegel, K. R., Ng, B. P., Jawanda, S., Proia, K. K., Zhang, X., Albright, A. L., & Zhang, P. (2020). Cost-effectiveness of diabetes prevention interventions targeting high-risk individuals and whole populations: a systematic review. *Diabetes Care*, *43*(7), 1593-1616. https://doi.org/10.2337/dci20-0018

Zoom Video Communications Inc. (2021). *Zoom Video Communications Software.* Zoom Video Communications, Inc. Retrieved February 23, 2021 from https://zoom.us/

Zorbas, C., Palermo, C., Chung, A., Iguacel, I., Peeters, A., Bennett, R., & Backholer, K. (2018). Factors perceived to influence healthy eating: a systematic review and meta-ethnographic synthesis of the literature. *Nutrition Reviews*, *76*(12), 861-874. https://doi.org/10.1093/nutrit/nuy043

Zyriax, B.-C., Letsch, B., Stock, S., & Windler, E. (2014). DELIGHT (Delay of impaired glucose tolerance by a healthy lifestyle trial)–A Feasibility Study on Implementing a Program of Sustainable Diabetes Prevention in German Companies. *Experimental and Clinical Endocrinology & Diabetes*, *122*(01), 20-26. https://doi.org/10.1055/s-0033-1355423

Appendices

Appendix A: Article-Based PhDs: Guidelines for the College of Arts, Social Sciences, and Celtic Studies

General Comment

The standard of scholarly achievement and professionalism expected of an article-based PhD is identical to that expected of the traditional monograph-type thesis. An article-based PhD will be no less rigorous academically than a monograph and should still not exceed 80,000 words as per university norms. Reference also section 6.2.6 'article-based' PhD in the university guidelines for research degree programmes.

Relevance to disciplines within the College

It is recognised that article-based PhDs are not equally relevant to all disciplines within the College. Certain disciplines or sub-disciplines (for example Physical Geography, Archaeology, Psychology, Social Work and Education) are more likely to encounter greater take-up of this format among their doctoral students. The traditional monograph route is the preferred option in Humanities, Languages, Literatures & Cultures and in many sub-disciplines of Sociology & Political Science and of Geography and Archaeology. There is no obligation on any discipline within the College to promote the article-based format over the traditional monograph format. The decision of a student to avail of this format should be made early in the PhD in accordance with the norms of the discipline and with the agreement of the supervisor(s) and GRC.

The Number and Status of Publications

A minimum number of substantial articles, based on the disciplinary norm, should make up the core of an article-based PhD thesis:

- In Geography, a minimum of three articles should make up the core, where the PhD candidate is the primary author.
- In Archaeology, a minimum of three articles should make up the core, where the PhD student is the single author.
- In both Geography and Archaeology, two of the articles should have been accepted for publication by internationally peer-reviewed journals relevant to the discipline in question, with the third submitted for review.

- In Psychology, three articles should make up the core of the PhD, with 2 of these accepted for publication and the third submitted for review.
- In Education, a minimum of two accepted substantial single-authored articles are required.
- In Political Science and Sociology, a minimum of three accepted articles are required.

Further articles may also be submitted. In the case of jointly-authored articles (for instance, in Geography), the applicant should be the primary author and must be capable of demonstrating that he/she made a substantial contribution to them. These articles should have either been published or have been accepted for publication by highly-ranked peer-reviewed journals relevant to the discipline in question. In the case of material accepted for publication, the student's supervisor/GRC must be able to verify that the manuscript has passed all stages of the peer review process.

The PhD thesis containing these articles should make a coherent and substantial contribution to knowledge in a specific field in order to qualify for award of the PhD degree.

In the case of jointly-authored papers, the candidate's contribution to the authorship and content of the papers must be made explicit in the other required material for PhD thesis.

It is the responsibility of the supervisor and GRC to sign-off that the candidate's work is worthy of PhD thesis for examination (EOG-020 Approval for Examination form). In other words, the supervisor and GRC should have reached a judgement that, in their view, the student's work is of the standard to merit the award of a PhD. During the viva, close attention should be paid to the nature and quality of the articles, and in the case of jointly-authored material, to the student's role in it. It must be emphasised that the examiners retain final judgment on the quality of the thesis.

Required Material

In addition to the articles, the PhD thesis must include the following, subject to disciplinary norms:

- a thorough critical review of previous scholarship and literature on the topic.
- a chapter locating the candidate's work within the existing scholarship, which will explicitly articulate the key research question(s) addressed by the candidate and the chosen methodology/theoretical framework, as appropriate.

- a concluding chapter, which draws the substantive material in the articles together so as to demonstrate their coherence and the full extent of their contribution to knowledge.
- in the case of jointly-authored papers (for instance, in Geography), the candidate's contribution to the authorship and content must be made explicit in this section.
- a full bibliography.

Supporting or Supplementary Material:

As appropriate to the discipline, the PhD thesis may be supported by appendices consisting of, but not limited to, the following kinds of information:

- Databases of key evidence.
- Lists and examples of archival material consulted.
- Research questionnaires, such as those used in the Social Sciences.
- Statistical analyses of full data sets.

Such detail is often inappropriate in the context of a journal, where word-counts are at a premium, but are essential in the context of a PhD thesis for a PhD.

Appendix B: PRISMA Checklist (Study One)

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4-6
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	7
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	7
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	7
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	8
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Supp. File 2
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	8
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	8-11
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	8-11
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	11

Section/topic	#	Checklist item	Reported on page #
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	NA
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I2) for each meta-analysis.	11
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	NA
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	NA
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	12
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	12-13
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	13
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	14-18
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	NA
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	NA
Additional analyses	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	NA
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	18-22
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	23-24
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	25-26
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	26

Appendix C: Systematic Review Search Strategy (Study One)

PubMed

1. Diabetes Mellitus, Type 2 [MeSH Term]
2. Prediabetic State [MeSH Term]
3. 1 OR 2
4. Preventive Health Services [MeSH Term]
5. Risk [MeSH Term]
6. Risk Reduction Behaviour [MeSH Term]
7. Education* [Text Word]
8. Intervention* [Text Word]
9. Prevention [Text Word]
10. Program* [Text Word]
11. OR 4/10
12. Cell Phone [MeSH Term]
13. Computers [MeSH Term]
14. Computers, Handheld [MeSH Term]
15. Electronic Mail [MeSH Term]
16. Fitness Trackers [MeSH Term]
17. Internet [MeSH Term]
18. Mobile Applications [MeSH Term]
19. Multimedia [MeSH Term]
20. Smartphone [MeSH]
21. Social Media [MeSH Term]
22. Software [MeSH Term]
23. Telemedicine [MeSH Term]
24. Telephone [MeSH Term]
25. Television [MeSH Term]
26. Text Messaging [MeSH Term]
27. Video Games [MeSH Term]
28. Video-Audio Media [Publication Type] [MeSH Term]
29. Virtual Reality [MeSH Term]
30. Wearable Electronic Device [MeSH Term]
31. Webcasts [Publication Type] [MeSH Term]

32. Digital [Text Word]
33. DVD* [Text Word]
34. Electronic [Text Word]
35. Online [Text Word]
36. Pedometer* [Text Word]
37. Sensor* [Text Word]
38. SMS [Text Word]
39. Technolog* [Text Word]
40. TV [Text Word]
41. OR 12/40
42. Adipose Tissue [MeSH Term]
43. Blood Glucose [MeSH Term]
44. Body Mass Index [MeSH Term]
45. Body Weight [MeSH Term]
46. Body Weight Changes [MeSH Term]
47. Glucose Intolerance [MeSH Term]
48. Glucose Tolerance Test [MeSH Term]
49. Glycated Hemoglobin A [MeSH Term]
50. Incidence [MeSH Term]
51. Prevalence [MeSH Term]
52. Waist Circumference [MeSH Term]
53. Waist-Hip Ratio [MeSH Term]
54. OR 42/53
55. 3 AND 11 AND 41 AND 54
56. Diabetes Mellitus, Type 1 [MeSH Term]
57. 55 NOT 56

CINAHL, EMBASE, MEDLINE, PsycINFO

1. Diabet*.ti.
2. Prediabet*.ti.
3. Pre-diabet*.ti.
4. OR 1/3
5. Education*.ti.
6. Intervention*.ti.

7. Prevent*.ti.
8. Program*.ti.
9. (risk adj2 reduc*).ti.
10. OR 5/9
11. “Social media”.tw.
12. App.tw.
13. Apps.tw.
14. Computer.tw.
15. Digital.tw.
16. DVD*.tw.
17. eHealth.tw.
18. e-Health.tw.
19. Electronic.tw.
20. eMail*.tw.
21. Internet.tw.
22. mHealth.tw.
23. m-Health.tw.
24. Mobile.tw.
25. Multimedia.tw.
26. Online.tw.
27. Pedometer*.tw.
28. Phone.tw.
29. Sensor*.tw.
30. Smartphone.tw.
31. SMS.tw.
32. Software.tw.
33. Technolog*.tw.
34. Telehealth.tw.
35. Telephone.tw.
36. Television.tw.
37. Text.tw.
38. Tracker*.tw.
39. TV.tw.
40. Video*.tw.

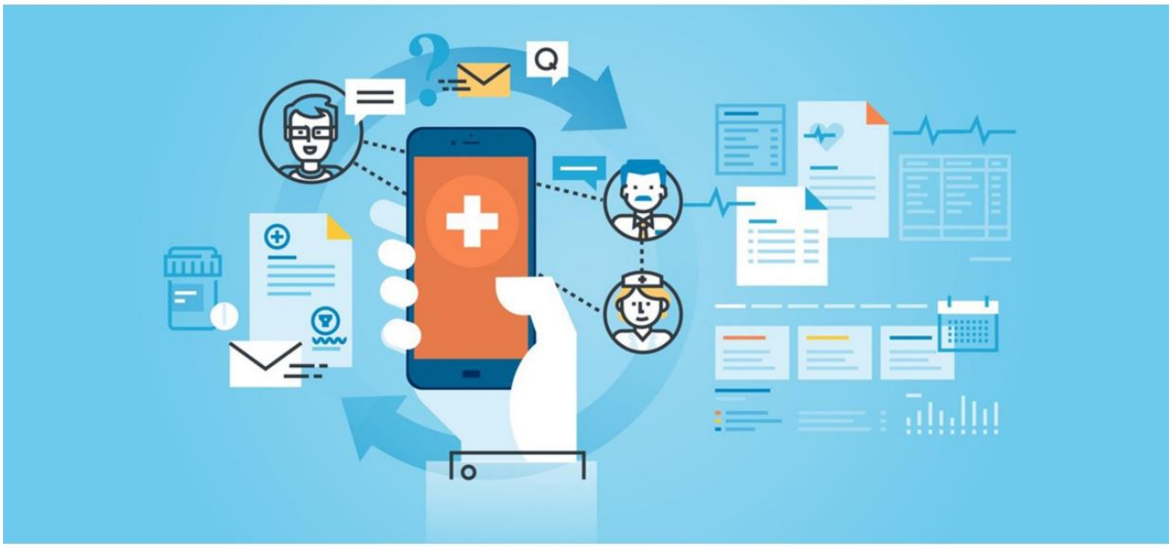
41. Virtual.tw.
42. Wearable*.tw.
43. Web*.tw.
44. OR 11/43
45. “Body fat”.tw.
46. “Body Mass Index”.tw.
47. “Fasting blood”.tw.
48. “Fasting glucose”.tw.
49. “Fasting plasma”.tw.
50. “Glucose tolerance”.tw.
51. “Waist circumference”.tw.
52. A1c.tw.
53. BMI.tw.
54. Glycated.tw.
55. HbA1c.tw.
56. Incidence.tw.
57. Prevalence.tw.
58. Waist-hip.tw.
59. Waist-to-hip.tw.
60. Weight.tw.
61. OR 45/61
62. 4 AND 10 AND 44 AND 61
63. “Type 1”.ti.
64. 62 NOT 63

Appendix D: Pre-Pilot Questionnaire (Study Two)

NUI Galway
OÉ Gaillimh

Attitudes and Perceptions of a Digital Diabetes Prevention Programme

A Survey for Adults Living in Ireland



This survey study is supported by the Health Behaviour Change Research Group within School of Psychology at the National University of Ireland, Galway and is currently funded by the Irish Research Council.

Health Behaviour Change Research Group

Irish Research Council
An Chomhairle um Thaighde in Éirinn

<u>Participant Information Sheet</u>

Please read the following information and complete the consent form on the following page.

Overview

The following survey is investigating the attitudes and perceptions people have towards a Diabetes Prevention Programme which uses technology to assist people in improving their eating behaviours and physical activity. Before you decide to begin, it is important that you understand why the research is being done and what it will involve.

Who is doing the research?

The research is being conducted by Luke Van Rhoon, a PhD candidate from the School of Psychology at the National University of Ireland, Galway. The research team also includes Prof. Molly Byrne and Dr. Jenny McSharry of the Health Behaviour Change Research Group at NUI, Galway. This research is supported by the Irish Research Council.

What is the purpose of this research?

Diabetes Prevention Programmes are interventions that educate and assist people in making lifestyle changes to improve their health, such as healthy eating and performing regular physical activity. We are investigating people's attitudes toward type 2 diabetes and digital health (e.g. health websites, phone apps); and perceptions of a Diabetes Prevention Programme that uses technology to help people change their health behaviours.

Why have I been chosen?

You have been chosen because you are an adult living in Ireland who may be considering making healthy lifestyle changes, or simply wish to maintain a healthy lifestyle, and our aim is to inform the development of a digital health programme that is tailored to meet these needs and interests.

What will I have to do?

You will be asked some general personal questions (e.g., height, weight) and current health behaviour questions which will assess whether you may be at risk of developing type 2 diabetes. You will then answer some questions about type 2 diabetes; diet and activity level; and, your experience with health technologies and devices. You will then read through an online brochure which presents a Diabetes Prevention Programme before answering some questions related to the programme. You are free to withdraw at any time without giving a reason and without penalty. A decision to withdraw or not to take part will not affect your rights in any way.

What are the advantages and disadvantages of taking part?

The survey includes an assessment of your risk of developing type 2 diabetes within the next 10 years and you will have the option of submitting your email address or alternative contact details to receive your risk score and more information about what it means. A disadvantage is the time you will give to complete the survey. However, you will have the chance to win one of two €100 One4all gift cards which are accepted in over 8,500 stores across Ireland and online.

Will my taking part in the study remain confidential?

Your survey responses will remain anonymous. Your name and contact details will not be linked to your survey responses. Data will not be distributed to a third-party.

What's next?

At the end of the survey you will have the option of submitting your email address or alternative contact information to enter the draw to win one of two €100 One4all gift cards, and/or to express your interest in participating in our follow-up study. For this follow-up study we are looking for survey completers who, based on their risk score, may be at risk of developing type 2 diabetes. This follow up study involves a 30-minute telephone or video call interview for which all participants will receive a €20 One4all gift card. Expressing your interest does not mean you have committed to participate, only that we will send you more information about the study. Submitting your details are optional.

What will happen to the results of the research study?

The results may be published in scientific journals and meetings in the field of health care. We would be happy to send a summary of the findings to you.

Where can I get more information?

If you have any further questions please contact Luke, the lead researcher, using the contact details below. If you have any specific questions on type 2 diabetes or your health in general, please contact your GP.

Luke Van Rhoon
School of Psychology - The National University of Ireland, Galway
Phone: 085 126 4297
email: l.vanrhoon1@nuigalway.ie

Participant Consent Form

Please initial inside EACH box and sign your name in the space below if you agree with the statements.

1) I confirm I have read the above participant information. ☐

2) I am satisfied that I understand the information provided and have had enough time to consider the information. ☐

3) I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without penalty, and without my legal rights being affected. ☐

4) I agree to take part in this survey study. ☐

Name: ____(Please use block letters)

Signature: _____________________________ **Date:** _____/_____/________

SECTION 1

For each item, please tick one box only. In the larger boxes, please enter numbers only.

1. Are you currently living in the Republic of Ireland?

- ☐ Yes
- ☐ No

2. Please enter your age in years.

☐

3. What is your sex?

- ☐ Female
- ☐ Male
- ☐ Other

4. To which one of the following groups do you consider you belong?

- ☐ White Irish
- ☐ White Irish Traveller
- ☐ Any other white background (please specify)________________________________
- ☐ Black
- ☐ Asian
- ☐ Other, including mixed background (please specify)__________________________

5. What is the highest level of education/training (full-time or part-time) you have completed to date?

- ☐ Primary education
- ☐ Lower secondary education (e.g. Junior Cert)
- ☐ Upper secondary education (e.g. Leaving Cert)
- ☐ Technical or vocational education
- ☐ Undergraduate degree (includes bachelors and honours degree)
- ☐ Postgraduate degree (e.g. Master's, PhD)

6. Please enter your height in centimetres (cm). [Note: 1 inch = 2.54 cm]

☐

7. Please enter your weight in kilograms (kg). [Note: 1 st. = 6.35 kg; 1 lb = 0.454 kg]

8. Please enter your waist circumference in centimetres (cm) at navel level.

9. Do you usually perform at least 30 minutes of physical activity or exercise each day?
This includes physical activity during work, leisure, or regular daily routine.

- ☐ Yes
- ☐ No

10. How often do you eat fruit or vegetables?

- ☐ Every day
- ☐ Not every day

11. Have you ever taken medication for high blood pressure on a regular basis?

- ☐ Yes
- ☐ No

12. Have you ever been found to have high blood glucose?
(e.g. in a health examination, during an illness, during pregnancy)

- ☐ Yes
- ☐ No

13. Have you recently or previously been diagnosed with type 1 or type 2 diabetes?

- ☐ Yes
- ☐ No

14. Have any members of your immediate family or other relatives been diagnosed with type 1 or type 2 diabetes? (blood relatives only)

- ☐ No
- ☐ Yes: grandparent, aunt, uncle or first cousin
- ☐ Yes: mother, father, brother, sister, my own child

SECTION 2

Please indicate how much you agree or disagree with each of the following statements. Please tick one box per statement. As these are your own views, there are no “right” or “wrong” answers.

15. My chances of developing diabetes in the next few years are great.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

16. I am concerned about the likelihood of developing diabetes in the near future.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

17. Because there are so many things that could happen to me, I think it is foolish to worry about diabetes.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

18. The older I get, the more I think about getting diabetes.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

19. If I get diabetes it will not affect my relationships with others that much.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

20. Getting diabetes will slow down my daily life.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

21. **Diabetes is a sickness that can be very painful.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

22. **The costs of living with diabetes are so bad that I really want to avoid them if I can.**

Strongly Disagree	Disagree	nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

23. **Most people who are important to me think that I should get more exercise.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

24. **Most people who are important to me think that I should have a healthier diet.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

25. **The people in my life whose opinions I value are physically fit.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

26. **The people in my life whose opinions I value have a healthy diet.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

27. **People who use digital wearable devices (e.g. FitBit) or smartphone apps have more prestige than those who don't.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

28. People who use digital wearable devices (e.g. FitBit) or smartphone apps have a high profile.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

29. Between the people I know, the use of digital wearable devices (e.g. FitBit) or smartphone apps are a status symbol.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

30. I know how to find helpful resources on the internet.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

31. I know how to use the internet to answer my health questions.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

32. I know what health resources are available on the internet.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

33. I know where to find helpful resources on the internet.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

34. I know how to use the health information I find on the internet to help me.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

35. I have the skills I need to evaluate health resources I find on the internet.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

36. I can tell high quality from low quality health resources on the internet.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

37. I feel confident in using information on the internet to make health decisions.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

38. I can achieve my health information goals on the Internet while helping other users achieve theirs.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

39. I have the skills I need to talk about health topics on the Internet with multiple users at the same time.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

40. I can identify the emotional tone of a health conversation on the Internet.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

41. I have the skills I need to contribute to health conversations on the Internet.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

42. **I have the skills I need to build personal connections with other Internet users who share health information.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

43. **I would be comfortable using an internet-connected device several times a week to participate in a lifestyle intervention online.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
☐	☐	☐	☐	☐	☐

44. **I feel that my previous experiences with online technologies are important to my success with using a lifestyle intervention.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
☐	☐	☐	☐	☐	☐

45. **Using internet technologies makes me more efficient in my daily functioning.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
☐	☐	☐	☐	☐	☐

46. **I believe that I am able to make good use of internet websites and web applications.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
☐	☐	☐	☐	☐	☐

47. **Using internet technologies provide me with a feeling of independence.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
☐	☐	☐	☐	☐	☐

48. I enjoy the challenge of figuring out the different functions of websites and web applications.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
☐	☐	☐	☐	☐	☐

49. I use an internet connected device to keep track of my lifestyle (e.g. daily tasks, goals, and meetings).

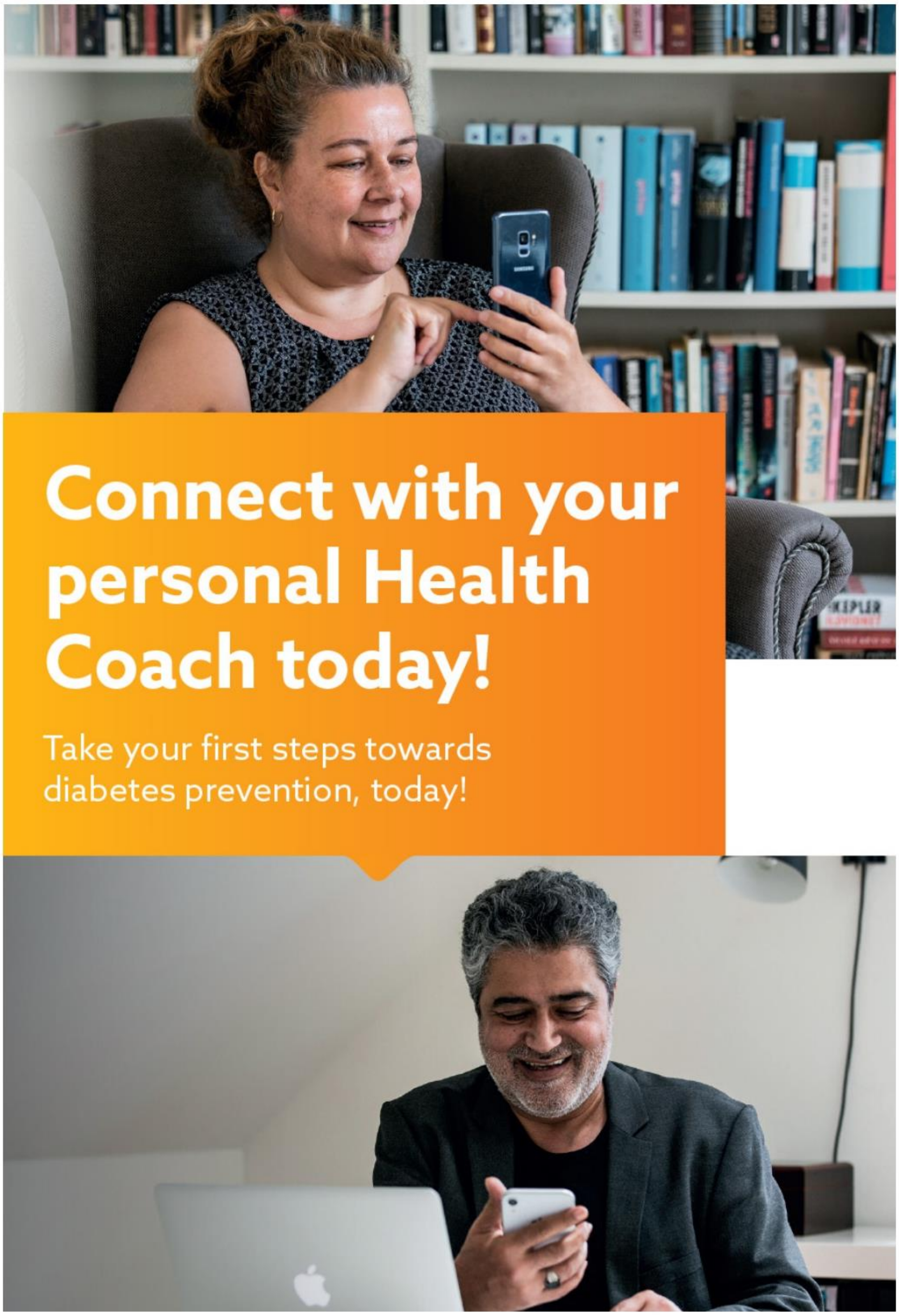
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
☐	☐	☐	☐	☐	☐

SECTION 3

The following pages contain a brochure of a digitial diabetes prevention programme; an intervention designed to assist people in improving their eating and physical activity behaviours, managing their weight, and preventing type 2 diabetes.

Please read the brochure carefully before proceeding to SECTION 4 which contains statements about the programme.

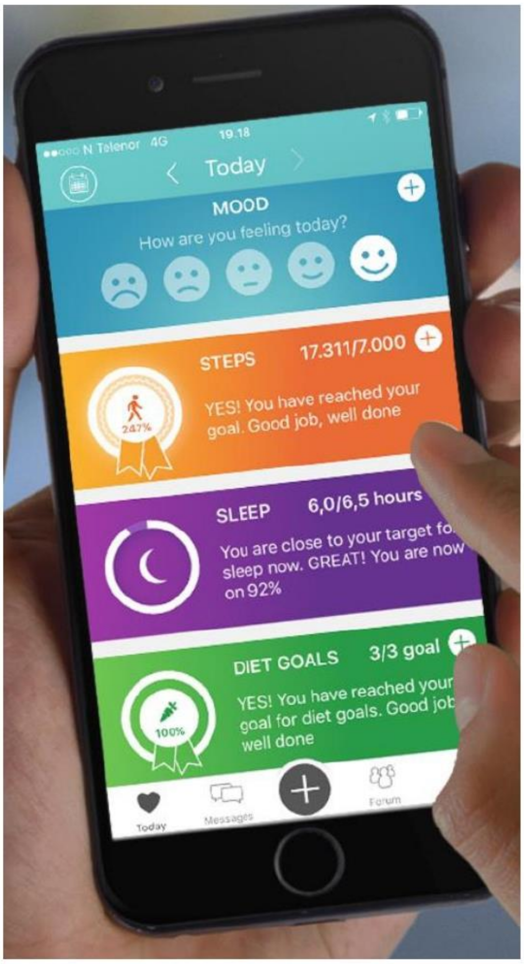
As before, please indicate how much you agree or disagree with each statement. As these are your own views, there are no "right"or "wrong" answers in this section.


Connect with your personal Health Coach today!
Take your first steps towards diabetes prevention, today!

The Liva App: A Personal Coach In your Pocket

The Liva app (available for iPhone and Android) has been built to incorporate lifestyle and behaviour change methodologies and includes the following features:

Self-monitoring of **vital metrics** such as weight, blood sugar levels, mood, sleep, steps, exercise etc.



Logging of **nutritional intake** through taking photos of the food consumed (shared with your own personal coach).

Setup and following of simple goals for **lifestyle change** which get marked off as you achieve them.

Participation in an **online support community** of people with the same challenges enabling mutual support to ensure engagement and continuous motivation.

Ongoing dialogue with a professional **health coach** who will remain with you throughout the programme to secure trust and continuity.

Meet your health coach and set your personalised goals

Choose from a number of our professional and accredited coaches. Liva will then arrange a video meeting with you and your personal coach. Together you agree on some lifestyle goals and log them onto the Liva app.

Tracking

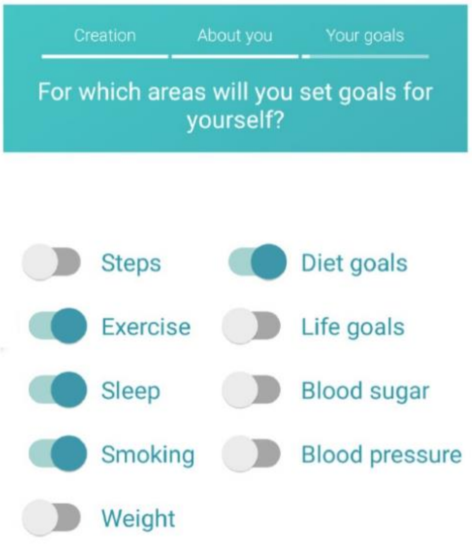
You log and track your progress via the Liva app towards your personal lifestyle goals.

1-2-1 personal coaching

Your health coach keeps in regular contact with you via a private message stream in the app. You can also find support in the community forum, a peer-to-peer communication space.

Sustainable Lifestyle Improvement

Ongoing, personalised 1-2-1 support from your health coach allows you to gradually achieve your goals in a sustainable way, improving your quality of life!

