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The Health Economics of Obesity in Ireland

by

Michelle Queally

A thesis submitted for

The Degree of Doctor of Philosophy

From

J.E. Cairnes School of Business and Economics

National University of Ireland, Galway

Supervisors

Professor Ciaran O'Neill (Primary)

Dr. Francis Finucane (Secondary)

Abstract

An abundant literature exists linking obesity to a range of health conditions as well as premature mortality (Calle et al., 1999, Larsson et al., 1984, Jagielski et al., 2014, Kearns et al., 2014, Pi-Sunyer, 1999, Reilly et al., 2003, Garrow, 1999, Guh et al., 2009). Excessive body weight has also been linked with a range of psycho-social issues inlcuding low self esteem, stigmatisation, discrimination and a range of mental health problems (Puhl and Brownell, 2003, Dove et al., 2009, Ozmen et al., 2007). The rising prevalence of obesity and the consequences in terms of health and wellbeing as well as economic welfare have prompted this thesis. Rather than providing an exhaustive examination of one specific issue this thesis seeks to explore a number of inter-related issues to demonstrate the breadth to which obesity impacts on lives and the complexity of the interrelationships those impacts can have. This thesis examines the role of different adiposity measurements in determining the relationship between obesity and service use in Ireland, what factors influence the values attached to alternative treatment modalities as well as how we infer cost effectiveness from other jurisdictions and what impact obesity has upon children in the school environment.

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Table of Contents

Declaration of work

I, **Michelle Queally**, certify that the Thesis is all my own work and that I have not obtained a degree in this University or elsewhere on the basis of any of this work.

Signed: -- Date: -------------------------

Acknowledgements

I consider myself to be very lucky regarding the support that I have received from my supervisors, family and friends; so after four years there are a lot of people to acknowledge and thank.

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Dedication

This thesis is dedicated to John, a wonderful partner and friend.

List of Abbreviations and Acronyms

CEA	Cost effectiveness analysis
CL	Conditional Logit
BMI	Body mass index
CVD	Cardiovascular disease
DCE	Discrete choice experiment
D&LM	Diet and lifestyle modification
HCU	Health Care Utilization
LC	Latent Class
MRS	Marginal rate of substitution
NIH	National Institute of health
PHI	Private health insurance
RPL	Random Parameter Logit
SRH	Self-reported health
WC	Waist circumference
WTHR	Waist to hip ratio
WThR	Waist to height ratio
WHO	World health organization
WTP	Willingness to pay

List of Tables

List of Figures

1. Introduction

1.1 Background to the thesis

The ongoing epidemic of obesity and its associated complications such as diabetes, increased cancer risk, and cardiovascular disease (CVD) is creating an unprecedented challenge for healthcare systems around the world. Fundamentally, when an individual's energy intake is greater than the amount of energy expended, the unused energy is converted into fat and deposited in the body (Hall et al., 2012). This "equation" can be deceptively simple as while it explains how people gain weight it does not explain why individuals make choices regarding food and exercise the result of which are weight gain. Nor does it account for differences in how individual bodies process the energy, making some perhaps more prone than others to weight gain. Beyond individual choice and the implications this has for weight gain are the broader implications for individuals and societies of obesity. These include not only the economic burden of obesity-related disease for individuals and society but indeed how society views obesity and engages with the obese at an individual level.

1.2 Motivation for the thesis

Unlike other major global health risks, such as tobacco and childhood nutrition, obesity is not decreasing (Ng et al., 2014). As outlined in the next section there are a plethora of studies detailing the increasing prevalence of obesity worldwide, currently estimated to be at 24% in Ireland (Alliance, 2015). Obesity is linked as a leading cause of death as previously noted, it increases the risk of other chronic conditions such as type 2 diabetes mellitus, hypertension stroke and cancer (Pi-Sunyer, 1993, Pi-Sunyer, 1999). Indeed the economic burden of obesity may be more related to the cost of managing chronic comorbidities that arise as a result of obesity rather than obesity itself. As discussed in the next section, a number of studies have quantified the costs of obesity. As part of these studies the measure of adiposity[1] that is used is important in terms of accurately quantifying the costs of obesity. In the medical literature the most commonly used measure, body mass index (BMI) has frequently been criticised primarily due to its inability to distinguish fat from muscle. This criticism is also valid when using BMI to estimate the economic burden of obesity in which there is the potential of misclassifying obesity, which in turn may lead to inaccurate cost estimates therein.

Although the cost estimates of obesity vary largely depending on the approach applied (top up or bottom down) and types of costs (direct or indirect) estimated along with the adiposity measure used (BMI or waist to hip ratio or waist circumference); the general consensus is that as the prevalence and severity of obesity is increasing so too is the demand and subsequent costs being placed on healthcare services to treat obesity and its related comorbidities. In this regard a number of these costs are possibly avoidable in the sense that there may exist cost-effective interventions to prevent and treat obesity; that is if it is possible to get people to engage with them. Furthermore there are areas where our understanding of the impact of obesity, or more correctly how society responds to obesity in terms of stigmatization or discrimination, that remain underdeveloped. If we can obtain a better understanding of the effects including non-health related effects around stigmatization – and how these might vary as we measure obesity for example in different ways – and of what might constitute successful cost-effective interventions we may be better placed to develop an appropriate policy responses.

[1] Excessive accumulation of lipids in a site or organ

1.2.1 Measurement and prevalence of obesity

BMI in adults is calculated by dividing the individual's weight in kilograms by the square of their height in metres is widely used to measure overweight and obesity, and the World Health Organisation (WHO) and the National Institutes of Health (NIH) use similar BMI cut-offs to define overweight (BMI > 25) and obesity (BMI > 30) in adults (Panel, 1998, Organization, 1999). Accordingly an individual is placed in one of six BMI categories; underweight, normal weight (BMI 18.5-24.9), overweight (BMI 25.0-29.9), class I obese (BMI 30.0-34.9), class II obese (BMI 35.0-39.9) or class III obesity ≥ 40.

Obesity prevalence is increasing as confirmed by the most recent global study which combined self-reported and measured BMI data to analyse the global, regional, and national prevalence of obesity in adults (Ng et al., 2014). According to this study between 1980 and 2013 the increase in obesity and overweight rates in adults was 28% and children 47% with the number of overweight and obese people rising from 857 million in 1980 to 2.1 billion in 2013 (Ng et al., 2014). In Ireland there is no shortage of studies quantifying obesity prevalence rates. Table 1 below extracted from (Dee et al., 2013) provides a comparison of the prevalence of obesity from SLÁN[2] 2007 (Morgan et al., 2008) and TILDA[3] (2010) (Barrett et al., 2011).

[2] Survey on Lifestyle and Attitude to Nutrition (SLAN). SLÁN is a series of surveys commissioned by the Department of Health and designed to produce baseline information for the ongoing surveillance of health and lifestyle behaviours in the Irish population.

[3] The Irish Longitudinal Study on Ageing (TILDA) is a large-scale, nationally representative, longitudinal study on ageing in Ireland.

Table 1. Summary of Irish obesity prevalence rates

Study	Population	Obesity Prevalence
SLÁN 2007	Males 50+	34%
	Females 50+	28%
	All	31%
TILDA 2010	Males 50+	37%
	Females 50+	31%
	All	34%

Source: (Dee et al., 2013)

1.2.1.1 Childhood obesity

The trend of increasing obesity among children and adolescents along with the increasing severity of obesity has caused particular concern. In Ireland (Ng et al., 2014) reported obesity rates of 6.9 % for boys under 20 and 7.2 % for girls under 20 and for Irish adults over 20, the rates for men and women are at about 23%. With children and adolescents it is harder to reach a consensus with respect to definitions of obesity largely because as their bodies undergo rapid physiological change their relationships between specific thresholds of adiposity and health risk are more difficult to predict (Flegal et al., 2006). Instead of using fixed BMI values to classify individuals (as used for adults) children's BMI is classified using thresholds that vary to take into account the child's age and sex. These thresholds are usually derived from a reference population, known as a child growth reference, which means that individual children can be compared to the reference population and the degree of variation from the expected value can be calculated (Dinsdale et al., 2011). BMI thresholds are frequently defined in terms of a specific z score, or percentile, on a child growth reference.

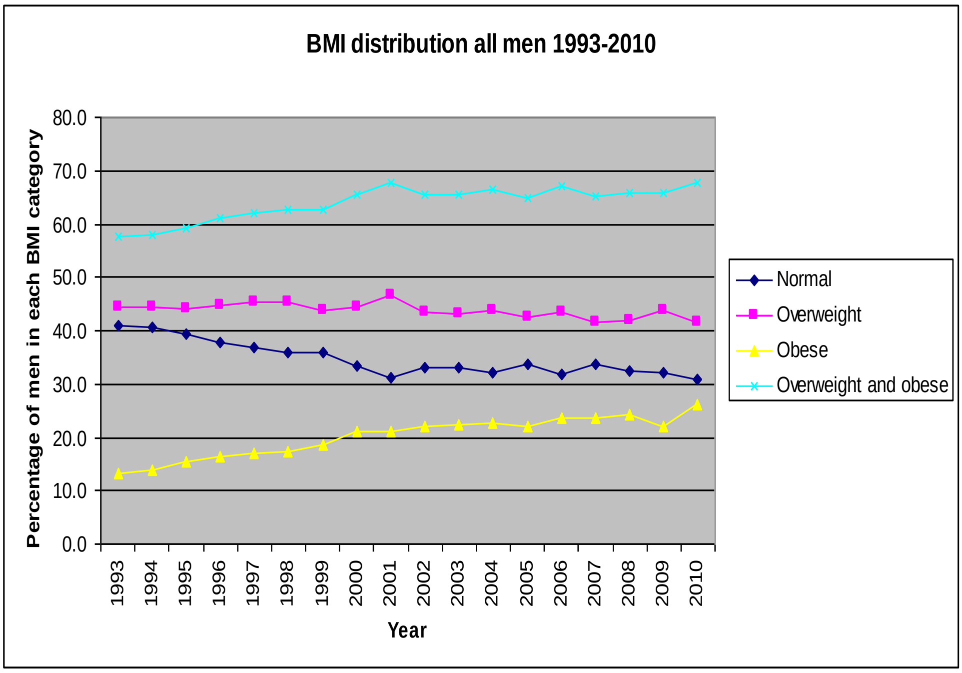
The percentile measures adiposity as the value of a variable below which a certain percentage of observations (or population) falls, i.e., the percentile refers to the position of an individual on a given reference distribution (Wang and Chen, 2012). Accordingly obesity is defined as a BMI at or above the 95th percentile for children and adolescents of the same age and sex. A BMI z-score (or standard deviation score) indicates how many units (of the standard deviation) a child's BMI is above or below the average BMI value for their age group and sex. For example a z score of 2.5 indicates that a child is 2.5 standard deviations above the average value, and a z score of –2.5 indicates a child is 2.5 standard deviations below the average value (Dinsdale et al., 2011). Currently the dominant measure is percentiles primarily due to their ease of use and interpretation (Preedy, 2012).

1.2.1.2 Severe obesity and gender differences

Figure 1 shows data from the Health Survey for England on trends in major BMI groups between 1993 and 2010 in men, while Figure 2 shows the trends for women for the same timeframe. In the UK the proportion of adults with a normal BMI decreased between 1993 and 2010, from 41% to 31% among men and from 49% to 40% among women. In the past there appears to have been little change in the prevalence of obesity between males and females (42% of men and 32% of women in 2010). However between 1993 and 2010, there has been a marked increase in the prevalence of obesity in which gender differences are also evident, from 13% of men who were obese in 1993 to 26% in 2010 and from 16% of women who were obese in 1993 to 26% in 2010. The overall prevalence of severe obesity (BMI ≥ 35 or 40 kg/m^2) increased from 0.8% in 1993 to 2.7% in 2010 with increases from 0.2% to 1.6% in men and from 1.4% to 3.8% in women. The rate of increase in obesity prevalence slowed down in the second half of the period and there are indications that the trend may be flattening out, albeit at a high level.

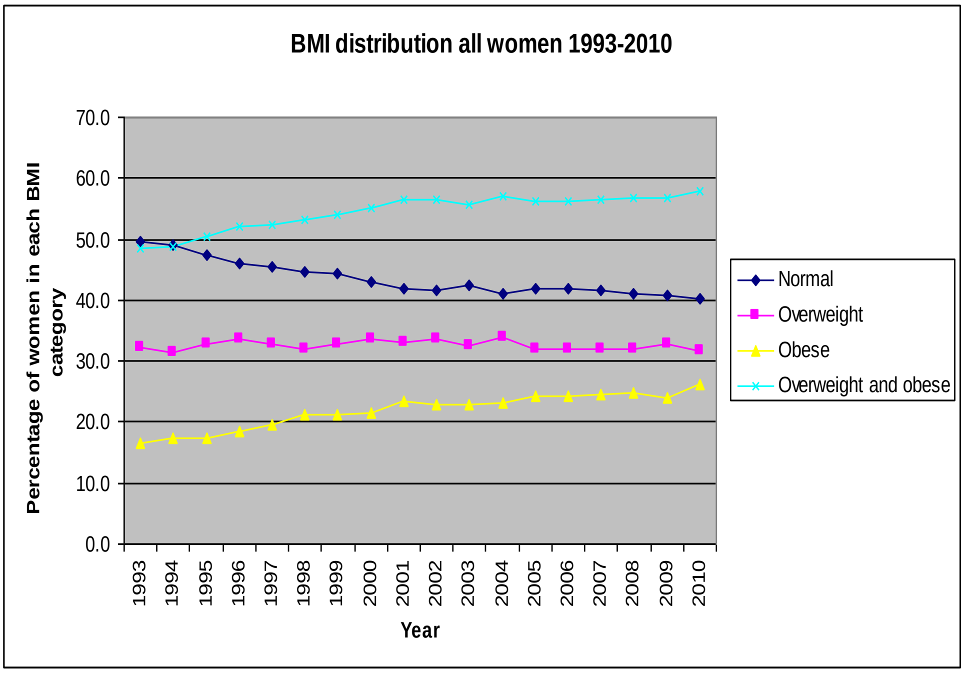
In many countries for example in America and Spain severe obesity is increasing faster than moderate obesity (if BMI is 30.0 - 34.9) (Kral et al., 2012, Sturm and Hattori, 2012, Sturm, 2007, Sturm, 2003, Basterra-Gortari et al., 2011) as shown in Figure 3. In Ireland the prevalence of severe obesity has not been formally quantified as of yet. However a national study (TILDA) shows that out of an Irish study population of those over the age of 50 (n= 5,841), approximately 3% of these were classified as severely obese (Mc Hugh et al., 2014). Of course, given the relationship between older age and obesity (body weight tends to increase with age (Baum and Ruhm, 2009), this may not be representative of the total Irish population.

Figure 1. UK BMI distribution of all men 1993-2010



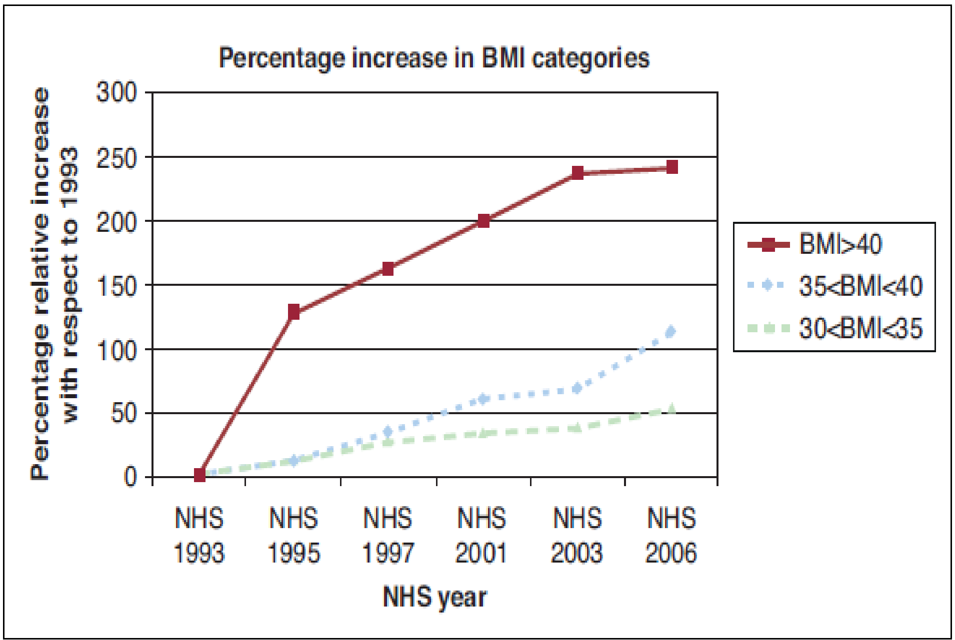
Source: (Hirani, 2010)

Figure 2. UK BMI distribution of all women 1993-2010



Source: (Hirani, 2010)

Figure 3. Relative increase (%) in prevalence of the different BMI categories in Spain between 1993 and 2006



Source: (Basterra-Gortari et al., 2011), National Health Survey data (raw)

1.2.2 Disease burden of obesity

A recent meta-analysis of 87 high quality prospective cohort studies among adults with overweight and obesity demonstrated the link between adiposity and a range of non-communicable diseases (Guh et al., 2009) details of which are outlined below in Table 2. All of these conditions adversely impact the overall quality of life and are associated with an increased risk of mortality (Huang et al., 2006a). While the evidence with respect to children is less substantive – many diseases not manifesting until adulthood – nevertheless a body of evidence exists linking obesity to numerous medical conditions including, but not limited to, fatty liver disease, sleep apnea, type 2 diabetes, asthma, hepatic steatosis (fatty liver disease), Caridovascular disease (CVD), high cholesterol, cholelithiasis (gallstones), glucose intolerance and insulin resistance, skin conditions, menstrual abnormalities, impaired balance, and orthopedic problems (Sahoo et al., 2015).

Table 2. Relative risk of developing disease according to obesity status (relative to normal BMI)

Disease	Measure*	Obesity*	
		Male	**Female**
Type 2 Diabetes Mellitus	BMI	6.7 (5.6-8.2)	12.4 (9.0-17.1)
	WC	3.1 (3.8-6.9)	11.1 (8.2-15.0)
CVD			
Hypertension	BMI	1.8 (1.5-2.2)	2.4 (1.6-3.7)
	WC	NR	1.9 (1.8-2.0)
Coronary artery disease	BMI	1.7 (1.5-2.0)	3.1 (2.8-3.4)
	WC	1.8 (1.5-2.3)	2.7 (2.1-3.5)
Cerebrovascular accident (stroke)	BMI	1.5 (1.3-1.7)	1.5 (1.3-1.7)
Cancer			
Breast (postmenopausal)	BMI	NR	1.13 (1.05-1.2)
Colorectal	BMI	2.0 (1.6-2.4)	1.7 (1.5-1.8)
Endometrial	BMI	NA	3.2 (2.9-3.6)
Ovarian	BMI	NA	1.3 (1.2-1.4)
Prostate	BMI	1.1 (0.9-1.3)	NA

Renal	BMI	1.8 (1.6-2.1)	2.6 (2.4-2.9)
Pancreas	BMI	2.3 (1.7-3.2)	1.6 (1.2-2.2)
Other			
Asthma	BMI	1.4 (1.1-1.8)	1.8 (1.4-2.3)
Osteoarthritis	BMI	4.2 (2.8-6.4)	2.0 (1.9-2.04)
Gallbladder disease	BMI	1.4 (1.0-2.0)	(1.2-4.6)

* *BMI=body mass index; WC=waist circumference; NA=not applicable; NR=not reported

Source (Guh et al., 2009)

1.2.3 Economic burden of obesity

Given its relationship with disease and premature mortality is it unsurprising that there is a significant economic burden associated with obesity (Dobbs et al., 2014). It imposes significant costs on healthcare systems both directly and perhaps more importantly indirectly. Around the world, 2 to 7% of all healthcare spending relates to measures to prevent and treat this condition, with up to 20% of all healthcare spending attributable to obesity, through related diseases such as type 2 diabetes and heart disease (Withrow and Alter, 2011, von Lengerke and Krauth, 2011, Lehnert et al., 2013). A recent report by the McKinsey Global Institute “The obesity Crisis 2015” reported that in the United Kingdom, obesity has the second-largest economic impact after smoking, costing the country nearly £47bn a year for obesity alone, (http://www.mckinsey.com/insights/mgi/in_the_news/the_obesity_crisis).

This compares with smoking and armed conflict which had estimated burdens of £57bn and £43bn respectively; together which are noted by the report to be the largest global economic impact areas driven by human behaviour.

The economic burden of obesity is related not just to excess use of health and social services; it also relates to lost productivity associated with illness related absenteeism, presenteeism and premature mortality. Comparing cost estimates is complicated by differences in the types of costs included in studies (direct and indirect); the different approaches to calculating cost (top down and bottom up), the perspective of cost (individual or society) as well as how obesity is reported (self-reported or measured BMI). In addition different measures produce different estimates based on the measure of adiposity used. This is an unexplored area in Ireland.

However BMI has been used in a number of studies in Ireland which have used a variety of approaches to estimate costs associated with obesity (Perry, 2012, Dee et al., 2013, Doherty et al., 2012, Vellinga et al., 2008a, Dee et al., 2015). Table 3 provides an overview of the studies that have quantified the costs of obesity in Ireland, beginning with the most recent estimates. From this table it can be seen that since 2005 the direct costs of obesity are estimated at €70m whereas in 2012 direct costs were estimated at €399 million. Although cost comparisons are difficult, there is a consensus that the cost of obesity is increasing worldwide; no study has documented to the contrary or even reported signs of a levelling off of costs.

A cost methodology employed in England to the Irish context by the National Taskforce for Obesity (2005) estimated the direct costs of obesity to be €70m euro for Ireland; in 2004 obesity related hospital stays were estimated to cost in the region of €13 million (Vellinga et al., 2008b); more recent estimates (2012) which include both direct and indirect costs are estimated at €1.13billion per annum for the Republic of Ireland (Perry, 2012). A study that is discussed in more detail in chapter two used SLÁN (2007) data and estimated the impact on use of GP services, hospital inpatient and hospital day care services of overweight and obesity (Doherty et al., 2013b). Translating increased utilisation into costs, primary health-care costs are estimated conservatively to be approximately €17 million higher per annum and secondary health-care costs approximately €24 million higher per annum in Ireland as a result of overweight and obesity in adults. Using a different approach (attributable fractions rather than econometric analysis) another study estimated the healthcare and productivity costs of overweight and obesity in Ireland across four categories: healthcare utilisation, drug costs, work absenteeism and premature mortality and reported that Irish healthcare costs of overweight and obesity in 2009 were estimated at €437 million (Dee et al., 2015).

In addition an issue that has received some attention in the literature recently relates to costs pertaining to the social or psychological costs, particularly costs associated with stigmatisation - that is costs that attend the prejudice experienced by obese individuals as a result of their obesity, perhaps grounded in a view that they are culpable in their illness. Obesity stigma leads to various negative psychological outcomes, including poor body image, self-esteem issues, anxiety, and depression (Puhl and Heuer, 2009). Weight-based discrimination and the psychological difficulties experienced by obese people may impede capable individuals from making economic and social contributions.

Estimating the cost of obesity prejudice is difficult but many studies have noted the economic implications of obesity prejudice. For example, studies on employment have shown hiring prejudice in which subjects report being less inclined to hire an overweight/obese person than a thin person, even with identical qualifications, as noted by Puhl et al it is expected that these attributions to affect wages, promotions (Puhl et al., 2008). Additionally overweight individuals can be reluctant to seek medical care, especially for their obesity, because they believe that they will be scolded and even humiliated, hence screening and treatment for diseases may be delayed- which can further increase costs (Puhl and Heuer, 2010). Stigmatization in educational settings has also been documented, which might reasonably be expected to affect self-esteem, intellectual self-efficacy, and more tangible outcomes such as academic performance, where one attends college and employment opportunities (Puhl and Latner, 2007). As noted though these remain relatively under-researched areas.

Table 3. Overview of studies estimating the cost of obesity in Ireland

Study	Study title	Costs included	Findings	Limitations
(Dee et al., 2013)	The cost of overweight and obesity on the island of Ireland.	Direct costs (inpatient and day case costs, out-patient costs, GP costs and drug costs) and Indirect costs (productivity losses associated with work Absenteeism and premature mortality.)	**€1.13 billion euro**; Of this €399 million (35%) were direct and €729 million (65%) were indirect costs.	Social, psychological and emotional costs were omitted from indirect cost calculations (due to a lack of national data on the economic cost of these variables).
(Doherty et al., 2013b)	Estimating the amount of overweight and obesity related	Examined the impact of overweight and obesity on healthcare utilisation use	Translating increased utilization into costs, primary healthcare costs are estimated conservatively to be approximately **€21.5**	Based on self-reported measures of height and weight

	healthcare use in the Republic of Ireland using Slán data	(GP services, hospital inpatient and hospital day case services)	**million** higher and secondary healthcare costs approximately **€30 million** higher in the Republic of Ireland as a result of overweight and obesity in adults.	
(Vellinga et al., 2008a)	Length of stay and associated costs of obesity related hospital admissions in Ireland	Analysed hospital discharges for adults and children where obesity was either a primary or secondary diagnosis and estimated the length of stay and associated hospital costs for obesity related illnesses	Between 1997 and 2004, there was a 45% increase in the number of obesity related discharges in adults. The annual cost for hospital stays in patients with a primary or secondary diagnosis of obesity was calculated to be **€4.4m** in 1997, rising to **€13.3m** in 2004.	Did not examine primary care costs or control for socio-demographic characteristics that might have confounded observed relationships in the hospital sector.
(Safefood, 2005)	Obesity the policy challenges The Report of the National Taskforce on Obesity 2005	Applied a cost methodology employed in England to Ireland to estimate costs which includes the costs of drugs, GP visits and hospital contacts	Direct costs of obesity was **€70m** euro	Due to the lack of data at the time of the study, the majority was extrapolated from the UK (and applied to an Irish setting)

1.3 Thesis objectives

This overall aim of this thesis is to explore the impact of obesity on healthcare systems in terms of cost, individuals in terms of stigma, and the value attached to alternative modes of treatment among severely obese individuals in Ireland. Specifically the thesis objectives are to:

1. Determine the relationship between alternative measures of adiposity and health service use, focusing on GP visits, outpatient visits and allied services[4]
2. Examine the value that severe obese individuals place on obesity treatment including their willingness to pay therein
3. Examine if there is evidence of any obesity related stigmatization in teachers of primary school children in Ireland
4. Determine what factors might influence the cost effectiveness of bariatric surgery as a treatment for severe obesity in Ireland

In summary the global obesity epidemic and its impact on global severity and mortality including the associated costs are well reported. Obesity, including the severity of obesity has been steadily increasing globally over the last 30 years. Health economics plays a role in understanding the problem of obesity and also in evaluating efforts to treat and prevent it. For example, the emerging fields of bariatric medicine and surgery have developed to meet the clinical needs of individuals affected by severe obesity. Severe obesity treatment that is bariatric surgery is a relatively expensive form of treatment. Health economics allows us to determine whether or not this and other forms of obesity treatments are cost effective

[4] Allied services represents that of the physiotherapist, home help, dietician, chiropody and public health nurse

approaches to treating obesity via economic evaluations[5]. How we ascertain cost effectiveness particularly in Ireland where a lack of data for severe obesity treatment (bariatric surgery) exists is important, which is examined in chapter five.

As part of an economic evaluation the costs associated with the related disease are assessed. As previously alluded to there are a number of different costs and different methods to assess the cost of obesity. One aspect of obesity related costs that is frequently analysed is that of healthcare utilisation whereby an understanding of what drives service use is sought after so as to better understand how to plan services. The general consensus is that obesity leads to increased healthcare use which in turn translates into costs. However in order to have a full understanding of this relationship it is necessary to know which measure of adiposity works best in predicting costs, which as previously alluded to – different measures may produce different cost estimates. The majority of studies use BMI with limited understanding of what the role other measures might play in developing our knowledge of the drivers of healthcare utilisation. Chapter two examines the role that different measures of adiposity play in predicting service use and subsequently costs.

As previously mentioned there are also indirect costs of obesity; the inclusion of which varies when evaluating the economic burden of obesity. In respect of obesity stigmatization this has the potential to underpin not just

[5] Economic evaluation is the process of systematic identification, measurement and valuation of the inputs and outcomes of two alternative activities, and the subsequent comparative analysis of these DRUMMOND, M. F. 1988. *Methods for the\ q& Economic Evaluation of Health Care Programmes.* Oxford University.. The purpose of economic evaluation is to identify the best course of action, based on the evidence available.

many health and wellbeing outcomes and thereby aspects of service use - self-esteem, depression etc. - but also many economic outcomes e.g. educational attainment, the labour market, and the urgency with which governments view the need for action. This also warrants examination and is examined in chapter four.

As demonstrated throughout this thesis, the economics of obesity is a complex issue, and one that is not refined to one specific topic or area of research. More recently the importance of patient preferences towards obesity treatment has been highlighted, where compliance to obesity treatment is somewhat less understood and influenced by a myriad of factors. For example is the speed with which weight loss is delivered more important than the permanency of the weight loss; are the risks of bariatric surgery viewed among those with the highest BMI viewed differently to those with lesser BMI. An understanding of these values and how individuals trade-off between these values will help us understand how best to tailor services. Chapter three incorporates an investigation of these preferences.

2. The relationship between health service use and alternative measures of adiposity

2.1 Introduction

Obesity results in substantial costs to the individuals and to society, notably from increased healthcare costs and lost productivity. Some of the increased healthcare costs include the costs incurred by excess use of healthcare services (e.g. GP, hospital), drugs, radiological or laboratory tests, and long term care (including nursing homes). As previously noted, an assessment of these costs is commonly used to inform economic evaluations which in turn is used to inform healthcare resource allocation decisions. How obesity is measured, that is, the index used to define obesity is important, given that costs are quantified according to the definition and severity of obesity and may vary depending upon the measure used.

Currently, perhaps due to its simplicity and ease of calculation BMI is the most commonly used index of obesity in the economic analysis of obesity. However, there is much criticism in the clinical research regarding the suitability of BMI particularly for predicting certain health risks (for example CVD and diabetes) and over the past decade this criticism has extended to the economics literature in the context of questioning its accuracy of predicting the costs of obesity. There are reasons to believe that alternative measures may provide different cost estimates because they capture aspects of health risk more precisely or at a minimum if used in conjunction with BMI a more robust predictor of risks. This is of particular relevance since the type of adiposity measure used in studies may influence findings particularly in terms of the magnitude of the economic burden of obesity and its distribution across services and individuals.

This chapter investigates the use of different adiposity measures based upon an expectation that the relationship between alternative adiposity measures is going to differ depending on not only the service used but also the gender of the person using the service. The objectives of this chapter are: (i) to gain insight into the role different measures of obesity play in explaining healthcare utilisation of services in Ireland and (ii) establish to what extent different measures of obesity influence healthcare utilisation across different identifiable sub-groups. The first wave (2009) of TILDA is used as the data source for this study.

2.2 Literature review

2.2.1 Overview of obesity measures

There are a number of limitations of BMI as an index measure of obesity. The fact that BMI cannot distinguish between fat and muscle mass (Wells et al., 2008) is of particular relevance in the context of the body changes; particularly in elderly people. Ageing is accompanied with a progressive increase in the ratio between fat and lean body mass (Deurenberg et al., 1991) in which changes such as a loss of muscle mass or an increase in fat mass deposited in the abdominal area are more prevalent among older persons (Dey et al., 1999, Perissinotto et al., 2002). It is now accepted that the distribution of body fat is an important determinant of metabolic abnormalities. Some authors note that the distribution of body fat is possibly more important than the degree of excess weight as measured by BMI (Walton et al., 1995). Because body fat is more likely to be deposited in the abdominal cavity with increasing age, it is claimed that BMI becomes a poor indicator of overall and abdominal fatness in older persons (Baumgartner et al., 1995, Seidell and Visscher, 2000).

Related to the choice of measure is whether there exists systematic issues related to how the measure is reported, specifically whether self-reported or measured BMI is used in when examining obesity and its consequences. In as much as self-reported BMI is more easily captured in population based surveys it is more likely to be found in those surveys and used by researchers. However, it is also more likely to include systematic errors in which men and women over-report their height, increasingly so at older ages (Nawaz et al., 2001). Men have been found to overestimate their height whereas women underreport their weight (Richardson, 2009). More broadly, issues with BMI in the measurement of adiposity include (Control, 2011):

- On average, older adults tend to have more body fat than younger adults for an equivalent BMI.
- On average, women have greater amounts of total body fat than men with an equivalent BMI.
- Muscular individuals, or highly-trained athletes, may have a high BMI because of increased muscle mass.

Waist circumference (WC) has been recommended as a better indicator of abdominal visceral fat (abdominal obesity) than BMI. Given the link between abdominal obesity and CVD and diabetes, WC is reported to be a better predictor for CVD and diabetes risk (Rankinen et al., 1999, Baumgartner et al., 1995). In the UK and the US, health authorities recommend measuring WC as a complementary diagnostic tool for obesity (Lee, 2014). That said, it still remains unclear which measure is the most appropriate for risk stratification - with different measures used for different risks (Schneider et al., 2010). Risks, moreover, may not be perfect predictors of service use and the relationship between different measures of adiposity and service use remains poorly understood.

According to the expert panel on the identification, evaluation, and treatment of overweight and obesity in adults, on the basis of WC, individuals can be divided according to gender into two groups; high or normal (Panel, 1998). Waist to hip ratio (WTHR) is a measurement of the WC divided by a measurement of the hip circumference (Panel, 1998). The American Heart Association recommended 102 cm for men and 88 cm for women as cut-off levels for WC, and 0.95 for men and 0.88 for women as cut-off levels for WTHR (Panel, 1998). More recently, a general cut-off of 0.5 has been suggested for WTHR (Ashwell and Hsieh, 2005). In older men, measures of WC may potentially be more sensitive indicators of disease risk than is BMI (Wannamethee et al., 2005).

Other measures include skinfold thickness measurement gives an estimate of the size of subcutaneous fat deposit, which is basically the fat under the skin - using callipers. There are different formulas used to calculate Body Density (BD) and Percentage Body Fat (% BF) and these vary according to the gender of the participant and the number of skinfold site. The WHO has proposed the cut-off point for % BF in men and women adults whereby an excess of 25% BF in men and a 35% BF in women would be defined as obese (Ho-Pham et al., 2011).

The lack of an acceptable gold standard for measuring adiposity presents challenges when undertaking economic analysis of obesity. Although the links between central obesity and conditions such as diabetes and coronary heart disease risk are well established (Ghandehari et al., 2009), the subsequent costs associated with central obesity are less documented in the economics literature. As stated by Burkhauser et al "obesity statistics can be greatly influenced by the choice of fatness used to define obesity"; (Burkhauser and Cawley, 2008). Therefore, using BMI to define obesity can result in substantial misclassification of individuals into weight groupings, which runs the risk of underestimating or overestimating the economic consequences of obesity. Due to its ease of measurement and calculation BMI is used in the majority of studies that examine the economic burden of obesity in Ireland (Keaver et al., 2013, Heinen, 2014, Kearns et al., 2014, Doherty et al., 2012, Layte and McCrory, 2011, Vellinga et al., 2008a, Dee et al., 2015, Harrington J, 2008, Madden, 2013), therefore an investigation as to what other adiposity measures conclude regarding the economic burden of obesity is warranted.

2.2.2 The use of alternative obesity measures in ascertaining the cost of obesity

The economic burden of obesity has been documented through various mechanisms to include direct and indirect costs of obesity (Finkelstein et al., 2014, Finkelstein et al., 2005, Finkelstein et al., 2010, Finkelstein et al., 2009, Folmann et al., 2007, Thompson et al., 2012, Colagiuri et al., 2010, Perry, 2012, Tsai et al., 2011, Withrow and Alter, 2011, Lehnert et al., 2013, Konnopka et al., 2011, Cawley and Meyerhoefer, 2012, Quesenberry Jr et al., 1998). For example, in Europe it was reported that between 1.9% and 4.7% of total annual healthcare costs were attributable to obesity (Müller-Riemenschneider et al., 2008, von Lengerke and Krauth, 2011); in Ireland, overweight and obesity are estimated to account for 2.7% of direct healthcare costs in the Republic of Ireland (Perry, 2012). However, in this section it is not the monetary cost of obesity that is of interest per se, rather if and to what extent measures of adiposity predict healthcare costs differently. Considering how different adiposity measures predict better health risks is important as it might be the case that different measures also predict better different types of healthcare use and subsequently- costs. If it is the case that the traditional measure of adiposity, BMI, does not identify certain healthcare use, this will have repercussions in terms of obtaining accurate estimates for the true cost obesity, according to service use. Table 4 below provides a brief overview of the studies discussed in this chapter.

Table 4. Overview of studies examining obesity and healthcare service use including those that use alternative measures of adiposity

Source	Title	Adiposity measure used	Type of healthcare examined	Findings	Limitations
(Cornier et al., 2002)	Relationship between Waist Circumference, Body Mass Index, and Medical Care Costs	BMI and WC	Inpatient and outpatient, laboratory and pharmacy,	WC "may be a better predictor of healthcare charges than the more widely used BMI".	Small sample size (n= 424) Examined direct costs only
Højgaard et al., 2008	Waist Circumference and Body Mass Index as Predictors of Healthcare Costs	BMI and WC	Direct healthcare costs[6]	WC is a better predictor of healthcare costs	Only one-third (35%) of the invited individuals participated in this study (possible sample selection bias)
(Colagiuri et al., 2010)	The cost of overweight and obesity in Australia	WC and BMI	Direct healthcare cost, direct non-healthcare cost (transport to hospitals, supported accommodation, home service and day centres, and purchase of special food) and	Reported that there was a variation in cost estimates according to what measure was used and that there was no one best measure for the use of	Examined direct costs only

[6] Ambulatory services, hospitalisation, prescription medication

			government subsidies (payments for the aged pension, disability pension, veteran pension, mobility allowance, sickness allowance and unemployment benefit.)associated with overweight and obesity	predicting obesity related healthcare costs.	
León-Muñoz et al., 2005	Relationship of BMI, Waist Circumference, and Weight Change with Use of Health Services by Older Adults	WC and BMI	Healthcare service use (GP visits, hospital admission, A&E, Influenza vaccination, home medical visits, more than one surgical intervention and admission to intensive care unit	Obesity and abdominal obesity were associated with greater use of certain healthcare services(did not report which was a better predictor of service use)	Only considered some obesity related chronic diseases. For example heart failure was omitted.
König et al., 2015	Health service use and costs associated with excess weight in older adults in Germany	BMI and waist-to-height ratio (WHtR)	Health service use (Inpatient care, Outpatient care[7], Nursing care)	Obesity is associated with increased service use and cost in elderly individuals, in particular in obese class ≥2	A short data collection period of 3 months (which as reported by the authors possibly increased the variance of calculated healthcare

[7] Outpatient physician services, Non-physician providers, Medical supplies, Pharmaceuticals

				individuals- again the focus was not on which was the best measure of adiposity and was thus not reported	costs)
Peytremann-Bridevaux and Santos-Eggimann, 2007	Healthcare utilization of overweight and obese Europeans aged 50–79 years	BMI	Healthcare utilization. (Ambulatory care, GP, visits to specialists, medication, hospitalization, surgery, home healthcare and domestic help).	Overweight and being obese were similarly associated with increased use of ambulatory care visits, GP visits and medication use, but not with visits to specialists, surgery, home healthcare or domestic help.	Used self-reported BMI (which is likely to be inaccurately reported)
(Doherty et al., 2013b)	Estimating the amount of overweight and obesity related healthcare use in the Republic of Ireland using Slán data	BMI	Healthcare utilization (GP services, hospital inpatient and hospital day case services)	Overweight and obesity are significant predictors of GP utilisation and obesity is a significant predictor of inpatient episodes.	Self-reported measures of height and weight

Mc Hugh et al., 2014	BMI and health service utilisation in the older population: results from The Irish Longitudinal Study on Ageing	BMI	Allied health services (dietetic services, public health nurse visits, chiropody and home help)	Overweight and obesity are associated with increased use of allied health	Limited to the older population Did not examine allied services individually (examined the services collectively) Did not examine if there were differences in service use according to gender
Doherty et al., 2014	An examination of the relationships between service use and alternative measures of obesity among community-dwelling adults in Ireland	BMI and WTHR	Healthcare use (GP, Hospital services-outpatient, inpatient and A&E)	Supported the inclusion of both BMI and central measures of adiposity when examining the relationship between obesity and healthcare use	Limited to the older population Did not examine allied services Did not examine if there were differences in service use according to gender

Indeed one of the first studies to examine the link between healthcare costs according to different measures of adiposity showed WC to be a superior measure of costs compared to BMI (Cornier et al., 2002). Although a small sample size (n=424), this study was significant in initiating a debate regarding the importance of adiposity measures in economic analysis, which previously was primarily reserved to clinical research.   In this study the authors used both BMI and WC to examine the relationship between healthcare costs and adiposity. The association between greater WC and increased total healthcare costs was found to be statistically significant while BMI was also associated with increased total healthcare costs; it was reported as not statistically significant. The differences in medical costs are reported to be primarily because of greater inpatient charges in the highest WC category, and not from outpatient, laboratory or pharmacy charges. These results suggest that it might be that those with poorly controlled diabetes and increased CVD risk require more inpatient care relative to outpatient care and that this is what the WC is capturing. It might also be that WC predicts better different healthcare service use according to gender. Considering that CVD risk factors are more common, more likely to cluster and more severe in diabetic women than men (Rivellese et al., 2010).

Furthermore, different adiposity measures may predict better different group's healthcare use (e.g. those obese with a lower income rather than those obese with a high income). In Cornier et al, that WC predicts costs better may be due to the fact that WC better predicts those of the lower income or lower SES. Also, the sample population used in Cornier et al was a random sampling of the Denver Health system, an ethnically diverse population of generally low socioeconomic status, and not of the general community. Or, the results may be indicative of some combination of all of these - reflecting both differences in objective health risk associated with different measures and differences in how healthcare systems respond to the needs of obese poor and rich people. One drawback of this study was that the population was non-generalizable (from one city in the United States) with a relatively low socio-economic status.

Around the time of Cornier et al publication, an increasing amount of clinical research was published evaluating WC and BMI as predictors of health risk; with studies reporting mixed findings in terms of each measures prediction values. In 2003, a study suggested that a combination of WC and BMI best predicted health risks in middle-aged men and women in clinical practice (Bigaard et al., 2003) and broadly speaking as the clinical research progressed this seemed to be the general consensus in clinical practise. Conversely no consensus exits with regards the use of adiposity measures in economic analysis. For example, a Danish study that used the same dataset as Biggard et al investigated whether the combined use of measured WC and BMI would improve the identification of high costs individuals (Højgaard et al., 2008). The study showed that WC for given levels of BMI predicts increased health costs; whereas BMI for given WC did not predict health costs except for a lower cost in non-obese women with normal WC.

In their study, (Højgaard et al., 2008) only direct public healthcare costs[8] were included in the analyses in which data were obtained from the Danish prospective cohort study Diet, Cancer and Health. A total of 55,705 participated in the study which was restricted to those with a BMI of 18.50 kg/m^2 or more and without a history of cancer at baseline. Ordinary least-squares (OLS) regression was used to analyse the relationship between future healthcare cost and BMI and WC across five models which controlled for age, income, level of education, smoking status and physical activity.

Along with the findings suggesting WC to be a better predictor of healthcare costs, the study also reports that when BMI and WC were examined together on a continuous scale, this not give a better prediction of costs than WC alone (whereas in clinical research the combination of these is said to

[8] For each study subject, the following information on healthcare use was obtained: (I) somatic in- and out-patient treatments (retrieved from the National Patient Register), (II) psychiatric in- and out-patient treatments (retrieved from the Danish Psychiatric central Register (III) primary sector healthcare services, including general practitioners, practicing specialists, dentists, physiotherapists, psychologists etc. (retrieved from the National health Insurance Register) and (IV) prescription drugs entitled to a subsidy (retrieved from the national medicine database).

better predict health risks). However, when WC was dichotomized into normal and high-risk categories, BMI remained a significant predictor of health risk. The authors suggest that the reason for this finding lies in the fact that when WC is treated as a categorical variable whilst BMI is a continuous variable, BMI may capture some of the variation in WC within a WC category. In addition, in a recent article Han et al. conclude that due to the large correlation between BMI and WC, a combination of the two measures adds relatively little to the risk prediction (Han et al., 2006). This is, however, based on cross-sectional data, implying only one single measurement of WC and BMI, - where longitudinal measures may be more informative. Furthermore the authors note the risk of selection bias, since only one-third (35%) of the invited individuals participated in this study, and it is likely that in general it is the healthier fraction who chose to participate in the study.

An Australian study used the AusDiab study[9] to examine the direct healthcare cost, direct non-healthcare cost and government subsidies associated with overweight and obesity defined by both WC and BMI (Colagiuri et al., 2010). The weight status of participants was assigned according to BMI alone, WC alone, and a combined definition based on BMI and/or WC. The findings show variation of cost estimates according to what measure was used, with similar to other studies, WC showing a slightly higher estimate. For example total annual healthcare cost (ambulatory services, hospitalisation, prescription medication) per person for those obese were; for BMI only; \$2540 (CI, \$2275–\$2805); for WC only; \$2819 (CI, 2565–3072) and for both WC and BMI \$2788 (CI 2542–3035) respectively. Even after adjusting for age and sex matched

[9] The Australian Diabetes, Obesity and Lifestyle (AusDiab) study is the largest Australian longitudinal population-based study examining the natural history of diabetes, pre-diabetes, heart disease and kidney disease.

participants the total annual direct cost differed across the three measures; BMI ($1364), for WC ($1739) and for BMI & WC ($2544). However, on examination of the the t-values, this study indicates that that there was no one best measure for the use of predicting obesity related healthcare costs. These results may be due to different measures predicting better different health risks and in turn different healthcare service use.

A recent study further refined adiposity measurements by estimating the incremental effect of WC on health-care costs among overweight and obese subjects after adjusting for BMI (Pendergast et al., 2010). This study expanded the previously discussed studies by using a larger population and wider age range examined data from two countries (10,816 individuals (United States: n = 5410; Germany: n = 5406; aged 30-70 years). The study reported that after adjusting for BMI along with other potentially confounding variables including sex, age, race, education level, health insurance, smoking status, alcohol consumption, and medical conditions (depression and cancer), the study showed that at any given BMI value, individuals with an elevated WC have greater health-care costs (including inpatient, outpatient, and pharmaceutical costs). The higher health-care costs observed were reflections of the higher disease prevalence among the subgroups with a higher WC.

To briefly sum up this section, the literature shows how different measures of adiposity can give different cost estimates according to service use estimated, with many studies showing WC to be a better predictor of healthcare costs. However given the variety of methods and modelling techniques applied including the use of different datasets and different costs examined, it is difficult to draw a conclusion as to which measure is best to use in economic analysis. Moreover it is difficult to discern whether these findings are in part influenced by the context in which the study was done - i.e. is it a function of the healthcare system and how it manages and treats obesity.

It may be the case that WC may be better at identifying healthcare costs that are associated with abdominal obesity. For example those with diabetes/CVD may have a higher use of inpatient hospital care (due to poorly controlled sugar/high blood pressure or heart attack). The cautious approach might be to include both measures in economic analysis, although even at that, studies suggest that WC is superior. Perhaps the lack of a consensus is due to a lack of available data in the first place, that is not having access to WC measurements to include in economic analysis. In this regard a number of studies have called for the inclusion of more accurate measures of obesity in datasets (Burkhauser and Cawley, 2008). For now however, although the limitations of BMI are well documented, uncertainty prevails as to which measure is best suited for economic analysis of obesity.

2.2.3 Obesity and healthcare utilisation in older populations

Considering that increased healthcare use is one of the main drivers behind increased healthcare costs of obese individuals (Lehnert et al., 2013) and that older people are reported to use more healthcare services than younger people (McNamara et al., 2013) it seems likely that older obese individuals would be "high-cost patients". However few authors have specifically investigated healthcare use in older adults according to obesity. Of the available studies the majority show that increased healthcare costs for older adults is associated with obesity, particularly in outpatient care, albeit the magnitude of excess costs is different between studies (Andreyeva et al., 2004, Wee et al., 2005, Wilkins et al., 2012). There are however, as discussed below a number of studies that report the contrary; that is, obesity is not associated with increased healthcare use in older adults. The use of different measures is not simply an academic question about refining the accuracy of estimates; given the nature of differences in cost estimates related to obesity among particular sub-groups it is fundamental to understanding whether there is an additional cost associated with obesity in these subgroups or not.

For example, using longitudinal data from the Medicare Current Beneficiary Survey (n = 8,754) a study that examined BMI and hospitalisation in the elderly noted that the association between BMI and adverse outcomes changes with aging and reported that BMI was not a predictor of hospitalization for most individuals aged 75 and older (Luchsinger et al., 2003). In this study the quintiles of BMI were examined and it was found that lower BMI, not higher BMI, was associated with adverse outcomes. The authors found that only individuals in the lowest BMI quintile had a significant increased risk of hospitalization and that this effect was confined in subgroup analyses to those aged 65 to 75. This study is likely to be observing an illness effect; individuals with low BMI may be cancer survivors or going through treatment for this or for some other form of disease. In the study the authors explain the finding such that individuals with high but not extreme BMIs (those classified as overweight and mildly obese) with related illnesses may have died before reaching age 75, and the surviving elders with higher BMI may have unidentified factors that are related to better health and thus have lower rates of hospitalization.

In Europe on the other hand, a Spanish study that used both measures of measured adiposity (BMI and WC) to examine the relationship between weight change and healthcare service use by older adults (n= 2919 aged older than 60 years) (León-Muñoz et al., 2005) suggested that obesity is associated with a greater use of certain healthcare services by older adults. The three main independent variables were BMI in 2001, WC in 2001, and weight change in the period 2001 to 2003. The relationship of BMI, WC, and weight change with health service use was summarized using odds ratios (ORs) obtained from logistic regression. These associations were adjusted for age, educational level, tobacco use, and alcohol consumption and also adjusted for chronic diseases. Healthcare service variables with several categories of frequency (e.g., number of visits to general practitioners, number of visits to hospital specialists) were dichotomized. With regard to the relationship between obesity as measured by BMI and health service use, a positive association between BMI and the annual rates of inpatient days and the number and costs of outpatient visits was observed. In addition the findings in this study are consistent with those of Cornier et al. (Cornier et al., 2002), in that abdominal adiposity assessed by WC was associated with increased total healthcare expenditures, in particular in-patient related expenditures.

Similarly as part of a cross-sectional analysis, a German study used the ESTHER[10] study to examine the association between obesity and healthcare service use in an older population using BMI and waist-to-height-ratio (WHtR) (König et al., 2015). Measured BMI was categorised as normal weight, overweight, obesity class 1 ($30 \leq BMI < 35$) and obesity class ≥ 2

[10] Recruitment of the ESTHER cohort was conducted between July 2000 and December 2002 and included 9,949 participants aged 50–74. Standardised postal questionnaires on sociodemographic, medical and lifestyle factors were completed at baseline and three follow-ups (2, 5 and 8 years). At the 8-year follow-up, supplemental information on severeity was collected by questionnaires sent to the study participants' general practitioners (GPs). In the 8-year follow-up, information from the participants' or GP's questionnaire were available for 7,012 study participants (80.9% response rate among survivors still mentally and physically able to respond). Information from both questionnaires was collected for 5,057 of the participants. In addition, all participants were asked to take part in a 3-h geriatric assessment conducted at their homes by trained study physicians, which included the measurement of body height, waist circumference (WC) and weight as well as an assessment of health service use to be used for the present analysis.

(BMI ≥ 35). WHtR was calculated and categorised as <0.6 versus ≥0.6. The direct costs of illness arising from the use of resources were the focus of the study costs. Using multiple regression analyses the findings showed that obesity was associated with significantly increased healthcare use. Those in obese class ≥2 (BMI 35.0 - 39.9) showed strongly increased costs particularly for pharmaceuticals compared with normal weight individuals. For these individuals the costs of pharmaceuticals were more than doubled and total costs increased by 74% in obesity class ≥2 individuals. After controlling for sociodemographic variables, obese class ≥2 individuals and those with WHtR ≥0.6 (abdominally obese) still showed significantly increased outpatient costs and total costs compared with normal weight individuals and those with WHtR <0.6; increased inpatient costs did not reach the level of significance. The authors attribute the latter as being due to the small proportion of users within the 3-month period.

An earlier study examined the association between overweight/ obesity and healthcare utilization in middle-aged and older Europeans using self-reported data from ten countries participating in the Survey of Health, Ageing and Retirement in Europe (SHARE) (Peytremann-Bridevaux and Santos-Eggimann, 2007). Findings from this study showed that in Europe, for both men and women, being overweight and being obese were similarly associated with increased use of ambulatory care visits, GP visits and medication use, but not with visits to specialists, surgery, home healthcare or domestic help. As part of the analysis, dichotomous measures of healthcare utilization during the previous 12 months included any use of ambulatory care, high use of a general practitioner, visits to specialists, high use of medication, hospitalization, high number of times hospitalized and nights spent in the hospital, surgery, home healthcare and domestic help. Logistic regressions adjusted for age, socio-economic status, smoking, physical activity, alcohol consumption, country of residence, and chronic conditions and all analyses were stratified by gender. The associations persisted after controlling for all of these factors.

However this study relied on self-reported height and weight, which can as previously outlined can be inaccurate which means that the true percentage of the overweight and obese population may be higher than the study estimates, and the healthcare utilization adjusted associations are likely to be overestimated. The fact that home help was not significantly predicted by obesity is a surprise finding. The authors note that although the situation in men could be partly explained by wives acting as caregiver in many households, this is unlikely to be an explanation for the care of overweight/ obese women themselves. More probably, the lack of significant associations is due to the relatively small number of disabled men and women having used those services during the previous 12 months and also possibly due to the fact that these services are not always included in the countries' basic health insurance package. Generally speaking although some studies report conflicting findings, the majority of studies report older aged obese individuals to be a significant predictor of healthcare costs. Relative to other age groups however, the healthcare use of older populations is somewhat limited.

2.2.4 Obesity and healthcare utilisation according to gender

Healthcare utilization and gender are indirectly related through several pathways, such as mental distress, physical illness, symptom perception, and perceived health status (Travis et al., 2010). The literature reports that women use more healthcare services than men, even after correcting for the use of healthcare services, such as gynaecology and obstetrics that are specific for women (Koopmans and Lamers, 2007). Women tend to have more minor illnesses and nonfatal chronic diseases, while men have more fatal chronic diseases and higher mortality rates (Travis et al., 2010). The factors that determine gender differences in the utilization of health-care services may vary at different stages of life (Travis et al., 2010). As noted by Travis et al in the reproductive age, the need for gynaecological care produces greater health-service use by adult women, but gender differences in utilization tend to diminish at advanced ages.

In the context of obesity measurement, the role of gender has been somewhat distinguished with regards different recommended waist circumference cut off points of obesity according to gender. However the use of alternative adiposity measures according to gender in studies examining the economic burden of obesity is somewhat less explored. There is a need to further investigate whether there exists differences in the relationship between measures of adiposity and healthcare costs across genders. For example there may be other factors at play regarding female healthcare utilisation such as the role of fertility in females.

2.2.5 Obese individuals healthcare utilisation research in Ireland

Although not specifically focusing on adiposity; a number of studies have examined the factors driving healthcare utilisation in Ireland (Leahy et al., 2014b, McNamara et al., 2013, Hudson and Nolan, 2014). For example, focusing on the drivers of service use in hospital, primary, community and social care services one study reported the following factors to have a significant impact on healthcare service use; age whether a person is employed; the presence of chronic diseases; having a medical card or private insurance and measures of capacity to undertake everyday tasks had significant impact on healthcare use (McNamara et al., 2013).

The role of adiposity in healthcare has been examined in the general population and also in the older population. For example using self-reported BMI measures derived from the Slán (2007) data[11], Doherty et al (2012) reported that overweight and obesity are significant predictor's healthcare utilisation for the general population (Doherty et al., 2012). In this study a seemingly unrelated probit model (which can accommodate for potential unobserved heterogeneity between utilization of different healthcare services e.g. latent characteristics that drive an individual to visit their GP could also potentially affect whether they attend hospital) was applied and three aspects of healthcare were modelled; visits to the GP, visits to the hospital as an inpatient and visits to the hospital for a day procedure. The utilisation of each group relative to those who were classed as normal weight based on their BMI category (underweight, normal weight overweight and obese) was analysed and findings presented for the average marginal effects for the bivariate specification models. This study also controlled for a range of variables (age, household income (categorized), marital status, gender, private insurance, medical card status and employment status.

Furthermore the analysis in the study considered the complex relationship between BMI and healthcare utilisation; BMI being a risk factor for many

[11] As previously noted, SLAN data is a nationally representative face to face survey of over 10 000 people in the Republic of Ireland aged 18 and over. The survey collected detailed information on various aspects of health status (both physical and psychological), medical card eligibility and access to private health insurance, as well as a range of demographic characteristics including age, gender, educational attainment, employment status, household income and marital status. It also includes questions on the utilisation of both primary and secondary healthcare. In particular respondents were asked to indicate on a categorical scale when the last time they visited the GP for their own health related needs was. They were also questioned about whether they had spent time in the previous year in hospital as an inpatient or whether they attended hospital for a day procedure (which we denote in our models as a day case). Questions were also posed to respondents regarding their approximate height and weight which formed the basis for their BMI categorisation. All data used here are self-reported including those relating to BMI.

other diseases (CVD, diabetes and certain cancers), the treatment of which is likely to lead to increased healthcare utilisation. Thus the impact of BMI on health service use was examined after removing the impact of BMI on the number of chronic conditions. This was done by first estimating the relationship between other chronic conditions and BMI, with the residual of this equation – chronic conditions unrelated to BMI – being entered into a second equation examining the relationship between service use and BMI.

The study reported overweight and obesity to be significant predictors of GP utilisation and obesity as a significant predictor of inpatient episodes. Translating increased utilization into costs, primary healthcare costs are estimated conservatively to be approximately €21.5 million higher and secondary healthcare costs approximately €30 million higher in the Republic of Ireland as a result of overweight and obesity in adults. The methods adopted by the paper are not unproblematic. For example, the reliance on self-reported measures of adiposity, leaves the study open to the criticisms previously outlined is respect of self-reported measures (systematic under and over reporting). Furthermore the use of the residual to identify focus on BMI related effects is likely to be less than precise.

That adiposity is positively associated with healthcare utilisation in the general population was also reported in the older population (Mc Hugh et al., 2014, Doherty et al., 2014, Leahy et al., 2014a). In their study McHugh et al used data from the Irish Longitudinal Study of Ageing (TILDA), a nationally representative study of adults aged ≥50 to estimate the effect of overweight and obesity on the use and cost of allied health services that had not been examined by Doherty et al (2013b) (dietetic services, public health nurse visits, chiropody and home help). Measured BMI was modelled as a categorical variable; normal (18.5–24.99 kg/m^2), overweight (25.00–29.99 kg/m^2), Class I obesity (30.00–34.99 kg/m2), Class II obesity (35.00–39.99

kg/m^2) and Class III obesity ($\geq$40 kg/m^2). Seemingly unrelated biprobit models were used in which the average marginal effects were estimated which represented the predicted probability of attending a service for each BMI category in comparison to the normal weight category (reference category in each model). Similar to the approach applied by Doherty et al (Doherty et al., 2013b) the impact of BMI on health on service use was examined after removing the impact of BMI on the number of chronic conditions (chronic condition residual).

Regression models were adjusted for socio-demographic characteristics including age, sex, marital status, education medical card status, self-rated health, depressive symptomology and self-reported doctor diagnosis of obesity-related chronic conditions (angina, stroke, chronic heart failure, myocardial infarction, diabetes, arthritis, cancer, chronic obstructive pulmonary disease, asthma, emotional or psychological issues including anxiety and depression). The results suggest that in addition to GP and hospital services, overweight and obesity are associated with increased use of allied health services (dietetic services, public health nurse visits, chiropody and home help), adjusting for sociodemographic and chronic disease factors.

Furthermore the study's estimates suggest that the cost of overweight and obesity-related allied health services was approximately €1.5 million per annum. However the analysis in this study examined allied services collectively, that is the service use of all services together (dietetic services, public health nurse visits, chiropody and home help) as opposed to examining the service use individually. This ignores the possibility of different relationships to different services. Additionally potential differences between gender and service use were not examined.

Using the same data (TILDA), in collaboration with colleagues the researcher examined the relationship between healthcare use and alternative measures of obesity (BMI and WTHR) (Doherty et al., 2014). This examination was made possible by the capture of WTHR in the dataset - data that was not available in the SLAN dataset. Also unlike SLAN data, adiposity was measured as opposed to self-reported. The findings of this study supported the inclusion of both general (BMI) and central measures waist-to-hip ratio (WTHR) of adiposity when measuring the impact of obesity on service use (Doherty et al., 2014). The study used waist-to-hip ratio, as both an alternative and in conjunction with BMI. The WTHR ratio is a measurement of the WC divided by a measurement of the hip circumference. A series of bivariate probit analyses were estimated in which the dependent variables were whether or not the individual had visited the GP in the previous 12 months and used hospital services.

Hospital services examined were outpatient, inpatient, and emergency department facilities. In the first of three fitted models in addition to a number of socio-demographic covariates, BMI was used as a sole measure of adiposity and found to be a significant predictor of service use for GP and Outpatient services. In a second model in which WTHR is used as a sole measure of adiposity, WTHR was also found to be a significant predictor of GP and outpatient use. In the third model (both measures of adiposity included) both BMI and WTHR were found to be significant predictors of GP and outpatient use. Given the significance of both of these adiposity measurements as predictors of service use as modelled in terms of marginal effects, this study supported the inclusion of both measures of adiposity when examining the relationship between obesity and service use.

Finally an earlier study that used the Hospital Inpatient Enquiry (HIPE) data for the years 1997-2004, Vellinga et al. (2008) analysed hospital discharges for both adults and children where obesity was either a primary or secondary diagnosis (Vellinga et al., 2008a). They found that over the study period there was a 45% increase in the number of obesity related discharges (identified according to the Hospital Inpatient Enquiry (HIPE) system) in adults. The annual cost for hospital stays in patients with a primary or secondary diagnosis of obesity was calculated to be €4.4m in 1997, rising to €13.3m in 2004. This study did not however, examine primary care costs nor did it seek to control for important socio-demographic characteristics that might have confounded observed relationships in the hospital sector.(Vellinga et al., 2008a).

2.2.6 Summary of literature

With increasing concerns regarding obesity-related diseases and its associated economic burden, it is imperative to apply accurate measures of adiposity. A review of the current adiposity measures show that whilst the limitations of BMI as a measure are well documented, there is no consensus as to what an alternative approach to using BMI might be. The validity of BMI has been challenged by alternative measures, such as: percent body fat, waist circumference, waist-to-hip ratio and skinfold measure. Over the past decade what seems to be emerging is that WC and BMI combined provide a better tool for identifying subjects with metabolic abnormalities or insulin resistance (Janssen et al., 2002, Zhu et al., 2004).

A number of economic analyses have sought to determine if WC may be a better measure at predicting costs. Unfortunately due to difference in models applied and different data used it is difficult to ascertain which measure is best used for economic analysis. Furthermore the lack of consensus may be due to a number of reasons, most likely due to the lack of data having WC as a measurement, inhibiting its use in economic analysis. That said, the literature does show (albeit sometimes conflicting) that the use of both measures might prove more accurate in predicting costs. The more accurate the measures are, the more clearly obese people will be identified and more unnecessary spending of curing obesity will be avoided. However, it is not easy to find the most accurate measure since obesity involves complex body composition. Currently, there are several measures of obesity being used by various researchers.

Population aging and increasing obesity prevalence indicate a likely strain on future healthcare service resources. On a global level, relatively little research has focused on obesity in the older population. This may be due to a number of reasons, for example that childhood obesity is seen to be a more pressing issue or that reducing the prevalence of obesity in older people is not seen to be as important in that they may not be of working age (tax contributing) and the indirect costs may not be as high. According to the literature, the majority of obesity related costs are attributed to increased healthcare service use. Those studies that have examined older populations' healthcare service use according to adiposity have primarily used BMI as the adiposity measure and to refer back to the initial point regarding the limitations of BMI as a measure of adiposity, this is almost ironic given the consensus that BMI is not a good predictor of the very diseases that older people are likely to have (CVD and diabetes).