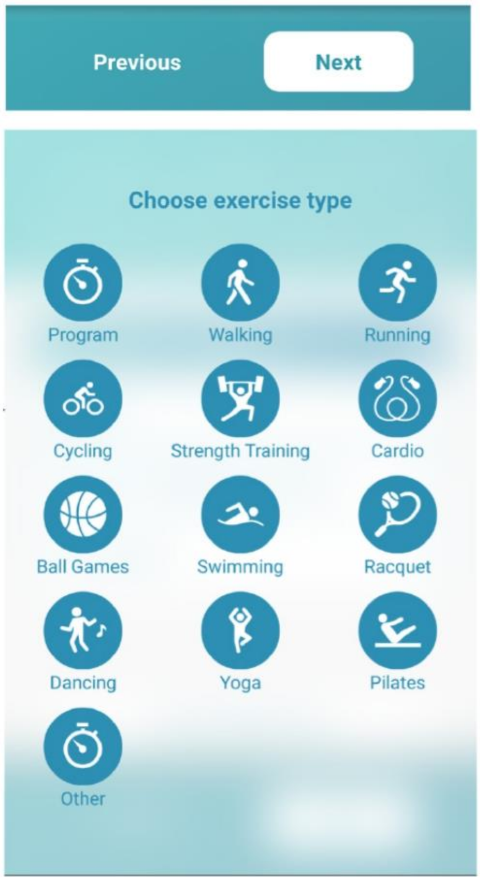


Your goals

Enter which goals you wish to focus on, together with your coach. Each area relates to the prevention of type 2 diabetes.

Goals could include hours of daily sleep, cigarettes per day (if you are a smoker aiming to quit), and weekly weight loss.

You can choose as many goals as you like.



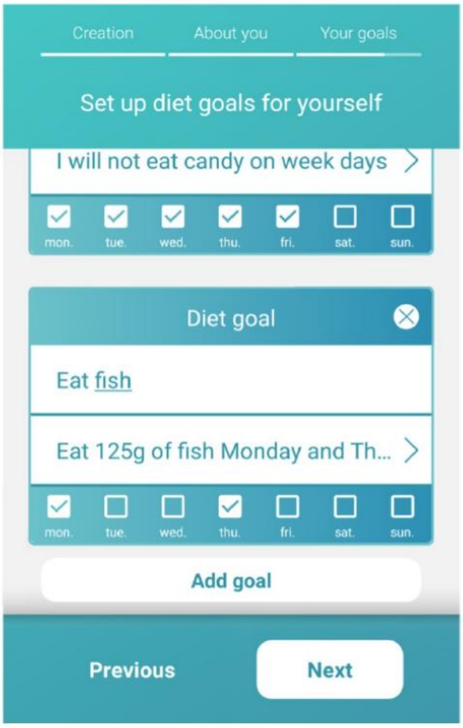
Exercise goals

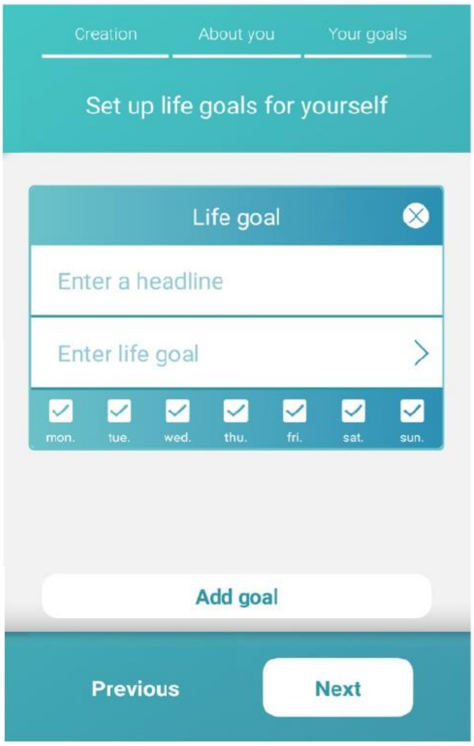
When choosing your exercise goals you can first choose the type(s) of activities you want to focus on.

You then choose how many minutes per week you wish to aim for and leave a description. E.g., if you have chosen "walking" as exercise, you can write "walking the dog" in the description.

You can create even more activities/exercise types.

Steps per day are also measured using your phone's pedometer. You can also set a daily step goal.





Your diet goals

You can choose a specific diet goal and then select the days you wish to follow this goal.

For example, your goal may be to eat no chocolate at all, or only on one day per week; or aim to eat fruit or vegetables every day.

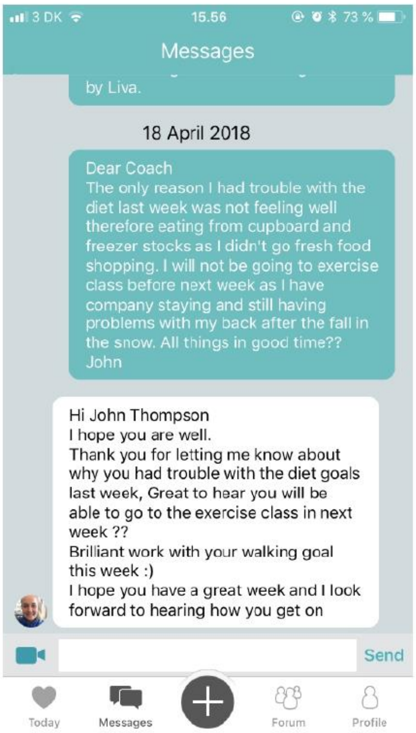
You could also choose to limit your alcohol consumption by setting a weekly goal of having no more than a few drinks per week.

Like all of the other goals, your health coach will assist you in setting diet goals that will help you to improve your health.

Your personal life goals

Your personal life goals are goals that go beyond the other categories. You can add and desribe any life goal you wish.

For example, you may choose to “let go of work during the weekends”.



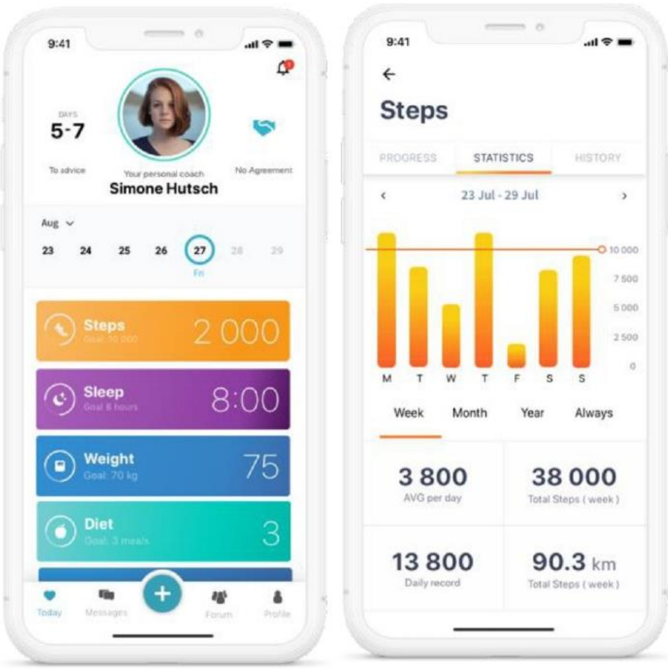
Your health coach

You can communicate with your health coach by sending instant messages or videos.

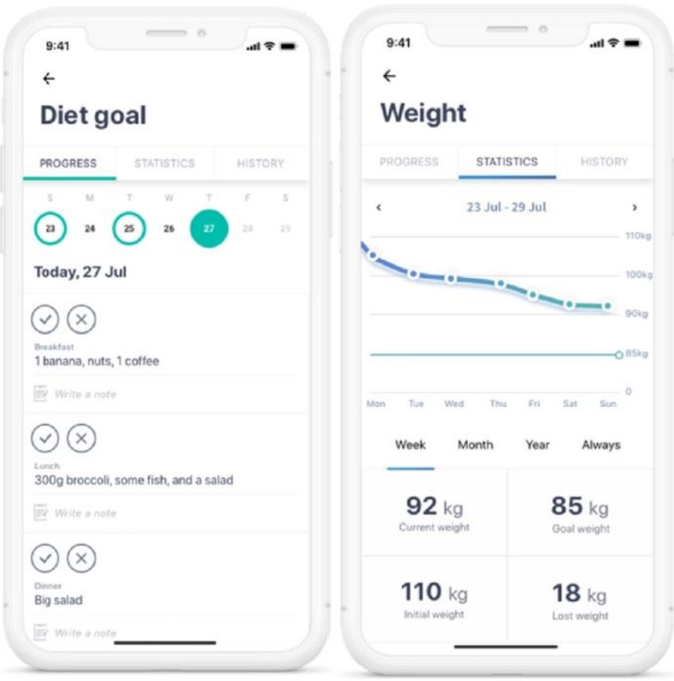
Your health coach will respond by sending you instant messages, videos, or PDFs (e.g. workout programmes and other educational resources).

Community forum

The forum is the community for other Liva users with an active programme. From here you can chat with other members; for example, arrange to meet up for a walk, or send and receive messages of support and encouragement.



The Liva app tracks your daily, weekly, and monthly progress



SECTION 4

Please tick one box per statement.

50. Using the programme would help me to improve my fitness.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

51. Using the programme would help me to improve my diet.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

52. Using the programme would help me to manage my weight.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

53. Using the programme would help me to prevent diabetes.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

54. Learning how to use the programme would be clear and understandable.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

55. Using the programme would not require a lot of mental effort.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

56. The programme tools seem to be easy to use.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

57. **I would it find it easy to get the programme tools to do what I want them to do.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

58. **Using the programme would be beneficial.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

59. **Using the programme would be unpleasant.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

60. **Using the programme is a good idea.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

61. **Using the programme would be enjoyable.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

62. **Assuming the programme is available, I intend to use it.**

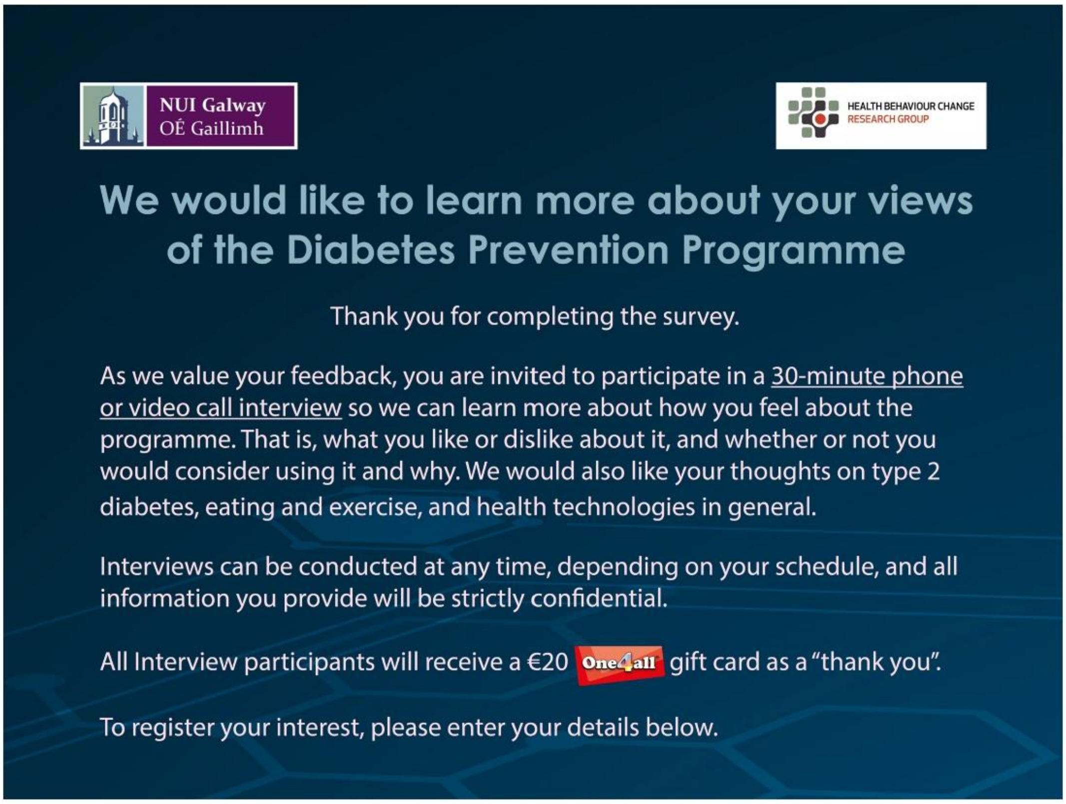
Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

63. **Given that the programme is available, I predict I would use it.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

<u>Thank you for completing the survey</u>

If you wish to opt in to any the following, please enter your email address <u>OR</u> alternative contact details below and tick the appropriate box(es).



Email:____

Phone/other:__________________________________

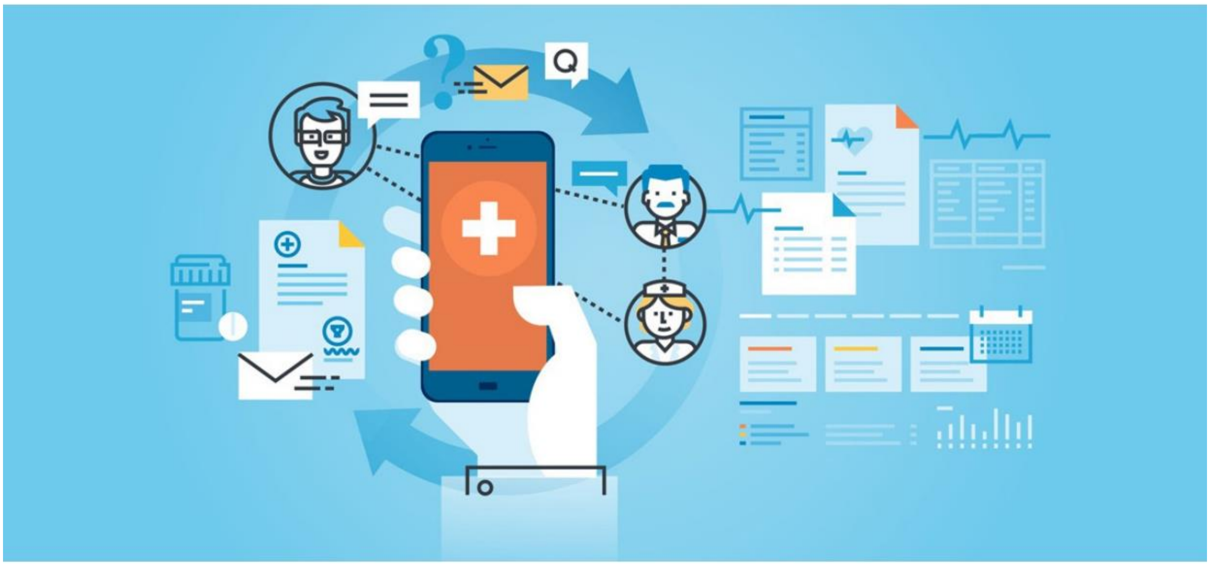
☐ I would like to receive my Type 2 Diabetes Risk Score, and more information about what it means.

☐ I would like to enter the draw to win a €100 One4All gift card.

☐ I am interested in participating in a 30-minute phone or video call interview and would like more information.

Thank you for your time

Please place this survey booklet into the reply-paid satchel and drop it in at your nearest post office or post box.



NUI Galway
OÉ Gaillimh

School of Psychology
National University of Ireland, Galway
Arts Millennium Building Extension
Lower Newcastle Road, Galway

HEALTH BEHAVIOUR CHANGE
RESEARCH GROUP

IRISH RESEARCH COUNCIL
An Chomhairle um Thaighde in Éirinn

Appendix E: Final Questionnaire (Study Two)

SECTION 1

For each item, please tick one box only. In the larger boxes, please enter numbers only.

1. **Are you currently living in the Republic of Ireland?**

- ☐ Yes
- ☐ No

2. **Please enter your age in years.**

☐

3. **What is your sex?**

- ☐ Female
- ☐ Male
- ☐ Other

4. **To which one of the following groups do you consider you belong?**

- ☐ White Irish
- ☐ White Irish Traveller
- ☐ Any other white background (please specify)______________________________
- ☐ Black or Black Irish
- ☐ Asian or Asian Irish
- ☐ Other, including mixed background (please specify)_________________________

5. **What is the highest level of education/training (full-time or part-time) you have completed to date?**

- ☐ Primary education
- ☐ Lower secondary education (e.g. Junior Cert)
- ☐ Upper secondary education (e.g. Leaving Cert)
- ☐ Technical or vocational education
- ☐ Undergraduate degree (includes bachelors and honours degree)
- ☐ Postgraduate degree (e.g., Master's, PhD)

6. **Please enter your height in centimetres (cm). [Note: 1 inch = 2.54 cm]**

☐

7. **Please enter your weight in kilograms (kg). [Note: 1 st. = 6.35 kg; 1 lb = 0.454 kg]**

☐

8. **Please enter your waist circumference in centimetres (cm) at navel level.**

☐

9. **Do you usually perform at least 30 minutes of physical activity or exercise each day? This includes physical activity during work, leisure, or regular daily routine.**

- ☐ Yes
- ☐ No

10. **How often do you eat fruit or vegetables?**

- ☐ Every day
- ☐ Not every day

11. **Have you ever taken medication for high blood pressure on a regular basis?**

- ☐ Yes
- ☐ No

12. **Have you ever been found to have high blood glucose? (e.g., in a health examination, during an illness, during pregnancy)**

- ☐ Yes
- ☐ No

13. **Have you recently or previously been diagnosed with type 1 or type 2 diabetes?**

- ☐ Yes
- ☐ No

14. **Have any members of your immediate family or other relatives been diagnosed with type 1 or type 2 diabetes? (blood relatives only)**

- ☐ No
- ☐ Yes: grandparent, aunt, uncle or first cousin
- ☐ Yes: mother, father, brother, sister, my own child

SECTION 2

Please indicate how much you agree or disagree with each of the following statements. Please tick one box per statement. As these are your own views, there are no 'right' or 'wrong' answers.

15. My chances of developing diabetes in the next few years are great.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

16. I am concerned about the likelihood of developing diabetes in the near future.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

17. Because there are so many things that could happen to me, I think it is foolish to worry about diabetes.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

18. The older I get, the more I think about getting diabetes.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

19. If I get diabetes, it will not affect my relationships with others that much.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

20. Getting diabetes will slow down my daily life.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

21. Diabetes is a sickness that can be very painful.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

22. The costs of living with diabetes are so bad that I really want to avoid them if I can.

Strongly Disagree	Disagree	nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

23. Most people who are important to me think that I should get more exercise.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

24. Most people who are important to me think that I should have a healthier diet.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

25. People who use digital wearable devices (e.g., FitBit) or smartphone apps have more prestige than those who don't.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

26. People who use digital wearable devices (e.g., FitBit) or smartphone apps have a high profile.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

27. Between the people I know, the use of digital wearable devices (e.g., FitBit) or smartphone apps are a status symbol.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

28. I know how to find helpful resources on the internet.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

29. I know how to use the internet to answer my health questions.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

30. I know what health resources are available on the internet.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

31. I know where to find helpful resources on the internet.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

32. I know how to use the health information I find on the internet to help me.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

33. **I have the skills I need to evaluate health resources I find on the internet.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

34. **I can tell high quality from low quality health resources on the internet.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

35. **I feel confident in using information on the internet to make health decisions.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

36. **I can achieve my health information goals on the Internet while helping other users achieve theirs.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

37. **I have the skills I need to talk about health topics on the Internet with multiple users at the same time.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

38. **I can identify the emotional tone of a health conversation on the Internet.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

39. **I have the skills I need to contribute to health conversations on the Internet.**

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

40. I have the skills I need to build personal connections with other Internet users who share health information.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

41. I would be comfortable using an internet-connected device several times a week toparticipate in a lifestyle intervention online.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
☐	☐	☐	☐	☐	☐

42. I feel that my previous experiences with online technologies are important to mysuccess with using a lifestyle intervention.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
☐	☐	☐	☐	☐	☐

43. Using internet technologies makes me more efficient in my daily functioning.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
☐	☐	☐	☐	☐	☐

44. I believe that I am able to make good use of internet websites and web applications.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
☐	☐	☐	☐	☐	☐

45. Using internet technologies provide me with a feeling of independence.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
☐	☐	☐	☐	☐	☐

46. I enjoy the challenge of figuring out the different functions of websites and web applications.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
☐	☐	☐	☐	☐	☐

47. I use an internet connected device to keep track of my lifestyle (e.g., daily tasks, goals, and meetings).

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
☐	☐	☐	☐	☐	☐

SECTION 3

The following pages contain a brochure of a digitial diabetes prevention programme, an intervention designed to assist people in improving their eating and physical activity behaviours, managing their weight, and preventing type 2 diabetes.

Please read the brochure carefully before proceeding to SECTION 4 which contains statements about the programme.

As before, please indicate how much you agree or disagree with each statement. As these are your own views, there are no 'right' or 'wrong' answers in this section.

SECTION 4

Please tick one box per statement.

48. Using the programme would help me to improve my fitness.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

49. Using the programme would help me to improve my diet.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

50. Using the programme would help me to manage my weight.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

51. Using the programme would help me to prevent diabetes.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

52. Learning how to use the programme would be clear and understandable.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

53. Using the programme would not require a lot of mental effort.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

54. The programme tools seem to be easy to use.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

55. I would it find it easy to get the programme tools to do what I want them to do.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

56. Using the programme would be beneficial.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

57. Using the programme would be unpleasant.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

58. Using the programme is a good idea.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

59. Using the programme would be enjoyable.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

60. Assuming the programme is available, I intend to use it.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

61. Given that the programme is available, I predict I would use it.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

Appendix F: Research Ethics Committee Approval Notice (Studies Two and Three)

NUI Galway
OÉ Gaillimh

NUIG RESEARCH ETHICS COMMITTEE DECISION LETTER

REC Application Reference Number: **20-Apr-15**
Title: **Factors and Experiences Influencing the Attitudes Toward, and Acceptance of a Digital Diabetes Prevention Intervention: A Mixed Methods Study of Adults at Risk of Developing Type 2 Diabetes and General Practitioners.**
Principle Applicant: **Luke Van Rhoon**
Application Type: **New**
Meeting Date: **27 April 2020**
Decision: **APPROVAL**

06 May 2020

Dear Mr Van Rhoon,

I write to you regarding the above proposal which was submitted for ethical review. I am pleased to inform you that your proposal has been granted full **APPROVAL.**

1. It is understood that if a participant is worried about their diabetes (actual or possible) they should contact their GP. However they might find a GP in the present circumstances would consider their risk factor would not be sufficient to merit an appointment. In which case maybe they should take their reading from the FINDRISC diabetes screening tool off the web site of the same and practise diet, weight loss and exercise until the Covid-19 high emergency decreases.
2. Likewise in the present situation GPs are facing a lot of demands and their attention to participating in this research at this stage might be less than in normal times. It is recommended that the researcher adds a note indicating that the Researcher is aware that what might be asked of them at this time may be an additional burden. Alternatively, Is there an option to delay the recruitment of GPs until later in the year when the COVID-19 situation is in a better state of control?
3. It is recommended that the researchers might suggest to participants to take care to wash their hands before attending to any communications arriving through the mail in regard to this study.
4. Given the COVID-19 situation, please consider whether there is risk to the ecological validity of the study as the data collection will occur during 'non-normal' times for all participants?

Please note the following:

1. Any significant alterations to an approved proposal must receive prior approval from the REC prior to implementation. Please request an Amendment Form;
2. You are responsible for notifying the REC in the event of serious or unexpected adverse effects, unforseen circumstances, the termination of the study, and any significant decisions by other Ethics Committees. Section 7 of the REC's Standard Operating Procedures gives further details on instances requiring follow-up reviews, and reporting obligations.
3. All NUI Galway Research Ethic Committee approval is given subject to the Principal Investigator submitting annual and final statements of compliance. See annual and final

statement of compliance forms attached. The first statement is due on or before 06 May 2021.

When the decision was taken I was chairing the meeting, and the following members were also present:

Dr Gordon Bromley	Dr Kate Dawson (Observer)	Dr Alex de Menezes
Dr Sinead Duane	Dr Mark Elliot	Dr Victoria Hogan
Dr Fionnuala Jordan	Dr Martina Kelly	Dr Marie Mahon
Dr Veronica McCauley (VC)	Dr Derek Morris	Dr Judith O'Connell
Dr Maureen O'Sullivan	Dr Stacey Scriver	Dr Eva Szegezdi
Mr Patrick Towers	Dr Jane Walsh	

Yours sincerely

Dr Kevin Davison

Chair, Research Ethics Committee

Appendix G: Recruitment Press Releases (Study Two)

People urged to take part in online Diabetes prevention survey

By **Michael Malone** - October 5, 2020

Researchers from NUI Galway are inviting people to take part in a survey to share their views on Diabetes, diet, exercise and a programme that uses a smartphone app and live health coaching to help people improve their health.

The Prevention of Type 2 Diabetes study is a 15-minute online survey that is open to all people aged over 18 living in Ireland, and the findings will be crucial to developing an online Diabetes Prevention Programme.

Type 2 Diabetes can be prevented through healthy eating and regular physical activity. However, taining healthy behaviours can be challenging, particularly during a pandemic.

“We aim not only to prevent Diabetes, but help people to better manage their diet, exercise, and daily stress in the long run,” said Luke Van Rhoon, PhD Candidate in Health Psychology at NUI Galway.

“This is particularly important as we currently face many new physical and psychological challenges due to the emergence of Covid-19.”

He said that technology is becoming increasingly vital in the self-management of our health and how we communicate with health care professionals, friends, and family.

“Although online Diabetes Prevention Programmes have been successfully implemented in other countries, it is important to create a unique programme that suits the needs of the Irish population.”

This study is funded by the Irish Research Council and is supervised by Professor Molly Byrne and Dr Jenny McSharry, Directors of the Health Behaviour Change Research Group at NUI Galway.

“In Ireland, like in many countries around the world, we are seeing an increasing prevalence of Type 2 Diabetes in the community, linked with growing levels of obesity and lower levels of physical activity,” said Professor Molly Byrne.

“Developing new programmes which people really want to engage with to prevent Diabetes is a priority for our health services.

“Online programmes can overcome some of the challenges affecting face-to-face programmes and we now know from the research that digital health interventions can be effective in increasing physical activity, changing diets and promoting weight loss.

For more information about the Diabetes Prevention Study visit, http://www.pret2d.com/survey or to request a paper-based survey with free return postage, contact Luke Van Rhoon at l.vanrhoon1@nuigalway.ie.

All participants will be entered into a draw to win one of two €100 One4All gift cards. There is also the opportunity to participate in a follow-up phone or video interview study, if participants choose to do so.

Michael Malone

To get in touch with Galway Daily, email editor@galwaydaily.com

NUI Galway seeks participants for diabetes prevention study

galwaybayfm.ie/galway-bay-fm-news-desk/nui-galway-seeks-participants-for-diabetes-prevention-study/

6 October 2020

Galway Bay fm newsroom:

Researchers from NUI Galway are inviting members of the public to take part in a new diabetes study.

Researchers from the School of Psychology want the public to share their views on diabetes, diet, exercise, a programme that uses a smartphone app and live health coaching to help people improve their health.

The Prevention of Type 2 Diabetes study is a 15-minute online survey that's open to anyone over 18 years old, who's living in Ireland.

The investigation aims to develop an online diabetes prevention programme to be delivered nationwide.

According to the Healthy Ireland Survey, over 800 thousand adults over 40 nationwide have, or are at risk at developing type 2 diabetes.

More information about the NUIG study is available online at pret 2 d .com/survey.

Date for the diary:
Next Friday and Saturday is Undergradate Open Day at NUI Galway –
Register your interest now: http://www.nuiglaway.ie/opendays/
We've had a huge response to the interviews recorded with the Ukrainian families in Ballindooley Castle with Sally-Ann Barrett last week. Thanks so much to everyone that contributed in some small way and helped them out. You can listen back to the interviews on our website.
#Ukraine #GalwayTalks

Galway Bay FM's first ever Galway's Greatest Awards 2022 are kicking off this week!
We're looking to recognise the #LocalHeroes in our community. You can nominate the places and services that are the greatest in Galway from beauty salon to breakfast, workplace to gym, hairdresser to hotel, pub to local tradesperson and more.
Get your nominations in now. #linkinbio
Then stay listening for The Galway Greatest Awards with Local Hereos.ie – find a trusted plumber, electrician, locksmith and more in minutes with a 12 month guarantee backed by Bord Gáis Energy.
#GalwaysGreatestAwards #BordGáisEnergy #LocalHeroes

Corrib Oil in Gort are launching their brand new look store and Corrib Deli this Saturday from 12 -2pm.
To celebrate on Mollie in the Morning this week Mollie and Ollie will give away a €100 Corrib Oil Gift Card every day. You can spend your €100 Corrib Gift Card on anything at their 20 service stations including at the new look store in Gort!
Tune in from 6:30am for a chance to enter.
#corribdeli #mollieinthemorning #corriboil @corriboil

NUI Galway Seek Participants for Diabetes Prevention Study

Researchers from the School of Psychology in NUI Galway are inviting people to share their views on Diabetes, diet, physical activity, and a programme that uses a smartphone app and live health coaching to help people improve their health.

The PRE-T2D (Prevention of Type 2 Diabetes) study is a 15-minute online survey that is open to all people aged over 18 living in Ireland and findings will be critical to the development of an online Diabetes Prevention Programme to be delivered in Ireland.

According to the Healthy Ireland Survey, over 800,000 adults over 40 in Ireland either have, or are at risk of developing Type 2 Diabetes. This condition can be prevented through healthy eating and regular physical activity. However, maintaining healthy behaviours can be challenging, particularly during a pandemic.

Luke Van Rhoon, PhD Candidate in Health Psychology, Health Behaviour Change Research Group, NUI Galway, said: "We aim not only to prevent Diabetes, but help people to better manage their diet, exercise, and daily stress in the long run. This is particularly important as we currently face many new physical and psychological challenges due to the emergence of Covid-19. Technology is becoming increasingly vital in the self-management of our health and how we communicate with health care professionals, friends, and family. Although online Diabetes Prevention Programmes have been successfully implemented in other countries, it is important to create a unique programme that suits the needs of the Irish population."

This study is funded by the Irish Research Council and is supervised by Professor Molly Byrne and Dr Jenny McSharry, Directors of the Health Behaviour Change Research Group at NUI Galway.

Professor Molly Byrne, said: "In Ireland, like in many countries around the world, we are seeing an increasing prevalence of Type 2 Diabetes in the community, linked with growing levels of obesity and lower levels of physical activity. Developing new programmes which people really want to engage with to prevent Diabetes is a priority for our health services.

"Online programmes can overcome some of the challenges affecting face-to-face programmes and we now know from the research that digital health interventions can be effective in increasing physical activity, changing diets and promoting weight loss. Our research which is being conducted in collaboration with the National Programme for Diabetes, will provide really important findings to ensure that online Diabetes Prevention programmes which are developed in Ireland are usable by the people who will benefit most from them."

For more information about the Diabetes Prevention Study visit, http://www.pret2d.com/survey or to request a paper-based survey with free return postage, contact Luke Van Rhoon at l.vanrhoon1@nuigalway.ie.

All participants will be entered into a draw to win one of two €100 One4All gift cards. There is also the opportunity to participate in a follow-up phone or video interview study, if participants choose to do so.

Previous Post

Pharmacists welcome decision to allow them to vaccinate outside the pharmacy premises

Next Post

Minister for Health to introduce range of affordable healthcare measures next month

Are Viruses the Underlying Cause of Chronic Fatigue?

Daffodil Day, Friday March 25th

Obesity drug which can lower body weight by 3-4 stone approved for patient use

RECOMMENDED NEWS

Pharmacists urge Rethink on Healthcare Spending

Pharmacist Tips to Get Your Immune System in Tune

'Sunshine Vitamin under the Spotlight'

Sligo Pharmacist Hilary Dolan Shortlisted for The People's Pharmacist of the Year 2021

NUI Galway Seek Participants for Diabetes Prevention Study

ct
5

Researchers are asking the public for their views to develop an online programme to support healthy behaviours to prevent Diabetes

)20
ed:
3

Researchers from the School of Psychology in NUI Galway are inviting people to share their views on Diabetes, diet, physical activity, and a programme that uses a smartphone app and live health coaching to help people improve their health.

The PRE-T2D (Prevention of Type 2 Diabetes) study is a 15-minute online survey that is open to all people aged over 18 living in Ireland and findings will be critical to the development of an online Diabetes Prevention Programme to be delivered in Ireland.

According to the Healthy Ireland Survey, over 800,000 adults over 40 in Ireland either have, or are at risk of developing Type 2 Diabetes. This condition can be prevented through healthy eating and regular physical activity. However, maintaining healthy behaviours can be challenging, particularly during a pandemic.

Luke Van Rhoon, PhD Candidate in Health Psychology, Health Behaviour Change Research Group, NUI Galway, said: "We aim not only to prevent Diabetes, but help people to better manage their diet, exercise, and daily stress in the long run. This is particularly important as we currently face many new physical and psychological challenges due to the emergence of Covid-19. Technology is becoming increasingly vital in the self-management of our health and how we communicate with health care professionals, friends, and family. Although online Diabetes Prevention Programmes have been successfully implemented in other countries, it is important to create a unique programme that suits the needs of the Irish population."

This study is funded by the Irish Research Council and is supervised by Professor Molly Byrne and Dr Jenny McSharry, Directors of the Health Behaviour Change Research Group at NUI Galway.

Professor Molly Byrne, said: "In Ireland, like in many countries around the world, we are seeing an increasing prevalence of Type 2 Diabetes in the community, linked with growing levels of obesity and lower levels of physical activity. Developing new programmes which people really want to engage with to prevent Diabetes is a priority for our health services.

"Online programmes can overcome some of the challenges affecting face-to-face programmes and we now know from the research that digital health interventions can be effective in increasing physical activity, changing diets and promoting weight loss. Our research which is being conducted in collaboration with the National Programme for Diabetes, will provide really important findings to ensure that online Diabetes Prevention programmes which are developed in Ireland are usable by the people who will benefit most from them."

For more information about the Diabetes Prevention Study visit, http://www.pret2d.com/survey or to request a paper-based survey with free return postage, contact Luke Van Rhoon at l.vanrhoon1@nuigalway.ie.

All participants will be entered into a draw to win one of two €100 One4All gift cards. There is also the opportunity to participate in a follow-up phone or video interview study, if participants choose to do so.

-Ends-

Marketing and Communications Office

PREVIOUS | **NEXT**

red Stories

March 2022

ay welcomes campus for Open

Monday, 14 March 2022

Afghan refugees visit NUI Galway

Wednesday, 9 March 2022

Decarbonisation and just transition focus for NUI Galway's first Global Challenges project

Appendix H: Recruitment Flyer (Study Two)

Have Your Say on Digital Health and Type 2 Diabetes Prevention

Researchers at the National University of Ireland, Galway are investigating the use of smartphone programmes that help people to increase their physical activity, improve nutritional habits, and prevent Type 2 Diabetes.

- **The Pre-T2D study** is seeking **adults living in Ireland** to complete a **15-minute online survey** on your health behaviours, technology experiences, and perceptions of Type 2 Diabetes.
- All participants can go into the draw to **win one of two €100 One4All gift cards.**
- After the survey you will also receive information about our optional 30-minute phone/video call follow-up interviews. All interview participants will receive a €20 One4All gift card.

To complete the survey and find out more about the study, please visit http://www.pret2d.com/survey.
If you require further information please contact Luke, the research lead at: l.vanrhoon1@nuigalway.ie
This email can also be used to request a paper-based survey that comes with free return postage.

Appendix I: Participant Information Sheet (Study Two)

Participant Information Sheet

Overview

The following survey is investigating the attitudes and perceptions people have towards a Diabetes Prevention Programme which uses technology to assist people in improving their eating behaviours and physical activity. Before you decide to begin, it is important that you understand why the research is being done and what it will involve.

Who is doing the research?

The research is being conducted by Luke Van Rhoon, a PhD candidate from the School of Psychology at the National University of Ireland, Galway. The research team also includes Prof. Molly Byrne and Dr. Jenny McSharry of the Health Behaviour Change Research Group at NUI, Galway. This research is supported by the Irish Research Council.

What is the purpose of the research?

Diabetes Prevention Programmes are interventions that educate and assist people in making lifestyle changes to improve their health, such as healthy eating and performing regular physical activity. We are investigating people's attitudes toward type 2 diabetes and digital health (e.g. health websites, phone apps), and perceptions of a Diabetes Prevention Programme that uses technology to help people change their health behaviours.

Why have I been chosen?

You have been chosen because you are an adult living in Ireland who may be considering making healthy lifestyle changes, or simply wish to maintain a healthy lifestyle, and our aim is to inform the development of a digital health programme that is tailored to meet these needs and interests.

What will I have to do?

You will be asked some general personal questions (e.g., height, weight) and current health behaviour questions which will assess whether you may be at risk of developing type 2 diabetes. You will then answer some questions about type 2 diabetes, diet and activity level, and your experience with health technologies and devices. You will then read through an online brochure which presents a Diabetes Prevention Programme before answering some questions related to the programme. You are free to withdraw at any time without giving a reason and without penalty. A decision to withdraw or not to take part will not affect your rights in any way.

What are the advantages and disadvantages of taking part?

The survey includes an assessment of your risk of developing type 2 diabetes within the next 10 years and you will have the option of submitting your email address or alternative contact details to receive your risk score and more information about what it means. A disadvantage is the time you will give to complete the survey. However, you will have the chance to win one of two €100 One4all gift cards which are accepted in over 8,500 stores across Ireland and online.

Will my taking part in the study remain confidential?

Your survey responses will remain anonymous. Your name and contact details will not be linked to your survey responses. Data will not be distributed to a third-party.

What's next?

At the end of the survey you will have the option of submitting your email address or alternative contact information to enter the draw to win one of two €100 One4all gift cards, and/or to express your interest in participating in our follow-up study. For this follow-up study we are looking for survey completers who, based on their risk score, may be at risk of developing type 2 diabetes. This follow up study involves a 30-minute telephone or video call interview for which all participants will receive a €20 One4all gift card. Expressing your interest does not mean you have committed to participate, only that we will send you more information about the study. Submitting your details are optional.

What will happen to the results of the research study?

The results may be published in scientific journals and meetings in the field of health care. We would be happy to send a summary of the findings to you.

Where can I get more information?

If you have any further questions please contact Luke, the lead researcher, using the contact details below. If you have any specific questions on type 2 diabetes or your health in general, please contact your GP.

Luke Van Rhoon

School of Psychology - The National University of Ireland, Galway Phone: 085 126 4297

email: l.vanrhoon1@nuigalway.ie

Appendix J: Participant Consent Form (Study Two)

Participant Consent Form

Research Team: Mr. Luke Van Rhoon, Professor Molly Byrne, Dr. Jenny McSharry

Purpose of Study: To investigate the attitudes and perceptions towards a structured diabetes prevention programme that is delivered using technology (e.g., smartphone).

If you have any questions regarding this consent form or any other questions about this study, please contact Luke Van Rhoon (l.vanrhoon1@nuigalway.ie)

Please initial inside EACH box and sign your name in the space below if you agree with the statements

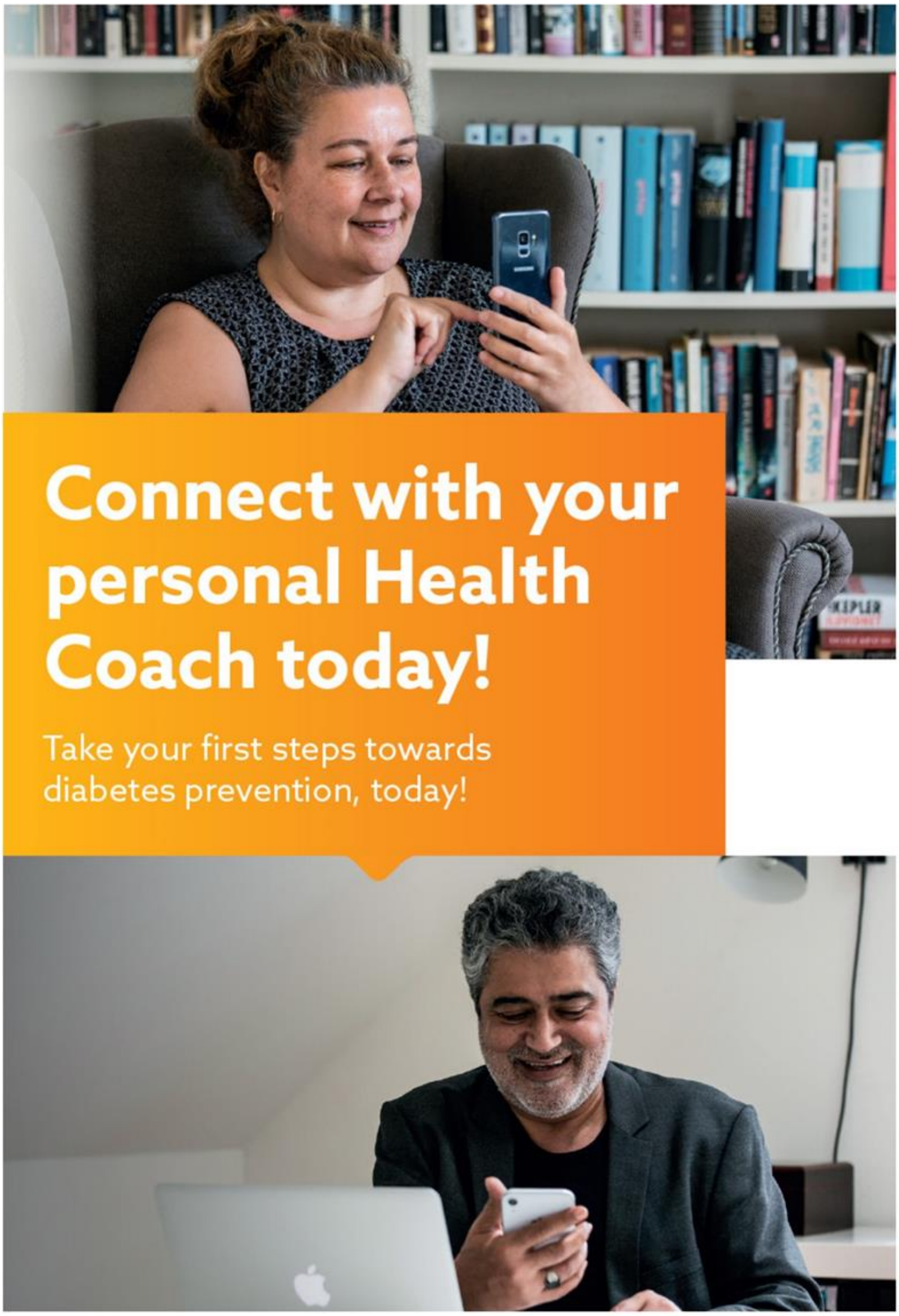
1. I confirm that I have read the document entitled *Participant Information Sheet*. ☐
2. I am satisfied that I understand the information provided and have had enough time to consider the information. ☐
3. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected. ☐
4. I agree to take part in the above study. ☐

Name: ____ (Please use block letters)

Signature: _____________________________________

Date: ______ / ______ / ______

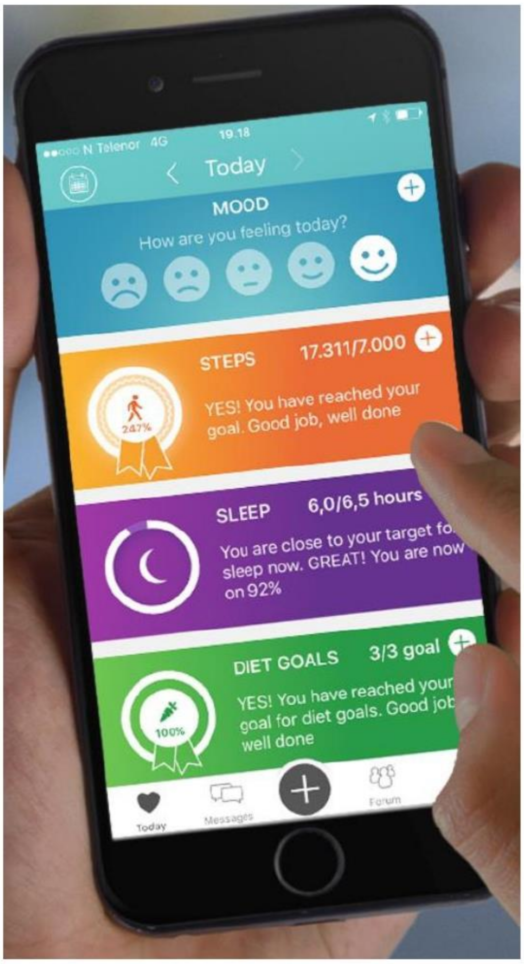
Appendix K: Digital DPP Colour Brochure (Studies Two and Three)



The Liva App: A Personal Coach In your Pocket

The Liva app (available for iPhone and Android) has been built to incorporate lifestyle and behaviour change methodologies and includes the following features:

Self-monitoring of **vital metrics** such as weight, blood sugar levels, mood, sleep, steps, exercise etc.



Logging of **nutritional intake** through taking photos of the food consumed (shared with your own personal coach).

Setup and following of simple goals for **lifestyle change** which get marked off as you achieve them.

Participation in an **online support community** of people with the same challenges enabling mutual support to ensure engagement and continuous motivation.

Ongoing dialogue with a professional **health coach** who will remain with you throughout the programme to secure trust and continuity.

Meet your health coach and set your personalised goals

Choose from a number of our professional and accredited coaches. Liva will then arrange a video meeting with you and your personal coach. Together you agree on some lifestyle goals and log them onto the Liva app.

Tracking

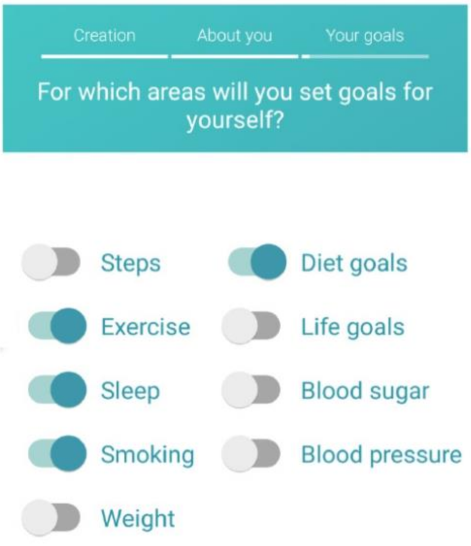
You log and track your progress via the Liva app towards your personal lifestyle goals.

1-2-1 personal coaching

Your health coach keeps in regular contact with you via a private message stream in the app. You can also find support in the community forum, a peer-to-peer communication space.

Sustainable Lifestyle Improvement

Ongoing, personalised 1-2-1 support from your health coach allows you to gradually achieve your goals in a sustainable way, improving your quality of life!

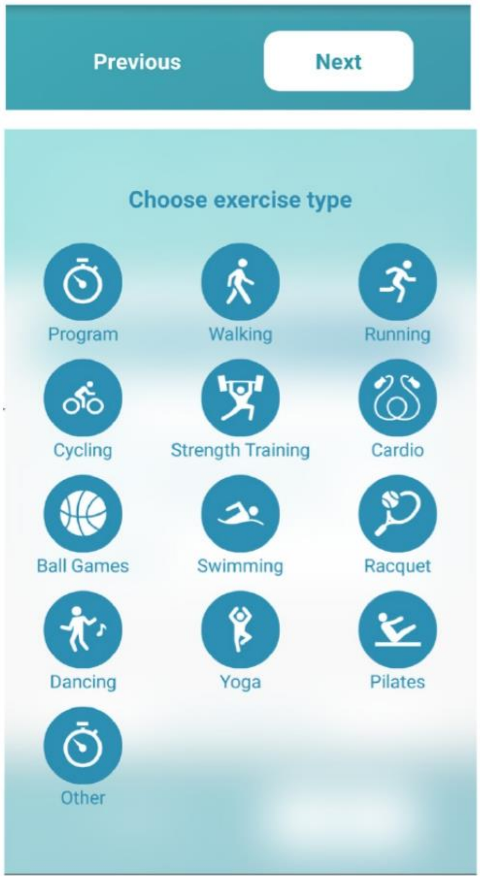


Your goals

Enter which goals you wish to focus on, together with your coach. Each area relates to the prevention of type 2 diabetes.

Goals could include hours of daily sleep, cigarettes per day (if you are a smoker aiming to quit), and weekly weight loss.

You can choose as many goals as you like.



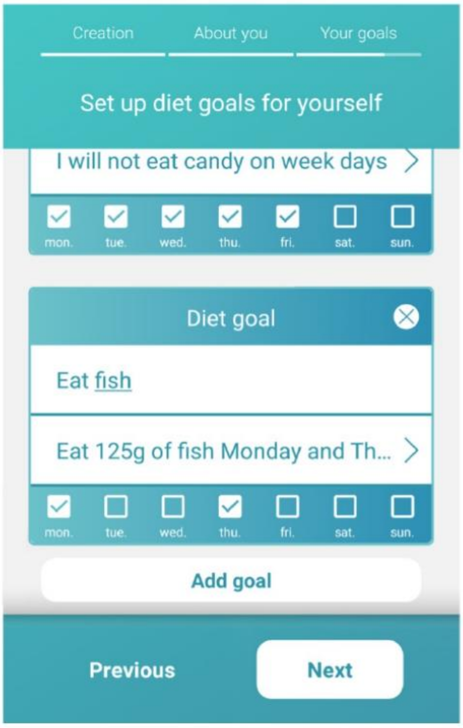
Exercise goals

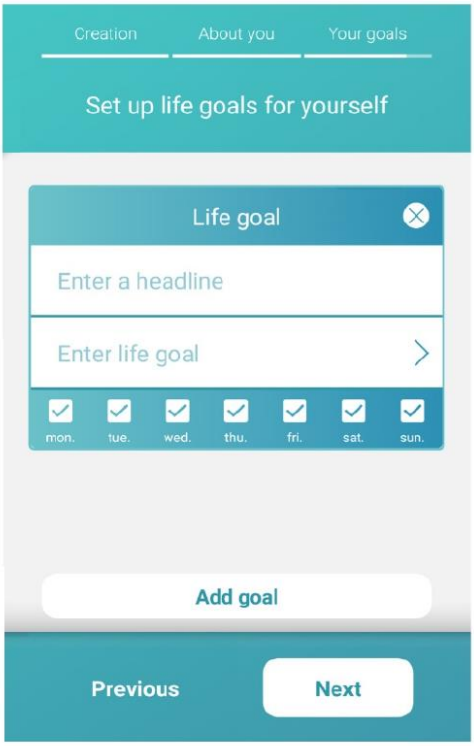
When choosing your exercise goals you can first choose the type(s) of activities you want to focus on.

You then choose how many minutes per week you wish to aim for and leave a description. E.g., if you have chosen “walking” as exercise, you can write “walking the dog” in the description.

You can create even more activities/exercise types.

Steps per day are also measured using your phone’s pedometer. You can also set a daily step goal.





Your diet goals

You can choose a specific diet goal and then select the days you wish to follow this goal.

For example, your goal may be to eat no chocolate at all, or only on one day per week; or aim to eat fruit or vegetables every day.

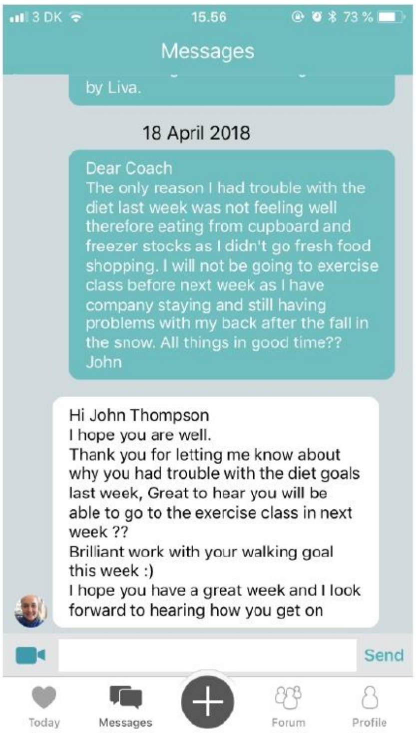
You could also choose to limit your alcohol consumption by setting a weekly goal of having no more than a few drinks per week.

Like all of the other goals, your health coach will assist you in setting diet goals that will help you to improve your health.

Your personal life goals

Your personal life goals are goals that go beyond the other categories. You can add and desribe any life goal you wish.

For example, you may choose to "let go of work during the weekends".



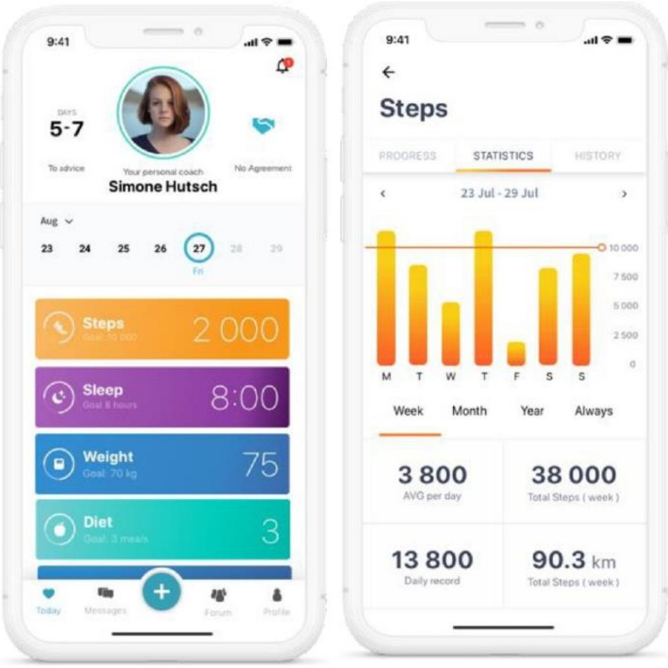
Your health coach

You can communicate with your health coach by sending instant messages or videos. Your health coach will respond by sending you instant messages, videos, or PDFs.

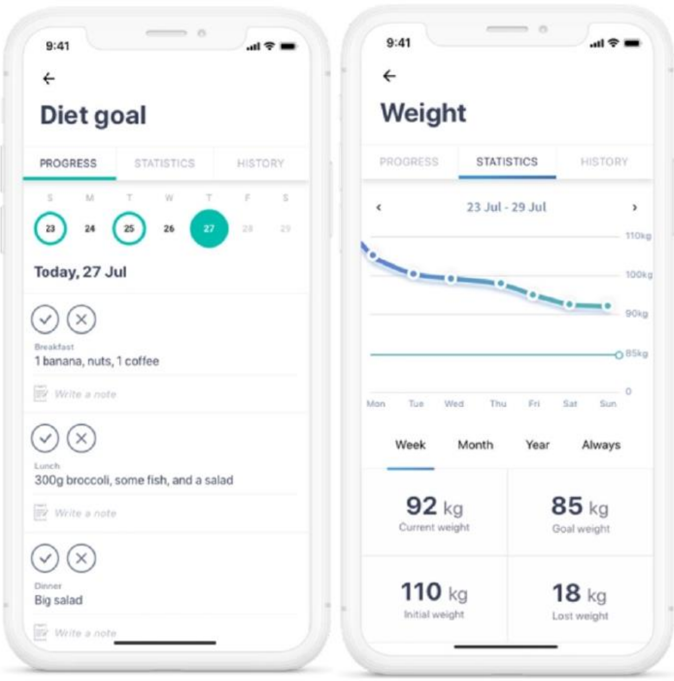
These include educational resources that cover diabetes, lifestyle change, physical activity and exercise, diet, overcoming obstacles, reducing stress, sleep, and creating heathy habits.

Community forum

The forum is the community for other Liva users with an active programme. From here you can chat with other members; for example, arrange to meet up for a walk, or send and receive messages of support and encouragement.



The Liva app tracks your daily, weekly, and monthly progress



Appendix L: COREQ Checklist (Study Three)

No. Item	Description
Domain 1: Research team and reflexivity	
Personal characteristics	
1. Interviewer/facilitator	One researcher (LV) conducted the video interviews.
2. Credentials	Bachelor of Health Sciences (Nutrition, Psychology), Bachelor of Science (Psychological Sciences - Hons.), Master of Health Psychology.
3. Occupation	PhD Candidate.
4. Gender	Male.
5. Experience in training	Trained in qualitative research design, with experience with conducting interviews.
Relationship with participants	
6. Relationship established	LV contacted eligible participants from a previous survey study who had expressed interest in a follow-up interview. Otherwise, participants had no relationship with the researcher.
7. Participant knowledge of the interviewer	Participants were informed that the researcher was a PhD candidate completing a study in the areas of type 2 diabetes mellitus (T2DM) prevention and digital health, and the goal was to explore their views and experiences to inform the development of a digital diabetes prevention programme (DPP) in Ireland.