For example it might be the case that those within a lower BMI category but who have abdominal obesity as measured by WC may not be identified as high service users according to a high BMI but would be according to a high WC. Adiposity in older adults is further complicated by the illness effect. The Centre of Disease Control (CDC) note that factors such as age, sex, and muscle mass can influence the relationship between BMI and body fat- all of which are particularly relevant in an older population. In addition little is known regarding sex differences in severity and healthcare utilization.

In Ireland there have been three key studies that examine the cost of overweight and obesity (Doherty et al., 2013b); examine the role of adiposity in determining the relationship between adiposity and healthcare service use (Doherty et al., 2014) and finally a study that examined the relationship between obesity and allied service use (Mc Hugh et al., 2014). The first study (Doherty et al 2013) provides an estimate of the cost of overweight and obesity in Ireland according to obesity related service use. The study reports that when increased utilization is translated into costs that primary healthcare costs are estimated to be approximately €21.5 million higher and secondary healthcare costs approximately €30 million higher in the Republic of Ireland as a result of overweight and obesity in adults.

The second study Doherty et al (2014) provides for the first time an analysis of the relationship between obesity and healthcare service use using both measures of obesity, the findings of which indicate that both measures of adiposity ought to be used when examining this relationship. The third study uses methods developed by Doherty et al (2013) and extends the examination of the relationship between obesity and service use to explore allied service use. This study does not examine if and how this might vary according to different measures of adiposity; nor does it explore according to genders. It is important to understand the extent to which the role of adiposity plays in predicting service use and costs, particularly in a population in which the current measure (BMI) is likely to be in erroneous (predicting common conditions in older people; CVD; diabetes). While a large national and international literature has examined the economic burden of obesity, there is much less evidence of the role of different measures of adiposity, particularly in the older population. This is despite the fact that older people are more frequent and intensive users of healthcare.

The objective of this chapter is to examine the role of adiposity in predicting the use and cost of healthcare, by comparing the relationships between health service use and adiposity using BMI, the waist-to-hip ratio, and both BMI and the waist-to-hip ratio as measures of adiposity controlling for a range of covariates among a large representative sample of Irish community-dwelling respondents. Of particular interest is the service use of allied services (dietician, chiropody, physio, home-help and public-health nurse) both collectively and individually.

Although as previously noted, a positive relationship has been established between BMI and utilisation of various health-care services, however studies examining the contribution of alternative adiposity measures to gender differences in health-service use are limited and somewhat non-existent. Accordingly, this chapter examines gender differences in the utilization of the principal types of healthcare services according to alternative measures of adiposity among the older adult population in Ireland. To summarise, the hypothesis tested in this analysis is that the use of alternative measures of adiposity is important in predicting healthcare service use; that is the significance of BMI and WTHR in predicting service use may vary depending on the service examined. Furthermore the hypothesis is that the prediction of service use according to adiposity measure will vary according to gender.

2.3 Methods

There are essentially two primary analyses in this chapter; each of which extend the methods deployed by Doherty et al (2014) – which I coauthored- that used the same data from TILDA to examine the relationship between healthcare service use and alternative measures of adiposity (Doherty et al., 2014). The first analysis follows on from this paper and examines the relationship between healthcare service (specifically outpatient) use according to gender using different measures of adiposity. The second analysis examines the relationship between allied service use (dietician, public health nurse, physiotherapy, home help and chiropody), collectively and independently (that is each service examined separately) and alternative measures of adiposity.

2.3.1 Data

TILDA is a study based on a population-representative sample of over 8000 community dwelling individuals aged 50 or over. The TILDA data was collected between October 2009 and February 2011. One of the aims of TILDA is to provide a comprehensive internationally comparable baseline data on older people along with providing new insights into the causal pathways underlying the ageing process (http://tilda.tcd.ie/). Each participant of TILDA underwent an interview in their home which was administered using a computer-aided personal interview (CAPI). The participant filled in a self-completion questionnaire and was invited to undergo a detailed health assessment. TILDA has twenty-four sections that cover a wide arrange of topics from demographics, physical and mental health including self-reported doctor-diagnosed chronic conditions, employment/retirement and health service use. Further details of the survey, sampling frame etc. are attached in appendix one.

2.3.2 An intuitive model for the utilisation of healthcare services

There has long been interest in what influences people's behaviour in relation to their health and what prompts people to use health services. There exists therefore, a substantial body of literature examining multiple aspects of health or health care seeking. Many existing models seek to explain the steps taken by people to act in the interest of their health and the determinants or factors that affect these pathways and lead to actual service use. For example behavioural models such as Andersen (1968) (Andersen, 1968) consist of predisposing factors such as sex, age, occupation, education; enabling factors such as income, household materials; and need factors, that is, perception of illness and service indicators. These models are based on *determinants* that affect decision-making and take into account economic circumstance, distances to travel, level of education, previous consumer satisfaction and perceived quality of services, for example.

Another group of models used to understand health behaviours are grounded in an expected utility framework (Arrow, 1963) for example (Johannesson et al., 1993, Folland, 2006, Armitage and Conner, 2000). Expected utility provides a structure by which it may be possible to better understand individual's behaviour regarding their healthcare demand (Arrow, 1990). Within this framework it is assumed the individual seeks to maximize their utility subject to constraints on time and disposable resources (Von Neumann and Morgenstern, 2007). The theory also assumes that people are risk averse and make choices between taking a risk that has different implications on wealth.

The essence of utility theory is a mathematical proof that shows if a person's preferences conform to the axioms (completeness, transitivity and independence), then two important consequences follow. First, one can infer the person's values (known as a utility function) from observing his or her choices. Second, this person's choices can be described as if he or she were following a decision rule of maximising expected utility (in which "expected" is used in the usual probability- theory sense to indicate a probability- weighted average). In other words expected utility maximising posits human choice as a process of considering the payoffs from each possible outcome, the probability of its occurring, and the degree of risk aversion. Expected utility theory (EUT) is not a model of how consumers should behave when faced with choices, but rather provides a basis for predictions and hypothesis testing based on how they are observed to behave.

In this analysis the expected utility framework is presented to shed light on an individual's decision to utilize healthcare, in particular GP, Outpatient and Allied services. Utility can be differentiated into two types, *outcome* utility and *process* utility. The former can in this context be interpreted as the reduction in the probability of a worsening of obesity related morbidities or indeed dying from these morbidities. For this analysis it is assumed that visits to these services (GP, Outpatient and Allied services) generate utility either directly and/or through the health gains associated with them. This is similar to an approach by McGregor et al (2006) who draw on the utility maximising framework as an intuitive model for understanding GP visits (McGregor et al., 2006b). Process utility which is elicited from the decision making process itself (McGuire et al., 2005) can be thought of in terms of how the decision to utilize healthcare is managed as well as in terms of how the healthcare itself is offered. This intuitive framework can also be presented in terms of disutility. As noted by McGregor et al healthcare visits' may also give rise to costs in terms of financial outlays and/or the opportunity costs of time (McGregor et al., 2006b).

When deciding to utilise healthcare, many attributes which will impact upon both the outcome and process utility of the healthcare utilisation will be included in individual's utility function. Furthermore when deciding to utilise healthcare, the utility function will encompass a range of influences, the value attached to the service (whether positive or negative) will vary as will the individuals risk adversity and knowledge of the issues around the decision being made. For example as previously alluded to, central obesity is a risk factor for CVD and diabetes. In Ireland, the GP offers screening for CVD and diabetes. One positive attribute of visiting the GP and partaking in such screening may be the potential reduction in severity and mortality as a result of early detection of the screen and subsequent prescription of lifestyle changes/medication. Those individuals who assign greater weight to this attribute (reduction in the risk of severity and mortality), such as individuals with a greater probability of acquiring diabetes CVD or those who value health more highly, may be more likely to visit the GP to screen. As the probability of acquiring these diseases increases with age, or in individuals who have a family history of, or genetic predisposition to CVD; individuals with these characteristics may elicit additional utility from visiting the GP for a screen and in consequence be more likely to attend. (It is acknowledged that the predictions of EUT in this respect are identical to those of Grossman's application of human capital theory to health and healthcare use which could be adopted as an alternative interpretive framework).

2.3.3 Description of variables

While the majority of details of the variables used in this chapter are provided in Table 5, this section details the rationale underlying the specification and/or inclusion of some of those variables in slightly greater depth.

Health service use

In the TILDA questionnaire respondents were asked if they had received the services of wide range of healthcare services in the previous 12 months. This chapter focuses on GP services, outpatient services along with whether or not respondents received services from the dietician, public health or community nurses, chiropody, physiotherapy and home help – of which are individually modelled and also collectively modelled as “allied services”; of which are modelled as the dependent variables. In the questionnaire respondents were asked “in the last 12 months, did you visit the ...particular service in question”. This variable provides a dichotomous result in that respondents may answer either *yes* or *no*. For this analysis three outcomes were modelled as the dependent binary variables for ease of interpretation; GP visits, Outpatient and Allied services (dietetic services, public health nurse visits, chiropody and home help).

Gender

Some gender differences in healthcare seeking behaviour has been documented with some explanations related to the fact that seeking healthcare may be greater during a woman’s reproductive years (Cashin et al., 2002). A growing body of literature in the United States suggests that men are less likely than women to seek help from health professionals for conditions such as stress, depression, substance abuse and physical disabilities (Galdas et al., 2007). While earlier research in the United Kingdom shows men are more likely to feel reluctant to seek any type of health services and therefore delay longer (Galdas et al., 2005). This reluctance on the part of males is little understood and the authors concluded that ‘traditional masculine behaviour’ was the cause – though what this actually means is unclear. Subsequently different levels of utility may be enjoyed according to gender status. It may be that males are less likely to be carers and as such do not incorporate the impact of their poor choices on others to the same extent as females.

Education

Education level has been divided to a dichotomous variable describing whether or not the respondent has a third level degree or not. Taken directly from the questionnaire, education level is a categorical variable which has the possibility of being either: none, primary incomplete, primary complete, Intermediate/junior/group certificate or equivalent, Leaving certificate or equivalent, Diploma/certificate, Primary degree and Postgraduate/higher degree. Education may impact the decision to consume health care either as a proxy for unobserved time preference and/or as an indicator of information possessed by the individual in respect of health risks.

Social isolation

Experiences of loneliness and social isolation can lead to increased health care use among older adults. For example it might be that an individual builds a relationship with their doctor over the years, so a visit to the doctor's office is like seeing a friend. Indeed a growing body of research is establishing loneliness as a significant public health issue among older adults. As shown in table 5 the variable “Socsocnet” is used to control for loneliness and social isolation in this study. As part of TILDA, social isolation was measured using the Berkman-Syme Social Network Index (SNI). This measure is a questionnaire to assess the type, size, closeness, and frequency of contacts in a respondent’s current social network. The SNI is a self-reported questionnaire for use in adults aged 18–64 years old that is a composite measure of four types of social connections: marital status (married vs. not married); sociability (frequency of contacts (0=few to 1=many) with close children, relatives and friends, church group membership (yes (1) or no (0)), and membership in other voluntary organisations (yes (1) or no (0)). Scores from each social connection type are combined to create four levels (0-4) of social connection or engagement: most isolated (0-1), moderately isolated (2), moderately integrated (3) and most integrated (4) (Berkman and Syme, 1979).

Entitlement status

External factors, such as the healthcare system may influence an individual's participation in health service use. Currently in Ireland there are two main categories of eligibility to free at the point of use access to publicly funded health services in Ireland (www.citizensinformation.ie). Those in Category I (full medical cardholders) are entitled to free at point of use publicly funded health services (including inpatient and outpatient hospital care, GP care and other primary and community care services), but must pay a co-payment (€2.50) per prescription item. Eligibility for a full medical/GP visit card is assessed primarily on the basis of an income means test. Those in Category II are entitled to subsidised publicly funded hospital services and prescription medicines (the latter up to a monthly deductible of €144 per family), but must pay the full cost of GP services (and other primary and community care services).

These entitlements are important as negative attributes, or costs, that might also impact upon the net utility elicited from a treatment. Research shows a correlation between entitlement to services and uptake of services; it has been shown, for example, that eligibility for free public healthcare is associated with a significantly higher number of GP visits, even after controlling for a wide variety of both subjective and objective indicators of health need. (Hudson and Nolan, 2014). Indeed the research findings are unambiguous; those with full medical or GP visit cards have a significantly higher number of GP visits, even after controlling for health need (Layte and Nolan, 2014, Layte and Nolan, 2004, Nolan and Smith, 2012).

In addition Private Health Insurance (PHI) can play a complementary role in the sense that it may afford faster access relative to those who don't hold PHI to secondary care. Within EUT insurance may be seen as a way of managing risk adversity. Alternatively possession of PHI may indicate differences in the tastes and preferences of individuals for health and derived demand for health care. For each of these variables (PHI and medical card status) a dichotomous variable described either as yes or no as to whether or not the respondent had medical card status and PHI.

Comorbidities

In the TILDA questionnaire, respondents were asked "Has a doctor ever told you that you have any of the conditions on this card"? This was furnished with a large list (over 25) of conditions. In this analysis, a composite health variable (morb) was specified as the sum of the various self-reported conditions. Had each of these been included individually it would meant having a large number of variables which could potentially lead to the model being over specified. Furthermore, similar to that of allied services, some conditions had very few observations which would question the statistical power in terms of providing any meaningful results. In addition the severity of the condition is not known, so comparing one condition to another will not provide any meaningful results either. As noted by McGregor et al (2006) individuals with apparently the same health characteristics (i.e., when health is controlled in the function) may exhibit different patterns of GP attendance due to differences in the severity of their health conditions (McGregor et al., 2006a).

Measures of adiposity

One of the main advantages of TILDA over existing national and international datasets is the availability of objective information on the health of respondents, collected via nurse-led health assessments. BMI and waist-to-hip ratio measures were extracted from TILDA. Although there is a general consensus that when using BMI that anyone with a BMI greater than 30 would be deemed obese; for WTHR's there is some variations as to what is deemed a cut off for health risk or obesity. For the purpose of this chapter the classification variables were classified according to WHO recommendations in which the WHO states that abdominal obesity is defined as a waist–hip ratio above 0.90 for males and above 0.85 for females, or a BMI above 30.0. BMI was categorised as normal (18.5–24.99 kg/m^2), overweight (25.00–29.99 kg/m^2), moderate obesity (30.00–34.99 kg/m^2), severe obesity (35.00–39.99 kg/m^2) or severe obesity (≥40 kg/m^2).

Table 5. Variables and description used for this analysis

Variable	**Description**	**Coded**
Dependent variables		
GP Visits	Describes whether or not an individual has visited a GP in the past 12 months	Dichotomous variable 1 if a person has visited the GP and 0 otherwise
Outpatient	Describes whether or not an individual has been to a hospital as an outpatient in the past 12 months	Dichotomous variable 1 if a person has been an outpatient and 0 otherwise
Inpatient	Describes whether or not an individual has been to a hospital as an inpatient in the past 12 months	Dichotomous variable 1 if a person has been an inpatient and 0 otherwise
Allied [Dietician, physiotherapist, community nurse, chiropody and home	The variable “allied” was developed which added four variables together; Dietician,	Count variable 0 = the number of

help	physiotherapist, community nurse, chiropody and home help. Each of these services describe whether or not an individual used the service in the past 12 months	individuals who have used none of the four services 1 = the number of individuals who have used one of these services 2 = the number of individuals who have used two of these services and so forth for those who have used three, four and five of the services in the past 12 months
Explanatory variables		
Gender		1= females 0= males
Body Mass Index	Based on measured weight and height	BMI is modelled as a continuous variable
Waist To Hip Ratio (WTHR)	Based on measured WTHR measurements. Since the marginal effects for BMI and the WTHR cannot be directly compared because they are scaled differently, for comparative purposes WTHR measure was rescaled to make it comparable to BMI[12].	WTHR is modelled as a continuous variable
Education	Describes those who have third level education	Dichotomous variable 1 = Primary degree and 0 = No degree
Medical card only	Describes those who have a	Dichotomous variable

[12] (Rescale formula:(WTHR - mean_WTHR)/stddev_WTHR *stddev_BMI + mean_BMI)

	medical card only	1= Medical card only and 0 otherwise
Private Health Insurance (PHI)	Describes those who have a PHI cover	Dichotomous variable 1 = Private health insurance only and 0 otherwise
Morb	This describes the number of comorbidities conditions that individuals reported having had diagnosed by a doctor from a list furnished by interviewers The conditions included in this variable are: any heart problem/condition; diabetes, stroke/mini stroke, COPD, asthma, arthritis, osteoporosis, cancer, , mental health problems, alcohol problems	Count variable: 0 = the number of individuals who have none of these comorbidities 1 = the number of individuals who have one of these comorbidities 2 = the number of individuals who have two of these comorbidities
Socsocnet	In TILDA the social isolation was measured using the Berkman-Syme social network index (SNI). The SNI is a self-reported questionnaire for use in adults aged 18–64 years that is a composite measure of four types of social connections: marital status (married vs.	Categorical variable: Individuals are categorised into four levels of social connection: socially isolated (individuals with low intimate contacts—not married, fewer than six friends or relatives, and no membership in either church or community

	not); sociability (number and frequency of contacts with children, close relatives, and close friends); church group membership (yes vs. no); and membership in other community organisations (yes vs. no).	groups), moderately isolated, moderately integrated, and socially integrated
Smoker		Dichotomous variable 1 = Smokes 0 = Does not smoke

2.3.4 Overview of statistical analysis

The sample used in this analysis was confined to those on whom measurements were taken. An examination of the usable sample table 6 revealed it to be similar in characteristics to the full sample apart from those from lower socio-economic groups who were under-represented in the measured group relative to the full sample. As the purpose of the exercise was to examine variation among the sample rather than to derive population estimates of service use - differences between the full and measured sample are not seen as material.

Table 6. Comparative descriptive details of the full TILDA sample and of those with both BMI &WTHR measurements

Variable	**All Tilda**	**Those with BMI & WC measurements only**
Total respondents	8,504	6,110

Mean age	62.96	62.30
Sex (%)	55.55 % female	55.50 % female
Number of comorbidities	1.35	1.35
Medical card (% with MC)	46.78%	41.88%
PHI (%)	57.70%	63.26%
Mean BMI	28.49	28.49
Mean WTHR	.90	.90

There were a number of factors to consider when establishing how best to model healthcare service use according to adiposity measures. In instances where count data is available, it is common that a Poisson, negative binomial or related regression model would be employed (Cameron and Trivedi, 1998). However this approach was thought to be somewhat cumbersome in respect of this study; count data (frequency of visits) to healthcare services was only available for some services. For example the frequency of visits to allied services was not recorded, only whether or not respondents used the service was asked. To reflect the role of the GP as gatekeeper to some services within the Irish healthcare system and the information this may contain in respect of disease severity and/or tastes for healthcare (McGregor et al., 2006a) a model that accommodated potentially correlated errors between the healthcare services (that is GP and all other services) was required and also one that offered ease of interpretation. On the other hand there are also services in which the GP may play a lesser role in terms of onward referral, for example physio or chiropody services. These services form part of "allied services" and in essence require different model estimation. Thus for those services where a bivariate modelling approach was inappropriate, a probit model was estimated. First however, an outline the bivariate approach is provided.

2.3.4.1 Bivariate Probit Model

Bivariate probit and logit models, like the binary probit and logit models, use binary dependent variables, commonly coded as a 0 or 1 variable. Two equations are estimated, representing decisions that are dependent. Thus, the bivariate model estimates decisions that are interrelated as opposed to independent. This is relevant in the context of this analysis in which a GP visit may lead to an onward referral to outpatients or inpatients in hospital. The bivariate probit model is thus a joint model for two binary outcomes in which the outcomes may be correlated. In other words, it allows for correlation between the corresponding error terms. If the correlation turns out insignificant, then two separate probit models can be estimated, otherwise a bivariate probit model must be used. The model is expressed in terms of latent variables, in which the unobserved latent variables are presented as:

$$y_1^* = x_1' \beta_1 + \varepsilon_1$$
$$y_2^* = x_2' \beta_2 + \varepsilon_2$$

Thus, there are two latent variables y_1^* and y_2^* each of which is assumed to be a linear function of a set of explanatory variables (which may or may not be the same for each decision) and an error term.

In the estimations in this chapter, the binary choice variables y_1^* and y_2^* relate to whether or not a person visits a GP and whether or not that person visits the other healthcare service in question (either outpatient, inpatient or allied services), respectively, and the outcome of each decision is equal to one if the latent variable is greater than zero (e.g. the individual visits the GP/visits or uses the other healthcare service in question) and equal to zero otherwise (e.g. the does not visit the GP/does not visit or use the other healthcare service in question). A vector of explanatory variables, x_1, that includes adiposity measures and other socio-demographic characteristics. β_1 represents the coefficients to be estimated in the model and ε_1 represents the error term

The bivariate probit model specifies the outcomes such that:

The first model becomes:

$y_1^* = x_1' \beta_1 + \varepsilon_1 \text{ where } y_1 = 1 \text{ if } y_1^* > 0, 0 \; otherwise$

The second model becomes:

$y_2^* = x_2' \beta_2 + \varepsilon_2 \text{ where } y_2 = 1 \text{ if } y_2^* > 0, 0 \; otherwise$

The error terms in the model are assumed to have a joint or bivariate normal distribution which allows for a nonzero correlation between the errors. In other words, it is assumed that the two error terms are not independent of each other. Therefore the error structure captures the potential correlation between utilization of both healthcare services can be described as:

Allowing for the possibility $\begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \mid X \sim \mathcal{N}\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix} \right)$ of correlation between the error terms of the two equations recognizes that there may be unobservable characteristics of individuals that influence both decisions. For example, it may be the case that unobserved preferences for healthcare for example the "worried well" would make an individual more likely to visit one health service and the other (call her HA1) though worried well status would be unobserved in terms of the covariates that could be included in the model. In this case it would be;

$$\mathrm{U}_1 = HA1 > 0 \; and \; \mathrm{U}_2 = HA1 > 0$$

On the other hand an otherwise similar individual (call her HA2) with unobserved tastes for more alternative medicine (e.g. home remedies or more holistic approaches to their health) may be more inclined towards acupuncture or homeopathy and eschew more formal medical services. In this instance, it would be the case that u1;HA2 < 0 and u2;HA2 < 0.

$$\mathrm{U}_1 = HA2 < 0 \; and \; \mathrm{U}_2 = HA2 < 0$$

Marginal effects and predicted values can be estimated similarly to those for the binary probit models. Accounting for unobserved heterogeneities is important since a model which fails to do so would predict the same probability of, for example, visiting the GP or other services for both individuals. This modelling approach controls for this unobserved heterogeneity in preferences by allowing for correlation between the error terms in both decisions. In other words, it allows the probability of one outcome to be dependent on the value or probability of the other; which is of particular importance given the role of the GP as gatekeeper in Ireland. The "rho" outlines the correlation coefficient between the bivariate regression, which, as previously noted if significant confirms the appropriateness of the use of the bivariate probit approach; if non-significant the researcher could proceed by estimating separate probit. The decisions for healthcare use would not be interrelated and can be estimated independently. For this study a total of three bivariate probit models will need to be estimated to examine GP and outpatient; GP and inpatient and finally GP and allied services. Based on the illustrative cases set out above, it is conceivable that ρ could be positive or negative though based on the examples given it seems reasonable to hypothesise a positive ρ in respect of hospital services and a negative ρ in respect of some allied services at least.

As previously alluded to a number of variables were controlled for including the respondent's age (continuous), gender (when all of the sample was included) the number of chronic conditions the respondent reported having been diagnosed by a doctor from a list presented by interviewers (entered as a count variable), education (third level degree or not), social isolation (categorical defined according to isolation scale), whether or not the individual had a medical card or private medical insurance and finally whether or not the respondent was a smoker. For the purpose of comparison, the same variables were controlled for throughout each of the models and also the functions were estimated in a similar fashion for all models; based first on BMI, then the waist-to-hip ratio and then with both measures of adiposity present. In all instances the primary interest is the estimation of likely service use according to alternative measures of adiposity.

The relationship between adiposity measures and chronic health conditions is complex; with high adiposity being a risk for the development of certain chronic health problems such as diabetes and heart disease. In order to account for this the impact of health status on health service utilisation was separated from the impact related to adiposity. Further analysis, similar to that applied by Doherty et al was conducted to isolate the impact of adiposity on health and thereby health service use (Doherty et al., 2014).

For each model, the relationship between health and adiposity was initially modelled in which a count of conditions was regressed on adiposity, the residual from this gives a measure of conditions that are not related to adiposity. In other words from this regression a residual which captures the non-adiposity related aspects of health was used in the regression of service use along with measures of adiposity. Subsequently the non-adiposity measures of chronic conditions are captured in the residual allowing the adiposity measures to predict adiposity ones. The residual on the count of chronic conditions, age, and measures of adiposity were entered into the functions as quadratics to allow for possible nonlinearity in relationships with the dependent variable.

The analysis begins by considering the service use between GP and outpatient service use according to gender. For the latter the sample was split according to males and females and a separate analysis was conducted for each gender in which a bivariate probit was estimated for each sample. Indeed for all gender analysis, this format was followed. In instances where the sample was not split according to gender (that is the whole sample was being examined), gender was included as a covariate. Once the bivariate probit model was estimated, the usual approach to calculating marginal and average effects was followed in order to predict, for example, the impact of a change in one explanatory variable on the marginal probability of an outcome, for example the effect of the measure of adiposity on the likelihood of using a GP service (marginal effects were estimated at the average). After estimating GP and outpatient services, the service use between GP and allied services was examined. Allied service use was examined as a total of all five services and also as shown in appendix two; each service was also examined individually. Similar to GP and outpatient service use, GP and allied service use was split according to gender and modelled in similar fashion as previously outlined to examine if different adiposity measures better predict service use according to genders.

In each model the adiposity measures, BMI and WTHR are presented as continuous variables; similar results were found using BMI as a categorical variable. BMI and WTHR measures are scaled differently. Due to this difference, the marginal effects for BMI and WTHR cannot be directly compared. Thus for comparative purposes the WTHR was rescaled measure to make it comparable to BMI according to this rescaling formula; (WTHR - mean_WTHR)/stddev_WTHR *stddev_BMI + mean_BMI) (Doherty et al., 2014).

2.4 Results

2.4.1 Descriptive statistics

Respondents that did not have both measures of adiposity (measured BMI and WTHR) were excluded from the analysis, leaving an analytical sample size of 6,110 individuals (2,394 excluded); thus all analysis is reported on those that had both measures only. As per Table 7, of the 6,110 participants included in the analysis, the mean age was 62 ±9.07 years, 55% were female (n=3,391). According to BMI classifications a total of 23% (n= 1,373) of participants were classified as normal weight, 43% as overweight (n = 2,608), 24% as obese class I (n = 1,469), 7% as obese class II (n = 456) and 3% as obese class III (n= 158).

Cut-off points for obesity as defined by WTHR ratio differ for males and females; as a reminder; the WHO indicate that abdominal obesity is defined as a WTHR above 0.90 for males and above 0.85 for females. According to these recommended definitions of obesity, the analysis in this chapter shows that the average WTHR for both males and females is within the abdominal obesity range; males had a mean WTHR .96 and the mean WTHR for females was .85. This is interesting as according to BMI cut offs the mean BMI is within the overweight category (albeit just under that of the obesity range category) at BMI 29.

In line with national figures, quite a large percentage of the sample holds either a medical card or PHI; although the percentage that have PHI seems to be slightly above average that of national figures. According to the Social Isolation Measure, on average respondents in this sample are what is referred to as “moderately integrated”.

Table 7. Characteristics of TILDA respondents with both measure of adiposity

Characteristic	(*n*=6,110) Mean (Std dev)
Percentage Female	55.5%
Mean age (y)	62 (9.07)
Average BMI	29 (4.64)
Average WTHR males	.96 (.06)
Average WTHR females	.85 (.06)
Educational attainment	
Postgraduate/higher degree	14%
Entitlements	
Medical card only	45%
Private Health insurance only	63%
Average Number Chronic Conditions	3.5

2.4.2 Model results

In this analysis, the independent variable of key interest is the measure of adiposity according to BMI and WTHR. Across all marginal effects estimations, three models were estimated in which alternative measures of adiposity were examined individually and collectively; model one BMI only; model two WTHR only and model three included both measurements of BMI & WTHR. In the interests of brevity and for ease of exposition, the results presented in this section pertain to the marginal effects of GP and outpatient and GP and allied service use which are shown in table 9 and table 10, respectively. To facilitate the interpretation of results table 8 provides a brief overview of the type of models used for allied service use for all three sample sizes (male & female, male only & female only) according to the model three (both BMI and WTHR included in the model). A full set of regression results in respect of this table is attached in appendix two – table 47 to table 65.

The results in Table 8 below clearly show the complexities in modelling relationships and the need for care in interpreting results. To assist in interpretation the researcher estimated a bivariate model in which the rho was significant, in instances where the rho was not significant a probit model was estimated. Table 8 reports not just the method of estimation but also the relationship between service use and the measures of adiposity modelled. The findings clearly demonstrate the potential to obtain not only different but apparently conflicting results in terms of the relationship between adiposity and service use as well as specific measures of adiposity and service use.

Considering that allied services were defined by the total of a number of different types of healthcare services, there was a number of ways to specify this dependent variable, for instance individually or collectively (the independent variables for allied services was specified as 1 if the respondent used any of the services and 0 otherwise). Furthermore when the sample was split according to gender and also partitioned according to individual allied services, the use of different methods of analysis was possible. Each of these were explored individually (findings attached in appendix two). Not only does this demonstrate the complexity of the modelling exercise but more importantly it demonstrates that there may be different relationships between different measures of adiposity and different aspects of health service use for males and females. Also indicated in table 8 is the model fit for each model estimated. In the cases of bivariate approaches the statistically significant rho indicates the correlation between the errors between GP and outpatient and also GP and allied services. Also in all models the chi-squared test estimates show to be significantly different from zero.

Table 8. Overview of health services examined and the resulting significant adiposity measure when both adiposity measures were included in the model

Health service use	**Sample examined**	**Model used**	**Significant adiposity measure**	**Goodness of fit**
GP: Allied services				
GP: Allied services (all five services)	Males and females	Bivariate Probit	BMI & WTHR	Log pseudolikelihood = -3547.5061 athrho .1984934 (p<0.000) chi2(1) = 13.30 Prob > chi2 = 0.0003
GP: Allied services (all five services)	Males	Probit	Neither measures are significant	Log pseudolikelihood = -677.84265 chi2(13) = 300.67 Prob > chi2 = 0.0000
GP: Allied services (all five services)	Females	Bivariate Probit	Neither measures are significant	Log pseudolikelihood = -2006.7675 /athrho .2576231 (p<0.000) chi2(1) = 12.3778 Prob > chi2 = 0.0004
Dietician				
Dietician	Males and females	Probit	WTHR	Log pseudolikelihood = -311.24593 chi2(14) = 120.00 Prob > chi2 =

				0.0000
Dietician	Males only	Probit	WTHR	Log pseudolikelihood = -150.30176 chi2(13) = 92.70 Prob > chi2 = 0.0000
Dietician	Females only	Probit	WTHR	Log pseudolikelihood = -159.8797 chi2(13) = 56.05 Prob > chi2 = 0.0000
Chiropody				
Chiropody	Males and females	Biprobit	BMI	Log pseudolikelihood = -2523.1065 /athrho .3679047 (p< 0.007) chi2(1) = 7.24878 Prob > chi2 = 0.0071
Chiropody	Males only	Probit	WTHR	Log pseudolikelihood = -259.445 chi2(13) = 150.32 Prob > chi2 = 0.0000
Chiropody	Females only	Probit	BMI	Log pseudolikelihood = -1393.5907 chi2(1) = 123.37Prob > chi2 = 0.0000
Public health nurse				

Public Health nurse	Males and females	Bivariate Probit	WTHR	Log pseudolikelihood = -2651.0179 /athrho .155701 (p< 0.070) chi2(1) = 3.27 Prob > chi2 = 0.0704
Public Health nurse	Males only	Probit	Neither measures are significant	Log pseudolikelihood = -328.82227 chi2(13) = 136.55 Prob > chi2 = 0.0000
Public Health nurse	Females only	Probit	WTHR	Log pseudolikelihood = -491.48508 chi2(13) = 199.68 Prob > chi2 = 0.0000
Home help				
Home help	Males& females	Probit	Neither measures are significant	Log pseudolikelihood = -441.89749 chi2(14) = 298.08 Prob > chi2 = 0.0000
Home help	Males	Probit	WTHR	Log pseudolikelihood = -149.42338 chi2(13) = 146.48 Prob > chi2 = 0.0000
Home help	Females	Probit	Neither	Log pseudolikelihood

			measures are significant	= -287.59835 chi2(13) = 211.91 Prob > chi2 = 0.0000
		Physiotherapy		
Physio	Males& females	Probit	Neither measures are significant	Log pseudolikelihood = -1824.3194 chi2(15) = 430.43 Prob > chi2 = 0.0000
Physio	Males	Probit	Neither measures are significant	Log pseudolikelihood = -378.56611 chi2(13) = 69.93 Prob > chi2 = 0.0000
Physio	Females	Probit	Neither measures are significant	Log pseudolikelihood = -617.23072 chi2(13) = 75.59 Prob > chi2 = 0.0000
		GP: Outpatient		
GP: Outpatient	Males and females	Bivariate Probit	BMI & WTHR	Log pseudolikelihood = -5294.6974 athrho .4149614 (p< 0.000) chi2(1) = 155.05 Prob > chi2 = 0.0000
GP:	Males	Bivariate	WTHR	Log pseudolikelihood

Outpatient	only	Probit		= -2364.3662 chi2(1) = 65.03 Prob > chi2 = 0.0000 athrho .3903921 (p <0.000)
GP: Outpatient	Females only	Bivariate Probit	BMI	Log pseudolikelihood = -2915.2491 athrho .4311844 (p< 0.000) chi2(1) = 89.02 Prob > chi2 = 0.0000
GP: Inpatient				
GP: Inpatient	Males and females	Bivariate Probit	WTHR	Log pseudolikelihood = -3783.0358 athrho .3409502 (p<0.000) chi2(1) = 42.03 Prob > chi2 = 0.0000
GP: Inpatient	Males only	Bivariate Probit	WTHR	Log pseudolikelihood = -1720.536 athrho .365497 (p<0.000) chi2(1) = 21.67 Prob > chi2 = 0.0000

GP: Inpatient	Females only	Bivariate Probit	WTHR	Log pseudolikelihood = -2045.6221 athrho .3252015 (p< 0.000) chi2(1) = 21.24 Prob > chi2 = 0.0000

As shown in table 9 below and as reported by Doherty et al (Doherty et al., 2014), in the case of visiting the GP, BMI is found to be a significant predictor of service use, with significant positive marginal effects of 0.006 and 0.004 across both models one and three respectively. In other words the probability of attending the GP increases by 0.006 for those with a higher BMI (BMI is modelled as a continuous variable[13]). Similarly, the WTHR is found to be a significant predictor of GP use in model two and model three, with estimated marginal effects of 0.335 and 0.256 respectively. A similar pattern emerges in the case of outpatient services. Both BMI and the waist-to-hip ratio are found to have significant marginal effects across the models. In the case of BMI, the marginal effects associated with outpatient use are 0.005 and 0.003 in models one and three, respectively.

Table 10 shows findings for the analysis of allied services. Both BMI and WTHR are found to be a significant predictor of allied service use, with significant marginal effects across all three models. For allied services in model three where both measures were included the findings show BMI and WTHR to have significant positive marginal effects of 0.002 and 0.125

Similar results were found when BMI was modelled as a categorical variable, but for simplicity both measures as presented as continuous variables. Modelling BMI as a categorical variable necessitates WTHR to also be modelled as a categorical variable. Considering the different cut off points for WTHR that exist for males and females this further partitions the sample size.

respectively for allied services, which in other words indicates that as BMI and WTHR increases individuals are 0.002 and 0.125 more likely to use allied health services.

While not the focus of this study, the results of the analysis are consistent with intuition in respect of the relationships between the likelihood of service use and the variables used to explain these. Individuals who are sicker, as indicated by their chronic conditions who enjoy better access to services or who have a higher preference for healthcare are more likely to use allied services than those who are not. However in terms of the latter when allied services are examined on an individual basis, whether or not an individual has PHI is not always a significant predictor of service use, for example in the context of dietician or chiropody service use. Those who are deemed (according to previous outlined scoring algorithm) to be socially isolated are more likely to use allied services. Females are more likely to use allied services compared to their male counterparts but broadly speaking little differences exist between males and females service use according to the explanatory variables used in the analysis. In some instances for example the use of chiropody services, PHI is more likely to be a significant driver of service use for males than for females. With respect to educational attainment, broadly speaking this does not appear to be a significant predictor of service use.

Table 9. Independent marginal effects from biprobit results for alternative adiposity measures included for GP and Outpatient services

GP (*n* = 5564)															
Model 1: BMI						**Model 2: WTHR**					**Model 3: BMI & WTHR**				
Variable	**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**	
Age	.003	.001	.00	.0013	.004	.003	.000	.00	.001	.004	.003	.000	.00	.001	.003
Female	.017	.009	.05	.000	.035	.032	.011	.00	.010	.054	.029	.011	.01	.006	.051
Res. Chronic Conditions	.070	.006	.00	.058	.082	.070	.006	.00	.057	.082	.070	.006	.00	.057	.081
Medical card	.100	.012	.00	.076	.124	.099	.012	.00	.076	.124	.091	.010	.00	.071	.112
PHI	.010	.010	.32	-.009	.030	.012	.010	.24	-.007	.031	.011	.010	.27	-.008	.031
Smoke	-.007	.008	.36	-.024	.008	-.010	.008	.23	-.026	.006	-.008	.008	.29	-.025	.007
Third level education	.010	.011	.37	-.012	.032	.010	.011	.35	-.011	.032	.010	.010	.33	-.010	.031

Social isolation measure	.017	.005	.00	.007	.027	.018	.005	.00	.008	.028	.017	.005	.00	.007	.027
BMI	.003	.001	.00	.001	.005						.004	.001	.00	.001	.006
WTHR						.192	.065	.00	.065	.320	.218	.076	.00	.069	.368
<u>Outpatient</u>															
Age	-.000	.000	0.69	-.002	.001	-.000	.000	.70	-.002	.001	-.000	.000	.71	-.002	.001
Female	.021	.013	0.10	-.004	.047	.030	.016	.06	-.002	.062	.030	.016	.07	-.003	.063
Res. Chronic Conditions	.113	.006	0.00	.101	.124	.112	.006	.00	.100	.124	.112	.006	.00	.100	.124
Medical card	.058	.006	.00	.024	.090	.057	.016	.00	.023	.090	.058	.017	.00	.023	.090
PHI	.013	.015	0.39	-.016	.042	.013	.015	.37	-.016	.043	.013	.015	.36	-.015	.043
Smoke	.041	.013	0.00	.016	.067	.041	.013	.00	.015	.067	.041	.013	.00	.015	.067
Third level education	.040	.017	0.02	.006	.075128	.041	.017	.01	.007	.075	.041	.017	.02	.006	.075
Social isolation measure	.014	.007	0.05	-.000	.029	.015	.007	.04	.000	.029	.015	.007	.04	.000	.029
BMI	.000	.001	0.60	-.002	.003						.003	.001	.04	.000	.006

WTHR						.074	.096	.44	-.115	.263	.230	.112	.04	.008	.451

Table 10. Independent marginal effects from bivariate probit results with alternative adiposity measures included for allied services

GP visits: Number of obs = 5564																
Model 1: BMI						Model 2: WTHR						Model 3: BMI & WTHR				
Variable	Marg Effects	Std. Err.	P>|z|	95% Conf. Interval		Marg Effects	Std. Err.	P>|z|	95% Conf. Interval		Marg Effects	Std. Err.	P>|z|	95% Conf. Interval	
Age	.002	.000	.00	.001	.004	.002	.000	.00	.001	.003	.002	.000	.00	.001	.003
Female	.018	.009	.03	.001	.035	.033	.011	.00	.010	.056	.030	.011	.01	.007	.053
Res. Chronic Conditions	.070	.006	.00	.058	.082	.070	.006	.00	.058	.082	.070	.006	.00	.058	.082
Medical card	.091	.010	.00	.071	.111	.091	.010	.00	.071	.111	.091	.010	.00	.071	.111
PHI[14]	.012	.010	.24	-.008	.032	.013	.010	.18	-.006	.034	.013	.010	.20	-.007	.033
Smoke	-.0076	.008	.38	-.024	.009	-.009	.008	.24	-.0267	.006	-.0085	.008	.30	-.025	.008
3level ed	.007	.010	.50	-.014	.028	.007	.010	.47	-.013	.029	.008	.0111	0.44	-.013	.029
Social isolation measure	.017	.005	.00	.007	.027	.018	.005	.00	.008	.028	.017	.005	.00	.007	.027

[14] Private health insurance

BMI	.006	.001	.00	.004	.008						.004	.001	.00	.001	.006
WTHR						.335	.065	.00	.207	.463	.226	.076	.00	.076	.377
Allied services															
Age	.005	.0005	00	.004	.006	.00	.000	.00	.004	.006	.005	.000	.00	.004	.006
Female	.033	.008	.00	.016	.050	.044	.010	.00	.024	.065	.041	.010	.00	.020	.063
Res. Chronic Conditions	.037	.003	.00	.030	.043	.037	.003	.00	.031	.043	.036	.003	.00	.030	.043
Medical card	.081	.011	.00	.059	.103	.082	.011	.00	.060	.104	.081	.011	.00	.059	.103
PHI	-.027	.009	.00	-.046	-.008	-.028	.009	.00	-.047	-.009	-.027	.009	.00	-.045	-.008
Smoke	.000	.008	.94	-.016	.017	.000	.008	.99	-.016	.016	.000	.008	.97	-.016	.017
Third level education	-.000	.012	.97	-.024	.024	.000	.012	.95	-.023	.025	.000	.012	.98	-.024	.024
Social isolation measure	-.008	.004	.07	-.017	.0008	-.008	.004	.08	-.017	.001	.007	.004	.09	-.017	.001
BMI	.003	.000	.00	.001	.004						.002	.001	.06	-.000	.004
WTHR						.171	.060	.00	.052	.290	.125	.070	.07	-.013	.264

2.5 Discussion

The motivation for this study stems from a desire to better understand the relationship between adiposity and health service use in Ireland. It builds on two previous works that have examined the relationship between adiposity allied service use (Mc Hugh et al., 2014) and also the relationship between alternative measures of adiposity and health service use focusing on certain health services only (Doherty et al., 2014). The analysis in this chapter develops the work of these studies to look in greater detail at the role that gender plays across the different adiposity measures in examining healthcare utilization and also to extend the analysis to examine individual services used under the umbrella of allied services. From this analysis there are a number of findings that warrant comment however in the interest of brevity the discussion will focus on the findings pertaining to the use of allied services according to different measures of adiposity, whilst also discussing how the findings for allied services and outpatient services vary according to gender status.

One of the key findings is that when examining the role of obesity in service use, not only is the measure of adiposity important, so too is the gender differences that may exist indicating that gender may be an important factor to take into account when examining health service use and subsequent costs. Unlike previous studies, this study does not limit the services explored and examines all services collectively and individually and explores not just alternative measures of adiposity but alternative measures of adiposity which have been identified in the literature as having different thresholds in respect of at risk status. The findings in this study underscore the importance of doing this as the role of alternative measures of adiposity clearly differs between genders.

The analysis that examines each of the services according to gender is attached in appendix two (table 47 to 50 shows GP and outpatient according to males and females and also GP and allied service according to males and females, respectively). From table 47 the bivariate analysis for GP and outpatient service use shows that for males statistically significant positive marginal effects of 0.006 and 0.007 were observed in model one (BMI only) for GP and outpatient service use respectively; 0.409 and 0.544 in model two (WTHR only); and model three which included both BMI and WTHR showed only the WTHR to be a significant predictor of outpatient use with a 0.480 marginal effect for outpatient service use. For females as shown in table 50, focusing on model three (includes both measures of adiposity) the opposite can be seen compared to males in that BMI is a significant predictor of service use for outpatient use with a 0.003 marginal effect on outpatient service use.

As shown in table 8 and as previously alluded to when allied services are examined individually (as opposed to collectively) the use of different models report different findings. For example when allied services are examined collectively in which males and females are examined separately neither measures of adiposity indicate significance in predicting allied service use, whereas as can be seen from table 8 when examined individually different findings are reported. This insignificance of adiposity measures for collective allied service use for both sexes may be an artifact of the relatively crude method used to define allied service. For example it might be the case that there were already few observations for certain services which may have resulted in even fewer observations when partitioning the sample and examining according to gender. Furthermore considering that different modelling approaches for males and females were required when examining [combined] allied services, it might be the case that there are different behavior patterns regarding service use of allied services for males and females and thus individual analysis of each service according to males and females was warranted. Subsequently the findings regarding allied service use from hereon, primarily relate to the analysis which examined each of the five allied services individually according to alternative measures of adiposity and also according to gender (as opposed to a total of all allied services).

Mc Hugh et al reiterated findings from Doherty et al (Doherty et al., 2014) that, in addition to GP and hospital services, overweight and obesity are associated with increased use of allied health services as measured by BMI (Mc Hugh et al., 2014). The findings of this analysis show that obesity as measured by WTHR is also associated with increased use of allied services and furthermore indicates, similar to Doherty et al for outpatient service use, that both BMI and WTHR are significant predictors of allied service use. In addition the study extends the analysis of McHugh to examine each service use individually and finds that in this context the measures of adiposity that predict service use differ not only according to the type of service but also according to gender status. That said when allied services are examined collectively according to gender status, neither measure of adiposity show to be significant in terms of predicting service use. This clearly demonstrates the merit of examining services individually and partitioning the sample based on gender.

As outlined previously the BMI classification system may underestimate or overestimate health risks in certain adults, such as, highly muscular adults, adults who naturally have a very lean body build and adults over 65 years of age. This analysis suggests that along with the potential misclassifications of BMI; assuming the same adiposity measures for males and females may also lead to “misclassifications” in terms of the relationship with service use and ultimately cost. Few studies have examined the impact of obesity on allied health service use. Those studies that have examined this relationship indicate that users of services such as chiropody are likely to be older, be female and have chronic conditions such as diabetes, CVD, obesity, osteoporosis or osteoarthritis (Menz et al., 2008). A recent study examined the utilisation of 13 allied health services provided through Medicare program in Australia and reported that the seven most utilised Medicare allied health services were: podiatry, physiotherapy, dietetics, chiropractic, speech pathology, exercise physiology and diabetes education (Cant and Foster, 2011). According to TILDA Ireland's most utilised allied health services are physiotherapy chiropody, home help and dietetics.

In this analysis, a series of bivariate probit models were estimated. These models have been previously used in the main TILDA patterns and determinants of healthcare utilization report[15]. Table 8 shows that of the analysis that used bivariate modelling, the correlation in the error terms of the bivariate models is positive and statistically significant. Given this positive correlation it is reasonable to infer that there are unobserved characteristics that influence utilization of both GP and allied healthcare services. As previously explained this may be due to the models inability to model preferences or tastes. An intuitive explanation is that this positive correlation suggests that in instances where the models over/under predict GP use they also over/under predict other service use. A failure to model individual preferences or tastes may be one cause of this; those who like health care would be over predicted by both equations and under predicted in both equations for those who don't like it. Or those with a liking for

[15]This report states that with respect to healthcare utilisation the key drivers are poor self-rated health, limitations of daily activity, presence of one and more chronic conditions and entitlement status.. These explanatory variables in the hurdle and bivariate models are consistent with expectations in terms of the signs and significance of estimated marginal effects in the Irish context.

healthcare may use more health services associated with divergent patient health beliefs and help-seeking behavior.

While not the focus of this study, the results of the analysis are consistent with intuition in respect of the relationships between the likelihood of service use and the variables used to explain these. In line with the previously discussed utility maximising model of care and indeed previous work, this research highlights the differential utilisation rates between medical card holders and non-medical card holder indicating that individuals who are sicker, who enjoy better access to services (medcard) or have a higher preference for healthcare (privmed) are more likely to use healthcare services than those who are not. Interestingly in the case of inpatient service use when both sexes are examined those with a medical card were significantly more likely to use inpatient services compared to those without a medical card; whereas in this instance PHI was not a significant predictor of service use. This may be a result of different PHI packages that are on offer with some packages focusing on day to day GP care whilst others focus on hospital care.

Of further interest is that when service use is examined according to gender, PHI is a significant predictor of for example inpatient service use for females and not for males. This may be due to a number of factors, most likely maternity inpatient care or the more likely nature of worried well women compared to men. This might be a function of sample size and a weaker relationship for women who may be managed mostly in primary care. Furthermore given that chronic conditions are likely to affect the demand for health services, it is unsurprising that the results show that those with a number of chronic conditions are more likely to have increased use of the majority of all healthcare services examined in this analysis. In this instance it might be the case that those with established chronic conditions may derive a higher utility from visiting the GP and possibly reducing the risk of developing further complications regarding their health risk, for example diabetic complications. Also, in line with the utility maximising model and the literature (Addis and Mahalik, 2003) is the fact that that men are less likely than women to seek help from primary healthcare professionals; with some literature reporting that men fear that help seeking behaviour will make them appear ‘vulnerable, dependent and weak (Banks and Baker, 2013).

The findings in this chapter show that women are more likely to use the majority of healthcare services then men. Several data sources suggest that women make higher use on average of primary care than men (Hunt et al., 2011). However, surprisingly third level education appears to be a predictor of outpatient service use only with marginal effects of .0410778 when both males and females were included in the analysis. However when these were examined separately third level education attainment was a significant predictor of outpatient service use for females only with marginal effects of .0521142.

A recent study suggests that lonely older adults are likely to turn to physicians for social contact (Gerst-Emerson and Jayawardhana, 2015); thus those who perceive themselves to be lonely or indeed are subconsciously lonely may derive more utility from a GP visit compared to their more socially connected counterparts. In line with research the findings in this study show that those who are socially isolated are also more likely to visit the GP and use allied services perhaps reflecting an independent impact on health of isolation

Studies have shown that the association between obesity and health service use is only partially explained by chronic illness (Raebel et al., 2004, Peytremann-Bridevaux and Santos-Eggimann, 2007) leading to the suggestion that the adverse effects of obesity itself, and not just the demands of chronic illness, may result in increased health service utilisation (Peytremann-Bridevaux and Santos-Eggimann, 2007). Thus how obesity is measured can influence how we assess or quantify this health service utilisation. Indeed, as outlined by (Doherty et al., 2014) the predictive value of different measures of obesity in respect of ill health are important to individuals and healthcare providers. However, as noted by the authors such measures of risk are subject to interpretation by individuals whose knowledge of them will vary and as discussed in chapter two, whose attitude to risk will vary as will a range of other health and non-health related factors that might influence service use.

2.5.1 Applying a gender lens

The study of the factors underlying gender differences in the utilization of health-care services among the elderly is particularly relevant. First, because this population group, whose size is progressively growing, uses these services most frequently; second, because the predominance of women over men increases with age, and health services use tend to be greater among the former. That men and women may have different thresholds for healthy weights has been acknowledged in most dietary guidelines until the mid-1990s when the Department of Health and Human Services (1995), the WHO Consultation on Obesity (1997) and the NHI Expert Panel (1998) substituted the gender-specific criteria with universal ones (Kuczmarski and Flegal, 2000). Concerns have been raised since then about the accuracy of using the same BMI criteria in men and women (Rahman and Berenson, 2010). In this chapter whether or not different adiposity measures predict similar effects of service use for males and females is examined. The results suggest that significant predictors of healthcare use as predicted by alterative adiposity measures vary according to the service that is being examined and also in terms of gender. For example, in the case of dietician service use WTHR is a significant predictor of service use for both males and females whereas for chiropody service use WTHR is a predictor of service use for males and BMI for females. In the case of outpatient service use BMI is a better predictor of service use for females and WTHR for males.

It is often the case that obesity levels are reported to be higher in men than in women and that the rate of increase in obesity tends to be higher among men (Alliance, 2011, Richardson et al., 2008). Again how this is measured is important. Using BMI as an indicator of obesity, a higher proportion of men (38%) compared to women (33%) are obese; however, using waist circumference as an indicator of obesity, a higher proportion of women (56%) have a 'substantially increased' waist circumference than men (48%). (http://tilda.tcd.ie/assets/pdf/Obesity_in_an_Ageing_Society_Report.pdf). It has already been suggested by Doherty et al that the inclusion of either measure on its own may not provide the most complete picture of the association of adiposity with healthcare usage (Doherty et al., 2014).

The findings from this thesis confirm this and goes one step further suggesting that different measures of adiposity may provide diverse findings according to gender and might provide a biased account of the association of adiposity with healthcare usage. For example if this study applied the more commonly used BMI as the *only* measure of adiposity across the gender analysis of service use according to the degree of obesity, the findings would provide an erroneous account of the association of adiposity with healthcare usage for males, considering that BMI in males proved non-significant for certain healthcare service use.

If we use BMI only we underestimate the impact of obesity on service use in males and females in respect of outpatient services, inpatient services, public health nurse services and dietician services. If we use WTHR only we underestimate in the case of males and females in respect of chiropody services and allied services. Using both is clearly important and the importance is particularly marked in respect of males and females where different measures of adiposity impact differently on service use according to gender. For example for outpatient services BMI is a significant predictor of service for females whereas WTHR is a significant predictor of service for males; highlighting the caution that must be taken when examining the relationship between different services according to gender where there runs the risk of underestimating the effect if only one measure is used.

2.5.2 How do the findings relate to existing literature

To the best of the author's knowledge no study has assessed the implications of using different measures of adiposity on allied health service use. However the use of allied services according to BMI has been explored (Mc Hugh et al., 2014) along with the use of GP and Outpatient services according to BMI and WTHR (Doherty et al., 2014). Also the association between body fatness as measured by BMI and various categories of health service use has already been examined using TILDA (Leahy et al., 2014b). Although not the focus of this chapter, this study support those of other studies that there is an association between body fatness and health care utilisation (Bertakis and Azari, 2005, Heithoff et al., 1997, Quesenberry et al., 1998, Raebel et al., 2004, Wolf, 2012). The findings in this chapter also support the findings of (Doherty et al., 2014) in that the combined use of alternative measures of obesity might prove a more beneficial and accurate measure for obesity and related cost of illness studies and furthermore go beyond this to indicate that the role of measures differs across gender.

A study discussed previously – Cornier et al (Cornier et al., 2002) used both BMI and WC to examine the relationship between healthcare costs. In this study, the association between higher WC and increased total health care costs was found to be statistically significant while the association between increased BMI and total health care costs was reported as not statistically significant. These findings are comparable to the findings in this chapter which shows that the relationship between adiposity and service use as well depends on the service examined. Significantly unlike the other study it indicates that it cannot simply be assumed that the relationship is the same across genders depending on the service and the measure of adiposity used.

2.6 Conclusion

Understanding what measures best predict what type of healthcare service use along with whether or not this differs according to gender is central to understanding the relationship between adiposity and healthcare use as well as the accurate prediction of the obesity burden related to healthcare service use. The analysis in this chapter was twofold; firstly whether or not healthcare service use varies according to the adiposity measure used and secondly the extent to which the relationship between the measures of adiposity used varied with respect to gender. The findings suggest that the use of both adiposity measures provides greater insight into the relationship between obesity and use of allied services.

Furthermore the results show that the significance of the measures of adiposity varies for some services according to gender status which suggests that alternative measures should also be explored when examining male and female's service use. For example WTHR is a significant predictor of services for chiropody and outpatient services (examined separately) for males (and not for females) whereas conversely BMI is a significant predictor of services for chiropody and outpatient services (and not for males); similarly for outpatient services,

The analysis in this chapter supports the inclusion of both BMI and WTHR measures of adiposity when examining the impact of obesity on service use according to gender status. Overall the results point to the complementary role played by both measures in predicting service use. The primary finding from this study confirms that of Doherty et al which calls for the combined use of WC and BMI with regards service use of the GP and extends this to allied service use. Furthermore this study underscores the subtle nature of the relationships between adiposity and service use by highlighting the differences between genders and the importance of not assuming the relationship is the same across services. Other analyses assumed the two genders were the same and/or measures of adiposity were the same. As evident from this study – this is not the case, thus importantly the findings of this study suggest that the combined use of WC/WTHR and BMI is warranted in the context of gender analysis.

Accurate adiposity measurement is important when quantifying the economic burden of obesity. However, knowledge regarding the extent of the obesity burden is of little use without knowledge of how to abate or treat the problem. Given the multifaceted nature of obesity, the heterogeneity of treatments including individual differences (that may react different to treatment) knowledge of the value or indeed factors affecting compliance to obesity treatment would prove useful. This would help inform the design of treatments and also enable appropriate and more individually tailored approaches to obesity treatments. The next chapter explores the values that the end users that is those obese individuals place on different aspects of a number of obesity treatments.

3. The preferences and willingness to pay for obesity treatments

3.1 Introduction

Given the prevalence of obesity and its comorbidities, commissioning cost effective weight management services should be prioritised. Developing such services requires insight into the preferences of recipients for service attributes if compliance is to be maximised. The objective of this chapter is, using stated preferences methods to quantify the value that morbidly obese patients place on different attributes of various obesity treatments. Without trying to give a rigorous definition, the term “stated preference methods” refers to a family of techniques which use individual respondents’ statements about their preferences in a set of, in this instance obesity treatment options to estimate utility functions. This is explained further in this chapter, however for the moment, by their nature stated preference methods require purpose-designed surveys that allow the elicitation of data on preferences and pertinent individual characteristics that might influence these.

This chapter details the design, development and administration of a discrete choice experiment (DCE) which was undertaken to explore the preferences of severely obese individuals for obesity treatment. Despite the growing prevalence of obesity surprisingly little is known about the preferences of candidates for obesity treatment for attributes of those treatments. This chapter is divided into six sections, literature review, methods, descriptive results, model results, discussion and finally a summary and conclusion of the DCE. There are also sub sections within each of these sections. For example the literature review is divided into three sections.

3.2 Literature review

The broad aim of the literature review was to complete a pragmatic review of literature pertaining to the development, implementation and evaluation of DCEs. Firstly, this literature review was undertaken to inform the DCE by identifying the key concepts and definitions within the discrete choice framework, in particular addressing methodological issues concerned with DCE's. Secondly, this review sought to inform the study as to what attributes have clinical relevance in the context of the health risks associated with obesity and also the extent to which obesity treatment might alter these health risks for each individual. An understanding of this was important so as to ensure that when designing the DCE the choices presented to respondents were medically relevant and plausible. Finally, this review sought to assess the gap that exists in the literature regarding the severely obese patient preferences and their willingness to pay (WTP) for obesity treatment.

Ensuing from the above this review is divided into three sections whereby;

1. Section 1 reviews DCE as an approach in terms of the theoretical framework, experimental design and appropriate modelling approaches;
2. Section 2 identifies valid attributes of obesity treatments that impact on health risk for those who are severely obese. (Although final choice of attributes was also informed following focus groups, the literature provided the necessary information so as to ensure all valid attributes were explored);
3. Section 3 examines, which if any studies have applied the DCE approach to examine obesity related issues

Search strategy

The search for the literature was carried out in a pragmatic way using PubMed, Science Direct and the Cochrane Library. The latter provided access to systematic reviews internationally recognised as "*the highest standard in evidence-based health care*" (Cipriani et al., 2011). Further databases such as Embase and Scopus were used for the search; however it was found that these searches repeated the findings of those used in the former mentioned databases, thus those former mentioned databases were primarily used for this review.

In addressing the three previously outlined objectives the search essentially involved three stages. The first part of the literature search included the search terms "discrete choice experiment" OR "discrete choice modelling" OR "discrete choice experiment health" OR "discrete choice experimental design "OR "contingent valuation" OR "willingness to pay" OR "stated preferences" OR "patient preferences". For this search studies were included if they were related to DCE experimental design, methodology or theory, if they were based on choice-based response data (as opposed to rating or ranking exercises) and if they were written in English. Studies were excluded based on their title. Considering that the DCE theoretical framework dates back to the nineteen sixties, all studies relating to theoretical framework and guidance as to how to undertake a DCE since this period were included for this part of the literature review that is since 1960.

This search was not limited to the health literature and included DCE experimental design, methodology and theory from the environmental literature. This was so as to ensure to capture all of the DCE design and methodology literature. The retrieved publications were then reviewed with respect to their background details and classified according to the specific topic areas covered by DCEs; namely DCE theoretical framework, DCE experimental design and DCE modelling.

The second part of the literature examination included search terms were “obesity” OR “severely obese” OR “severe obesity” OR “obesity treatment” “health risk obesity” OR “comorbidities obesity”. Finally the third part of the literature examination included search terms such as “preferences severely obese” OR “stated preferences obesity” OR “discrete choice obesity” OR “obesity treatment preferences” OR “Irish discrete choice” OR “discrete choice experiment Irish”.

Search approaches used in the search of the grey literature involved the utilisation of “Advanced Search” interfaces where available to include synonyms and the application of limits as stated elsewhere, where possible. Bibliographic searching was supplemented by reviewing references from identified key articles and by Internet searching of relevant web sites.

3.2.1 Section 1: Foundations of Discrete Choice Experiments

3.2.1.1 Introduction

The value of many goods and services provided to society can be difficult to quantify because there are no conventional markets on which they are traded, for example enviromental or many healthcare services. In order to value such non-market goods, many governments and organisations elicit individuals’ revealed or stated preferences in relation to those goods (Dolan and Metcalfe, 2007). Two broad paradigms of choice data exist known as revealed preference (RP) and stated preference (SP) data. Within these paradigms there are notable differences between the two whereby distinct methods of valuation exist for each approach. For example SP approaches include: discrete choice experiment, contingent valuation, conjoint analysis, and the contingent choice methods. RP approaches include: market price methods, productivity methods, hedonic pricing methods, travel cost methods, substitute cost methods, replacement cost methods, and damage cost avoidance methods (Carson and Bergstrom, 2003).

3.2.1.2 Revealed Preferences (RP)

RP methods uncover estimates of the value of non-market goods by using evidence of how people behave in the face of real choices. In other words, these models assume that the preferences of consumers can be revealed by their purchasing or behavioural habits (e.g. travel cost). The two most common RP methods are hedonic pricing method and the travel cost method. Hedonic pricing method involves examining people‘s purchasing decisions in markets related to the non-market good in question (Boardman, 2010). This has most commonly been applied using data from housing and labour markets (Osland, 2013). The travel cost method involves observing costs incurred in the consumption of the non-market good in question. The travel cost method has most predominantly been used to estimate the value of recreational sites (e.g. a river, a park, or a beach) (Brown Jr and Mendelsohn, 1984).

3.2.1.3 Stated Preference (SP)

SP refers to situations where choices are observed in hypothetical situations (Jaeger and Rose, 2008). According to Louviere and Street (2000) there are two main reasons for using stated rather than revealed preferences in health economics (Louviere and Street, 2000). Firstly, it may be necessary to approximate the demand for a new product that does not yet exist for example a hospital provider opening a new hospital in a new location. Secondly, it may be that the good or its surrogates may not be traded in real markets. Especially in the healthcare sector economists frequently have to deal not just with a lack of market prices but the absence of traded goods through which estimates of value might be inferred. For instance, in cases of mandatory social health insurance the contribution rate is usually exogenous and does not reflect an individual's preference.

SP methods use specially constructed questionnaires to elicit preferences and estimates of the WTP for or willingness to accept (WTA) a particular hypothetical outcome in a hypothetical situation using hypothetical scenarios (Carson et al., 2014). The WTP or WTA is a measure of how much the respondent values the intervention. Following Hicks (Hicks, 1943), one can use either the concept of compensating variation or the concept of equivalent variation measures of consumer surplus to estimate the value to the individual of an increment or decrement to utlity associated with a good. The difference between WTA and WTP for the same good or service has been widely studied through both theory and experiments (Horowitz and McConnell, 2002).

Compensating variation measures the amount of money that is required after the change to make a respondent's level of utility the same as before the change, while equivalent variation measures the amount of money that is required before the change, to make utility the same as it would be after the change – in essence they differ that is, in terms of the reference point for utility. Within both these concepts, a distinction can be made between WTA (when compensation is required) and WTP (when a payment is required). WTP is the maximum amount of money an individual is willing to give up to receive a good. WTA is the minimum amount of money that an individual would need to be compensated for foregoing a good.