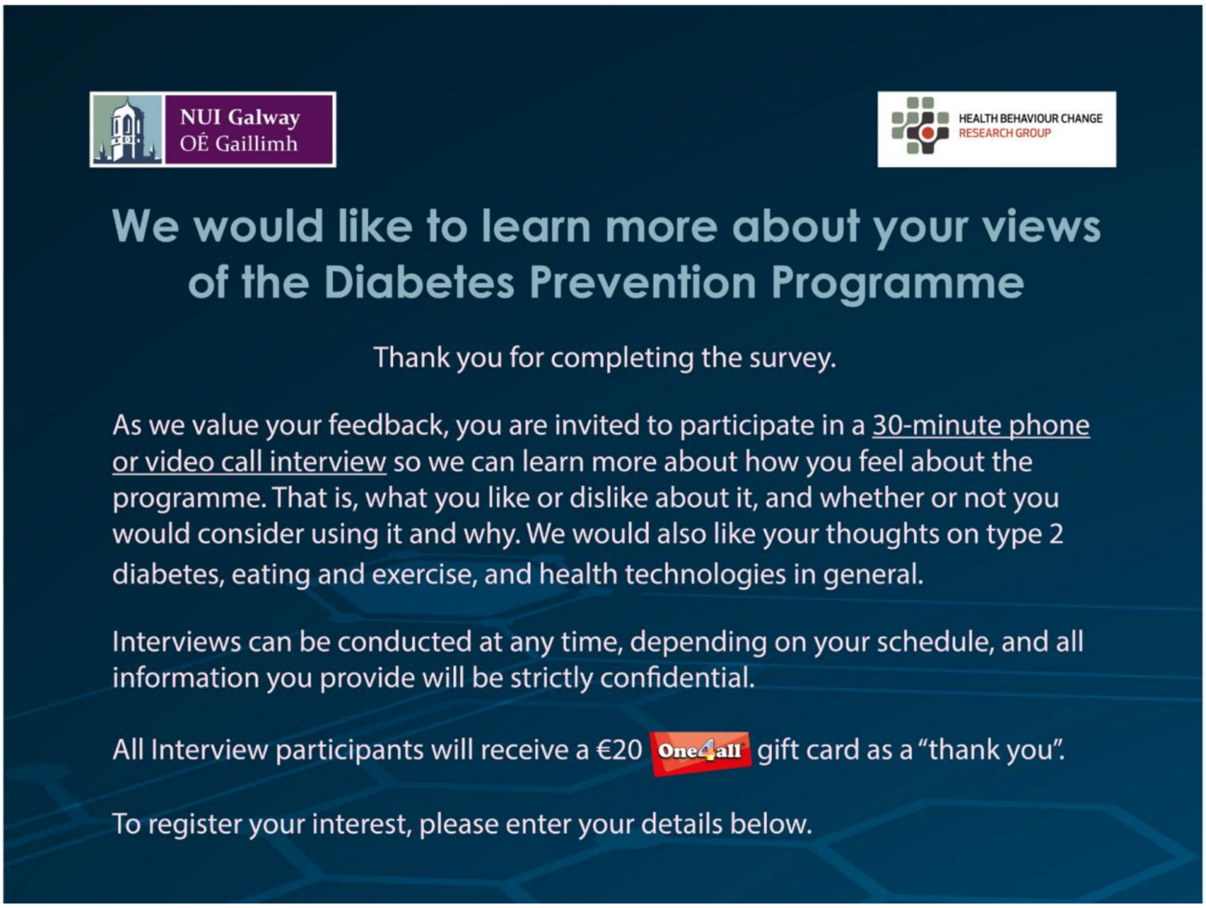
8. Interviewer characteristics	The researcher was closely engaged with the research process and has developed and delivered diet and physical activity interventions for people of the same demographic as participants in this study, therefore personal bias could not be avoided. The researcher aimed to inform the content and communication strategies of a new intervention and reduce the relative risk of T2DM incidence in Ireland.
Domain 2: Study design	
Theoretical framework	
9. Methodological orientation and theory	Deductive and inductive content analysis was applied.
Participant selection	
10. Sampling	English-speaking adults aged 18 and over currently living in the Republic of Ireland who are at risk of developing T2DM by either Body Mass Index (≥25) or FINDRISC score (≥15) and had no previous diagnosis of type 1 or T2DM, were recruited using stratified sampling based on gender, age, BMI, and FINDRISC category.
11. Method of approach	Eligible participants were contacted via email.
12. Sample size	Seventeen women provided informed consent and were interviewed.
13. Non-participation	Of the 37 eligible people contacted for an interview (26 females, 11 males), 17 did not reply (7 females, 10 males), and 3 declined due to work or family commitments (2 females, 1 male). A complete recruitment flowchart can be found in Appendix P.

Setting	
14. Setting of data collection	Interviews were conducted online via Zoom or Microsoft Teams, and audio was recorded. All participants were residing in Ireland at the time of interview.
15. Presence of non-participants	No non-participants were present.
16. Description of sample	The sample of 17 women was predominantly white (*n* =16), and all had completed tertiary education. The mean age was 50 years. Detailed sample characteristics are presented in Table 5.2.
Data collection	
17. Interview guide	The interview guide was developed based on a digital health acceptability model developed by the present authors, and by reviewing qualitative research around T2DM. The guide was then reviewed by the research team, key collaborators, and university research ethics committee, and subsequently pilot tested on one adult at risk of developing T2DM.
18. Repeat interviews	No repeat interviews were conducted.
19. Audio/visual recording	Audio recording was used to obtain the interview data.
20. Field notes	Field notes were taken before, during, and after each interview.
21. Duration	Interview duration ranged between 22 and 45 minutes, with an average duration of 33 minutes.
22. Data saturation	Data saturation was informed by the concept of *information power* (see Malterud et al., 2016). Based on this assessment it was agreed that a sample size of between 14 and 18 participants would achieve sufficient information power. After ten interviews were conducted, transcribed, and reviewed, the researchers performed an assessment of the sample's information power. This process

	was repeated after each subsequent interview until it was decided that after 17 interviews, the information power was sufficient to answer the research questions.
23. Transcripts returned	Transcripts were not returned to participants for comment and/or correction.
Domain 3: Analysis and findings	
Data analysis	
24. Number of data coders	Two researchers (LV and CT) coded and verified the data.
25. Description of coding tree	Coding was conducted through deductive content analysis. Six categorisation matrices befitting the research framework were developed, each containing categories and (where appropriate), sub-categories. Transcripts were read thoroughly, and sections of text were assigned descriptive codes under each relevant category or sub-category. Potentially relevant text that did not fit an existing category or sub-category was coded under prospective new categories. A summary of the deductive content analysis process, including final categorisation matrices and example codes, is presented in Appendix AJ.
26. Derivation of themes	Themes were identified via inductive content analysis, and therefore derived from the data.
27. Software	QSR International's NVivo software (released in March 2020) was used to manage the data.
28. Participant checking	Participants did not provide feedback on the findings.
Reporting	
29. Quotations presented	Participant quotations are presented in the manuscript to illustrate the themes and findings, while additional supporting quotations can be found in appendices AK and AL. Each quotation is identified by a participant number.

30. Data and findings consistent	There is consistency between the data presented and the findings. The unit of analysis was the theme rather than the prevalence or frequency of statements. However, for *desired features for the Digital DPP*, results were based on frequency. Additionally, some statements of quantification are included (e.g., statements such as many, often, some, several), but this is for illustrative purposes only and not to provide estimates of prevalence.
31. Clarity of major themes	Major themes were clearly presented and numbered with unique headings under each of the relevant research topics (categories) and sub-topics (sub-categories). An overview of the content analysis which includes a visual map of the generated themes is presented in Figure 5.2.
32. Clarity of minor themes	Minor themes are also displayed in the overview in Figure 5.2. However, with the view of brevity, sub-theme discussion in the manuscript was integrated into the discussion of their subordinate themes, and thus each sub-theme did not contain its own separate heading.

Appendix M: Recruitment Flyer (Study Three)



Appendix N: Participant Information Sheet (Study Three)

Participant Information Sheet

Overview

You are invited to take part in a study exploring the views and perceptions people have towards type 2 diabetes, health technology and a digital diabetes prevention programme.

Before you decide, it is important that you understand why the research is being done and what it will involve. If there is anything you are not clear about, we will be happy to explain it to you. Please take as much time as you need to read this information. You should only consent to participate in this study when you feel you understand what is being asked of you, and have had enough time to think about your decision.

Who is doing the research?

The research is being conducted by Luke Van Rhoon, a PhD candidate from the School of Psychology at the National University of Ireland, Galway. The research team also includes Professor Molly Byrne and Dr. Jenny McSharry of the Health Behaviour Change Research Group in School of Psychology at NUI, Galway.

What is the purpose of this research?

Diabetes Prevention Programmes are programmes that assist people in making lifestyle changes to improve their health and prevent type 2 diabetes, such as improving eating behaviours and being more physically active. This research is exploring peoples' views of a diabetes prevention programme that is delivered using technology (e.g., phone app). The aim is to inform the development and further improvement of digital health in Ireland by creating a programme that is designed specifically for people living in Ireland.

What will I have to do?

You are invited to take part in a 30-minute interview to discuss your views of Type 2 diabetes, technology, physical activity and diet. The interview will be conducted via video call or telephone.

A few days before the interview you will be sent a small PDF brochure and two short videos that showcase a diabetes prevention programme. You will view these before the interview as you will discuss (during the interview) your opinions of the programme.

What are the advantages and disadvantages of taking part?

The findings of the research will be used to inform the development and tailoring of digital health programmes for people in Ireland. A disadvantage is the time you will give to take part in the focus group. However, at the end of the session you will be sent a €20 One4all gift card to your preferred mailing address as a "thank you" for donating your time.

Will my taking part in the study remain confidential?

In order to accurately capture the discussion, with your permission, the researcher will record audio (if by phone) or video (if by video call) of the session. The dialogue will then be typed up on a computer. Your name and any names or places you mention will be taken out, so that if someone were to read the typed up interview, they would not know who you are. The original recording will be held on a USB stick in a locked cabinet that only the research team can access. The findings from this study will be used in research reports but no names or any other identifying intormation will be included. All quotes from the interview will be anonymous.

What happens if I change my mind?

It is up to you to decide whether or not to take part. If you do decide to take part you will be asked to keep this *Information Sheet* and to read and sign a *Consent Form.* If you decide to take part you are still free to withdraw at any time and without giving a reason. A decision to withdraw, or a decision not to take part, will not affect your rights in any way. Although we hope you participate, your participation is voluntary.

What happens if something goes wrong?

If you have a concern about any aspect of the interview process, please contact Luke Van Rhoon, using the details below. If you remain unhappy with a response, please contact Research Ethics Committee at NUI Galway (ethics@nuigalway.ie).

What will happen to the results of the research study?

The results may be published in scientific journals and meetings in the field of health care. We would be happy to send a summary of the findings to you.

Where can I get more information?

If you would like to take part in the study or if you have any further questions please do not hesitate to get in touch with Luke using the contact details below.

Contact details:

Name:	Mr. Luke Van Rhoon
E-mail:	l.vanrhoon@nuigalway.ie
Telephone:	(085) 126 4297
Address:	Room AMBE G043, School of Psychology, National University of Ireland, Galway, University Road, Galway

THANK YOU FOR TAKING THE TIME TO READ THIS INFORMATION

Appendix O: Participant Consent Form (Study Three)

NUI Galway OÉ Gaillimh — IRISH RESEARCH COUNCIL An Chomhairle um Thaighde in Éirinn — HEALTH BEHAVIOUR CHANGE RESEARCH GROUP

Participant Consent Form

Research Team: Mr. Luke Van Rhoon, Professor Molly Byrne, Dr. Jenny McSharry

Purpose of Study: To explore peoples' views of type 2 diabetes and digital health, and their perceptions of a diabetes prevention programme that uses technology to assist people in changing their health behaviours.

If you have any questions regarding this consent form or any other questions about this study, please contact Luke Van Rhoon (l.vanrhoon1@nuigalway.ie)

Please initial inside EACH box and sign your name in the space below if you agree with the statements

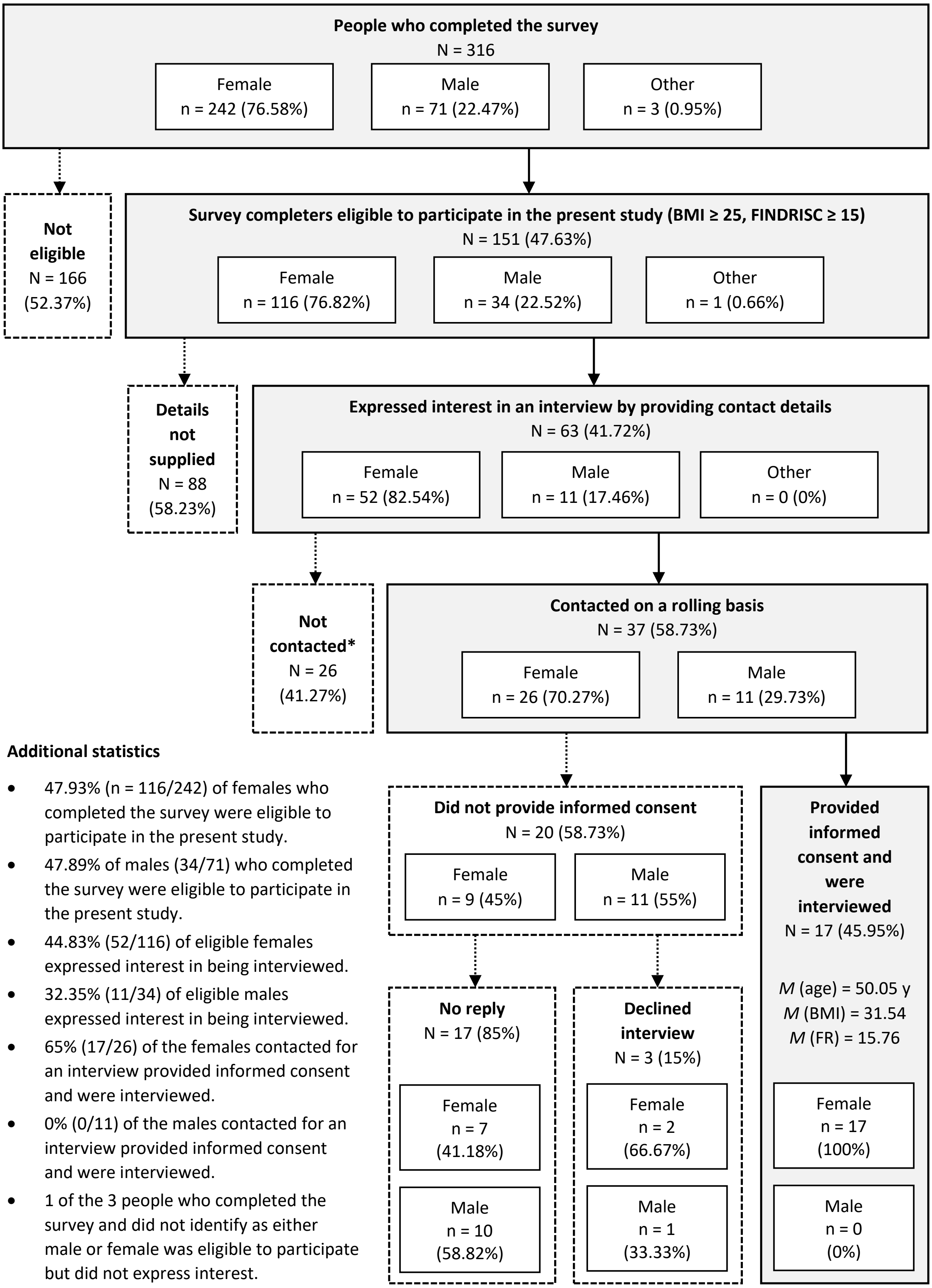
I confirm that I have read and understand the information for this study and have had the opportunity to ask questions.	☐
I agree to take part in this research study and understand that all my details will be kept confidential, and my name will not appear on any reports or documents.	☐
I understand that the interview will be audio-recorded and that only the research team will hear the recording.	☐
I understand that my participation is voluntary and that I am free to withdraw myself or my data at any time without giving any reason and without any adverse consequences or penalty.	☐
I give permission for anonymous quotes from the interview to be included in reports of the findings from the research.	☐

Name: ____ (Please use block letters)

Signature: _____________________________________

Date: ______ / ______ / ______

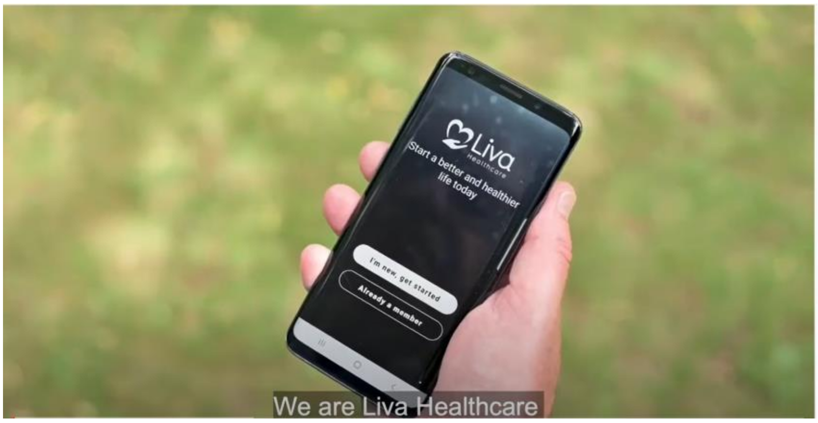
Appendix P: Recruitment Flowchart (Study Three)

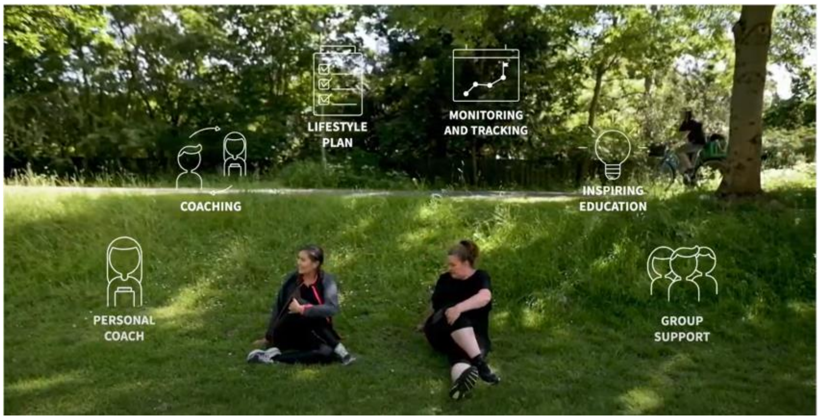


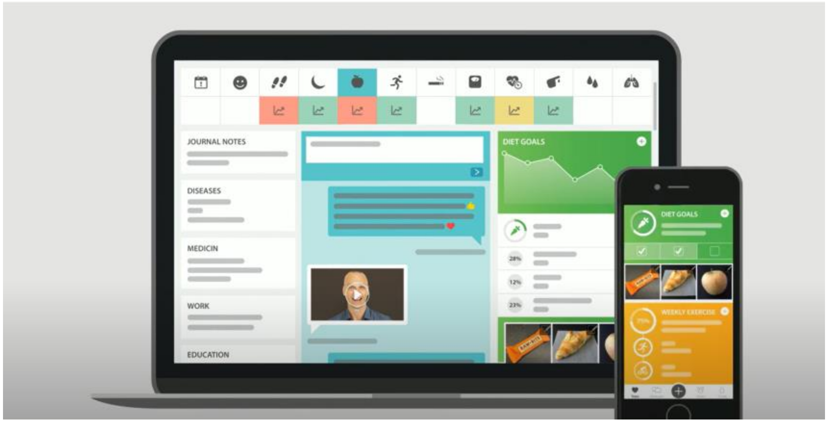
Additional statistics

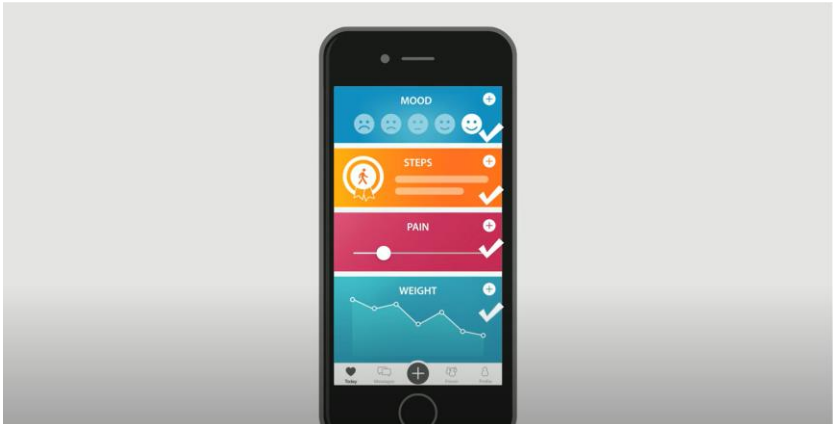
- 47.93% (n = 116/242) of females who completed the survey were eligible to participate in the present study.
- 47.89% of males (34/71) who completed the survey were eligible to participate in the present study.
- 44.83% (52/116) of eligible females expressed interest in being interviewed.
- 32.35% (11/34) of eligible males expressed interest in being interviewed.
- 65% (17/26) of the females contacted for an interview provided informed consent and were interviewed.
- 0% (0/11) of the males contacted for an interview provided informed consent and were interviewed.
- 1 of the 3 people who completed the survey and did not identify as either male or female was eligible to participate but did not express interest.

Appendix Q: Digital DPP Video Screenshots (Study Three)









Appendix R: Interview Topic Guide (Study Three)

The pre-interview starts with a brief introduction on the research and the aims of the study. The participant is asked again if they had viewed the brochure and two videos prior to the interview and if they feel they have a basic idea on what the Digital DPP is all about. The participant is informed that they can choose not to answer a question and/or can end the interview at any time without explanation or penalty. The participant is given the opportunity to ask any questions before the interview begins. Consent to proceed with the interview and to record the audio is again asked before the interview begins and the recording commences.

No.	**Question**	**Additional prompt (where appropriate)**	**Related framework factor**
1	What is your current understanding of type 2 diabetes as a condition?		Knowledge of type 2 diabetes
2	Is type 2 diabetes something that you have thought about in relation to your own health?	Can you share some of these thoughts?	Perceived threat of type 2 diabetes
3	How would you describe your current level of physical activity?	Type, frequency, duration, intensity	
4	What do you feel makes physical activity easy? What helps you remain physically active?		Facilitators to physical activity
5	What type of challenges and barriers do you experience that you feel make it difficult for you to be physically active?		Barriers to physical activity
6	How would you describe your current diet or eating behaviours?	Healthy/unhealthy, snacks, fruit and vegetables, portion size	
7	What do you feel makes it easy to eat healthily?		Facilitators to healthy eating
8	What type of challenges and barriers do you experience that you feel make it difficult for you to eat healthily?		Barriers to healthy eating
9	Has anyone ever suggested that you make changes to your lifestyle to improve your health?	Who? Can you describe your experience?	Social influence on health behaviours

10	What types of lifestyle changes have you made recently to try and improve your health or maintain good health?		Social influence on health behaviours
11	How do you feel about using technologies such as mobile phones, the internet, smartphone apps, or wearable devices in your everyday life?	Confidence in using, enjoyment, need, frequency, duration	
12	How do you feel about using technologies to communicate with other people on health-related issues?	Family/friends/colleagues, work/social	Communicative eHealth literacy
13	How do you feel about using technologies to monitor or help you improve your health?	Confidence in using, enjoyment, need, frequency, duration, usefulness	eHealth readiness
14	What sources of information do you have to learn about health technologies and help you decide what to use?	Can you tell me about this information? Who/where? Can you describe your experience?	Social influence on health technology use
15	Can you tell me about any concerns you have about using health technologies?	Confidence in using, cost, reliability, data security/privacy	eHealth readiness
Participant is asked to refer to the brochure and videos they had viewed on the Digital DPP. They are then informed that the remainder of the interview will be a discussion on their thoughts and perceptions of the programme.			
16	What were your first impressions of the programme?	While reading the brochure and watching the videos, upon reflection, given what has already been discussed	Perceived usefulness
17	What did you like about the programme?	The app, interface, technology, aesthetic, relevance to you	Perceived usefulness
18	What didn't you like about the programme?	The app, interface, technology, aesthetic, relevance to you	Perceived usefulness
19	In what way do you feel this programme would be useful for you?	Prevent T2D, improve health/wellbeing, improve fitness, maintain/lose weight	Perceived usefulness

20	When we talk about "usability" we're basically describing how easy a programme is to use. How would you describe this programme's usability?	The app, the technologies, the materials	Perceived ease of use
21	Would you use a programme like this?	Reasons for this decision	Intention to use the DPP
22	What features should a programme have to make it appealing for you?		Desired features for the digital DPP
Participant is asked if there were anything they would like to would like to add, or if they require more information on anything that was discussed. The participant is thanked for their time.			

Appendix S: Participant T2DM Risk Notification Email (Study Two)

Dear [participant name],

Thank you again for completing the PRE-T2D survey. You are receiving this email as you opted in to receive your Type 2 Diabetes risk score. This score was obtained from the information you provided in the opening section on the survey which is based on the FINDRISC screening questionnaire.

Your FINDRISC score is: [score]

This score suggests that you could be at [low, slightly elevated, moderate, high] risk of developing Type 2 Diabetes.

It is important to note that this score, no matter the number, does not mean that you either have or will develop Type 2 Diabetes. A definitive risk assessment and diagnosis can only be obtained via a blood test. However, if you have any concerns about your score or would like more information about Type 2 Diabetes, please visit the following links and/or speak with your GP.

https://www.diabetes.ie/living-with-diabetes/are-you-at-risk/

https://www.hse.ie/eng/health/az/d/diabetes,-type-2/treating-type-2-diabetes.html

Thank you again once again for participating, your submission will be invaluable as we work towards improving the health of people across the country. Please share the survey link pret2d.com/survey with your family and friends. Everyone can help us to prevent Type 2 Diabetes.

Kind Regards,

Luke Van Rhoon

(Research Lead – PRE-T2D Study)

Appendix T: Reference List for Articles Included in the Systematic Review (Study One)

Study (year)	Reference(s)
Aguiar et al. (2016)	*Aguiar, E. J., Morgan, P. J., Collins, C. E., Plotnikoff, R. C., Young, M. D., & Callister, R. (2016). Efficacy of the type 2 diabetes prevention using lifestyle education program RCT. *American Journal of Preventive Medicine, 50*(3), 353-364. doi: 10.1016/j.amepre.2015.08.020
	Aguiar, E. J., Morgan, P. J., Collins, C. E., Plotnikoff, R. C., Young, M. D., & Callister, R. (2014). The PULSE (Prevention Using LifeStyle Education) trial protocol: a randomised controlled trial of a Type 2 Diabetes Prevention programme for men. *Contemporary Clinical Trials, 39*(1), 132-144. doi: 10.1016/j.cct.2014.07.008
	Aguiar, E. J., Morgan, P. J., Collins, C. E., Plotnikoff, R. C., Young, M. D., & Callister, R. (2017). Process evaluation of the type 2 diabetes mellitus PULSE program randomized controlled trial: recruitment, engagement, and overall satisfaction. *American Journal of Men's Health, 11*(4), 1055-1068. doi: 10.1177/1557988317701783
	Rollo, M. E., Aguiar, E. J., Pursey, K. M., Morgan, P. J., Plotnikoff, R. C., Young, M. D., ... & Callister, R. (2017). Impact on dietary intake of a self-directed, gender-tailored diabetes prevention program in men. *World Journal of Diabetes, 8*(8), 414. doi: 10.4239/wjd.v8.i8.414
	Morgan, P. J., Callister, R., Collins, C. E., Plotnikoff, R. C., Young, M. D., Berry, N., ... & Saunders, K. L. (2012). The SHED-IT community trial: a randomized controlled trial of internet-and paper-based weight loss programs tailored for overweight and obese men. *Annals of Behavioral Medicine, 45*(2), 139-152. doi: 10.1007/s12160-012-9424-z

Study (year)	Reference(s)
Aguiar et al. (2016)	Morgan, P. J., Collins, C. E., Plotnikoff, R. C., McElduff, P., Burrows, T., Warren, J. M., ... & Callister, R. (2010). The SHED-IT community trial study protocol: a randomised controlled trial of weight loss programs for overweight and obese men. *BMC Public Health, 10*(1), 701. doi: 10.1186/1471-2458-10-701
Arens et al. (2018)	*Arens, J. H., Hauth, W., & Weissmann, J. (2018). Novel app-and web-supported diabetes prevention program to promote weight reduction, physical activity, and a healthier lifestyle: observation of the clinical application. *Journal of Diabetes Science and Technology, 12*(4), 831-838. doi: 10.1177/1932296818768621
Block et al. (2015)	*Block, G., Azar, K. M., Romanelli, R. J., Block, T. J., Hopkins, D., Carpenter, H. A., ... & Block, C. H. (2015). Diabetes prevention and weight loss with a fully automated behavioral intervention by email, web, and mobile phone: a randomized controlled trial among persons with prediabetes. *Journal of Medical Internet Research, 17(*10), e240. doi: 10.2196/jmir.4897
	Block, G., Azar, K. M., Block, T. J., Romanelli, R. J., Carpenter, H., Hopkins, D., ... & Block, C. H. (2015). A fully automated diabetes prevention program, Alive-PD: program design and randomized controlled trial protocol. *JMIR Research Protocols, 4*(1), e3. doi: 10.2196/resprot.4046
	Block, G., Azar, K. M. J., Romanelli, R. J., Block, T. J., Palaniappan, L. P., Dolginsky, M., & Block, C. H. (2016). Improving diet, activity and wellness in adults at risk of diabetes: randomized controlled trial. *Nutrition & Diabetes, 6*(9), e231. doi: 10.1038/nutd.2016.42

Study (year)	Reference(s)
Castro Sweet et al. (2018)	*Castro Sweet, C. M., Chiguluri, V., Gumpina, R., Abbott, P., Madero, E. N., Payne, M., ... & Prewitt, T. (2018). Outcomes of a digital health program with human coaching for diabetes risk reduction in a Medicare population. *Journal of Aging and Health, 30(*5), 692-710. doi: 10.1177/0898264316688791
Cha et al. (2014)	*Cha, E., Kim, K. H., Umpierrez, G., Dawkins, C. R., Bello, M. K., Lerner, H. M., ... & Dunbar, S. B. (2014). A feasibility study to develop a diabetes prevention program for young adults with prediabetes by using digital platforms and a handheld device. *The Diabetes Educator*, *40*(5), 626-637. doi: 10.1177/0145721714539736
	Cha, E., Umpierrez, G., Kim, K. H., Bello, M. K., & Dunbar, S. B. (2013). Characteristics of American young adults with increased risk for type 2 diabetes: a pilot study. *The Diabetes Educator*, *39*(4), 454-463. doi: 10.1177/0145721713486199
Estabrooks and Smith-Ray (2008)	*Estabrooks, P. A., & Smith-Ray, R. L. (2008). Piloting a behavioral intervention delivered through interactive voice response telephone messages to promote weight loss in a pre-diabetic population. *Patient Education and Counseling, 72*(1), 34-41. doi: 10.1016/j.pec.2008.01.007
Everett et al. (2018)	*Everett, E., Kane, B., Yoo, A., Dobs, A., & Mathioudakis, N. (2018). A novel approach for fully automated, personalized health coaching for adults with prediabetes: pilot clinical trial. *Journal of Medical Internet Research,* 20(2), e72. doi: 10.2196/jmir.9723
Fischer et al. (2016)	*Fischer, H. H., Fischer, I. P., Pereira, R. I., Furniss, A. L., Rozwadowski, J. M., Moore, S. L., ... & Havranek, E. P. (2016). Text message support for weight loss in patients with prediabetes: a randomized clinical trial. *Diabetes Care, 39*(8), 1364-1370. doi: 10.2337/dc15-2137

Study (year)	Reference(s)
Fukuoka et al. (2015)	*Fukuoka, Y., Gay, C. L., Joiner, K. L., & Vittinghoff, E. (2015). A novel diabetes prevention intervention using a mobile app: a randomized controlled trial with overweight adults at risk. *American Journal of Preventive Medicine, 49*(2), 223-237. doi: 10.1016/j.amepre.2015.01.003
Kramer et al. (2010)	*Kramer, M. K., Kriska, A. M., Venditti, E. M., Semler, L. N., Miller, R. G., McDonald, T., ... & Orchard, T. J. (2010). A novel approach to diabetes prevention: evaluation of the Group Lifestyle Balance program delivered via DVD. *Diabetes Research and Clinical Practice, 90*(3), e60-e63. doi: 10.1016/j.diabres.2010.08.013
Limaye et al. (2017)	*Limaye, T., Kumaran, K., Joglekar, C., Bhat, D., Kulkarni, R., Nanivadekar, A., & Yajnik, C. (2017). Efficacy of a virtual assistance-based lifestyle intervention in reducing risk factors for Type 2 diabetes in young employees in the information technology industry in India: LIMIT, a randomized controlled trial. *Diabetic Medicine, 34*(4), 563-568. doi: 10.1111/dme.13258
Ma et al. (2013)	*Ma, J., Yank, V., Xiao, L., Lavori, P. W., Wilson, S. R., Rosas, L. G., & Stafford, R. S. (2013). Translating the Diabetes Prevention Program lifestyle intervention for weight loss into primary care: a randomized trial. *JAMA Internal Medicine, 173*(2), 113-121. doi: 10.1001/2013.jamainternmed.987 Azar, K. M., Xiao, L., & Ma, J. (2013). Baseline obesity status modifies effectiveness of adapted diabetes prevention program lifestyle interventions for weight management in primary care. *BioMed Research International*, 2013. doi: 10.1155/2013/191209

Study (year)	Reference(s)
Ma et al. (2013)	Ma, J., King, A. C., Wilson, S. R., Xiao, L., & Stafford, R. S. (2009). Evaluation of lifestyle interventions to treat elevated cardiometabolic risk in primary care (E-LITE): a randomized controlled trial. *BMC Family Practice, 10*(1), 71. doi: 10.1186/1471-2296-10-71
	Ma, J., Xiao, L., & Blonstein, A. C. (2013). Measurement of self-monitoring web technology acceptance and use in an e-health weight-loss trial. *Telemedicine and e-Health, 19*(10), 739-745. doi: 10.1089/tmj.2013.0009
	Xiao, L., Yank, V., Wilson, S. R., Lavori, P. W., & Ma, J. (2013). Two-year weight-loss maintenance in primary care-based Diabetes Prevention Program lifestyle interventions. *Nutrition & Diabetes, 3*(6), e76. doi: 10.1038/nutd.2013.17
Michaelides et al. (2016)	*Michaelides, A., Raby, C., Wood, M., Farr, K., & Toro-Ramos, T. (2016). Weight loss efficacy of a novel mobile Diabetes Prevention Program delivery platform with human coaching. *BMJ Open Diabetes Research and Care, 4*(1), e000264. doi: 10.1136/bmjdrc-2016-000264
	Michaelides, A., Major, J., Pienkosz Jr, E., Wood, M., Kim, Y., & Toro-Ramos, T. (2018). Usefulness of a novel mobile diabetes prevention program delivery platform with human coaching: 65-week observational follow-up. *JMIR mHealth and uHealth, 6*(5), e93. doi: 10.2196/mhealth.9161
Piatt et al. (2013)	*Piatt, G. A., Seidel, M. C., Powell, R. O., & Zgibor, J. C. (2013). Comparative effectiveness of lifestyle intervention efforts in the community: results of the Rethinking Eating and ACTivity (REACT) study. *Diabetes Care, 36*(2), 202-209. doi: 10.2337/dc12-0824

Study	Reference(s)
Piatt et al. (2013)	Piatt, G. A., Seidel, M. C., Powell, R. O., & Zgibor, J. C. (2016). Influence of patient-centered decision making on sustained weight loss and risk reduction following lifestyle intervention efforts in rural Pennsylvania. *The Diabetes Educator, 42*(3), 281-290. doi: 10.1177/0145721716636962
Ramachandran et al. (2013)	*Ramachandran, A., Snehalatha, C., Ram, J., Selvam, S., Simon, M., Nanditha, A., ... & Oliver, N. (2013). Effectiveness of mobile phone messaging in prevention of type 2 diabetes by lifestyle modification in men in India: a prospective, parallel-group, randomised controlled trial. *The Lancet Diabetes & Endocrinology, 1(*3), 191-198. doi: 10.1016/S2213-8587(13)70067-6
Sepah et al. (2014)	*Sepah, S. C., Jiang, L., & Peters, A. L. (2014). Translating the diabetes prevention program into an online social network: validation against CDC standards. *The Diabetes Educator, 40*(4), 435-443. doi: 10.1177/0145721714531339
	Sepah, S. C., Jiang, L., Ellis, R. J., McDermott, K., & Peters, A. L. (2017). Engagement and outcomes in a digital Diabetes Prevention Program: 3-year update. *BMJ Open Diabetes Research and Care, 5*(1), e000422. doi: 10.1136/bmjdrc-2017-000422
	Sepah, S. C., Jiang, L., & Peters, A. L. (2015). Long-term outcomes of a Web-based diabetes prevention program: 2-year results of a single-arm longitudinal study. *Journal of Medical Internet Research, 17*(4), e92. doi: 10.2196/jmir.4052
	Su, W., Chen, F., Dall, T. M., Iacobucci, W., & Perreault, L. (2016). Return on Investment for Digital Behavioral Counseling in Patients With Prediabetes and Cardiovascular Disease. *Preventing Chronic Disease, 13*, E13. doi:10.5888/pcd13.150357

Study	Reference(s)
Tate et al. (2003)	*Tate, D. F., Jackvony, E. H., & Wing, R. R. (2003). Effects of Internet behavioral counseling on weight loss in adults at risk for type 2 diabetes: a randomized trial. *JAMA, 289*(14), 1833-1836. doi: 10.1001/jama.289.14.1833
Wong et al. (2013)	* Wong, C. K., Fung, C. S., Siu, S. C., Lo, Y. Y., Wong, K. W., Fong, D. Y., & Lam, C. L. (2013). A short message service (SMS) intervention to prevent diabetes in Chinese professional drivers with pre-diabetes: a pilot single-blinded randomized controlled trial. *Diabetes Research and Clinical Practice, 102*(3), 158-166. doi: 10.1016/j.diabres.2013.10.002
Wilson et al. (2017)	* Wilson, M. G., Sweet, C. M. C., Edge, M. D., Madero, E. N., McGuire, M., Pilsmaker, M., ... & Kirschner, S. (2017). Evaluation of a digital behavioral counseling program for reducing risk factors for chronic disease in a workforce. *Journal of Occupational and Environmental Medicine, 59*(8), e150. doi: 10.1097/JOM.0000000000001091

*Main study paper

Appendix U: Quality Assessment Summaries for All Studies (Study One)

Checklist criteria		Aguiar (2016)	Arens (2018)	Block (2015)	Castro Sweet (2017)	Cha (2014)	Estabrooks (2008)	Everett (2018)	Fischer (2016)	Fukuoka (2015)	Kramer (2010)	Limaye (2017)	Ma (2013)	Michaelides (2016)	Piatt (2013)	Ramachandran (2013)	Sepah (2014)	Tate (2003)	Wilson (2017)	Wong (2013)
1.1	Source population or area well described	++	+	++	+	++	++	++	++	++	++	++	++	+	++	++	+	++	++	++
1.2	Eligible population or area representative	++	+	++	+	++	+	+	++	++	++	++	+	+	++	++	+	+	++	++
1.3	Selected participants or areas representative	++	+	++	++	+	++	++	++	+	+	+	+	+	++	++	+	+	++	++
2.1	Allocation: selection bias minimised	++	+	++	NA	NA	++	+	++	++	+	++	++	NA	+	++	NA	++	NA	++
2.2	Interventions (& comparisons) well described & appropriate	++	+	++	++	++	++	++	++	++	++	++	++	+	++	++	++	++	++	++
2.3	Allocation concealed	++	NR	NR	NA	NA	NR	+	NR	++	NA	NR	NR	NA	+	+	NA	NR	NA	+
2.4	Participants &/or investigators blinded	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.5	Exposure to intervention & comparison adequate	++	+	++	NA	NA	++	++	++	++	++	++	++	NA	+	++	NA	++	NA	++
2.6	Contamination Acceptably low	++	++	++	NA	NA	++	++	+	++	++	++	++	NA	++	++	NA	++	NA	++
2.7	Other interventions similar in groups	++	++	++	NA	NA	++	+	+	++	++	++	+	NA	+	++	NA	++	+	++
2.8	All participants accounted for at study conclusion	++	+	++	++	++	+	++	++	++	+	+	++	++	+	++	+	++	+	+

2.9	Setting reflects usual UK practice	+	++	++	+	+	++	+	++	++	++	+	++	+	+	+	+	+	+	+
2.10	Intervention or control reflects usual UK practice	+	++	++	+	+	++	+	++	++	++	+	++	+	+	+	+	++	+	+
3.1	Outcome measures reliable	++	+	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
3.2	Outcome measures complete	++	++	++	+	++	++	++	++	++	++	++	++	++	++	++	+	++	+	+
3.3	All important outcomes assessed	++	+	++	++	++	++	++	++	++	++	++	++	+	++	+	++	++	++	++
3.4	Outcomes relevant	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
3.5	Similar follow-up times in groups	++	+	++	NA	NA	++	++	++	++	++	++	++	NA	++	++	NA	++	NA	++
3.6	Follow-up time meaningful	+	+	+	++	+	+	+	++	+	+	++	++	+	++	++	++	++	++	++
4.1	Groups similar at baseline	++	+	++	NA	NA	++	+	++	++	+	++	++	NA	++	++	NA	++	NA	++
4.2	ITT analysis conducted	++	+	++	++	+	++	+	++	++	++	++	++	++	++	++	++	++	++	++
4.3	Study sufficiently powered	++	+	+	NR	+	NR	+	++	++	++	++	++	++	++	++	NR	+	NR	NR
4.4	Estimates of effect size given or calculable	++	++	+	++	++	++	++	+	++	++	++	++	++	+	++	++	++	++	++
4.5	Analytical methods appropriate	++	+	++	++	++	+	++	+	++	++	++	++	++	++	++	+	++	++	++
4.6	Precision of intervention effects given or calculable	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
5.1	Study results internally valid (i.e. unbiased)	++	+	++	++	+	++	+	++	++	++	++	++	++	+	++	++	++	++	++
5.2	Findings generalisable to source population (i.e. externally valid)	++	+	++	+	+	++	+	++	+	++	++	+	+	++	++	+	+	++	++

Appendix V: The Proportion of Baseline Weight Lost at Each Follow-Up for Interventions Included in the Primary Effectiveness Analysis (Study One)

Study (year) *Intervention*	Follow-up point									
	Short Term				Long Term					
	3 months	16 weeks	5 months	6 months	12 months	15 months	65 weeks	18 months	24 months	36 months
Aguiar (2016)	**-3.74%**	-	-	**-4.85%**	-	-	-	-	-	-
Block (2018)	-	-	-	**-3.60%**	-	-	-	-	-	-
Castro Sweet (2017)	-	**-6.5%**	-	**-8.0%**	**-7.5%**	-	-	-	-	-
Cha (2014)*	-2.50%	-	-	-	-	-	-	-	-	-
Estabrooks (2008)	-2.63%	-	-	-	-	-	-	-	-	-
Everett (2018)*	-1.9%	-	-	-	-	-	-	-	-	-
Fischer (2016)		-	-	-1.93%	-1.35%	-	-	-	-	-
Fukuoka (2015)	**-5.8%**	-	**-6.8%**	-	-	-	-	-	-	-
Kramer (2010)	**-5.6%**	-	-	-	-	-	-	-	-	-
Limaye (2017)	-0.73%	-	-	-1.48%	-1.35%	-	-	-	-	-
Ma (2013)	**-4.9%**	-	-	**-4.7%**	-	**-5.0%**	-	-	-	-
Michaelides (2016)	-	**-5.65% (S)** **-6.33% (C)**	-	**-6.58% (S)** **-7.50% (C)**	-	-	**-6.15% (S)** **-7.36% (C)**	-	-	-
Piatt (2013) *DVD*	**-5.67%**		-	**-3.49%**	-	-	-	-4.6%	-	-
Piatt (2013) *Internet*	**-6.26%**		-	**-3.11%**	-	-	-	**-5.25%**	-	-
Sepah (2014)	-	**-5.0% (S)** **-5.2% (C)**	-	-	-4.7% (S) -4.9% (C)	-	-	-	-4.2% (S) -4.3% (C)	-3.0% (S) -2.9% (C)
Tate (2003) *BI*	**-3.02%**	-	-	-2.80%	-2.24%	-	-	-	-	-
Tate (2003) *BeC*	**-4.76%**	-	-	**-6.03%**	-4.8%	-	-	-	-	-
Wilson (2017)	-	**-4.6%**	-	-	-0.93%	-	-	-	-	-
Wong (2013)	-	-	-	-0.69%	-1.57%	-	-	-	-1.47%	-

Note: S: starters, defined as participants who read at least one article during any 4 of the 16 initial intervention weeks, C: Completers, defined as participants who read at least one article per week during any 9 of the 16 weeks. Bold text denotes clinically significant weight loss.
*Studies that applied per-protocol or similar analyses only, rather than intention-to-treat.

Appendix W: Mean Changes in Body Weight and Glycaemia from Baseline to Most Recent Follow-up (Study One)

Author(s) (year) *Intervention*	Weight change	Proportion of sample that achieved target weight loss‡	Change in A1c	Change in Fasting Glucose
Aguiar et al. (2016)	*At 6 months* Intervention (n = 53) -5 kg (p < .05)* Control (n = 48) +0.5 kg (p > .05) [p < .001, d = 1.15]*	*At 6 months* 5% weight loss Intervention: 42.1% Control: 4.8% [p < .001]*	*At 6 months* Intervention (n = 53) -0.4% (p < .05)* Control (n = 48) -0.2% (p < .05)* [p = .002, d = 0.64]*	*FPG at 6 months* Intervention (n = 53) -0.08 mmol/L (p > .05) Control (n = 48) -0.03 mmol/L (p > .05) [p = .742, d = 0.07]
Arens et al. (2018) †	*Intervention: At 8.3 months* *Standard care: at 11.6 months* Intervention (n = 109) -2.4 kg (p < .0001)* Standard Care (n = 57) -0.01kg (p = .99) [p = .057] adj. for baseline	*Over time* Chance to achieve 5% weight reduction. Intervention: 6.2 times greater than Standard Care	Not Reported	Not Reported
Block et al. (2015)	*At 6 months* Intervention (n = 163) -3.3 kg Control (n = 176) -1.26 kg [p < .001]*	*At 6 months* 5% weight loss Intervention: 35.3% Control: 8.3%	*At 6 months* Intervention (n = 163) -0.26% Control (n = 176) -0.18% [p < .001]*	*FG at 6 months* Intervention (n = 163) -0.41 mmol/L Control (n = 176) -0.12 mmol/L [p < .001]*
Castro Sweet et al. (2018)	*At 12 months* Intervention (n = 501) -7.1 kg (p = .001)* Control: NA	Not Reported	*At 12 months* Intervention (n = 69) -0.14% (p = .0001)* Control: NA	Not Reported

Author(s) (year) *Intervention*	Weight change	Proportion of sample that achieved target weight loss‡	Change in A1c	Change in Fasting Glucose
Cha et al. (2014) †	*At 3 months* Intervention (*n* = 13) -2.9 kg (*p* = .031, *d* = -0.12)* Control: NA	Not Reported	*At 3 months* Intervention (*n* = 13) -0.4% (*p* = .007, *d* = -0.76)* Control: NA	*FG at 3 months* Intervention (*n* = 13) +0.28 mmol/L (*p* = .112, *d* = 0.39) Control: NA
Estabrooks and Smith-Ray (2008)	*At 3 months* Intervention (*n* = 28) -2.3 kg Control (*n* = 31) -2 kg [*p* = .13] [when adjusting for baseline values]	Not Reported	Not Reported	Not Reported
Everett et al. (2018) †	*At 3 months* Intervention (*n* = 38) -1.6 kg (*p* = .02)* Calibration (*n* = 9): not reported	Not Reported	*At 3 months* *Change in median values* Intervention (*n* = 38) -0.10% (*p* = .04)* Calibration (*n* = 9): not reported	*FG at 3 months* *Change in median values* Intervention (*n* = 38) -0.01 mmol/L (*p* = .59) Calibration (*n* = 9): not reported
Fischer et al. (2016)	*At 12 months* Intervention (*n* = 78) -2.6 lbs Control (*n* = 79) -0.56 lbs [*p* = .05]	*At 12 months* 5% weight loss Intervention: 38.5% Control: 21.5% [*p* = .02]*	*At 12 months* Intervention (*n* = 78) -0.09% Control (*n* = 79) +0.19% [*p* = .07]	Not Reported
Fukuoka et al. (2015)	*At 5 months* Intervention (*n* = 30) -6.2 kg Control (*n* = 31) +0.3 kg [*p* < .001]*	*At 5 months* 10% weight loss Intervention: 29% Control: 0%	*At 5 months* Intervention (*n* = 30) -0.10% Control (*n* = 31) -0.04% [*p* = .25]	*FPG at 5 months* Intervention (*n* = 30) -0.02 mmol/L Control (*n* = 31) +0.02 mmol/L [*p* = .63]

Author(s) (year) *Intervention*	Weight change	Proportion of sample that achieved target weight loss‡	Change in A1c	Change in Fasting Glucose
Kramer et al. (2010)	*At 3 months* DVD (*n* = 22) -5.4 kg (*p* < .0001)* Face-to-face (*n* = 26) -6.3 kg (*p* < .0001)*	Not Reported	*At 3 months* DVD (*n* = 21) -0.16% (*p* = .002)* Face-to-face (*n* = 26) -0.31% (*p* < .0001)*	*FG at 3 months* DVD (*n* = 21) -0.26 mmol/L (*p* = .003)* Face-to-face (*n* = 26) +0.06 mmol/L (*p* = .098)
Limaye et al. (2017)	*At 12 months* Intervention (*n* = 133) -1 kg Control (*n* = 132) +0.7 kg [*p* < .001]*	Not Reported	Not Reported	*FPG at 12 months* Intervention (*n* = 133) +0.19 mmol/L Control (*n* = 132) +0.33 mmol/L [*p* = .022]*
Ma et al. (2013)	*At 15 months* Self-directed (*n* = 81) -4.5 kg Coach-led (*n* = 79) -6.3 kg Usual Care (*n* = 81) -2.4.kg Self-directed vs Usual Care [*p* = .02]*	*At 15 months* 5%, 7%, and 10% weight loss Intervention: 46.9%, 37.6%, and 17.2% Usual care: 24.6%, 14.7%, and 3.5% [*p* = .007*, *p* = .006*, and p = .01*]	Not Reported	*FPG at 15 months* Self-directed (*n* = 81) -0.15 mmol/L Coach-led (*n* = 79) -0.23 mmol/L Usual Care (*n* = 81) +0.01 mmol/L Self-directed vs Usual Care [*p* = .01]*
Michaelides et al. (2016)	*At 65 weeks* Starters (*n* = 59) -5.9 kg (*p* < .001)* Completers (*n* = 47) -7.1 kg (*p* < .001)*	Not Reported	Not Reported	Not Reported

Author(s) (year) *Intervention*	Weight change	Proportion of sample that achieved target weight loss‡	Change in A1c	Change in Fasting Glucose
Piatt et al. (2013) *GLB-DVD*	*At 18 months* DVD (n = 64) -4.5 kg (p < .0001)* Internet (n = 44) -5.2 kg (p < .0001)* Face-to-face (n = 96) -4.9 kg (p < .0001)* Self-selected (n = 56) -5.9 kg (p < .0001)*	*At 6 months* 5% weight loss DVD: 51.5% Internet: 57.1% F2F: 51.9% SS: 66.7%	Not Reported	Not Reported
Piatt et al. (2013) *GLB-Internet*	*At 18 months* Internet (n = 44) -5.2 kg (p < .0001)* DVD (n = 64) -4.5 kg (p < .0001)* Face-to-face (n = 96) -4.9 kg (p < .0001)* Self-selected (n = 56) -5.9 kg (p < .0001)*	*At 6 months* 5% weight loss Internet: 57.1% DVD: 51.5% F2F: 51.9% SS: 66.7%	Not Reported	Not Reported
Ramachandran et al. (2013)	Not Reported	Not Reported	Not Reported	*FPG at 5 years* Intervention (n = 171) +0.4 mmol/L Control (n = 157) +0.2 mmol/L [*not significant*]
Sepah et al. (2014)	*At 3 years* Core (n = 187) -3 kg (p = .0009)* Post-core (n = 144) -2.9 kg (p = .0024)*	*At 12 months* 5% weight loss Core: not reported Post-core: 47%	*At 3 years* Core (n = 187) -0.31% (p = .0008)* Post-core (n = 155) -0.33% (p = .0005)*	Not Reported

Author(s) (year) *Intervention*	Weight change	Proportion of sample that achieved target weight loss‡	Change in A1c	Change in Fasting Glucose
Tate et al. (2003) *Basic Internet*	*At 12 months* Basic Int (*n* = 46) -2 kg Int + BeC (*n* = 46) -4.4 kg [*p* =.04]* favours BeC	Not Reported	Not Reported	*FBG at 12 months* Basic Int (*n* = 46): not reported Int + BeC (*n* = 46): not reported [*p* = .93]
Tate et al. (2003) *Internet and Behavioural e-Counseling*	*At 12 months* Int + BeC (*n* = 46) -4.4 kg Basic Int (*n* = 46) -2 kg [*p* =.04]* favours BeC	Not Reported	Not Reported	*FBG at 12 months* Int + BeC (*n* = 46): NR Basic Int (*n* = 46): NR [*p* = .93]
Wilson et al. (2017)	*At 12 months* Intervention (*n* = 634) -0.9 kg Control (*n* = 1,268) +0.6 kg [*p* < .05]*	*At 12 months* 5% weight loss Intervention: 31% Control: 20% [*p* < .001]*	Not Reported	*FBG at 12 months* Intervention (*n* = 634) -0.08 mmol/L Control (1,268) +0.01 mmol/L [*p* < .05]*
Wong et al. (2013)	*At 24 months* Intervention (*n* = 54) -1 kg Control (*n* = 50) -0.4 kg [*p* = .094]	Not Reported	Not Reported	*FPG at 24 months* Intervention (*n* = 54) +0.03 mmol/L Control (N = 50) +0.04 mmol/L [*p* = .468]

Note: For the purpose of standardisation, all body weights reported in lbs were converted to kg, and all fasting glucose measures reported in mg/dL were converted to mmol/L, (*p*): within-group result, [*p*]: between-group result, FG: fasting glucose, FBG: fasting blood glucose, FPG: fasting plasma glucose, NA: not applicable.
*Statistically significant at $p < .05$, †studies that applied per-protocol or similar analyses rather than intention to treat, ‡weight loss target as described by the authors of each study.