The SP method includes a number of approaches such as contingent valuation method (CV) and DCE. The CV method involves constructing and presenting a hypothetical market to a respondent, detailing the description of a good or service, how it will be provided, and the method and frequency of payment. Following this, questions are posed, the responses to which allow the researcher to estimate the respondent‘s WTP or WTA, with a view of establishing an estimate of the average WTP/WTA across the sample of people surveyed. If the sample is representative of the target population, then this estimate can be aggregated to obtain an estimate of the total value of the outcome or good (Boardman, 2010).

DCE’s are a method for eliciting preferences in a manner that allows a quantitative analysis of responses and the estimation of values and is an appropriate framework to analyse individuals’ stated behaviour in response to a broad range of hypothetical choices (Train, 2009). Information is provided on whether the attributes, which are the characteristics of the treatment/intervention in question are important (statistically significant), the direction of importance (sign of the estimated parameter), and relative importance (size of the estimated parameter). The use of cost as one of the attributes "traded/varied" permits the researcher under a number of assumptions to infer in monetary terms the value of increments or decrements to the level of other attributes. More recently DCE’s have gained popularity in health economics ((Ryan et al., 2001a, Ryan and Gerard, 2003, Ryan et al., 2008, Ryan et al., 2012), including in contexts related to priority-setting (Bryan et al., 2002, Johnston et al., 2005, Tappenden et al., 2007, Baltussen and Niessen, 2006, Baltussen et al., 2010, Youngkong et al., 2010).

3.2.1.4 Theoretical framework of DCE

Originating in mathematical psychology, DCE’s were pioneered in marketing (Louviere and Woodworth, 1983) and have become very popular in transportation and environmental economics (Adamowicz and Boxall, 2001, Boxall et al., 1996). Since the first application in health economics, (Propper, 1995) the number of studies using DCE’s has grown rapidly

(Clark et al., 2014, de Bekker-Grob et al., 2012). The DCE method has its theoretical grounding in Lancaster's model of consumer choice (Lancaster, 1966) and its econometric basis in random utility theory (RUT) (McFadden, 1974).

3.2.1.4.1 Random utility theory (RUT)

An important concept for discrete choice modelling is the random utility theory (RUT) developed by McFadden (1974). The RUT is the theoretical basis for integrating behaviour with economic valuation in the DCE method. According to RUT, individuals hold some construct of (indirect) "utilities" for choice alternatives. The idea behind RUT is that is that part of an individual's utility for an alternative is hidden (or latent); thus researchers cannot observe all factors affecting individuals preferences. Therfore as shown below in equation 1, the latent utility of alternative *i* in a choice set C_n (as percieved by individual *n*) is considered to be decompasable into two separable parts: a systematic (explainable) component (V_{in}) and a random unexplainable component (ε_{in}), representing unmeasured variation in preferences. This error component implies that predictions cannot be made with certainty.

$$\mathbf{U}_{ij} = \mathbf{V}_{in} + \boldsymbol{\varepsilon}_{in} \quad \text{(Eq. 1)}$$

In simple terms the notion is that one cannot measure utility (predict choices) exactly because, for example, one may not be able to observe or measure every characteristic of the individual, product, or choice situation that affects choice behaviour. However, if one can observe sufficient information about the individual, the product, or the choice situation, one can use that information to help predict choice. The systematic component shown in equation 2 below is at least a function of attributes of the goods/services, where the characteristics of individuals are included.

$$V_{in} = X_{in}\,\beta + Z_n\,\gamma \quad \text{(Eq. 2)}$$

X_{in} represents the vector of attributes, such as the cost or quality of alternative *i* as viewed by individual *n* and Z_n is a vector of characteristics of individual *n*, and β and ϒ are vectors of coefficients to be estimated. The basic assumption is that individual *n* will choose alternative *i* if and only if that alternative maximises his/her utility amongst all *j* alternatives included in the choice set C_n.

Thus, from equation 1, alternative *i* is chosen if and only if

$$(V_{in} + \varepsilon_{in}) > (V_{jn} + \varepsilon_{jn}) \;\; \forall\, j \neq i \,\text{ḥ}\, C_n \quad \text{(Eq. 3)}$$

Rearranging to place the observable and unobservable components together yields

$$(V_{in} - V_{jn}) > (\varepsilon_{in} - \varepsilon_{jn}) \;\; \forall\, j \neq i \,\text{ḥ}\, C_n \quad \text{(Eq. 4)}$$

As previously noted, the researcher does not observe (ε_{in}-ε_{in}), and consequently cannot determine exactly if (V_{in}-V_{jn}) > (ε_{in}-ε_{in}). Therefore, choice outcomes can only be determined up to the analysis of the probability choosing one alterative over another. Indeed, this is the key difference between random utility theory and classical consumer theory; that is that the former assumes that individual choice behaviour is intrinsically probabilistic rather than deterministic.

Thus, as the actual distribution of (ε_{in}-ε_{in}) across the population is not known, for the analysis it is assumed that it relates to a certain distribution. Together with the type of choice modelled the latter distribution will determine the specific econometric model form for the choice probability. If the choice faced by respondents is dichotomous or includes only two alternatives then a binary probit or logit model are suitable. When three or more alternative choice options are available to the individual, the multinomial logit model (MNL) is the most commonly used specification. Some of the appropriate models in discrete choice modelling are discussed in the next section.

3.2.1.5 Discrete choice modelling

Economists have developed sophisticated econometric techniques for analysing DCE's and within this context several comprehensive reviews were consulted to inform the analysis of this DCE (Blamey et al., 2000, Louviere and Lancsar, 2009, Louviere et al., 2011, Scarpa and Rose, 2008, de Bekker-Grob et al., 2012, Ryan and Farrar, 2000, Ryan and Gerard, 2003, Ryan et al., 2001b, Bliemer and Rose, 2006, Bliemer and Rose, 2010, Lancsar and Louviere, 2008b, Lancsar and Louviere, 2008a, McIntosh, 2006b, Hensher et al., 2005, Street and Burgess, 2007, Reed Johnson et al., 2013, Mangham et al., 2009) and its application in health research (Guttmann et al., 2009, de Bekker-Grob et al., 2012, Ryan, 2004, Ryan and Farrar, 2000, Ryan and Gerard, 2003, Ryan et al., 2001b).

Discrete choice modelling literature has developed over the past number of years in which a number of econometrically advanced models able to uncover an increasing degree of behavioural aspects have been developed, typified by the progression from conditional logit, latent class and also mixed logit models (RPL model) of which are summarised below. This section draws on (Hensher and Greene, 2003) to describe the models (conditional logit, random parameter logit and latent class models) that will be used in this study to analyse the choices made by respondents from the DCE survey and subsequently estimate economic values (WTP) of the functional obesity treatment attributes.

3.2.1.5.1 Conditional logit (CL)

The conditional logit model (also termed the multinomial model in the literature) is one of the most widely used discrete choice models (Heiss, 2002) and is well grounded in probability theory (McFadden, 1974). The reason for the popularity of the MNL is that it has a number of convenient properties including ease of estimation, a closed form specification without requiring complex integration and generally good statistical performance of the model (Louviere et al., 2000).

The CL model is underpinned by the `Independently and Identically Distributed' (IID) condition of error terms. Louviere et al. (2000) note that IID implies that the associated variances of the unobserved components of a random utility expression describing each alternative in a choice set are identical (identically distributed). Further, these unobserved effects are uncorrelated between all alternative pairs (independent). In other words, each alternative has its own unobservable component which is represented by an unknown distribution. Under this assumption the choice probability takes the following form:

$$P_{ij} = \frac{\exp(V(Z_{ij}))}{\sum_{h=1}^{C} \exp(V(Z_{ih}))} \qquad \text{(Eq. 5)}$$

where the conditional indirect utility function generally estimated is:

$U_{ij} = \beta + \beta_1 Z_1 + \beta_2 Z_2 + \ldots . \beta_n Z_n$ (Eq. 6)

Where β is the alternative specific constant (ASC) which captures the effects on utility of any attributes not included in the obesity treatment programme attributes, which represents the 'status quo' in this DCE study, *n* is the number of obesity treatment programme attributes considered, and the vectors of parameters β_1 to βn are attached to the vector of attributes (Z). The model can be easily extended such that a range of additional regressors are included to characterise socio-demographic characteristics that might explains variations in choices between individuals.

The CL has become the workhorse amongst probability models when analysing DCE data (Long and Freese, 2006). The CL is often the starting point for the discrete choice analysis to ensure the analysis produces sensible results before estimating more complex models. However it is important to understand how the simplicity and convenience of the CL comes at the cost of flexibility in handling preference heterogeneity and maintaining forecast accuracy.

Three topics elucidate the power of logit models to represent choice behaviour, as well as delineating the limits to that power; taste variation, substitution patterns and repeated choices over time, (Train, 1998).

1) The CL can represent systematic taste variation, which means taste variation that relates to the observed characteristics of the respondent or decision maker. However the limitation of the CL model is that it cannot represent random taste variation, that is, differences in tastes that cannot be linked to observed characteristics. For example, it is

possible to interact socio-demographic information with the parameters so that its value varies with demographics, however, if two people have the same demographic information (e.g. education and income), then the CL model assumes they have the same tastes.

The CL model implies proportional substitution across alternatives, that is, the relative odds between any two outcomes are independent of the number and nature of other outcomes being simultaneously considered. The CL assumes the random, individual specific unobserved utility (error) terms to be independently distributed, each with an extreme value type 1 distribution (EV1): this is well known in the literature as the identically and independently distributed (IID) assumption (Hensher et al., 2005). It carries an associated behavioural implication, known as independence from irrelevant alternatives (IIA). The IIA is where the scale values used to estimate individuals (n) value only calculates the value for the attributes and individual characteristics that make up the alternative. That is, the value for two alternatives is unaffected by other attributes within other alternatives. McFadden (1986, p. 280) describes the IIA as both: "*a blessing and a curse*", demonstrating that despite its practical advantages there is a number of limitations with the underlying property

The IIA is in fact the most criticised component of the CL model within the literature. Violating the IIA may lead a model to incorrectly predict the probability of alternatives being chosen and can also affect the WTP measures which can lead to problems in the reliability of model results (Hess et al., 2012, Hess and Hensher, 2010). For example in the context of this study, it is possible that the CL model could overestimate the probability of choosing a particular obesity treatment, while at the same time underestimating the probability of choosing another obesity treatment. Indeed a number of tests of the IIA exist. This thesis used the Hausman and McFadden test.

2) In DCE's the researcher observes the sequence of choices by each respondent. Data that represent repeated choices like these are called "panel data". The CL model can capture the dynamics of repeated choice, if unobserved components are independent over time in repeated choice situations (panel data). However, the CL model cannot handle situations where unobserved components are correlated over time (Train, 1998) (since the unobserved factors are assumed to be unrelated over choice). In other words the model does not account for the panel nature of most DCEs, therefore, it cannot capture correlation between unobserved factors for any one respondent over the series of choice situations (Train, 2003). This is important for panel like data, as correlations are expected to exist between the choice situations presented to an individual (Hensher et al., 2005).

3.2.1.5.2 Mixed logit model

A popular alternative to the CL model in recent years is the mixed logit (ML) model. The "random parameter logit" model (RPL) forms part of a generalised modelling framework known as the mixed logit model. This model takes into account the panel nature of the data by using simulated maximum likelihood estimation to allow parameters to be estimated over a distribution (Train, 2003). In the RPL model, each β is treated as a random parameter and is permitted to vary across the sampled individuals. This contrasts with the CL model, in which the βs' are fixed (non-random) parameters, and as such are not allowed to vary across respondents individuals. In other words, one can specify the model in a way that each choice alternative can be correlated for each respondent (Hensher & Greene, 2001).

The RPL model takes the CL model as a basis and simplifies it by allowing the coefficients of systematic variables to vary across the individuals. This is done through the division of unobservable component of the utility function into two: one which is correlated over alternatives and the second part is identically and independently distributed, as it is given by:

$$U_{ij} = \beta X_{ij} + \eta_i X_{ij} + \varepsilon_{ij} \quad \text{(Eq. 7)}$$

Where, X_{ij} is a vector of observed attributes of alternative within a choice set, β is the vector of coefficients of these attributes, η_η denotes the vector of k standard deviation parameters and, $\boldsymbol{\varepsilon_{ij}}$ -random portion of utility. Thus, $\eta_i X_{ij} + \varepsilon_{ij}$ is the unobserved portion of utility because of the influence of η_η, which is correlated across individuals (Train, 1998). The probability of individual *i*, choosing alternative j in a choice situation t, is expressed as following:

$$P(j|\mu_i) = \frac{\exp(\alpha_{ji} + \gamma_j z_i + \eta_i x_{ji})}{\sum_{j=1}^{J} \exp(\alpha_{ji} + \gamma_j z_i + \eta_i x_{ji})} \quad \text{(Eq. 8)}$$

Where, α_{ji} is a fixed or random alternative specific constant for i individuals and j alternatives (j=1,…,J), $\gamma_j z_i$ is a vector of systematic parameters responsible for individuals characteristics, η_{ji} denotes a parameter vector which is randomly distributed over individuals, z accounts for individual-specific characteristics, x_{ji} is the vector of attributes and is μ_{ji}

the individual specific random disturbance of unobserved heterogeneity (Louviere et al., 2000a; Train, 1998). However, in order to estimate RPL model it is necessary to assume how the coefficients are distributed over the individuals (Train, 1997).

The main departure of the RPL model from the basic CL models is the fact that beta parameters (individuals preferences) are allowed to vary across the population rather than remaining fixed (an assumption which leads to preference homogeneity). In other words the RPL model allows preference parameters in deterministic utility to be estimated over continuous distributions, representing preference heterogeneity over the population whereby the taste distributions involve both mean and variance estimates (Train, 1998).

Here, β_k represents the sample mean preference weight for each attribute k, and k σis the standard deviation of the preference weights (β_{ik}) across the sampled individuals (i.e. around the mean β_k). The w_{ik} represent the unobserved individual-specific heterogeneity in the preference weights (Greene, 2003). As mentioned, the specification of the RPL model is the same as the CL model except that the β varies over the decision-maker rather than being fixed parameters (Hensher et al., 2005). It is necessary to specify the distribution for the βs. The selection of the distribution of the random parameters across the population is probably one of the most hotly debated areas in the application of RPL specifications. This is because the choice of the most appropriate distribution function for random parameters will always depend on the particular study requirements and objectives. Within this context it was necessary to review this literature so as to inform this DCE with regards appropriate RPL specifications, as discussed in the next section.

3.2.1.5.3 Latent class model

Another debate in the literature relates to whether unobserved taste heterogeneity is more suitably accommodated through a continuous (e.g. RPL model) or finite distribution such as that used in a Latent Class model. This debate has resulted in a number of studies comparing the two (Greene, 2003, Hynes et al., 2008, Provencher and Bishop, 2004, Scarpa and Rose, 2008). The decision on whether to use RPL or a LC model depends on the analyst's choice because there is little or no empirical evidence to support one over the other (Provencher and Bishop, 2004, Provencher and Moore, 2006). In the context of obesity, latent class analysis has been used to examine latent subgroups regarding weight loss strategies used among women (Lanza et al., 2010), parenting characteristics associated with children's BMI (Berge et al., 2010), and maternal pregnancy weight status associated with Attention Deficit Hyperactivity Disorder symptoms in their offspring (Rodriguez et al., 2008). These study results have demonstrated that LCA is an effective and valid approach in categorizing individuals with similar preferences.

The latent class (LC) model is applied in this study to examine the sources of heterogeneity in preferences across classes of respondents. The basic approach for the LC model estimation is to repeatedly estimate the model for different numbers of preference classes. Fit criteria (discussed below) can be used to identify the number of classes that best fits the data. Unlike the RPL model which specifies the random parameters to follow a continuous distribution, the latent class model assumes that preferences can be captured by a discrete number of classes, based on a non-parametric distribution.

Following (Greene and Hensher, 2007), suppose β takes C possible values labelled β1 … ; βc with probability $prob_c$ in this case the mixed logit becomes the LC model. The choice probability is:

$$Prob_{ni} = \sum_{c=1}^{C} prob_c \left(\frac{exp(\beta_c' x_{ni})}{\sum_j exp(\beta_c' x_{nj})} \right)$$

[Eq. 9]

The expected probability of alternative *i* being chosen is the expected value (over classes) of the class specific probabilities. The share in the population in class (c) is $prob_c$ which can be estimated in the model along with the β's for each class. In this study the latent class model is specified in order to account for the panel nature of the DC experiment whereby it simultaneously estimates the probability of class membership, the relationship between this and a range of explanatory variables and the number of classes.

In the LC model members of each class have similar tastes. However, the classes are latent, i.e. they are not observable by the analyst rather there exists a probability of membership that can be estimated. The researcher can specify how many classes they wish to estimate. Though no specific guidance is given on the criterion as to how many classes to estimate, (Swait and Adamowicz, 2001) emphasize the importance of considering other factors when selecting an optimal number of latent segments. For example, the number of classes influences the significance of parameters. Classes with low membership probabilities tend to have less significant parameters as the number of segments increase. Therefore, the number of segments or classes to estimate is one of the crucial factors that should be addressed in the LC (Swait and Adamowicz, 2001). Usually analysts (e.g. (Boxall and Adamowicz, 2002) (Haener et al., 2001) use statistical information criteria values such as Akaike Information Criteria (AIC), Bayesian Information

Criteria (BIC) which penalise for additional parameters to determine the number of classes. The reason for this is log-likelihood is not valid for LC model. Other factors including judgement, the objectives of the study, the significance of parameters, should also be used to determine the number of classes to estimate (Garrod et al., 2012, Scarpa and Thiene, 2005).

Finally, the log-likelihood (LL) statistic is an indicator of how much unexplained information there is in the data after the model has been fitted (Field, 2009). Larger values of LL indicate more unexplained observations. The Akaike and Bayesian Information Criteria (AIC and BIC) are two additional measures which can be used to compare models with different numbers of parameters. The AIC is a relative measure of improvement in LL with respect to an increase in the number of parameters estimated. AIC = (-2LL + 2k)/n, where k = is the number of parameters and n is the sample size. BIC = (-2LL +k*ln(n))/2. The BIC is scaled so that it favours models with a large log likelihood, few parameters, and smaller sample sizes (i.e., the penalty for model complexity increases as the sample size increases) (Tofighi and Enders, 2008). Lower AIC and BIC scores are preferred. This study used each of these criteria to assess model fit along with the McFadden's R^2 value. In the RPL model, this is similar to the R^2 in conventional analysis except that significance occurs at lower levels. According to (Hensher et al., 2005) values of R^2 between 0.2 and 0.4 are considered to be extremely good fits.

3.2.1.6. Background to willingness to pay calculations

The rationale underlying the WTP approach is derived from demand theory, in which the calculated ratios are known as the marginal rate of substitution (MRS). According to Bateman et al. (2002) the choice experiment method is compatible with utility maximization and demand theory. The marginal willingness to pay for an attribute in the choice experiment is the ratio of that attribute coefficient and payment attribute coefficient (Morrison et al., 1999).

The WTP therefore quantifies the trade-off between two attributes and thus their relative importance in the determination of overall utility. When the trade-off is made with respect to the cost of a good or a service to the respondent, the MRS is called the marginal willingness-to-pay (WTP). In this way, the marginal WTP for an attribute measures the change in cost to the respondent that compensates a change in the attribute level, while all other attributes are held constant.

The WTP describes the maximum amount of money that consumers are willing to pay (must give up) in order to get an additional improvement in an attribute (Bennett and Adamowicz, 2001) such that their utility is left unchanged. Therefore the aim of the WTP method is to ascertain the maximum amount of money that a patient would be willing to pay, hypothetically, to receive/consume the commodity/service. This represents a monetary valuation for the change in utility that the consumers experience when they consume/receive the commodity/service. Thus WTP represents the 'value' of the commodity or service (Donaldson, 2001). It has been suggested in the literature that the most relevant outcome of discrete choice models is the derivation of consumers' monetary valuation of the attributes that characterize the alternatives among which they choose (Train and Weeks, 2005). In the context of health economics WTP measures can inform policy makers by providing information about how much people value some goods or services and can thus inform the pricing of these goods or services (Hanley et al., 2003).

It is relevant to note that there are a number of issues surrounding WTP estimations. Methods for measuring WTP can be affected by bias resulting from unpredictable over- or under-estimation. In stated preference valuation surveys, hypothetical bias can be defined as the difference between what a person indicates they would pay in the survey or interview and what a person would actually pay. There is the suspicion that individuals overstate their valuation of a good or service, whereby estimated hypothetical WTP is generally higher than actual WTP for real goods, thus, providing evidence for the existence of ‘hypothetical bias’ (Moser et al., 2014). According to the literature, there is the argument that the stated WTP includes elements of ‘purchase of moral satisfaction’ or ‘warm glow’ which is not related to the particular good (Kahneman and Knetsch, 1992, Kahneman et al., 1993). A recent study (Blumenschein et al., 2008) provides a review of the methods developed to tackle hypothetical bias in CV methods. These methods are also applicable in DCEs (Hensher, 2010) and were applied in this DCE.

Such methods include what is referred to as a ‘cheap talk script’ which basically involves an explicit discussion about hypothetical bias to the respondent. Respondents are told what hypothetical bias is, that it is a common problem in hypothetical valuation questions, and why it might occur and are essentially asked to refrain from it. In this DCE, respondents were presented with a cheap talk script prior to answering questions. According to some studies cheap talk has the ability to reduce WTP in hypothetical markets to levels similar to actual payments (Murphy et al., 2005a, Murphy et al., 2005b). Another approach to mitigating hypothetical bias is based on 'respondent certainty' about WTP, in which follow up questions can be asked after the choice cards to assess respondents' certainty of answers regarding WTP.

Despite all of the empirical work on hypothetical bias, there is still no widely accepted theory of hypothetical bias in stated preference surveys (Murphy et al., 2005a) "The underlying causes of hypothetical bias are not yet sufficiently understood, and the theoretical or systematic explanation remains as one of the major questions in the stated preference economic analysis"(Mitani and Flores, 2010). However responding to WTP questions is a hypothetical instance; one does not know what the respondent would pay in a real situation. In fact, respondents, in reality, might not know what they would be willing to pay for the product/service themselves in a real situation.

3.2.2 Section 2: Medical literature

3.2.2.1 Introduction

A review of the medical literature was undertaken to inform the design of the DCE in terms of defining the characteristics of obesity and obesity treatment. That said, this review served only as guidance for informing the medical aspects of this DCE; a team of medical experts (endocrinologists, dietician, diabetes nurse and public health nurse) who were familiar with the management and treatment of severely obese individuals were also consulted and subsequently also informed this study from a medical perspective. This section of the literature review sought to (i) determine the impact of excess body weight on health (ii) establish what health outcomes are associated with weight loss in individuals who are obese and severely obese and finally (iii) describe the approaches that exist to treat obesity and severe obesity and within this to establish, where possible, what impact each of these approaches have on the degree and duration of weight loss.

There were challenges in quantifying the scientific medical evidence regarding obesity treatment efficacy. As discussed below a number of studies that examined the relationship between increased BMI and health risk, for example CVD risk was identified. However the quantity (and quality) of studies that examined the inverse relationship, that is the effect of a reduced BMI on health risks is somewhat less. Other issues relate to the fact that some observational studies were not specifically designed to test the hypothesis that weight loss increases or decreases relative risk of severity and mortality. Further, some studies were unclear as to the method by which the weight loss was achieved. Therefore it can be difficult to ascertain precise information regarding obesity treatment effects. This review focused mainly on randomized control trials (RCTs) which provide the highest quality of evidence available regarding the association between weight loss and subsequent severity and mortality. A number of national guideline reports regarding obesity treatment were also consulted.

3.2.2.2 Health risks associated with severe obesity in adults

Chapter one has previously outlined the health risks associated with obesity some of which include hypertension, dyslipidaemia, type 2 diabetes mellitus, coronary heart disease (CHD), stroke, gallbladder disease, osteoarthritis, sleep apnoea and respiratory problems, and some cancers (Jensen et al., 2014). Furthermore earlier studies have outlined that it is the severely obese who suffer the most disability (Martin et al., 1995). In addition, fertility can be negatively affected by obesity. In women, early onset of obesity favours the development of menses irregularities, chronic oligo-anovulation and infertility in the adult age (Brannian, 2011). Those with severe obesity have far more serious health consequences than moderate obesity (Sturm and Hattori, 2012).

Sturm and Hattori (2012) reported that severe obese individuals who are 45–90 kg (7-14 stone) or more overweight have on average far more complex health issues and encounter very different challenges in the health care system than the majority of moderately obese individuals (BMI 30–35) (Sturm and Hattori, 2012). Other studies report a higher comorbidity prevalence in the severely obese population (Schauer et al., 2003, Sjöström et al., 2012, Sjöström et al., 1999); higher health risks within subgroups of the population including women (Colditz et al., 1995, Durazo-Arvizu et al., 1998, Huang et al., 1998, Manson et al., 2001) and children (Kelly et al., 2013); the health related quality of life amongst children with severe obesity is severely diminished (Schwimmer et al., 2003); also psychological aspects of severe obesity can negatively impact on individuals (Stunkard and Wadden, 1992, Dixon et al., 2003).

Studies have also outlined the increased risk of severity and mortality associated with severe obesity. For example, using data from the third National Health and Nutrition Examination Survey in the USA it is estimated that the years of life lost for white men aged 20 to 30 years with a severe level of obesity (BMI >45) is 13 years (Fontaine et al., 2003).

Another concern regarding risk is how to communicate risk to survey respondents. Often in DCE's risk is included as an attribute, for example a DCE might reference 'risk of fatal heart attack' as an attribute or a particular type of treatment. In an earlier review (Ryan and Gerard, 2003) noted the difficulties individuals have understanding risk, and commented on health economists giving little consideration to explaining the risk attribute to respondents. There is substantive literature that describes and evaluates different tools for effective communication and elicitation of risk in DCE's (Seston et al., 2007, Fischhoff et al., 2011, Klein and Stefanek, 2007, Brust-Renck et al., 2013, James, 2012, Lin and Milon, 1995, Lau et al., 2012, Loomis and DuVair, 1993, Lloyd, 2001, Leikas et al., 2007, Waters et al., 2006, Nguyen et al., 2009, Schapira et al., 2001, Johnson et al., 2006, Dohmen et al., 2011, Telser and Zweifel, 2002, Slovic, 1987, Slovic, 2000, Harrison et al., 2014, Fischhoff et al., 1993, Gigerenzer and Edwards, 2003, Grisolia et al., 2012, Bennett, 1999, Telser and Zweifel, 2007).

Many alternative representations of risk have been developed in the literature, including representing risk changes in percentage terms, absolute terms and via visual presentations such as grids, charts and ladders (Brust-Renck et al., 2013, Ancker et al., 2006, Schapira et al., 2001). A recent systematic review that examined risk as an attribute in DCE's (Harrison et al., 2014) alluded to earlier studies that outlined the fact that the communication of risks and probabilities and the distinction between risks is problematic (Kahneman and Tversky, 1973). According to Harrison (2014) there is little available evidence to indicate that a consistent approach to communicating/framing risk information has been used in DCE studies (Harrison et al., 2014). However this study did find evidence supporting more sophisticated methods of presenting risk information through the use of graphical or pictorial images, the use of icon arrays and risk ladders (Harrison et al., 2014).

Absolute values (i.e., numbers), relative values (i.e., percentage changes), and visual aids are some of the methods that have been used to convey risk within DCE's. The use of absolute numbers (e.g., a change from 1 in 5000 to 1 in 10000) provides a baseline risk level, as well as an indication of the scale of change, in contrast to the same information being expressed simply as a 50% reduction in risk. Absolute values have been used in various studies investigating consumers' valuations of risk reductions (Baker et al., 1998, Machado and Mourato, 2002, Cowan and Cowan, 2000). A more recent study examined consumers' valuations of foodborne risk reductions in a DCE in which the risk reductions were presented in terms of percentages (i.e., 0%, 40%, 80%) from an unspecified baseline level (Goldberg and Roosen, 2007).

Visual aids are also used to convey risks to respondents. For example, an earlier study used photographic representation of different defects on apples when eliciting consumers' WTP for food safety (Baker, 1999). A later study used risk grids to elicit Canadians' WTP for mortality risk reductions (Krupnick et al., 2002). In their study they showed respondents two different risk grids composed of 1000 squares, each square representing the chance of death. White squares denote chances of surviving, and red squares represent chances of dying. Reductions in the risk of dying are represented by changing coloured squares (red to blue). They then asked people a set of questions to familiarise them with the probability concept. They asked people which one of the persons shown in the two grids was most likely to die in the given time period. After familiarising people with the risk concept and reduction in risks, they asked people how much they were willing to pay for a certain amount of reduction in the occurrence of risk.

Indeed, there is an increasing interest in the literature with regards the effect of different risk presentations on choice behaviour. An earlier study (Gottlieb et al., 2007) considered probabilities presented via five methods: percentages, numbers, risk grids and simultaneous risk cards. The study used low-risk and low probability, and high-risk, low-probability information to investigate individuals' responses to risks. Using a logistic regression analysis, they found that presentation format, problem type, and version of the problem (low or high probability) had a significant effect on individuals' choices. More specifically, the authors found that uncertainty information was processed differently when it was presented in a percentage format than when it was presented in other formats. They indicated that absolute numbers was processed more similarly to information extracted from experiences than to probability information (i.e., percentages).

The authors indicated that the reason why percentages differed from absolute numbers and experienced information was the fact that percentages are unit-less, and contain no information about the number of times an event occurred. In this regard, a study in the same year indicated that risk reductions given in terms of probabilities may give a positive signal to consumers regarding the safety of products in question (Leikas et al., 2007). Whereas, risks given in terms of absolute numbers may be perceived as a negative information and as a result such information may affect consumers' risk valuations.

In summation recommendations as to what the best method to convey risk vary in the literature. Some studies have found that people interpret percentages better than absolute values (Sheridan et al., 2003, Waters et al., 2006), whereas others found the opposite (Gigerenzer and Edwards, 2003). Regardless of the advantages and disadvantages of each format - people have different levels of familiarity and understanding of risk and therefore understanding the impacts of these alternative risk formats on respondents' choice behaviour and the associated valuations of risk reductions is important.

3.2.2.3 Benefits of weight loss

Although weight gain has been demonstrated to increase health risks in adult populations, it does not necessarily follow that weight loss can reverse these impacts (Lau et al., 2007). Weight loss is associated with improvement of risk factors for disease (Vidal, 2002) although the literature shows mixed reports of the exact benefits. There are many reasons for such conflicting reports some of which include the difference in study populations across examined, different treatment comparators (surgery, diet, drug therapy etc.) and also different timeframes. With the exception of the Swedish Obese Subjects (SOS) trial (Torgerson and Sjöström, 2001), controlled intervention studies demonstrating the precise relationship between weight loss and reduced mortality have been lacking. Results from this study demonstrate that maintained effects on risk factors over 10 years require 10%–30% maintained weight loss.

3.2.3.4 Increased health risk as a result of increased body weight

One study found that every 10kg (1.6 stone) increase in body weight is associated with an increase of 3mmHg and 2mmHg in systolic and diastolic blood pressures, respectively, which can lead to CVD complications like hypertension (Poirier et al., 2006). According to a UK report (Mattingly et al., 2009) the risk of coronary artery disease increases 3.6 times for each unit increase in BMI, and the risk of developing type 2 diabetes is about 20 times greater for people who are very obese (BMI over 35), compared to individuals with a BMI of between 18 and 25. In their website the UK Department of Health outline that studies have shown that severely obese individuals are likely to die on average 11 years earlier than those with a healthy weight, although the study on which this claim is based is not referenced (www.nationalarchives.gov.uk).

3.2.2.5 Improved risk as a result of reduced body weight

With reference to the other relationship, that is improved risk as a result of reduced weight some studies report improvements in CVD risk factors with a sustained weight loss of 3%, although a weight loss of 5% or more is generally considered to be clinically meaningful (Van Gaal et al., 1997). One of the seminal studies regarding CVD risk is the Framingham heart study (Hubert et al., 1983) which began in 1948, recruiting and following over 5,000 participants. Since 1948, the participants have continued to return to the study every two years for a detailed medical history, physical examination, and laboratory tests, and in 1971, the study enrolled a second generation - 5,124 of the original participants' adult children and their spouses - to participate in similar examinations. A large amount of analysis has been undertaken on this study. For example an earlier study examined the effect of weight loss among overweight middle-aged and older adults on the long-term risk of hypertension. The findings of this study suggest that a weight loss of 6.8 kg or more can reduce the long-term risk of hypertension by 21% to 29% in those overweight middle-aged and older adults (Moore et al., 2005). A more recent study using the Look AHEAD[16] study which recruited participants throughout the U.S also provides empirical support for the assertion that modest weight losses of 5–10% of initial weight are sufficient to produce significant, clinically relevant improvements in CVD risk factors in overweight and obese patients with type 2 diabetes (Wing et al., 2011).

3.2.2.6 Obesity paradox

It is relevant to mention that a growing body of research suggests some people who are classed as obese have a better chance of surviving the chronic diseases that obesity causes in the first place, compared to those leaner individuals. This phenomenon has been labelled the 'obesity paradox' and according to the literature, has researchers puzzled. The evidence for the obesity paradox has found those who are overweight or obese are more likely to survive renal failure, heart failure, diabetes and coronary heart disease, regardless of their age relative to their leaner counterparts (Curtis et al., 2005, Uretsky et al., 2007, Lavie et al., 2009). This obesity paradox was first described in a large cohort of patients undergoing percutaneous coronary intervention for ischaemic heart disease, where those with a low or normal body mass index (BMI) had a higher risk of complications at the time of their procedure and greater 1-year mortality compared to overweight and obese patients (Gruberg et al., 2002). In 2001, (Mosterd and Hoes, 2007) studied the prognosis of patients diagnosed with heart failure. They did statistical analyses on more than 5,000 patients, some of whom had heart failure. They found that patients with

[16] The eligibility criteria for this study included being aged 45–76 years (later increased to age 55–76 years); having a BMI ≥25 kg/m^2 (≥27 kg/m^2 if treated with insulin), systolic and diastolic blood pressure (SBP and DBP) <160/100 mmHg (with or without antihypertensive drugs), and triglycerides <600 mg/dL (with or without drugs for dyslipidemia); and successful completion of a valid maximal-graded exercise test.

low BMIs and low blood pressure had more in-hospital deaths than patients with higher BMIs. So, even though obesity is a well-known risk factor for heart failure and would be expected to cause problems for obese heart-failure patients, it seems that the opposite could be true. It may also be that those with low BMI are not monitored as closely.

3.2.2.7 Associated comorbidities of obesity

CVD (CVD)

Cardiovascular Disease (CVD) refers to conditions that involve narrowed or blocked blood vessels that can lead to a heart attack, chest pain (angina) or stroke (http://www.mayoclinic.org/). Other heart conditions, such as those that affect the heart's muscle, valves or rhythm, are also considered forms of heart disease (Anderson et al., 1991). Hypertension also referred to as high blood pressure can lead to stroke and heart attack. The normal level for blood pressure is approximately 120/80, where 120 represent the systolic measurement (peak pressure in the arteries) and 80 represents the diastolic measurement (minimum pressure in the arteries) (Burt et al., 1995). Blood pressure between 120/80 and 139/89 is called prehypertension (to denote increased risk of hypertension), and a blood pressure of 140/90 or above is considered hypertension (Burt et al., 1995).

It is established that, among other risk factors obesity is an underlying risk factor for CVD; although the exact extent of this relationship seems to be inconclusive in the literature. According to the literature the relationship between weight loss and the subsequent effect on individual’s health risk is not clearly defined. This may be is partly due to the relatively poor measure that is relied on for measuring obesity, that is, BMI (as previously discussed in chapter two of this thesis). It may also be due to the difference in observational studies regarding study design, limitations and bias.

Diabetes

Diabetes is a long-term condition caused by too much glucose, a type of sugar, in the blood and can lead to blindness, renal failure, and non-traumatic amputation of the lower limbs and is also a risk factor for circulatory disease (Mellitus, 2005). It is also known as diabetes mellitus. There are two types of diabetes, type 1 and type 2. Obesity is a risk factor for type 2 diabetes. Type 2 diabetes occurs when not enough insulin is produced by the body for it to function properly, or when the body's cells do not react to insulin. This is called insulin resistance (Group, 2002).

Cancer

Cancer is a term used to describe a group of illnesses where there is an overgrowth of tissue cells (www.cancer.ie). All of these illnesses have individual risk factors and treatments. One in three Irish people will develop cancer during their lifetime (www.ncri.ie). Excess body weight, whether in people with overweight or obesity, is an important risk factor for some cancers. In 2002, the International Agency for Research on Cancer (IARC) reviewed the evidence for an association between body weight and cancer (Initiative and Obesity, 2011). The IARC concluded that sufficient evidence existed for avoiding weight gain to protect against cancer. This evidence applied to colon, breast (postmenopausal), endometrial, kidney (renal cell) and oesophageal cancers. No effect was found for premenopausal breast cancer, and insufficient evidence was available for other cancers (IARC, 2002).

Obstructive sleep apnoea

Obstructive sleep apnoea (OSA) is a disorder in which a person temporarily stops breathing during the night. These gaps in breathing are called *apnoea*. The word apnoea means absence of breath. An obstructive apnoea episode is defined as the absence of airflow for at least 10 seconds (Lavie et al., 2000). Obesity is a risk factor for sleep apnoea, even in adolescents and children. Obesity can contribute to sleep apnoea when fat deposits fill throat tissue. In adults, most but not all individuals with obstructive sleep apnoea also have obesity (Shinohara et al., 1997). The complications of sleep apnoea are considered to be serious medical conditions some of which include obstructive sleep apnoea which can increase the risk of recurrent heart attack, and abnormal heartbeats, such as atrial fibrillation and also increase the risk of stroke (http://www.mayoclinic.org/diseases-conditions/sleep-apnea/basics/complications/con-20020286). Furthermore as noted by the Mayo Clinic, people with sleep apnea are more likely to develop insulin resistance and type 2 diabetes compared with people without the sleep disorder.

Mental health

The WHO has defined positive mental health as “a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community” (Organization, 2001). A person struggling with his or her behavioural health may face stress or depression. Depression has been defined as a state of low mood and aversion to activity that can affect a person's thoughts, behaviour, feelings and sense of well-being (Salmans, 1995). Mental health issues may lead to obesity and vice versa, particularly anxiety and depression although the relationship between the both is not clearly defined in the literature. This association between obesity and depression has been examined repeatedly by cross-sectional studies (Scott et al., 2007, Scott et al., 2008, De Wit et al., 2009)]. A recent systematic review and meta-analysis of longitudinal studies examining the bidirectional relationship between obesity and depression confirmed a reciprocal link between obesity and depression (Luppino et al., 2010). The obese cohort had a 55% increased risk of developing obesity over time, whereas the group suffering from depression had a 58% increased risk of obesity.

That said, in general the relationship between obesity and common mental health disorders is complex and there are conflicting reports in the literature as regards this relationship (Patel and Prince, 2010). There are several theories about how the two are linked. Some researchers suggest that obesity can lead to common mental health disorders, whilst others have found that people with such disorders are more disposed to becoming obese. Indeed some studies have found no association between the two. For example (Atlantis and Baker, 2008) conducted a systematic review of epidemiological studies that assessed the association between obesity and depression. This review included 24 epidemiological studies (4 cohort and 20 cross-sectional studies) and the review demonstrated weak evidence supporting the hypothesis that obesity increases the incidence of depression. In another study (Roberts et al., 2003) highlights that the evidence for this relationship between obesity and depression has not been uniformly robust.

Similar findings were reported in a later study, that is, that the causal direction of the relationship between obesity and depression is uncertain and high quality controlled trials are needed to explore the association (Gariepy et al., 2010). It is particularly relevant in the context of this study that beyond diminishing quality of life and functioning, depressed mood presents additional threats to obese individuals by counteracting adherence to treatment and lifestyle changes and increasing the risk of complications (Hryhorczuk et al., 2013).

3.2.2.8 Approaches to treating obesity and severe obesity

A report published by the National Institute of Health (Initiative and Obesity, 2011) identified a number of potentially effective weight loss interventions including diet, exercise, behavioural strategies; use of pharmaceutical interventions in conjunction with strategies to change lifestyle and finally surgery for selected severely obese patients. These are discussed in more detail in the next section. Recommendations also include the use of maintenance strategies such as continued therapist contact and prevention strategies such as screening and counselling.

A review of the medical literature, particularly treatment guidelines for obesity treatment shows that there is less agreement about the management of obesity than there is about, for example the health side-effects of obesity (Initiative and Obesity, 2011). This is not surprising given the multifaceted nature of obesity and the fact that a one size fits all approach may not be appropriate when it comes to obesity treatment.

Nonetheless, there is an agreement that lifestyle interventions remain the cornerstone treatment for obesity, but adherence is poor and long-term success is modest (Scheen, 2008). That said, diet, exercise, and behavioural modification is recommended to be included in all obesity management approaches for individuals with a BMI $\geq$25 kg/m^2 and that other tools such as pharmacotherapy for individuals with (BMI $\geq$ 25 kg/m^2 with comorbidity or BMI over 30 kg/m^2) and bariatric surgery (BMI $\geq$35 kg/m^2 with comorbidity or BMI over 40 kg/m^2) be used as adjuncts to behavioural modification to reduce food intake and increase physical activity when this is possible (Initiative and Obesity, 2011).

In Ireland a HSE publication (HSE Framework Action on Obesity 2008-2012) states that at present, obesity prevention and treatment programmes are provided unevenly throughout the country depending on the services available in each area. In their report the HSE outline that they will standardise practice to ensure that "all clients, whether normal weight or overweight/obese, receive advice, information and support on eating a healthy diet and including sufficient physical activity to achieve or maintain a healthy weight".

Diet

This section discusses obesity treatment options with reference to a New Zealand document (Jull et al., 2009). This is used as a reference guide as it clearly defines the various components of obesity treatment. Given the vast amount of available diets, it is imperative that all respondents of the DCE have a clear comprehension on what we mean by 'diet'. Thus, according to the New Zealand Clinical Guidelines for Weight Management in New Zealand Adults categorise dietary interventions as follows;

• Low energy diets – 1000 to 1,600 kcal or 4,200 to 6,720 kJ per day;

• Very low energy diets - < 1,000 kcal or < 4,200 kJ per day;

• Modified macronutrient diets – diets that differ substantially from the acceptable distribution range of 50 to 55% total energy from carbohydrates, 20 to 35% from total fat and 15 to 25% from protein. These can be further categorised as:

• Low carbohydrate (≤ 40% total energy from carbohydrates);

• Low fat (≤ 10% total energy from fat);

• High protein (≥ 35% total energy from protein); and

• High carbohydrate (≥ 65% total energy from carbohydrate).

There is no specific recommended line of treatment for the obese, as it depends on the individual in question.

Physical activity and exercise

Physical activity and / or exercise may be included as components of lifestyle interventions for weight loss. Physical activity can be defined as any body movement that involves the use of one or more large muscle groups and raises the heart rate (Waxman, 2005). Exercise, a type of physical activity, is variously defined and has cross-over with physical activity in its definition; it can be considered a planned, structured and usually repetitive activity that enhances or maintains physical fitness and / or overall health and wellness. The frequency, intensity and duration of the activity are parts of an exercise prescription. Exercise may consist of aerobic activity, flexibility-based activity and / or anaerobic activity such as weight training (Ainsworth et al., 2011). Physical activity is critical for promoting weight loss maintenance (Mozaffarian et al., 2012). However, exercise alone is not the most effective approach of promoting weight loss (Wing, 1999) and must be undertaken alongside controlled calorie intake.

Psychological interventions

Psychological interventions in obesity treatment are a class of treatments for weight loss in overweight and obesity that are used alone or in combination with other intervention types. The goal of psychological therapies is to assist the individual to make long-term changes in the individual's lifestyle by monitoring and modifying their food intake and physical activity levels (Hardeman et al., 2000). There are a variety of different types of psychological interventions that can be used to facilitate weight loss. Some of these include psycho-education, stimulus control strategies (to counteract triggers for eating), self-monitoring, behaviour modification (to reduce excessive eating and promote a pattern of regular eating behaviour) and cognitive therapy work towards implementing lifestyle changes and addressing underlying psychological issues (Thompson, 2001, Logue et al., 2010). That said there is little guidance on specifically what type of psychological input should be included in relevant treatments and services. As such the care pathway in Ireland seems to be that often treatment services are designed around eating behaviour and exercise behaviour, by relevant professionals such as dietitians and exercise physiologists, and then psychological input, interventions or services are added on (if even).

Pharmacotherapies

Pharmacologic therapy can be considered in an obese patient who has significant comorbidities or has failed to achieve weight loss goals through lifestyle modification alone (Hainer et al., 2008). These medications promote weight loss through effects on appetite, increasing satiety, and decreasing hunger, perhaps by aiding in resisting food cues or by reducing caloric absorption (Sumithran et al., 2011). Current drug therapy is recommended for patients with a BMI $\geq$30 kg/m^2 or a BMI $\geq$27 kg/m^2 with an obesity-related disease (e.g. hypertension, type 2 diabetes mellitus)(Hainer et al., 2008). For example, the criteria of the US National Institutes of Health and the European Union for the use of pharmacotherapy include a BMI of at least 27.0 kg/m^2 with a persistent comorbidity or a BMI of at least 30.0 kg/m^2 (Snow et al., 2005).

However findings on the effectiveness of drug therapy are limited by short intervention periods, high attrition, inadequate description of methods, and data analyses that used biased approaches to deal with missing data (Yanovski and Yanovski, 2014). Further a long line of prescription weight loss offerings have been associated with safety problems, most notably the fen-phen[17] combination, which was linked to heart valve damage in 1997 (Padwal et al., 2003). That said, there are numerous studies that report the efficacy of pharmacologic therapy for obesity (albeit different findings across the studies). Figure 4 below outlines the medications used for weight loss as outlined by (Snow et al., 2005).

[17] The drug combination fenfluramine/phentermine, usually called fen-phen; an anti-obesity treatment.

Figure 4. Medications used for weight loss

Drug	Mechanism of Action	Side Effects
Phentermine/Topiramte	Appetite suppressant	Dizziness, dry mouth, constipation
Locaserin	Appetite suppressant	Nausea, dizziness
Phentermine	Appetite suppressant: sympathomimetic amine	Cardiovascular, gastrointestinal
Diethylpropion	Appetite suppressant: sympathomimetic amine	Palpitations, tachycardia, insomnia, gastrointestinal
Orlistat	Lipase inhibitor: decreased absorption of fat	Diarrhea, flatulence, bloating, abdominal pain, dyspepsia
Bupropion	Appetite suppressant: mechanism unknown	Paresthesia, insomnia, central nervous system effects
Fluoxetine	Appetite suppressant: selective serotonin reuptake inhibitor	Agitation, nervousness, gastrointestinal
Sertraline	Appetite suppressant: selective serotonin reuptake inhibitor	Agitation, nervousness, gastrointestinal
Topiramate	Mechanism unknown	Paresthesia, changes in taste
Zonisamide	Mechanism unknown	Somnolence, dizziness, nausea

Source: (Snow et al., 2005)

Bariatric surgery

The emerging fields of bariatric medicine and surgery have developed to meet the clinical needs of individuals affected by severe obesity. A range of surgical procedures can be performed with the purpose of inducing weight change in patients with obesity. The National Institute for Health and Clinical Excellence (NICE) has issued guidelines for bariatric surgery. NICE currently recommend bariatric surgery for obese patients with a BMI of >40, and for less obese patients (BMI >35) with medical comorbidities. The Royal College of Surgeons in Ireland has also published guidelines for the delivery of obesity surgery, with similar indications as outlined (Royal

College of Surgeons in Ireland, 2008). Bariatric surgeries can be classified as outlined below. Chapter five provides a more detailed overview of the different types of bariatric surgery available. It is also important to note that there are specific risks associated with each type of bariatric surgery (these are described to respondents in the DCE as outlined in the questionnaire). Finally a range of other therapies that are not used or discussed in this DCE may be used to facilitate weight loss in people with overweight and obesity. These include herbal medicines, physical therapies and acupuncture.

3.2.2.9 Impact of interventions on health risks and on the degree and duration of weight loss

This literature review showed that it is difficult to gauge exact health outcomes according to weight loss, with conflicting reports regarding the impact of interventions on health risks including the degree and duration of weight loss. Also, there is less documented evidence of the benefits of weight loss than there is, for example, for the evidence of the associated risks of obesity and secondary diseases (Scheen, 2008). Nevertheless, there is evidence that weight loss can, for example, reduce the risk for type 2 diabetes and CVD risk factors (Lindström et al., 2006). As outlined earlier a modest (5 to 10%) weight loss, such as that produced by lifestyle modifications and medications, has been shown to produce significant improvements in many conditions (Allison et al., 2008).

In general, surgery is reported to be the most effective weight loss approach for severely obese individuals (Buchwald et al., 2004), which is the study population in this DCE. The degree of weight loss achieved with different types of bariatric surgery has been investigated in a number of meta-analyses. However, this literature review showed that the results of each analysis of bariatric surgery are not always comparable; studies have focused on one particular surgical intervention (for example band as opposed to sleeve), and/or have included study types other than RCTs and/or have included interventions that are no longer in current use. Studies show considerable heterogeneity regarding the definition of each study population, the length of follow-up, and the presentation of outcomes.

A recent comprehensive review of bariatric surgery (Picot et al., 2009) systematically reviewed 26 studies in relation to bariatric surgery, which included 23 RCTs and found that surgery was more effective than non-surgical options for weight loss for severely obese individuals. The included studies in this paper showed that Laparoscopic adjustable gastric banding (LAGB) was associated with an excess weight loss18 of 39.0% to 87.2% and BMI reduction of 7.4 to 18 kg/m^2; Roux-en-Y gastric bypass (RYGB) was associated with an excess weight loss of 60.5% to 84.4% and BMI reduction of 10.7 to 15 kg/m^2; sleeve gastrectomy was associated with an excess weight loss of 66% to 69.7% and a BMI reduction of 27.5 kg/m^2. According to this review weight loss was still apparent at up to 10 years after surgery.

An earlier study (Buchwald and Williams, 2004, Buchwald et al., 2004) demonstrated that bariatric surgery has a powerful treatment effect in severely obese persons with type 2 diabetes mellitus. In their study they report that 82% of patients had resolution of the clinical and laboratory manifestations of diabetes in the first 2 years after surgery (Buchwald et al., 2009). A study that examined bariatric surgery outcomes in the Irish setting (Chang et al., 2010) concluded that LAGB can achieve satisfactory weight loss with significant improvement in Quality of Life (QoL) and

[18] Excess weight is the amount of weight that is in excess of the ideal body weight The percentage of excess weight loss (%EWL) is a common metric for reporting weight loss after bariatric surgery. The %EWL can vary depending on the definitions of ideal body weight (IBW) used and the preoperative weight.

comorbidities; provided patients undergo thorough preoperative preparation and rigorous postoperative follow-up.

In summation, a review of the medical literature showed that obesity is complex in terms of the associated risks and also the associated benefits of addressing obesity via weight loss. This presents a formidable therapeutic challenge. Because the aetiology of obesity is complex and multifactorial, approaching its management must be similarly broad and comprehensive, thus a one size fits all approach to obesity treatment would not be deemed appropriate. From the literature it cannot be said with certainty, for example, if an individual loses a certain amount of weight that this in turn will reduce risk by a certain amount. Nonetheless this review provided the researcher with the necessary background information to draft various scenarios for the choice cards in the DCE, which served as a basis for further refinement with medical expertise.

3.2.3 Section 3: Patient preferences in DCE's

3.2.3.1 Introduction

The importance of patient experiences are being increasingly recognized (Coulter and Jenkinson, 2005, Coulter, 2005). According to (Ryan, 2004) the National Institute for Clinical Excellence (NICE) plan to have a patient centered evaluation of technologies in addition to the current assessments of clinical and cost effectiveness. A later study (McIntosh, 2006a) outlined that future work should explore the incorporation of DCE's into the economic evaluation modelling framework.

There are valid motives to elicit patient preferences with regards to obesity treatment. In the literature it is speculated that greater compliance with any weight loss initiative is associated with greater weight loss (Wright et al., 2007, Wright et al., 2010, Wadden, 1993, Wadden et al., 1994, Hamilton and Greenway, 2004), and greater weight loss is associated with greater economic benefits (Andreyeva et al., 2004, Collins and Anderson, 1995, Cornier et al., 2002). As outlined by (Roux et al., 2012) because the responsibility for achieving successful weight loss, to a great degree, falls on the shoulders of the individuals attempting weight loss and that their success, in most instances, is related to individuals' willingness and ability to comply with a given program. Thus understanding which factors may influence program choice and compliance and how this might vary between individuals could be informative in developing more appropriate interventions than might currently be the case. A DCE can provide a useful tool in gaining insights into the factors influencing compliance and adherence to weight loss initiatives, while also providing other useful information such as WTP.

3.2.3.2 An overview of DCE obesity related studies

Prior to 1990 no DCE had been undertaken in healthcare (Smith, 2000). However, as mentioned, in the past decade there has been a growing interest in the development and application of DCE's in health economics. Considering the increasing demand that obesity places on health care services along with the failure of many public health strategies to reverse obesity it is not surprising that researchers have sought to gain a deeper understanding of obesity treatment from the patient/end user perspective (Narbro and Sjöström, 2000). Although the techniques vary, some studies have explored the preferences for community-based weight loss programs (Roux et al., 2012); preferences for lifestyle interventions to reduce obesity (Ryan et al., 2014) preferences of overweight and obese patients for weight loss programmes (Mühlbacher and Bethge, 2013); preferences for diet and exercise programmes (Owen et al., 2009); preference for bariatric surgery

(Khawali et al., 2014) and WTP to reduce childhood obesity (Cawley, 2008).

One of the earliest and largest studies to explore WTP for obesity treatment used data from the Swedish Obese Subjects study (Narbro and Sjöström, 2000) which applied a CV to assess WTP. In this study the authors included an open-ended question to elicit the maximum amount of money obese patients were willing to pay for a treatment that would relieve them from overweight-related problems- stating that this amount must be realistic in relation to their ability to pay. They were also asked if they needed a loan to cover the payment. This study concluded that obese patients are willing to pay approximately twice their monthly salary for effective treatment and that a higher WTP was associated with higher weight and poorer perceived health (Narbro and Sjöström, 2000). The average monthly WTP was SEK 26,906 (US $3,280) and the median value was SEK 10,938 (US $1,330).

The patients in this study (Narbro and Sjöström, 2000) were asked their WTP on a monthly basis; however it is not clear from the study if the weight loss effects were proposed to be permanent or indeed for how long people are willing to pay. The merits of this study relate to its large sample size of 3,549 respondents, to which, no study since has reported on WTP for obesity treatment using such a large sample size. However over 50% of participants indicated that their WTP was more than they earned which might undermine the validity of the findings, as might ambiguity as to the duration of benefits. That said overstated or unrealistic or expressions of WTP are not unique to this study.

A more recent study (Cawley, 2008) that used the same technique (CV) examined public WTP for childhood obesity initiatives among residents of a New York State. This study used data from the Empire State Polls which is an annual telephone survey of New York State residents. Rather than asking respondents how much they would be willing to pay directly, respondents were asked how much they would be willing to spend in increased tax dollars for a public policy that led to a 50% reduction in paediatric obesity in their town. Findings from this study report that the mean WTP for this public policy was $46.41, per person per annum which was extrapolated to a total tax support of $691 million by New York state residents.

An important issue that this paper highlighted (also something that may be applicable to the above study) is the need for cautious interpretation of WTP estimates because people's responses can be very sensitive to the way questions are worded. This paper showed that the level of public support for anti-obesity policies was influenced by how the issue of costs was framed. When costs were not mentioned, 92.1% of respondents agreed with improving the nutrition of food in school cafeterias. When the authors changed the question to "even if it requires raising taxes," at the end, agreement fell to 69.5%. If the question began with a discussion of costs, only 40.5% of respondents agreed. A similar pattern was found regarding increasing the quality and quantity of physical education in schools.

While the above two studies, almost a decade apart provide some insight of patients WTP for obesity treatment along with the public's WTP for [childhood] obesity prevention policies, a drawback of these studies relates to the [CV] technique used. By applying this technique nothing is revealed about the value of the different attributes that might comprise the obesity treatment; that is the ability to identify the elements of a program that are highly valued by respondents is somewhat limited in the CV technique. Also the validity of the WTP estimates are open to question because of the methods used. In this context some researchers consider DCE to possess several advantages over the CV technique (Bateman et al., 2008, Bateman

and Langford, 1997, Hanley et al., 2001). Particularly when choosing an obesity treatment there are many factors to consider, some of which might include cost, time and risks associated with the types of treatment (e.g. drug therapy or surgery). A technique that might be deemed more appropriate to capture the multi-attribute nature of obesity treatment might be a DCE.
One of the most recent obesity related DCE studies (Ryan et al., 2015) explored preferences for lifestyle interventions in the general public (n=504) in the UK focusing on the following components of the programme; weight change; short-term and longer-term health gains; time spent on the intervention and financial costs incurred. One of the findings reported in this study was that a total of 131 respondents consistently chose their current lifestyle, within which 69% stated they were overweight.

In this regard the authors highlighted that due to the generation of negative values in this study this implied that compensation may be required to encourage the uptake of a [lifestyle intervention] service. Subsequently it was suggested that financial incentives could be used to help maximise uptake of healthy lifestyle interventions. What is interesting about this study is that it captures preferences for lifestyle interventions across varying degrees of BMI. The shortcomings of this study are that the data relies on self-reported BMI, which as outlined previously can lead to underestimations of weight. This study reports that 55% of the sample was overweight or obese however it is unclear as to what percentage of the study sample had established diabetes. This is important in the context that one of the attributes used in their study explores the “risk reduction in diabetes” however different valuations may be exhibited depending on whether or not a person already has diabetes or pre diabetes or not.

In their study it might have been useful to control for those who already have diabetes or an alternative option might be to present a substitute attribute such as “chance of diabetes remission” to those who already have diabetes. The same constraint applies for the next attribute “risk reduction in high blood pressure”; however bearing in mind that high blood pressure is supposed to be asymptomatic - they may not know they have it. Perhaps the CVD, diabetic and blood pressure history of the individual was determined however this is not clear from the paper as this information is not reported in the characteristics of respondents. However, given that this is a web based survey there are obvious limitations in the opportunities that exist to take this sort of detailed history confidently. Finally this survey seeks to explore two health risk attributes. The notion of whether or not respondents of a survey actually understand risk is something that is discussed above. The literature shows that individuals experience difficulty in understanding risk, having two risks attributes in the one DCE study might prove very difficult for respondents to understand, especially in a web based survey.

Conversely, an earlier study by (Roux et al., 2012) which examined individual’s preferences regarding community-based weight loss programs did not include *any* notions of risk regarding the decisions faced by respondents regarding weight loss. Thus their study does not provide us with any understanding of how people trade-off between various risks associated with obesity and its subsequent treatment. The study focused on secondary aspects of an obesity intervention rather than on efficacy aspects, for example - travel time to the program and whether the program was individual or group-focused. The finding from this study suggest that service attributes play a marked role in the decision-making of individuals choosing a weight loss program-for example respondents were willing to pay about $85 for 10 minutes less of travel to get to the weight loss programme (Roux et al., 2012). Another shortcoming of this study is that the sample used was self-selected, which means that it may not have been representative of the general adult population attempting weight loss.

A recent study applied a DCE to explore preferences within weight reduction therapy for overweight and obese orthopaedic and cardiological rehabilitation patients (Mühlbacher and Bethge, 2013). Again, there are no risk attribute defined in this study. A total of eight attributes are described in this study; strategies for weight loss, variety of therapy measures available, type of advice, therapy plan, hotel and service aspects (infrastructure quality), coordination & referral, social contacts (interaction) and finally technical competence (specialisms). This is slightly over the recommended five to seven attributes for a DCE and may have led to possible confusion and heuristic issues among respondents. Findings from the study show that patients are prepared to forego “hotel and service aspects” if these are compensated by coordinated, individualized and competent treatment interventions.

One limitation of this study is that the sample size is small –seventy two respondents, especially given the number of attributes. Because of this, there was no analysis of subgroup differences that might exist within the sample population in terms of preferences according to age, gender or BMI. Although this study reports that overweight and obese patients prefer continuous guidance, treatment and also aftercare the BMI of the population group is not reported in this paper so it is difficult to assess what level of obesity these patients are or draw any inferences in terms of preferences across varying BMI categories, which is important considering that the study is exploring preference for weight loss programs. It may for example, be the case that obese, overweight and severely obese patients have different preferences. Given that both these studies ((Roux et al., 2012, Mühlbacher and Bethge, 2013) focus on aspects of process utility rather than consequential utility and fail to consider risk reduction - this may be unrealistic when considering the choices individuals are likely to confront in reality.

Each of the above studies gives a different perspective on the issues of obesity, with some describing the trade-offs that patients and the public are willing to make for obesity treatments and some providing a microeconomic view on how much obese patients value different attributes of interventions. These studies explored preferences for obesity interventions at one point in time. There have however been studies that examine participants' experiences over the course of an obesity intervention and its follow-up. An Australian study (Owen et al., 2009) used a DCE to investigate the influence of a trial lifestyle intervention on participants' preferences for a range of exercise and diet programs and whether these differ between successful and unsuccessful participants.

In their study participants were allocated to either a control group or to one of two intervention groups, Group A and Group B- both groups participating in a 16-week program. An online DCE questionnaire was administered to all participants at baseline, 16 weeks and 12 months. The pattern of preferences over time captured the initial enthusiasm of participants, including eagerness for support and supervision, followed by a gradual waning during the course of the intervention. The preferences of the control group remained steadily focused on diet at 16 weeks whereas the preferences of the intervention groups changed substantially. However the intervention sample (n=39) was divided into three groups based on percentage change in their abdominal fat over the 12 months: Gainers, Neutral (no loss to a 5% loss) and Losers (>5% loss), with Losers and Gainers the groups of interest for analysis. There were some differences in preferences in terms of those who successfully lost weight and those who did not.

At baseline the Gainers focused almost exclusively on supervised individual exercise and a high level of support. At 16 weeks this enthusiasm had waned and they favoured self-directed exercise rather than supervised or group exercise. In terms of the Losers – although they favoured higher levels of support and supervised exercise at baseline, they also uniformly considered other factors such as type of diet and exercise duration. At 16 weeks they also moved away from supervised exercise programmes and group exercise was avoided. Preference for high levels of support waned somewhat but only marginally so. Losers had a clear focus on higher weight loss and body shape change at 16 weeks, which may be a function of their having experienced successful outcomes. However, while an interesting concept and in consideration of the above mentioned findings that authors note that no firm conclusions could be drawn as to differences in the characteristics or preferences of those who lost weight and those who gained weight. Similar to other studies, the study was based on a small sample size – fifty five respondents.

Although these studies provide insights from the patient perspective regarding the importance of service characteristics of weight loss programs, it only explored one obesity intervention – that is D&LM. Notwithstanding the importance of lifestyle modification, it is, however, not the *only* form of obesity treatment and indeed many studies outline that this type of obesity treatment alone may not be suitable for all obese people (Buchwald et al., 2007, Buchwald et al., 2009, Buchwald and Williams, 2004). Considering that severe obesity is increasing (Sturm, 2007, Sturm, 2003) and that more intensive obesity interventions may be required for some individuals, it seems reasonable to include these treatment interventions in DCEs that are used to explore obesity treatment. Such treatments include bariatric surgery which was not explored in any of the above mentioned studies.

A recent study used an on-line survey to describe the preferences and WTP for obesity medications among people seeking weight loss in the United States and United Kingdom (Doyle et al., 2012). This study outlined how much patients are willing to trade attributes of an *efficacious* intervention using attributes such as body weight loss and side effects. Risk is also incorporated as one of the attributes, i.e. health improvements described as a percentage of future health risk reduction. Although on-line surveys might enable more responses to the survey in essence it means dealing with a self-selected sample along with self-reported data along with some issues as to whether or not the interviewee understood the survey. Nonetheless this study had 502 obese participants (n = 251 United States; n = 251 United Kingdom). However another weakness of online surveys as alluded to by (Ryan et al., 2014) is the reliance on self-reported data. In (Doyle et al., 2012) study, the data relied on self-reported anthropometrics (i.e., height and weight). While it may have been preferable to recruit and collect clinical histories directly from clinical sites but this would have presented its own concerns regarding the representativeness of the sample, since many obese individuals do not seek medical advice.

Doyle et al (2012) found that percentage weight loss was the most important factor for patients and a reduction in long-term health risk was relatively less important. However, perhaps this finding ought to be interpreted with caution given the correlation that exists between the two attributes and the difficulties of people understanding risk relative to understanding weight loss as outcomes. Participants placed a high value on weight loss and similar to a more recent study by Ryan et al (Ryan et al., 2014) , participants preferred to avoid changes to their current lifestyle. The study also showed that participants placed less value on reducing long-term risks to health. However one of the best known characteristics of human decision making that is involved in some of our poor health decisions is called delay discounting. Delay discounting refers to our tendency to discount (reduce) the value of a positive or negative event if it occurs in the future – which is what might be occurring in the previously mentioned findings and may also be occurring in other DCEs. Also another issue relates to whether or not people actually understand what is meant by health risk. Studies have shown that people have difficulty in understanding what is meant by health risk and also in this regard display different perceptions of such risk (Slovic, 1987, Slovic, 2000).

Participants were willing to pay £6.51/$10.49 per month per percentage point of weight loss that a pharmacotherapy could provide while they had a much greater WTP (£28/$52 per month) to avoid making more substantial modification to diet and exercise. The fact that they are willing to pay to avoid modifications to diet might explain why these individuals do not fall within the healthy weight category, however it may also draw reference to the previously discussed study by Ryan et al (2015) that alluded to the notion of implementing financial incentives so as to incentivise those overweight or obese individuals to change their lifestyle or to take up some form of exercise.

Bariatric surgery is growing in popularity as the most effective treatment for obese individuals, especially those with comorbidities (Dixon et al., 2011). A recent Brazilian study (Khawali et al., 2014) used the CV technique to evaluate patient preferences for surgical treatment of severe obesity. Considering the heterogeneity of outcomes from drug therapy and surgical approaches, it is recommended that severely obese patients participate in their treatment decisions. Within this regard this study examined what outcomes most influenced the acceptance of bariatric surgery, so in essence it is slightly different to the previously discussed studies. This study presented the obesity treatment scenarios using two formats of the CV technique, namely, a dichotomous approach and a bidding game. According to their findings, sleep apnoea was the comorbidity that most influenced the acceptance for bariatric surgery. The limitation of this study is that the sample was based on those who have already identified bariatric surgery as their preference. Therefore, their study reflects only the strength of preference within this patient population. Also a small sample size of sixty-five respondents was used for this study.

In summary, this literature review identified a gap that exits regarding the preferences of severely obese individuals for obesity treatment. Although there are some studies that explore the preferences for bariatric surgery no study has explored bariatric surgery relative to other more conventional therapies such as D&LM. The studies discussed in this section examine either one or the other form of obesity treatment, that is D&LM or drug therapy or bariatric surgery; exploring how people trade-off between the attributes of one particular treatment (and not between all treatments). Also the study population used in the above studies varies with some studies exploring the preferences of the general public, or of those overweight or obese, or of rehabilitation patients, but none explore the severely obese population specifically. Further none of these studies were undertaken within the Irish context. As discussed in chapter five Ireland has a different healthcare system in terms of delivery and finance relative to that of other systems that may well impact on the preferences of respondents for different attributes.

3.2.3.3 DCE's and preferences within the Irish context

Although the majority of Irish DCE studies relate to environmental studies as opposed to studies in healthcare (Giblin and McNabola, 2009, Campbell, 2007, Campbell et al., 2006), there is an interest in establishing individual's attitudes and preferences regarding obesity treatment and subsequent policies. A recent report (Heery et al., 2014), aimed at determining public acceptance of a range of policies to address obesity in Ireland, examined support for obesity-prevention policies in a nationally representative sample of the over 500 Irish adults in Ireland. Using a Likert scale respondents were asked whether they strongly agreed, agreed, neutral, strongly disagree or don't know with various statements, such as *"Children should have to participate in a minimum of 30 minutes exercise a day while at school"* or "*The government should award companies for healthy food innovations"*.

A total of 30 obesity-oriented policies were divided into four groups: Child-focused policies; Informational interventions; Fiscal measures (Industry-regulation measures); and Industry-regulation measures regulatory measures relating to businesses, such as restrictions on portion size in restaurants, health insurance price reductions for normal weight individuals and banning special offers on high sugar and high fat foods). This report showed that although high levels of support were evident for most interventions, the degree of support varied by intervention type. For example there was a greater acceptance of child focused interventions (e.g., exercise in schools) in comparison with adult-focused interventions. In fact of the top five policies which the Irish public strongly agreed with, four of these policies were child-related. Comparatively, lower levels of support were evident for policies that may be viewed as restricting personal choice (e.g. restricting portion sizes in food outlets). Overall, the findings indicated substantial public readiness for addressing obesity in Ireland, particularly through child-focused policies, informational measures, subsidies for healthy foods and co-operation between government and the food industry.

As stated previously, no DCE study has examined obesity and/or its treatment preferences in Ireland. It is worthwhile however, to note two Northern Ireland studies have examined via DCE's; trading off dietary choices, physical exercise and CVD risks (Grisolia et al., 2013) and also the public perceptions of coronary events risk factors (Al Hamarneh et al., 2012). Grisolia et al (2013) used computer assisted personal interviews to apply a DCE to 493 representative respondents in Northern Ireland, to analyse how individuals trade-off health risks against lifestyle choices (Grisolia et al., 2013). One of the strengths in this study is the fact that the respondents' health and personal details are taken into account and are used to inform the study which ensured that the choice questions were tailored and individually generated.

The other DCE assessed public perceptions of coronary heart disease (CHD) risk factors in a total of 1000 adults (without CHD) from Northern Ireland (Al Hamarneh et al., 2012). Respondents were presented with eight choice sets; each composed of two hypothetical individuals in which respondents were asked to choose the individual they perceived to be at greater risk of having a coronary event in the next 10 years. The findings from this study showed that respondents perceived the contribution of very high cholesterol to the overall risk of having a coronary event in the next 10 years to be the highest, followed by smoking and very high blood pressure. Whereas, in reality the main individual contributors to the overall risk of having a coronary event in the next 10 years were being in an older age group (50 years and older), followed by very high cholesterol and very high blood pressure in males, while in females the main individual contributors are being in an older age group (50 years or older) followed by diabetes, very high cholesterol and very high blood pressure.

This study highlighted some of the problems that can be encountered when explaining and communicating health risk in a DCE. Almost two thirds of respondents in the study were less than 50 years old (65.0%); it is known that younger people find it difficult to consider their risk of dying in the next

10 years (Al Hamarneh et al., 2012). In addition, the actual CVD risk for people younger than 40 is close to zero (Conroy et al., 2003).

3.2.4 Summary of literature

In terms of establishing an understanding as to how best to conduct a DCE, this review revealed an abundance of literature offering practical guidelines therein (Ryan et al., 2001b, Ryan et al., 2001a, Ryan and Gerard, 2003, Lancsar and Louviere, 2008b, McIntosh, 2006b, Guttmann et al., 2009, Mangham et al., 2009, Coast and Horrocks, 2007, Kuhfeld, 2006, Montopoli and Anderson, 2001, Ryan et al., 2012). When undertaking a DCE there are a number of integrated stages to be followed including; identification of the attributes, identification of the levels, experimental design, data collection and data analysis. Within each stage, a number of decisions must be made, for example at experimental design stage the researcher must be aware of what models are to be applied to model the DCE data (the experimental design can affect what models can be used).

Other decisions include what type of design to apply- whether or not to have a labelled or unlabelled (discussed further in appendix seven) DCE, the number of attributes and levels along with the inclusion of an opt-out/ status quo option. Such decisions must be based on a number of factors some of which include the sample size, the sample population along with other practical issues such as time and budget constraints. Furthermore the review showed that the majority of obesity related DCE’s focus on the more conventional lines of treatment such as diet and lifestyle; the one study that did explore bariatric surgery did not compare this to other treatment options.

However, there were two fundamental points that this review highlighted. Firstly, the DCE attribute selection, which is potentially one of the most important aspects of the DCE design, is poorly reported and unclear whether this element of research is conducted rigorously in many of the DCEs examined in this literature. Furthermore little to no formal guidelines have been established as to the correct procedure or practise for determining the attributes (apart from outlining the need to undertake qualitative research). That said, in the last three years there has been an increasing interest in developing or reporting more rigorously this stage of the DCE development (Coast et al., 2012, Walker et al., 2015, Abiiro et al., 2014).

Secondly, when designing a DCE it is important to ensure that choice sets are medically plausible; this is relevant in the context of informing policy. Additionally as part of this DCE it was necessary to explain to respondents the medical terms for certain attributes, along with explaining the health risks associated with obesity. However, given the multifaceted nature of obesity, it was not possible to derive an exact causal –effect relationship between weight loss and reduced health risk, in fact in the context of the "obesity paradox" there are mixed reports as to the magnitude of this relationship.

3.3 Methods

This section discusses the methodological approach taken for this DCE, detailing the design, development and analysis of the DCE. The DCE implemented in this thesis involved extensive background research and was the result of a lengthy process. In order to inform the survey design the process began with a literature review as summarized in the previous section, which was followed by undertaking qualitative research with medical experts and also with obese individuals so as to inform the attributes and levels to be included in the DCE. This entailed conducting focus groups and interviews with obese individuals and medical experts[19] respectively. The qualitative pre-investigation, semi-structured interviews determined the desires and expectations of individuals with regards the obesity treatment. While the focus groups identified the attributes and levels, the medical expertise examined the experimental design to ensure that the choices presented were medically plausible as part of a validation exercise.

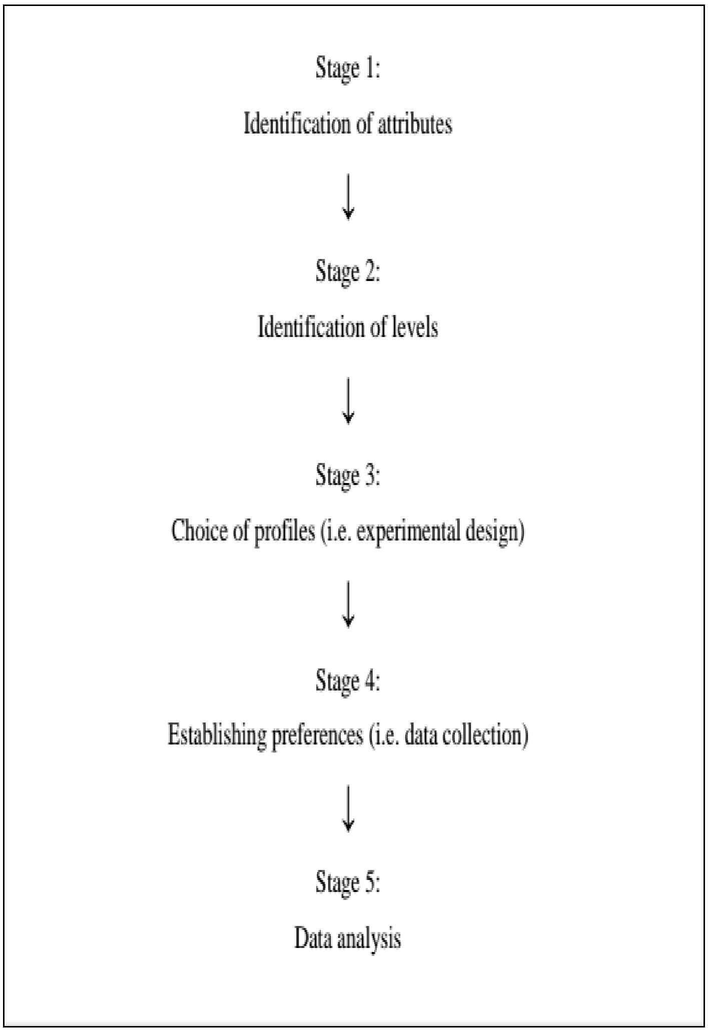
After considering the decision problem, (what the preferences of severely obese individuals might be for obesity treatment) and the attributes and levels to include in each choice set (stage 1 and stage 2), the development of the choice card scenarios is described (stage 3). Stage 4 describes the data collection including the pre-pilot and pilot studies. The questionnaire administered is attached in Appendix three; an outline of this questionnaire is provided further below. The final stage describes the data analysis (stage 5) including the coding of the attributes along with a discussion of the choice models used in this DCE including an overview of their interpretation.

[19] The medical experts consulted in this research were Dr Francis Finucane (consultant endocrinologist and obesity lead in the West of Ireland, Aine Cunningham (diabetes nurse) Lena Griffin (obesity nurse) Laura Tierney (cardiology nurse) Sharon Linnane (public health nurse)

3.3.1 Framework for the DCE design

The researcher consulted with the relevant literature and DCE guidelines including (Bridges, 2003, Lancsar and Louviere, 2008b, Louviere et al., 2000, Louviere and Lancsar, 2009, Louviere et al., 2011, Ryan, 2004, Ryan and Farrar, 2000, Ryan and Gerard, 2003, Ryan et al., 1998, Ryan et al., 2001b, Ryan and Wordsworth, 2000, Train, 2003, Train and Weeks, 2005) which provided solid guidance on good practice when conducting a DCE. A framework model proposed by Ryan et al (2001) (Ryan et al., 2001b) which consisted of five main stages –previously alluded to and summarised in Figure 5 (identification of the attributes, identification of the levels, experimental design, data collection and data analysis) was followed for this DCE.

Figure 5. The five stages of a DCE study



Source: (Ryan et al., 2001b)

3.3.2 Stage 1: Identification of attributes

Conceptual framework for developing attributes and attribute-levels

Within a DCE each alternative presents a choice card which is described by a bundle of attributes and each attribute is described by a number of levels. The responses of the choice cards are then used to determine whether preferences are significantly influenced by the attributes and also their relative importance. The attributes should be important to those respondents completing the DCE and [where appropriate] to policy makers, with the levels of the attributes being plausible and capable of being traded (Ryan, 1996). The validity of the DCE largely depends on appropriately specifying these attributes and levels (Mangham et al., 2009). A misspecification of these can have detrimental impacts on the design and implementation of the DCE and can risk producing erroneous DCE results, which in turn can misinform policy implementation (Abiiro et al., 2014).

Attributes can be quantitative (e.g., waiting time) or qualitative (e.g., the choice of hospitals) and are considered to be based on knowledge gathered from interviews, group discussions, literature reviews, and expert opinions (Coast and Horrocks, 2007). There are no design restrictions on the number of attributes that can be included in a DCE, though in practice most DCEs have contained fewer than 10, so as to ensure that respondents are able to consider all attributes listed when making their choice (DeShazo and Fermo, 2002). Having a large DCE can place too much of a cognitive burden on respondents and also respondents may lack experience in thinking about abstract concepts such as values and preferences (Mazzotta and Opaluch, 1995).

With too many attributes, the participants may be encouraged to apply a simple decision rule in which they base their response on a single or subset of attributes. Indeed studies have found that a large number of attributes can have a detrimental effect on a person's ability to choose, contributing to a higher error variance, while it appears the number of levels had a much smaller negative effect (Caussade et al., 2005). Deciding what attributes to include in the DCE must be weighed against task complexity and cognitive burden from the perspective of the respondent. Attributes must be formulated in a way that ensures that the respondents understand the content of the attribute and in a clear and concise manner. Some of the literature directly points to qualitative work as a basis for ensuring this (Mays and Pope, 2000, Kuper et al., 2008).

Analytic methods for qualitative research undertaken

According to (Coast, 2012) identifying attributes and their levels exclusively on the basis of a literature review may be easier to implement, but may also lead to the non-inclusion of some important attributes. To be included in the DCE, the conceptual attributes must be considered important by the target population, whose preferences will be elicited in the final DCE, and reflect the needs of their local context. As part of this PhD research this requires a rigorous qualitative study within the local context to include input from the target population and also experts within the field.

A multi-stage attribute development process was adopted. The researcher initially identified policy relevant conceptual attributes from a literature review (discussed in the previous section). These conceptual attributes and potential attribute-levels were used as a basis for ensuring there was no omission of medically relevant attributes. These attributes were compared with the attributes identified directly by respondents to be most important. To scale down the context-specific attributes to a number manageable within a DCE and to ensure that the final attributes and levels conformed to the theoretical postulations of a DCE, the researcher elicited expert opinion and further validated the results through a pilot study.

The researcher applied a thematic analysis approach in conducting the qualitative research. Thematic analysis has been described as 'identifying, analysing and reporting patterns (themes) within data. It minimally organises and describes your data set in (rich) detail. However, frequently it goes further than this, and interprets various aspects of the research topic' (Braun and Clarke, 2006). Thus from the focus groups, the researcher manually developed codes, words and phrases that served as labels for sections of data.

Focus groups

Focus group discussions are commonly used in valuation studies and are generally considered as a necessary step in the initial stages of valuation research (Kaplowitz and Hoehn, 2001). The aim of the focus group discussions in this DCE was to inform the identification of the attributes and levels to use in the DCE and also to provide ideas on how best to present information in the questionnaire by establishing what level of understating exists within this cohort regarding obesity and its treatment. Additionally an important goal of the focus group discussions was also to ascertain the appropriate level of choice task complexity.

In order to ensure content validity, the focus group instruments, that is, the pictorial aids and proposed questions were reviewed prior to administration by an external team consisting of a PhD colleague who acted as the focus group facilitator (Caroline Finn), and the PhD researcher. The focus group facilitator and researcher examined the transcribed reports independently and subsequently discussed and compared individual analyses in which the data were grouped according to common themes that reflected the main research questions and key issues which transpired from the discussion. It is worth noting that there are limitations of focus groups such as respondents feeling peer pressure to give similar answers to others and to the moderator's questions and in addition focus groups can be difficult to steer and control, so time can be lost to irrelevant topics.

Recruitment of focus groups

Ethics approval was granted by the Galway Research Ethics board to conduct the main DCE and also focus groups (attached in appendix five). In order to ensure that the focus group participants were representative of those to be included in the main study (i.e. severely obese help seeking individuals), individuals with established severe obesity who were enrolled in a cohort which formed part of an established lifestyle modification programme known as the CLANN (Changing Lifestyle with Activity and Nutrition) were identified and invited to participate. The program provided a study population of individuals' ≥18 years old with a BMI ≥40 kg $m\text{-}^{2}$ (or ≥35 with comorbidities). All individuals were referred to the programme by a hospital-based, multidisciplinary health team.

A total of twenty- seven people who were within their first week of enrolment in the program were invited to participate in the focus groups with a total of twenty-five giving consent to participate. This enabled four focus groups to be conducted, (three groups of six participants and 1 group of seven participants). An incentive of a free (healthy) group lunch was provided to those who participated in the focus groups. The researcher approached individuals as a group whilst attending a talk at a local building and invited these individuals to participate in the DCE survey. The researcher was made aware of their adiposity levels by the staff administering the program prior to focus group recruitment.

It should be noted that other avenues were explored to recruit focus group participants, such as approaching local weight loss groups (Weight Watchers, Slimming World, Unislim). However due to confidentiality reasons it was not feasible to include these in the study. Also participants within these groups may not be representative of the general sample that was sought, that is, those *severely* obese. Thus inviting those who were already established as severely obese (by medical expertise at Galway University Hospital) was deemed the best approach to recruiting focus group participants.

Structure of focus groups

As previously noted a PhD colleague acted as moderator in the focus groups (Caroline Fin) to ensure some participants did not dominate the discussion. Each focus group lasted on average an hour and a half. All sessions were audio-taped and transcribed for subsequent detailed descriptive analysis. The first three focus groups followed the same, semi-structured format as detailed in the five steps below, allowing new ideas to be brought up during the discussion but also ensuring that the framework of themes relating to obesity treatment be explored. The fourth focus group was used to investigate individual's understanding of the identified attributes from the other groups along with a more free flowing discussion of individual's experience and education as regards obesity treatment. This was undertaken so as to give an idea to the researcher as to the level of detail that may be required when explaining the attributes in the DCE.

The focus group participants were provided with a very brief one page information sheet explaining the aim of the research. Limited details of the research was provided, so as not to influence the discussion but still keep it within the realm of what information was required; that is to establish what attributes of obesity treatment are of importance to these severely obese individuals, including how they would rank these in terms of importance and the WTP therein.

The structure of each of the first three focus groups was as follows;

1. Participants were provided with blank sheets and asked to write down (in no particular order) the attributes (described as characteristics) of obesity treatment they thought were important to them. This was done prior to the focus group discussion so as to prevent any dominating views influencing people's thoughts as regards obesity treatment. In order to explain what was required from the participants the following example was provided; *imagine if you were going on holidays and you were in the process of booking a flight. What are the characteristics or "attributes" that are important to you when choosing to book a particular flight?* A pictorial aid (attached in Appendix six) was then shown and passed around to participants so as to show by example what some attributes might be. The picture illustrated an aeroplane seat and highlighted some attributes such as "leg room" "cost" "inflight entertainment". Next, participants were asked to imagine that they were seeking obesity treatment and to write down all of the obesity treatment characteristics that they deemed important (for themselves). There was no distinction drawn between health outcomes of obesity treatment, side effects, or service characteristics of obesity treatment. Participants were asked to list everything that they felt was important to them when seeking obesity treatment.
2. Next the focus group facilitator initiated a discussion regarding what attributes were identified, details of which are highlighted in the next section below.
3. Subsequent to the discussion participants were asked to refer back to their list and if they felt the need to add more attributes to it to do so.
4. Participants were then asked to consider all of their attributes and to identify how important each attribute was using a Likert scale. To rate the attributes, a 1 to 5 Likert scale was used, starting from "not at all important" to "very important".

5. Participants were then asked to rank each attribute in terms of relative importance.
6. Participants were asked to define and discuss how they might describe each attribute. This informed what levels might need to be assigned. Once the participants had identified the attributes they were asked, for example, in the context of one of the identified attributes "method of weight loss" "*how much weight loss would you be satisfied with and within what timeframe would you like/expect or hope this to be achieved"*

The information provided from the first three focus groups enabled the researcher to draft a list of attributes which were then presented to participants in the fourth focus group. Participants were presented with pictorial depictions of obesity treatments (drugs, diet, hypnosis and surgery) and asked to discuss their interpretations of them. A similar structure as detailed above was followed for the fourth focus group, however with some minor changes as outlined below.

1. In the fourth focus group participants were provided with pictorial depictions of obesity attributes as identified in the previous three focus groups and asked to write down their understanding of each attribute. Participants were also presented with show-cards depicting obesity related conditions, including diabetes, heart conditions, sleep apnoea, depression and cancer. Participants were asked if there was any attribute or medical condition that they would like to add to the list and if so, to do so.
2. Next the focus group facilitator initiated a discussion regarding the identified attributes including participants understanding and views therein.

3. Subsequent to the discussion participants were asked to refer back to their list and if they felt the need to add more attributes to it to do so.
4. Participants were then asked to consider all of their attributes and to identify how important each attribute was using a Likert scale. To rate the attributes, a 1 to 5 Likert scale was used, starting from “not at all important” to “very important”.
5. Participants were then asked to rank each attribute in terms of relative importance
6. Participants discussed what aspects of obesity and obesity treatment they were not or were less familiar with.
7. Participants were asked their WTP (via an open ended question) for each of the identified attributes.

Focus group findings

The age range in the focus groups was 23 to 63 years old. The average BMI was 45 whilst 69% of participants were female. This formative phase informed the design of the DCE scenarios and identified key attributes and their levels while also informing other aspects of the questionnaire, for example determining the level of explanations required prior to the presentation of the choice cards. Although attributes were defined based on participants responses, the researcher also referred to Brigg’s criteria: relevance to the research question, relevance to the decision context and whether attributes are related to one another (Briggs, 1986) when examining the identified attributes.

Findings from the focus groups identified a total of six attributes for obesity treatment; amount of weight loss, reduction in the risk of heart attack, reduction in the risk of developing diabetes, access to psychological services, cost incurred and finally the method of obesity treatment. A summary of the focus group responses (from the Likert scale) indicated that almost two thirds of the participants ranked access to psychological support services as the most important aspect of obesity treatment; suggesting that both process and consequentialist aspects of utility are important. The focus groups were also used to establish WTP approximations whereby approximately two thirds of respondents were willing to contribute in the region of €20 to €80 per month for the provision of the obesity treatment programs to treat their own obesity. The following themes emerged from the focus groups;

More support services as part of weight loss treatments

The majority of participants expressed the view that more obesity support services were needed. Many expressed the view that obesity is a "complex disease" and that as such it should be treated "*with the same complexity"*. In particular mental health emerged as a key factor in obesity treatment. In the focus group many participants *blamed* their obesity as a result of mental health issues; participants believed that psychological problems "*within themselves*" were the main reason for their obesity and as such these issues must be addressed in order to treat the obesity. Feelings of dissatisfaction were expressed relating to current psychological support services in Ireland. Subsequently participants outlined that they would be willing to pay large amounts to ensure access to psychological support was offered as part of an obesity treatment. They believed access to ongoing psychological support was a vital characteristic for any obesity treatment to be effective. Examples included a "free pass" to visit a psychologist on a monthly basis or group sessions with a qualified psychologist.

"I am obese not because I eat too much but because of mental health issues"

- (P2)

Reduction in the risk of developing comorbidities associated with obesity

As previously noted the final focus group were presented with show-cards depicting obesity related conditions, including diabetes, heart conditions, sleep apnoea, depression and cancer. Participants were asked to rank these conditions according to those that were of the least and of the most importance to participants in terms of avoiding them. For example the chance of having a heart attack was identified as an important concern to participants – in terms of wanting to avoid the most; more so with the male participants. From this discussion participants did not perceive high blood pressure or other cardio vascular risk factors as important rather were more concerned with the risk of fatal heart attack. The primary concern of dying suddenly and leaving family behind was expressed strongly from the male participants.

Other obesity related health risks such as developing diabetes were discussed. Some participants already had diabetes and discussed how they would like to go back to a stage where they do not have to inject themselves with insulin. Related to this, bariatric surgery was discussed as some people outlined how they had heard that it can "cure" diabetes.

"I know that I should be concerned with cholesterol and general wellbeing but one of the main reasons that I am here is that I don't suddenly drop dead from a heart attack and leave family who are not provided for behind me with a lot of bills"

- (P5)

"How am I going to lose this weight, how much time and effort will it take- and how much weight can I lose?"

- (P2)

Method used for the obesity treatment

Participants were concerned with how they lose the weight. Some complained about having tried "*every diet under the sun*" and were tired of the conventional diet and lifestyle modification weight loss method and want to try something else. Bariatric surgery was brought up by a number of focus group participants as an option for weight loss, with some favouring it and others state how they "*detest"* surgery as an obesity treatment. Surprisingly the majority of participants seemed well [accurately] informed as to the meaning, risks and consequences of bariatric surgery. In essence, these participants are what are referred to as "bariatric patients" in that taking their health measures (BMI and comorbidities) into account they would be deemed suitable for bariatric surgery and this would have been discussed with them along their diet career path by medical staff as an option for obesity treatment. Other methods of obesity treatment that were discussed were behavioural change (hypnotherapy), drug therapy, and the more conventional diet and lifestyle changes. In general it was agreed by all participants that the method by which they lose weight is important.

"How I would lose the weight is important to me like I am so sick of all of the fad diets and trying to exercise more and getting no results – but then there are risks involved in the more extreme measures, it is hard to know what is the best way and safest way to lose weight but the way in which I would do it is important to me"

- *(P6)*

Other issues discussed in the focus group included the time that it takes other people to notice the weight loss in a person. Cost was also discussed within the context of the expense that obesity incurs on the individual in terms of paying for diets and "always trying to buy healthy" and medication for conditions associated with obesity such as diabetes. Also the price that each treatment option would cost was important to people. What the payment vehicle for obesity treatment might be was discussed where participants felt that a direct payment would be easier to understand and also to "*grasp what could be afforded for a specific period of time"*

With reference to the two types of study design - labelled and unlabelled design participants in the focus group favoured an unlabelled DCE design. An unlabelled design is whereby the choice card was presented as "Option A" and "Option B" as oppose to a named or labelled design which might name the obesity treatment option as "Weight Watchers". When participants were asked the reasons for preference it was outlined that when completing the labelled choice card they found that they were basing their choices around "recent media hype" as opposed to what details were in front of them. The following feedback was given;

- (P2)

"I heard recently that Weight Watchers had all of their points system wrong and that they did not take into account sugar/protein intake"

- (P6)

"*I saw a programme on TV that showed a woman dying of a heart attack after finishing the Atkins diet"*

- (P3)

"As much as I care about my health and how much weight I lose- how I lose this weight is also important for me – do I have to take drugs – if so would this affect other things- if I was to have surgery this means more time off work for me"

Weight loss

Participants were asked to list, rank and discuss the characteristics of an obesity treatment program that was most important to them. For example, as expected “amount of weight loss” was an attribute identified by the majority as a very important component of any obesity treatment. Conversely, there was disagreement regarding the metric used to measure obesity – more so in terms of a metric that participants could understood, i.e., Body Mass Index, Kilograms or Stone. Within this context it was discussed how people best understand weight loss measurements. It was expressed that body mass index (BMI) was difficult for participants to grasp and also that many participants still associate the measurement of weight loss with the older metric form of stone as opposed to kilogram (this might be due to the fact that the majority of the groups are of an older generation; ≥ 45).

Participants were then asked to elaborate further how much weight loss they would deem to be a “dream” amount of weight loss, how much they would be happy with, how much they would find acceptable, and how much they would be disappointed with. This replicated the categories used by Foster (1997) to explore patients’ views of “reasonable” weight loss prior to an intervention (Foster et al., 1997). Following initial introduction, the moderator explored participants' experiences of previous weight loss treatments and used the pictorial cards to introduce information about different characteristics that an obesity treatment service might have. Participants were encouraged to discuss their views and express their preferences about different characteristics of an obesity treatment, as well as discussing possible trading between attributes (i.e. how much of one attribute would they be willing to give up to get more of another). Throughout the discussion, participants discussed issues on current obesity treatment services in Ireland, the comorbidities and cost associated with obesity, as they understood it to be.

Branded obesity treatment

As discussed the decision of whether or not to label the DCE was explored in the focus groups. A number of obesity treatments were discussed some of which included the Atkins Diet, Cabbage Soup Diet, Mediterranean Diet and Glycaemic Index Diet. Based on these discussions the facilitator presented three choice cards to participants in the focus group, each of which displayed the option of three weight loss alternatives. Different options used for different focus groups. One of the choice cards included the headings of some of the diets discussed; "Weight Watchers diet" "Milk Diet" and "Glycaemic Index Diet", another choice card presented a choice card which included specific weight loss methods; "diet and lifestyle modification" "drug therapy" "bariatric surgery" and a final choice card was presented with the headings "Option A" "Option B" and "Option C".

Each alternative was described by the various [hypothetical] levels- for example the price that each alternative might cost and the potential weight loss that might be associated with each alternative. After completing the sample choice cards, participants were then asked to rank which choice card they understood the most and which choice cards they felt described the attributes of interest best. Participants were also asked to consider which choice card might/did lead them to ignoring any of the attributes and which choice card might lead/did lead them to just focusing on one attribute or indeed if the labelling or title of the alternatives influenced them to consider or not consider all of the attributes. They were also asked to consider which choice card gave them the option to express preferences that would be as close to their real world preferences as possible.

Cost

Participants discussed the cost of undergoing a diet in terms of healthier foods often being more expensive and the cost associated with time off work and travel to doctors for medical treatment was discussed. It was outlined that the most comprehensive manner to express cost was per month as people would be better able to determine how much they could afford as it would be in line with their monthly wages for those who were working. There was a general consensus that the obesity was the responsibility of the individual and thus it should be the individual that ought to pay out of pocket as opposed to taxes. That said, they believed that the Government should build and improve on current obesity treatments. From these four focus groups a draft of possible attributes was compiled. Participants reported that the cost of healthy foods makes it more difficult to eat a nutritious diet. They commented that "Money's probably the biggest thing that restricts" and "Cost always comes with eating healthy." Several participants stated that they often choose to eat fast food due to its affordability. Focus group members also discussed cost as being a disadvantage of exercising. They described the expenses involved with paying for gym memberships and gym equipment. For example, a participant stated that "one of the cons of exercising is that you have to pay for the gym membership and all that stuff, whereas if you have it at home, you have to buy the equipment, too."

Willingness-to-pay (WTP)

To identify the payment vehicle to be used a direct WTP question was included at the focus group stage. Here, participants were asked to consider the value that they would put on an obesity treatment service and how they think it ought to be paid for; indirect tax, direct tax, personal out of pocket payment. Participants were presented with an example relating to the purchase of an article of clothing to help in understanding the concept of monetary value.

You go to a shop and suddenly you see something that you really like, and think about buying it but suddenly you look at the price, say it cost €100 –

too much – I don't want to pay that and you go home and think that you might wait until it gets to a lower price – say that the maximum you would pay is €50. Then you come back 2 or 3 weeks after that and the price of the good has changed – say, imagine, half price, €50 – and you really like it and you think '€50, I would pay €50 for that' and you buy it and you take it home. The economist will say that the value to you of the good is €50 because you've already identified that as the maximum WTP article.

Following this participants were asked how much they might be WTP for an obesity treatment service. The monetary value of a service was a difficult concept to understand for the participants. Initially, participants expressed reluctance to pay for the service. However, after it was explained that this was an exercise to infer value, and that money is one way of looking at value, they engaged with the exercise. An example was given if the current diet and exercise program that participants were enrolled in (which is provided publicly and thus free) was to be rolled out on a 'pay as you go' capacity – how much would they be willing to pay.

Interviews with medical experts

This DCE is designed in collaboration with medical expertise, so where the medical literature was lacking (for example in terms of establishing the weight loss - health risk reduction relationship) information was complemented by medical expertise. Medical expertise was recruited after a brief presentation by the researcher at Galway University Hospital which was attended by staff within the hospital. Subsequently individual interviews with medical experts (Endocrinologist, Dietician, Obesity nurse, Diabetes nurse, Cardiac nurse, Physiotherapist and Pharmacist) were undertaken to inform the study further. There were two waves of interviews with medical expertise; the first after the focus groups and the second after the experimental design. Fundamentally, participants in the focus groups identified what they perceived as important in terms of obesity treatment in which the first wave involved medical experts checking the identified attributes and levels to ensure that these were sensible and medically plausible (before including them in an experimental design). The second wave of interviews was conducted once the experimental design was completed. From this, scenarios were developed which were then presented to medical expertise to ensure that the scenarios were (again) medically plausible. For example if it was reasonable to assume if an individual loses x amount of weight that a y amount of a health risk would be subsequently reduced.

In the first wave of interviews a draft of attributes (developed following the focus groups) was presented to medical expertise. The primary purpose of which was to ensure the drafted levels which describe the attributes were medically meaningful and if not how this might be corrected. These interviews helped confirm, from a medical perspective how much weight loss is feasible (and safe) for those severely obese and what is a reasonable timeframe over which this might be attained. There was only one attribute that was identified by the focus group that was dismissed by the medical expertise (as not being practised within the healthcare system in Ireland) and that was hypnotherapy.

These interviews also clarified the expected timeframe for weight loss. Although the timeframe agreed by the majority of focus group participants was 12 months, there were a small number of participants who identified 6 months as a timeframe for weight loss. However medical expertise outlined that 12 months would be a more appropriate timeframe for weight loss. Asides from these issues the medical expertise did not have anything more to add in terms of additional attributes that had not been previously identified in the focus groups. The reason for this may be that those participants in the focus groups are help-seeking severely obese individuals who already have gone through a “diet-career” and are consequently well educated in terms of what their own obesity related health risks are.

The second wave of interviews with medical expertise was conducted at a more advanced stage of the DCE design, that is, after the experimental design was completed. Medical experts were asked to review the choice cards along with a draft of the survey for clinical appropriateness, comprehensiveness and general impressions. At this stage the medical expertise highlighted a number of issues, for example; how best to describe individual health risk to respondents. Each individual differs in terms of what risk factors determine an individual’s risk, for example, suffering a heart attack. Options as to how best to assign levels to the risk attributes were therefore discussed with medical expertise. For example the Framingham Heart study (Hubert et al., 1983) was deliberated as an option of presenting individual risk. This would mean inputting a series of risk factors into a computer application [designed by the Framingham Heart study] to determine individual risk. However this technique would not be ethically viable, i.e. having a medically unqualified individual providing individual health risks to respondents. From this discussion it was concluded that the most appropriate way to assign and describe risk was to describe the risk as an *overall* group risk of those within the higher BMI category rather than as an individual risk – this was tested at the pilot stage.

Other matters that were highlighted in the interviews included the possible correlation between attributes such as the amount of weight loss and health risk. The option of imposing restrictions on the survey design was discussed to avoid presenting respondents with implausible treatment options. For example this would include restricting the survey design such that the minimum amount of weight loss (2 stone) would only appear as a choice alongside a minimal reduction in the risk of heart attack (5%) and vice versa. Another restriction might be that the maximum amount of weight loss is presented only with bariatric surgery as the method of weight loss and not, for example via diet and lifestyle modification. This was tested at the pre-pilot stage and determined to be too restrictive (see section 3.3.4.2). Subsequent further discussions with medical expertise found that, in fact, all choice options presented were plausible and a severely obese individual *could* lose this amount of weight via diet and lifestyle modification only.

Attributes used in this DCE

Following focus group findings and interviews with medical expertise Table 11 below provides an outline of the attributes used for this DCE and table 12 provides an outline of their coding. These attributes are explained in greater detail below.

Table 11. Description of attributes used in this DCE

Attributes	**Definition of Attribute (as described to respondent)**
Amount of weight loss in 12 months	This is the amount of weight that you would potentially lose over a 12 month period - as measured in stone.
Risk reduction of fatal heart attack over a 10 year period	The heart attack risk refers to the risk of having a fatal heart attack which will result in your death over the next 10 years. The risk presented in the choice card represents the reduced risk that you will have as a result of obesity treatment. For example your risk of fatal heart attack will be reduced from 30% to 15% as per

	Option A in table 13 further below.
Cost (per month)	Each of the treatments will come with additional cost to you. This cost will be paid by you for by means of a monthly contribution to a [hypothetical] health fund for a 12 month period, regardless of whether or not you have a medical card or private health insurance.
Psychological services	This describes whether or not you would have access to psychological services. If the choice is yes this means you can visit an on-site psychologist once a month for a 12 month period.
Method of weight loss	This describes the method in which you would attempt to lose weight. There are three alternatives to choose from (each alternative is explained in the questionnaire); diet & lifestyle modification; drug therapy plus diet & lifestyle modification and finally bariatric surgery – specifically sleeve gastrectomy.

3.3.3 Stage 2: Setting levels for the attributes

In DCE's each attribute is assigned a range of defined dimensions called levels which may be defined continuously or categorically. Hence, following the attribute selection, the next stage involves defining the attributes by outlining plausible levels which describes the attributes. Ryan (1999) described three success factors, outlined below when choosing the levels for each attribute (Ryan, 1999). If the level interval is too narrow or too wide, the attribute can be dominated or dominating, and non-trading can result, leading to insignificant or extreme estimated parameters respectively (Kjær and Universitet, 2005). According to Ryan (1999) the levels must be:

• plausible to respondents;

• actionable to respondents; and,

• constructed so that respondents are willing to make trade-offs between combinations of the attributes.

Table 12. Attribute coding and attribute level description

Attributes	**Coding**	**Levels**
Amount of weight loss in 12 months	Continuous	(Stone) 0, 2, 4,6
Cost (per month-specified as the amount that the respondent would have to pay as a direct out of pocket expense)	Continuous	€20, €30, €40, €50, €65, €85
Psychological services	Dummy coded	Yes/No
Method of Weight loss	Effects coded	Diet & lifestyle modification Drug therapy plus diet & lifestyle modification Bariatric surgery
Risk reduction of fatal heart attack /stroke over a 10 year	Continuous	(Percentage Risk) 5%, 10% 15% 20%,

period		25%, 30%

Amount of weight loss in a 12 month period

People generally think of weight change in raw numbers rather than percentages (Doyle et al., 2012). This DCE uses stone as the weight loss metric. In the focus groups 'stone' was expressed to be the most comprehensible weight loss metric to participants. Therefore respondents were presented with choice cards with the weight loss measured in stone. This attribute was described as an amount of weight loss within a 12 month timeframe ranging from 2 stone, 4 stone or 6 stone weight loss. The intervals for the attribute weight loss (described as stones) was informed by medical experts.

The status quo option which was the third choice alternative on the choice card, described the alternative as the respondents current situation, that is, not participating in any obesity treatment and subsequently there was no weight loss in this option. Findings from the focus group showed that participants were concerned with the time that it takes to lose the weight. Participants found it difficult to envisage any weight loss without knowing how long it might take – hence why the timeframe was included in this DCE. Furthermore the majority of focus group participants expressed a preference for a weight loss over a longer period of time rather than a shorter period of time. Again, this may be due to their "education" with regards weight loss in the context of their "diet career" in that individuals who have spent years trying to lose weight (as these participants reported) are now aware that there are no short term fixes when it comes to weight loss. It might alternatively signal a desire on their part to procrastinate.

Method of weight loss

This attribute is described by three levels which are outlined below; D&LM, drug therapy alongside D&LM and bariatric surgery;

Diet & lifestyle modification

In this study this attribute is described as incorporating calorie control and increased physical activity of up to 30 minutes per day. A diet rich in vegetables, fruits, fibre-rich whole grains, lean meats and poultry, fish and low in saturated and Trans fats[20], cholesterol, sodium and added sugars. It was also highlighted to respondents that modifying their daily routines can also affect their expenses, as different foods have different prices.

Bariatric surgery- Sleeve gastrectomy

Sleeve gastrectomy was chosen as the type of surgery as it is the primary surgery publicly available in Galway University Hospital. Sleeve gastrectomy is a surgical weight-loss procedure in which the stomach is reduced to about 25% of its original size, by surgical removal of a large portion of the stomach. The result is a sleeve or tube like structure. The procedure permanently reduces the size of the stomach, although there could be some dilatation of the stomach later on in life. The procedure is generally performed laparoscopic ally and is irreversible. As with all types of surgery- there are risks involved. Immediately after bariatric surgery, the patient is on a very restricted diet for a number of weeks.

Drug therapy plus diet & lifestyle modification

This is diet and lifestyle programme alongside a drug therapy such as Orlistat (Xenical), which reduces intestinal fat absorption by inhibiting an enzyme called lipase in the pancreas. It is intended for use in conjunction with a healthcare provider-supervised reduced-calorie diet.

[20] Each of these types of fats, salt and sugar were previously explained to respondents in a food information presentation that each respondent attended, delivered by medical expertise (dietician and nurse)

Cost

The cost attribute was described as the expected monthly cost of undertaking an obesity treatment for a 12 month period. This was specified as the amount that the respondent would have to pay as a direct out of pocket expense regardless of whether or not that person had a medical card or voluntary health insurance. Although the cost attribute was defined as a result of the bands identified in the focus groups (along with reviewing what other studies used for WTP bands) the researcher also sought to determine if these WTP bands are in line with actual costs of obesity treatments. For example monthly cost of obesity therapies –were sought from pharmacy prices, Primary Care Reimbursement System (PCRS) and also the British National Formulary. The cost of healthy eating was explored (McDermott and Stephens, 2010). The cost of attending psychologists was also explored using Irish databases (www.psihq.ie). Finally average costs of surgery were explored. A total of seven price levels ranging from €20, €30, €40, €50, €65, and €85 per month were used to describe the cost attribute. It can be seen that whilst these additional cost bands may cover for example the increased cost of eating healthier or a monthly gym membership, it would not cover, for example the cost of bariatric surgery (given that this is a 12 month pay period). Thus the WTP bands are not truly reflective of actual costs of treatments rather the WTP therein; but are reflective of a reasonable range of what people could and would pay. In other words an attempt was made to make the "prices" presented to individuals reflective of those the focus group suggested as possible values but also realistic of those that might in fact be required. Where on the prices could not realistically be met by a typical individual the maximum WTP that the focus group suggested was used.

Access to psychological support services

This attribute was described as having access to psychological support services in the form of a councillor for a one hour session once per month for a 12 month period. The attribute was described as yes or no in terms of whether or not the access was provided as component of a particular obesity treatment.

Risk of fatal heart attack over a 10 year period

The attribute 'risk of fatal heart attack' was described to respondents as a percentage reduction in the risk of suffering a fatal heart attack to 5%, 10%, 15%, 20% or 25% -these were the risks should the respondent choose alternative A or B. In the status quo option (alternative C) the risk was described as a 30% risk of having a fatal heart attack. In other words, if a respondent opts for this status quo alternative, by not making any changes to their current situation the participant has a 30% of having a fatal heart attack (as informed by medical experts). Alternatively by undertaking an obesity treatment (selecting alternative A or alternative B) they can reduce their risk of fatal heart attack to 5% 10% 15% 20% or 25%. This is presented as an absolute risk, for example "your risk will be 20%".

It is reported that many or perhaps even most people struggle to comprehend information on risk levels probabilities (Erdem and Rigby, 2013). The context and question format used to elicit risk attitudes are important and do matter (Harrison et al., 2014). In order to ensure that risk was presented correctly in this survey a review of the risk communication literature was undertaken to identify the key steps for communicating risk; in particular a study that reviewed using risk as an attribute in DCE's was consulted (Harrison et al., 2014). In order to deal with this, the researcher ensured that a clear description of health risk was explained to the respondent.

3.3.4 Stage 3: Constructing the choice sets

3.3.4.1 Experimental design

Experimental design can play a significant role in a DCE. The type of design implemented depends on the objectives of the study, the type of study and also on the information available. Different design strategies embody different assumptions and so are likely to be appealing under different circumstances. An experimental design is required in a DCE because often the combination of attributes and levels yields a large number of choice sets which could affect respondents' decisions and even response reliability (Chung et al., 2011). For example in this DCE the combination of attributes and attribute levels (two attributes with six levels; two attributes with three levels; and one attribute with two levels) result in ($6^2*3^2*2^1$) 324 hypothetical obesity treatment models. Thus this necessitates an experimental design so as to map the attributes and levels into manageable choice sets of alternatives to which respondents indicate their choices.

Broadly speaking there are two schools of thought regarding the statistical properties of experimental design; that is efficient design and orthogonal design. A design is orthogonal when every pair of levels occurs equally often across all pairs of attributes, or when the frequency for level pairs are proportional (Reed Johnson et al., 2013). While orthogonal designs are more prevalent in the earlier DCE literature, efficient design has recently emerged as an alternative with new algorithms to facilitate the design. Efficient designs have been empirically shown to lead to smaller standard errors in model estimation at smaller sample sizes compared to orthogonal designs (Bliemer and Rose, 2010, Bliemer and Rose, 2011, Bliemer et al., 2009). This is a distinct advantage for the proposed DCE in this thesis, given the small sample size envisaged for this research. Further, efficient designs are less restricted and often enable much smaller designs in terms of the number of choice sets. For this DCE a Bayesian efficient design was implemented.

The Bayesian design approach was introduced in the marketing literature by (Sandor and Wedel, 2001) and has been widely used for DCE's e.g. (Bliemer and Rose, 2006, Bliemer and Rose, 2010, Kessels et al., 2006). This approach takes into account the uncertainty about the assumed prior parameter value β_0. In a Bayesian design a prior distribution is assumed for the parameters in the design stage, which is then incorporated into the appropriate design criterion.

Thus, this type of design is generated on the basis of the variance covariance matrix. Since it is not possible to know the variance covariance matrix the asymptotic variance covariance (AVC) matrix is used, of which require some prior parameter values. For this DCE, priors were taken the focus groups to inform the initial pre-pilot construction of the experimental design. Choice sets for the pilot survey were developed on the basis of priors gleaned from pre-pilot study. After the pilot, the results were analysed and priors were used from this to inform the construction of the experimental design for the main study.

The construction of choice sets was completed using a software package called NGene (Rose et al., 2012) in which the attributes and levels were entered into the software package which then constructed choice sets by randomly combining each of the attributes at different levels so as to give different scenarios for each obesity treatment alternative. The software created choice sets such that attributes at different levels were packaged in such a way that trading across attribute levels would be revealed through choices made thus allowing preferences to be revealed. The order of choice sets were randomized to mitigate any ordering impacts (Loureiro and

Umberger, 2007). A total of 36 choice sets were designed in which there was an option to choose from one of three obesity treatment alternatives; alternative a, alternative b or alternative c.

At experimental design stage there are a number of decisions that must be made regarding the design of the choice cards. In particular, whether or not to include an opt out or status quo alternative in the choice set along with whether or not to design a labelled or unlabelled experiment were important in the context of this study. Firstly in terms of the former, when designing a DCE it is possible to design a choice set that includes a status quo option, or an opt out option, or a forced option. A forced choice, as the name suggests, forces individuals to choose one of the alternatives on offer with no option to opt out. Alternatively by including either a status quo or an opt out alternative; this gives respondents the option to opt out of the choice set or remain at “status-quo”. When respondents choose an opt out option, this indicates that they choose none of the hypothetical options. Alternatively for the status quo option, respondents choose between the hypothetical alternatives *and* their current alternative. Acknowledging that it is realistic in some health economics applications to not include a status-quo, however as discussed in the next section, it made sense in the context of this study to include a status quo option in the choice set.

A recent study examined the extent that the inclusion of an opt-out option in a DCE effects choice behaviour (Veldwijk et al., 2014). In their study the authors noted that there was a consensus to include an opt-out option in DCEs that aim to determine the potential participation in an elective program, because such an option is more in accordance with the respondent's choice options in real life; the authors cited a number of studies therein (Lancsar and Louviere, 2008a, Ryan and Farrar, 2000, Ryan et al., 2007, de Bekker-Grob et al., 2012). Studies also show an increase in the external validity of welfare estimates derived from DCE's that include a status quo or opt out option (Adamowicz and Boxall, 2001) and an improvement in the statistical efficiency of parameters estimated from discrete choice models (Anderson and Wiley, 1992, Louviere et al., 2000).

Forcing respondents to choose is problematic if respondents would not have chosen one of the alternatives in practice such that the inappropriate use of forced choices may result in biases with respect to parameter estimates (Kroll et al., 2002). That is, individuals may be forced to take up a choice when in reality they would choose not to. In the context of this study, non-participation in an obesity treatment is a relevant alternative for certain individuals; failure to include an opt-out or status quo alternative when this is a realistic policy alternative, may overestimate participation - distorting welfare measures. (Adamowicz and Boxall, 2001) suggested that the non-inclusion of the status quo could be problematic because there "would not have been a 'base' or reference alternative to consider.

In the context of this study, non-participation in an obesity treatment is a relevant alternative for certain respondents; failure to include an opt-out or status quo alternative when this is a realistic policy alternative, may overestimate participation - distorting welfare measures. Thus a status quo option was included. In this DCE the status quo option describes what individuals were currently doing [as regards obesity treatment] whereby this meant *not* undertaking any obesity treatment. By remaining at status quo respondents would not lose any weight, nor would they reduce health risks (which are already high due to this being a severely obese cohort). It should be noted that although this cohort (described in more detail in section 3.3.4.1) were currently enrolled in a lifestyle modification program, the survey was conducted within the first week and as such the status quo option was explained and presented to respondents with reference to the way in which they behaved days earlier before enrolling in the program, that is not participating in any obesity treatment.

Another fundamental decision when designing DCE's is whether to use labelled or unlabelled choice tasks. Unlabelled DCE's refer to an experiment in which the title of each alternative is generic (e.g., alternative 1, alternative 2 etc.) and the only way to differentiate between the alternatives is through the attributes and their levels (Hensher et al., 2005). Labelled DCE's refer to alternatives in which the alternative's name conveys additional information beyond just the attributes and the labels may communicate information regarding the tangible or intangible qualities of the alternatives (Hensher et al., 2005). Labelled and unlabelled DCE's are typically used for different purposes and to achieve different outcomes.

Although both types of design are widely used in the literature, the majority of published DCE's in health care use unlabelled or generic designs (Kruijshaar et al., 2009). According to de Bekker-Grob (2012), this may be a result of the perception that labelled experiments are difficult to construct. (de Bekker-Grob et al., 2012, Bekker-Grob et al., 2010). However, the primary advantage of a labelled design is that by using labels it may be more realistic and less abstract so that responses may better reflect the real preferences (Blamey et al., 2000). The design of a labelled DCE does generally mean that a larger sample size is required because it is assumed that, most of time, there are interactions between the alternative label and the attributes. In a health-care setting this may not be feasible because the target group of patients or medical specialists may be too small.

Studies exploring and comparing labelled and unlabelled DCE's are limited in health economics and appear to be more common in other disciplines such as market research (McClure et al., 2004, Shen and Saijo, 2009, Bjørner et al., 2004). Nonetheless de Bekker-Grob et al (2012) provides some insights into the feasibility and difference in results from labelled and unlabelled choice experiments (de Bekker-Grob et al., 2012). According to this paper, the inclusion of labels plays a significant role in individual choices but can reduce the attention respondents give to the attributes. This paper showed that the inclusion of labels reduced the attention that respondents gave to the attributes (i.e., increased non-trading behaviour) in which respondents focused only at the alternative labels.

Similarly Blamey et al (2000) highlighted that respondents have a higher propensity to ignore attributes when labelled alternatives are included in the DCE (Blamey et al., 2000). This paper outlined that the inclusion of labels reduced the attention respondents gave to the physical attributes of a good and caused a reallocation of utility for these attributes towards a value for the label itself. Correspondingly, in a study that sought to explore whether or not labels had an influence on the processing strategy adopted by respondents in the context of determining recreational site choice using the DCE methodology, it was found that labelling alternatives may result in the labels having a considerably larger impact on how respondents reach their choice outcomes than may be anticipated when designing DCE's. (Doherty et al., 2013a).

The literature shows that unlabelled DCE's encourage respondents to choose an alternative by trading-off attribute levels. Thus if the objective is to estimate attribute values, it may be desirable to use an unlabelled DCE to reduce non-trading behaviour because of alternative labels. Subsequently, in the context of this study (as supported by the focus groups) it appeared more appropriate to use an unlabelled DCE design. The final design resulted in 24 choice sets, which were blocked into two groups of twelve whereby respondents were presented with one of the blocks which contained 12 choice cards. The purpose of this was to keep the task reasonable for respondent (Tonsor et al., 2005) which also helps to promote respondent completion rates and minimise error due to fatigue. In order to ensure that an even number of blocks was administered, every second block was administered to each respondent.

Table 13 Sample choice card

	Option A	**Option B**	**Option C**
Amount of weight loss in 12 months	2 stone	6 stone	0 stone
Risk of heart attack over a 10 year period	15%	15%	30%
Cost (per month)	€40	€50	€0
Psychological services	Yes	No	No
Method of weight loss	Diet & lifestyle modification	Bariatric surgery	No weight loss programme
Please tick the one option you prefer **best**.	□	□	□

3.3.5 Stage 4: Establishing preferences (data collection)

Consideration was given as to how best to collect the DCE data. DCE instruments can be administered on paper or with computer-based administration software (Kruk et al., 2010). Typically DCE's have been self-administered via postal questionnaires (Ryan et al., 2001b); or self-administered in the presence of a researcher such as (Mühlbacher and Bethge, 2013) (Roux et al., 2012) although, they have been administered by interview (Bryan et al., 2002) and are increasingly being administered electronically (Ryan and Gerard, 2003, Bryan et al., 2002) such as (Owen et al., 2009). With reference to response rates interviewer based administration is generally accepted as the best approach (Ryan and Gerard, 2003). However there are also possibilities of interviewer led biases to consider (Jenkins and Dillman, 1995). Internet surveys have a number of advantages over mail surveys; namely that they can survey large numbers at a small marginal cost (Ryan and Gerard, 2003).

However the literature also seemed to show that paper based surveys might be the preferred method of data collection. Early comparisons of computer- and paper-based tasks generally favoured paper for better performance according to the metrics of speed, accuracy and comprehension (Wilkinson* and Robinshaw, 1987) (Muter and Maurutto, 1991) and also in terms of having a hard copy of data for verification purposes. It is though accepted that these early studies predated many of the more recent developments with computers and tablets that have occurred in the intervening period.

Findings from the focus groups and pre-pilot study showed that respondents found it difficult to interpret the choice cards without some form of explanation and opportunity to ask questions. It was subsequently decided that the best approach for this DCE was to conduct self-administered face –

to-face surveys. The decision to administer on paper was primarily due to the focus group findings regarding what respondents found easier to complete. Cost was also a consideration. All individuals consented to participation in writing.

3.3.5.1 Identification of study sample

This study sought to identify the preferences of severely obese individuals for obesity treatment. During the initial stages of investigation it was established that there are two categories of severely obese people, those who seek help to treat their obesity and those who do not. Those who seek help include those who present themselves in clinics and show up for appointments at the GP and or other services. It became apparent that it would not be possible to capture those severely obese individuals who do *not* seek help or treatment. This would entail going to individuals homes in which ethics approval for this might be difficult to obtain.

Thus far, this DCE has outlined how the researcher invited those enrolled in a diet and lifestyle programme to participate in the study. However, it should be noted that prior to identifying and inviting this cohort of individuals, another cohort of severely obese individuals was identified and surveyed but were later deemed to be inappropriate for this study. Details are outlined below, the "dismissal" of this cohort was primarily due to the fact that a number of those within this cohort had already undergone bariatric surgery and obesity drug therapy and thus the results of the DCE were somewhat biased, in that respondents did not trade between the attributes; additionally many of those within this cohort were unable to walk (which had implications in terms of preferences and expectations for exercise and weight loss, respectively).

With regards the sample cohort included in this study, it is noted that these individuals were currently enrolled in a diet and lifestyle program at the time of the survey, albeit within the first days of enrolment and that this may present some form of bias as regards treatment preferences. However there is a high probability that those help seeking who are severely obese have, or are going to be enrolled in some form of conventional obesity treatment such as diet and lifestyle modification, given that this is the first step in terms of treatment.

Considering that this DCE examines obesity treatment preferences, the potential of bias may be reduced if individual's experience of obesity treatment is kept to that of the more conventional type; that is diet and lifestyle modification so as to ensure that individuals can trade-off between all of the attributes and valid welfare measures can be derived therein. In fact it would prove difficult to capture the preferences of those help seeking severely obese population *without* the chance of some sort of partiality as regards diet and lifestyle modification, the key is to try to keep the potential of bias to a minimum.

As outlined previously, when deciding upon the experimental design, it is important to be aware of the study sample that the design is to be administered to. Prior to the design stage of this study, the researcher delivered a presentation of the proposed research to staff at the weight management clinic at Galway University Hospital (GUH). From this and along with further discussions, two potential study populations were identified for this study; a cohort of individuals who were attending the weight management clinic and also a cohort of individuals who are referred to a particular lifestyle intervention programme (CLANN).

Because each of these cohorts represented help seeking severely obese individuals ethics approval was applied for (and granted) to administer surveys (and focus groups) to both of these cohorts. It was initially envisaged that individuals from both groups could be used, however given the differences that existed in terms of patient characteristics along with under gone obesity treatment, this was not possible.

Initially the pilot surveys were administered to those attending GUH weight management clinic. Severely obese patients who were attending an outpatient clinic appointment with the consultant endocrinologist were approached by the researcher (whilst in the waiting room) to ask if they wish to give consent to partake in the survey. Full details and information etc. was provided and the surveys were conducted in a private room. A total of seven surveys were carried out. However it became apparent that the DCE was not appropriate for those in this group. Although this group *did* represent those help seeking severely obese individuals, the extent of their obesity treatment history differed considerably which significantly influenced this cohorts preference and indeed ability to trade between attributes. For example there were patients who already underwent bariatric surgery, who have completed the “Milk diet”[21], who were currently taking [medically prescribed obesity treatment] medication.

Other characteristics of patients included those with poorly controlled diabetes (as confirmed in their medical chart) along with those who were

[21]The milk Diet has been used by patients for 10-14 days prior to undergoing weight loss surgery. Skimmed milk is usually consumed three times per day i.e. 1 pint for breakfast, lunch and dinner. This very low calorie diet is used under strict medical supervision as there are some health risks involved. The aim of the calorie reduction is for the body to use up the glycogen and fat fuels stored in the liver so that the liver shrinks and makes it easier for the surgeon to access and operate on the stomach. Skimmed milk is used because it is very low in fat and calories but also because it provides nutrients such as calcium, phosphorous, magnesium and B vitamins which are essential for good health.

unable to walk for any distance. The implications of this were that it was difficult for these patients to trade-off between the attributes in the DCE, considering for example those who are unable to exercise, or those who have already had surgery. This was evident in the choice card answers where there was evidence of non-trading behaviour from the choice cards.

Subsequently this cohort was deemed unsuitable for the purpose of this study and the other identified sample of severely obese help seeking patients was used for this study. This cohort which formed part of an established lifestyle modification programme for patients with severe obesity was identified. The program provided a study population which included bariatric patients, meaning that these individuals are deemed *suitable candidates* for bariatric surgery (but had not undergone the surgery); ≥18 years old with a BMI ≥40 kg m^2 (or ≥35 with comorbidities) who were willing to attend a community-based facility for eight weeks. Each patient was referred after careful assessment for suitability by the hospital-based, multidisciplinary health team. Patients with poorly controlled diabetes or hypertension, symptoms suggestive of untreated ischaemic heart disease, an inability to walk 10 meters or those deemed unlikely to attend for the full programme (e.g. frequent clinic non-attendance) were excluded from the intervention and study group. This cohort was deemed suitable for this study as this cohort represented those help seeking individuals who will have access to obesity services. Also relative to the previous group there is a lesser risk of biased results in terms of preferences given that all option of obesity treatments are accessible to this cohort; that is there were no patients with whom already had surgery and all patients were able to exercise. Thus from hereon in those within the CLANN group are referenced to and no further work was undertaken (following the seven surveys) with those attending the weight loss clinic at GUH.

3.3.5.2 Pre-pilot study

Prior to the pilot study a pre-pilot study was conducted whereby a total of fifteen individuals were invited to participate; twelve individuals agreed to participate. These individuals were recruited from the same cohort that was used to recruit for the pilot and main study. These individuals were representative of the target sample population (severely obese help seeking individuals) according to age, gender and BMI. This was confirmed by checking the medical charts of those who agreed to participate in the pilot and comparing these to the most recently reported data on those help seeking severely obese (Somerville et al., 2015).

Objective of pre-pilot study

There were three primary aims to the pre-pilot study. Firstly it was used to test the design aspects of the DCE with particular reference to the restrictions imposed on the attributes at the experimental design stage as described in section 3.3.3.1. Secondly, given the previously discussed potential difficulty that people have in understanding risk, the pre-pilot used to test if and how well respondents understood the concept of risk, particularly when there were two risks included as attributes. Finally the pre-pilot was tested to see if the ordering of the choice cards, that is in what order each choice is presented had any influence on individuals choices. For example the ordering of choice cards can inflict a left-to-right bias when respondents are completing the choice cards (meaning the scenarios presented first are more likely to be chosen).

Administration of pre-pilot

Thus this pre-pilot presented two health risks (risk of developing diabetes and risk of heart attack) in the choice cards; each of which could be potentially reduced as a result of obesity treatment. The pre-pilot tests were divided into two surveys; survey one presented one health risk (risk of heart attack) as an attribute in the choice cards whilst survey two presented two health risks as attributes (risk of heart attack and risk of developing diabetes) -whereby all other attributes and levels were identical across both surveys. The aim was to establish and compare how people managed the interpretation of health risks. The risk of heart attack was used in survey one as this was deemed to be more important (relative to the risk of developing diabetes) in the focus groups. This pre-pilot also varied the layout of the choice cards, for example the status quo option was presented both on the far right and far left of the choice cards to determine if this impacted on peoples choice of the status quo option.