Appendix X: Behaviour Change Techniques Identified in All Interventions (Study One)

No.	Behaviour Change Technique	Aguiar (2016)	Arens (2018)	Block (2015)	Castro Sweet (2017)	Cha (2014)	Estabrooks (2008)	Everett (2018)	Fischer (2016)	Fukuoka (2015)	Kramer (2010)	Limaye (2017)	Ma (2013)	Michaelides (2016)	Piatt (2013) *DVD*	Piatt (2013) *Internet*	Ramachandran (2013)	Sepah (2014)	Tate (2003) *BI*	Tate (2003) *BeC*	Wilson (2017)	Wong (2013)	TOTAL (Inc. Imp.)	TOTAL (Exc. Imp.)
Cluster One: Goals and planning																								
1.1	Goal setting (behaviour)	✓	✓	✓	*	✓	-	✓	*	*	*	✓	✓	*	*	*	-	✓	-	-	*	-	16	8
1.2	Problem solving	-	✓	-	*	✓	✓	-	✓	✓	*	-	✓	*	✓	✓	✓	*	-	-	*	-	14	9
1.3	Goal setting (outcome)	✓	✓	✓	*	-	-	✓	*	*	*	✓	✓	*	✓	✓	-	✓	-	-	*	-	15	9
1.4	Action planning	✓	-	✓	-	-	✓	-	-	-	*	-	✓	-	*	*	-	-	-	-	-	-	7	4
1.5	Review behaviour goals	-	-	-	-	✓	-	-	-	-	✓	-	✓	-	*	*	-	-	-	-	-	-	5	3
1.7	Review outcome goals	-	-	-	-	-	-	-	-	-	✓	-	*	-	*	*	-	-	-	-	-	-	4	1
Cluster Two: Feedback and monitoring																								
2.2	Feedback on behaviour	-	✓	✓	*	✓	-	✓	*	*	*	-	*	✓	✓	✓	-	✓	-	✓	*	-	15	9
2.3	Self-monitoring of behaviour	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	-	-	✓	✓	✓	-	✓	✓	✓	✓	-	16	16
2.4	Self-monitoring of outcome(s) of behaviour	-	✓	✓	✓	-	-	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓	✓	-	15	15
2.7	Feedback on outcome(s) of behaviour	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Cluster Three: Social support																								
3.1	Social support (unspecified)	✓	-	✓	✓	-	-	-	*	*	✓	✓	✓	*	*	*	-	✓	-	✓	✓	-	14	9
3.2	Social support (practical)	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	1	1
3.3	Social support (emotional)	-	-	-	*	-	-	-	✓	✓	-	-	-	*	-	-	-	*	-	-	*	-	6	2

No.	Behaviour Change Technique	Aguiar 2016	Arens 2018	Block 2015	Castro Sweet 2017	Cha 2014	Estabrooks 2008	Everett 2018	Fischer 2016	Fukuoka 2015	Kramer 2010	Limaye 2017	Ma 2013	Michaelides 2016	Piatt 2013 *DVD*	Piatt 2013 *Internet*	Ramachandran 2013	Sepah 2014	Tate 2003 *BI*	Tate 2003 *BeC*	Wilson 2017	Wong 2013	TOTAL (Inc. Imp.)	TOTAL (Exc. Imp.)
Cluster Four: Shaping knowledge																								
4.1	Instruction on how to perform the behaviour	✓	✓	-	-	-	-	-	-	-	-	✓	-	-	-	-	✓	-	-	-	-	-	4	4
4.2	Information about antecedents	-	-	-	*	-	-	-	-	*	-	✓	-	✓	-	-	-	*	-	-	*	-	6	2
Cluster Five: Natural consequences																								
5.1	Information about health consequences	✓	-	✓	-	-	-	-	-	-	-	✓	-	-	-	-	✓	-	-	-	-	✓	5	5
Cluster Six: Comparison of behaviour																								
6.1	Demonstration of the behaviour	✓	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
6.2	Social comparison	-	-	✓	✓	-	-	-	*	*	-	-	-	*	-	-	-	✓	-	-	*	-	7	3
Cluster Seven: Associations																								
7.1	Prompts/cues	-	-	-	-	-	-	✓	-	-	*	-	*	-	*	✓	-	-	-	-	-	-	5	2
Cluster Eight: Repetition and substitution																								
8.2	Behaviour substitution	✓	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	✓	-	-	-	-	-	3	3
8.3	Habit formation	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
8.4	Habit reversal	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
8.7	Graded tasks	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Cluster Nine: Comparison of outcomes																								
9.1	Credible source	-	✓	✓	-	-	-	-	✓	-	✓	-	✓	-	✓	✓	-	-	-	-	-	-	7	7
Cluster Ten: Reward and threat																								
10.1	Material incentive (behaviour)	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
10.2	Material reward (behaviour)	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1

No.	Behaviour Change Technique	Aguiar 2016	Arens 2018	Block 2015	Castro Sweet 2017	Cha 2014	Estabrooks 2008	Everett 2018	Fischer 2016	Fukuoka 2015	Kramer 2010	Limaye 2017	Ma 2013	Michaelides 2016	Piatt 2013 *DVD*	Piatt 2013 *Internet*	Ramachandran 2013	Sepah 2014	Tate 2003 *BI*	Tate 2003 *BeC*	Wilson 2017	Wong 2013	TOTAL (Inc. Imp.)	TOTAL (Exc. Imp.)
Cluster Eleven: Regulation																								
11.2	Reduce negative emotions	-	-	✓	-	-	-	-	-	-	-	✓	-	-	-	-	✓	-	-	-	-	-	3	3
Cluster Twelve Antecedents																								
12.3	Avoidance/reducing exposure to cues for the behaviour	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	1	1
12.5	Adding objects to the environment	✓	✓	-	✓	-	-	-	-	-	✓	-	✓	-	✓	✓	-	✓	-	-	*	-	9	8
Cluster Fourteen: Scheduled consequences																								
14.4	Reward approximation	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
TOTAL BCTs (including imputed BCTs)		13	3	10	11	10	11	6	2	10	13	10	10	10	13	13	5	5	2	2	11	1		
TOTAL BCTs (excluding imputed BCTs)		13	3	10	5	4	5	6	2	5	7	10	10	4	7	7	5	5	2	2	3	1		

Note: ✓BCT explicitly present, *BCT identified via imputation.

Appendix Y: All Coded Digital and Non-Digital Components (Study One)

Key:

MoD = Mode of Delivery

SMS = Short Message Service (text message)

IVR = Interactive Voice Response

Web = Website

DVD = Digital Video Disc

SCU = Self-contained unit

App = Smartphone application

E/S = Email and SMS

W/E = Website and email

W/I = Website and IVR

A/S = Smartphone app and SMS

W/A = Website and smartphone app

S/E = SMS and email

Physical Per. = Physical Peripheral

*Denotes imputed components

Technological Components and Features				Study	Non-Technological Components	
Digital Component	MoD	Feature	Level		Format	Non-Digital Component
Food Information	Web	Health/Lifestyle Information	Passive	Aguiar (2014)	Hard Copy	Nutrition Education
Weight Loss Information	DVD	Health/Lifestyle Information	Passive		Hard Copy	Exercise Education
Pedometer	SCU	Activity Tracking	Passive		Hard Copy	Exercise Diary
Physical Activity Diary	Web	Activity Tracking	Passive		Hard Copy	Weight Log
Food Diary	Web	Diet Tracking	Passive		Hard Copy	Food Diary
					Hard Copy	Waist Circumference Log
					Hard Copy	Resistance Training Guide
					Physical Per.	Tape Measure
					Physical Per.	Gymstick Resistance Band
Blood Glucose Log	App	Weight/Biomeasure Tracking	Passive	Arens (2018)	Face-to-Face	Nutrition Education
Blood Glucose Measuring Device	SCU	Weight/Biomeasure Tracking	Passive		Face-to-Face	Physical Activity Education
Weight Log	App	Weight/Biomeasure Tracking	Passive		Face-to-Face	Health Coaching
Waist Circumference Log	App	Weight/Biomeasure Tracking	Passive			
Blood Pressure Log	App	Weight/Biomeasure Tracking	Passive			
Pedometer	SCU	Activity tracking	Passive			
Online Health Coaching	App	Online Health Coaching	Interactive			
Attitudes Questionnaire	App	Health/Lifestyle lessons	Interactive			

Technological Components and Features				Study	Non-Technological Components	
Digital Component	MoD	Feature	Level		Format	Non-Digital Component
Push Notifications	App	Reminders/Prompts	Passive	Block (2015)		
Reminders	E/S	Reminders/Prompts	Passive	Block (2015)		
Weight Log	Web	Weight/Biomeasure Tracking	Passive	Block (2015)		
Activity Log	Web	Activity Tracking	Passive	Block (2015)		
Diet Log	Web	Diet Tracking	Passive	Block (2015)		
Links to External Resources	W/E	Health/Lifestyle Information	Passive	Block (2015)		
Physical Activity Assessment	Web	Health/Lifestyle Lessons	Interactive	Block (2015)		
Dietary Assessment	Web	Health/Lifestyle Lessons	Interactive	Block (2015)		
Behavioural Strategy Lessons	Web	Health/Lifestyle Lessons	Interactive	Block (2015)		
Diet Lessons	Web	Health/Lifestyle Lessons	Interactive	Block (2015)		
Physical Activity Lessons	Web	Health/Lifestyle Lessons	Interactive	Block (2015)		
Downloadable Worksheets	W/E	Health/Lifestyle Lessons	Interactive	Block (2015)		
Online Points/Currency System	Web	Gamification	Interactive	Block (2015)		
Team Challenges	Web	Gamification	Interactive	Block (2015)		
Social Message Board	Web	Social Media and Support	Interactive	Block (2015)		
Family and Friend Referral System	Web	Social Media and Support	Interactive	Block (2015)		
Automated Health Coaching	W/I	Automated Feedback	Interactive	Block (2015)		
Weight Log	W/A	Weight/Biomeasure Tracking	Passive	Castro Sweet (2018)	Hard Copy	Resistance Exercise Guide*
Wireless Scale	SCU	Weight/Biomeasure Tracking	Passive	Castro Sweet (2018)	Hard Copy	Diet Log*
Pedometer	SCU	Activity Tracking	Passive	Castro Sweet (2018)	Physical Per.	Resistance Band*
Physical Activity Log	W/A	Activity Tracking	Passive	Castro Sweet (2018)	Physical Per.	Measuring Tape*
Diet Log	W/A	Diet Tracking	Passive	Castro Sweet (2018)		
Weight Notifications	W/A	Reminders/Prompts	Passive	Castro Sweet (2018)		
Health/Lifestyle Lessons*	W/A	Health/Lifestyle Lessons	Interactive	Castro Sweet (2018)		
Physical Activity Lessons*	W/A	Health/Lifestyle Lessons	Interactive	Castro Sweet (2018)		
Diet Lessons*	W/A	Health/Lifestyle Lessons	Interactive	Castro Sweet (2018)		
Online Social Forum	W/A	Social Media and Support	Interactive	Castro Sweet (2018)		
Online Health Coaching	W/A	Online Health Coaching	Interactive	Castro Sweet (2018)		

Technological Components and Features				Study	Non-Technological Components	
Digital Component	MoD	Feature	Level		Format	Non-Digital Component
Physical Activity Log	App	Activity Tracking	Passive	Cha (2014)	Face-to-Face	Nutrition Education
Food Log	App	Diet Tracking	Passive		Face-to-Face	Exercise Education
Homework Assignments	A/W	Health/lifestyle lessons	Interactive		Face-to-Face	Health Counseling
					Hard Copy	Health Summary
					Hard Copy	Educational Materials
Physical Activity Tips	IVR	Health/Lifestyle Information	Passive	Estabrooks (2008)	Face-to-Face	Healthy Lifestyle Education
Nutrition Tips	IVR	Health/Lifestyle Information	Passive			
Automated Diet Coaching	IVR	Automated Feedback	Interactive			
Automated PA Coaching	IVR	Automated Feedback	Interactive			
Weight Loss Advice	App	Health/Lifestyle Information	Passive	Everett (2018)	Face-to-Face	Lifestyle Counseling
Diet Advice	App	Health/Lifestyle Information	Passive		Hard Copy	T2D Prevention Information
Physical Activity Advice	App	Health/Lifestyle Information	Passive			
Digital Body Weight Scale	SCU	Weight/Biomeasure Tracking	Passive			
Weight Log	App	Weight/Biomeasure Tracking	Passive			
Weight Notifications	App	Reminders/Prompts	Passive			
Personalised Push Notifications	App	Reminders/Prompts	Passive			
Physical Activity Log	App	Activity Tracking	Passive			
Automated Physical Activity Coaching	App	Automated Feedback	Interactive			
Health/lifestyle Advice	SMS	Health/Lifestyle Information	Passive	Fischer (2016)	Face-to-Face	Diet Support
Physical Activity Advice	SMS	Health/Lifestyle Information	Passive		Face-to-Face*	Health/Lifestyle Education*
Nutrition Advice	SMS	Health/Lifestyle Information	Passive		Face-to-Face*	Physical Activity Education*
Links to Additional Resources	SMS	Health/Lifestyle Information	Passive		Face-to-Face*	Nutrition Education*
Weight Report Reminders	SMS	Reminders/Prompts	Passive		Phone	Motivational Interviewing

Technological Components and Features				Study	Non-Technological Components	
Digital Component	**MoD**	**Feature**	**Level**		**Format**	**Non-Digital Component**
Health/lifestyle Videos	App	Health/Lifestyle Information	Passive	**Fukuoka (2015)**	Face-to-Face	Health/Lifestyle Education
Physical Activity Videos	App	Health/Lifestyle Information	Passive		Face-to-Face	Physical Activity Education
Diet Videos	App	Health/Lifestyle Information	Passive		Face-to-Face	Diet Education
Pedometer	A/S	Activity Tracking	Passive			
Physical Activity Log	App	Activity Tracking	Passive			
Reminders	A/S	Reminders/Prompts	Passive			
Weight Log	App	Weight/Biomeasure Tracking	Passive			
Diet Log	App	Diet Tracking	Passive			
Auto Self-Monitoring Feedback	App	Automated Feedback	Interactive			
Health/Lifestyle Messages	App	Automated Feedback	Interactive			
Physical Activity Messages	App	Automated Feedback	Interactive			
Diet Messages	App	Automated Feedback	Interactive			
Health/Lifestyle Quizzes	App	Health/Lifestyle Lessons	Interactive			
Physical Activity Quizzes	App	Health/Lifestyle Lessons	Interactive			
Diet Education Quizzes	App	Health/Lifestyle Lessons	Interactive			
Health/Lifestyle Education Videos	DVD	Health/Lifestyle Information	Passive	**Kramer (2010)**	Hard Copy	Health/Lifestyle Worksheets
Physical Activity Education Videos	DVD	Health/Lifestyle Information	Passive		Hard Copy	Physical Activity Worksheets
Nutrition Education Videos	DVD	Health/Lifestyle Information	Passive		Hard Copy	Nutrition Worksheets
Pedometer	SCU	Activity Tracking	Passive		Hard Copy	Weight Log*
					Hard Copy	Physical Activity Log
					Hard Copy	Diet Log
					Hard Copy	Pedometer Guide*
					Hard Copy	Resistance Training Guide*
					Hard Copy	Stretching Guide*
					Physical Per.	Resistance Bands*
					Phone	Remote Health Coaching

Technological Components and Features				Study	Non-Technological Components	
Digital Component	MoD	Feature	Level		Format	Non-Digital Component
Lifestyle Advice	SM/E	Health/Lifestyle Information	Passive	Limaye (2017)	Hard Copy	Diet Information
Physical Activity Advice	SM/E	Health/Lifestyle Information	Passive		Hard Copy	Physical Activity Information
Diet Advice	SM/E	Health/Lifestyle Information	Passive		Face-to-Face	Lifestyle Modification Class
Stress Management Advice	SM/E	Health/Lifestyle Information	Passive			
Facebook Group	Web	Social Media and Support	Interactive			
Health/Lifestyle Education Videos*	DVD	Health/Lifestyle Information	Passive	Ma (2013)	Hard Copy	Health/lifestyle worksheets*
Physical Activity Education Videos*	DVD	Health/Lifestyle Information	Passive		Hard Copy	Physical activity worksheets*
Nutrition Education Videos*	DVD	Health/Lifestyle Information	Passive		Hard Copy	Nutrition Worksheets*
Pedometer	SCU	Activity Tracking	Passive		Hard Copy	Pedometer Guide*
Physical Activity Log	Web	Activity Tracking	Passive		Hard Copy	Resistance Training Guide*
Reminders	Email	Reminders/Prompts	Passive		Hard Copy	Stretching Guide*
Weight Log	Web	Weight/Biomeasure Tracking	Passive		Physical Per.	Resistance Bands*
Diet Log	Web	Diet Tracking	Passive		Physical Per.	Weight Scale
Online Health Coaching	Web	Online Health Coaching	Interactive			
Health/Lifestyle Education	App	Health/Lifestyle Information	Passive	Michaelides (2016)	Phone	Remote Health Counseling
Physical Activity Education	App	Health/Lifestyle Information	Passive			
Diet Education	App	Health/Lifestyle Information	Passive			
Health/Lifestyle Challenges*	App	Reminders/Prompts	Passive			
Physical Activity Challenges*	App	Reminders/Prompts	Passive			
Diet Challenges*	App	Reminders/Prompts	Passive			
Weight Log	App	Weight/Biomeasure Tracking	Passive			
Physical Activity Log	App	Activity Tracking	Passive			
Diet Log	App	Diet Tracking	Passive			
Online Health Coaching	App	Online Health Coaching	Interactive			
Group Messaging	App	Social Media and Support	Interactive			

Technological Components and Features				Study	Non-Technological Components	
Digital Component	MoD	Feature	Level		Format	Non-Digital Component
Health/Lifestyle Education Videos*	DVD	Health/Lifestyle Information	Passive	**Piatt (2013)** *DVD*	Hard Copy	Health/Lifestyle Worksheets
Physical Activity Education Videos*	DVD	Health/Lifestyle Information	Passive		Hard Copy	Physical Activity Worksheets
Nutrition Education Videos*	DVD	Health/Lifestyle Information	Passive		Hard Copy	Nutrition Worksheets
Pedometer	SCU	Activity Tracking	Passive		Hard Copy	Weight Log
					Hard Copy	Physical Activity Log
					Hard Copy	Diet Log
					Hard Copy	Pedometer Guide*
					Hard Copy	Resistance Training Guide*
					Hard Copy	Stretching Guide*
					Physical Per.	Resistance Bands*
					Physical Per.	Measuring Cups and Spoons
					Phone	Remote Health Coaching
					Face-to-Face	Group Debriefing Sessions
Health/Lifestyle Education Videos*	Web	Health/Lifestyle Information	Passive	**Piatt (2013)** *Internet*	Hard Copy	Health/Lifestyle Worksheets
Physical Activity Education Videos*	Web	Health/Lifestyle Information	Passive		Hard Copy	Physical Activity Worksheets
Nutrition Education Videos*	Web	Health/Lifestyle Information	Passive		Hard Copy	Nutrition Worksheets
Pedometer	SCU	Activity Tracking	Passive		Hard Copy	Weight Log
Reminders/prompts	Email	Reminders/Prompts	Passive		Hard Copy	Physical Activity Log
Online Counseling	Web	Online Health Coaching	Interactive		Hard Copy	Diet Log
					Hard Copy	Pedometer Guide*
					Hard Copy	Resistance Training guide*
					Hard Copy	Stretching Guide*
					Physical Per.	Resistance Bands*
					Physical Per.	Measuring Cups and Spoons

Technological Components and Features				Study	Non-Technological Components	
Digital Component	**MoD**	**Feature**	**Level**		**Format**	**Non-Digital Component**
Healthy Lifestyle Education	SMS	Health/Lifestyle Information	Passive	**Ramachandran (2013)**	Hard Copy	Diet Information
Diet Information	SMS	Health/Lifestyle Information	Passive		Hard Copy	Physical Activity Information
Physical Activity Information	SMS	Health/Lifestyle Information	Passive		Face-to-Face	Healthy Lifestyle Education
Wireless Scale	SCU	Weight/Biomeasure Tracking	Passive	**Sepah (2014)**	Hard Copy	Resistance Exercise Guide*
Weight Log	W/A	Weight/Biomeasure Tracking	Passive		Hard Copy	Diet Log*
Pedometer	SCU	Activity Tracking	Passive		Physical Per.	Resistance Band*
Physical Activity Log	W/A	Activity Tracking	Passive		Physical Per.	Measuring Tape*
Diet Log	W/A	Diet Tracking	Passive		Physical Per.	Photo Frame
Weight Notifications	W/A	Reminders/Prompts	Passive			
Health/Lifestyle Lessons*	W/A	Health/Lifestyle Lessons	Interactive			
Physical Activity Lessons*	W/A	Health/Lifestyle Lessons	Interactive			
Diet Lessons*	W/A	Health/Lifestyle Lessons	Interactive			
Online Social Forum	W/A	Social Media and Support	Interactive			
Online Health Coaching	W/A	Online Health Coaching	Interactive			
Weight Loss Tips	Web	Health/Lifestyle Information	Passive	**Tate (2003)** *Basic Internet*	Face-to-Face	Diet Information
Weight Loss Resources	Web	Health/Lifestyle Information	Passive		Face-to-Face	Exercise Information
Weight Submission Reminders	Email	Reminders/Prompts	Passive		Face-to-Face	Behaviour Change Information
Message Board	Web	Social Media and Support	Interactive		Hard Copy	Diet Log
Weight Loss Tutorials	Web	Health/Lifestyle Lessons	Interactive		Hard Copy	Exercise Log
Weight Loss Tips	Web	Health/Lifestyle Information	Passive	**Tate (2003)** *Behavioral e-Counseling*	Face-to-Face	Diet Information
Weight Loss Resources	Web	Health/Lifestyle Information	Passive		Face-to-Face	Exercise Information
Food Diary	Web	Diet Tracking	Passive		Face-to-Face	Behaviour Change Information
Exercise Diary	Web	Activity Tracking	Passive		Hard Copy	Diet Log
Message Board	Web	Social Media and Support	Interactive		Hard Copy	Exercise Log
Weight Loss Tutorials	Web	Health/Lifestyle Lessons	Interactive			
Remote Health Coaching	Email	Online Health Coaching	Interactive			

Technological Components and Features				Study	Non-Technological Components	
Digital Component	MoD	Feature	Level		Format	Non-Digital Component
Wireless Scale	SCU	Weight/Biomeasure Tracking	Passive	Wilson (2017)	Hard Copy	Resistance Exercise Guide*
Weight Log	W/A	Weight/Biomeasure Tracking	Passive		Hard Copy	Diet Log*
Pedometer*	SCU	Activity Tracking	Passive		Physical Per.	Resistance Band*
Physical Activity Log	W/A	Activity Tracking	Passive		Physical Per.	Measuring Tape*
Diet Log	W/A	Diet Tracking	Passive			
Weight Notifications*	W/A	Reminders/Prompts	Passive			
Health/Lifestyle Lessons*	W/A	Health/Lifestyle Lessons	Interactive			
Physical Activity Lessons*	W/A	Health/Lifestyle Lessons	Interactive			
Diet Lessons*	W/A	Health/Lifestyle Lessons	Interactive			
Online Social Forum	W/A	Social Media and Support	Interactive			
Online Health Coaching	W/A	Online Health Coaching	Interactive			
T2D/Prediabetes Information	SMS	Health/Lifestyle Information	Passive	Wong (2013)	Hard Copy	T2D/Prediabetes Information
Lifestyle Modification Information	SMS	Health/Lifestyle Information	Passive		Hard Copy	Health Behaviour Information

Appendix Z: Digital Features Identified in All Interventions (Study One)

Digital feature	Aguiar (2016)	Arens (2018)	Block (2015)	Castro Sweet (2017)	Cha (2014)	Estabrooks (2008)	Everett (2018)	Fischer (2016)	Fukuoka (2015)	Kramer (2010)	Limaye (2017)	Ma (2013)	Michaelides (2016)	Piatt (2013) *DVD*	Piatt (2013) *Internet*	Ramachandran (2013)	Sepah (2014)	Tate (2003) *BI*	Tate (2003) *BeC*	Wilson (2017)	Wong (2013)	TOTAL
Passive features																						
Health/Lifestyle information and advice	✓	-	✓	-	-	✓	✓	✓	✓	✓	✓	*	✓	*	*	✓	-	✓	✓	-	✓	16
Activity tracking	✓	✓	✓	✓	✓	-	✓	-	✓	✓	-	✓	✓	✓	✓	-	✓	-	✓	*	-	15
Reminders and prompts	-	-	✓	✓	-	-	✓	✓	✓	-	-	✓	*	-	✓	-	✓	✓	-	*	-	11
Diet tracking	✓	-	✓	✓	✓	-	-	-	✓	-	-	✓	✓	-	-	-	✓	-	✓	✓	-	10
Weight and biomeasure tracking	-	✓	✓	✓	-	-	✓	-	✓	-	-	✓	✓	-	-	-	✓	-	-	*	-	9
Total passive features	3	2	5	4	2	1	4	2	5	2	1	5	5	2	3	1	4	2	3	4	1	
Interactive Features																						
Interactive health and lifestyle lessons	-	✓	✓	*	✓	-	-	-	✓	-	-	-	-	-	-	-	*	✓	✓	*	-	9
Online health coaching	-	✓	-	✓	-	-	-	-	-	-	-	✓	✓	-	✓	-	✓	-	✓	✓	-	8
Social media and support	-	-	✓	✓	-	-	-	-	-	-	✓	-	✓	-	-	-	✓	✓	✓	✓	-	8
Automated feedback	-	-	✓	-	-	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	4
Gamification	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Total interactive features	0	2	4	3	1	1	1	0	2	0	1	1	2	0	1	0	3	2	3	3	0	
Total digital features	3	4	9	7	3	2	5	2	7	2	2	6	7	2	4	1	7	4	6	7	1	

Note: ✓Feature explicitly present, *Feature identified via imputation.

Appendix AA: Digital Feature Descriptions (Study One)

Passive Features

Health and Lifestyle Information and Advice. This includes health and lifestyle-related information, advice, and educational materials. These may come in the form of information on how to eat healthily and increase physical activity; how to reduce stress; and how to make lifestyle changes to improve overall health, lose weight, or reduce the risk of developing type 2 Diabetes. This feature only includes information and advice that can be read (e.g., via website) or viewed (e.g., via online video or DVD) and does not include structured, interactive lessons or quizzes.

Activity Tracking. This includes any digital tool used to count, track, and/or record physical activity behaviours. Such tools include pedometers, accelerometers, and digital physical activity logs. These tools may require participants to enter their own data (e.g., steps per day, exercise session duration), or they may record the data automatically. Activity tracking is a passive feature, as although participants use these tools to record data, they offer one-way interaction with no return feedback. However, if for example, a smartphone application automatically tracked a participant's daily steps and the participant automatically received feedback on their performance (e.g., messages of praise and encouragement and/or adjustment of the daily step goal), the application would contain two features: activity tracking, and automated feedback. This two-feature scenario also applies to diet tracking, and weight and biomeasure tracking.

Reminders and Prompts. This describes any one-way message or notification sent to participants with the purpose of reminding them to complete a specific action or task. Forms can include text messages, alarms, push notifications, and calendar reminders either sent by a health coach or delivered automatically. The types of notifications may include reminding a participant to weigh themselves, eat five servings of fruit and vegetables, drink water, or submit their tracking logs. These reminders and prompts are part of the intervention protocol and do not include cases where participants set their own reminders.

Diet Tracking. This includes any digital tool used to count, track, and/or record dietary behaviours. Diet tracking tools can include calorie counters, food diaries, and digital food scales. These tools mostly require participants to enter their own data such as the number of servings of foods and beverages consumed each day, and/or daily caloric intake.

Weight and Biomeasure Tracking. This includes any digital tool used to count, track, and/or record body weight or other biological outcome measures such as blood glucose. These tools include wireless digital body weight scales, digital blood glucose monitors, and digital diaries that are used to track outcome data.

Interactive Features

Interactive Health and Lifestyle Lessons. This feature includes interactive educational sessions such as lessons, tutorials, or quizzes in which participants read or view health and lifestyle information and advice as described above, and then respond in the form of assignments, case studies, or quiz responses. Feedback on these responses may or may not be given.

Social Media and Support. This includes any digital tool that either enables participants to interact with others (e.g., other participants, friends, family members) socially, or that is used by participants to seek social support. This includes Facebook groups, online message boards or chat rooms, peer-to-peer instant messaging, and online referral tools to share the intervention content with others. This does not include digitally-facilitated interactions with a health coach as this would fall under the online health coaching feature.

Automated Feedback. This feature describes automated two-way behavioural and lifestyle support. Feedback is automatically generated, based on participants' action(s), or reported data. This can be facilitated by Interactive Voice Response (IVR), automated text message, and smartphone application. For example, in IVR, a participant receives an automated telephone call that provides a range of health messages or lifestyle tips. Participants then have the option to select a specific message or provide an alternative response to the message via the phone's keypad. The IVR system then tailors the next call or tip based on the participant's previous response.

Gamification. For this review, gamification refers to any digital component that was used as a game or part of a game to add fun or challenge to the intervention whilst providing explicit incentive or reward. An example would be the use of an online points system. Here, participants may earn digital points each time they complete a specific action or series of tasks. These points may be used as friendly competition among participants, or they may be redeemed for actual prizes and rewards.