Pre-pilot findings

Analysis of the pre-pilot study highlighted five main issues for consideration. Firstly it showed that whilst respondents understood the concept of risk, as shown by the follow up questions to the risk tutorial, they experienced difficulty interpreting the health risk attribute in terms of whether the percentage risk of heart attack [as presented in the DCE] represented a percentage *reduction* in the risk of heart attack or whether it meant an *actual* percentage risk of heart attack. Secondly respondents experienced difficulty understanding risks when two risks were presented in one choice set. This was determined by examining the follow up questions relating to how the respondent felt about the choice cards in terms of ease of completion and comprehension. This showed that respondents struggled to disentangle the two health risks and found it too difficult to 'trade-off' between these risks and some even reported ignoring the health risk attribute as they could not decide between the two. It is also possible (and found) that some respondents in the survey may already have diabetes. Therefore a separate and different DCE would need to be presented to those respondents which included an attribute "the chance of diabetes remission" replacing the attribute “risk of developing diabetes”. This in itself complicates the survey, reduces the sample size and most importantly it increase the cognitive burden and complexity for the respondent. Additionally according to medical expertise it is very difficult to determine how much ones chance of developing diabetes could be reduced as a result of a specific type of obesity treatment and subsequent weight loss.

Thirdly the pre-pilot survey revealed that the restrictions imposed regarding what attributes appear within the same choice were too stringent and in essence failed to capture any independent effect across the attributes. When the choices were restricted there was very little variation in terms of the attributes and levels presented. Fourthly there were some misunderstandings in terms of the meaning of one of the attribute levels, namely bariatric surgery; that is, some respondents reported that they were confused between the different types of bariatric surgery available. Even though only one surgery option was presented in the choice cards, respondents needed more clarification as to what exactly that was. Finally the ordering of choice cards did not appear to have any impact on the choices made in terms of the status quo option.

Following the pre-pilot findings and further consultation with the literature and medical expertise some changes were made to the survey. These changes included removing the attribute *risk of developing diabetes* and presenting just one health risk within the choice sets, i.e. *the risk of fatal heart attack*. Other changes included re-writing the description that explains the interpretation of the risk of heart attack and also re-writing the explanation of bariatric surgery to ensure that these were defined more clearly, along with providing an information sheet. Finally the restrictions (such as bariatric surgery appearing only with a high amount of weight loss) imposed in the design of the choice cards regarding the attributes were removed. The pre-pilot surveys were not used in the analysis but proved to be a valuable source of information for this study. Using these findings every effort was made to ensure that descriptions of attributes were clear and concise going forward.

3.3.5.3 Pilot study

Next, the pilot study was conducted. Hensher et al. states that the use of 30-40 respondents "provides a feasible chance of receiving valuable data, proving a cost effective approach to collecting data" (Hensher et al., 2005). A total of fifty individuals were invited to participate in the pilot study; forty-one people gave their informed written consent to be included in the pilot study. These individuals were severely obese adults, recruited from the same previously described group. Using the database which stored the health details of the full sample size it was ascertained that these participants were representative of the severely obese population who seek help regarding their obesity treatment in terms of BMI and associated comorbidities. Table 14 below provides an overview of the demographic characteristics of the pilot sample.

Objective of the pilot study

The purpose of this pilot study was to further test aspects of the design including other sections of the questionnaire to determine if it needed further refinement or amendment. Another purpose of pilot surveys in DCEs is to provide prior information whereby the attributes generated from the pilot work will be used to further develop and update the experimental design for the main study. The statistically efficient design used in this study requires as much information as possible on the model parameters, which in turn enables a reduction in the number of respondents needed to achieve a given level of accuracy (Zwerina, 2013).

Administration of pilot study

The pilot study was administered 1-1 face to face using a pen-and-paper questionnaire in the presence of the researcher. The researcher read out the explanation for each section of the survey and the participant then completed the survey. Participants of the pilot study were encouraged to comment on the survey (upon completion); a brief questionnaire was administered after the survey which asked the participant questions in relation to the comprehension and layout of the survey and any other feedback they may be willing to provide.

Findings of pilot study

Findings from the pilot suggest that respondents understood the task at hand. This was ascertained from the post choice card questions on the survey. Of the 41 respondents, 29 found the survey either interesting and/or educational. Only two respondents found the survey difficult to understand and three respondents found the survey long. The results from the pilot questionnaire suggested that the survey flowed well and that it did not require any major changes. However some questions were removed from the survey and some descriptions were shortened to reduce the length of the survey. For example, one question which asked how often an individual exercised in the form of cycling was removed as this exercise was quite difficult for those who are severely obese. Otherwise the survey remained largely unchanged and thus was included in the analysis.

Table 14. Descriptive characteristics of pilot study (n=41)

Respondent characteristics	
Age (mean, sd)	48 +/- 10.78
BMI (mean, sd)	45 +/- 8.56
Female (%)	107 (68%)
Private Health Insurance	49 (49%)
Medical card	103 (66%)
Education	
3rd level university or equivalent	57 (36%)
Primary school only	40 (26%)
Secondary school (Leaving Certificate & Junior	60 (38%)
Relationship status	
Married or in a relationship	96 (39%)
Not in a relationship	61 (61%)
Employment	
Not working	17 (11%)
Working	66 (42%)
Homemaker	74 (47%)
Household Income	
Less than €7 800	36 (23%)
€7,800 - €15,599	23 (14%)

€15,600- €23 399	36 (23%)
€23,400- €31, 199	27 (17%)
€31,200- €46,799	12 8%)
€46,800- €62, 399	6 (4%)
€62,400- €77, 999	4 (2%)
€78,000- €116,999	1 (1%)
€117,000 and over	1 (1%)
Refused	9 (7%)
Comorbidities	
Type 2 diabetes	22 (46%)
Depression	60 (38%)
Hypertension	82 (52%)
Dyslipidaemia	27 (17%)
Sleep Apnoea	27 (17%)

3.3.5.4 Main study

A cross-sectional study with individuals with established severe obesity enrolled in lifestyle intervention program was performed. Participants were recruited while attending their first gym class at the beginning of this program and were asked if they would like to participate in the survey whereby signed informed consent was required. In many cases, these individuals have already gone through a 'diet career' whereby numerous attempts to lose weight on their own had generally failed. The survey was administered face-to-face during visits by the researcher to the local community care centre using paper based questionnaires in a private room. Surveys were completed within the first week of the ten week programme. Questionnaires took approximately 35 minutes to complete. For those who were unable to attend the community centre [n=5] to complete the survey it was administered elsewhere (3 administered in a hotel café in a private corner, 1 administered in a garage waiting room and 1 administered in a hospital waiting room). Confidentiality of responses was ensured with survey coding, and secured encrypted storage of data.

Additional information about the participants, including measured BMI and diagnosed illness information were abstracted from the participant's medical chart. However, in order to ensure that there were no sample selection issues, the patient charts were examined for those who refused to participate. However only that of age, gender, BMI and diagnosed medical conditions could be compared (information pertaining to socioeconomic details was not on the patients charts).

3.3.5.5 Questionnaire Outline

In addition to the DCE choice cards, supporting information was collected from respondents to assist in characterising the study sample. This section provides an outline of the survey questionnaire; the full questionnaire is attached in Appendix four. The questionnaire contained seven sections designed and ordered according to the principles of the Total Design Method (Dillman, 2011, Dillman, 1978). Because of the attention curve, the choice cards were presented near the beginning of the questionnaire and the socio-demographic and health care utilisation (HCU) questions positioned later in the questionnaire. Information such as the socioeconomic characteristics of respondents along with self-perceived health states as well as motivation-type questions (so as to gather insight into the intrinsic motivation of individuals) were obtained – all of which were piloted.

The first part of the questionnaire was used to introduce respondents to the questionnaire. Respondents were told that the study was being conducted on behalf of the National University of Ireland, Galway indicating the subject of the study, why the respondent has been chosen, who is carrying out the survey, and how the results will be used. Respondents were told that the questionnaire was about preferences around obesity treatment and their participation might prove important in the future on informing decisions about obesity treatment. This section was intended to be deliberately brief and not to present extraneous information to participants that might impact on responses and thus bias results or the sample of those agreeing to participate. Respondents were informed that they could withdraw at anytime

Section A: General attitudes towards the development of obesity treatments

This section includes only one question and was principally designed to introduce respondents to the questionnaire and to ascertain their personal opinions and attitudes towards the development of obesity treatments. This section also aimed to expose respondents to making trade-offs before the important valuation section [DCE] of the questionnaire. The question asks participants to indicate whether they thought the development of obesity treatments was less or more of a priority relative to other government health care spending areas such as mental health, paediatric care, cancer care, and disability care.

Section B: Probability tutorial and risk attitude

In this survey risk was communicated to respondents as an attribute in the choice card and we also elicited respondent's attitude towards risk, that is do they consider themselves to be a risk averse or risk seeking. With reference to presenting risk as one of the attributes it is important that respondents understand what is meant by risk. This is to ensure that they will be able to trade-off between all of the attributes and in turn to provide valid results. Therefore it was necessary to ensure that the concept of risk was understood by respondents. Following a review of the risk literature respondents were presented with a risk tutorial using visual aids. The purpose of this was to describe risk to the respondents with a view of ensuring that the respondent understood the concept of risk.

A tutorial developed by (Alberini and Chiabai, 2007) which was initially used to assess the WTP for reducing mortality risk for CVD and respiratory causes. In this tutorial the concept of probability was explained using simple examples of flipping a coin and throwing a dice, and then, increasing the degree of complexity and abstraction whereby respondents were shown a grid square, with red blocks representing the chances of suffering a fatal CVD risk, and white blocks representing the chances of not suffering any such risk. To test whether respondents understood the concept of probability, they were asked to choose among two hypothetical scenarios described by different fatal CVD risks. Those that understood the concept of probability would choose the alternative with the lowest risk, corresponding to the graph with the smaller number of red blocks. Respondents that failed this test were shown the probability tutorial once more until they understood the concept.

As mentioned this study also elicited respondents risk attitude. The questionnaire includes some questions regarding how risky and how impulsive the respondent perceives themselves to be. Respondents are asked to give an assessment of their willingness to take risks in general by ranking their risk taking measures on a scale of 1-10, 1 meaning the respondent is risk averse and 10 meaning that the respondent is risk seeking. A similar scale was used to elicit how impulsive a respondent might consider themselves to be.

Section C: DCE

In this section respondents were presented with the DCE choice cards, whereby each respondent was asked to indicate their preferred alternative in a panel of repeated choice sets – twelve in total. Each choice card presented three alternative obesity treatment options (including the status quo option). Each alternative was described by a specific amount of weight loss; the method of weight loss, the risk of a fatal heart attack, whether or not there is access to psychological support services and what the cost for this alternative might be to the respondent. Prior to these choice cards, the attributes and levels were explained to ensure that the respondent understood each of the attributes and the task at hand.

A number of 'warm-up' choice tasks were performed so as to ensure respondents' had an understanding of the task and as outlined by Carson to allow respondents "*to get a feel for the choice cards*" (Carson et al., 1994). One mock set of choice cards was presented to enable the respondent to get a grasp of the choice card. A dominant choice set that is a choice set in which one weight loss treatment is logically preferable was presented to assess the understanding of the questionnaire (rationality test). Respondents were asked some follow up questions regarding how they felt about the choice cards including if they ignored any attributes and how they would rank the attributes.

Section D: Health of respondent

Using the EQ-5D 3L questionnaire respondents was asked to rate their own perceived health "How is your health in general, is it very good, good, fair, poor or very poor". Also using the EQ-5D respondents were asked to rate their mobility, pain and discomfort, anxiety, depression and their ability to carry out usual care and routine activities. Respondents were asked if they had been diagnosed by a doctor against a list of various conditions including diabetes, hypertension, sleep apnoea, dyslipidaemia and depression. Finally respondents were also asked about their historic weight loss attempts. We had access to respondents' health chart which was used to confirm the self-reported illnesses and BMI.

Section E: Socioeconomic status

It is important to identify sources of variability across individuals (e.g. income, education, attitude towards health issues and health experiences) that could lead to important behavioural differences (heterogeneity). Therefore in addition to the choice cards, the respondents were asked some questions to indicate their socio-demographic status. Usually studies compare respondent characteristics between the study group and the general population.

Section F: Healthcare utilisation

In this section respondents were asked questions regarding their health care utilisation. The purpose of asking this was not entirely related to the DCE itself, rather to inform another aspect of the thesis that is chapter five that discusses the cost effectiveness of severe obesity treatment. For example respondents were asked if they visited the GP and other health services in the past 12 months and if so approximately how many times.

3.3.6 Stage 5: Data analysis

As outlined by Ryan et al (2008) the interpretation and understanding of choice models requires an understanding of the data (Ryan et al., 2008). Because the data matrix generated from DCE's is unique in terms of its panel like presentation this section provides an outline of how the data was entered and coded for this study. One feature common to DCE datasets is that respondents answer more than one discrete choice question, resulting in multiple observations for each individual. Further, choice sets presented to individuals contain two or more alternatives, giving multiple observations for each choice set. The number of observations in a dataset depends on the number of respondents, the number of choice sets per respondent and the number of alternatives in each choice set.

In this DCE each respondent is presented with 12 choice cards, each with three alternatives (Alternative A, Alternative B and Alternative C (status quo option). As each choice contributes three observations and each respondent faces 12 choices, there are 36 observations per respondent (12 choices x 3 observations per choice). All the variables were presented in a sequence that first describes how the data is organized (respondent identifier, choice set identifier), then the independent variables from the experimental design (attribute levels) was presented followed by the dependent variable (what option respondents chose). The dataset also includes other variables relating to the individual, such as socioeconomic characteristics, health status, attitudinal questions and health care utilisation.

Table 16 below shows a choice set for an individual who makes a choice among three alternative obesity treatments A, B, and the status quo -

alternative C; this table could be expanded in terms of columns for all other variables. For example, if interested in how the choices made are related to the cost of the alternative treatments and the incomes of the individuals making the choices. To record the choice made by the respondent in this example three rows of data were required. Each of the three rows represents a binary choice for a specific alternative (obesity treatment). The variable 'ID' identifies the individual, and thus the choice sets in this example. The variable 'Alternative' identifies the alternatives; A, B or C. Technically, this variable is not required, but having such a variable provides added flexibility for model specification. The variable 'Choice' represents the dependent variable. In this example it is a variable that indicates whether a particular obesity treatment alternative is chosen. This variable indicates the chosen alternative by the value 1 and the unchosen alternatives by the value 0. In this example, the variable 'Price' varies across the alternatives but obviously the variable 'Income' does not. Variables that vary across alternatives are called alternative-specific attributes. Socio-demographic variables that are constant across alternatives are called individual-specific attributes.

Table 15. Sample data recording for DCE

ID	**Alternative**	**Choice**	**Cost**	**Income**
1	A	0	€20	€23,400- €31, 199
1	B	1	€30	€23,400- €31, 199
1	C	0	€40	€23,400- €31, 199

3.3.6.1 Data Coding

As outlined previously in table 12, some of the attributes in this study are coded as continuous (amount of weight loss, risk of heart attack and cost) while others are dummy coded (access to psychological services). For the remaining qualitative attribute (method of weight loss) effects coding is used. For this attribute there are in fact two types of coding that could be deemed suitable; dummy coding and effects coding for attributes. A recent study indicated that both dummy and effect coding produce similar results in terms of the model goodness of fit but showed that the estimated parameters are different according to whether or not the attribute was dummy coded or effects coded which can lead to different value of WTP. (Hasan-Basri and Karim, 2013).

When dummy coding is used the effect of the L*th* level of the L-1 levels of an attribute which is converted into L1 dummy variables (each dummy is set equal to 1 when the qualitative level is present and set equal to 0 if it is not) becomes perfectly correlated with the constant term in the regression(Greene, 2003). Because the estimated β parameters are correlated with the constant β0, this introduces an identification problem since the utility associated with the Lth level of the attribute cannot be separated from other elements of utility incorporated in the constant term (dummy variable trap).

Effects coding is an alternative to dummy coding in which the effects of the L*th* level of the L-1 levels of an attribute are uncorrelated with the constant (Louviere et al., 2000). This forces the parameter value for the base category to equal the negative sum of the parameter values for the other estimated categories. Thus, the ‘left out’ category is not incorporated into the constant as in traditional dummy variable estimation. Hensher et al (2005) advocates the use of effects coding because along with the dummy coding correlation issue, dummy coding implicitly assumes that the reference level has a standard deviation of zero (Hensher et al., 2005).

Because the characteristic of dummy coding is that the estimated β parameters are correlated with the constant β0. This trait potentially introduces an identification problem since the utility associated with the Lth level of the attribute cannot be separated from other elements of utility incorporated in the constant term. For example in this study, with reference to the attribute – “method of weight loss” which is described by three levels; “diet and lifestyle modification”, “drug therapy alongside diet and lifestyle modification” and “bariatric surgery”; the use of dummy coding would mean that one of the levels (the level coded 0) would become correlated with the constant which in this case is the status. However effects coding does not have this disadvantage (Louviere et al., 2000) and allows an own interpretation for the estimated constant (as oppose to been correlated with the constant [status quo in this study]).

In effects coding, instead of assigning the baseline level to zero, effects coding sets it to the minus sum of the estimated levels (i.e. the sum of all levels should sum to zero). In order to explain this further the researcher draws on an earlier paper that examined effects coding (Bech and Gyrd-Hansen, 2005). An indirect utility function can be expressed as follows:

$$V_{im} = \bullet_0 + \bullet_1 D_{j1} + \bullet_2 D_{j2}$$

where V_{im} refers to the response of respondent *i* on choice card *m*, $\bullet_0$ to $\bullet_2$ are the estimated coefficients and D_{j1} and D_{j2} are the dummy variables. Only two dummy variables are included with three levels of qualitative attribute. The role of intercept (constant) (i.e. $\bullet_0$) is to capture the average effect on utility for all factors that are not included in the model. By using dummy coding values, the utility of respondent i for average effect on utility at basic level are indifferent at $\bullet_{0.}$ On the other hand, this is not the case in effects coding as the utility at basic level is estimated by $\bullet_0 \; - \bullet_1 \; - \bullet_2$ while the average effect on utility remains the same at $\bullet_0$.

3.3.6.1.1 The Selection of the distribution of the randomly varied attributes in the RPL model

The literature suggests the choice of the distribution seems to be based on choices by researchers that are not always clearly articulated or defended suggesting they may to some degree be arbitrary in nature (Train, 2008). This approximation may essentially be a function of how the researchers perceive reality. For example, if the researcher believes that the population has mixed opinions for a particular attribute, or policy development, then the researcher must select a type of distribution that will express both positive and negative signs (i.e., positive and negative preferences), e.g. a normal distribution. Indeed according to the literature the most common distribution is a normal distribution where β indicates the mean and indicates the standard deviation which represents the individual's tastes relative to the average tastes of the population (Hensher and Greene, 2003).

However a weakness of a normal distribution is that at the extremes it can include behaviourally inconsistent signs (Hensher and Greene, 2003). This limitation may not be relevant or applicable for all of the parameters in a study. However, for example, if the cost parameter is specified with a normal distribution, this runs the risk of retrieving extreme (negative and positive) estimates for marginal WTP. With respect to cost, a common way of dealing with it to assume this is fixed which implies that the scale parameter (which is the standard deviation of unobserved utility) is the same for all observations. In their paper Carson et al (2013) outline the motivations for advocating a fixed cost specification (Carson and Czajkowski, 2013) and as such were used to inform this DCE. Consistent with steps recommended by Hensher et al. (2005), for the estimation of RPL, at the beginning all the parameters except the cost parameter were specified to be normally distributed (Train, 1998; Revelt & Train, 1998).

3.3.6.1.2 Willingness to pay calculations

Before calculating the WTP, analysts have to make sure that both attributes used to calculate the WTP are statistically significant, otherwise the calculated WTP is meaningless (Hensher et al., 2005). For the CL model the ratio of the parameter in question and the cost parameter is the standard approach of deriving WTP in DCE's. However for those variables "effects coded", the numerator for the ratio is given by the difference between the two parameters representing the levels defining the unit gain. Appendix seven shows step by step WTP calculations for dummy and effects coded attributes.

WTP distributions may greatly vary depending on model specifications. There has been considerable debate with regards WTP estimations in which a number of approaches to measure WTP each with differential theoretical foundations and methodological implications have been presented and discussed in the literature (Train, 2003, Train and Weeks, 2005, Blumenschein et al., 2008, Crastes et al., DeShazo and Fermo, 2002, Hanley et al., 2001, Hensher et al., 2005, Lancsar and Louviere, 2008b). Unsurprisingly there is a debate in the literature as to what the most appropriate questionnaire format (e.g DCE or CVM), corresponding model and analytical technique might be for eliciting and measuring WTP.

One debate relates to the specification of the cost parameter, that is whether or not to hold it as fixed. Specifying the cost parameter as random runs the risk of retrieving extreme (negative and positive) estimates for marginal WTP. For example, depending on the choice of distributions (e.g. the cost parameter), this can lead to WTP distributions which are heavily skewed perhaps towards high values (Hole and Kolstad, 2012). Thus a relatively common approach to dealing with this [heavily skewed] issue, is to hold the cost parameter as fixed within the specified model (Hole and Kolstad, 2012) while the distributions for the other attributes may be specified as normal.

Earlier studies in the environmental literature for example (Revelt and Train, 1998) and (Goett et al., 2000) mention that using such a fixed parameter allows an easy derivation and interpretation of the distribution of WTP. Furthermore, with a fixed parameter, no proportion of the sample is predicted to have a positive parameter for price (Goett et al., 2000). Following this, the cost parameter in this study was held fixed. However, it is noted that there are limitations of holding this as fixed. For example, Scarpa and Rose (2008) state that assuming a fixed cost parameter is counter-intuitive and that preferences should vary across respondents with regards to cost (Scarpa and Rose, 2008), whilst (Daly et al., 2012) mention that relying on a fixed cost parameter may lead to inferior models by assuming no heterogeneity, and may lead to biases due to confounding the other parameters. By holding the cost fixed, this implies that the standard deviation of unobserved utility is the same for all observations. In other words, it may be unreasonable to assume that all individuals have the same preferences for price. (The researcher weighed this against other previously discussed limitations of holding cost as random and following guidelines of other authors, held the cost parameter as fixed).

For the RPL model this DCE used Krinsky and Robb parametric bootstrapping (Krinsky and Robb, 1986) method. This method is based on taking a large number of draws from a multivariate normal distribution with means given by the estimated parameters and covariance given by the estimated covariance matrix of the parameters. Based on a number of draws taken from the joint distribution of the parameters, simulated values of WTP can be calculated. A Normal distribution was chosen because (given the symmetric shape of a Normal distribution) it implies that both negative and positive signs for the parameters can be observed in the population.

3.3.1.1.3 Summary overvew of DCE models

The most widely used method to model choice among mutually exclusive alternatives has been the Conditional Logit (CL) model (McFadden, 1974), which belongs to the family of Random Utility Maximization (RUM) models. The main advantage of the CL model is its simplicity in terms of both estimation and interpretation of the resulting choice probabilities and elasticities. In general it provides an easy-to-handle estimation process but is limited to several assumptions. The most popular CL extension is the random parameter logit (RPL) model which estimates with respect to the panel nature of the data. The RPL allows parameters to vary randomly over individuals by assuming some continuous heterogeneity distribution a priori while keeping the CL assumption that the error term is independent and identically distributed (i.i.d) extreme value type 1. The Latent Class (LC) discrete choice model offer an alternative to RPL by replacing the continuous distribution assumption with a discrete distribution in which preference heterogeneity is captured by membership in distinct classes or segments. In effect, all individuals in a given class have the same parameters (fixed parameters within a class), but the parameters vary across classes (heterogeneity across classes). The models are similar in a way that they both incorporate heterogeneity in respondents' preferences on attributes. While the RPL assumes a continuous distribution of the parameters to introduce heterogeneity, the LC uses discrete classes to reach the same. In this thesis the CL, RPL and LC models are used to present findings, albeit the discussion focuses on the latter two.

3.3.7 Summary of methods

This section outlines the stages in the design and development of the DCE and provides an overview of the questionnaire administered. Designing and developing the DCE involved a lengthy phase of design and testing. The process began with a review of the literature. Next, to further inform the design of the DCE in terms of identifying and refining the attributes, focus groups and one-to-one interviews were conducted. Interviews and discussions were held with clinicians and obesity experts to develop levels for the attributes and ensure that the survey was accurate from a medical perspective. This section described the sequential Bayesian experimental design used to develop the choice tasks. In order to test the DCE in the field, it was subjected to pre-pilot and pilot surveys. Subsequent to the findings of these studies some changes were implemented to the DCE such that the pre-pilot surveys were not used in the main analysis and the pilot surveys were used in the main analysis.

3.4 Descriptive results

3.4.1 Introduction

As noted by De Vaus (2002) the examination of respondent demographic information can provide initial detail about the respondents and can provide a logical place to begin when analysing statistical data (De Vaus, 2002). This section presents some descriptive statistics from the DCE.

3.4.2 Study sample

The data which forms the basis of this chapter was collected over a 17 month period from May 2013 to October 2014 in a single-purpose survey. Every eight weeks a new group were enrolled and invited to participate in the study within their first week of enrolment. A total of ten groups of on average 23 individuals were approached to participate in this study (some participated in focus groups/pre pilot/pilot, of which were not asked to participate in the main study). A total of 192 individuals who were enrolled within their first week of an eight-week programme were invited to participate in DCE study. Out of this invitation 13 individuals declined to participate and four individuals did not show up to complete the survey, a response rate of approximately 90%.

Those who declined and who did not turn up were similar to those who completed the study for age and BMI, however no socioeconomic characteristics could be compared. A total of twelve people completed the pre-pilot study which was not used in the final analysis. This left a total of 163 individuals who completed the main survey. Of this 163, six individuals were excluded from the analysis for various reasons[22]. These six individuals had similar medical charts for BMI, comorbidities and age to those who were included in the DCE analysis. Also their socioeconomic profile was

[22] Two respondents with poor eyesight, one person left the survey uncompleted, two participants experienced a language barrier and one person had literacy difficulties

similar. Finally our survey observed the choices that 157 respondents made on 12 choice cards, resulting in a total of 1,884 observations. Table 16 below provides a comparison of demographics of those who participated and declined in this study with no material difference between those who consented and those who did not.

Table 16. Demographics of those who consented and declined in the study

	Participants who consented in the study	**Participants who declined consent in the study**
Female	67%	65%
Average age	48	50
BMI	47	46
Type 2 diabetes	57%	54%

3.4.3 Descriptive statistics of respondents

This section presents the demographic profile of the 157 respondents who completed the DCE and accompanying questionnaire. The results are presented in an order more conducive to analysis, and not necessarily in the same order as the questions appear in the questionnaire. In order to determine if the demographics of the sample in this study are similar to other published data regarding help seeking severely obese individuals a comparison of the demographic profile is provided, where possible, to Irish published data (Somerville et al., 2015) and international published data (O'Connell et al., 2010).

The majority of respondents in this thesis are female (67%), mainly because of a higher participation rate of women in lifestyle modification programs, as discussed in chapter one. The average age of respondents in the DCE is 48 years. The highest proportions (34%) of respondents are in the 45-54 years of age category, with only 7% of respondents 65 years of age or over, which may be a survival effect and 24% between the ages of 18 and 24. Almost two thirds of the sample reported being married (49%) or having a partner (13%), while 19% are single and 13% report themselves as divorced or separated. Almost 3% are widowed while the remainder (6%) are living with parent (s).

3.4.3.1 Age and gender of respondents

Figure 6 below shows that respondents were categorised into six age-groups. The majority of respondents were in the 45-54 age categories, which accounted for 35 percent of the sample (54 individuals) with a mean age of 48 ±10.80 years. As seen from Table 17, 45% of males were in this [45-54 age] category while only 29% of females were in this category.

Figure 6. Age of respondents

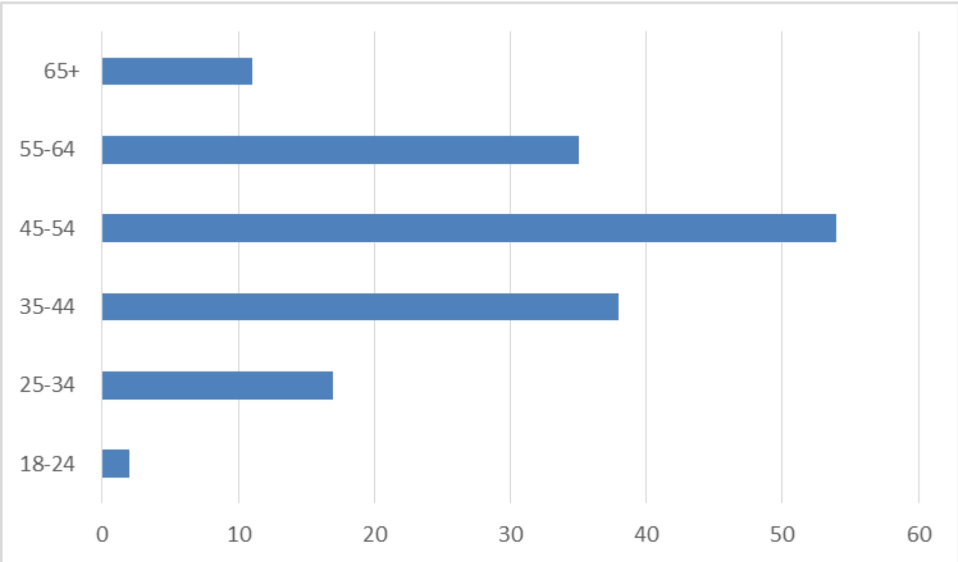
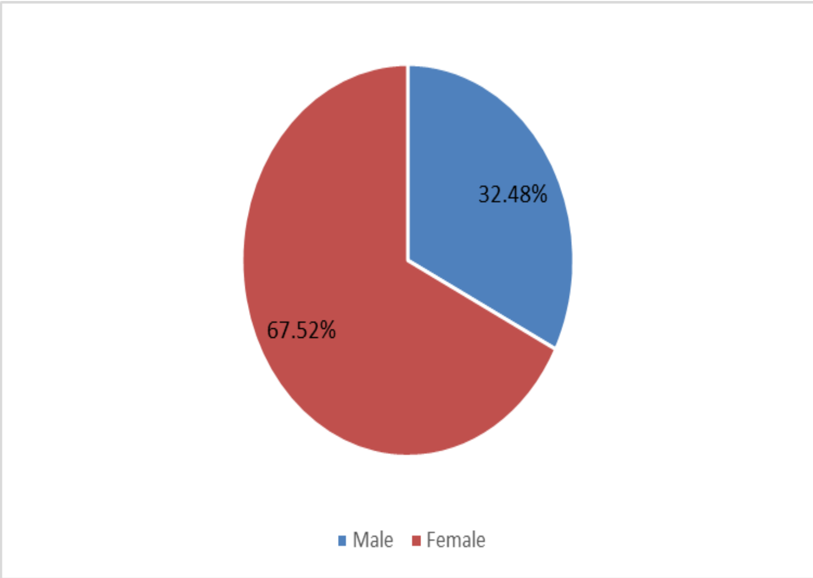


Table 17. Age category according to gender

Age category	**Total persons n (%)**	**Female n(%)**	**Male n(%)**
18-24	2 (1%)	2 (1%)	-
25-34	17 (11%)	16 (15%)	1 (2%)
35-44	38 (24%)	29 (27%)	9 (17%)
45-54	54 (34%)	31 (29%)	23 (45%)
55-64	35 (22%)	21 (20%)	14 (27%)
65+	11 (7%)	7 (7%)	4 (8%)
Total		106	51
Mean age Median	47.57 (SD 10.80) 47		
Range (min-max)	19-69		

Figure 7. Gender of respondents



3.4.3.2 Relationship status

Table 18 below shows the descriptive results of the mutually exclusive and collectively exhaustive categories regarding relationship status used in this DCE. The findings show that almost half of all respondents were married (49%). Across gender, 52% of females were married 43% of males were married. Overall, a little over 19% reported themselves as being single.

Figure 8. Relationship status of respondents

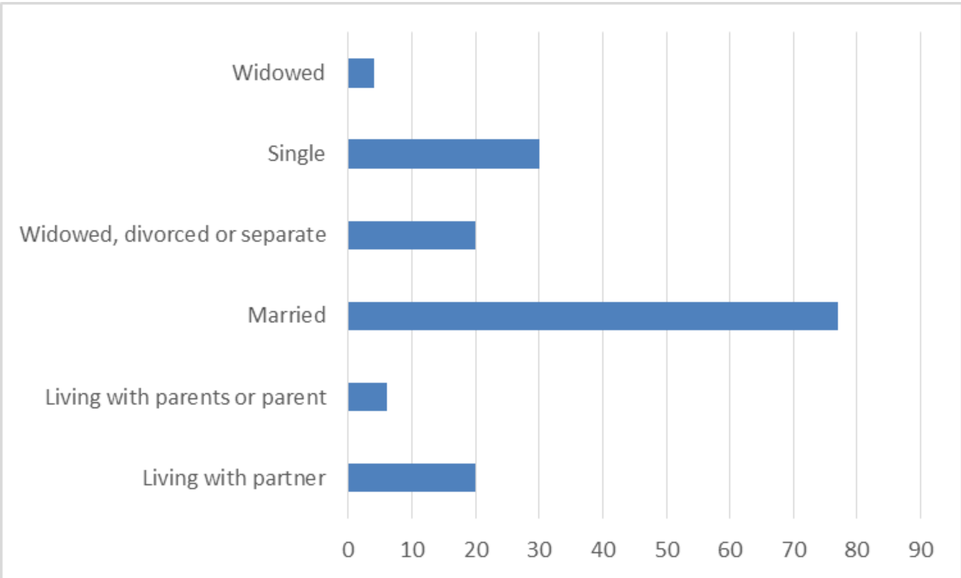


Table 18. Relationship status according to gender

Relationship status	Total persons n(%)
Married	77 (49.04 %)
Living with partner	20 (12.74 %)
Living with parents or parent	6 (3.82%)
Divorced or separated[23]	20 (12.74%)
Single	30 (19.11%)
Widowed	4 (2.55%)
Total	157

[23] Described as not currently living with the partner in which they were separated or divorced from

3.4.3.3 Education

Figure 9 provides a graphical illustration of the breakdown of educational attainment of this sample population. Accordingly, the share of respondents who have completed primary level education only is 4%, which are those within the older age category while the highest level of educational attainment for 35% of respondents is secondary school education. A total of 40% of respondents obtained a 3rd level University or college equivalent degree while 22% obtained some form of technical training between secondary school and University. Table 19 below shows the educational attainment.

Figure 9. Educational attainment of respondents

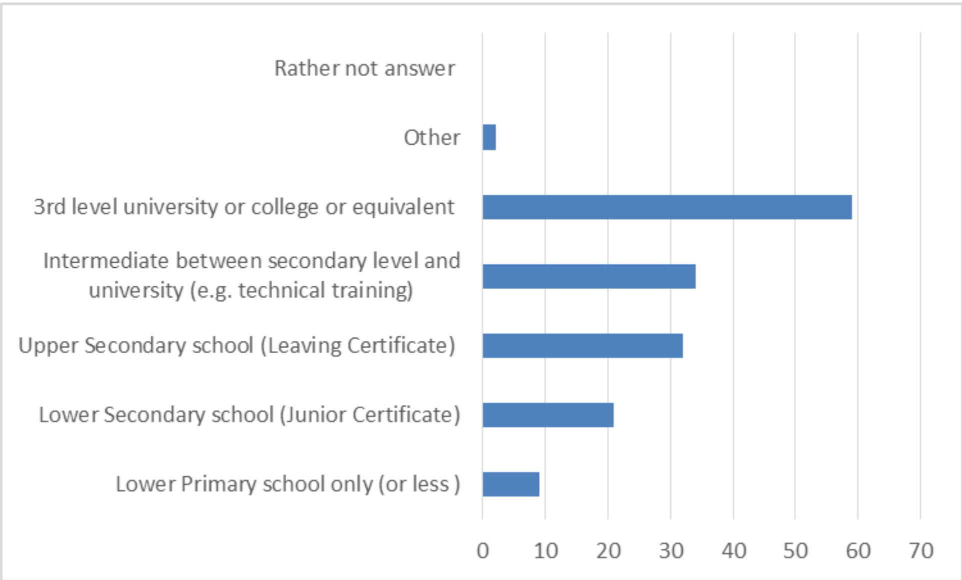


Table 19. Educational attainment

Educational Attainment	**Total persons n(%)**
3rd level university or college or equivalent	62 (40%)
Intermediate between secondary level and university (e.g. technical training)	33 (22%)
Upper Secondary school (Leaving Certificate)	34 (22%)
Lower Secondary school (Junior Certificate)	21 (13%)
Lower Primary school only (or less)	7 (4%)
Total	

Table 20 compares, where possible, the educational attainment of those with a BMI ≥30 in TILDA to the educational attainment of those in this DCE. It is clear that our sample population appear to be slightly better educated, for example with 40% of the sample population in this DCE obtaining a 3rd level degree or equivalent compared to 25% of the sample in TILDA obtaining either a diploma, degree or postgrad. Conversely 36% of the TILDA populations educational attainment was primary school only compared to just 4% of our study population.

One reason for this difference may be due to the fact that the TILDA study population may represent a different obese population to this DCE study population. This study captures the help seeking obese population which may not be the case in TILDA. Also TILDA are aged 50 plus which may account for this alone. As discussed in chapter one, studies have shown that there is a difference in those obese who seek help, for example, attending weight management clinics to those who do not. Although, that said whether differences exist in these two cohorts as regards educational attainment has not yet been quantified. However the educational attainment in this DCE is similar to another Irish study that describes help seeking severely obese individuals (Somerville et al., 2015). This is discussed further in table 25 below which provides a comparison of sociodemographic profile between this DCE and Somerville et al.

Table 20. Education attainment compared with TILDA

	This DCE	TILDA (BMI≥30)
Lower Primary school only (or less)	7 (4.46%)	35.58%
Lower Secondary school (Junior Certificate)	21 (13.38%)	23.65%
Upper Secondary school (Leaving Certificate)	34 (21.66%)	15.67%
Intermediate between secondary level and university (e.g. technical training)	33 (22%)	-
3rd level university or college or equivalent	62 (40%)	24.97%

3.4.3.4 Employment

This section examines the employment status of respondents in this DCE. The largest proportion of the sample of this DCE (24%) is employed. Table 21 presents the breakdown of the sample according to employment status across gender profile. From this we see that just 13% of females report themselves as being unemployed compared to men at 6%. Over half of the male population (51%) are employed either full time or part time, while 40% of females report being employed. Interestingly a quarter of all males report themselves as being unable to work due to health reasons.

Figure 10. Employment status of respondents

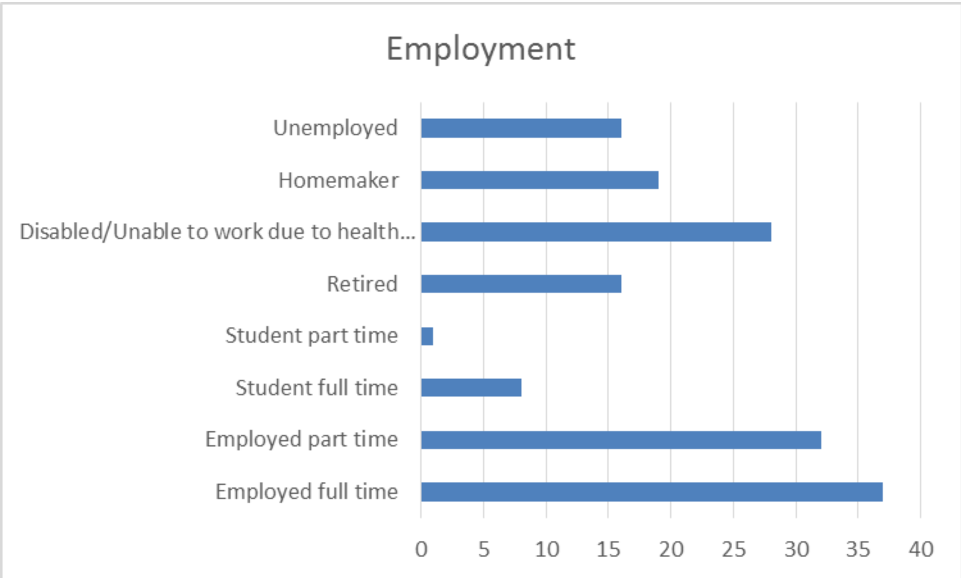
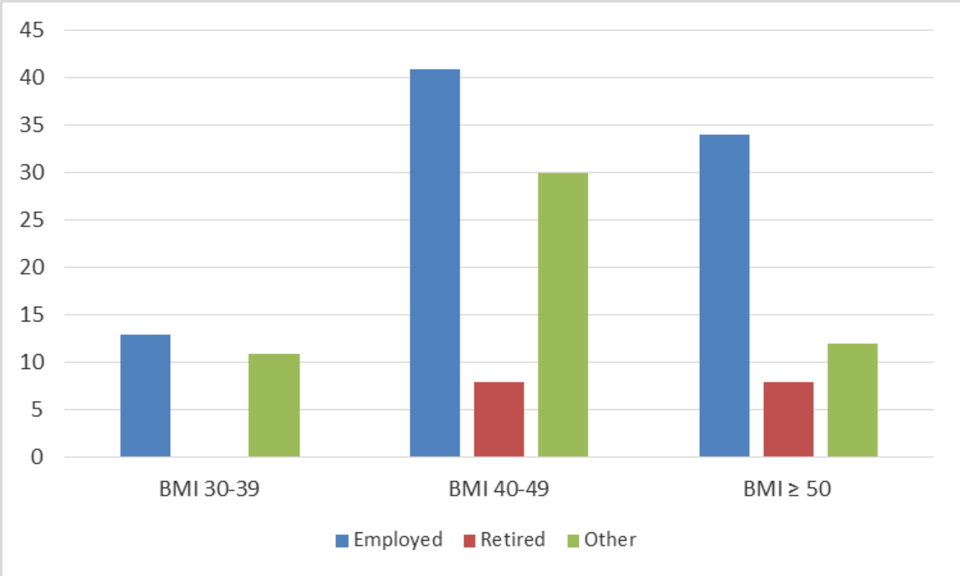


Table 21. Employment status according to gender

Employment	**Total persons n(%)**	**Female n(%)**	**Male n(%)**
Employed full time (30+hours/week)	37 (23.57%)	20 (19%)	17 (33%)
Employed Part time	31 (19.75%)	22 (21%)	9 (18%)
Student Full time	8 (5.10%)	7 (7%)	1 (2%)
Student Part time	2 (1.27%)	1 (1%)	1 (2%)
Retired	16 (10.19%)	11 (10%)	5 (10%)
Disabled/ Unable to work due to health reasons	28 (17.83%)	15 (14%)	13 (25%)
Homemaker	18 (11.46 %)	16 (15%)	2 (4%)
Unemployed	17 (10.83%)	14 (13%)	3 (6%)
Total	157	106	51

Figure 11. Distribution of BMI by employment status of respondents in DCE



3.4.3.5 Income

Table 22 summarises details of the respondents' household incomes in this DCE in which just under 60% of households report an income between €15,600- €46,799.

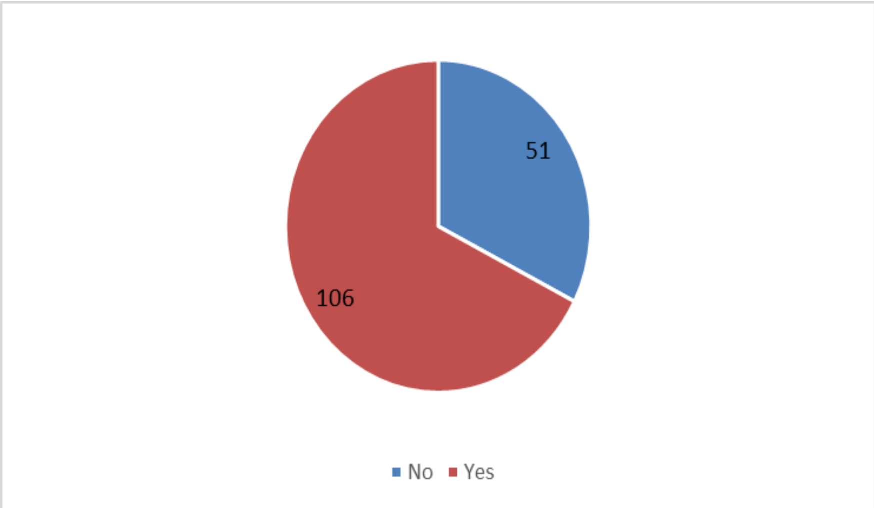
Table 22. Household income

Income	Household Income
Less than €7 800	8 (5.10%)
€7,800 - €15,599	20 (12.74%)
€15,600- €23 399	41 (26.11%)
€23,400- €31, 199	33 (21.02%)
€31,200- €46,799	20 (12.74%)
€46,800- €62, 399	10 (6.37%)
€62,400- €77, 999	6 (3.82%)
€78,000- €116,999	5 (3.18%)
€117,000 and over	2 (1.27%)
Not answered	12 (7.64%)

3.4.3.6 GMS eligibility and private health insurance

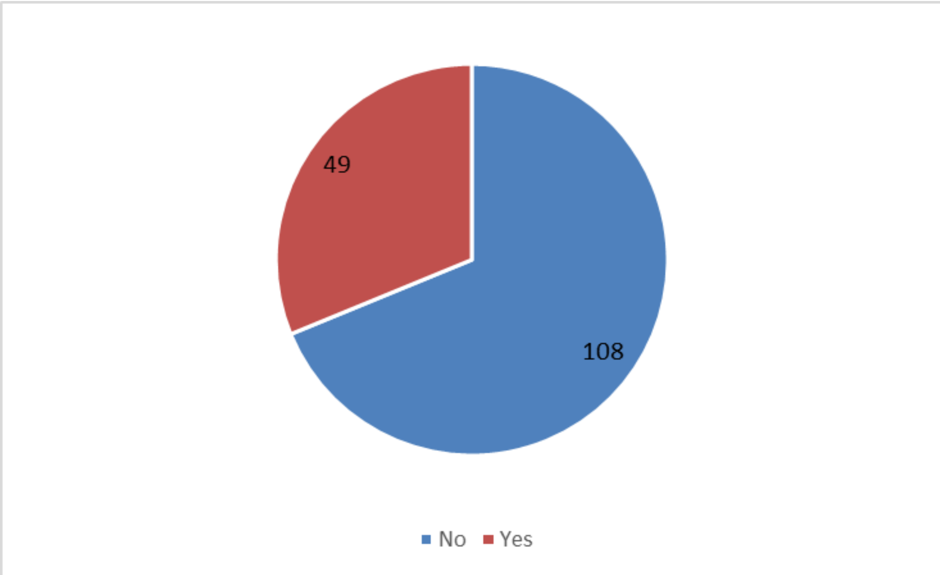
The findings from this study show that just over two thirds (68%) of the sample have medical cards as shown in Figure 12. Respondents may be entitled to medical cards by virtue of comorbid conditions and need for care e.g. diabetes.

Figure 12. Medical card status



Similar to the population at large, figure 13 below shows that about 30% have PHI - suggesting this group do not have tastes for healthcare that are atypical of the population at large.

Figure 13. Private health insurance status



3.4.3.7 BMI

This study uses measured BMI whereby the weight and height of all respondents was measured by medical professionals. In this study it was not feasible to compare measured BMI to self-reported BMI because at the time of meeting the respondents the majority of them had been informed of their BMI and carried it with them on a personal card. As outlined previously BMI is interpreted using standard weight status categories that are the same for all ages and for both men and women. In this study BMI is reported as per Class I obesity BMI 30–39.9-; Class II obesity; BMI 40- 49.9 Class III obesity; BMI $\geq$ 50. Figure 14 and 15 below shows the distribution of the BMI. Almost half (68 individuals, 43%) of the cohort have a BMI between 40 and 49, with a further 38% of the cohort having BMI ranges above 50.

Figure 14. BMI of respondents

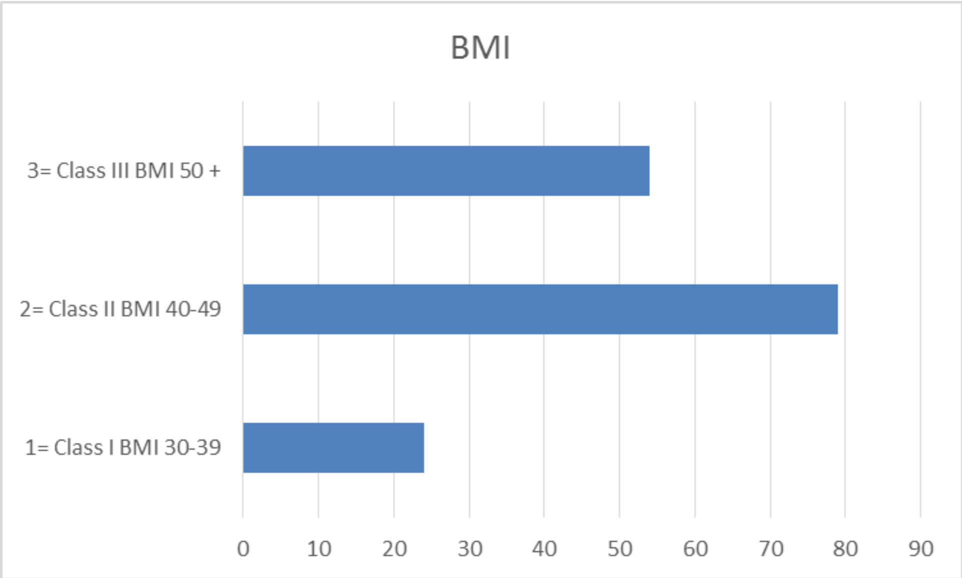


Figure 15. BMI distribution

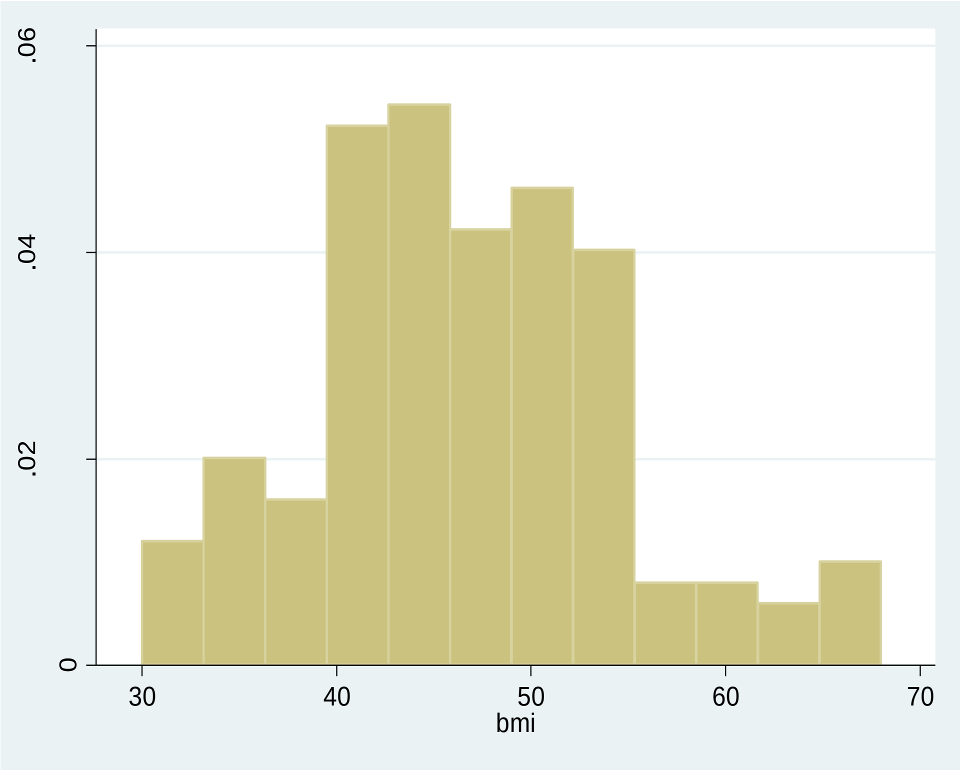


Table 23 below shows that over 50% of females had a BMI between 40 and 50, similarly with 49% of males having a BMI between 40 and 50.

Table 23. BMI according to gender

BMI	**Total persons** **n(%)**	**Female** **n(%)**	**Male** **n(%)**
30-39.9	24 (15%)	13 (12%)	11 (22%)
40-49.9	79 (50%)	54 (51%)	25 (49%)
50+	54 (34%)	39 (37%)	15 (29%)

In Table 24 below the socio-demographic profile according to the findings of the only other Irish study that examines a similar study population was compared (where possible); that is a severely obese help seeking population (Somerville et al., 2015). From this it can be seem that the sample characteristics are broadly comparable to this study. Somerville et al., (2015) uses data from the only other public weight management clinic which is located in Dublin. From this it can be seen that age, gender and marital status are similar across studies. While it is difficult to draw direct comparisons due to the different format of questions, there are similarities across the employment status, particularly with the percentage unemployed and also those reporting themselves to be homemakers or home carers.

Table 24. Comparison of sociodemographics across other published data

	Overall study sample (n =157)	**BMI $_{30–39}$ (class 1 obese)**		**BMI $_{40–49}$ (class 2 obese)**		**BMI $_{50}$ (class 3 obese)**	
		This DCE (n=24, 15%)	Somerville 2015 (*n* = 11, 6.3%)	This DCE (n=79, 50%)	Somerville 2015 (*n* = 68, 38.6%)	This DCE (n=54, 34%)	Somerville 2015 (*n* = 97, 55.1%)
Female (%)		67.5%		51%	66.2%	37%	62.9%
Mean age (years)	47.5 ±10.8 years	50.2 ±10.5 years	-	47.6 ±11.2 years	47.6	46.2 ±10.2 years	46.6
Marital status							

Married	49%	50%	-	46%	57.8%	54%	52.3%
Living with partner		21%	-	8%	-	17%	-
Living with parent (s)		0%	-	5%	-	4%	-
Separated/divorced		17%	-	15%	-	7%	-
Widowed		0%	-	4%		2%	-
Single		13%	-	23%	-	17%	-
Work status							
Full time employed		38%		15%		30%	
Part-time/casual employment		13%		27%		13%	
Unemployed		8%		10%		13%	
Home duties		8%		11%		12%	

Retired		17%		13%		4%	
Student		4%		4%		11%	
Disabled/unable to work due to health reasons		12%		20%		17%	
Level of education							
Primary		8%		3%	16.2%	6%	16.7%
Secondary		29%		33%	45.6%	41%	44.8%
Trade/apprenticeship/certificate		25%		20%	38.2%	20%	38.5%
3rd level degree		38%		44%		33%	

3.4.3.8 EQ-5D self-reported health

This section describes respondents' self-reported–health (SRH) according to the EQ-5D instrument. Permission was granted by the EuroQol Research Foundation to use these elicitation methods as part of this study. As can be seen from the Table 25, it can be inferred that most respondents report themselves as having some problems in particular with pain/discomfort and also anxiety/depression

Table 25. EQ-5D profile of respondents

EQ-5D profile	Mobility	Self-Care	Usual Activities	Pain/Discomfort	Anxiety/Depression
No problems	78 (50%)	137 (87%)	52 (33%)	31 (20%)	48 (31%)
Some problems	77 (49%)	20 (13%)	97 (62%)	120 (76%)	94 (60%)
Extreme problems	2 (1%)	0	8 (5%)	6(4%)	15 (9%)

3.4.3.9 Self-reported and measured health

An advantage of this study is that the researcher had access to respondent's medical charts. This allowed the researcher to compare self-reported and diagnosed medical conditions. From table 26 it can be seen that over 70% of respondents report themselves as being depressed albeit having not being diagnosed medically[24]. Similarly almost 80% of respondents report

[24] The Hospital Anxiety and Depression Scale (HADS) ZIGMOND, A. S. & SNAITH, R. P. 1983. The hospital anxiety and depression scale. *Acta psychiatrica scandinavica*, 67**,** 361-370., is a self-assessment scale and was applied by medical experts to detect states of depression, anxiety and emotional distress amongst those individuals within this study. The HADS is a fourteen item scale that generates ordinal data. Seven of the items relate to anxiety and seven relate to depression. Each item on the questionnaire is scored from 0-3

themselves as having hypertension with just under 40% of those haven been clinically diagnosed.

Table 26. Diagnosed and self-reported health conditions

Type 2 diabetes		**Depression**		**Hypertension**	
Measured	Self-reported	Diagnosed	Self - reported	Diagnosed	Self - reported
57%	57%	41%	69%	36%	79%

and this means that a person can score between 0 and 21 for either anxiety or depression. According to the scoring metric of this scale those who scored less than or equal to eight are considered not to be depressed or suffer anxiety based on their score. Those who score between eight and eleven are considered to be depressed and those who score greater than eleven are a cause for concern with regards their depressed state.

3.5 DCE results

3.5.1 Introduction

This chapter describes the findings of the DCE study undertaken in an Irish severely obese population sample and presents the empirical results of the econometric modelling estimations of individuals' attribute preferences from the DCE. This study aimed to explore the relative importance of various attributes of obesity treatment according to those severely obese while also establishing the WTP for such attributes. In order to analyse these preferences, a number of discrete choice models were estimated (Conditional Logit (CL) model, Random Parameter Logit (RPL) model and the Latent Class model) which were based on all 157 surveys from the sample of severely obese individuals. This study required survey respondents to repeatedly choose between a status quo option describing the current situation regarding their obesity treatment and two mutually exclusive alternatives that present different levels for the attributes of obesity treatment. This section begins with an explanation of the variables that were used in the study. The remainder of the section discusses the interpretation of estimates starting with the CL model, RPL model and finally, the LC model.

3.5.2 Definition and coding of variables

In order to better understand the derivation of the probability models and how the choice procedure works, it is useful to have a clear picture of how observations of discrete choices are represented and also how the attributes are coded. The variables used are presented in Table 27 and can be divided into two types. The first type refers to the variables that describe the attributes of the obesity treatment in the choice cards and the second refer to the variables that relate to respondents' socio-demographics.

As shown below in Table 27 the attribute variables have levels ranging from two to six levels. These attributes are explained previously in section 3.3.3 (methods section), however a brief outline is provided here. Three of the five attributes including the ‘amount of weight loss’ the ‘risk of fatal heart attack’ and the ‘cost’ attribute are coded as continuous variables thereby retaining the actual measurement units for these attributes. In this context the attributes cannot be compared in terms of their overall importance due to the different units of measure used, that is, weight lost as measured in stone; reduction in the risk of heart attack as measured in percentages and cost is described as Euros. That said and as discussed further on the magnitude of the parameter can be compared in terms of what was important in influencing individuals’ utility changes.

The next attribute ‘access to psychological services’ describes whether or not the obesity treatment provides monthly access to a psychologist which is coded as a binary variable; yes or no. The final attribute in this study ‘method of weight loss’ is described using three categories; D&LM, drug therapy alongside D&LM and bariatric surgery. Effects coding, a coding mechanism (discussed previously in section 3.3.6) was used to code this variable. Appendix seven (table 70) also shows the results of the estimated model using dummy coding for this attribute including step by step calculations of WTP when the attribute is effects coded (the WTP calculations differ slightly when an attribute is dummy coded – albeit produces the same WTP estimates whether dummy or effects coded).

The “status-quo” option in the choice cards represents the constant variable in this DCE. The ‘status quo’ option describes an alternative in the choice set which reflects the respondents’ current situation prior to them been referred to the programme in which they were enrolled in at the time of the survey. The enrolment to the programme only occurred a few days prior to the survey taking place (respondents were capture within the first week of enrolment). Subsequently, respondents were asked to imagine that it was a week earlier when they were *not* enrolled in any lifestyle programme and asked to imagine themselves making these choices as if it was the previous week; such that the survey was introduced by saying, imagine this was last week and you are not enrolled in any programmes. The respondent was asked to imagine themselves making these choices. This was stated at the beginning of the survey by the researcher and was also included in the survey description, along with a reminder of this in the section preceding the choice cards in the questionnaire. Considering that the respondents were very recently recruited to the program and within the first five days of the program, respondents were deemed not to be familiar enough with the program to give a valuation as if this was the status quo.

Within the status quo option, there is no cost or weight loss, however there is a 30% risk of fatal heart attack for this severely obese cohort as a result of not opting for any obesity treatment and continuing with current habits, which in this severely obese group place respondents at relatively high health risk. In this study the number of participants who choose the status quo option was extremely low, 4% (n=7) compared to other studies (e.g. (Ryan et al., 2014) whereby 26% of respondents opted for the current situation (status quo).

Table 27. Variable description

Variable	Definition	Type	Coded as
Weight loss	Amount of weight loss in 12 months as described using the metric stone	Attribute of DCE Continuous variable	(Stone) 0, 2, 4,6
Heart risk[25]	Risk reduction of fatal heart attack over a 10 year period	Attribute of DCE Continuous variable	(Percentage Risk) 5%, 10% 15% 20%, 25%, 30%
Cost	A monthly hypothetical cost imposed on the respondent to be paid into a hypothetical health fund for a 12 month period	Attribute of DCE Continuous variable	€20, €30, €40, €50, €65, €85
Psychological services	Whether or not the obesity treatment provides access to an on-site psychologist that the respondent would visit once per	Attribute of DCE Binary variable	Yes/No

[25] The current risk of fatal heart attack for those severely obese is described as 30%; this risk is presented within the status quo option. By undertaking an obesity treatment respondents can potentially reduce their risk of fatal heart attack **to** 5%, 10% 15% 20%, or 25%.

	month		
Method of weight loss	This describes the method in which the weight loss would be achieved as described by three levels; diet and lifestyle modification, drug therapy alongside diet & lifestyle modification and bariatric surgery	Attribute of DCE Categorical variable (Qualitative)	Effects coded (the reference category which is diet and lifestyle modification)
Status Quo	Describes the respondents current situation, that is, not participating in any obesity treatment	Constant variable in the DCE	Described as no cost, no weight loss, no access to services and a 30% risk of fatal heart attack
Age	The age of respondents was modelled as a continuous variable		
Gender	0 = males 1=females		
Working	This is described as 0 or 1; respondents who are working or not working. 0= respondents who are unemployed, unable to work, retired and students. 1= respondents who are working full and part time including		

	those who describe themselves as homemakers
Education	This is described as 0 or 1 which refers to whether or not an individual has a 3rd level education. 0= no 3rd level education 1= respondents who have a 3rd level University degree including Intermediate between secondary level and university (e.g. technical training)
Marital	This is described as 0 or 1; married or common law marriage [cohabiting couples] or not 0= respondents who are single, living with parents or parent, widowed, divorced or separated 1= respondents who are married or living together
Good health	Respondents' self-rate their general health according to a visual analogue scale which ranged from 1-10. According to this scale 0 represented the worst imaginable health state and 10 represented the best imaginable health state. We further categorised this continuous variable to represent the following; 0= respondents who rated themselves at 5 or <5 = poor or below average perceived general health 1= respondents who rated themselves at 6 or >6= good or above average perceived general health
Risk taking	Respondents' self-rate their risk attitude to describe themselves as either a risk adverse individual or a risk taking individual according to scale which ranged from 1-10. According to this scale, 0 represented an individual who

	perceived them self to be risk averse and 10 represented an individual who perceived them self to be risk taking. We further categorised this continuous variable to represent the following; 0= respondents who rated themselves at 5 or <5 = risk averse 1= respondents who rated themselves at 6 or >6 = risk taking
BMI	The body mass index (BMI) of respondents is based on a measured BMI and was modelled both as a continuous variable and categorical variable
Type 2 diabetes mellitus	This is described as 0 or 1; clinically diagnosed with type 2 diabetes or not. 0= respondent does not have type 2 diabetes 1= respondent has type 2 diabetes
Hypertension	This is described as 0 or 1; clinically diagnosed with hypertension or not. 0= respondent does not have hypertension 1= respondent has hypertension
Depression	This is described as 0 or 1; clinically diagnosed with depression or not. 0= respondent does not have depression 1= respondent has depression
Household Income	This is the respondents' gross household income is coded as 0 or 1; average or below average or above average

	0 = Less than €7 800 - €31, 199 1= €31,200 - €117,000 and over
Private health insurance	This describes whether or not respondents have private health insurance (PHI) or not 0= respondent does not have PHI 1= respondents has PHI
Medical card	This describes whether or not respondents have a medical care (MC) or not 0= respondent does not have MC 1= respondents has MC

3.5.3 Interpretation of the model parameter estimates

From the model outputs we can interpret the parameters in terms of the statistical significance, the size and the sign or direction of the parameters. Estimates found to have a positive parameter value show an increase in utility; consequently, any estimates found to have a negative parameter value show a decrease in associated utility. The sign of the parameters indicates how an increase or a decrease, or, in some attributes the availability or non-availability of a particular dimension of an attribute affects the likelihood that the respondent will choose an obesity treatment within which that attribute range exists. As stated previously WTP for each attribute is calculated as the ratio of parameters for the attribute (or level) with the parameter of cost, the results of which are presented further in section 3.5.9.

In this DCE respondents who were found not to consider all of the attributes were removed from the analysis to test if results might differ. Such behaviour was identified as per those respondents consistently opting or avoiding a particular method of obesity treatment. This analysis showed that seven respondents displayed this behaviour. The researcher completed the analysis including and excluding these seven respondents. The results indicated that excluding the seven respondents that displayed non-trading behaviour did not materially change the results. All results are therefore presented with the inclusion of these seven respondents.

3.5.4 Conditional Logit model results

The face validity of the CL model can be tested by examining the signs and significance of parameter estimates in relation to a priori hypotheses. That is that the model produces the expected sign, for example a negative sign would be expected for the cost attribute and also for the “risk of heart attack” attribute. As shown in table 28 below the CL model performed well in the sense that, the results from the CL model are in accordance with our priori hypotheses. All the parameters of the model were significant at the 1% level and had the expected sign, suggesting that all of these attributes influence respondents preferences for obesity treatment. That is, the respondents showed a positive preference towards more weight loss, they preferred access to psychological services compared to no access to psychological services.

Relative to diet and lifestyle modification as a treatment option; respondents showed negative preferences towards bariatric surgery. This may be a result of a form of risk aversion given the relative risks associated with any surgery compared to non-invasive treatment. Respondents also showed negative preferences towards choices that had a high risk of fatal heart attack and finally respondents preferred a lower cost treatment. Relative to diet and lifestyle modification respondents perceived a negative utility for bariatric surgery while a positive utility was perceived for drug therapy alongside D&LM (again relative to diet and lifestyle modification).

As per table 27 the parameter 'status quo' describes respondent's current lifestyle habits – (not participating in any obesity treatment). Table 29 shows that the size of the estimated value for the parameter "status quo" is the largest estimated value in this analysis. Furthermore it has a negative sign implying that respondents have a strong preference to engage in some form of obesity treatment. In other words, there is a disutility associated with the status quo.

Table 28 shows the estimated parameter values for two levels that are used to describe the method of obesity treatment that is, drug therapy alongside D&LM and bariatric surgery. As explained in section 2 the estimated parameter value shows the value of a change in utility from a respondent going from the baseline treatment, which is D&LM to either or these other two treatments. The results show that there is a negative utility associated with changing treatment from the base case, D&LM to bariatric surgery. On the other hand the results show that there is a positive utility associated with drug therapy alongside D&LM as indicated by the positive and significant parameter value.

The attribute "risk of fatal heart attack" has a negative sign which indicates that the higher the risk of experiencing a fatal heart attack, the less utility that a respondent will derive from a treatment scenario. In line with intuition, respondents expressed positive utility for the attribute 'weight loss' as interpreted from the positive sign, meaning that a respondent would obtain a higher utility from a greater amount of weight loss and subsequently be more likely to choose an obesity treatment with a greater amount of weight loss. Similarly a positive utility was expressed for an obesity treatment that provided access to psychological services.

The negative sign for the cost attribute indicates that the higher the cost to obtain some form of obesity treatment, the less utility is derived and the less likely the respondent would be to choose that scenario. This implies that the increasing cost for the treatment is associated with a disutility and that the probability of choosing any obesity treatment decreases as the cost increases. As outlined in section 3.3.6.2.1 there are limitations associated with the CL model and subsequently further models were estimated.

Table 28. Conditional Logit Results

Variable	Coefficient (***, **, * Significance at 1%, 5%, 10% level)	Standard error
Weight loss	0.121***	0.02
Risk of fatal heart attack	-0.026***	0.01
Access to psychological services	0.294***	0.06
Drug therapy alongside D&LM	0.227***	0.04
Bariatric surgery	-0.540***	0.05
Cost	-0.00***	0.00
Log likelihood function	-1525.22	
AIC	1.62656	
Bayes IC	1.62659	
Note ***, **, * ==> Significance at 1%, 5%, 10% level		

3.5.5 Random Parameter Logit Model

For the analysis an assumption that the attribute parameters for all attributes used in the study are normally distributed, except for the cost parameter and the constant [status quo] was undertaken A relatively common practice in the literature to date is to hold the cost parameter fixed in RPL models (Revelt and Train, 1998), which was the approach taken in this DCE. By fixing the cost parameter, the derivation of WTP estimates is computationally straightforward and results in the distribution of WTP to be the same as the distribution of the non-cost attributes. As outlined by (Revelt and Train, 1998) by fixing the cost parameter, the implicit cost for each attribute will be distributed in the same way as the attribute's parameters. WTP in this DCE therefore becomes a function of the other variables in the model which are assumed to be normally distributed and therefore make WTP normally distributed.

In order to examine whether or not heterogeneity exists in the sample the significance of estimated standard deviations of each parameter are examined from the estimation model. A significant standard deviation indicates that heterogeneity exists around the mean parameters[26]. Following on from this the possible sources of heterogeneity are identified by including some socioeconomic variables in the model.

[26] The significance of the standard deviations is calculated automatically by Nlogit

Table 29. Random parameter logit model results

Attribute	Coefficient (Standard Deviation)	Standard Error
Weight loss	0.289*** (0.526***)[27]	0.065 (0.058)
Risk of fatal heart attack	-0.094*** (0.133***)	0.019 (0.017)
Access to psychological services	0.692*** (1.328***)	0.150 (0.163)
Drug therapy alongside D&LM	0.472*** (1.305***)	0.126 (0.178)
Bariatric surgery	-1.821*** (2.273***)	0.261 (0.236)
Cost	-0.024***	0.003
status quo	-2.719***	0.340
R-squared	.44	
LL	-1169.35640	
AIC	1.25409	

[27] Standard deviation in parenthesis

Bayes IC	1.28939

3.5.5.1 Interpretation of the RPL model parameter estimates

Table 29 above shows the mean estimated parameters in the RPL model in which all the parameters of the model were significant at the 0.1% level and also the direction of the sign of the parameters is matching the sign direction as estimated by the CL model. In the output of the RPL model shown above, all variables except the status quo (constant) and cost (which is fixed) are specified as random, drawn from a normal distribution. In general, the sizes of the estimated parameter values are substantially larger as estimated by the RPL model compared to the CL model. This is in line with the literature, as described by Revelt and Train (1998) (Revelt and Train, 1998), the increase in parameter size is because of the fact that the parameters are normalized by the unobserved portion of utility, which differs across the two estimation approaches; i.e. explaining more of the unobserved heterogeneity so the error is smaller (as more is explained).

In general, the interpretation of the random parameters is much the same as in the CL model; however, the mean of the random parameter is the average of the parameters drawn over the number of replications from the chosen distribution (the normal distribution in this case). In comparison with the CL model, there are five additional variables in the output window. These are derived standard deviations of parameter distribution calculated over each of the number draws and as such relate to the extent of the dispersion around the mean of the parameter. Insignificant parameter estimates would indicate that the dispersion around the mean is statistically equal to zero. That would suggest that all information about the people's preference towards these variables is captured in the estimated mean. As noted by Rigby and Burton (2006) for an attribute to be declared as having no impact on choices, both the estimate of the mean and the standard deviation would have to be not significantly different from zero (Rigby and Burton, 2006).

However, as table 29 shows, this is not the case in this DCE where the estimated standard deviations of the parameters are statistically significant. This suggests that there exists heterogeneity in the parameter estimates across the sample population (around the mean parameter estimate). It can be interpreted that different individuals have different preferences that differ from the mean estimate for the sample population, in other words that there is unobserved heterogeneity. For example the RPL model shows that severely obese individuals have heterogeneous preferences for each of the obesity treatment attributes, in particular with regards the choice of method to treat obesity. The highest level of heterogeneity exists for the attribute that describes the method of weight loss, which is 'bariatric surgery', as evident in the significant and very large attribute standard deviation (2.27310***) relative to the mean estimate (-1.82124***).

3.5.5.2 The selection of the distribution of the randomly varied attributes

The choice of distribution is something that is widely debated in the literature. In this DCE all non-cost attributes were assumed to be independently normally distributed in the population with a mean and standard deviation, the latter reflecting the deviation in individual tastes relative to the average tastes in the population. Following Layton and Brown (2000) (Layton and Brown, 2000) and Revelt and Train (1998) (Revelt and Train, 1998), the cost parameter (cost) was not allowed to vary in the population.

3.5.6 Socio-demographic Interactions with RPL model

It is reasonable to assume that individuals seeking obesity treatment do not have identical socio-demographic characteristics and preferences for obesity treatment attributes may differ depending on socio-demographic characteristics. The results show a significant amount of heterogeneity with regards preferences for obesity treatment, not only in terms of the method of treatment but also with reference to all of the attributes estimated. For example, results from the RPL model show that bariatric surgery is negatively valued by respondents albeit quite a large standard deviation around this attribute suggesting heterogeneity around this preference. Thus some socioeconomic variables were interacted to explore this heterogeneity further.

As outlined in Table 30 below a number of socio demographic variables were used to help explain preferences according to for example age, income, and gender, some of which were significant in explaining choices. Table 30 provides [only] those attribute interactions that were estimated as being statistically significant in the RPL model. The results suggest that females do not exhibit as much of a negative preference for bariatric surgery as males. Those with a higher BMI also do not have as much of a negative preference towards bariatric surgery as those within the relatively low BMI category. Individuals who perceive themselves as risk taking individuals and also those who have a medical card do not exibit negative preferences for bariatric surgery compared to their respective counterparts. Conversely, older individuals show a relatively lesser liking or preference towards bariatric surgery compared to their younger counterparts.

In table 30 the first column on the left shows the attribute, to the right of which is the parameter main effects shows the parameter value as estimated from the RPL model for each attribute prior to any interaction. The next column shows the variable that was statistically significant when interacted with the attributes. For example age was statistically significant with both the attribute that describes risk of fatal heart attack and also the amount of weight loss. A brief discussion of this table is provided in the next section.

Table 30. Interactions and main effects with the RPL model

Attribute	**Parameter Main Effects** (Standard Deviation)	**Variable interacted**	**Interaction Effects** (Standard Deviation)
Risk of fatal heart attack	-0.094*** (0.133***)	Age	-.004*** (.131***)
Weight loss	0.289*** (0.526***)	Age	-.005 (0.526***)
Access to psychological services	0.692*** (1.328***)	Females	.861*** (1.09***)
Bariatric surgery	-1.821*** (2.273***)	Females	.696*** (2.135***)
Drug therapy alongside D&LM	0.472*** (1.304***)	Females	-.350* .927***

Weight loss	0.288*** (0.526***)	Risk taking	.206*** (0.526***)
Bariatric surgery	-1.821*** (2.273***)	Risk taking	.600*** (2.135***)
Weight loss	0.289*** (0.526***)	BMI	.013** (.523***)
Access to psychological services	0.692*** (1.328***)	BMI	.03065** (1.202***)
Bariatric surgery	-1.821*** (2.273***)	BMI	.054*** (2.240***)
Weight loss	0.289*** (0.526***)	Medical card	-.315*** (.523***)
Bariatric surgery	-1.821*** (2.273***)	Medical card	1.392*** (2.240***)
Non-random parameters in utility functions			
Cost	-0.024***		-.021***
Status Quo	-2.719***		-2.80***
Model fit			
R-squared	.4350350		.4405017

LL	-1169.35640		-1158.04157
AIC	1.25409		1.26862
Bayes IC	1.28939		1.37744

3.5.6.1 Age

The results for obesity treatment preferences as estimated using the RPL, presented in table 30, reveal a negative and highly significant interaction term between age and risk of heart attack. This indicates that those respondents who are older have a relative preference in choosing obesity treatments that have the lowest risk of heart attack, compared to their younger counterparts. This may be because they view the risk as more immediate.

3.5.6.2 Gender

With reference to the interaction of gender which was females, the findings show that compared to males, females have a less dislike towards bariatric surgery as an obesity treatment relative to D&LMs, This is indicated by the positive interaction term for bariatric surgery when interacted with females; prior to which bariatric surgery was negative in the main RPL model. Also, compared to males; females have a preference to choose a treatment that provides access to psychological services. There may be a number of reasons for this; it may be that women are more aware of the problems obesity brings to health and are subsequently more willing to look at surgical weight loss.

3.5.6.3 Risk taking

Because respondents who are risk taking may be less likely to be interested in reducing their health risk, this analysis sought to estimate if this was the case. In the DCE respondents were asked whether or not they perceive themselves as being risk taking or not. This variable was interacted with the main RPL model as shown in table 30. The findings suggest that relative to those who perceive themselves to be low risk taking; those who are high risk taking do not have a disutility towards bariatric surgery. This may also suggest that this sub-group are less concerned with the potential risk of surgery.

3.5.6.4 BMI

Individuals with a higher BMI have a positive utility for bariatric surgery as a course of obesity treatment compared to that of D&LM; compared to their lower BMI counterparts.

3.5.6.5 Medical card

Respondents with a medical card did not exhibit a negative utility towards bariatric surgery relative to those that did not have a medical card, as indicated by the positive value from the interaction effect.

To briefly sum up this sub-section, the RPL model is useful to explore heterogeneity; however one limitation in this regard is that the model assumes a continuous distribution of preferences, while peoples' preferences might cluster in some cases which led to the next step which was to estimate the Latent Class model.

3.5.7 Latent class model

A key issue when using a LC model specification is how many latent classes should be estimated for the model. In this study, models with a number of different latent classes were examined to determine what specification provides the best representation for this data. After comparing the model criteria (including the Akaike information criterion (AIC) and Bayesian information criterion (BIC) which penalise for additional parameters) across the different number of classes, it was found that 2 classes performed the best based on the model fit statistics as well as the signs and significance of the parameters. Initially five classes were however estimated and as the number of classes decreased, AIC and BIC decreased, indicating improved model fit. The results for the two class LC model are presented in Table 31 below.

It is common to examine differences between the parameter estimates and membership probabilities for the classes in LC models so as to get an overview of the differences in preferences between respondents probabilistically assigned to different classes. According to the LC model it can be interpreted that respondents within a certain class are assumed to have the same or similar preferences for the attributes whereas preferences are thought to differ between respondents assigned to different classes. Using this model table 31 shows that class two contains a slightly larger proportion of respondents with 56% of the sample allocated to this class compared to 44% of the sample probabilistically allocated to class one.

In general the results are similar to previous estimated models in terms of the direction of the signs of the parameter values (in terms of negative utility associated with cost and also the risk of heart attack) are thus are in line with our expectations across both classes. There is however one change with regards to the sign of the estimated parameter for bariatric surgery in class one. In this model, the results show a positive utility associated with bariatric surgery for individuals assigned to class one. The estimation results reveal that those respondents probabilistically assigned to class one have a preference for surgery, for cheaper treatments with access to psychological services.

Respondents probabilistically assigned to class two reveal that members of this have a preference for drug therapy, for cheaper treatments which offers access to psychological services, as indicated by the highly significant parameter estimates. In this class the attribute "weight loss" is no longer significant suggesting that the utility of the members of this class is not significantly influenced by the amount of weight loss that an obesity treatment may provide. Class two prefer drug therapy alongside diet and lifestyle modification as the method of weight loss compared to class one as per parameter signs. While it is not recommended to directly compare coefficients across classes, it is apparent that the main difference between class one and class two is in the preference for drug therapy alongside D&LM and bariatric surgery, cost and status-quo.

Across both classes the results indicate significant heterogeneity in preferences, as revealed by the differences in magnitude and significance of the utility function estimates in the two classes. In general the results show that all attributes, except for the attribute "weight loss" in class two are significant in both classes for obesity treatment attributes. Furthermore, members of both classes are not happy with their current situation as indicated by the large negative parameter estimate for "status quo". The size of this parameter is large which indicates that it is quite important.

Table 31. Latent class model results

	Class one		**Class two**	
	Parameter estimate	**Standard error**	**Parameter estimate**	**Standard error**
Weight loss	0.245***	0.037	0.029	0.036
Risk of fatal heart attack	-0.038***	0.010	-0.041***	0.010
Access to psychological services	0.394***	0.091	0.355***	0.107
Drug therapy alongside D&LM	-0.230***	0.072	0.965***	0.097
Bariatric surgery	0.399***	0.084	-2.153***	0.171
Cost	-0.008***	0.002	-0.017***	0.002
Status quo	-2.704***	0.449	-1.040***	0.251
Class Membership Probabilities	.443		.557	
LL	-1295.110		1284.206	
AIC	1.37920		1.27627	
BIC	1.42332		1.34391	

R^2	.38		.43	

The same socio-demographic variables [age BMI, risk profile and gender] estimated in the previous models are interacted with the above LC model so as to compare the two classes in terms of what influences the probability of membership. Table 32 below shows that the only socio-demographic factor that influences class membership is BMI; which was positive. Those within the higher BMI category are more likely to be probabilistically assigned in class one relative to class two. It is noted that bariatric is negative in class two whereas it is positive in class one. So perhaps those severely obese views bariatric as their only hope and are more inclined to opt for this relative to other treatments; whereas those in class two preferred drug therapy as a method of obesity treatment and also access to psychological services.

Table 32. Latent class socioeconomic interactions

	Class one		**Class two**	
	Parameter estimate	**Standard error**	**Parameter estimate**	**Standard error**
Weight loss	.246***	.037	.029	.038
Risk of fatal heart attack	-.038***	.010	-.041***	.011
Access to psychological services	.396***	.095	.352***	.109
Drug therapy	-.236***	.075	.962***	.094
Bariatric surgery	.409***	.086	-2.14***	.162
Cost	-.008***	.002	-.017***	.002
Status quo	-2.705***	.494	-1.04***	.255
Constant	-3.718**			
BMI	.06691*** (.02427)			
AIC	1.37856 2597.20719			
BIC	1.43738 2708.03024			
R^2	.3822531			

3.5.8 Model fit

As shown in Table 33 below the R^2 of the CL model (.43) and RPL with interactions (.44) indicates a good fit along with all of the parameters being statistically significant and consistent with intuition. Comparing the log likelihood (LL) across the CL and RPL model, table 33 shows that the RPL model has a higher level of parametric fit in which the LL decreases from -1525.22213 to -1169.35640 respectively, with the CL having a lower, i.e. better LL. A comparison of the AICs & BICs between the CL, RPL and LC model suggests that adding heterogeneity to the taste parameters leads to a model improvement. Lower AIC and BIC scores are preferred. Overall the RPL and LC models appear to perform similarly. From this it can be seen that there is not much difference in for example the R^2 across all models with the RPL having a slightly higher $R^{2.}$ In terms of ease of interpretation and best confirming with intuition the RPL model with interactions might be a preferred option for modelling findings for this thesis. That said the LC model also provides useful information that would be beneficial for policy in terms of describing cohorts of similar individuals.

Table 33. Model fit across models

	CL	**RPL**	**RPL with Interactions**	**Latent Class one**	**Latent Class two**
LL	-1525.22	-1169.36	1148.97	-1295.11	1284.21
AIC	1.63	1.25	1.26	1.38	1.28
BIC	1.63	1.29	1.39	1.42	1.34
R^2	.43	.43	.44	.38	.43

3.5.9 Willingness to pay

For this DCE the WTP estimates were calculated initially from the CL model in which the WTP for each attribute is calculated as the ratio of parameters for the attribute (or level) with the parameter of cost. Table 34 shows mean WTP estimates and confidence interval estimations (using the Krinsky & Robb method[28]). According to table 34 the WTP for the attribute "weight loss" is €12.12 per stone per month. This means that the respondents are on a monthly basis willing to pay €12.12 (in the RPL model) or €14.77 (in the basic CL model) or a higher €29.83 (in the LC model for class one) to obtain a one stone weight loss within a 12 month period. The respondents in this study are willing to pay €3.14 (in the basic CL model) or €3.93 (in the RPL model) or €4.66 (in the LC model) to avoid increasing their risk of heart attack within the next ten years by one percentage point. This appears low however it must be noted that this represents a 1% reduction in risk, which it itself it a relatively low reduction of risk.

According to the signs of the parameter estimates discussed earlier, estimates across both the CL and RPL model show that relative to D&LM respondents have a negative utility associated with bariatric surgery and a positive utility associated with drug therapy (relative to D&LM), which is not surprising given that these are help seekers and the help that they have sought thus far is diet and lifestyle modifications. However the signs of these parameter value estimates differ according to the LC model – for class one; 44% of the sample population. As shown in table 34 according to the RPL model and the LC model (class one) respondents are willing to pay €36.85 and €27.2, respectively to go from participating in a D&LM program to participating in drug therapy alongside D&LM program. Finally

[28] parametric bootstrap

respondents are willing to pay €35.19 (in the basic CL model) €29.09 (in the RPL model) and €11.11 or €20.69 (in the LC model) for a change in access to psychological. The Krinsky & Robb simulation cannot be undertaken using the LC model because the estimated variance matrix of estimates is singular.

Table 34 A comparison of willingness to pay across the models

Attribute	**CL**	**RPL**	**LC Class one**	**LC Class two**
Weight loss	€14.77	€12.12 €12.26 KR[29] (-30.56-56.44)	€29.83	(Parameter is not significant)
Risk heart	€-3.14	€-3.93 €-3.97 KR (-15.40-6.93)	€-4.66	€-1.66
Psych services	€35.19	€29.09 € 26.74 KR (-78.99 -130.18)	€11.11	€20.69
Drug therapy	€27.23	€36.85[6] €22.14 KR (-86.20-132.87)	€-27.93	€56.28
Surgery	€-64.68	€-102.14 €-79.32 KR (-265.78-98.21)	€48.57	€-12.55

[29] This represents the WTP using the Krinsky and Robb technique. Numbers in parentheses denote the lower and upper confidence intervals, at the 95% level, estimated using the bootstrapping procedure by Krinsky and Robb (1986).

3.5.10 Summary of results

This DCE was administered to a sample of severely obese individuals who were asked to state their preferences for obesity treatments in Ireland. Hypothetical obesity treatment scenarios were created by combining several selected attributes at different levels. The attributes included; the amount of weight loss, the risk of fatal heart attack, cost, method of obesity treatment and access to psychological service. All attributes were provided at various levels whereby the responses were analysed using various estimation models which showed all of the selected attributes to be statistically significant in influencing respondents probable choice of obesity treatment.

This DCE study shows that respondents do not opt for the status quo but rather opt for diet and lifestyle modification and or diet and lifestyle modification alongside drug therapy. Most respondents value some attributes positively, a sub-group however do not value bariatric surgery positively. Bariatric surgery is preferred less than diet and lifestyle modification, but is preferred more when comparing with the status quo option.

The findings with regards the other four attributes; amount of weight loss, access to psychological services and risk of fatal heart attack and cost are in line with intuition. Respondents show a positive utility towards a higher amount of weight loss and access to psychological services while showing a negative utility towards a high risk of fatal heart attack .When socio-demographic data is interacted with these it is found, again, in line with intuition that older respondents are more concerned about reducing the risk of heart attack as indicated by the statistically significant interaction term. Although the number of years of life lost would be higher for the younger respondents, this finding it may due to those older appreciating the risk of fatal heart attack more keenly.

Those with a higher BMI and also females have strong positive preferences to opt for treatments that offer access to psychological services. In general all three model estimates reveal a strong statistical significant negative utility for price parameter, implying that respondents are unsurprisingly more prone to favour a treatment with a lower price. Finally the findings show that respondents wish to change from their current situation, as indicated by the negative value of the 'status-quo' option. This is not surprising given they have opted for a programme that implicitly indicates dissatisfaction with the status quo. In this DCE respondents could have opted to have no cost imposed on them by choosing the 'status quo' option in all or any of the choice sets.

3.6 Discussion

3.6.1 Introduction

This section discusses the results of the DCE in terms of the parameter values estimated in this study. In the interest of brevity only findings from the RPL and LC models are discussed. The findings are initially discussed according to the RPL model followed by a discussion of the interactions that were undertaken as part of the analysis. Next, the results according to the LC model are discussed.

3.6.2 Random Parameter Logit Model

The results from the DCE support the focus group findings, with all attributes included in the DCE impacting on preferences. Overall respondents showed a positive utility towards achieving large amount of weight loss compared to a lower amount of weight loss; respondents valued access to psychological services compared to having no access; they showed preference toward reduction in the risk of heart attack; relative to D&LM respondents indicated a positive value for drug therapy and a negative utility towards bariatric surgery and finally respondents showed a preference for cheaper obesity treatments as indicated by the negative utility of the 'cost' attribute.

In order to provide an intuitive explanation of the results it is useful to refer to the health economics literature, in which there are a number of models; both formal and intuitive that attempt to model health behaviours (Grossman, 1972) including those models that have sought to frame obesity into economic theory and policy (Mann, 2008). From these, an intuitive framework, based upon expected utility is presented to understand how individuals may elicit utility from healthcare treatment, which in the context of this study is obesity treatment. In this regard, utility (and disutility) is elicited from the attributes of obesity treatment and the characteristics of the individuals will determine how these attributes are weighted in the utility function.

3.6.2.1 Risk of fatal heart attack

The parameter estimated for risk of heart attack is negative and significant, suggesting that respondents prefer alternatives with a low risk of a fatal heart attack ($p < 0.01$). As expected, respondents had a negative preference for programmes with no or little risk reduction for heart attack, whereas those resulting in a large reduction were preferred. Avoiding heart attack and its consequences were highlighted in the focus group as important to those severely obese. Although the findings in this DCE showed a seemingly low WTP for a reduction in heart attack, it must be noted that the reduction was for a 1% risk reduction only.

That said, the seemingly low WTP for a reduction in the risk of heart attack is similar to the findings of a study undertaken by Doyle et al (2012) (Doyle et al., 2012). In their study they use an on-line DCE survey to describe the preferences and WTP for obesity medications among people seeking weight loss in the United States and United Kingdom (Doyle et al., 2012). Risk is also incorporated as one of the attributes, i.e. health improvements described as a percentage of future health risk reduction. In their study health improvement was described as a % of future health risk reduction. The results show that improvements in long-term health risk reduction were not as highly valued by participants. Patients in the study were only willing to pay an additional £6.00/$12.50 for a weight loss treatment that reduced their risk of diabetes, heart disease, or stroke by 10% compared to another treatment that did not reduce the long-term risk. In their study the authors highlight this as a relatively low WTP and that the health risk reduction levels may have been unrealistically large (25% and 50% reductions in stroke, heart disease, and diabetes), leading participants to disregard health improvement relative to other attributes.

One reason for the seemingly low WTP may be as a result of the time period being too long or into the future (10 years). When people are asked about their WTP today for risk reductions that may start now and last into the future the researcher assumes that the respondents apply their own implicit discount rates to future benefits. An earlier study (Hammitt and Liu, 2004) implemented a stated preference survey in Taiwan to assess the impact of latency on the WTP to reduce environmental risks of chronic and degenerative diseases. In their survey, risks were characterised according to the latency period (the period over which the benefit is spread) whether they involved cancer or non-cancer risks and whether they affected the lungs or the liver. The latency period proposed in the scenario was 20 years. The results show that latency has a negative impact on WTP; the WTP to reduce latent fatal risk is about 25% smaller than WTP for reducing a similar though immediate risk. A CV survey in Japan to estimate current and future WTP for reducing mortality risk by 5 in 1000 (Itaoka et al., 2007). WTP for a future risk change was found to be significantly smaller than that for a current risk change.

3.6.2.2 Amount of weight loss

Findings from our study show that respondents' exhibit positive utility for weight loss with a WTP of approximately €12 per stone lost in weight per one month period. Although not directly comparable, but nonetheless similar in terms of WTP (Doyle et al., 2012) found that patients were willing to pay £6.51/$10.49 per month per percentage point of weight loss that a pharmacotherapy could provide. In their study participants placed a high value on weight loss and avoiding changes to their lifestyle. Participants in Doyle's study were of a slightly lower BMI ranging from

BMI 36 to BMI 37 across the three countries investigated. Conversely, as discussed below respondents in our study showed a negative utility towards the status quo option.

It is interesting that other studies show that the study respondents valued therapies that did not require substantial lifestyle modifications. In Doyle et al (2012) (Doyle et al., 2012) study and also Ryan et al (2014) (Ryan et al., 2014) respondents exhibit a positive utility towards their current lifestyle which as highlighted by Ryan et al (2014) indicates that respondents are willing to pay to continue with their current lifestyle rather than take up a lifestyle intervention programme. However it is known that most attempts in weight loss would require substantial lifestyle modifications (Foster et al., 1997, Klem et al., 1997). It is subsequently interesting to note that often policy makers are searching for the best policy approach to implement to an appropriate subgroup of the population; however as DCE's can show; certain subgroups of the population may reject such policies/interventions.

3.6.2.3 Method of obesity treatment

This study explored respondents' preferences for various methods of obesity treatments including drug therapy and bariatric surgery. The reference case for the method of obesity treatment was the conventional method of treatment, that is, D&LM. Option C in the choice cards in this DCE described the status quo alternative which defined the current lifestyle of this population; that is, not participate in any obesity treatment. The negative and significant constant [status quo] implies a general dislike for respondents' current lifestyle or indeed the consequences of this in terms of weight and health. This suggests that, everything else being equal, respondents prefer to change what they are currently doing rather than participate in their current lifestyle (which is described as not undertaking any lifestyle intervention). Unsurprisingly within this context certain lifestyle interventions are more likely to be taken up than others. There was a negative preference towards interventions including bariatric surgery, while those involving drug therapy were preferred; each of these obesity interventions was relative to D&LM. Within these preferences a significant heterogeneity existed.

Ceteris paribus a negative overall WTP implies respondents are worse off if the programme is implemented, and they would require compensation by that amount of money to remain on the same level of utility. For example, the negative WTP of –€79.82/month from a treatment with bariatric surgery implies they would have to be compensated by –€79.82/month for moving from a D&LM intervention to the new situation[bariatric surgery], to leave them on the same level of utility. This negative WTP was also found in a study by (Ryan et al., 2015) which showed that the negative WTP of –£2.61/week from a programme with healthy eating implies that everything else equal, respondents would be worse off if they moved from their current lifestyle to that new lifestyle intervention with a content of healthy eating, and they would have to be compensated for the move.

3.6.2.4 Access to psychological services

This study examined preferences for the attribute access to psychological services compared to no access to psychological services. As previously outlined a positive utility was shown by respondents towards this attribute "access to psychological services".

3.6.2.5 Interactions with the RPL model

The results of the DCE presented some notable remarks with reference to the heterogeneity that existed around the estimated coefficients. A number of variables were interacted into the RPL model; demographic variables included in the model were age and gender; some socioeconomic details including the medical card status; other variables relate to health and individual characteristics – BMI and whether or not the individual perceives themselves to be a risk taker. The results showed that age was a significant predictor of preferences. The older individuals significantly valued alternatives that offered a larger amount of weight loss. Older individuals also exhibited a stronger preference in choosing obesity treatments that reduce the risk of heart attack over the next ten years. In this instance it may be that the older respondents are exhibiting a low time preference[30] meaning that they tend to value future utilities more than present gratifications and thus in this context, would derive utility from a treatment that reduces the future risk of heart attack. This risk of heart attack may be a risk that is more appreciated or indeed more immediate to those older compared to those younger. Moreover, getting older might lead respondents to attribute less importance to long-term investments in health, since the future is seen as something that is relatively brief. In other words that the time period over which the benefits will be enjoyed is likely to be less.

As regards gender differences, the findings also show that relative to males females show a positive utility towards access to psychological services while also showing a negative utility towards drug therapy relative to D&LM as indicated by the negative coefficient sign. The gender distribution (64%-67% female) in this study may reflect the fact that weight concerns and dieting behaviours are more prevalent among women than men, or that women are more likely to be severely obese (Neumark-Sztainer et al., 1999) and thus weight loss initiatives may have higher female participation. In other words women are more likely than men to diet or try other weight-loss practices (Davy et al., 2006). Although the findings in this DCE did not

[30] Time preference refers to an individual characteristic that represents the rate at which a person is willing to trade a current satisfaction with a future benefit

suggest that females attached a higher value to weight loss, the findings *did* suggest that women attach a higher value to bariatric surgery as the method of obesity treatment. This is somewhat in line with the literature which shows that women disproportionately utilize bariatric surgery relative to sex-specific prevalence of severe obesity (Erickson et al., 2004, Santry et al., 2005, Santry et al., 2007).

One of the reasons for this may relate to fertility issues among females. As previously stated, obesity has been shown to adversely impact fertility. It is well established that weight loss is associated with significant improvement in many parameters of reproductive function. In particular, weight loss with bariatric surgery improves ovulatory function and menstrual regularity (in obese and severely obese individuals) (Jungheim, 2015). Musella et al (2012) investigated 110 women, identified with subfertility who underwent bariatric surgery and reported that 69% of those patients became pregnant, with greater weight loss and lower BMI being positively associated with pregnancy (Musella et al., 2012). This may be one of the reasons as to why females in this DCE study have a stronger preference than males in this study. In this study 42% of women were between the age of 25 and 44. According to many studies, reproductive age women comprise the majority of bariatric patients (Shah and Ginsburg, 2010).

Individuals with a higher BMI showed a positive utility towards access to psychological services. One of the reasons for this may relate to the established link between obesity and depression (Luppino et al., 2010) (as previously discussed) and the need to seek treatment therein. Additionally the individuals within the higher BMI category showed a positive utility towards bariatric surgery as the method of obesity treatment; the reasons for which may be twofold. Cawley (2006) describes how addictive behaviour, such as eating and physical activity patterns, that lead to obesity can be a result of inconsistent time preferences. People with inconsistent time preferences know that going to the doctor would be best in the long run but keep putting off such visits. If increased bodyweight is related to inconsistent time preferences, then one would expect people in higher BMI categories to postpone doctor visits unless they are forced to go to the doctor with, e.g., an acute disease. This may be the case here, that is, that these individuals have postponed earlier doctor visits and presented themselves to the clinic at a time when their BMI has reached severe or extreme levels whereby [severe obesity] this has instigated other health problems, such as, for example diabetes or sleep apnoea. Subsequent to presenting themselves to medical expertise they may (or may not) have been informed that the more conventional treatments (diet and lifestyle modification) may not be appropriate and that a more suitable treatment might be that of bariatric surgery. Thus it might be that the preferences that this DCE is capturing are also an echo of the medical sentiments. That said another plausible reason for this preference is that it might be the case that those in the higher BMI category have come to the end of their “diet-career” and now bariatric surgery is seen to be the last resort.

Those with a medical card compared to those with no medical card exhibit a positive utility for bariatric surgery whilst, paradoxically appear to be less concerned with the amount of weight loss as indicated by the negative value of the parameter. Those with medical cards are likely to be less well-off, of a lower socioeconomic status and may discount more heavily future benefits hence going after quick gains. In the context of those medical card holders often being sicker or having a chronic disease(s), how long an individual expects to live given they have a chronic illness may result in these individuals anticipating that they will die sooner therefore opting for the ‘quick-fix’ as it were. It might also be that it also be that they will face lower lost earnings associated with time off work recovering from the bariatric surgery operation or face lower out of pocket costs associated with any rehabilitative care.

Finally those who deem themselves to be risk taking have a positive utility towards bariatric surgery, whilst also exhibiting a strong preference towards the options that offer a larger amount of weight loss. A parallel can be drawn here between those who are older and those who deem themselves to be risk taking; both “cohorts” value or derive utility from large amounts of weight loss, but it might be that those who deem themselves to be risk taking have a high time preference (compared to those elderly in the sample) and together with their risk taking attitude want a quick fix and appear to discount the risks that are associated with bariatric surgery, which is not surprising given their attitude towards risk.

3.6.3 Latent class model

As previously outlined the latent class approach uses a different approach to the RPL and involves probabilistically splitting the sample population into a set of *unobserved* homogeneous segments. In other words the LC model yields unobserved (latent) classes of people. In general, the goal of latent class analysis is to ascertain the most parsimonious and interpretable set of classes (Huh et al., 2011). The goal of the latent class analysis in this DCE study was to identify distinct subtypes of individuals with respect to their preferences for obesity treatment. Also the same demographic and socioeconomic characteristics that were included in the RPL model were included in the model and only that of BMI significantly predicted membership of latent class.

Interestingly, the LC model show a positive utility associated with bariatric surgery for individuals assigned to class one (approximately 44% of the sample) and in line with intuition those within class one are those who are significantly more likely to be at the higher end of BMI. Also those in this class exhibit a negative utility towards drug therapy as a method of obesity treatment. Converse to class one, those in class two membership have a preference for drug therapy as a method of obesity treatment. Across both classes individuals exhibit a negative utility towards the status quo indicating that both classes wish to change their current lifestyle, which from the perspective of the respondent was imagined to be whereby individuals were *not* participating in any form of obesity treatment.

3.6.4 Other results from the questionnaire

While not the focus of this study this section discusses the demographics, self-rated health (SRH) and also the health care utilisation (HCU) of the study population in this study. As shown earlier in table 25, the study population was deemed representative of the overall clinic population when comparisons were made with published Irish data (Somerville et al., 2015) and also international published data (O'Connell et al., 2010).

3.6.4.1 Demographics

There is a larger percentage of females in the sample in this DCE. Research indicates that men do not find weight management programs to be appealing (Wolfe and Smith, 2002). When compared with women, men are less likely to intentionally engage in independent weight loss behaviors (Lemon, Rosal, & Zapka, 2009). A 2014 study from Kansas State University showed differences in health satisfaction between obese men and women. That study found that 72.8%–94.0% of overweight and obese men were satisfied with their health as compared to 56.7%–85.0% of overweight and obese women. This skewed male body perception hinders the likelihood of seeking healthcare advice (Fuchs et al., 2015).

Outcomes from the first UK bariatric surgery report (http://nbsr.co.uk/) suggest that women are more likely to come for surgery at an earlier age, even though studies in other surgical specialties have shown that women are sometimes at greater risk of adverse events following surgery. It is also interesting to ask that if obesity rates are the same for both sexes, why are women more willing to come for bariatric surgery more frequently than men. It is estimated that men make up 36% of the severely obese population in the United States, although they account for fewer than 20% of patients choosing weight loss surgery each year. The typical demographic profile of a bariatric surgery patient is a woman 35 to 49 years of age with private insurance who belongs to a higher socioeconomic class (Adams, 2008). This is a smilar profile to respondents in this DCE in which as already described the majority are female with under half of females (42%) between the age of 25-44, albeit a lower percentage of women have PHI. However this may be partially explained in the differences in healthcare systems between the US and Ireland (discussed further in chapter five).

A handful of studies have attempted to better understand men's views on weight loss and weight interventions. An earlier study interviewed 91 overweight/obese male workers aged 18-55 in the U.K. (Hankey et al., 2002). They found that men identified improved health as their primary motivator for losing weight, followed by improved fitness, increased well-being, and enhanced appearance. More recently, (Anderson and Funnell, 2010) conducted a study assessing weight loss motivations. They found that a desire to increase attractiveness, improve health, and build strength were important motivating factors for men. Overall, the results of these studies indicate that reasons for weight loss in men may differ depending on age, culture, and social class. This is important in the context of this study in terms of explaining why, for example women place a larger value on bariatric surgery as an obesity treatment option. If men are more concerned with increasing attractiveness and improving health it might be the case that men "dismiss" mental health or mental well-being as less important, a view that may help explain why women place a higher value towards access to psychological services.

3.6.4.2 Self-reported health (SRH)

The EQ-5D is a generic preference-based measure of health and is one of the most widely used instruments for estimating quality-adjusted life years (QALYs) within the context of economic evaluation. The EQ-5D is simple to administer and has been found to have higher completion rates in older people relative to other generic preference-based measures of health (Szende and Williams, 2004) . Surprisingly in this study those within a higher BMI seem to rate their health to be very good. Explanations for this may be due to the fact that society has become more tolerant of higher body weights: many overweight/obese adults do not perceive their weight to be a health risk (Gregory et al., 2008). There is also emerging evidence to suggest that some obese individuals do not perceive themselves to be overweight, particularly men (Kuchler and Variyam, 2003). Indeed, it may also be due to the fact that society has become more tolerant of higher body weights: many overweight/obese adults do not perceive their weight to be a health risk (Gregory et al., 2008). It may also be that they have taken longer to reach a severe obese state and have time to adjust in terms of their expectations of life. It could also be that they are a different phenotype who do not suffer the health related effects to the same degree or have adopted "coping" strategies such as minimising physical activity and staying at home to avoid contact with more normal weight individuals.

There is mixed evidence on whether or not obesity has a negative impact on SRH. Indeed the findings in this DCE study are in contrast to recent findings by (Somerville et al., 2015) which, using data from the public weight management service in Dublin, reported that the mean SRH and psychological well-being scores in the severely obese patients are substantially lower than in the Irish population at large. Their study suggests that much of the impairment in SRH seen in this population of severely obese patients can be explained by comorbidities. A recent study that used Irish data showed that being obese has a statistically significant negative impact on self-reported health, with these effects most pronounced for those who are most obese (Cullinan and Gillespie, 2015). In another study (Herman et al., 2013) which used data from the Canadian Community Health Survey (used self-reported BMI), shows that the prevalence of fair/poor SRH was higher for overweight/obese females and obese males and for underweight individuals, compared with their healthy weight counterparts; overweight males had a similar prevalence of fair/poor SRH to healthy weight males.

The findings of this study show that while respondents show that they wish to do something or take action about their obesity, as indicated by the negative utility value for the status quo parameter, there is significant heterogeneity surrounding what this “action” might be. In addition many respondents report themselves as being depressed. Within this regard a one size fits all approach to treating severe obesity as per recommended guidelines for bariatric surgery might not be appropriate, this however, is an established datum. The selection of suitable candidates for bariatric surgery is stringent; nonetheless the findings of this study might assist clinical guidelines in defining appropriate subgroups for potential surgery.

For example results from this study show that females, those with a higher BMI, those younger respondents and finally those who perceive themselves to be risk taking exhibit positive utility towards bariatric surgery whereas those older and who perceive themselves to be in good health exhibit the opposite utility. Further, prior to exploring the socio-demographics of the sample, the results showed there was a negative preference towards interventions involving bariatric surgery, while the intervention involving diet and lifestyle were preferred. This suggests that some respondents regard D&LM as the more acceptable solution for reducing weight, rather than surgery. The implication of this been that bariatric surgery is not a suitable line of treatment for this subgroup of respondents.

There may be many reasons for the slightly lower value attached to reducing the risk of heart attack (it must be noted that this attribute represents a 1%

reduction only). One notion may relate to the fact of whether or not the Irish population are aware of heart attack risk, it may be that individuals are inured to the risk of heart disease. A report entitled *A Picture of General Practice Research in Ireland 2010-2011 through Research & Audit Activity* that sought to examine heart disease risk awareness among females reported that 60% of females incorrectly identified breast cancer as the main cause of death while only 13% of females correctly identified heart disease. Thus it might be that individuals are not aware of the seriousness of the risk of heart attack and in turn have little appreciation for reducing that risk, when presented with other options. However as noted previously this finding is more than likely an artefact of the relatively little (1%) reduction in the risk of heart attack offered.

This section makes an effort to put all empirical findings together and discuss therein. To reiterate, the main objective of this DCE is to examine the preferences of help-seeking severely obese population regarding obesity treatment and to estimate their WTP therein. Overall, attributes exert different degrees of influence on choices with some exerting positive utility and others negative utility. This DCE shows that individuals do want to do something to treat their obesity as indicated by the negative values attributed to their current situation (status quo) of doing nothing. Nonetheless this finding may not be surprising given that this cohort comprises of help seeking individuals. That said, the key findings of this study relate to the heterogeneity that surrounds the preferences within this cohort and the implications therein, that is, how the sociodemographic profile of individuals may influence preferences and thus compliance to obesity treatment.

Considering the severity of obesity of this cohort and their indications of motivation to treat their obesity (as per negative status quo attribute) this cohort has been described by medical experts (FF) as "bariatric patients", in that they would be deemed suitable candidates for bariatric surgery. However, according to the results of this DCE, not all individuals in this cohort have a preference for bariatric surgery. Although bariatric surgery is preferred relative to doing nothing, it is least preferred relative to other treatment methods such as diet and lifestyle medication and drug therapy. Unsurprisingly those that *do* prefer bariatric surgery are those within the higher BMI category. In addition, those who have a medical card also prefer bariatric surgery and finally females also exhibit a preference for bariatric surgery compared to males. Broadly speaking the results suggest that those at the higher end of BMI may have exhausted options for weight loss, women may be worried about fertility and the medical card holders may not have to take time off work/loose material amounts of income.

In general the empirical findings from this DCE indicate that both socio – demographic as well as, for example how respondents rate their risk attitude and health status provide some meaningful results. These results might prove useful for policy makers and practitioners alike in the context of designing and allocating resources for obesity treatments for the severely obese population. For example given that the success rate of bariatric surgery among other things fundamentally depends on compliance to pre and post weight management initiatives in terms of food restrictions, this study has identified a subgroup within those potentially deemed suitable for bariatric surgery who exhibit preferences towards bariatric surgery when presented with alternative treatment options. These preferences might be deemed positive in terms of influencing compliance to obesity treatment. Thus, it poses the question of whether or not it would prove beneficial in focusing on providing access to bariatric treatment to, for example females with a higher BMI. That said, the underlying reasons for preferences for surgery may be different; as stated female preferences may relate to fertility issues and the benefits that this surgery can offer therein whereas those with medical cards who have a preference for bariatric surgery, this may relate to preferences for a quick fix regarding obesity treatment.

3.6.5 Conclusion

This DCE aimed to identify individuals' preferences and WTP values for several obesity treatment attributes in Ireland. The main motivation for studying individuals' preferences behaviour in terms of obesity treatment is the increasing prevalence of obesity alongside a range of ineffective obesity treatments that do not appear to be abating the issue, particularly considering the increase in prevalence of severe obesity. The literature review in this chapter identified best practise for conducting a DCE, including steps to be taken in the design and analysis of a DCE. Primary data of a DCE was analysed using a range of econometric models were applied including the standard C) model, RPL model and also the LC model to measure preference patterns among respondents.

The empirical results obtained from the RPL and LC models provide a number of insights to understanding consumers' choice behaviour. The results of the RPL model revealed a considerable degree of preference heterogeneity, even within such a seemingly similar group (in terms of their BMI levels and diagnosed medical conditions). Firstly respondents in this DCE exhibit a preference to change their current situation by choosing to participate in some form of obesity treatment. This finding cannot be taken for granted as other studies show the contrary, that is, people (including those overweight and obese) do not wish to alter their current situation. Although acknowledging that these other studies may not have been of people who have just enrolled in a lifestyle modification programme.

Secondly, considering that bariatric surgery is a recommended line of treatment for this (severely obese) cohort, this study shows that some respondents prefer other treatment options. Although respondents still have a preference for bariatric surgery relative to no treatment (status quo); when given the choice with the other two obesity treatments examined in this DCE (diet and lifestyle modification and diet and lifestyle modification alongside drug therapy), bariatric surgery is not favoured. The findings in this study might suggest that one person's view of bariatric surgery as an 'option' might be viewed by another person as a 'threat'. The latter may be due to preconceived thoughts or opinions of bariatric surgery and these respondents may undertake all attempts to avoid this surgery. This notion might be relevant in the context of motivating individuals to lose weight.

From this DCE it can be confirmed that one cannot afford to adopt a single approach for all severely obese individuals seeking obesity treatment. On the one hand, the evidence presents a class of individuals, those who prefer to askew surgery; these include those who perceive themselves to be in good health and also those who are older. On the other hand, there are those individuals that are keen on surgery, those who are females, more risk taking, within the higher BMI category and those who also have a medical card.

In interpreting the findings from this study, it is important to remember that valuing WTP using a DCE represents a monetary equivalence of preference. In this study cost was also found to have a significant impact on preference, with individuals showing a strong disutility to pay for the most expensive treatment scenarios. In conclusion treatment for obesity ranges from life style modifications, such as diet and exercise, to pharmacotherapy, and to surgical interventions with varying degrees of invasiveness. The effectiveness, safety, and costs of these interventions also vary and as this DCE shows, so too does the value attached, by its users to each of these treatments. This value and WTP by users must be borne in mind when designing and allocating obesity treatments to ensure that the obesity treatment in question is appropriate for that individual and also to ensure that a positive health outcome in terms of weight loss is achieved. As previously alluded to weight loss can significantly reduce the economic burden of obesity.

Indeed this thesis explores the many issues that relate to the economic burden of obesity in which chapter two explored how we assess this burden and this chapter providing an indication of how we might better understand individuals' values and behaviours so as to better understand, design and allocate resources to adequately treat obesity and in turn endeavour to abate obesity. It is also worthwhile to note that the costs of obesity are not only related directly to treating it or its related conditions; the economic burden of obesity can be somewhat less obvious and can manifest itself into a less palpable economic burden. The next chapter examines one of the indirect costs of obesity and seeks to ascertain its extent in Ireland; that is whether or not there is evidence of obesity stigmatisation in the primary education system in Ireland.

4 Obesity stigma

4.1 Introduction

While knowledge of the value and WTP for obesity treatment along with a certainty that the most accurate measurements of adiposity are being used to determine the economic burden of obesity is important; so too is knowledge of what the full extent of the economic burden of obesity might be, that is both the direct and indirect costs therein. As indicated in chapter one it is often the case that cost of illness studies exclude indirect costs which may lead to an underestimation of the full extent of the economic burden of obesity. As previously noted this thesis examines a number of topics that are relevant when ascertaining the economic burden of obesity in which a number of sub populations are examined. For example the previous two chapters examined obesity among older Irish citizens (aged 50 and older) and also the severely obese population. Another important group that warrant investigation are the younger population, that is the children who are obese, who, as discussed below are more likely to become obese adults in which a whole range of obesity related medical conditions manifest into adulthood.

There are however other non-medical indirect costs associated with obesity, one of which relates to obesity stigmatisation. This concept has been well documented in the healthcare sector in terms of medical professionals' stigma toward obese individuals and also in the employment sector in terms of those obese individuals obtaining lower wages and promotions; however obesity stigma in the early educational setting has been explored to a lesser extent. This chapter addresses this gap by exploring whether or not there is evidence of obesity stigma towards children by their primary school teachers.

The increasing prevalence of obesity including among children is well documented in the literature (Ng et al., 2014, Sahoo et al., 2015, Peeters et al., 2014, Heinen, 2014, Boylan et al., 2014) and previously noted in chapter one of this thesis. Also noted in chapter one (table 2) are the variety of health issues that obesity can give rise to - both physical and psychological in nature (Guh et al., 2009). Excess weight is associated with an increased incidence of CVD, type 2 diabetes mellitus, certain cancers and premature mortality (Swinburn et al., 2011, Pi-Sunyer, 1993, Pi-Sunyer, 1999). Studies show that some in society view obesity very negatively and tend to believe that people who are obese are "weak-willed" and "unmotivated" (Anderson and Wadden, 1999). Obese individuals are often aware of these negative views, and internalize them, putting themselves at risk for disorders of mood, anxiety, and substance abuse (Collins and Bentz, 2009). While many of the consequences for health may not become manifest until adulthood and even middle age, the stigmatization of obese people can give rise to adverse consequences even at a young age.

Stigmatization refers to negative attitudes that affect our interpersonal interactions and activities in a detrimental way (Brownell, 2005) and can become manifest in respect of verbal types of bias (such as ridicule, teasing, insults, stereotypes), physical stigma (such as grabbing, or other austricising behaviours), or other barriers and obstacles due to weight (such as medical equipment that is too small for obese patients, chairs or seats in public venues which do not accommodate obese persons). In this chapter the impact of stigmatization related to obesity in respect of assessed ability by teachers of children is examined. Thus this chapter seeks to establish if adiposity related to the child or its care giver impact on perceptions by teachers of the child's ability, when other factors including objective test measures are controlled for and; whether the role of adiposity is affected by other characteristics such as gender. There is work that demonstrates the intergenerational aspect of adiposity, using parents may well be acting as an instrumental variable. In other words, whether children who are obese or whose parents are obese are more likely to be assessed to be of lower ability than their non-obese peers. That is whether they are stigmatised in terms of ability by virtue of their body shape.

4.2 Literature review

This review identifies and discusses the literature that examines the role of adiposity in academic performance and also in influencing teachers' academic expectations for their child/pupil. The search for the literature was carried out in a pragmatic way using PubMed, Science Direct and the Cochrane Library. Search terms used were "obesity stigma" "teacher expectations" "teacher bias" and "obesity academic performance".

4.2.1 Measuring and defining childhood obesity

The issue with defining childhood obesity is that children's body fat content changes as they grow and is different for boys and girls (Moreno et al., 2011), meaning that a single categorisation cannot be used to define childhood overweight and obesity; each sex and age group needs its own categorisation. Thus childhood obesity has typically been defined in terms of relative weight for height and age according to sex (Lahti-Koski and Gill, 2004) . In this approach, cut-off points for overweight and underweight are defined as a set percentage above or below the standard weight for a given height in the individual's age and sex group. Although the standard weight is usually determined as the mean or median determined from a reference distribution for the population, the issue is that a variety of cut-off points have been proposed.

One classification system uses percentiles[31] in the reference growth curves[32] to define weight status with the 85th percentile commonly used as the cut-

[31] A percentile is the value of a variable below which a certain percentage of observations (or population) falls, i.e., the percentile refers to the position of an individual on a given reference distribution WANG, Y. & CHEN, H.-J. 2012. Use of percentiles and z-scores in anthropometry. Handbook of Anthropometry. Springer..

32 Many countries have developed growth reference charts by performing cross-sectional studies in children from birth into adulthood. This has allowed the construction of charts that indicate the normal changes in weight and height that would be seen in both girls and boys at different ages.

off point for overweight and 95th/ 97th percentile for obesity (Himes and Dietz, 1994, Barlow and Dietz, 1998). A more sophisticated measure of weight status involves calculating the Z (or standard deviation) score by subtracting the reference value from the measured weight and dividing by the standard deviation of the reference population (Kiess et al., 2004). A Z score of 2 or more (i.e. 2 SD above the median) is usually taken to indicate obesity. However, it is difficult to calculate without the assistance of a computer and a more difficult concept for lay people to interpret (Kiess et al., 2004). Figure 16 below provides an overview of the comparisons that can be drawn between the two methods of measurement; Z scores and percentiles, while figure 17 provides an outline of the cut-off points for each measurement. This chapter uses percentile cut off points.

The definition of childhood obesity (relative weight for height and age) provides a simple assessment process but it has a number of limitations. It is based on the concept that a certain level of deviation from the median or reference population weight defines obesity regardless of whether the median changes (Kiess et al., 2004). This limits its use in monitoring and surveillance as the reference curves are likely to vary between countries and may change over time within one country. In addition, it is arbitrary and has not been associated with any objective measure of obesity-related health outcome in children and adolescents. Another tool for identifying overweight and obese children is BMI, but because BMI for age relies on reference growth curves, this definition of overweight and obesity suffers from many of the same limitations as relative weight for height and age. Consequently a workshop organized by the International Obesity Task Force (IOTF) in 1997 concluded that some of these limitations could be overcome by developing a set of BMI percentile curves based on an international reference population and by defining cut-off points in relation to the percentiles that equates to a BMI of 25 kg/m^2 and a BMI of $30kg/m^2$

in adults. In doing so, the cut-off points for overweight and obesity are defined on the basis of a BMI percentile which has been associated with excessive risk of ill health in adulthood rather than being dependent on the median BMI value (Lahti-Koski and Gill, 2004).

The fundamental problem with defining childhood obesity is the lack of strong evidence for any one particular definition or cut off points; (i.e. percentile charts or z-scores). Similar to the previous chapter in this thesis which discussed the importance of using appropriate measures in measuring obesity, in the case of children this appropriate measures is also important but more so at the heart of the debate the calculation used to assess obesity measures in children. Although percentiles have predominately been used in measuring obesity in Ireland, like other countries, there is a lack of consensus about assessment criteria for childhood obesity and currently no agreed standards exist for assessing Irish children. That there is a lack of consensus as to which measure should be used, which has complicated empirical work and the comparison of findings from studies that use different measures. For example, an earlier study (Griffin et al., 2004) found that in a study of inner city Dublin children, the prevalence of overweight within the group differed between the standard definitions of weight status. The WHO has recommended the use of growth reference (or "growth chart"), mainly based on Z -scores of anthropometric measures, to assess children's nutritional status and growth (Cole et al., 2000) whereas the International Obesity Task Force (IOTF) recommends the use of percentiles.

Aside from the calculation debate, similar to the previous chapter the measurement debate is also relevant in the context of children with some earlier authors outlining central adiposity in children to be more relevant to health outcomes than overall adiposity estimated by BMI (Freedman et al., 1999). In this regard waist circumference has been advocated as a good indicator of central adiposity (Savva et al., 2000). In 2001, McCarthy et al. developed waist circumference percentile curves for British children using 1990 data in which waist circumference-for-age z-scores were computed (McCarthy et al., 2001). Also, cut-off points were estimated for overweight (including obesity) and obesity, using the 91st and 98th centile, respectively (waist circumference measurements were not available for this study).

Figure 16. Comparison of percentiles and Z-scores in anthropometry

	Percentiles	Z-scores
1. Definition	The percentage of observations (or population) falls below the value of a variable	The number of standard deviation (SD) away from the mean, when the distribution is normal
2. Scale	Rank scale	Continuous scale (from $-\infty$ to ∞)
3. Strengths	(a) Intuitively more understandable (b) Indicating the expected prevalence	(a) Allowing comparisons across ages and sexes (b) Able to quantify the extreme values (c) Good for assessing the longitudinal changes in growth status
4. Limitations	(a) Not comparable across different anthropometries (b) Extreme values are lumped to the highest/ lowest percentile (c) Not suitable for assessing longitudinal growth status	Difficult to perceive than percentiles, especially for the public
5. Under normal distribution, a percentile must correspond to a fixed Z-score.		
Following is a list of usually used percentile-Z-score conversion values.		
	0.2nd	−3
	2.3rd	−2
	2.5th	−1.96
	5th	−1.64
	15th	−1.04
	16th	−1
	50th (median)	0
	84th	+1
	85th	+1.04
	95th	+1.64
	97.5th	+1.96
	97.7th	+2
	99.8th	+3

This table lists the key definitions and scales of percentiles and Z-scores, and compares their strengths and limitations. In practical setting, users would often face the task to convert Z-scores to percentiles or vice versa. Thus, this table also shows the corresponding values between percentiles and Z-scores

Figure 17. WHO use of percentiles and Z-scores, cut off points

Table 2.2 The 1995 WHO growth reference: use of percentiles and Z-scores

Outcomes	Anthropometric measures and cut points	Indication of growth/nutrition problems
Infants and children (<10 years)		
Stunting	HAZ < –2 *Z* score, or <3rd percentile	Chronic malnutrition
Wasting/thinness	WHZ < –2 *Z* score, or <3rd percentile	Acute malnutrition, current malnutrition
Overweight	WHZ > 2 *Z* score	Overweight
Adolescents (> =10 years)		
Stunting	HAZ <–2, or <3rd percentile	Chronic malnutrition
Thinness	BMI-for-age < 5th percentile	Underweight
At risk of overweight	BMI-for-age > =85th percentile	Overweight
Obese	BMI-for-age > =85th percentile and triceps and subscapular skinfold thickness-for-age > =90th percentiles	Obesity

This table summarizes the cut-points of percentiles and Z-scores to define problematic growth status in children and adolescents when using anthropometric measures. These cut-points based on statistical distribution are often adopted by other growth references/standards including the recent new WHO growth standards and references

HAZ: Height- or length-for-age Z-score; *WHZ*: Weight-for-age Z-score; *BMI*: Body mass index (WHO 1995)

4.2.2 Adiposity and academic achievement

Academic achievement is understood as an educational-related term associated with the extent to which pupils achieve their educational goals (Armstrong, 2006). The relationship between adiposity and academic achievement has been examined in a number of studies and at a very basic level, two broad streams of literature have emerged, reporting mixed findings of the impact that adiposity has on academic attainment. The two streams of literature include studies that examine the relationship between adiposity and *actual* academic achievement and more recently studies that examine the relationship between [pupils] adiposity and teachers academic *expectations* therein; in other words if teachers' academic expectations of obese children differs to that of the non-obese children and how this might impact on academic attainment. Although this chapter is primarily concerned with the latter, it is useful to discuss the evidence regarding adiposity and *actual* academic achievement; which may potentially be the basis on which teachers expectations are formed.

On one hand a number of studies suggest that overweight and obese students are no less academically able their non-obese counterparts (Kaestner et al., 2011, Carter et al., 2010, MacCann and Roberts, 2013), whereas on the other hand a number of studies indicate that adiposity is inversely associated with academic achievement (Sabia et al., 2009, Gunstad et al., 2007) indicating that obese students tend to obtain lower school grades than non-obese students (Huang et al., 2006b, Karnehed et al., 2006, Sabia, 2007). The differences in findings may relate to a number of factors including whether or not actual ability was controlled for in the study; if obese students obtain lower grades – the differences in grades would be accounted for by ability which would mean that they *are* less academically able. Another reason, which is key to this chapter is that it may be due to systematic differences between groups unrelated to ability such as prejudice against heavier students by teachers.

It is clear from the literature that the adiposity – academic relationship is a very complex relationship in which adiposity may effect academic attainment in both positive and negative ways - through a mechanism that is currently poorly understood. For example, Grossman and Mocan (2011) have noted the number of ways in which obesity may affect academic attainment (Grossman and Mocan, 2011). First, peers and teachers may discriminate against obese children and this will adversely affect educational achievements. Second, obesity may affect health in ways that lower achievement. Obesity is associated with sleeping disorders, depression and these illnesses may result in poor cognitive functioning and more missed days of school. For example, a recent systematic review (Caird et al., 2011) suggested that obesity may result in poor mental health outcomes such as low self-esteem or depression, which in turn impact upon educational attainment. Third, obesity may affect how children spend their time and specifically how much time they spend studying. Obese children may spend less time in physical activity and engaged in social activities, and as a result, spend more time studying, which suggests that obesity may positively affect educational achievement. Another point highlighted by Sabia (2007) is that poor academic performance may cause psychological stress, which reduces one's appetite and resultant body weight (Sabia, 2007). The issue is, if obesity lowers educational attainment, this will, among other things, worsen the already significant health problems of obese persons given the protective effects of education on health (Grossman, 2006). While often conflicting, an overall pattern emerges from the research evidence suggesting that there is a weak negative association between obesity and educational attainment in children and young people; i.e. that higher weight is associated with lower educational attainment (Datar and Sturm, 2006, Datar and Sturm, 2004, Datar et al., 2004, Kamijo et al., 2012).

A recent study reported that obese children tend to perform poorer academically than normal-weight children (Black et al., 2015). Reporting similar findings using the BMI-for-age growth charts Kamijo et al. (2012) provided an empirical basis for the negative relationship between BMI and scholastic performance (Kamijo et al., 2012). The study evaluated the association between adiposity and cognition (cognitive control and academic performance) in 126 preadolescent children aged 7-9 years. The WRAT3[33] was used to assess academic achievement in the content areas of reading, spelling, and maths. Multiple hierarchical linear regression analyses with WRAT3 as the dependent variable were used, controlling for confounding variables (age, sex, IQ, SES, and maximal oxygen

[33] The WRAT3 is a paper- and pencil-based academic achievement assessment that has been age-normed referenced and has been strongly correlated with the California Achievement Test–Form E and the Stanford Achievement Test WILKINSON, G. S. 1993. *WRAT-3: Wide range achievement test administration manual*, Wide Range, Incorporated.

consumption[34]) with weight status measures added to step 2 of the analysis. The study reported that higher BMI was associated with poorer academic achievement scores. However, causation is not inferred here.

Similarly Datar et al. (2004) reported association but no causation when they examined the relationship between *overweight* children (defined as those children who had a BMI 95th percentile for their age and gender) and academic performance in 11,192 kindergartens and (Datar et al., 2004). The study showed that overweight children scored lower on maths and reading tests than their non-overweight counterparts. Multivariate regression was used to estimate the independent association of overweight status with children's maths and reading standardized test scores (children were given individually administered maths and reading assessments) and controlled for socioeconomic status, birth weight, physical activity, and behavioural factors such as parent-child interaction and television watching. The study initially found that overweight boys scored lower in reading than non-overweight boys with a similar difference among girls. However after controlling for socioeconomic and behavioural variables the study found that the differences, except for boys' maths scores at baseline, became insignificant. This indicates that overweight is a marker, but not necessarily a causal factor, affecting academic performance.