Appendix AB: Summary of Behaviour Change Technique Use in Effective and Non-Effective Interventions Excludes Imputed BCTs (Study One)

No.	Behaviour Change Technique	All interventions (*N* = 21)		Effective ST (*N* = 12)		Not Effective ST (*N* = 7)		Effective LT (*N* = 4)		Not-Effective LT (*N* = 8)	
		n	%	*n*	%	*n*	%	*n*	%	*n*	%
Cluster One: Goals and planning											
1.1	Goal setting (behaviour)	8	38.1	4	33.3	3	42.9	1	25	2	25
1.2	Problem solving	9	42.9	4	33.3	3	42.9	2	50	2	25
1.3	Goal setting (outcome)	9	42.9	6	50	2	28.6	2	50	3	37.5
1.4	Action planning	4	19	3	25	1	14.3	1	25	0	0
1.5	Review behaviour goals	3	14.3	2	16.7	1	14.3	1	25	0	0
1.7	Review outcome goals	1	4.8	1	8.3	0	0	0	0	0	0
Cluster Two: Feedback and monitoring											
2.2	Feedback on behaviour	9	42.9	6	50	2	28.6	2	50	3	37.5
2.3	Self-monitoring of behaviour	16	76.2	11	91.7	4	57.1	3	75	6	75
2.4	Self-monitoring of outcome(s) of behaviour	15	71.4	11	91.7	3	42.9	4	100	6	75
2.7	Feedback on outcome(s) of behaviour	1	4.8	0	0	0	0	0	0	0	0
Cluster Three: Social support											
3.1	Social support (unspecified)	9	42.9	8	66.7	1	14.3	2	50	4	50
3.2	Social support (practical)	1	4.8	0	0	1	14.3	0	0	1	12.5
3.3	Social support (emotional)	2	9.5	1	8.3	1	14.3	0	0	1	12.5
Cluster Four: Shaping knowledge											
4.1	Instruction on how to perform the behaviour	4	19	1	8.3	1	14.3	0	0	1	12.5
4.2	Information about antecedents	2	9.5	1	8.3	1	14.3	1	25	1	12.5
Cluster Five: Natural consequences											
5.1	Information about health consequences	5	23.8	2	16.7	2	28.6	0	0	2	25

No.	Behaviour Change Technique	All interventions (*N* = 21)		Effective ST (*N* = 12)		Not Effective ST (*N* = 7)		Effective LT (*N* = 4)		Not-Effective LT (*N* = 8)	
		n	%	*n*	%	*n*	%	*n*	%	*n*	%
Cluster Six: Comparison of behaviour											
6.1	Demonstration of the behaviour	2	9.5	1	8.3	1	14.3	0	0	0	0
6.2	Social comparison	3	14.3	3	25	0	0	1	25	1	12.5
Cluster Seven: Associations											
7.1	Prompts/cues	2	9.5	1	8.3	1	14.3	1	25	0	0
Cluster Eight: Repetition and substitution											
8.2	Behaviour substitution	3	14.3	1	8.3	1	14.3	0	0	1	12.5
8.3	Habit formation	2	9.5	2	16.7	0	0	0	0	0	0
8.4	Habit reversal	1	4.8	1	8.3	0	0	0	0	0	0
8.7	Graded tasks	1	4.8	1		0	0	0	0	0	0
Cluster Nine: Comparison of outcomes											
9.1	Credible source	7	33.3	5	41.7	1	14.3	2	50	2	25
Cluster Ten: Reward and threat											
10.1	Material incentive (behaviour)	1	4.8	1	8.3	0	0	0	0	0	0
10.2	Material reward (behaviour)	1	4.8	1	8.3	0	0	0	0	0	0
Cluster Eleven: Regulation											
11.2	Reduce negative emotions	3	14.3	1	8.3	1	14.3	0	0	1	12.5
Cluster Twelve Antecedents											
12.3	Avoidance/reducing exposure to cues for the behaviour	1	4.8	0	0	1	14.3	0	0	1	12.5
12.5	Adding objects to the environment	8	38.1	7	58.3	0	0	3	75	2	25
Cluster Fourteen: Scheduled consequences											
14.4	Reward approximation	1	4.8	0	0	1	14.3	0	0	0	0
	Average number of BCTs per intervention	6.4		7.2		4.7		6.5		5	

Note: ST: short term (≤6 month) follow-up, LT: long term (≥12 month) follow-up. *N*: number of interventions, *n*: number of interventions in which the BCT was identified, %: proportion of interventions in each category that used the BCT.

Appendix AC: Summary of Digital Feature Use in Effective and Non-Effective Interventions Excludes Imputed Features (Study One)

Digital features	All interventions (*N* = 21)		Effective ST (*N* = 12)		Not Effective ST (*N* = 7)		Effective LT (*N* = 4)		Not-Effective LT (*N* = 8)	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Passive features										
Health and lifestyle information and advice	13	61.9	6	50	6	85.7	1	25	5	62.5
Activity tracking	14	66.7	11	91.7	2	28.6	4	100	3	37.5
Reminders and prompts	9	42.9	6	50	3	42.9	3	75	3	37.5
Diet tracking	10	47.6	9	75	1	14.3	3	75	3	37.5
Weight and biomeasure tracking	8	38.1	6	50	1	14.3	3	75	1	12.5
Average passive features per intervention	2.57 features		3.2 features		1.86 features		3.5 features		1.88 features	
Interactive features										
Interactive health and lifestyle lessons	6	28.6	3	25	2	28.6	0	0	2	25
Social media and support	8	38.1	6	50	2	28.6	2	50	5	62.5
Online health coaching	8	38.1	7	58.3	0	12.5	4	100	3	37.5
Automated feedback	4	19.0	2	16.7	2	28.6	0	0	0	0
Gamification	1	4.8	1	8.3	0	0	0	0	0	0
Average interactive features per intervention	1.29 features		1.58 features		0.86 features		1.5 features		1.25 feature	
Average total features per intervention	3.86		4.75		2.71		5		3.13	

Note: ST: short term (≤6 month) follow-up, LT: long term (≥12 month) follow-up. *N*: number of interventions, *n*: number of interventions in which the feature was identified, %: proportion of interventions in each category that used the digital feature.

Appendix AD: BCTs: Most Frequently Identified and Most Effective by Imputation vs No Imputation (Study One)

BCTs most frequently identified in effective interventions (short term)	
With imputations included	With imputations excluded
Goal setting (behaviour)	Goal setting (behaviour)
Problem solving	Problem solving
Goal setting (outcome)	Goal setting (outcome)
Feedback on behavior	Feedback on behavior
Self-monitoring of behavior	Self-monitoring of behavior
Self-monitoring of outcome(s) of behavior	Self-monitoring of outcome(s) of behavior
Social support (unspecified)	Social support (unspecified)
Adding objects to the environment	Credible source
	Adding objects to the environment
BCTs most frequently identified in effective interventions (long term)	
With imputations included	With imputations excluded
Goal setting (behaviour)	Problem solving
Problem solving	Goal setting (outcome)
Goal setting (outcome)	Feedback on behavior
Feedback on behavior	Self-monitoring of behavior
Self-monitoring of behavior	Self-monitoring of outcome(s) of behavior
Self-monitoring of outcome(s) of behavior	Social support (unspecified)
Social support (unspecified)	Credible source
Adding objects to the environment	Adding objects to the environment
Most effective BCTs (short term)	
With imputations included	With imputations excluded
Social support (unspecified)	Social support (unspecified)
Adding objects to the environment	Adding objects to the environment
Most effective BCTs (long term)	
With imputations included	With imputations excluded
Problem solving	Adding objects to the environment

Note: The eight most frequently identified BCTs under each condition are listed. Nine BCTs are listed in the 'imputations excluded' column in the short term as two BCTs each registered the 8^{th} highest frequency. The most effective BCTs were those identified at a considerably greater frequency in effective interventions versus non-effective interventions. All BCTs are listed in the order in which they appear in the BCT Taxonomy v1.

Appendix AE: Digital Features: Most Frequently Identified and Most Effective by Imputation vs No Imputation (Study One)

Digital features most frequently identified in effective interventions (short term)	
With imputations included	With imputations excluded
Health and lifestyle info and advice (P)	Activity tracking (P)
Activity tracking (P)	Diet tracking (P)
Diet tracking (P)	Online health coaching (I)
Digital features most frequently identified in effective interventions (long term)	
With imputations included	With imputations excluded
Activity tracking (P)	Health and lifestyle info and advice (P)
Reminders and prompts (P)	Activity tracking (P)
Online health coaching (I)	Diet tracking (P)
	Online health coaching (I)
Most effective digital features (short term)	
With imputations included	With imputations excluded
Activity tracking (P)	Activity tracking (P)
Diet tracking (P)	Diet tracking (P)
Online health coaching (I)	
Most effective digital features (long term)	
With imputations included	With imputations excluded
Activity tracking (P)	Activity tracking (P)
Reminders and prompts (P)	Weight and biomeasure tracking (P)
Weight and biomeasure tracking (P)	Online health coaching (I)
Online health coaching (I)	

Note: P: passive feature, I: interactive feature

The three most frequently identified features under each condition are listed. Four digital features are listed in the 'imputations excluded' column in the long term as two features each registered the 3rd highest frequency. The most effective features were those identified at a considerably greater frequency in effective interventions versus non-effective interventions. All features are listed in the order in which they appear in the summary tables.

Appendix AF: Average Number of BCTs and Digital Features Used Per Intervention, Including and Excluding Imputations (Study One)

Average number of digital features used		
	Imputations included	Imputations excluded
All interventions (*N* = 21)		
Total features	4.3	3.86
Passive features	2.9	2.57
Interactive features	1.43	1.29
Effective short term (*N* = 12)		
Total features	5.58	4.75
Passive features	3.75	3.2
Interactive features	1.83	1.58
Not effective short term (*N* = 7)		
Total features	2.71	2.71
Passive features	1.86	1.86
Interactive features	0.86	0.86
Effective long term (*N* = 4)		
Total features	6	5
Passive features	4.25	3.5
Interactive features	1.75	1.5
Not effective long term (*N* = 8)		
Total features	3.88	3.13
Passive features	2.38	1.88
Interactive features	1.5	1.25

Average number of BCTs used		
	Imputations included	Imputations excluded
All interventions (*N* = 21)	9	6.4
Effective short term (*N* = 12)	11.3	7.2
Not effective short term (*N* = 7)	5.4	4.7
Effective long term (*N* = 4)	11.5	6.5
Not effective long term (*N* = 8)	7.8	3.7

Appendix AG: Factors and Assessment Items of the Hypothesised Research Model (Study Two)

Factor (abbreviation)	Assessment item
Perceived Seriousness of T2D (PSe)	PSe1: If I get diabetes it will not affect my relationships with others that much. (Item reverse scored) PSe2: Getting diabetes will slow down my daily life. PSe3: Diabetes is a sickness that can be very painful. PSe4: The costs of living with diabetes are so bad that I really want to avoid them if I can.
Perceived Susceptibility to T2D (PSu)	PSu1: My chances of developing diabetes in the next few years are great. PSu2: I am concerned about the likelihood of developing diabetes in the near future. PSu3: Because there are so many things that could happen to me, I think it is foolish to worry about diabetes. (Item reverse scored) PSu4: The older I get, the more I think about getting diabetes.
Subjective Norm (SN)	SN1: Most people who are important to me think that I should get more exercise. SN2: Most people who are important to me think that I should have a healthier diet.
Image (IM)	IM1: People who use digital wearable devices/or smartphone apps have more prestige than those who don't. IM2: People who use digital wearable devices or smartphone apps have a high profile. IM3: Between the people I know, the use of digital wearable devices and smartphone apps are a status symbol.
eHealth Readiness (eHR)†	eHR1: I would be comfortable using an internet-connected device several times a week to participate in a lifestyle intervention online. eHR2: I feel that my previous experiences with online technologies are important to my success with using a lifestyle intervention. eHR3: Using internet technologies makes me more efficient in my daily functioning. eHR4: I believe that I am able to make good use of internet websites and web applications. eHR5: Using internet technologies provide me with a feeling of independence. eHR6: I enjoy the challenge of figuring out the different functions of websites and web applications.

Factor (abbreviation)	Assessment item
Communicative eHealth Literacy (CeL)	CeL1: I can achieve my health information goals on the Internet while helping other users achieve theirs. CeL2: I have the skills I need to talk about health topics on the Internet with multiple users at the same time. CeL3: I can identify the emotional tone of a health conversation on the internet. CeL4: I have the skills I need to contribute to health conversations on the internet. CeL5: I have the skills I need to build personal connections with other internet users who share health information.
General eHealth Literacy (GeL)	GeL1: I know how to find helpful resources on the internet. GeL2: I know how to use the internet to answer my health questions. GeL3: I know what health resources are available on the internet. GeL4: I know where to find helpful resources on the internet. GeL5: I know how to use the health information I find on the internet to help me. GeL6: I have the skills I need to evaluate health resources I find on the internet. GeL7: I can tell high quality from low quality health resources on the internet. GeL8: I feel confident in using information on the internet to make health decisions.
Perceived Usefulness (PU)	PU1: Using the intervention would help me to improve my fitness. PU2: Using the intervention would help me to improve my diet. PU3: Using the intervention would help me to manage my weight. PU4: Using the intervention would help me to prevent diabetes.
Perceived Ease of Use (PEU)	PEU1: Learning how to use the intervention would be clear and understandable. PEU2: Using the intervention would not require a lot of mental effort. PEU3: The intervention tools seem to be easy to use. PEU4: I would it find it easy to get the tools to do what I want them to do.
Attitude Towards the Programme (ATT)	ATT1: Using the intervention would be beneficial. ATT2: Using the intervention would be unpleasant. (Item reverse scored) ATT3: Using the intervention is a good idea. ATT4: Using the intervention would be enjoyable.
Intention to Use the Programme (INT)	INT1: Assuming the intervention is available, I intend to use it. INT2: Given that the intervention is available, I predict I would use it.

†All eHealth Readiness items were measured using the questionnaire's original six-point Likert scale (strongly disagree to strongly agree).

Appendix AH: All Individual Indirect Paths of the Revised Structural Model (Study Two)

Indirect Path							Unstandardised Estimate	95% CI Lower	95% CI Upper	Standardised Estimate	*p* Value
HS	→	PSe	→	PU			-0.003	-0.006	0.000	-.016	.088
HS	→	PSu	→	PU			-0.002	-0.005	0.000	.039	.052
HS	→	PSu	→	INT			0.006	0.001	0.012	.087	< .001
SN	→	PSe	→	PU			0.005	0.001	0.011	.021	.094
SN	→	PSu	→	PU			0.019	0.013	0.025	.077	.048
SN	→	PSu	→	INT			0.029	-0.062	0.122	.172	< .001
SN	→	PU	→	INT			0.025	-0.054	0.107	.053	.215
IM	→	PU	→	INT			0.007	-0.009	0.042	.091	< .001
eHR	→	PEU	→	PU			0.084	0.029	0.152	.083	< .001
eHR	→	PEU	→	INT			0.075	0.026	0.136	.014	.037
eHR	→	PU	→	INT			0.020	0.002	0.053	.202	< .001
CeL	→	PEU	→	PU			-0.254	-0.344	-0.169	.068	.016
CeL	→	PEU	→	INT			0.093	0.049	0.153	.011	.056
CeL	→	PU	→	INT			0.083	0.045	0.138	-.145	< .001
GeL	→	PEU	→	PU			0.022	0.005	0.049	.015	.551
GeL	→	PEU	→	INT			0.320	0.234	0.419	.003	.381
PSe	→	PU	→	INT			0.017	0.000	0.037	.038	.102
PSu	→	PU	→	INT			0.015	0.000	0.034	.083	.055
PEU	→	PU	→	INT			0.063	0.009	0.125	.255	< .001
HS	→	PSe	→	PU	→	INT	0.056	0.009	0.110	-.016	.091
HS	→	PSu	→	PU	→	INT	0.196	0.154	0.240	.039	.051
SN	→	PSe	→	PU	→	INT	0.060	-0.022	0.146	.021	.090
SN	→	PSu	→	PU	→	INT	0.140	0.081	0.204	.077	.048
eHR	→	PEU	→	PU	→	INT	0.071	0.000	0.151	.083	< .001
CeL	→	PEU	→	PU	→	INT	0.102	0.013	0.190	.068	.015
GeL	→	PEU	→	PU	→	INT	0.595	0.465	0.737	.015	.561

Note: 95% CI: confidence interval for the unstandardised estimate, HS: health status, PSe: perceived seriousness, PSu: perceived susceptibility, SN: subjective norm, IM: Image, eHR: eHealth readiness, CeL: communicative eHealth literacy, GeL: general eHealth literacy, PU: perceived usefulness, PEU: perceived ease of use, INT: intention to use the digital DPP.

Appendix AI: All Direct, Indirect, and Total Effects of the Revised Structural Model (Study Two)

Endogenous variable		Exogenous variable	Standardised direct effect	*p* value	Standardised indirect effect	*p* value	Standardised total effect	*p* value
PSe	←	HS	-.27	< .001	-	-	-.27	< .001
	←	SN	.34	< .001	-	-	.34	< .001
PSu	←	HS	.30	< .001	-	-	.30	< .001
	←	SN	.59	< .001	-	-	.59	< .001
PU	←	PSe	.06	.155	-	-	.06	.183
	←	PSu	.13	.021	-	-	.13	.018
	←	SN	.08	.166	.10	< .001	.18	< .001
	←	IM	.14	< .001	-		.14	< .001
	←	eHR	.32	< .001	.08	< .001	.40	< .001
	←	CeL	-.23	< .001	.07	.002	-.16	.002
	←	GeL	-	-	.02	.569	.02	.569
	←	PEU	.41	< .001	-	-	.41	< .001
	←	HS	-	-	.02	.393	.02	.393
PEU	←	eHR	.21	< .001	-	-	.21	< .001
	←	CeL	.17	.007	-	-	.17	.008
	←	GeL	.05	.525	-	-	.05	.459
INT	←	PSu	.29	< .001	.08	.055	.37	< .001
	←	PU	.63	< .001	-	-	.63	< .001
	←	PEU	.07	.083	.26	< .001	.32	< .001
	←	PSe	-	-	.04	.104	.04	.104
	←	HS	-	-	.10	< .001	.10	< .001
	←	SN	-	-	.29	< .001	.29	< .001
	←	IM	-	-	.09	< .001	.09	< .001
	←	eHR	-	-	.27	< .001	.27	< .001
	←	CeL	-	-	-.09	.020	-.09	.020
	←	GeL	-	-	.01	.564	.01	.564

Note: HS: health status, PSe: perceived seriousness, PSu: perceived susceptibility, SN: subjective norm, IM: image, eHR: eHealth readiness, CeL: communicative eHealth literacy, GeL: general eHealth literacy, PU: perceived usefulness, PEU: perceived ease of use, INT: intention to use the digital DPP.

Appendix AJ: Deductive Content Analysis Summary (Study Three)

The following six matrix tables capture the process of deductive content analysis. During this analysis, sections of text that were relevant to any of the study categories or sub-categories were 'coded' to one or more relevant categories. Sub-categories were created where required. For example, when coding text to the *Knowledge of T2DM* category, the need for the subcategories of *Type of Knowledge* and *Source of Knowledge* became apparent. Example codes represent actual codes that were identified.

Personal Health Matrix

Category	Sub-category	Example codes
Knowledge of T2DM	Type of Knowledge*	It's a lifestyle disease
		Caused by stress
		Leads to heart problems
	Source of Knowledge*	Conversations with GP
		Newspaper articles
		Search the HSE website
Perceived Threat of T2DM		Previous gestational diabetes
		Family member has T2DM
		It's something to avoid

*Denotes sub-categories that were generated during deductive content analysis.

Social Influence Matrix

Category	Example Codes
Social Influence on Health Behaviours	Family suggested I lose weight
	Health professionals don't care
	YouTube Influencers
Social Influence on Technology Use	Sibling recommended the watch
	They're a status symbol
	Received the watch as a gift

eHealth Literacy Matrix

Category	Example Codes
eHealth Readiness	Just use the phone's pedometer
	Insurance companies stealing data
	Too tech dependent
Communicative eHealth Literacy	Uncomfortable talking to random people
	Prefer doing my own thing
	Message board gatekeepers

Health Behaviour Matrix

Category	Sub-category	Example codes
Healthy Eating	Barriers to Heathy Eating	Didn't know that's unhealthy
		Don't like fruit or vegetables
		Addicted to chocolate
	Facilitators to Health Eating	Ready-made meals save time
		Giving up junk food for Lent
		Prefer simple food labels
Physical Activity	Barriers to Physical Activity	Gyms are closed
		No walking paths nearby
		Persistent back pain
	Facilitators to Physical Activity	Walking with friends
		Getting outside as a reward
		Schedule a daily exercise time

Intervention Matrix

Category	Sub-category	Example codes
Perceived Usefulness	What is Useful*	Encouragement from health coach
		Motivating each other
		Diet feedback
	What is Not Useful*	Broadband black spots
		Older people not tech savvy
		Not into sharing personal info
Perceived Ease of Use		I'll get used to it
		Looks basic
		User friendly interface
Intention to Use the Digital DPP		If my doctor recommended it
		I'd have to try it first
		When there's more time

*Denotes sub-categories that were generated during deductive content analysis.

Feedback Matrix

Category	Example Codes
Desired Features for the Digital DPP	Match with people my own age
	YouTube exercise videos
	Can adapt to my needs

Appendix AK: Additional Supporting Quotes by Theme (Study Three)

Supplemental Table 1

Knowledge of Type 2 Diabetes

Sub-category	Theme	Quotations
Type of knowledge	Precipitating factors	My eldest brother had type 2 diabetes, and I think the reason he had it is he drank alcohol. He drank too much alcohol every day, even though he didn't realise it himself, nobody around him realised it. (P1) It seems to be accepted that it is a lifestyle disease. That it can be managed by diet, by exercise, I suppose by reduction in stress. But…I do think we're missing out on something. I think there's something there that hasn't been investigated enough because a 'lifestyle disease' is a very easy label. I think there could be something genetic. (P3) I suppose the thing that comes to mind first of all is that your lifestyle could have an awful lot to do with it. (P5) I suppose my understanding of type 2 diabetes is would be that it's more the lifestyle one as you get older or through diet and stuff…you may be susceptible to it or because of your lifestyle choices and diet. (P6) It's avoidable. It's really, from your lifestyle you can develop it. (P7) Well I don't know. The 'in' word now 'stress' [laughs]. I don't know if that's anyways related. (P12) It's…mostly based on the lifestyle that you may be leading that can lead to it or contribute to getting it…in addition to stress, not being as active as you should be, could be, making different food choices…yeah, the exercise, diet, those are the main ones I can think. (P14) I think it's always something that's associated with someone who is overweight or obese initially. (P16)
	Potential implications	There's a number of side effects of type 2 diabetes. Like reduced lifespan, heart, peripheral neuropathy, kidneys, eyes. (P9)

		I suppose the things you worry about with…the eye problems and the heart problems and stroke problems, and kidney and bone and all the other things that can go wrong with diabetes. (P11) You would feel guilty if you have it in the sense that you could have prevented it. It does lead to um, major problems with circulation, eyesight, different things. (P12) There would be certain amount of limitations in your life when you have it. In terms of um, how it makes you vulnerable if you get injured or any of those kind of things…and also, if you're on medication, I believe the medication is pretty tough on your liver and things like that. (P15)
Source of knowledge	Personal research and experience	I would go to Google, and I'd look to see what organisations kind of specialise in diabetes, which would probably be my main source of information. (P5) I don't get information as such unless I look for it myself…there might be something on the HSE website, but again you need to know from the reputable sources, and if you don't have, if you don't have knowledge not to look up just Wikipedia or something, you know, you could get false information but I'd be going really to the HSE or something like that or, Mayo Clinic rather than just kind of fad websites. (P7) I'm a dietician who's worked in this area. My very own work is infant and young child nutrition. Back in the day I would have, even when working at the university it would've been all around me so. (P9) I work with people who work with lots of patients with diabetes so I would know a bit about type 2 diabetes…to be honest until I came to start working with this team, I'd never heard of critical limb ischemia, I didn't know how horrendous foot ulcers were, they put the pictures up, and you kind of want to be sick, it's awful. (P11) Yeah, I've probably bought some books on it…there's diabetes.co.uk website with a very good forum, so I would've been looking at that. (P13)

	Through the media	Through the media…so there's things once you've seen it one place, you see it everywhere so in the last few years I am seeing a lot more about the concern about type 2 diabetes, and how important it is to try to not get it. (P11) I guess through newspapers and then, um, other probably internet information, and yeah so looking at websites. (P13) There's a radio presenter. He has type 2 diabetes, so I've been listening to him over the last couple of years since he got his diagnosis, talking about it. (P14)

Supplemental Table 2

Perceived Threat of Type 2 Diabetes

Theme	Quotations
Acknowledging own risk	I got gestational diabetes five years back during my daughter's birth, I was pregnant with her, and I got it. And during that time my doctor, because I'm also overweight, so my doctor gave me this ultimatum that you will get diabetes because of family history and because gestational diabetes. (P4) I know I'm a prime candidate for type 2 diabetes. Based on my lifestyle, weight, the fact I had it in pregnancy already so, it's in the family. It's a worry, yeah. (P7) I suppose the onset of the asthma, and then my brother getting type 2 diabetes, I suppose those were the main things that got me thinking about it. My own life. (P8) My father has type 2 diabetes, and he's a little overweight but not crazy overweight and I had very high blood sugar when I was pregnant but just one point off where I needed to do anything about it and that's supposed to be a risk factor, so I do think about it. (P11) I'd probably be higher risk…now I know my grandmother had diabetes, um, I honestly don't know which, she was insulin dependent, so she was. (P12) I have an interest in it because I had gestational diabetes in both my pregnancies so I'm aware that I'm maybe at high risk of having it in the future, of having type 2 diabetes. (P13) It would be something I'd be nervous about I suppose, I've been just conscious of it for the last few years, especially since I've started going out with my partner. We don't always make the best choices, so I would've been conscious of it at intervals. (P14)

	I think the fact that I was told I was at a higher risk of developing diabetes after having the kids…I mean I had seen an endocrinologist and he's kind of said 'yeah you are prediabetic'. (P16) That's how she's [the GP] described it. I'm not there but you know I'm in that little gap where if I'm not careful, I'll fall over…she basically told me that I was out of the no risk zone but I wasn't, I wasn't in the diabetes zone so basically I was dancing here in no man's land and it wasn't a good place to be. (P17)
Taking action to prevent diabetes	If it is possible to prevent type 2 diabetes, I want to know that I'm doing the right thing and I want to know how to do it and I don't want to discover in a couple of years' time that I wasn't doing it properly… I got my readings down from 48 to 41 and now it's back at 44 and so is it sustainable? (P2) I think it's a good thing that we can at least change our lifestyle, and we can adopt things, I know better, I have, I am taking very little sugar intake. I try to watch carbohydrates. (P4) Because for me, I like to think about what I can do myself, rather than just medication. I'd rather medication to be the final resort to try and see what else I can do before that stage. (P5) I know it's a lifestyle choice. I can avoid it if I really, really put my mind to it. Um, and I suppose it's just, if I do get it I'll feel guilty 'cause I know I could have prevented it and then looking up information on it is really kind of what you have to do to prevent it. (P7) If my weight reaches a certain point I think right, I need to be good and not let this keep going, I don't want to put myself where I am at any more risk because of that. (P11) I've tested myself with his [participant's partner's] gadget to test my bloods and stuff just to see where I am, and like even the last few years going to the doctor and stuff, it would be something I would always ask them to check…I know myself what I need to do. (P14) I really am not interested in taking medication so I just said to him [the GP]: 'give me three months to see what I can do about reversing it'. And I reversed it back about three points. (P15)
People lack awareness	I am very conscious of that a lot, 'cause I'm in medical healthcare now, and a lot of elderly people are becoming type 2 diabetic and they don't think it's serious. (P1) Interesting things like the man who kept coming in for his lunch and he came in with a friend one day and he said: 'it's great here, and because it's organic it doesn't put on any weight', and I felt that I just had to correct that as he was

	lathering the organic cream onto his apple pie (laughs), you know so he thought because it was vegetarian and organic, it was healthy, and, therefore, he could eat all he wanted. So probably another educational area, gap. (P9) In Ireland it's something that's definitely not treated as a chronic disease…they don't believe diabetes to be the same extent to be as severe as say cancer… it's crazy basically…the way people understand diabetes, and they just don't seem to think that it's as debilitating as it can be…I feel like the younger people are more aware, whereas the older, they're more stuck in their ways. (P10) By what we're reading and everything else it seems to be a rampant disease. Diabetes at the moment, and you would think we are being educated on it, but sadly it doesn't seem to be sinking in. (P17)

Supplemental Table 3

Social Influence on Health Behaviours

Theme	Quotations
Interactions with health personnel	*Negative interactions* Share it with your doctor? Ha ha! To get lacerated? And it thrown in your face? I'd love to meet the doctor who would welcome you using something like that [a digital DPP]. They're very far back with it. (P3) I had some testing, free testing done…it was the peripheral resistance testing…she [the GP] was absolutely scathing 'go away with that! I don't need that'. And I had one or two other tests done she said 'keep them if you want them! I'm not interested!' And my friend had the same thing because we bought a blood pressure machine between the two of us and it was mainly for her actually, and the doctor was appalled. (P3) When I went to the diabetes clinic, she seemed to be very well informed but, however, they were stuck for time I suppose, and they probably didn't spend as much time maybe educating the likes of myself as what they perhaps could've done. I think that's often a difficulty when you're going in as a public patient you know they don't really have the time to sit with you. (P5) But no other information [on T2DM] anywhere really…we get like a health screening maybe once a year or something, and then they give about your weight…well, that's it. That's all, they just give out to you for it. (P7) I've asked my GP about weight before, but he's just kind of 'ah you know yourself what you need to do' so. Yeah. I mean, the only suggestion he made at the time was get a personal trainer, and I'm like oh well no I can't really afford that. (P8)