One of the key things from this study is that it highlights the importance of controlling for socioeconomic status, noting that not controlling for it may overestimate the association between overweight status and test scores. For example in their study, children with family income greater than $75,000 and mothers with more than a bachelor's degree were significantly less

34 Undertaken as part of the fitness assessment; involved walking/running on a treadmill at a constant speed with increasing grade increments of 2.5% every 2min until volitional exhaustion occurred.

likely (p 0.05) to be overweight and also had significantly higher test scores (p 0.05). Finally, the authors note that even though the significant differences in test scores by overweight status can be explained with other individual characteristics, (particularly parental education and the home environment), its significant (unadjusted for behavioural or socioeconomic variables) association with worse academic performance can contribute to the stigma of overweight as early as the first years of elementary school. This point is of key importance in that studies showing a worsening academic performance by overweight/obese children may in fact be instigating teachers to expect less of those obese pupils, which as discussed in the next section, has in itself negative repercussions. The same might be said for gender differences.

Some studies suggest that the academic attainment of girls is more negatively affected by obesity than for boys. For example, Sabia (2007) found a significant negative relationship between BMI and grade point average (GPA) for both white and non-white females aged 14-17 in the United States, but no significant relationship was found for males (Sabia, 2007). Similarly Booth et al. (2014) reported that girls obese at 11 years had lower academic attainment at 11, 13 and 16 years compared with those of a healthy weight (Booth et al., 2014). The main reason put forward is the higher social pressure on obese girls and women than on boys and men and therefore a greater self-esteem impact that in turn negatively affects their educational performance. In addition to this, Okunade et al (2009) estimated the causal effect of being overweight or obese as an adolescent on the likelihood of on-time high school graduation (Okunade et al., 2009). The study found no adverse impact of overweight or obesity on timely high school completion for males, but a significant average negative effect on females.

However, not all studies confirm this negative association. A recent study showed that there were few significant differences in mathematics or reading test scores for overweight and obese students versus non-obese students, and suggested that overweight and obese students are no less able than non-obese students (MacCann and Roberts, 2013). This study included 383 eighth-grade students (usually aged 13-14) and 1036 students from 24 community colleges and universities. Focusing on eighth-grade students, these students completed tests as part of the study (vocabulary and mathematics).

Along with this students and parents reported the students'GPA - grades from the previous semester for english, mathematics, science and social studies – the results of which were compared with the tests that the students completed. Results from the test that the students completed as part of the study showed that obese students had significantly lower mathematics and vocabulary scores than healthy-weight students but after controls were accounted for, the effect size for these differences was no longer significant. On the other hand trends for GPA were different: both obese and overweight students obtained poorer GPA than healthy-weight students, with a large effect size for obese students, and a moderate effect size for overweight students.

After controls were accounted for, this difference was still significant. Thus school grades (as marked by the child's teacher) showed much larger discrepancies between healthy-weight and obese students than did the test scores. This study demonstrates that overweight and obese students are not obtaining the same grades as their healthy-weight counterparts, despite no clear differences in either mathematics or vocabulary test scores. This difference was also unrelated to income level, as SES is held constant. Whatever the causal mechanism, the result is clear: overweight and obese students are not receiving the grades that would be predicted from their test scores, achievement drive and socioeconomic backgrounds.

In the same context, the UK Avon Longitudinal Study of Parents and Children followed nearly 6,000 children and found that higher body weight at age 11 predicted lower scores on standardized tests at age 11, 13, and 16 (Team, 2001). This was particularly the case in girls and was *not* explained by lower IQs. Such findings leads to the question of whether or not obese children are really under-performing in school, or do their teachers just think they are (and grade pupils accordingly). Indeed a number of studies which controlled for objective measured ability suggest that teachers perceive heavier students as less academically capable than their thinner peers, e.g. (Kenney et al., 2015).

4.2.3 Obesity stigma and academic achievement

There is a growing body of research documenting the negative impact of prejudice against obese children and young people on the health, educational and social (Brownell, 2005, Puhl and Brownell, 2001, Phelan et al., 2015, Sabin et al., 2012, O'Brien et al., 2007, Khandalavala et al., 2013, Hall and Skipworth, 2015, McVey et al., 2013, Allison and Lee, 2015, Latner and Schwartz, 2005). A number of studies suggest that obesity may induce stigmatisation, phenomena which in turn impact upon educational attainment (Crosnoe and Muller, 2004, Kaestner et al., 2011, Kaestner and Grossman, 2009, Do Wendt, 2009). The prevalence of weight-related discrimination has been described as one of the last socially acceptable areas of public discrimination, and has led to calls for action against it (Friedman et al., 2008). A recent systematic review of the views of UK children about obesity and body shape found that: “children whatever their body size, did not emphasise the health implications of being overweight. Instead they saw – and had experienced – overweight bodies as having problematic social and psychological consequences, including bullying and isolation" (Rees et al., 2009). Weight stigmatization is defined as prejudice in which the attribute of being obese or overweight influences one's expectations about the person, usually in terms of negative character assessments (Puhl and Brownell, 2001) in which an obese individual may be frequently stereotyped as lazy, unmotivated, less competent, and lacking in self-discipline (Puhl and Heuer, 2009).

In the context of educational institutions obesity stigma may be interpreted as a tendency to discount the ability and/or achievements of obese students or it might be that this may extend to active discrimination in terms of giving less attention to obese children or lower marks in exams almost as a way of punishing them for being obese (Puhl and Latner, 2007). Obesity stigma is particularly concerning in the area of education for children, considering the impact of obesity upon peer relationships during childhood when the learning of social skills occurs (Puhl and Latner, 2007) and has negative consequences for their psychological, social and physical health. For example, poor cognitive and academic performance during youth have been associated with higher severity and mortality, anxiety disorders, depression, psychological distress, coronary heart disease and some cancers later in life (Jaycox et al., 2009).

Furthermore obesity stigma has economic as well as social costs, which in the case of children may only be realised in later years of life. Education is often used as a main measure of social status. Stigma towards overweight students in educational institutes may lead to lower attained education (MacCann and Roberts, 2013, Shore et al., 2008, Karnehed et al., 2006, Fowler-Brown et al., 2010). Lower educational attainment at childhood is a fundamental cause of lower socio-economic status of obese people in their later life. High educational achievement influences which occupation might be chosen in the future life and, consequently, the eventual income. It may be obese individuals have lower educational attainment which results in lower paid jobs, less satisfying jobs, lower promotional opportunities, and lower wages that contribute to absenteeism but all of this might start with prejudice among teachers - hence the importance this current study.

Considering that schools constitute the main site of peer interaction for most children, it is not surprising that studies show that obese students cite school as the primary site of weight-based stigma (Neumark-Sztainer et al., 1999, Stott et al., 2014). Research shows that negative attitudes toward obese children begins as early as preschool age, from three to five years old (Puhl and Latner, 2007). In this study, preschoolers report that their overweight peers are “mean and less desirable playmates” compared to non-overweight children, and they believe that overweight children are mean, stupid, ugly, unhappy, lazy and have few “friends” (Puhl and Latner, 2007). In addition to bias from peers in the classroom, obese youth are also vulnerable to negative attitudes from teachers. Some studies that surveyed teacher attitudes found that some teachers believed that obese persons are untidy, more emotional, less likely to succeed at work and more likely to have family problems (Hague and White, 2005, Campbell, 2013, Stott et al., 2014, Neumark-Sztainer et al., 1999).

Furthermore the literature shows that negative stereotypes associated with obesity are particularly pertinent to the Physical Education (PE) teachers (Lynagh et al., 2015). Studies have found that PE teachers are more likely to perceive obese students to have worse social, reasoning, physical, and cooperation abilities than non-overweight students (Stott et al., 2014, Neumark-Sztainer et al., 1999). This is of grave concern considering that today’s youth are considered the most inactive generation in history (George et al., 2007) and PE teachers can play an important role in the treatment and prevention of overweight in children by giving them the skills and confidence they need to participate in physical activity for a lifetime and educating children about the importance of health-related fitness concepts.

An earlier study examined the implicit and explicit anti-fat attitudes (obesity stigma) of a large group of PE students and a similarly matched sample of non-PE students in either their first or third year of university study (O'Brien et al., 2007). The study found that PE students have a strong implicit anti-fat bias that is significantly greater than that displayed by non-PE students similarly matched in age, education and BMI. Information was elicited via a paper and pencil questionnaire using implicit association test (IAT)[35] as a measure. The negative sterotype also extends to "regular teachers"[36]. A recent Australian study, using a series of pen-and-paper validated measures[37] investigated the beliefs and attitudes of PE teachers (n=62) and regular teachers (n=177) towards obese children (Lynagh et al., 2015). The study indicated that *both* regular and PE teachers had a strong implicit negative bias toward obese children. Both groups in this study reported lower expectations for obese children compared to non-obese children across both physical and social skills.

Furthermore it has been shown that obese youth report that weight based teasing is ignored by PE teachers (Fox and Edmunds, 2000). If teachers themselves have high levels of obesity stigma then they may not identify and stop weight biased teasing when it occurs in their classes, or they may

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[35] The Implicit Association Test (IAT) measures attitudes and beliefs that people may be unwilling or unable to report. The IAT was introduced in the scientific literature in 1998 and is now widely used in social psychology research

[36] Those teachers that teach the day to day subjects such as Maths, English and Irish
[37] for example the 12-item Anti-Fat Attitudes Questionnaire CRANDALL, C. S. 1994. Prejudice against fat people: ideology and self-interest. *Journal of personality and social psychology,* 66**,** 882. (AFAQ)

inadvertently or intentionally make inappropriate comments. Not surprisingly those students who have experienced weight based criticism during physical activity report less enjoyment of, and less participation in, physical activity, sport and exercise (Faith et al., 2002). Overweight students may therefore aim to avoid physical education which, in essence can further perpetuate the stereotype that overweight people are lazy and may prevent them from developing the fundamental skills and experience in physical activity and sports that would contribute to life-long physical activity patterns.

Regardless of the type of teacher (PE or regular) the research indicates that low expectations of obese pupils and obesity stigma amoung teachers plays a role in the relatively poorer performace of obese pupils. Expectation bias was defined as the difference between observed and predicted teacher expectation.(De Boer et al., 2010). Weight bias among teachers may influence obese students' academic performance (Puhl and Latner, 2007). If biased attitudes unintentionally result in differential treatment of obese students, their educational potential may be compromised. Thus it might be the case that teachers have lower expectations of high BMI pupils and as such, do not stimulate their interest in the study process as much as they stimulate the interest in normal-weight pupils.

However a new Harvard study (Kenney et al., 2015) which followed a nationwide cohort of kindergarten children for ten years examined how weight changes between the ages of 10 and 14 affected teachers rating of the children's abilities, taking into account a range of factors such as socioeconomic status and family situation. Over 3,000 children completed maths and reading standardised tests at age 10-11 and also at age 13-14. The study found that weight gain had no effect on test scores, but it did make a difference to how teachers rated the students academic competence. In all cases, as weight went up, evaluations went down, although the figures only reached statistical significance for girls' reading skills and boys' maths skills—a difference that might be down to gender stereotypes. Teacher perceptions of boys' reading ability decreased more if the boys had been heavier to start with, compared with those who were only just starting to gain weight. Although this study didn't assess the actual anti-fat attitudes of the teachers—meaning it's not possible to link the two directly—previously discussed studies have reported negative weight-related stereotypes and anti-fat attitudes being held by teachers at every stage of the school system, from kindergarten upwards (Puhl and Latner, 2007).

Although not the focus of this study - there are a number of other factors that may influence teacher's academic expectations that warrant a mention, such as the socioeconomic status (SES) of the child. Research indicates that children from low-SES households and communities develop academic skills more slowly compared to children from higher SES groups (Lin et al., 2013, Makhoul and Ibrahim, 2014). Students from working-class or lower-class backgrounds are less likely to perform well in school than are children from middle-class homes (Hauser-Cram et al., 2003) children of more educated parents (a key component of social class) consistently scored higher than children of less educated parents (Natriello, 2002). This is particularly relevant in Ireland considering that research has shown that socio-economic factors impact on a child's chances of becoming obese, with parents' social class, education all having a major impact (Walsh and Cullinan, 2015).

A recent study (Campbell, 2013) using data from Millennium Cohort Study (MCS)[38] examined whether teachers' assessments differ according to each key characteristic; income, gender, special educational needs, ethnicity and language for children with similar scores on the tests. Thus, teachers' assessments of the cohort members' reading and maths ability and attainment at age seven are compared to the children's independent performance in cognitive tests. The study found that there were inequalities in teacher perceptions of pupils' reading and maths ability and attainment which correspond to the characteristics delineating the academic achievement therein.

For example boys from low-income families less likely to be judged by their teachers as 'above average' in reading than their equally scoring peers and girls from low-income families less likely to be judged by their teachers as 'above average' in maths than their equally scoring peers. Considering the link between obesity and low socio-economic status (White et al., 2007), for example in Ireland it was recently reported that children in poorer households were 2.5 times more likely to be obese than those in well off households (Walsh and Cullinan, 2015); a consideration of these factors is important when examining teachers expectations or judgement of pupils.

Finally, there is also literature to suggest that late entrants perform better academically and throughout life compared to children who are younger in the year group (the summer-born children). The research suggests that this "birthdate effect" is most pronounced during pre-school and primary school,

38 The Millennium Cohort Study included 11,695 English children at its first sweep in 2001, and four additional waves have taken place to date, in 2004, 2006, 2008, and 2012. The paper used data from wave four, when the pupils were seven years old, and in year two at primary school. Analysis is restricted to children in England, in order to allow comparison with and interpretation in the context of DfE statistics on pupil attainment. The sample is restricted to include only children whose parents report not paying school fees in order to ensure comparability for state school pupils in England.

and that the effect it is thought to remain significant during higher education (Sykes et al., 2009). For example, a study showed that children born during autumn months - the beginning of the Irish academic year - were on average achieving better exam results (Crawford et al., 2007). In another study in the UK a sample of over a thousand children in 38 schools who were assessed at beginning and end of the their first year of school (Tymms et al., 1997) and again in Year 2 (Tymms et al., 2000) it was found that children who were older in the year-group attained higher scores in both mathematics and reading attainment. Further research suggests that the youngest children in the year group tend to be less mature than their older counterparts, and that teachers may not make sufficient allowances for their level of attainment (Sharp et al., 2009).

4.2.4 Summary of literature

In summary, the majority of studies suggest educational disparities between obese and nonobese groups, however it is unclear from these studies why obese groups experience poorer outcomes. Findings must be handled with care given not only the lack of consensus regarding the obesity – academic attainment relationship, but differences in measures used, the lack of causal links, and the possibility that stigma is impacting on performance directly and indirectly. Nonetheless considering that there is evidence of obesity stigma in healthcare (Khandalavala et al., 2013) and in education in terms of PE teachers (Lynagh et al., 2015) (attitudes that could "spill over to other teachers and children) along with the fact that there is evidence to suggest that those obese children have a lower educational attainment compared to their leaner counterparts (Kaestner et al., 2011, Caird et al., 2011); it might be the case that teachers make assumptions in their own mind as to how a child will perform in their tests – according to their weight status (BMI). Moreover there is reason to believe that similar to PE teachers that other teachers exhibit prejudice towards those obese children. If this is the case this may have detrimental effects on teaching and learning. The paucity of research in this area is significant given the importance of education to life-time well-being.

Furthermore, while many of the studies examining teachers' academic expectations have controlled for socioeconomic status and the childs' BMI, whether or not teachers also exhibit prejudice towards students according to the weight status of parents is important and has not been looked at in any great detail thus far, particularly in Ireland. In addition to this, given the increasing focus on efforts to reduce childhood obesity worldwide, and expectations placed on schoolteachers, it is important to understand their attitudes and beliefs regarding obese children. The hypothesis for this study is that there may be biases within teacher perceptions of pupils aged nine, according to pupil characteristics (socioeconomic status, BMI and actual test scores). Furthermore as it is also established that teachers may form a bias based on parental socioeconomic status the hypothesis goes further to suggest that the parental/caregivers' BMI will also be of significance in influencing teachers expectations. In order explicitly to investigate this, regression modelling compares teacher judgements of pupils who differ according to a BMI, socioeconomic status and also parental BMI.

4.3 Methods

4.3.1 Data

The data used in this study was derived from the Growing Up in Ireland (GUI) study, a longitudinal study of a nationally representative sample of children in Ireland, see appendix three for more details on the GUI data as extracted from (Williams et al., 2011). This analysis uses only the first wave of data. The second wave did not have the required information, that is; students test score as predicted by the teachers. The design of GUI involved interviewing a nationally representative sample of children including their parents, teachers and carers in the first wave of data collection (from September 2007 to June 2008), and subsequently returning to the same set of children and their families for a second interview three years later (August 2011 to March 2012). So far, three rounds of research with the Infant Cohort (at 9 months, 3 years and 5 years) and two rounds of research with the Child Cohort (at 9 years and 13 years) have been carried out. The principal objective of GUI is to describe the lives of Irish children, to establish what is typical and normal, as well as what is atypical and problematic, in order to improve Irish policy and services (Williams et al., 2011). GUI has outlined the following nine objectives of the study (http://www.growingup.ie);

1. to describe the lives of children in Ireland in the relevant age categories, to establish what is typical and normal as well as what is atypical and problematic
2. to chart the development of children over time, to examine the progress and wellbeing of children at critical periods from birth to adulthood
3. to identify the key factors that, independently of others, most help or hinder children’s development
4. to establish the effects of early childhood experiences on later life

5. to map dimensions of variation in children’s lives
6. to identify the persistent adverse effects that lead to social disadvantage and exclusion, educational difficulties, ill health, and deprivation
7. to obtain children’s views and opinions on their lives
8. to provide a bank of data on the whole child
9. to provide evidence for the creation of effective and responsive policies and services for children and families

This chapter focuses on the child cohort which is made up of over 8,500 children who were selected randomly through the National School system. A nationally representative sample of 900 schools was selected from throughout the Republic of Ireland including mainstream national schools, private schools and special schools. Over 2,300 individual teachers cooperated with the study. The sample of 8,500 nine-year-old children was then randomly selected from within these schools. The children and their parents were given an information pack on the study and invited to participate. To gather as much information as possible about each child, information was collected from the child, their parent(s)/guardian(s), school teacher and Principal, and childminder (where relevant).

Each child was asked to complete a Drumcondra[39] test in maths and reading (Kellaghan, 1976). This test was administered by a fully trained Study Researcher (fieldworker) who visited each school. These tests have been developed for Irish school children and are grade-specific linked to the national curriculum (Layte and McCrory, 2011). The teacher was unaware of the score that they obtained in the tests, nor were they present at the time

[39] It is common practice for schools to assess pupils using standardised tests such as the Drumcondra Primary Reading Test-Revised (DPRT-R) and the *Drumcondra Primary Mathematics Test-Revised* (DPMT-R). Schools are also now required to report results of Standardised tests at the end of 1st class (or beginning of 2nd class) and the end of 4th Class (or beginning of 5th class).

of the test administration. This is important as the child's teacher was asked to predict the child’s maths and reading test scores. The teachers were asked to complete two short questionnaires; the first about the school and the second about how the child is doing in school. As part of the second questionnaire, teacher-reported judgements of pupils were elicited which asked the teacher to rate the child’s ability and predicted attainment [reading/maths] in relation to each child in the teacher’s class. Teachers were asked to predict if each child would score ‘above average/ average/below average at maths and reading. The child's Principal was also asked to complete a short questionnaire about the school.

The study researcher then arranged to visit the home of the child where the child's parent(s)/guardian(s) and the child were asked to fill out separate questionnaires (Williams et al., 2011). In cases where the child was cared for by a childminder, relative or other carer for more than eight hours per week, permission was sought from the child's primary carer to contact this person who was sent a questionnaire to complete and return through the post. Further discussion of the GUI study, the sampling and interview process are contained in appendix three.

4.3.2 Overview of variables

The dependent variable in this analysis is the teachers predicted maths and reading test score for the child. In this analysis, the hypothesis is that those children with a high BMI including those children whose parent/caregiver has a high BMI are likely to be predicted to score average or below average in maths and reading according to the child’s teacher. The key independent variables in this study are those indicating whether or not the child including the child’s parent/caregiver were obese at the time of the survey (according to their measured height and weight used to calculate their BMI). In addition to this there a number of other variables were included in the analysis; the child's month of birth, the child's gender, the child's actual test scores and SES. Table 35 below provides an overview of the variables followed by a brief outline of each variable.

Table 35. Overview of variables used in this study

Variable	**Description**	**Coded**
Dependent variable: Predicted test scores in maths Predicted test scores in reading	The teachers predicted test score for each child indicates whether each child is judged as relatively more or less able compared to their peers. This teacher was asked to predict if the child would score average, above average or below average. For the purpose of modelling, this was then split into a binary variable	Binary: 0 = average/below average 1 = above average
Gender	Boy or girl	Binary 0= boys, 1= girls
Child's month of birth	In order to assess the "birthdate effect[40]" a variable which outlined the child's month of birth was created and then dichotomised into a binary variable to describe whether or not the child was born in the early or later part of the year.	Binary 0 = born early in the year (Jan-June) 1 = born late in the year (July-Dec)
Parent BMI	Based on measured weight	Reported using BMI as a

[40] The birth month of young children can affect their well-being as well as test scores

	& height described as a categorical variable[41]	categorical variable such that < 18.5 = underweight 18.5–24.9 = normal weight 25.0–29.9 = overweight 30.0 + = obese
Child BMI	Based on measured weight & height using the International Obesity Task Force (IOTF) cut –off points. Described as a categorical variable	Healthy weight is defined as a BMI of less than 19.46 for boys and 19.45 for girls. Overweight is defined as a BMI of 19.46 to less than 23.38 (for boys) or 19.45 to less than 23.46 (for girls) and obesity as a BMI of 23.38 or over (for boys) and 23.46 or over (for girls)
Parental educational attainment	Described as the parent/caregivers educational attainment status	Described as; none or Primary, lower Secondary, higher Secondary/Tech/Vocational/,no Degree, Primary and Postgrad
Equalised Household Annual Income[42]	The Equivalised Scale used in Ireland assigns a value for	Lowest €503.7783- €10530.65 1st €10534.48 - €14610.27

42 In order to make meaningful comparisons between households on their income, household size and structure must be taken into account. The income that a household needs to attain a given standard of living will depend on its size and composition. For example, a couple with dependent children will need a higher income than a single person with no children to attain the same material living standards. "Equivalisation" means adjusting a household's income for size and composition so that we can look at the incomes of all households on a comparable basis. This is done by creating an 'equivalised' income. In Growing Up in Ireland, an equivalence scale was used to assign a "weight" to each household member. The equivalence scales assigned a weight of 1 to the first adult in the household, 0.66 to each subsequent adult (aged 14+ years living in the household) and 0.33 to each child (aged less than 14 years). The sum of these weights in each household gives the household's equivalised size – the size of the household in adult equivalents. Disposable household income is recorded as total gross household income less statutory deductions of income tax and social insurance contributions. Household equivalised income is calculated as disposable household income divided by equivalised household size. This

	each member of the household so as to make comparisons across different types of household	2nd €14637.58 - €18797.37 3rd €18814.07 - €25046.98 Highest €25060.24- €223115.6
Employment	This variable was described by 10 categories; employee (incl. apprenticeship or self-employed outside farming, Farmer, Student full-time, On State training scheme (FAS, Failte), Unemployed, actively looking for a job, Long-term sickness or disability, Home duties / looking after home or family and retired. For the purpose of this analysis this variables was split into a binary variable ; working or not working in which working included home duties.	Not working = 0 Working =1
Religion	This described the religion status of the parents. Similar to Employment, this variable was further broken down into a binary variable. Initially this variable described religion as; Christian – no denomination, Roman Catholic, Anglican/Church	Non-Catholic = 0 Catholic =1

gives a measure of household disposable income which has been "equivalised" to account for the differences in size and composition of households in terms of the number of adults and/or children they contain.

	of England/Episcopalian, Other Protestant, Jewish, Muslim, Other (specify), Other Orthodox churches	
Actual test scores	This is the percentage score that each child obtained according to the Drumcondra maths and reading tests. This was initially a continuous variable (%) however for the purpose of this analysis this was split into a binary variable which was described as above average or average or below average. The average score obtained in reading and maths was 70.66% and 56%, respectively and this was used as a basis to define those who obtained above or below this mark.	Average/below average = 0 Above average =1
School ID	Clustering was undertaken so as to establish the relativity of teachers predictions; If everyone in the class is obese, an obese child may be less likely to experience stigma- which is why this analysis uses clustering	

4.3.2.1 Predicted test scores for maths and reading

As stated, in this analysis, the teachers predicted maths and reading test scores for each child was used as the dependent variable. As outlined, responses were recoded into binary variables (0/1) representing a rating of 'average and below average' or 'above average' respectively.

4.3.2.2 Body mass index

The measured BMI of the child and the child's parent/caregiver was included. The analysis reports findings using BMI as a categorical variable (for adults and children, of which results did not differ when BMI as a continuous variable was used. The hypothesis is that those children including those children whose parent/caregiver had a high BMI may be predicted to score average or below average in their maths and reading test score. It possible that teachers may show stigma towards obese parents/ caregivers and that this is passed down to the child in terms of influencing teacher's predictions or expectations as to how well that child will do in school. A notion of "like father like son" (or mother/daughter) in that the children of those obese parents may also be perceived to be lazy, unmotivated etc (obesity stigma) by the teachers and as such perceived by the teacher to do less well off in school compared to those children of leaner parents. This hypothesis is based on observations in the literature in respect of socio-economic status of parent s and assessments of children's ability.

Children's height and weight measurements recorded in GUI enabled the computation of the child's BMI. Appendix three provides details on how the measurements were taken as part of the GUI study. For the purpose of this analysis, the International Obesity Task Force (IOTF) cut-offs for boys and girls aged 9 years and 6 months was applied. The IOTF define healthy weight as a BMI of less than 19.46 for boys and 19.45 for girls. Overweight is defined as a BMI of 19.46 to less than 23.38 (for boys) or 19.45 to less than 23.46 (for girls) and obesity as a BMI of 23.38 or over (for boys) and 23.46 or over (for girls). Subsequently this analysis used the 85-and 95-percentile of BMI by age and gender to define overweight and obese categories respectively, which is appropriate for children (Fu et al., 2003). The IOTF guidelines were chosen because of their wide application in recent literature, with a growing accord on percentiles instead of weight-for-height Z -scores for assessing overweight and obesity in children over 2 years old (Kuczmarski and Flegal, 2000, Kuczmarski et al., 2002, Wang and Lobstein, 2006). These cut-of points have been applied in previous GUI reports (Layte and McCrory, 2011) and also other Irish studies that examine childhood obesity(Heinen, 2014, Walsh and Cullinan, 2015) which will make comparisons with this study easier. Furthermore the consensus is that percentiles are easier to understand and use in practice, both by health professionals and the public (Preedy, 2012) and in addition to this, authors suggest that alternative measures can give much higher childhood obesity rates compared to the IOTF method (Twells and Newhook, 2011).

Given the relatively smaller number of observations for those underweight for both the primary caregiver (1%) and the child (7%) the underweight category was excluded from the analysis for both the primary caregiver and child. For the primary caregiver and child adiposity was described using those within a normal weight category (defined by BMI) and those who were overweight and obese were combined.

4.3.2.3 Child’s month of birth

In Ireland, children enter school based on being age four in September (Street, 2011); they may be recently turned four or about to turn five and thus may be at different levels of development. As previously discussed, there is literature to suggest that late entrants perform better academically and throughout life compared to children who are younger in the year group (the summer-born children). For this analysis a variable which outlined the child's month was created and dichotomised into a binary variable; whether or not the child was born in the early or later part of the year; January-June and July- December, respectively.

4.3.2.4 Socioeconomic status

Research shows that students with low parental education have a have higher risk of lower educational attainment (Co-operation and Development, 2012). It might be the case that teachers are aware of this and have lower expectations of those students whose parents have a low education. Consequently this analysis controls for the educational attainment of the child's parents described as: none or primary, lower Secondary, higher secondary /TechVocational, non-Degree, Primary and Postgrad. Furthermore considering that pupils from disadvantaged backgrounds tend to be perceived by teachers as less able than their more advantaged peers (Campbell, 2013), the parent/caregiver's income and employment status was also controlled for as part of the analysis. As per table 36 equivalised household annual income was described as those in the lowest quintile, 2nd, 3rd, 4th and highest quintile. The employment status of the parent/caregiver was described as: employed (incl. apprenticeship or self-employed outside farming), farmer, student full-time, on State training scheme (FAS, Failte), unemployed, actively looking for a job, long-term sickness or disability, home duties / looking after home or family and retired. The parent/caregiver's marital status was included - described in the analysis as: married and living with husband / wife, married and separated from husband / wife, divorced, widowed and never married[43].

[43] This information refers to the primary caregiver only

4.3.2.5 Religion

Some studies have noted that Non-Catholics may be discriminated in Irish schools due to the expectation of compliance with the Catholic ethos of these institutions (Vasquez del Aguila and Cantillon, 2012). It might be the case that non-Catholics experience discrimination by virtue of their minority status; their difference casting them as "other" and are open to discrimination as a result. It could also be that non-Catholic is a proxy for migrant status where language may be a barrier and this may explain lower teacher expectations. A binary variable described as catholic or no-catholic is included in this analysis

4.3.2.6 Child's ability according to actual test scores achieved

To take account of educational attainment, the actual test score in both maths and reading in according to the Drumcondra tests were included in the analysis (of which the teachers were unaware of the results of).

4.3.2.7 School ID

Finally, the relationship between obesity and lower academic achievement can be stronger in schools with a lower average body size among students (Crosnoe and Muller, 2004). If the teacher is basing opinions on the size of the child they need to be doing this relative to something. If everyone in the class is obese, an obese child may be less likely to experience stigma- which is why this analysis uses clustering. Clustering will also control for teachers having higher or lower standards in terms of expectations.

4.3.3 Overview of statistical analysis

In this study there exists an assessment of ability, the observed counterpart of which is this above/below average predicted test score measure. The previously outlined variables influence the assessment of ability in particular ways (both positively and negatively); some are "legitimate" e.g. measured ability and some "illegitimate" e.g.. prejudice related to obesity or gender. The probit model used for this analysis is non-linear and reports marginal effects. The dependent variable (predicted test scores) takes on the value of an above or below average predicted score. The purpose of this model is to estimate the probability that an observation with particular characteristics will fall into a specific one of the categories. The probit model assumes that while we only observe the values of 0 and 1 for the variable Y, there is a latent, unobserved continuous variable Y. We assume that Y can be specified as follows:

$y_1^* = \beta_0 + \beta_1 x1i + \beta_2 x2i + \cdots + \beta_k xki + ui$

And that

$Y_i == 1 \text{ if } y_1^* > 0$

$Yi = 0 \; otherwise$

where x_1; x_2; :::; x_k represent vectors of random variables, and u represents a random disturbance term (Jones, 2007).

4.4 Results

4.4.1 Descriptive results

Table 36 below shows the percentage in each BMI category for Child and child's parents. As previously stated the IOTF thresholds for children of nine and a half years of age are applied in this report. In addition a table of cut off points provided by Cole et al was followed (Cole et al., 2000) along with replicating cut off points of a recent study that used the same data (Walsh and Cullinan, 2015). The IOTF define healthy weight as a BMI of less than 19.46 for boys and 19.45 for girls (there is no underweight category). Overweight is defined as a BMI of 19.46 to less than 23.38 (for boys) or 19.45 to less than 23.46 (for girls) and obesity as a BMI of 23.38 or over (for boys) and 23.46 or over (for girls). As per table 36 74% of the children are within a healthy weight category and as indicated in table 37 the average BMI is 18. Table 37 outlines the indicators that were used to capture socioeconomic status in this study, namely the parent or caregiver's educational attainment, marital status and equivalised income

Table 36. BMI Categories for children according to IOTF cut off

BMI Category	**Child**	**Child's primary caregiver**
Normal	74%	49%[44]
Overweight	19%	33%
Obese	7%	18%

[44] Those primary caregivers who were underweight were excluded from the analysis as there was only 1% of the primary caregiver reported as being underweight. Similarly those children who were underweight (7%) were excluded from the analysis)

Table 37. Descriptive statistics

Characteristic	**(*n*= 8,136)**
	Mean (Std dev)
Percentage female	51
Average BMI of children	18 (3.04)
Average BMI of girls	18(3.19)
Average BMI of boys	17 (2.87)
Average BMI of primary caregiver	26 (4.9)
Primary caregiver education	
None or primary	3
Lower Sec	14
Hi Sec/TechVoc/UppSec+Tech/Voc	31
Non Degree	25
Primary	16
Postgrad	10
Marital status of primary caregiver	
Married & living with husband / wife	82.97
Separated from husband / wife	4.68
Divorced	1.65
Widowed	0.65
Never married	10.06
Equivalised Household Annual Income - Quintiles	
Lowest 503.7783- 10530.65	13.12
1st 10534.48 - 14610.27	17.29
2nd 14637.58 - 18797.37 |	20.07
3rd 18814.07 - 25046.98	22.92
Highest 25060.24- 223115.6	26.59

Figure 18 and figure 19 below show the distribution of the primary caregiver's BMI and the child's BMI respectively – each of which are derived from measured data (as opposed to self-reported). Child's and parents BMI are positively correlated implying that obese parents are more likely to have obese children but as the correlation stands at 28% approximately, clearly the relationship is not deterministic.

Figure 18. Primary caregiver BMI

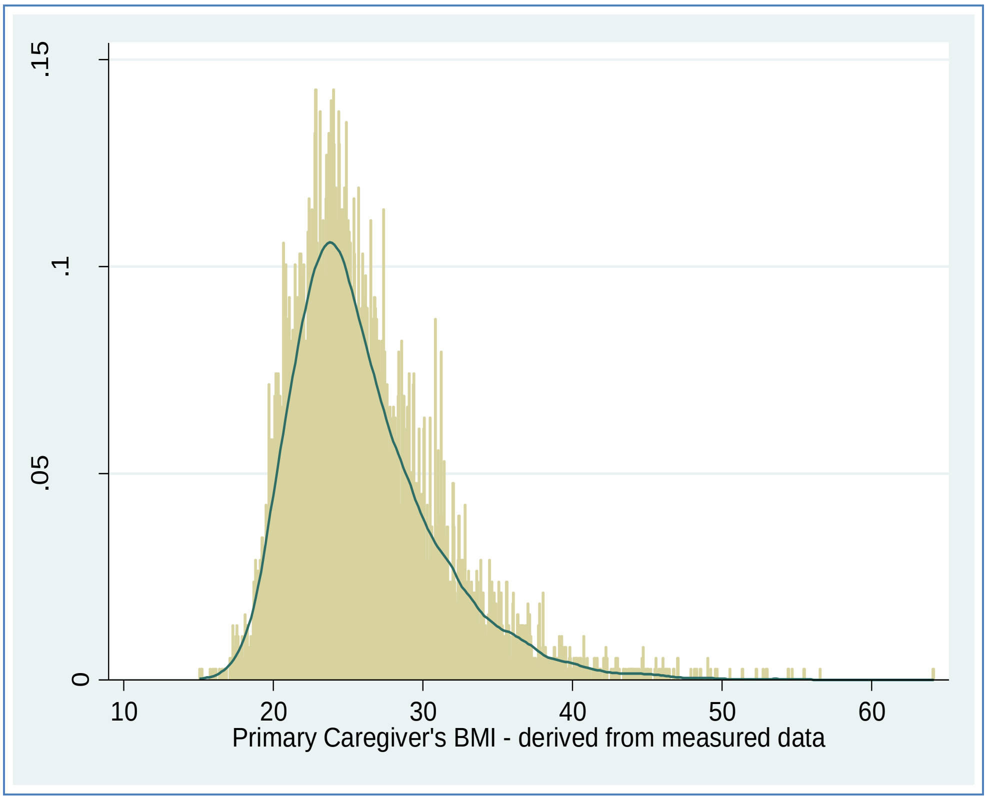
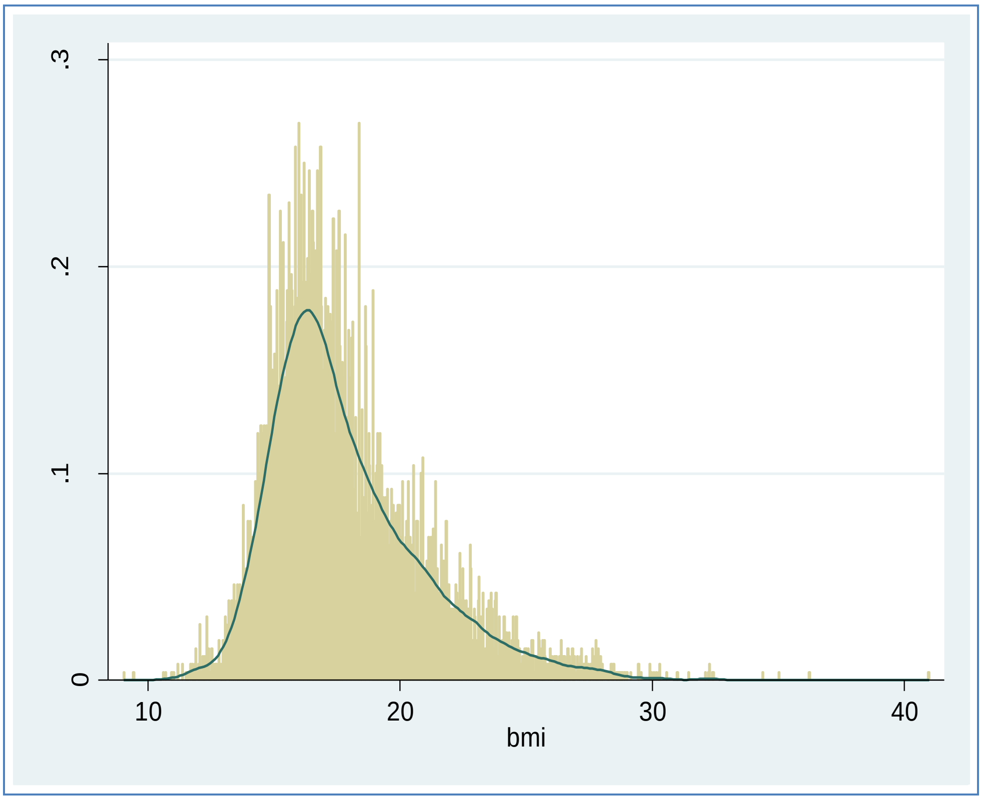


Figure 19. Children's BMI



4.4.2 Model results

As part of the GUI study, teachers predicted their students score (below average, average or above average) for maths and reading, which is the dependent variable in this analysis. In all, 6363/ 6307 children had teacher ability ratings of maths and reading, respectively. Given that maths and reading are two different subjects and also that teachers expectations of students for each subject are likely to differ, two regressions were necessary for this analysis. Table 38 and table 39 show the marginal effects of the probit regressions which were used to examine teacher's expectations according to predicted scores for each child's maths and reading, respectively.

According to the results, parent/caregiver's BMI explains more of the variation than that of the child's BMI, particularly in the case of predicted reading test scores. For both reading and maths, the findings indicate a relationship in which those children whose parent/primary carer is overweight or obese are more likely to be predicted in the below average quintile for maths and reading compared to those who parents/ primary carer are of normal weight when actual test scores are among the variables controlled for.

For example table 38 shows that relative to those parents/caregiver who are normal weight, a parent/caregiver who is overweight or obese will significantly influence teachers to predict their child as performing average or below average in their maths. Those parents/caregiver who overweight or obese are 3% more likely to have their children's maths performance (test score) predicted to be average or below average according to their teacher ($p<.007$). Similarly for reading, those children with an overweight or obese parent/primary caregiver are 4% significantly more likely to be predicted by teachers to score average or below average in their reading scores ($p<.001$) The researcher experimented with using the child's BMI (only) in the analysis and found that, as indicated in appendix three (table 70 and 71) it was borderline (negatively) significant in influencing predicted maths scores ($p<.08$) and non-significant in influencing predicted reading scores (table 71). Appendix three, table 66 and table 67 shows results using the primary caregiver and child's BMI as a continuous variable for maths and reading, respectively - in which similar findings were reported when both the primary caregiver and child's BMI are included, albeit as a categorical variable (table 68 & 69).

Table 68, appendix three shows that when both the child and primary caregiver's BMI are included in the regression, both the parent/caregiver and the child with a higher BMI negatively impacted on predicted maths test scores. In the regression those children with a higher BMI were significantly more likely to be predicted to score average or below average in their maths compared to those children within a normal weight range ($p< 0.056$). However whilst similar findings were reported regarding the caregivers [higher] BMI negatively impacting on the predicted reading scores; as table 67 indicates the child's BMI did not significantly impact on predicted reading scores.

Socioeconomic characteristics were also found to have a significant influence on the teachers' expectations of the child. It can be seen from table 38 that those children of parents/caregiver who were never married are 7% more likely to be predicted to score average/below average for maths ($p< 0.045$), whereas parental marital status does not have any significant impact for predicted readings scores. Parental educational attainment also plays a role in influencing teacher's expectations. Those children whose parents have a Degree or Postgraduate Degree are 9% (p< 0.021) and 15% (p< 0.000) significantly more likely to be predicted to score above average in their maths, respectively - similar findings are also reported for reading. The child's gender and month of birth also show significant findings with differences existing according to each subject, particularly in terms of gender roles. For example girls are 5% (p< 0.000) significantly more likely to be predicted to score average or below average for maths whereas for reading they are 5% significantly more likely to score above average (p< 0.000). The child's month of birth is more significant in influencing predicted maths scores than reading in which children born in the later part of the year (July-December) are 3% more likely to be predicted to score above average in their maths (p< 0.036); however for reading the month of birth does not appear to have any significant effect.

Table 38. Marginal effect for predicted maths test score [BMI as categorical]

Predicted average maths test score	**dy/dx (St. error)**	**z**	**P>|z|**	**[95% Conf. Interval]**	
Females	-.055 (.015)	-3.74	.00	-.084	-.026
Primary caregiver BMI (reference case is normal weight)					
Overweight and obese	-.038 (.014)	-2.69	.00	-.066	-.010
Marital status[45] (reference case is married and living with husband / wife)					
Married and separated from husband / wife	-.001 (.088)	-0.01	.99	-.172	.170
Divorced	-.070 (.111)	-0.63	.53	-.287	.147
Never married	-.070 (.036)	-2.00	.05	-.139	-.001
Equivalised Household Annual Income Quintiles Reference case is lowest quintile (€503.7783-€10530.65)					
1st €10534.48 - €14610.27	.022 (.028)	0.75	.45	-.034	.077
2nd €14637.58 - €18797.37	-.005 (.026)	-0.20	.84	-.057	.047

[45] Those who were widowed were dropped from the analysis (few observations)

3rd €18814.07 - €25046.98	.052 (.028)	1.86	.06	-.003	.106
Highest €25060.24- €223115.6	.048 (.029)	1.67	.09	-.008	.104
Actual maths test score	.0115 (.000)	25.38	.00	.011	.012
Education					
Lower Sec	.039 (.037)	1.02	.30	-.035	.112
Hi Sec/TechVoc/UppSec+Tech/Voc	.070 (.037)	1.86	.06	-.004	.143
Non Degree	.059 (.038)	1.55	.12	-.016	.133
Primary Degree	.093 (.039)	2.31	.02	.015	.171
Postgrad	.157 (.040)	3.88	.00	.078	.238
late year	.031 (.015)	2.09	.04	.002	.060

This table is the marginal effects according to a probit regression. Probit regression details are as follows;

Number of obs = 5645

Wald chi2(16) = 851.39

Prob > chi2 = 0.0000

Pseudo R2 = 0.1741

Log pseudolikelihood = -3114.7047

Table 39. Marginal effect for predicted reading test score [BMI as categorical]

Predicted average reading test score	**dy/dx (St. error)**	**z**	**P>|z|**	**[95% Conf. Interval]**	
Females	.056 (.016)	3.50	0.000	.025	.087
Primary caregiver BMI (reference case is normal weight)					
Overweight and obese	-.048 (.015)	-3.20	0.001	-.077	-.019
Marital status (reference case is married and living with husband / wife)					
Married and separated from husband / wife	-.090 (.080)	-1.11	0.266	-.249	.069
Divorced	.032 (.117)	0.27	0.787	-.197	.261
Never married	-.067 (.038)	-1.75	0.079	-.142	.008
Equivalised Household Annual Income Quintiles Reference case is lowest quintile (€503.7783-€10530.65)					
1st €10534.48 - €14610.27	.060 (.031)	1.88	0.060	-.003	.123
2nd €14637.58 - €18797.37	.011 (.029)	0.39	0.693	-.049	.068
3rd €18814.07 - €25046.98	.072 (.030)	2.47	0.014	.015	.129
Highest €25060.24- €223115.6	.063 (.030)	2.14	0.033	.005	.122
Actual reading test score	.014	24.34	0.000	.013	.016

	(.000)				
Education					
Lower Sec	.082 (.040)	2.06	0.039	.004	.160
Hi Sec/TechVoc/UppSec+Tech/Voc	.102 (.040)	2.57	0.010	.024	.180
Non Degree	.114 (.041)	2.80	0.005	.078	.248
Primary Degree	.118 (.041)	2.84	0.004	.036	.199
Postgrad	.163 (.043)	3.76	0.000	.078	.248
late year	-.009	-0.58	0.565	-.040	.023

This table is the marginal effects according to a probit regression. Probit regression details are as follows;

Number of obs = 5600

Wald chi2(16) = 705.27

Prob > chi2 = 0.0000

Pseudo R2 = 0.2036

Log pseudolikelihood = -3074.1409

4.5 Discussion

Teacher bias towards obese pupils has been suggested as a potential pathway through which obese children attain relatively lower levels of academic achievement. The analysis in this chapter investigated whether teacher's judgement of pupil's academic ability are influenced by the body shape of the child they teach along with whether the body shape of that child's parent/caregiver influences their judgement. The data for this analysis is obtained from the GUI dataset which includes nine year old children attending public schools in Ireland. The overall findings that emerge from this analysis warrant comment. With reference to the limited knowledge (particularly in the Irish context) regarding the role that the body shape (along with other socio-economic indicators) plays in influencing teachers perceptions of pupils ability; this study provides some indication previously unavailable, that within the Irish educational system there is evidence that teachers exhibit biased judgements of pupils according to both the child and the child's caregiver body shape (BMI). Because both independent measures of pupil test performance (actual test scores) and indicators of teacher perceptions of pupils are used in this analysis, findings support the possibility that the process of stereotyping may be instrumental in systematic pupil attainment differentials. Care is of course warranted with this interpretation given the borderline significance only of the child's adiposity when examined alone.

If correct and supported in subsequent analyses, this finding is of concern particularly in light of increasing levels of childhood obesity along with the fact that both high and low expectations can create self-fulfilling prophecies[46] (Rosenthal, 1963). Intuition would indicate that students must

[46] Rosenthal conducted a number of laboratory experiments "Pygmalion experiment" in which random rats were assigned to research assistants who had to train the rats to go through the maze. The assistants were told that some rats were "maze bright" and others the

believe that they can achieve before they will risk trying, and young people are astute at sensing whether their teachers believe they can succeed. By the same token, teachers must truly believe their students can achieve before they will put forth their best effort to teach them. The teacher's beliefs must be translated into instructional practices if students are to benefit: actions speak louder than attitudes. What teachers say, perceive, believe, and think can support or thwart students (Nel, 1992). For example according to the findings in this study, teachers have lower expectations for students with obese parent/caregiver and may assign them slower-paced and more fragmented instruction; and these students may adjust their expectations and efforts, which results in even lower performance. Beliefs influence how teachers may teach (Kagan, 1992). Most would agree that teachers' beliefs have an influence on their perceptions and, ultimately, their behaviours. Thus, having an understanding of teacher belief structures is important to the improvement of professional teacher preparation programs as well as teaching practices (Goodman, 1988). The worrying thing is according to some, once set, teachers’ expectations do not change a great deal. (Ferguson, 2003).

This study is the first to examine, in an Irish context the subject matter of obesity bias within the educational system. Nonetheless, the findings in this

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opposite. What was found was that when the assistants believed the rats were bright, those rats got through the maze more quickly than those rats that were told to be less intelligent. This was then applied to teachers and students where teachers were told of students who were bloomers and likely to make substantial progress- in which they made more than expected progress. The explanation provided as to why some of the “bloomers” made larger than expected gains was that when teachers believed some students were smarter than others this led teachers to interact differently with them than they did with students for whom they had low expectations. In turn this gave students messages about what was expected of them and increased the probability that they would respond accordingly. In this way students would fulfil expectations of them. This phenomenon came known to be the self-fulfilling prophecy effect.

study echo international findings, that evidence of obesity stigma among teachers. However what differs with the study in this thesis is that the parental/caregiver's BMI explains more of the obesity stigma than that of the child, as indicated by the negative coefficient of parental BMI. Significant negative associations between academic expectations and parental body shape indicate that having negative attitudes toward obese children's parent/caregiver may be translated into beliefs that children of obese parents are intellectually inferior.

That the child's BMI was only borderline significant in this study echo findings of an earlier study which did not find child's BMI to be significant regarding teachers academic expectations (Shackleton and Campbell, 2014). In their study the author's used waist circumference as the measure of adiposity in children (along with BMI and body fat percentage in their further analysis) from the Millennium Cohort Study (fourth wave where children were approximately seven years old). Logistic regression analyses were used to test whether teachers' perceptions of the child's reading and mathematics ability were influenced by the pupil's waist circumference, conditional upon cognitive test scores of reading and maths ability. After adjustment for cognitive test scores, no significant overall relationship was found between the pupil's waist circumference and the teacher's judgements of ability. When included on its own in this analysis, child's BMI is borderline significant. The study undertaken here is arguably more robust given its ability to control for month of birth effects and possible clustering effects within the school. It is unfortunate that waist to hip or waist circumference measures were not available to allow a more direct comparison.

Although not the focus of the study, the analyses showed that a number of socioeconomic factors were also significant regarding teachers academic expectations. This is in line with the literature which has showed teacher expectation bias to be related to gender and socio-ethnic background of students (Timmermans et al., 2015). Those parents/caregivers who had an educational obtainment from secondary school upward had a significantly positive impact on teachers predicted judgement of test scores, with those parents/caregivers with postgraduate education having the strongest impact. According to the literature, the common view is that more educated parents provide an environment, which improves their children's opportunities and decision processes (Chevalier, 2004). This analysis offers an alternative and perhaps less benign interpretation of relationships. That is, that teachers may identify more strongly with parents educated to a level similar to themselves and adopt prejudicial opinions in respect of less well educated parents.

Similarly, children of parents who never married are more likely to be expected to obtain average or below average in their maths and reading, controlling for other covariates including socio-economic status. There is evidence that teachers negatively label children from one-parent homes (Hallinan et al., 1990) and also children of divorced or separated parents (Hallinan et al., 1990). It might also be that the teachers hold the view that unmarried parents lack the joint resources needed to carry out family responsibilities. Children from lower income families are less likely to be judged 'above average' by their teachers, which is also in line with the literature. Campbell analysed information on nearly 5,000 seven-year-olds in English state schools who are being followed by the Millennium Cohort Study (MCS) (Campbell, 2013). The study compared teachers' perceptions of the pupils' reading and maths ability with their scores on standardised assessments carried out by survey interviewers during home visits. Teachers tended to perceive low-income children as less able than their higher income peers with equivalent scores on cognitive assessments. For example, 29 %

of children from lower income families were rated below average at reading by their teachers, compared to 20 % of their equally-able peers from more affluent homes. The difference was similar in maths. As noted here though socio-economic status was controlled for using a number of covariates and yet marital status remained significant. That the majority of children in the study were educated and assessed in schools where a catholic ethos dominated and a particular perspective on that ethos perhaps operated cannot be discounted. That stigma extends beyond body shape though seems probable.

Similar to the analysis in this chapter, a child's gender influenced the teacher's perceptions. According to Campbell, boys were more likely to be judged above average in maths than girls who had scored equally well on cognitive tests (Campbell, 2013). By contrast, girls were more likely to be judged above average in reading than equally-able boys. Echoing these findings, the analysis in this chapter shows that teachers tend to rate girls maths abilities lower than those of the male pupils with the reverse being the case in respect of reading. Although this is commonly reported in studies; that some teachers mark boys' primary school maths tests more favourably than girls (Lavy and Sand, 2015) is a worrisome trend. This may impact girls' uptake of mathematics and science subjects in Secondary school and also University. In fact according to Lavy and Sand entrance rates into maths and science degrees at university level can also be traced back to the impacts of teachers' gender bias in primary school (Lavy and Sand, 2015).

Higher levels of mathematics and science education have been linked to greater employment opportunities and higher earnings (Thévenon et al., 2012), meaning a primary teacher’s attitude towards maths can have a serious impact on a child’s future success. Furthermore it has been found that girls (more than boys) rated personal encouragement from teachers as very important in choosing university courses (Maltese and Tai, 2011). On the other hand, in the context of gender bias, a crucial point made by Campbell (2013) is that his study does not conclude that there is anything unusual about teachers in their apparent tendency to stereotype pupils: stereotyping is a universal human process (Campbell, 2013), though that is not to say it should be allowed to blight the opportunities and futures of children.

To sum up the discussion, the findings of this analysis are significant in the context of current proposed educational reform in Ireland in which teachers will be the final judges of 40 % of the work that junior certs (pupils aged 12-15) do for State certification. With reference to the indications that this analysis shows in terms of what might be evidence of bias among teachers; that attainment indicators depend heavily on teacher assessment invites many questions in terms of the implications that non-anonymised marking by teachers of junior cert work may have, given that this is only three or four years on from the nine year olds assessed in this study. Although this marking may be anonymised it might be the case that coursework which will form part of the overall grades throughout the year will not be marked anonymously.

Furthermore, although this analysis did not specifically examine PE teachers, given the vast amount of evidence indicating PE teachers are biased towards obese children, it is reasonable to assume that PE teachers in Ireland may also exhibit obesity bias similar to the teachers in this study. Ireland is currently implementing a number of childhood obesity prevention programs across the schools, (e.g. Be Active after School programme (Be Active ASAP); the ‘Lifestyle’ programme in Longford & Westmeath, Offaly and Laois (for children aged 5-10 years); the ‘Cool Dude’ Food Programme in Dublin South East/ Wicklow (for children aged 8-12 years and the 'Bounce – Built to Move' programme in Galway (for children aged 9 – 12 years)). If PE teachers (along with regular teachers) are biased towards obese children, this could be detrimental could prove to be a counterproductive for these initiatives.

4.6 Conclusion

A literature exists that suggests there is an obesity stigma/prejudice against overweight and obese people and that this extends into assessment of intellectual ability among children. The findings from this analysis indicate that there is evidence of obesity stigma among teachers towards the pupils that they teach. This stigma is shown according to teacher's judgements of how well they predict their pupils to do in Maths and English, that is whether or not they predict the pupil to obtain above or below average test score; whereby those predicted to obtain a below average score are significantly more likely to be obese and/or have obese parents/caregivers. The potential repercussions of this bias could be detrimental in the Irish educational system, particularly if teachers who already teach their pupils are to grade these pupils in State exams (Junior Certificate).

This study demonstrates that obesity should not be understood solely as a health issue. It is assumed that teachers have inclusive and bias-free attitudes toward obesity, yet teacher attitudes and skills for working with overweight children are seldom addressed as part of their training. A quote mentioned in an article from Rouse and Barrow (2006), states how Martin Luther King, Jr. in 1967 felt concerning socioeconomic status and its effects on education, "The job of the school is to teach so well that family background is no longer an issue." However we are still facing the same issues faced 40 years ago, with the added bias of obesity. It seems likely that at some point, lower expectations and lack of confidence will start to impact on actual in-class behaviour. There is also a cost of biased lower expectations in terms of limiting students opportunities, for example obese children may be less likely to go on to higher education.

The current understanding of the adverse economic impact of obesity may be understated if obesity also negatively affects early human capital accumulation. If increased body weight reduces the academic performance of adolescents or young adults (either as a direct result of obesity or as a result of lower expectations/stigma), then the obesity-specific gap estimated by Cawley (Cawley, 2010) may reflect only part of the economic harm of obesity. Heckman (2011) calculates that every initial dollar invested in early childhood education generates 7 to 10 cents per year (Heckman, 2011). As Heckman argues, "the logic is clear… invest early to close disparities and prevent achievement gaps, or we can pay to remediate disparities, when they are harder and more expensive to close". The evidence is both convincing and concerning that biased lower teachers expectations can widen the disparities for educational attainment. The fact that this study shows a negative correlation between obesity and teachers expectations is even more concerning in the context of the increasing problem of childhood obesity being attempted to be prevented in the school setting – a setting that shows biased towards obesity.

The implications of childhood obesity stigma with regards academically underachieving or not attending third level education and the subsequent effect regarding the likelihood of attaining jobs (and paying taxes etc.) is important and as previously mentioned is sometimes not taken into consideration when analysing the burden of obesity. Whilst quantifying the economic burden of obesity is important so too is ascertaining how to prevent and treat obesity in a cost effective manner, particularly as noted in chapter one the increasing prevalence of obesity along with its increasing severity. The latter of which requires a more invasive line of treatment so as to treat the severity of obesity. The next chapter examines how we in Ireland ascertain the cost effectiveness of such treatment.

5. Cost effectiveness of bariatric surgery

The previous chapters in this thesis examined how we measure obesity; how obesity treatment is valued by those severely obese and also explored obesity stigma an indirect cost of obesity all of which help inform our understanding of the economic burden of obesity. However with regards the allocation of obesity treatment, an understanding of the economic burden of obesity is not sufficient; the treatment must be deemed to be cost effective. Positive studies in a number of jurisdictions indicate a broad consensus that bariatric surgery is a cost-effective treatment for severe obesity.

No comparable study has been conducted in an Irish context and while findings from other jurisdictions may be generalizable to Ireland, it is important that current evidence be critically appraised mindful not only of the particular healthcare system that pertains in Ireland but also of emerging evidence in respect of the cost effectiveness of bariatric surgery. Efforts to produce cost effectiveness evidence in Ireland have been hampered by the absence of procedure codes for bariatric surgery and by the difficulty in linking patient records to track their resource utilisation throughout the complete patient pathway. This chapter provides a critical appraisal of current cost effectiveness evidence and examines specific features of the Irish healthcare system and its capacity that have a bearing on the likely cost effectiveness of bariatric surgery in this context.

Firstly an overview of bariatric surgery in terms of the types of procedures, costs and effectiveness evidence is provided. This is followed by a review of current International evidence on the cost effectiveness of bariatric surgery. From this the final section discusses a number of factors that may influence and hinder a CEA of bariatric surgery in the Irish setting. This includes (i)

Irish data limitations (ii) Ireland's low throughput of bariatric surgery and how Ireland differs regarding the bariatric care pathways and (iii) the Irish healthcare system; specifically how Ireland's healthcare presents incentives that may differ from other jurisdictions and may serve to make the bariatric patient case-mix and health outcomes that exist in Ireland different to those of other jurisdictions from where evidence of cost-effectiveness might otherwise be inferred.

5.1 Introduction

Surgical strategies for weight loss, collectively referred to as bariatric surgery have been in place for over half a century and are being considered with favour due to their success in providing sustained weight loss for the severely obese population (Ashrafian et al., 2011). Bariatric surgery is expensive thus an important question is whether this surgery offer value for money or "cost-effective" for severe obesity treatment. One way of determining this is to undertake an economic evaluation which involves identifying, measuring and valuing both the inputs (costs) and outcomes (benefits) of bariatric surgery.

The two most common evaluations are cost-effectiveness analysis (CEA) and cost utility analysis (CUA). A CEA is a decision-making assistance tool with its parameter of interest referred to as the incremental cost-effectiveness ratio (ICER) whereas CUA uses a common measure of outcome to enable comparison between a range of interventions, for example QALYs (quality adjusted life years). The ICER is defined by the difference in cost between two possible interventions divided by the difference in their effect; representing the average incremental cost associated with one additional unit of the measure of effect (Drummond et al., 2005). In other words a CEA indicates that health benefits are (or are not) achieved at an acceptable price relative to country-specific cost-effectiveness thresholds.

Undertaking an economic evaluation of bariatric surgery in Ireland is problematic due to the absence of quality data, specifically cost and utility data. Importantly the opportunity to collect such data is restricted due to the limited throughput of patients undergoing bariatric surgery in Ireland and the predominance of private insurance in the finance of the patients that do. The limited throughput while presenting challenges for the conduct of an economic evaluation of bariatric surgery in Ireland raises other more fundamental questions about the capacity that currently exists in Ireland in respect of this intervention and the implications this may have not just for economies of scale but also for outcomes and cost effectiveness.

5.2 An overview of bariatric surgery

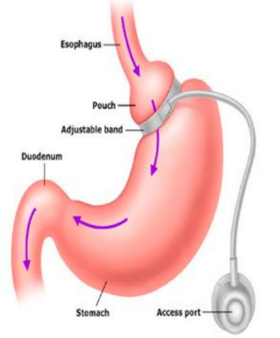
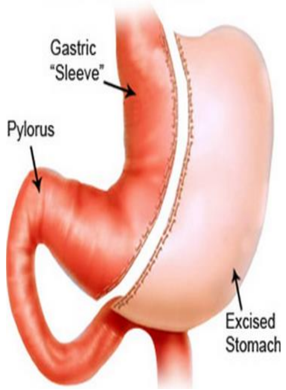
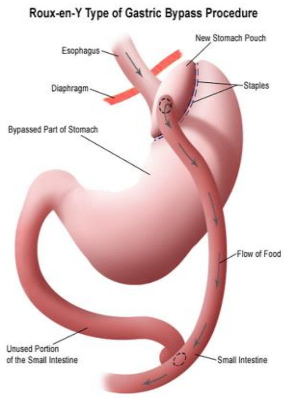
When conventional treatments have proven ineffective or of limited benefit, bariatric surgical interventions may be considered for treating severe obesity (BMI $\geq$ 40 kg/m^2). The guidelines for bariatric surgery from the National Institutes of Health in the USA (Panel, 1998, Panel, 1991) are similar to those in Europe (Fried et al., 2013) in that patients with a BMI>40 kg/m^2, or with a BMI>35 kg/m^2 and a serious obesity-related comorbidity, who have failed to respond to conservative treatment (diet, exercise, pharmacology) are eligible for bariatric surgery. In 2014 the National Institute for Health and Care Excellence (NICE) updated its guidelines and recommended for earlier consideration of bariatric surgery for those people with diabetes mellitus (Tower and Plaza, 2014). In Ireland, there are no published national guidelines for bariatric surgery; personal communication with medical professional (FF)[47] indicates that Irish clinicians follow international guidelines regarding bariatric surgery in terms of patient candidature.

In very basic terms, bariatric surgery is conducted by constricting the stomach, re-sectioning or bypassing a part of the stomach. The aim is to restrict intake and/or malabsorption of food; the ultimate aim is modification of eating behaviour, that is, smaller quantities of food consumed (Buchwald et al., 2007). The result is that a person no longer consumes as much food as before; the surgery reducing the actual physical amount of food a person consumes before feeling fuller. Currently there are three types of bariatric procedures performed. Differences exist between these related to the amount of weight loss, types of complications and reoperation rates as well as the actual nature of the surgery involved(Padwal et al., 2011). All of these can be performed laparoscopically which (compared to open surgery) results in a lower rate of complications such as wound infection and incisional hernias (Reoch et al., 2011). Table 40 below provides an outline of the different types of surgery (in layman's terms). Bariatric surgery works in one of three ways and is thus defined accordingly:

- Restriction, or limiting the amount of food intake by reducing the size of the stomach
- Malabsorption, or limiting the absorption of foods in the intestinal tract by "bypassing" a portion of the small intestine to varying degrees
- Combination of both restriction and malabsorption

[47] The paucity of data that exists in Ireland regarding bariatric surgery necessitated personal communication with medical experts in the field of severe obesity treatment. Primarily consultant Endocrinologist Dr Francis Finucane (FF), appointed lead in the development and delivery of services for severely obese patients regionally provided the required details. Other experts were also contacted and are referenced throughout this chapter.