	One doctor will say: 'oh, your bloods show prediabetes' and the next one will say: 'ah no, everyone is pre-something, don't worry about it'. So that lack of consensus and lack of action…my experience has been if you look for an annual check-up you are likely to be seen as overanxious and offered some sort of, you know, anti-depressants or something…which leads to a frequent change in GPs. (P9) I think you're kind of on your own you know…'cause they [GPs] don't even want to see you…you're not going to be annoying them by going in and saying oh, you know, 'can you weigh me?' (P12) I actually had a call with the dietitian on Thursday, and sometimes you feel like when you're talking to health professionals that they actually don't care. Um, and the pain I was getting in my foot on a walk…it really can get you down. I said to her on Thursday I want to get out walking…and she said, 'why do you not?'…It can put pressure, and you feel crap all the time about it. It definitely gets to the point where people don't actually believe… I come off the phone on Thursday and I wanted to cry, and I was like, I don't want to meet that lady again. (P16) *Positive interactions* I was sent to a dietitian, and she said, 'you work hard…we will educate your stomach, so that you will never have a difficulty with weight again.' So, she taught me so beautifully. It was so humane to reduce what I was eating and improve the quality of what I was leaving on my plate. (P3) The local health food shop where we come from…they're a great source of information and they seem to be far more knowledgeable that other people you might think have the knowledge…I think they're probably more customer-focused than sales focused. (P5)
Influence from family members	I have a daughter who has, who is very extremist in calories and all of that so like, as a result of that now I can hardly enjoy a Magnum ice cream because she says there's something like eight spoons of sugar in it. So every time I have an ice cream I can't really, it's not as enjoyable as it used to be before that because thinking of eight spoons of sugar. (P1) My son would have accused me of being a sneaky eater in that if I had that cake I wouldn't necessarily eat it with the rest of the group. I would keep it until I couldn't resist it anymore. So he would call me a sneaky eater. (P3) They [my family] wouldn't comment on my weight…but it's more like if you really want to be healthy you shouldn't be working so much or you should go out or, it's yeah, the specifics would be, 'you should take more exercise.' (P8) All they [friends and family] ever tell me is that I overdo it. 'You're too hard on yourself, have a treat.' "No wonder your knees are bad, you're pushing yourself", you know? (P15)

Supplemental Table 4

Social Influence on Health Technology Use

Theme	Quotations
Exposure via family or friends	*Adopters of Health Technologies* I decided years ago, it was one of the first ones, a Garmin, I forget the name. So I got it as a present, got it for Christmas. I was, thought it was great, I had it at work and I was one of the first, I would think years ago. (P1) Everybody's wearing Apple watch and um, you know it's very common it's I think somehow status symbol…everybody knows even my 10-year-old boy he's having that…I know people that they are just wearing they even don't know that these can give them benefit …like they are just wearing, just because everybody is wearing. They actually don't know what is the use of that. (P4) If I wanted something I think I ask my sister about what sort of an app you know, she's recently upgraded her Garmin so I'm kind of looking at a Garmin at the moment 'cause the Garmin seems to be quite; well, they're quite expensive but then you know, they link to your phone and everything. (P5) I think somebody else (a friend) told me about My Fitness Pal and I actually did use that maybe two years ago just 'cause I thought I was getting heavier than I wanted to be, and I thought at the time I'll just keep track of what I'm eating. (P11) All of my family have them now, they're all going on about them…people like to have something else to focus on and be like: 'oh look I did 12,000 steps today'…I have the health app that Samsung have on the phone, so I'd use that every now and again. (P14) *Non-Adopters of Health Technologies* I've a friend who has, now his is more geared at exercise for the elderly or physical activity for the elderly, but again it's based on a message coming to your phone and, you know that sort of thing, and we discussed it at various times but I'm not even motivated enough to download the free trial for him even though he asks me frequently if I would even have a look at it. (P9)

	I do have a friend and to me she became obsessive and, no I wouldn't definitely like to do that. (P17)

Supplemental Table 5

eHealth Readiness

Theme	Quotations
Security and privacy concerns	I think with education, like they'd have a problem with their insurance policies knowing everything about them and their risks and their accidents and everything. And health care having all their history and big brother knowing everything…there are problems with it obviously, concerns. (P1) I'm very cagey. I will not sign in to any health app on my phone that monitors my health because I do not trust the health insurance companies…I have no doubt they would either pay so well, they would get the information, or they would hack so well. (P3) I feel there can be a lot of issues around data protection. 'Cause I know, I'm currently doing a module on data protection so it's all health information, apps and things like that so um, I feel a lot of patients…they're very privatised with their information. It's quite difficult, especially here in Ireland, I feel a lot of the older generation, you can hardly get their name, never mind any information out of them. (P10) So yeah, I'm certainly thinking a lot about this tracker, and where that information is going, and I guess, you know, since our data's being scraped all the time…I guess I would probably feel more comfortable about that if you felt your data was going to actual research. (P13) I don't like the idea that some of them can, you can sign up to swipe, like, your bank card from your watch. That kind of freaked me out a bit. I couldn't figure out to do that, it wasn't something I would do anyway. Or some of the ones that read your text messages. That's a step too far for me. It'll only be a matter of time before we get calls on our watch. (P16)
Why eHealth did not work	I had a Fitbit, I gave it away. I was using just the bare minimum. It had a lot more capability, but I didn't give myself enough time to educate myself how to use it (P1) I had a Fitbit there a couple of years ago, but I stopped wearing it 'cause I got obsessed with looking at how much sleep I was getting, and I nearly felt tired if I didn't. (P6) The watch actually doesn't suit me at the minute. I'm allergic to the strap. (P7)

	I found it annoying because I don't always carry my phone with me, and I just presumed that you have to have your phone with you, and I don't carry my phone the whole time, so it was just kind of annoying…it's just a kind of a very blunt instrument really. It doesn't really tell you anything except a number. (P8) My daughter gave me a smartwatch a few years ago or a Fitbit and after about a month I sent it back and got my money back. My son-in-law…if it's 10 o'clock at night, and he hasn't closed the circles in his Fitbit and reached all his goals and targets at 10 o'clock at night in the winter and the snow, he would go out to jog or walk or whatever in order to meet his targets before he goes to bed. I would never do that. (P9) I started to try to adopt a keto diet, and so I was using a particular website called Diet Doctor and eating keto diet and that for a couple of months I guess. Why did I give it up? I think it was just driving me a bit crazy. I find for me it's not very healthy to really hyperfocus on what I'm eating. (P13) I think it can be, probably you could become a bit obsessed you know? You don't want to spend time setting, programming your watch or your app when you should be actually doing your walking. Don't want to spend too much time switching through them, just get out and go… I found them awkward because sometimes they didn't always fit right or didn't always count. (P16)
Why eHealth does work	It's nice to have a watch on because when your watch tell that you are on so far since morning, and you did not move…it gives you more motivation that okay, we can do a little more, so I think it's a good thing. (P4) I use them in my everyday life, and I go for a run, I use apps for music and then apps to track the distance…I always want to make sure that I have set a minimum and that I don't go back from the minimum. (P5) She's a Slimming World consultant. She runs the Zoom call and then the rest of the participants during the week, and they talk to you then about how you got on that week…But the Zoom calls, they are good, it's nearly like a shared community. (P7) I do occasionally watch a fitness and physical activity video that comes from somewhere in the US. A free one on YouTube that is aimed at seniors and some of those are much better. (P9) I used My Fitness Pal the most and yeah, I found it very good 'cause you were able to track your food according to the brand and everything and right down to the small details. Things like that open up your eyes to what you're actually eating…it was very motivating to be able to just see where you're at in your day and what you're allowed and what you're not allowed more or less. (P10) I did a short series of coaching sessions with someone on mindfulness and eating, which I guess is similar to intuitive eating but it's not the actual intuitive eating

	programme so um, that was one-to-one though over Zoom, so that was really helpful. (P13) When I thought about the Fitbit I needed it for motivation. I think this morning I've already done about 8,000 steps. I aim for over 10 every day…it's on me all the time. You know except when I shower. (P15)

Supplemental Table 6

Communicative eHealth Literacy

Theme	Quotations
Information exchange	There was a Keto group…I joined that group also, so because of these two groups on Facebook I got a lot of ideas for making food like, what can be in my lunch, what can be in my dinner. (P4) There's a Zoom call every week, and you're chatting to people. I find it good, and it's accountable you know you're accountable for what you eat and there's support there to what you eat and give you tips and things when, you get bored with your food and there's ideas and stuff, and if you're not losing weight, and you think you've done good, they'll give you hints and tips on how to speed it up or you know what you could be doing wrong and that kind of thing so it is good yeah, I do like it. (P7) There's one for like slimming world recipes…it's all a similar demographic, and everyone's trying to support each other like 'look what I lost this week, and I found this really nice recipe' and things like that, so I think it's a similar type of situation and it definitely seems to work with 1000s of people on the page and everyone's really supportive with each other. So, I just think no matter the age it's definitely beneficial. (P10)
Keeping a low profile	When I say I do Pilates class I actually don't talk to them, I just listen to them, and so I use it as I, I wouldn't be setting up Zoom. (P2) Like I don't socialise a lot with people I don't know, so I was not like connecting with them, but I was reading, I'm a quiet reader so I was reading each and every chat and post and everything so that's how I got ideas. (P3) I think there's a little bit of resistance at the beginning. Partly, even for the Pilates by Zoom you know, is the camera on? Do I want the camera on? Maybe I want the camera off at the moment. There's a little bit of anxiety until you get to be more confident with it. (P10) I think it depends on how you engage in it. So I chose, I used it as a source of information, but there are definitely people who are, you know, asking questions and posting their results and being more actively involved. (P13)

	Very seldom I would ever ask a question…or they're going to think, 'oh she knows it all, so like she's had one child, and all of a sudden she's like, quite extraordinary'…That would be good, to be able to view the information but not necessarily be under pressure to post. (P16) I don't like oversharing as a rule. So, you know, for a second it would take too much acclimatisation to, if I was the one to put up a post or something to get, you know? Whereas I don't mind replying to people to talk something through, but for me to instigate or the, yeah, that for me is, that is harder. I feel I would learn more than contribute more. (P17)

Supplemental Table 7

Healthy Eating

Sub-category	Theme	Quotations
Barriers to healthy eating	Cravings and comfort eating	We sometimes would open a box of chocolates at work, and we could just plough our way through them because we're so busy, we're just getting a quick fix. We wouldn't be thinking, we'd just open them, and they are addictive, and you start, and you'd eat them all. (P1) We have our movie night on Friday so that's full of sweets and I'm addicted to chocolate and sweets. So that's my problem. I eat healthy during the day and snack in the evening, which is really bad. (P7) That's just…the snacking and treats and chocolate and stuff…it's comfort eating and I don't, I haven't managed to grapple with that yet. (P8) I found myself getting into really bad habits over Christmas, 'cause you feel like you deserve that extra treat because of the pandemic and you deserve it. (P10) Cutting out sugar. Basically, which is basically an addiction of mine. I'm not joking [laughs]. It's awful [laughs], it's awful. Um, I've never drank in my life, but I'd say it must be what an alcoholic feels. You taste sugar, that's it. (P17)
	Mixed messages	Trying to follow the pyramid, and I was eating more potatoes so I wouldn't be looking for biscuits afterwards and then somebody said to me 'well potatoes are actually quite high in carbs' so I stopped eating potatoes. (P2) I suppose knowing what actually, like you can think something is actually okay, but when it's examined, it's not, and you're kind of going like 'oh jeepers I thought that was alright' you know? (P12)

		Even things like the nutritionist would be like: ‘do not eat bananas, tropical fruit, full of sugars.’ The dietitian sent me a meal plan on Thursday and the first thing on it for breakfast was banana on toast, and I'm like ‘oh god’ I haven't had a banana in two years because. I really find there's a lot of conflicting information. (P16)
	High cost of healthy foods	Something like that you know, accessibility is a major thing, ‘cause everything is, a lot of the healthier options can be a lot more expensive, um so it's quite difficult to make that decision, especially if you're a student. I think that would be a major factor. (P10) What gets me is most of the unhealthy food is cheaper. Do you understand? Like I mean if you go into a, you know yourself, a shop. Like, I don't want to, I can't wrap my head around it, I don't understand it. (P12) Well, the cost of food…it's extortionate. I've made a conscious decision to try and eat what's in season, and I'd just buy the veg that is on special offer…I stopped buying strawberries and raspberries. (P16)
Facilitators to healthy eating	Being proactive	I am on portion control like previously if I am taking a one you know we use to eat ciabatta flat bread in our culture so if I was taking one of that now I am having half of that, so this is how I am trying to manage. (P4) I've been trying to kind of batch cook things and have things constantly on standby as opposed to reaching out for whatever's there or ordering a takeaway. (P10) Being organised. Having your meal plan done out and sticking to it. Ah, you know. It's not rocket science…I have done meal plans. Yeah, I'd have done Weight Watchers. Um, and it works when you write down what you're eating and keep track of it and all of that…and it's portion size as well, I suppose. (P12) I've been trying to do a shop once a week…and then there's a local fruit and vegetable guy, so instead of going into the supermarket again, just having plenty of fruit and vegetables. (P14)
	Knowledge is key	My background, I'm actually a dairy scientist…so I have a good understanding of the composition of foods, and we eat a reasonably healthy diet. (P2) I came to know that what comes in Keto diet, and how I can eat even what food I can make for myself like in lunch and or dinner, ideas from that. (P4)

		For me, until you measure something and actually find out the detail of it, it's all just a bit pie in the sky. I like to know what exactly something is going to be, you know, how is it measured? What is the weight?' (P5)

Supplemental Table 8

Physical Activity

Sub-category	Theme	Quotations
Barriers to physical activity	Limited opportunity	I am trying to adopt healthy lifestyle but it's very hard with this lockdown, and it's affected a lot because we are unable to do gym anymore. (P4) I'm home schooling at the moment, I'm working, running a house. I try and get out at least two or three times a week for about an hour, but then the weather's bad…so it's not good. (P7) I'm trying to commit to a walk every day so the weather's been really bad so that hasn't, so between work, and the weather, that doesn't always happen. (P13)
	Physical discomfort	I have late onset asthma as well, adult-onset asthma, which means it's harder to exercise, and so all these things have started, you know, getting me to think about my own health. (P8) I have really bad arthritis in both my knees, and it's quite painful sometimes to walk as I used to get gel injections. (P15) I have a problem with one of my feet, my right foot. I'm on antibiotics what since August. So I have a condition it's actually really terrible. I've got infections, and yeah, I have, wearing my cartilage. Last week I might have done about 3k, the week before I did 3k every day, but then I could hardly walk. (P16)
	Lacking interest or motivation	Sometimes it's just easier to say 'ah, I'll just have a cup of coffee here, and I won't go out'. There is a treadmill about 30 feet away from me and twice in the last week I used it for a total or 9 minutes one time and 2 minutes the other time. So, you know it's not lack of opportunity. (P1) When I was working it's very easy to come from work and say, I live in the country okay, so our road is narrow, and it's dark. It's easy to come home from work and say 'oh, I'm too tired I couldn't, I'll do it tomorrow.' (P2) I did start walking more over the spring and the summer even a bit into the autumn, but that has stopped recently, 'cause it's, I don't want to be part of that world [on walking for leisure]. (P9)

Facilitators of physical activity	Having social support	I would walk with a friend. I would swim with another friend. But it was the positive, the positive um, it was really her that got me going. So I would say it is to surround yourself with positive people who are doing the right thing. (P1) I've a close-knit group of friends around me, so we meet up and go for walks because that seems to be the only thing we can do at the moment…It became the new coffee, the new night out…where you'd be walking, and chatting, and catching up. (P6) I do if I'm with somebody, I don't like it on my own so then you can talk to them. No, I find walking very boring on your own. Unless I've somewhere to go yeah. (P7)
	Being outdoors	I like the fresh air…it's easier to go out on a fine day rather than when it's a cold day…I suppose one thing with this pandemic is that you're dying to get out for your walk in a day. (P6) Outside yeah, definitely outside. Especially when it's nice out, which is very rare over here but [laughs]. And just trying to get out of the house as much as I can, trying to go for a walk, and trying to see that there is a world out there outside of the screen [laughs]. (P10) If I am just sick of being indoors, I suppose that would be another thing. I just feel like I have to get outside and do something. (P11)
	Keeping to a routine	Well, I suppose with the lockdown I have more time, so we are exercising an awful lot more, and I started doing yoga nearly every night. (P5) I think having a standard routine. Um, something we've all found working from home you know we have to have your own routine otherwise you'd be just, you'd be so out of it, you'd be just sleeping through days. (P10) I spent most of the pandemic trying to get into a routine of doing yoga, so probably what made the difference there was fixing a time of day where nothing else was going to happen. (P13)

Supplemental Table 9

Perceived Usefulness

Sub-category	Theme	Quotations
What is useful	Health coach support	I'd like a health coach because I have Zoom, I've read various things myself, but I mean, one article will say A, the other article would say B, and well you need to know which is the best. (P2)

		I thought the coaching side of it is good…I suppose if you had questions on different things. Like instead of googling and guessing, that you could actually put it out there and ask someone who's going to give you an answer back that's evidence-based, and it's accurate. (P6) I think that would be very helpful in itself, and be able to have that consultation type environment to really be able to put a face behind why you're doing what you're doing. (P10) Someone that can actually look at the diary and go: 'yeah that's okay, that's not okay, maybe you could try this instead' you know? Um, just things like that. To keep you on the path. (P12)
	Support from other participants	I thought if you had a network then there was the thing, I think you could contact people, and then you know, are they struggling? Do they want to go for a walk? There might be some things there that could be beneficial, depending on where you live and what the network around you was like. (P11) There seems to be a lot of support from different sides. If there was people in your area that also had the app, that you could link in with people you can go for a walk with. (P14) Accountability…and there's a chat room and there's sharing, you're actually not alone and don't feel it's just me. Or just to chat with somebody having the same problems and talk through with you. (P17)
	Keeping track	Um, you know live self-monitoring, guiding and other exciting, and the tracking and the education. The overall package I liked. (P3) Monitoring and tracking actually is something could definitely be of benefit to people 'cause I feel like with a lot of these apps you don't necessarily see the day to day progress or week to week…like you'd like to see a progress report, and I suppose with the lifestyle plan working with that individual's lifestyle and not just saying you have to do X, Y, and Z to be whatever. Which is definitely something really important. (P10) I think some of thing about logging your activity is probably quite good in the same way that that My Fitness Pal sort of keeps you honest with yourself. (P11) If you log your exercise like if they can get the overall package of what you're doing in your day you know…they can get an overall picture of what you're doing and whether you're doing it right or wrong. (P12)

		Tracking the food I think is a good idea actually…I think it's a reminder, it's your conscience almost, so I think that I've never done it, but I actually think that could be a very good idea. (P17)
What is not useful	Social interaction	I would hate the part of meeting other people to talk about it. It just reminds me of an AA meeting. That for me that wouldn't work at all, I'd hate it. I'd feel uncomfortable about it and talking to people I don't know about my health. (P8) It's just the social media thing, you know I really am not interested in putting myself up on Facebook or anything like that. People I need to contact I will. I still prefer to speak to a human being…I wouldn't be interested in being involved in any kind of community goal either. I'm not interested about other people to be honest with you…I'm able to motivate myself. You know I create my own goals. (P15) The community forum. I'm not sure how much I would use that you know? I suppose for me, look I'm always afraid that my next-door neighbour's going to be on it with a different user ID [laughs]. And they'd say: 'did you see what [participant] said?' (P16)
	Accessibility Concerns	I think older generations…my parents they, well I suppose they wouldn't be very tech savvy. I don't think an app like that would be good for them because they just wouldn't manage it. (P6) There isn't as wide a broadband access around the country as people think they are, think there is, and here, if you go up the road, there's no internet access. (P9) I definitely think accessibility would be a major issue for rural parts of the country and the older generation. Yeah, so even just having a smartphone, but definitely broadband connections. (P10)

Supplemental Table 10

Perceived Ease of Use

Theme	Quotations
User friendly	Well, I thought it looked easy enough to use like, it's basic like, and I suppose anything like that needs to be basic and user friendly. But I suppose until you're actually using something, and physically using it on your device or your phone, that that's when you might say 'oh this is a bit tricky here to put this up or where do I look for that', but to me it looked very user friendly. (P6)

	Yeah, it looked fairly easy to use, it was very colourful…it didn't seem overly complicated or anything like that…it didn't seem like you'd have to go through four or five different clicks to get to what you wanted, it was one click option, that kind of thing, yeah that was good. (P7) 'I'm sure it would be pretty easy once you get started, once you navigate your way around it. There's usually good instructions with all of these apps anyway. (P14) I thought it looked to be laid out very well and very clear and quite user friendly…it did look like it was really user friendly and really easy to use. (P16)

Supplemental Table 11

Intention to Use the Digital Diabetes Prevention Programme

Theme	Quotations
Willing to try	Yeah, so the rest of it as I say is very hard to judge when you're looking at a brochure. Until you actually see it on the app and try to use it, I think there is nothing else I could say about it. (P2) I might have in the background for the um, you see I probably. I'm a little compliant and a lot non-conformist I think, and I'd have it there, maybe look at the, maybe look at the educational models, modules I might be seeing who's the healthcare support person. If they were good I might. (P3) I think so, I'd have to give it a go and see but from looking at it initially, yeah it's inviting…something I'd try, but again I'd have to see as I said I might lose interest after a while, but initially yeah it looks good. (P7) I would yeah, and I suppose it's only from use and that, that you'd might find pitfalls, or you know, things like that, that you'd go 'oh well I might change that, that could be changed' or, you know, something like that. But that's like with any app. You know? So um, no I think I would, I'd give anything a go [laughs]. (P12)
If it came physician recommended	I don't know if I would go sign up myself, I think I'd nearly have to have the doctor say to me 'you should do this'. I don't think I'd volunteer myself for it. But if I, you know, if the doctor said, 'do this' that you know 'yeah do this,' and if my medical records were feeding into it somehow you now, and if there was that connection with the GP, I'd feel comfortable enough. (P8) I think if it was something a doctor was recommending to me then I probably would. I would probably take it on face value that it was a legitimate thing. (P11)

Appendix AL: Desired Features for the Digital DPP (Study Three)

Supplemental Table 12

Desired Features for the Digital Diabetes Prevention Programme

Feature	Quotation
Blood glucose monitoring	If it monitors the blood sugars and things like that. I was surprised when I had the gestational diabetes, just how much your sugar can increase, even with a little chocolate bar. So, if it was monitoring things like that, I think it's good to know. Like even, I noticed when you have a proper meal and have something nice afterwards it doesn't spike as much, that kind of thing. (P7)
Nutritional information and advice	What can you put in your shopping list today and maybe calorie count per shopping list or something like that…if you had total carbs or something per meal or…if there was something like that it would be handy for me. (P7) Are there diet sheets and recipes included in it in anyway? But just, you know, a diet plan certainly where I would see maybe where I am going wrong and maybe even introduce new foods into my own diet. (P15)
Enables autonomy	I don't want somebody telling me, 'you ate too much pieces of meat yesterday, and you didn't have your fish today, and you should have your apple tomorrow.' No, I want to be told like, 'you need to eat X amount of fish twice a week and I go away and do it.' I don't want to be told what to do. I want to live my life. I want to know how to do it and the best way to do it and um, and to go away and work on it. (P2)
Suitable for people with gestational diabetes	I know from people that I know that have had gestational diabetes that, you know, the linking in, the keeping the food diaries, to checking in with the nurse, the app would do that very same thing without all that going in and out to the hospital…would someone with the likes of gestational diabetes if they got that would that, would they get access to that app? (P6)
Qualified health coaches	I like the coach thing. The checking in, but the qualifications of the coach would be my question because it gets mixed up in video one at around 2:24. You're talking about the healthcare professional, then you're talking after that about the doctor, so what is the healthcare professional involved? (P3) I'd be interested to see if the dietitians know enough about diabetes in particular. Are they experts within their field because I think nutrition probably is quite a vast area and what you might need to know for your nutrition in one disease might be slightly different for another disease. (P5)

Information privacy guarantee	I think there is a place for this type of thing, but prove that it's encrypted, it's private, and I suppose keep the judgement out of it. (P3)
Facilitates motivation	I think the overall thing you really need someone to motivate you and to keep you going…I think motivation would be something that would have to be high on my list there and realistic goals. (P16)
Sound evidence base	I'd like to know, has it worked, and as I say like, is it a long-term result, are there long-term results there, and did they claim that people are reversing diabetes after six months? We'll I've done that, so that's like, tell me about people who have been doing it for two years and where are they now? (P2) I think it is the platform to have right stuff, but it needs stuff, needs to be verified and validated. (P3) Something like that would be a good go-to thing where you could get information, and I suppose evidence-based information that's accurate, that's not like somebody making it up. (P6)
Need to be flexible, adaptable, and tailored	To leave it at the basic level if that's what one wants, and if they want a higher function then another person can get that out if it. And then because like, on my phone I can only, I just use certain amounts, I don't use it to the full function so we're all using things at different levels. (P1) I suppose people could opt in and out. Like as the group side of it people could opt in and out, and if they just want to do the coach side of it, the link with their coach, their doctor, upload their stuff on a one-to-one basis, that they have the choice to do that and then maybe as an add-on they could do the group or the forms. Because I suppose some people will just want to look 'I'll just link with my coach, my doctor, I don't want to be linking with anybody else.' But other people might thrive on linking with other people and groups and getting that, I suppose, shared experience group support. (P6) I'm always caught between whether you should be very prescriptive in these things, or should be tailored to suit the person's need, and I think it has to be tailored. I don't think something very prescriptive would work for me. (P8) I think that definitely having personalised goals that aren't computer-generated. That would be a massive thing. Um, because sometimes I feel like you're entering in data into the app, and you're like 'why am I even doing this?' Like no one's looking at it it's only me looking at it. (P10) Yeah, I think I would want to be…to be able to tailor it to you, you know. Maybe with its guidance…if a health coach is telling you, 'well you're focused on diet, but actually I think you really need to be exercising as well.' (P11) I would really want it to be able to completely ignore weight, so like even on my watch I have my weight set to 10kg so that none of the information on calories

	burned or anything like that is actually relevant to me because I just don't need to see that, it's not something I want to get drawn into. (P13) Flexible and not so much, you know, life happens. Yesterday was Mother's Day, and it was business as usual here…my husband pulled a muscle…on a day like that if you were talking with a health coach or dietitian or app, it is not a day when you could go off and do the walk or do whatever you know. There would have to be flexibility. (P16)
Gamification	The concept of getting incentive, financial incentive or getting points that you can cash in for gifts or whatever, I thought that was a good idea that I've never seen over here. (P9)
Homogenous peer groups	If there was, just say for example that someone who got type 2 diabetes um, well say that the type 2 people are, they are all in one group and then the type 1 in another group…so they're not under pressure with people who have type 2 diabetes…If there were shared kind of common goals. (P6) For example, chronic disease I mean, disease specific, do you know, because if you match a patient with arthritis, it won't be the same, it won't have the same mobility issues as someone with diabetes necessarily. Like that type of demographic as opposed to all people over 40 whatever. (P10) That it's enjoyable I suppose that, you know, it's not about what you can't have or can't do or whatever, that it's you're linking in with people who have the same motivation as you. (P14)
Linked to personal medical records	If the doctor said, 'do this' that you know 'yeah do this,' and if my medical records were feeding into it somehow you now, and if there was that connection with the GP, I'd feel comfortable enough. Again, it comes down to this holistic thing, you know, if the GP already has all that information this app will provide some other information that will help in my general health. Or the information the GP could feed into this will help. An extra layer of explaining isn't helpful. (P8)
Online exercise classes	I just thought if there was maybe, exercise classes, a bit informal. YouTube or something, I don't know, something like that. Especially now at home 'cause we can't go out, we can't go to the gym, and the online stuff has really taken off so again, sign up for a weekly class, and you have to do it. But it's on your own time…scheduled ones every week, and I know the forum as well is there. Me personally, I'd nearly like every week, you know a set time. If it's not there, and it's not scheduled I won't bother. (P7)
Reliable technology	I suppose as long as the app does what I want, I'd use it. But yeah, if it didn't, if it wasn't easy to use and didn't give me what I want, I wouldn't be that interested in it. (P2) It needs to be tried and tested beforehand because if people start to get the feel that something's not accurate or it's not picking up what it's supposed to be picking up, it just kind of gives a downer on it. (P5)
Easy setup	You don't want to spend time programming your watch or your app when you should be actually doing your walking. Don't want to spend too much time

	switching through them, just get out and go. So, if it's not working you know, unless it's a new skill I'm learning…I think to, for long term to sustain things to keep you going it would have to be easy and simple. (P16)
Reminders and prompts	Sometimes you know you have a lot of apps on your mobile and you forgot about that with time. So, I think it's a good thing that a little reminder of these type of things are good. (P4) There should be nearly a little red flag in the corner or something to say you didn't reach your target this morning, and I think that would be motivating. (P7) If you don't wear them, you're missing out as well. Like I took it off for a week and then I kind of got lazy then when I didn't keep it on all the time so, I don't know maybe it should beep at me or something and tell me to put it back on. Remind me it's there yeah, you get out of habit very quickly without using them. (P7)