Table 40. Summary of Bariatric Surgical Interventions

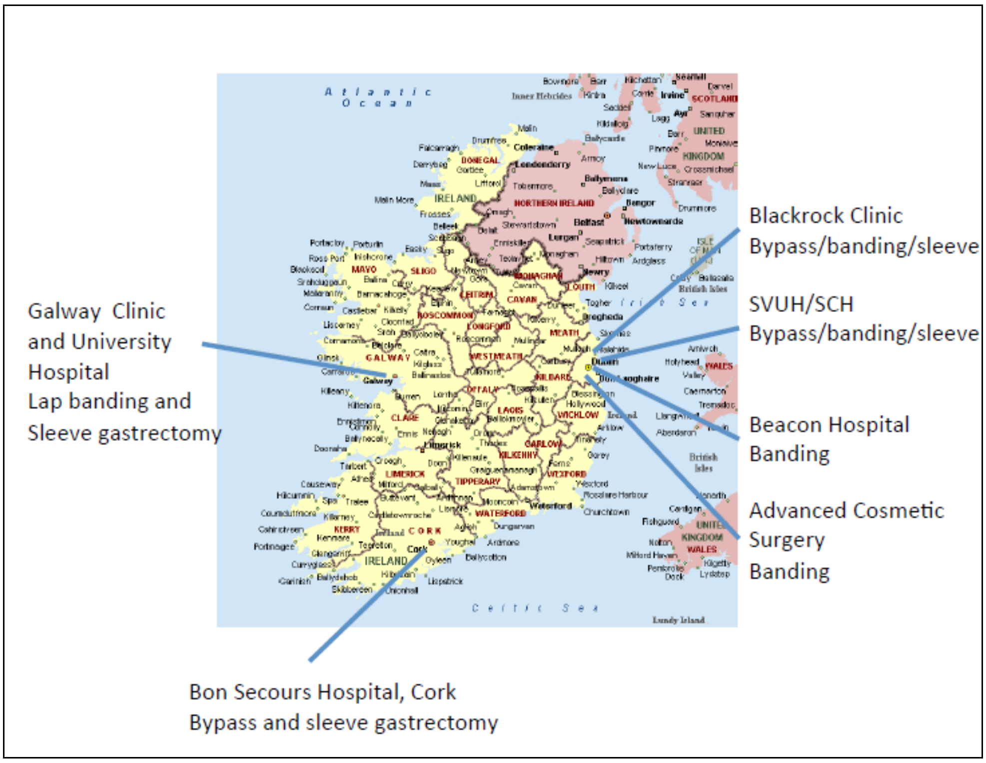
Procedure	Type	Description	Illustration
Adjustable Gastric Band (LAGB,)	Restrictive	This is an inflatable silicone device placed around the top portion of the stomach to treat obesity, intended to slow consumption of food and thus reduce the amount of food consumed.	
Sleeve Gastrectomy (SG)	Restrictive/endocrine or metabolic	The stomach is reduced to about 25% of its original size, by surgical removal of a large portion of the stomach along the greater curvature. The result is a sleeve or tube like structure. The procedure permanently reduces the size of the stomach and decreases the levels of ghrelin, a major hunger-inducing hormone.	
Gastric bypass Roux-en-Y Gastric Bypass (RYGB) Gastric bypass surgery makes the stomach smaller and causes food to bypass part of the small intestine	Restrictive and diversionary /malabsorptive	Roux-en-Y gastric bypass (RYGB) is a type of weight-loss surgery that reduces the size of the individual's stomach to a small pouch – about the size of an egg. It does this by stapling off a section of it. This reduces the amount of food the individual can take in at meals. The surgeon attaches this pouch directly to the small intestine, bypassing most of the rest of the stomach and the upper part of the small intestine.	

Types of bariatric surgical procedures which involve gastric bypass to some degree include: Roux-en-Y gastric bypass [RYGB P], biliopancreatic diversion [BPD], biliopancreatic diversion and duodenal switch, [BPD-DS]		This reduces the amount of fat and calories individuals can absorb from the foods – leading to weight loss. RYGB can be done as an open surgery, with a large cut (incision) on your abdomen to reach your stomach. Or it can be done as a laparoscopic	

Source: (Santry et al., 2005)

On a worldwide scale the most commonly performed procedures are the Roux-en-Y gastric bypass (RYGB), adjustable gastric banding (LAGB), and sleeve gastrectomy (SG), respectively (Buchwald and Oien, 2009). Personal communication with medical experts and private health insurance revealed that in Ireland, there are currently two Health Service Executive (HSE)-funded centres that perform bariatric surgery, St Columcille's Hospital in Loughlinstown in Dublin and University Hospital Galway; along with five other private clinics performing bariatric surgery in Cork, Dublin and Galway. As figure 20 below shows the procedures performed vary according to the clinic. For example in Galway the most common procedure in the public clinic is the SG whereas in the private clinic GB is more common. Furthermore a distinction cannot be drawn between the public and private in terms of types of procedures performed. As can be seen, the most common types of procedures perfomed in the two public hospitals also differ with SG in Galway and the bypass in Dublin being the most common.

Figure 20. Location of hospitals offering bariatric surgery in Ireland - public and private



Source: *Overview of Irish medical services and care pathways for obesity* (unpublished report)

5.3 Cost of bariatric surgery

A summary of the surgery cost estimates, extracted from (Holtorf et al., 2012) is listed in Table 41. The costs of bariatric surgery are influenced by several factors such as the cost of the intervention itself (e.g. band or sleeve), the cost of adaptations (e.g. band adjustment), adverse events, reversals, surgeon experience, the volume of surgeries undertaken by a unit, secondary health-related cost such as the cost of the general supportive care (e.g., dietary, educational, psychosocial). As discussed below, Ireland differs significantly regarding the volume of surgeries relative to other countries with a much lower throughput of surgeries. This may well impact on surgeon experience and in turn health outcomes and adverse events as well as the opportunity to exploit economies of scale in the conduct of this procedure. At a minimum it casts doubt on the appropriateness of inferring bariatric costs and outcomes from other countries; but it remains the case that there is a paucity of Irish data regarding bariatric cost.

Considering the variation of the types of procedures performed, as highlighted in table 40, it is not surprising that surgery cost estimates vary in Ireland. However national representative published cost data is limited, placing a reliance on regional (unpublished) data. For example using 2008 - 2010 data from the Galway HSE funded clinic, a report "*Gastric Sleeve Resection is a better baritrical surgical option when compared to laparoscopic adjustable gastric banding (LAGB)"* estimated the average mean cost of the GS and LAGB to be €7,332 and €11,601 respectively. These estimates included outpatient visits, band adjustment, radiological tests and rehospitalisation. Conversely, one of the only National reports that refer to bariatric surgery costs (*HSE framework for action on obesity 2008-2012*) reported a much higher cost of approximately €30,200 per gastric bypass procedure and €20,000 - €22,000 for LAGB in 2008; no cost was provided for the SG. However, the sources of these cost estimates are not provided nor is it clear if this includes data from each of the public clinics and what types of costs are included in this estimate. Given the lack of detail on the construction of costs the estimates provided must be treated with caution.

Table 41. Summary of publications reporting cost of bariatric surgery

Publication	Data Year	Cost	Country
Salem, 2008	2004	$16,200	USA
Paxton, 2005	Before 2005	$17,660 - $29,443	USA
Livingston, 2005	2001/2002	$19,794 - $23,355	USA
Ikramuddin, 2009	2007	$19,760	USA
Hoerger, 2010	2005	$15,536 - $20,326	USA
Chang, 2011	2010	$23,778 - $64,784	USA
Clegg, 2003	Before 2001	£9,627 - £10,795	UK
Ackroyd, 2006	1998-2003	£7,088 - £9,121	UK
Ackroyd, 2006	1998-2003	€12,166 - €17,197	GER
Ackroyd, 2006	1998-2003	€13,399 - €19,276	FRA

Source: (Holtorf et al., 2012)

5.4 Effectiveness of bariatric surgery

A 2014 Cochrane review concluded that bariatric surgery, results in greater improvement in weight loss outcomes and weight-associated comorbidities, compared with non-surgical interventions, regardless of the type of procedures used (Colquitt et al., 2014). An earlier study (Buchwald et al., 2004) reported that excess weight loss for all bariatric procedures combined was 61% in those severely obese. Other studies report the benefits for individual's functional status and psychological health (Neff and le Roux, 2013). It is also established that obesity-related diseases can be resolved or improved after bariatric surgery.

Buchwald et al calculated that after bariatric surgery diabetes improved or resolved in 86% of patients, hyperlipidaemia improved in 70%, hypertension improved or resolved in 78.5%, and obstructive sleep apnoea improved or resolved in 83.6% (Buchwald et al., 2004). Although diabetic outcomes vary with operative procedure, the effects of bariatric surgery on type 2 diabetes has been the subject of a number of systematic reviews. Buchwald reported 86% of 1835 patients from multiple case studies showed remission or improved control (Buchwald and Oien, 2013). Maggared et al reviewed 21 case series and reported a range of 64%-100% showing remission or improvement (Maggard-Gibbons et al., 2013).

The findings reported in these studies are important as they are often used to inform health economic models that have been developed to predict health outcomes as part of economic evaluations for bariatric surgery. It is therefore important that the findings reported are accurate. However, a review of the studies reporting bariatric effectiveness indicates that there are a number of issues. For example, few studies are based on randomised controlled trials giving rise to issue of sample selection. Similarly, long-term follow-up of patients – control and intervention - are rare casting doubt on some of the reported long term outcomes of the intervention. Table 42 extracted from (Courcoulas et al., 2014) provides examples of recent long-term studies of bariatrics outcomes and their limitations.

Most notable is the lack of long term random control trials (RCT's) data, which adds further uncertainty to projecting reliable long term health outcomes after bariatric surgery. A recent Cochrane review that systematically examined RCTs to assess the effects of bariatric surgery for obesity reported that the majority of RCTs follow participants for only one or two years and concluded that the long-term effects of surgery remain unclear (Colquitt et al., 2014). Table 43 summarises the deficiencies in knowledge of long-term bariatric surgery outcomes.

Furthermore, one of most commonly cited studies (Buchwald and Oien, 2009) has been criticised for having inadequate patient retention (Laiteerapong and Huang, 2010). Laiteerapong and Huang note that the accepted standard for patient retention in both published studies and clinical practice is 50%, which is far below the norm for clinical studies in other areas of medicine (Laiteerapong and Huang, 2010). As noted by the authors these low retention rates are highly problematic because they have the potential to introduce strong selection bias. Patient attrition after bariatric surgery is very likely related to satisfaction with the surgery and its effects. Thus, reported results from bariatric surgery likely overestimate rates of diabetes remission and improvement and underestimate costs.

Finally, it is noted by (Padwal et al., 2011) (and of particular relevance to the Irish context) that most evidence supporting the benefits of surgery comes from observational studies and relatively short-term RCTs performed in experienced, high-volume units. These are likely to be atypical of the outcomes and costs achieved in other setting and in particular those that pertain in Ireland, meaning the reported results may overestimate the benefits of surgery, underestimate the risks and the costs. As previously mentioned (and discussed further below), Ireland's throughput of bariatric surgery is relatively low. The two key issues regarding bariatric effectiveness data is that 1) there is large uncertainty regarding the long term effects and 2) the appropriateness of assuming that the evidence from other studies is applicable to Ireland, which has significantly lower throughput.

Table 42. Examples of Recent Long-term Studies of Bariatric Surgery Outcomes and Their Limitations

Source	Study Design	Populations and Procedures	Follow-up Duration	Published Outcomes	Limitations
Sjostrom et al,15-19 2004, 2007, 2009, and 2012 (Swedish Obese Subjects Study)	Prospective observational with matched controls	2010 Surgical cases (13% RYGB; 19% banding; 68% VBG) and 2037 matched controls	10-20 y, depending on the report	Surgery was associated with greater weight loss at 2 y (−23% vs 0%) and at 20 y (−18% vs −1%)16; lower overall mortality (HR, 0.71; *P* = .001)18; lower incidence of T2DM (HR, 0.17; *P* < .001),19 myocardial infarction (HR, 0.71; *P* = .02),16 stroke (HR, 0.66; *P* = .008),16 and cancer (in women only; HR, 0.58; *P* < .001)17; and greater remission of T2DM after 2 y (OR for remission, 8.4; *P* < .001) and 10 y (OR, 3.5; *P* < .001)15	Not randomized; includes mostly procedures (87%) that are no longer in use; involves patients from a single country with little racial/ethnic diversity
Adams et al,20 2007 (Utah Mortality Study)	Retrospective observational with matched controls	7925 RYGB cases and 7925 weight matched controls	Mean, 7.1 y	40% Reduction in all-cause mortality (HR, 0.60; *P* < .001) and 49% and 92% reductions in CV mortality (HR, 0.51; *P* < .001) and T2DM mortality (HR, 0.08; *P* = .005), Respectively	Not randomized; matching based on self-reported height and weight from driver's license database; includes only RYGB

					procedures; patients from a single state
Adams et al,3 2012 (Utah Obesity Study)	Prospective observational with matched controls	418 RYGB cases; 417 bariatric surgery seekers who did not undergo operation (control 1); 321 population based matched controls (control 2)	6 y	RYGB group lost 27.7% body weight compared with 0.2% weight gain in control group 1 and 0% change in control group 2; T2DM remission in 62% of RYGB patients and only 8% and 6% in each of the control groups (*P* < .001), while incident T2DM was observed in 2% of RYGB patients but 17% and 15% of each of the control groups at 6 y (*P* < .001); surgery associated with greater improvements in blood pressure, cholesterol, and quality of life (*P* < .01)	Not randomized; includes only RYGB procedures; patients from a single state
Maciejewski et al,21,22 2011 and 2012 (Department of Veterans Affairs)	Retrospective observational with matched controls	847 surgical cases and 847 matched controls	6.7 y	In unadjusted analyses, surgery was associated with reduced mortality (HR, 0.64; 95% CI, 0.51-0.80).22 After propensity matching patients, bariatric surgery was no longer significantly associated with reduced mortality in unadjusted HR (0.83; 95% CI,	Not randomized; includes older (mean age, 55 y), primarily male (74%) veterans; mostly RYGB

				0.61-1.14) and time-adjusted HR (0.94; 95% CI, 0.64-1.39) Cox regressions22; surgery was also not significantly associated with lower health expenditures 3 y after the procedure21	procedures
Courcoulas et al,23 2013 (Longitudinal Assessment of Bariatric Surgery)	Prospective observational	2458 Surgical cases (70.7% RYGB; 24.8% AGB; and 5% other procedures)	Currently 3 y (plan for 5 y)	Median percentage weight loss of 31.5% for RYGB and 15.9% for AGB; T2DM remission in 67.5% of RYGB cases and 28.6% for AGB; dyslipidemia remission in 61.9% RYGB cases and 27.1% AGB cases; HTN remission in 38.2% RYGB cases and 17.4% AGB cases; other procedures not reported	Not randomized; lacks nonsurgical control population; primarily RYGB procedures; in-person weight measures available on 66% of RYGB cases and 76% of LAGB cases
Arterburn et al,24 2013 (HMO Research Network)	Retrospective observational	4434 RYGB cases with T2DM	Median, 3.1 y	68% Of patients (95% CI, 66-70) experienced an initial T2DM remission within 5 y after RYGB; among these, 35.1% (95% CI, 32-38) redeveloped T2DM within 5 y; median duration of T2DM remission, 8.3 y	Not randomized; lacks nonsurgical control population; only RYGB procedures
Carlin et al,25 2013 (Michigan Bariatric Surgery Collaborative)	Prospective observational	8847 to 35 477, Varies depending on publication	30 d to 3 y, Varies depending on publication	Complication rates for SG (6.3%) were significantly lower than for RYGB (10.0%; $P < .001$) but higher than AGB (2.4%; $P < .001$). Excess body weight loss at 1 y was	Not randomized; lacks nonsurgical control; patients from a single state

				13% lower for SG (60%) than for RYGB (69%; *P* < .001) but was 77% higher for SG than for LAGB (34%; *P* < .001).	

Source: (Courcoulas et al., 2014)

Table 43. Deficiencies in Knowledge of Long-term Bariatric Surgery Outcomes

Area of Knowledge Gap	Issues and Problems	Potential Study Designs
Incidence of surgical complications	Standards for completeness of follow-up and management of missing data are needed	Comparative safety of surgical procedures; analyses of EMR* databases
Predictors of surgical outcomes	Very little data available to inform which patient should undergo which procedure	Comparative outcomes of surgical procedures; analyses of EMR databases
Overall mortality/survival	Data from observational trials only	Long-term observational and RCTs*; analyses of EMR databases
T2DM remission	Little data on durability of remission	Long-term observational and RCTs; analyses of EMR databases
T2DM microvascular complications	No data on long-term microvascular disease	Long-term observational and RCTs; analyses of EMR databases
CVD events (stroke and myocardial infarction)	Data from 2 observational studies only	Long-term observational and

		RCTs; analyses of EMR databases
Mental health outcomes including suicidality, alcohol, substance abuse, and other risk-taking behaviours	Comprehensive, long-term data lacking for most mental health outcomes	Long-term studies with focus on mental health outcomes; analyses of EMR databases
Cancer	Data from 2 observational studies only	Long-term studies with accurate cancer incidence; analyses of EMR databases
Reproductive outcomes	Very little data available	Shorter- and longer-term observational studies; analyses of EMR databases
Cost and health care use	Lack of data with standard reporting of cost and use Outcomes	Shorter- and longer-term data with cost and health care use; analyses of EMR databases outcomes in surgical vs control groups

* Abbreviations: EMR; electronic medical record; RCTs, randomized clinical trials; T2DM, type 2 diabetes mellitus

Source: (Courcoulas et al., 2014)

5.5 Cost effectiveness of bariatric surgery

This section summarises and critically reviews the evidence regarding the cost effectiveness of bariatric surgery, particularly focusing on the studies that were conducted within a decision modelling framework. The review focuses on studies between 2009 and 2015 inclusive[48]. This time period was chosen for two reasons firstly earlier studies are not relevant due to changes in practise and second to avoid repetition in which a Cochrane review published a systematic review of all bariatric surgery cost effectiveness studies up until the period 2009 (Picot et al., 2009). Considering the NICE updated guidelines (type 2 diabetes individuals with BMI ≥35 to be offered an early, rapid assessment for bariatric surgery) this review included studies that examined the cost effectiveness of bariatric surgery in treating diabetes.

The criteria for this review followed the PICOS (Population, Intervention, Comparator(s), Outcome(s) and Study Design) approach (Schardt et al., 2007). The inclusion and exclusion criteria presented in table 44 shows the studies included in this review. The evidence searching was conducted in two parts; electronic searching and searching the bibliographies of the selected papers for additional relevant references. Databases that were used for this search were MEDLINE, PubMed, EMBASE and the Cochrane Library. Search terms applied were "bariatric surgery economic evaluation", "severe obesity treatment", "bariatric surgery diabetes", "cost effectiveness analysis bariatric surgery" "diabetes severe obesity".

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[48] The timeframe was used so as to follow on from the most recent UK systematic review of bariatric surgery cost effectiveness which was published in 2009. The UK was chosen as personal communication with medical experts (FF) revealed that in the absence of Nationally established guidelines, Ireland generally follows the guidelines issued by NICE in the UK

Table 44. Inclusion and Exclusion Criteria

	Inclusion	**Exclusion**
Population	Adults Severe obesity Obesity and diabetes BMI ≥ 30 kg/m^2	Pregnant women Children/Adolescents Mild to moderate obesity population
Intervention **Comparators**	Surgery vs. non-surgical treatments only	Comparisons between different types of surgeries Robotic surgery
Outcomes	ICER and QALY	
Study Design	CEA and CUA (decision tree, Markov, other decision analytic model), no limit for sample size and time horizon for follow up included in the studies	Non-English studies Cost benefit analysis Cost minimization analysis

Table 45. Cost effectiveness of bariatric surgery literature

Study Author	Year & Title	Country	Intervention /comparator	Model types	Patient group	Key findings	ICER	Type of Economic Evaluation, Study Perspective	Finance model of healthcare system
United kingdom									
(Picot et al., 2009)	2009 The clinical effectiveness and cost effectiveness of bariatric (weight loss) surgery for obesity: a systematic review and economic evaluation	UK	Bariatric surgery vs non-surgical treatment	Markov	Patients BMI ≥ 35 kg/m^2 with significant comorbidities	Bariatric surgery was cost-effective in comparison to non-surgical treatment although the variability in estimates of costs and outcomes is large.	ICER Gastric Band: £1897 Gastric Bypass: £3160	Systematic review UK healthcare system	National health model: universal health care coverage of all citizens by a central government
European Countries									

(Anselmino et al., 2009a)	2009 Cost-effectiveness and budget impact of obesity surgery in patients with type 2 diabetes in three European countries(II)	Austria, Italy, and Spain	Adjustable gastric banding (AGB) and gastric bypass (GBP) vs. conventional treatment (CT)	Decision-tree modelling and Markov model	Patients BMI ≥ 35 kg/m2 and T2DM	In Austria and Italy, both AGB and GBP are cost-saving. In Spain, AGB and GBP yield a moderate cost increase but are cost-effective	ICER Austria €2861/QALY and €1201/T2DM-free-year for AGB and €1 447/QALY and €740/T2DM-free-year for GBP for Italy. €1,077/QALY and €452/T2DM-free-year for AGB and €1,246/QALY and €637/T2DM-free-year for GBP for	Payer-perspective	Social insurance model:

							Spain €1,456/QALY and €611/T2DM-free-year for AGB and €2,664/QALY and €1,362/T2DM-free-year for GBP		
(Mäklin et al., 2011)	2011 Cost–utility of bariatric surgery for severe obesity in Finland	Finland	Cost-utility of bariatric surgeries vs standard care	Decision tree and Markov	BMI>40 kg/m^2 or BMI>35 kg/m^2 with serious cosevere disease	Non-operative care would be more costly for the Finnish healthcare system on average after 5 years following surgery.	Mean cost €33 870 and €50 495 (This is an outlier in terms of the ICER but probably a function of the time period for follow up; just	CUA Finnish healthcare system	

							five years)		
(Borg et al., 2014)	2014 A Cost-Effectiveness Assessment for Sweden	Sweden	Gastric Bypass Surgical (GBS) vs conventional treatment	Markov	Uses an annual increment to update a patient's BMI over time.	Patients with a BMI 40-44 kg/m^2 , surgery was estimated to be cost-saving in men and judged cost-effective in women,	ICER €18,000/QALY		Societal
(Borisenko et al., 2015)	2015 Bariatric Surgery can lead to Net Cost Savings to Health Care Systems: Results from a Comprehensive European Decision Analytic Model.	Sweden	Gastric Bypass Surgical (GBS) vs conservative management	Markov	Severe obese patients with CVDs, type 2 diabetes	Bariatric surgery was cost saving in comparison with conservative management.	ICER< €-35,526/QALYs		Swedish healthcare payer perspective
Canada									
(Padwal et al., 2011)	Bariatric Surgery: A Systematic Review of the	All	adjustable gastric		Unclear[50]	cost-effectiveness of bariatric surgery	Incremental cost–utility	Systematic review	All

[50] This review also examined the clinical efficacy and safety evidence of bariatric surgery along with the association between number of surgeries performed and outcomes Whilst the study states that the review of clinical literature includes studies enrolling adult or adolescent (11 to 17 years) populations meeting guideline-concordant eligibility for surgery (Class III obesity or medically complicated Class II obesity), it does not state if this inclusion was also implemented for the review of economic analysis.

	Clinical and Economic Evidence		banding, Roux-en-Y gastric bypass, sleeve gastrectomy compared to non-surgical treatment[49]			compared with non-surgical management appears to be particularly favourable in patients with type 2 diabetes but current evidence base did not allow for definitive conclusions regarding the relative cost-effectiveness between different procedures	ratios (ICURs) ranging from $1,000 to $40,000 per QALY		
USA									
(Salem et al., 2005)	2008 Cost-effectiveness analysis of	USA	Laparoscopic adjustable	Decision tree	Patients BMI ≥ 35 kg/m^2	The modelled cost-effectiveness analysis showed	For base-case scenarios in men (aged 35	Payer-perspective	Private insurance model

[49] Although not the focus of this review this study also compares bariatric surgery with different types of procedures (as well as non-surgical procedures)

	laparoscopic gastric bypass, adjustable gastric banding, and non-operative weight loss interventions		gastric banding (LAGB) and Laparoscopic Roux-en-Y gastric bypass (LRYGB) vs non operative			that both operative interventions for severe obesity, LAGB and RYGB, were cost-effective at <$25,000 and that LAGB was more cost-effective than RYGB for all base-case scenarios.	yr with a BMI of 40 kg/m2), the ICER was $11,604/QALY for LAGB compared with $18,543/QALY for LRYGB. For base-case scenarios in women (aged 35 yr with a BMI of 40 kg/m^2), the ICER was $8878/QALY for LAGB compared with $14,680/QALY for LRYGB.		
(Ikramuddin et al., 2009)	2009 Cost-effectiveness of Roux-en-Y gastric bypass in type	USA	Roux-en-Y gastric bypass	CORE Diabetes Model	Mean BMI 48 kg/m^2; Type 2	compared with medical management, the	(ICER) of $21,973 per quality-		

	2 diabetes patients.		compared with standard care	model was run over a 35-year period	diabetes patients	Roux-en-Y gastric bypass procedure is cost-effective under very conservative assumptions for procedure costs and complication rates/costs,	adjusted life-year (QALY) gained		
(Campbell et al., 2010)	2010 Cost-effectiveness of laparoscopic gastric banding and bypass for severe obesity	USA	LAGB or LRYGB or no treatment	Cost-utility RCT, n=43, 5 years Literature review Markov modelling	Patients BMI ≥ 35 kg/m^2	ICERs were lower for individuals with higher initial body mass index and higher for older individuals. ICERs for men were generally higher than those of women.	ICER LAGB/LRYGB < US$ 25,000/QALY	n/a	
(McEwen et al., 2010)	2010 The Cost, Quality of Life Impact, and Cost–Utility of Bariatric Surgery in a Managed Care Population	USA	open and laparoscopic Roux-en-Y and no surgery	RCT, n=221, 2 years	Patients BMI ≥ 52 kg/m2；	Although not cost-saving, bariatric surgery represents a very good value for money. Its long-	(Incremental Cost/QALY) $48,662 [2 years] $1,425		

						term cost effectiveness appears to depend on the natural history and cost of late postsurgical complications and the natural history and cost of untreated severe obesity.	[lifetime]		
(Chang et al., 2011)	2011 Cost-effectiveness of bariatric surgery: should it be universally available?	USA	Bariatric Surgery in different populations	Decision Tree and Mixed proportional hazard model	BMI ≥ 35 people who had ORDs [51]and those who did not.	surgery treatment is in general cost-effective for people whose BMI is greater than 35 kg/m(2) with or without obesity-related comorbidities, and it is even cost-saving for super	ICER US$2413/ QALY (ORD group), US$3872/QALY (non-ORD group)	n/a	

[51] Coronary heart disease, hypertension, type 2 diabetes mellitus, dyslipidemia, and stroke.

						obese (BMI ≥ 50 kg/m(2)) with obesity-related comorbidities			
(Hoerger et al., 2010)	2010 Cost-Effectiveness of Bariatric Surgery for Severely Obese Adults With Diabetes	USA	gastric bypass surgery relative to usual diabetes care and the cost-effectivenes s of gastric banding surgery relative to usual diabetes care.	Centres for Disease Control and Prevention –RTI Diabetes Cost-Effectiven ess Model Literature review	Newly diagnosed and established Patients with T2DM	gastric bypass and gastric banding are cost-effective methods of reducing mortality and diabetes complications in severely obese adults with diabetes.	Bypass surgery had cost-effectiveness ratios of $7,000/QALY and $12,000/QALY for severely obese patients with newly diagnosed and established diabetes, respectively. Banding surgery had cost-	The payers' perspective (i.e. the insurers' + patients' co-payments)	Private insurance model: employme nt-based or individual purchase of private health insurance financed by individual and employer contributio ns.

							effectiveness ratios of $11,000/QALY and $13,000/QALY for the respective groups.		
(Wang et al., 2014)	2014 Cost-effectiveness of bariatric su rgical procedures for the treatment of severe obesity.	USA	Bariatric surgeries vs non-surgical treatment	Decision Analytic and regression	Reference case was defined as a 53-year old female with body mass index (BMI) of 44 kg/m2 .	Bariatric surgery appears to be cost-effective compared to no surgery using a lifetime timeframe. surgical procedures to treat severe obesity improve patient quality of life and their life expectancy by reducing BMI and other comorbidities, but are associated	ICER US$6,600, US$6,200 and US$17,300/QALY LRYGB, LAGB and ORYGB respectively vs. Non-surgical intervention		CEA, CUA, healthcare system perspective Healthcare system

						with higher lifetime direct medical costs.			
Australia									
(Keating et al., 2009)	2009 Cost-Effectiveness of Surgically Induced Weight Loss for the Management of Type 2 Diabetes: Modelled Lifetime Analysis	Australi a	LAGB and standard care	RCT data Markov model	type 2 diabetes in class I/II obese patients.	after 10 years the return on investment of surgical therapy is fully recovered through savings in health care costs to treat type 2 diabetes in the surgical group	ICER $- 48,400 per QALY		
(Lee et al., 2013)	2013 The Cost-Effectiveness of Laparoscopic Adjustable Gastric Banding in the Severely Obese Adult Population of Australia	Australi a	Laparoscopi c adjustable gastric banding (LAGB) and do nothing in different	Markov	Severe obesity BMI >40 and individuals with BMI >35	LAGB surgery is highly cost-effective and also ranks highly in terms of cost-effectiveness when compared to other population-level interventions for	ICER < $50 000/DALY	Health sector and third parties payer	

			scenarios			weight loss in Australia.			
Korea									
(Song et al., 2013)	2013 Bariatric surgery for the treatment of severely obese patients in South Korea--is it cost effective?	Korea	Bariatric Surgery vs non-surgical treatment	Markov	Severe obesity; BMI 30- <40 kg/m2	Bariatric surgery is a cost-effective alternative to nonsurgical interventions over a lifetime, providing substantial lifetime benefits for severely obese Korean people.	ICER US$1,771/QALY	Korean Health System	
Global									
(Faria et al., 2013)	2013 Gastric bypass is a cost-saving procedure: results from a comprehensive Markov model.	Global	Best medical management, gastric band, and gastric bypass	Markov	Severely obese patients; subgroup analyses was performed for patients without	Gastric bypass is cost effective. Patients with BMI > 35 kg/m^2, gastric bypass renders 1.9 extra QALYs and saves on average €13,244 per patient.	ICER €13,071 /QALY	CEA, CUA, societal perspective with universal coverage for	

					comorbiditi es, patients with diabetes mellitus, different age, and BMI groups.			healthcare	

This review showed that using modelling techniques, all studies that met the inclusion criteria report bariatric surgery to be cost effective for treating severe obesity. However there are a number of fundamental issues surrounding bariatric surgery cost effectiveness findings that may lead us to be cautious about the adoption of bariatric surgery in Ireland, some of which include; the uncertainty of long term outcomes of bariatric surgery (which is important when modelling long term health outcomes and costs), the lack of transparency regarding cost and resource data sources and finally the issue of inability to generalise results.

The non-generalizability of results is discussed in the second part of this review in terms of how Ireland differs with respect to a number of factors and how these may impinge on cost effectiveness findings. These factors include healthcare system differences such as entitlements to publicly funded healthcare (which can influence healthcare user and provider behaviour in terms of treatment compliance and the type of patient undergoing surgery –private or public patient); perspectives of the evaluations (i.e. of a healthcare system, a payers or a societal perspective); differences in treatment practises including the type of procedures performed (which can influence care pathways implemented) and; the volume of surgeries (which can influence costs and health outcomes).

It seems to be the case that the one certain consensus among the studies is the acknowledgement of the uncertainty regarding long term bariatric surgery outcomes. Studies published in the UK and Canada (Picot et al., 2009, Padwal et al., 2011) which systematically reviewed the cost effectiveness studies of bariatric surgery reported that bariatric surgery is cost effective for severe obesity treatment – with each review noting in particular the favourable cost effectiveness for those severely obese individuals with diabetes[52]. Picot et al also developed a health economic model that examined the cost effectiveness of bariatric surgery within a lifetime horizon. Three patient groups were considered: patients with BMI ≥40; BMI ≥30 and patients with BMI <35 from the National Health Service (NHS) perspective. As shown in table 45, ICERs remained within the range regarded as cost-effective (although not for the BMI 30-35 group). However uncertainty regarding resource use and costs associated with surgical management along with the absence of reliable long-term data on the effectiveness (in terms of sustained weight loss) were shortcomings of this model. The review also reported large variability in estimates of costs and outcomes from the reviewed studies and went onto suggest that there was a strong likelihood that many of the estimates were unreliable and not generalizable. This review formed part of an overall health technology assessment published as a Cochrane review and according to the report "directly influences decision-making bodies such as the NICE.

An Australian study examined the cost-effectiveness of LAGB in individuals with BMI >40 and those with BMI >35, compared to conventional treatment and reported LAGB surgery to be cost-effective (Lee et al., 2013). Again, the conflicting evidence on the long-term consequences of LAGB surgery beyond 5 years is highlighted as a limitation; the savings that were identified in the study were not clearly detailed. Information was unavailable for several important input parameters which included; disease disability weights; annual risk/cost of long-term surgical maintenance 2 years after initial LAGB surgery; cost offset data; health care costs for seemingly unrelated diseases and injuries; and time and travel costs

[52] The inclusion criteria differed for each review, Picot et al examined all cost-effectiveness analyses, cost–utility analyses, cost–benefit analyses and cost–consequence (36 studies were reviewed); whereas Padwal et al examined cost-utility and cost-minimisation studies only (13 studies were reviewed).

Padwal et al draws an interesting observation regarding cost-effectiveness models in terms of their ability to both underestimate and overestimate the economic effectiveness of surgery (Padwal et al., 2011). The author notes that because observational data and relatively short-term RCT data is generally used to model the long-term impact of changes in weight on QoL and health, these models might overestimate the economic effectiveness of surgery. Conversely, the author also notes that for a number of reasons it is also possible that existing models underestimate the economic effectiveness of surgery. These reasons include the assumption that the weight of patients not undergoing surgery remains stable long-term when it may in fact increase; surgically induced improvements that may occur in common obesity-related comorbidities such as osteoarthritis are usually ignored; and also reductions in the indirect costs of obesity are typically not considered, such as losses in productivity due to illnesses or employment discrimination.

In the absence of long term RCT data there is inevitably going to be assumptions about future outcomes and costs, which are often criticised for being based on short term empirical data or published reports (which do not have large numbers of persons followed up for prolonged periods and are not peer reviewed, are opinion pieces or/and lacking in transparency) which are also sensitive to assumptions about weight loss and the impact of weight loss on health-related quality of life, survival and costs. The question that these issues pose is one which asks is there an engagement in self-deception in respect of cost effectiveness or at least wishful thinking, given current available data.

Borisenko et al used decision analytic modelling techniques to conduct a cost-utility of bariatric surgery (GBP, SG, and GB) and concluded that bariatric surgery is cost effective in Sweden; ICER< €35,526/QALY

(Borisenko et al., 2015) but data sources for clinical data were not outlined. Similarly in the USA, (Chang et al., 2011) conducted a CEA using decision tree analysis and reported bariatric surgery to be cost effective but failed to outline the sources for the cost data, focusing more on citing effectiveness data sources. Furthermore a CEA from a global perspective applied a markov model to examine three different procedures for weight loss management (Faria et al., 2013) in which patients were assigned to one of three treatment strategies; GB, GBP and medical management and were assigned the respective costs and transition probabilities. The study reported gastric bypass as the most favourable surgery reporting an ability to save approximately €13,244/patient on a lifetime perspective. After sub group analyses, the benefit of intervention was reported to be higher in patients with a BMI between 40 and 50 kg/m^2.

Again, the sources of the distributions, probabilities, costs, and utilities were not explicitly outlined and seemed to be loosely modelled stating that they were "retrieved from the literature whenever available or retrieved from our institutional database". There is no evidence to suggest that the evidence used to inform the model is applicable on a global scale. Furthermore the societal perspective assumption of universal coverage for healthcare is not common across all jurisdictions, so it is debatable if these findings are indeed globally applicable as asserted in the paper.

Anselmino et al examined the cost-effectiveness of AGB and GBP vs. conventional treatment which is diet and lifestyle modification (CT) in patients with a BMI≥35 kg.m^2 and type 2 diabetes mellitus (T2DM) in Austria, Italy, and Spain (Anselmino et al., 2009b). The study reports that in Austria and Italy, both AGB and GBP are cost-saving and are thus dominant in terms of the ICER compared to CT. In Spain, AGB and GBP yield a moderate cost increase but are cost-effective. However, it is vague as to where the clinical evidence for the model input parameters were derived, stating that they were "obtained from the literature". Possibly the principal shortcoming of this study is that the Excel model used is extremely basic and is only estimated over a five year period.

A study in the USA used a more sophisticated Markov model is applied from the Centres for Disease Control-Research Triangle Institute (CDC-RTI) Diabetes Cost-Effectiveness Model (Hoerger et al., 2010). The cost effectiveness of GBP relative to usual diabetes care and GB surgery relative to usual diabetes care are estimated , by estimating rates of diabetes remission and relapse, as well as diabetes complications, deaths, costs, and quality-adjusted life-years (QALYs) (Hoerger et al., 2010). Two patient groups were considered: severely obese people (BMI ≥35 kg/m2) who are newly diagnosed with diabetes (no more than 5 years after diagnosis) and severely obese people with established diabetes (at least 10 years after diagnosis).

The authors reported that bypass surgery had ICERs of US$7,000 per QALY and US$12,000 per QALY for severely obese people with newly diagnosed and established diabetes, respectively. Banding surgery had ICERs of US$11,000 per QALY and US$13,000 per QALY for the respective groups. The authors caution that although the model parameters appear to favour bypass surgery, this may be due to the different characteristics of the people who opt for bypass surgery (e.g. higher BMI and more comorbidities). This reiterates a point discussed in the next section in terms of the type of procedure practised in a jurisdiction that may be influenced by patient characteristics which can in turn influence health outcomes and costs.

Finally an issue that does not appear to be discussed at length in the literature is the influence that industry supported studies has on study findings. For example one of the most widely cited papers regarding the outcomes of bariatric surgical interventions is a meta-analysis sponsored by a surgical device manufacturer (Buchwald and Oien, 2013). The article summarized the findings of 131 published reports, of which more than 75% were case series from individual centres, the inclusion of all consecutive patients was not a requirement, the percentage of patients followed-up ranged from unrecorded to 50-80% (average was less than 70%), and no standard endpoints were used for clinical outcomes.

Likewise, a report “Shedding the Pounds” (O’Neill, 2010)highlighted an economic argument for increasing the availability of bariatric surgery on the NHS was, in part commissioned by two manufacturers (Allergan and Covidien) of surgical devices (who may stand to profit from the expansion of bariatric services). Furthermore the previously discussed European study discussed further in the next section (Anselmino et al., 2009a) also received financial support from bariatric surgery consultants.

In summary, although the majority of studies argue that bariatric surgery is a cost-effective treatment there are a number of points that can be drawn from this review. The cost effectiveness of bariatric surgery has been evaluated in a number of studies worldwide, but appears to be hampered by a number of factors including heterogeneous sources of cost data along with different types of costs (direct or indirect) being examined along with an absence of clarity regarding data sources. Furthermore a number of differences makes comparability between CEA studies difficult for example; the use of different comparators (drugs or diet and lifestyle modification); different types of bariatric surgery being examined; different outcomes and patient groups examined; different perspectives; different modelling techniques using different timeframes; and also variations in the sources of effectiveness data (RCT, observational studies). While this review appears to provide a clear consensus (that bariatric surgery is cost effective), a lack of clarity around the data used, the tendency to recycle data, and the lack of long term follow up data may cause us to be more cautious about simply assuming it is cost effective rather than verifying this in a particular context which may be different to those even in well conducted studies.

5.6 Key factors likely to impact on the cost-effectiveness of bariatric surgery in Ireland

In the past authors have expressed surprise that economic analyses were being conducted without paying consideration to a number of issues when transferring the findings of multinational studies to national settings (Halliday and Darba 2003). The literature shows that the generalisability of CEA findings is dependent on, for example, the availability of health-care resources, clinical practice patterns, prices, the organization and financing of health-care systems, and health technology decision-making processes between jurisdictions (Manca and Willan, 2006). In terms of influencing the cost effectiveness of bariatric surgery in Ireland, the specific issues that this section focuses on relate to; the differences in the volume of bariatric surgery performed in Ireland, for example throughput is important for economies of scale and prices; Ireland's limited capacity in this area means those performing surgeries may enjoy significant economic rents[53] -; the differences that exist in healthcare systems along with the differences in obesity treatment patterns are discussed.

Furthermore cost effectiveness at a given threshold only applies when the state's money is being used. In the vast majority of cases in Ireland this is not the case and those going through the state system are likely to be a very different sample relative to those going through the private system - this and the numbers will impact on the CEA. Prior to this discussion, the first section focuses on why undertaking a CEA of bariatric surgery in Ireland is problematic in terms of the lack of data.

[53] Economic rent is the positive difference between the actual payment made for a factor of production (such as land, labour or capital) to its owner and the payment level expected by the owner, due to its exclusivity or scarcity

In addition to these factors, other differences worth noting that may influence access and provision of bariatric surgery (and in turn cost effectiveness) relate to the rationing and allocation of funds for bariatric surgery, including the opportunity costs therein. Over the past number of years the Irish healthcare system has endured radical resource cuts. From 2009 to 2013 financing of the HSE fell by 22%, which amounted to almost €3·3 billion less in public funding(Health Service Executive. Health service national performance assurance report. August 2013. http://www.hse.ie/eng/services/Publications/corporate/performanceassurancereports/perfassuranceAug13.pdf).

In Ireland, the prolongation of austerity has yielded increased rationing in light of other more pressing priorities in the healthcare system, for example rising waiting lists and the increasing demand for elderly care. Thus the opportunity cost of devoting resources to obesity treatment may not reflect those that pertained in other places at other times which is to say the threshold against which CEA was established elsewhere may not apply in Ireland. Moreover, as discussed further below, there appears to be different priorities for obesity resource allocation in Ireland, that is, a partiality to allocate funds towards obesity *prevention* as opposed to obesity *treatment* – as evident by resource allocation priorities published in Government documents (discussed below).

5.6.1 Bariatric surgery data limitations in Ireland

There is insufficient monitoring and tracking of severe obesity prevalence data within the Irish healthcare system. The uncertainty regarding prevalance rates of severe obesity in Ireland has implications in terms of the difficulty in estimating pattern of demands for service use and in turn making resource allocation decisions with certainty. However, although the prevalence of severe obesity has not yet been formally quantified, there are a number of studies that, although not designed to provide insight on obesity prevalence, are useful in informing estimations of severe obesity levels in Ireland. However, as noted in chapter one of this thesis, these studies are undertaken at one point in time and vary in quality in terms of how well characterised respondents are.

In Ireland earlier studies did not examine or report severe obesity. For example the 2007 Survey of Lifestyle, Attitudes and Nutrition in Ireland (SLÁN) provided estimates of BMI based on self-reported height and weight, focused on obesity in general and did not classify obesity according to severity. However as previously stated in chapter one TILDA shows that out of an Irish study population of those over the age of 50 (n= 5,841), approximately 3% of these were classified as severely obese (Mc Hugh et al., 2014). Madden (2013 (Madden, 2013) analysed this data using concentration indices[54] for obesity and suggested that over time the socio-economic gradient in obesity is rising, that is, more middle class people are becoming obese. Experts working in the field of obesity in Ireland estimate the rate of severe obesity to be slightly lower at approximately 2% of the Irish population. However, the key issue is what is not known; future prevalance patterns for severe obesity cannot be estimated with certainty, trends provide incomplete information and demand for healthcare among this cohort cannot be predicted with accurary.

In addition to prevalance uncertainty, there are a number of pitfalls regarding the manner in which bariatric activity is recorded, or rather *not*

[54] The concentration index is a standard measure of association which indicates the degree to which a condition such as obesity varies with a continuous measure of household resources, such as income or expenditure. It has the attractive property that it provides a single index of income related inequality in obesity and it can also be used in a decomposition analysis of the factors lying behind such income related inequality

recorded in Ireland. The three areas of concern relate to; 1) no National database in Ireland recording bariatric activity; 2) an ad hoc reporting system between the two public clinics performing bariatric surgery (that is no National database with little collaboration regarding the sharing of data or research between each clinic) and 3) a lack of distinction between public and private bariatric activity in certain reports. Surgical techniques and trends change over time and with experience, but collecting data means that important observations can be made that, in turn, lead onto and form the basis for research questions.

In Ireland there is no National database in which data on bariatric activity, for example, the number and type of procedures, can be or is required to be entered. The implication of this is such that the type of surgeries undertaken in the past is not known, nor is the current throughput of surgical teams being quantified or what the longer term outcomes of those teams are, nor are patient outcomes and benefits available (there is some clinic specific data available in each centre, however this only provides regional data).

This contrasts to other countries, for example in the UK the NHS England have mandated participation in Consultant Outcomes Publication audits as part of the NHS Standard Contract for 2013/14. The National Bariatric Surgery Registery (NBSR) was set up in which the key objective of the registry, according to its website (http://nbsr.e-dendrite.com/) is to accumulate sufficient data to allow the publication of a comprehensive report on outcomes following bariatric surgery. This includes reportage on weight loss, comorbidities and improvement of quality of life.

Secondly, in the absence of a national database, an ad hoc reporting system between the two clinics providing public access to bariartic surgery in Ireland is evident. Personal communication with medical expertise together with a review of unpublished reports indicated that although a number of types of procedures are performed in both clinics, procedures differ in terms of what the most common procedure performed is. In Dublin the gastric bypass (GBP) is most common whilst in Galway the gastric sleeve (GS) is the most common procedure. The difference in bariatric procedures might be due to different patient characteristics and requirements, however one would imagine that differences in severely obese patient characteristics in Dublin and Galway would not be vast and that differences may therefore relate more directly to the preferences of the treating physicians. What implications this may have for economies of scale and cost effectiveness is unclear.

Thirdly, in some reports the distinction between public and private bariatric surgery activity in Ireland is not clearly defined. For example, a report published from the UK database NBSR which provides a "comprehensive, nationwide analysis of outcomes from bariatric (obesity) and metabolic surgery in the United Kingdom & Ireland" does not clairify the location or type of Irish clinics participating in the data entry to the NBSR website. Personal communication with the website reveals that it is in fact just one private surgeon that is contributing data (http://www.obesitysurgery.ie/colm-joseph-o-boyle.html), yet this website, including all of the reports based on the data claims to be representative of Irish bariatric surgery concluding that ".. *surgery in the United Kingdom & Ireland is safe*...".

The public-private distinction is important as matters such as cost, surgeon experience and patient characteristics can differ which can subsequently influence health outcomes and costs and in turn the ICER. Thus bariatric surgey outcomes reported from this UK register are *not* representative of public sector practise in Ireland and may indeed be painting a more favourable picture of bariatric surgery, indicating encouraging results of bariatric surgey outcomes.

To sum up this section, the absence of reliable country specific data and information makes planning difficult and undermines attempts to improve the economic efficiency and equity of services. The characteristics of the bariatric patients at a national level are unknown. In the context of the public-private bariatric activity it is unclear as to whether the surgery is based solely on need or if it is an aspect of need and ability to pay. If policy makers are unaware of what current capacity is or what current demands are, developing an appropriate strategy and knowing what role bariatric surgery should have in it, is difficult.

It also poses the question of how confident we can be that current practise in Ireland is safe in the absence of a National data recording system or any long term published health outcomes, complication rates or mortality data. Along with this a review of Government Policy documents indicates that very little priority seems to be given to severe obesity treatment with a larger focus being placed on obesity prevention. The fact that obesity treatment guidelines lack clarity or any detailed discussion of bariatric care in Ireland is arguably likely to reflect either unease regarding the ability of Ireland to deliver bariatric care or willingness to fund this intervention given other demands it is currently facing.

5.6.2 Volume of bariatric procedures

The volume of bariatric surgery performed in any centre is important not only in terms of the surgical teams retaining their skills but also the downstream implications that this can have in terms of surgery safety and success, health outcomes and costs. While the evidence it is unclear exactly how many surgeries are conducted in Ireland in any one year, it seems clear that the throughput in Ireland is low relative to that in other jurisdictions and there is reason to suspect that this might impact on clinical outcomes in terms of complication rates and also costs. The importance of clinical outcomes for bariatric surgery in the context of CEAs cannot be underestimated considering the fact that much of the cost (increase or decrease) is predicted as per BMI change. Also, specific to the Irish context is the role that the mixed public - private surgeon activity plays, in which bariatric surgeons are permitted to practise privately and publicly. This complicates the assessment of how many surgeries are conducted by any given surgeon.

Annually, over 344,000 bariatric procedures are performed worldwide: 220,000 of these take place in the USA/Canada and 6000 are performed in the UK, with over 90% being performed laparoscopically (Buchwald and Oien, 2013). In order to develop a critical mass of surgical activity to ensure clinical excellence, centres ought to be doing 150-200 per annum. (Zevin et al., 2012). As noted earlier, in the absence of a National data registry it is difficult to ascertain trends and volumes of bariatric surgery in Ireland. Therefore a reliance on clinic specific reports along with medical expert's opinion is required to estimate actual throughput.

A recent (unpublished) 2014 report (*Overview of Irish medical services and care pathways for obesity*, Justin Geoghegan) from the Dublin bariatric clinic noted that Ireland performed on average 120-140 bariatric surgerical procedures per year (no date provided). It is unclear from the report if this combines public and private bariatric surgery activity or the throughput of each clinic individually. Even at the upper end of this limit and assuming all surgeries were performed in one centre (which they are not) Ireland is still below the lower bound of the level required to retain the necessary skills. The report also outlined that between 2002 -2013 a total of 256 bariatric surgeries were performed publicly in Dublin with GBP being the most common. Converserly in Galway SG is the most common procedure.Between 2009 and 2013 a total of 122 SG were performed. However, in Galway the throughput of surgery since this period appears to have declined. Personal communication with the bariatric service clinic in Galway indicated that in 2014 a total of 40 bariatric surgeries were performed and up to October in 2015 a total of seven surgeries have been performed in Galway for the year 2015.

Broadly speaking, the research suggests that the more experience the surgeons and the care team have, the more clinical outcomes are improved, whereby experience is gained (and maintained) with surgery practice via a consistent volume of patient throughput. Earlier studies (Nguyen et al., 2004) reported that high volume hospitals had shorter length of stay (3.8 days vs. 5.1 days for low volume hospitals), lower overall complications (10.2% vs. 14.5%) and lower cost ($10,292 vs. $13,908) which was driven to a large extent by the shorter hospital stay. Since hospital cost is a major driver in the overall cost of surgery, a reduction in the length of stay leads to an improved ICER.

However bariatric surgery has evolved over the past decade and both procedure type and technique have changed significantly (Encinosa et al., 2009). Due to minimally invasive techniques (laparoscopic surgery), fellowship training, patient selection and processes of care, adverse outcomes in bariatric surgery have apparently declined in recent years (Dimick et al., 2013, Carlin et al., 2013). However, even in light of recent advances in bariatric surgery, recent studies and analysis of bariatric registries concur with earlier studies which report that high volume hospitals and surgeon experience are favoured in terms of better outcomes and reduced costs (Birkmeyer et al., 2010, Dimick et al., 2013, Finks et al., 2011). Additionally in the UK a report using data from the National Bariatric Surgery Registry (NBSR) examined a cohort of surgery patients during 2011-2013 inclusive, (16,956 primary surgeries and 1,327 revisions or planned second stage procedures). This report noted that the short in-hospital stay is "almost certainly" due to the surgery being performed via a laparoscopic approach and surgeons being "sufficiently confident" in their operative technique.

In the USA Birkmeyer and colleagues reported the results of an analysis using data from the Michigan Bariatric Surgery Collaborative registry which contained data voluntarily submitted from 25 hospitals from 2006 to 2009; which given the voluntary nature of data submission is open to a sample selection problem (n = 15,275 operations) (Birkmeyer et al., 2010). This report assessed the complication rates of different bariatric procedures and variability in rates of serious complications across hospitals according to procedure volume and centre of excellence (COE) status.

The report concluded that the rates of serious complications were inversely associated with hospital and surgeon procedure volume, but unrelated to COE accreditation by professional organizations. In this regard a recent study in Taiwan suggested that annual surgical volume is the key factor in hospital resource utilisation (Chiu et al., 2012). The authors noted that in order to increase healthcare quality and decrease costs, payers may consider using high volume hospitals/surgeons preferentially for performing complex surgical procedures or consider providing expert consultation to low-volume surgeon. Furthermore a recent study stated that the inexperience or lack of training of the surgeon is frequently associated with an increase in post-operative severity and mortality, which may therefore reduce the benefit of surgery (Sánchez-Santos et al., 2012).

The cost of bariatric surgery includes many components, such as pre-operative assessment and care, the surgery episode itself, post-operative and follow-up care. Some studies suggest that offering patients bariatric surgery requires the establishment of specialist bariatric centres or Centres of Excellence (COE) with in-house multi-disciplinary expertise (Ashrafian et al., 2011). This is to achieve a cohesive treatment system for obese patients in terms of safety and efficiency. In this regard two centres in the UK have been accredited[55] as COE in bariatric surgery; Nuffield Hospital and Taunton NHS Trust (www.ifso.eu.org).

In Australia, the Centre for Obesity Research and Education (CORE) is an active bariatric COE at Monash, Victoria. Numerous criteria constitute a bariatric surgery COE but the primary criteria are surgeon volume greater than 50 cases and the hospital volume greater than 125 cases annually (Norton et al., 2009). In Ireland, even if the two public centres amalgamated they would not meet this criteria and unlikely that the surgeons undertaking those operations even allowing for private work would meet the criteria.

Broadly speaking, it is reasonable to assume that high volume operating clinics would benefit in terms of 'economies of scale' in providing resource-intensive services (Birkmeyer et al., 2002). Economies of scale such as spreading fixed costs over a greater number of procedures may be particularly relevant in the context of cost savings for bariatric surgery in terms of the quality of outcomes in avoiding readmission or complications.

[55] European Accreditation Council for Bariatric Surgery (EAC-BS) is the organization that examines the institutional facilities and the surgeon's qualifications and experience in order to ensure they offer safe and efficient management to severely obese and patients with other metabolic disorders that can be surgically treated (i.e. diabetes type 2).

However as is the case in Ireland, the volume of surgery is relatively low meaning that the hospital performing the procedures may not benefit from economies of scale. In Ireland it appears to be the case that there is ample work to keep one surgeon busy as, according to personal communication with medical experts (FF), surgeons performing bariatric surgery also perform other surgeries such as cancer surgeries. However economies of scale are not the same as economies of scope and there seems little evidence to suggest Ireland is able to enjoy the former.

In America the shortage of general surgeons has been noted with anticipated deficits of at least 1,875 surgeons predicted by 2020 (Williams and Ellison, 2008). Shortages in the number of general surgeons will undoubtedly translate into shortages of bariatric surgeons. In addition to the limited surgeon supply, there is already a high demand for bariatric surgeries (Santry et al., 2005), which will likely grow as more populations are proven to benefit from bariatric surgery.

5.6.3 Healthcare systems

The differences that exist in a country's healthcare system can influence cost-effectiveness findings (O'Sullivan et al., 2009). In particular the Irish healthcare system has a number of unique features that may potentially influence or even hinder the transferability of other countries cost effectiveness findings to the Irish setting. The section discusses how different access to healthcare in Ireland (whether universal coverage or out-of-pocket payments exists) along with healthcare incentives (the way in which healthcare providers are paid and how users pay for care) can influence the patient case-mix (the number and types of patients treated in a hospital) and the behaviour of both providers and users (in terms of health care utilisation) and in turn result in heterogeneity of health outcomes (according to patient type; private or public). That some of these factors are unique to Ireland and may have a role in determining cost effectiveness (as well as candidature for treatment) they should but often are not taken into consideration when inferring other countries cost effectiveness findings to the Irish setting.

In Ireland health policy, legislation and strategic management are the responsibility of the Department of Health and Children under the control of the Minister for Health and Children. Currently the Irish health system is primarily dominated by public funding (taxation), with elements of private funding running alongside it, including contributions from out of-pocket payments and voluntary private health insurance (PHI). Some individuals are entitled to a medical card in which eligibility is largely determined on the basis of income. A medical card grants its holder free access to a GP, prescription medications subject to a levy, free treatment in a public hospital bed, free access to an accident and emergency (A&E) department, and other less widely used benefits (Bourke and Roper, 2012). In 2011 approximately 37% of the Irish population had a medical card, while approximately a further three percent had a GP Visit card, (*HSE (2012): Annual Report and Financial Statements 2011. Naas: Health Service Executive)* which allows them free access to a GP but does not confer the other benefits of a medical card. Alongside the public health system is a system of voluntary PHI[56] in which in 2012 46% of the population had PHI (HIA, 2013a). However, PHI

[56] Ireland is currently undergoing a reform package for the Irish health system. One of the aims of this reform is to have a single-tier health system, where access is based on need rather than ability to pay. This has seen an introduction to Universal Health Insurance (UHI). Under the proposals, it has become obligatory to purchase health insurance, which would provide hospital and some primary care cover (Department of Health, 2013a). The State would pay for premiums on behalf of those on low incomes and subsidise premiums for a further cohort

does not cover all elements of healthcare – for example GP visits are not as a rule covered by insurance and individuals must pay a fee per visit.

In Ireland, bariatric surgery is provided via the public healthcare system and also within the private healthcare system. Therefore individuals with medical cards have access to (publicly funded) bariatric surgery in principle, albeit according to personal communication with medical experts (FF); a long waiting list (> 3 years) or individuals can also opt to pay for this surgery privately. There is a lack of clarity as to whether or not access to bariatric surgery is provided to those who have VHI. Through personal communication with the main Insurers in Ireland (Aviva, VHI and Laya healthcare) there are medical circumstances in which the [bariatric] "operation might be deemed a matter of life or death and in such cases would be covered by PHI" (personal communication with CHI and Aviva health insurers). The circumstances of the surgery are based on reports from the consultant endocrinologists and/or the bariatric surgeon. These restrictions - the small number of surgeons and the near refusals to fund may help explain the low throughput in Ireland.

Access to health care refers to the degree to which people are able to obtain appropriate care from the health care system in a timely manner (Escarce and Kapur, 2006). A number of concerns in relation to the equity of healthcare access in Ireland have been raised and are important in the context of describing the *type* of patient that is more likely to undergo bariatric surgery in Ireland. These equity concerns raise the question of whether the patients undergoing bariatric surgery in Ireland are comparable to that of other jurisdictions - which is important in the context of comparable health outcome probabilities. Current healthcare incentives and structures in place in Ireland imply that there is a reason to believe that the bariatric patient case mix may differ according to those patients who undergo surgery privately (being of a higher SES) and those patients who undergo surgery publicly (being of a lower SES). In Ireland those with PHI tend to be younger, from higher educational groups and less likely to have health problems (Francesca and Tapay, 2004). Conversely, medical card holders are more likely to be poorer and also have a poorer health status (Farrell et al., 2008). The implication is that those who have medical cards may experience poorer health outcomes from surgery relative to those who have PHI. Given the relationship between SES and PHI status it seems reasonable to infer that those in the public system in Ireland to whom CEA analysis would apply are likely to be different to those in the UK. The question is does this mean their outcomes may also be expected to be poorer; might they be less compliant with post-surgery care; might they have higher other comorbidities, lower life expectancy etc. than is assumed in the UK models and subsequently might transferring UK estimates result in an over estimate of the value of bariatric surgery.

What is of particular importance is how the patient case-mix can impact on the health outcomes and in particular how the patient case-mix may differ in Ireland relative to other jurisdictions that have reported bariatric surgery as cost effective. Such differences have well documented implications, for example an earlier study that observed the impact of SES and ethnicity on bariatric surgery found that (among other things) patients with higher SES lost more of their excess weight than other groups of patients (Toussi et al., 2009). In another study in the USA it was reported that Medicare patients (a proxy measure for low SES) "generally came into operations with worse health than other patients and fared worse following surgery". Researchers found Medicaid patients required longer hospital stays and ended back in the hospital more often than patients covered by private insurance (Waits et al., 2014). An earlier discussion paper reported that in the UK context, medical care may have a differential effectiveness in relation to social position: "…apart from problems of access (e.g. the inverse care law), treatments for major diseases may be on average less effective for lower socioeconomic groups because they more frequently have other conditions that contribute to poorer outcomes" (*McCarthy M. Causes and Contributions of Public Health. Discussion Papers for Meeting of the Issues Panel for Equity in Health. London, King's Fund; 2001*).

5.7 Differences in treatment patterns for bariatric surgery

The role of best practice and evidence-based medicine in bariatric surgery seems to be poorly understood. Significant gaps were identified in the published reports regarding pathways to bariatric surgery and multidisciplinary team use. To some extent the heterogeneity in the way bariatric surgery can be performed along with the lack of long term RCT evidence for bariatric surgery might explain why there is a lack of clarity regarding the bariatric care pathway in Ireland. Although it has been demonstrated that standardising patient care with a clinical pathway decreases the length of stay after bariatric surgery (Frutos et al., 2007, Campillo-Soto et al., 2008), no best practise guidelines have been established therein.

There are two implications of this in the Irish context; it questions the transferability of other jurisdictions findings and also in the context of no established national care pathway, this inhibits any nationally representative perspective been developed regarding bariatric surgery. For example in Australia (O'Brien, 2010) and in the UK gastric band (GB) is the most common procedure (Stroh et al., 2010). In Ireland the most commonly performed procedure is not known at a National level but unpublished reports including personal communication (FF) indicate that in Dublin gastric bypass is the most common and in Galway sleeve gastrectomy is the most common (GUH report 2014)[57]. The intensity of follow up along with the care pathways required for each type of procedure vary and in turn are likely to differ across jurisdictions. Such jurisdictional differences in care pathways can produce differences in health outcomes, resource input, utilisation of services, and expenditure among jurisdictions (Mullins et al., 2014). This draws further uncertainty to the applicability of other jurisdictions cost effectiveness findings to the Irish context. For example the care pathway of the GB is unique among surgical procedures in that the placement of the band is only the first step of a process of care that continues permanently in which the follow up program is crucial; whereas the intensity of follow up for the GS appears to be somewhat less. However that said, authors have criticised this viewpoint as a "*perceived lack of need for close follow up with the sleeve*" (O'Brien, 2010). Additionally in the absence of a clear pathway and protocols around this there will likely be greater heterogeneity and with it lower opportunities for economies of scale, and quality assurance.

A recent conference address delivered by Prof Wendy Brown[58] noted that in Australia there is much stronger focus on post-surgery care and weight maintenance *after* surgery, whereas as noted by Brown, in Ireland there is a stronger focus on pre-surgery care in motivating patients to lose weight prior to surgery. For example in Galway individuals have to first show some sort of behaviour change over a period of many months prior to a tentative surgery date. The period of behaviour change leading up to the surgery functions as a mechanism for practicing and developing commitment to

[57] Private surgery data was not accessible.
58 Associate Professor of Surgery at Monash University, Australia; director of the Monash University Centre for Obesity Research and Education (CORE), a leading international research institute dedicated to improving the health of obese patients. Wendy is the president elect of the Obesity Surgeons Society of Australia and New Zealand (OSSANZ), a board member of Australian and New Zealand Gastro-oesophageal Surgeons Association (ANZGOSA) and an examiner for the Royal Australasian College of Surgeons.

lifestyle changes. Figure 21 below shows that a number of different weight loss initiatives are available. However, according to personal communication with FF and unpublished (*Overview of Irish medical services and care pathways for obesity)* these weight loss initiatives are unique to the Galway clinic and the same programs are not implemented in the Dublin clinic. Figure 21 shows the care pathway in the Dublin clinic as extracted from *Overview of Irish medical services and care pathways for obesity* which shows the variations in care pathways. Therefore in Ireland there is a situation such that the only two public clinics providing access to bariatric surgery follow different care pathways. This further complicates the generalisability of any cost effectiveness findings to a National level.

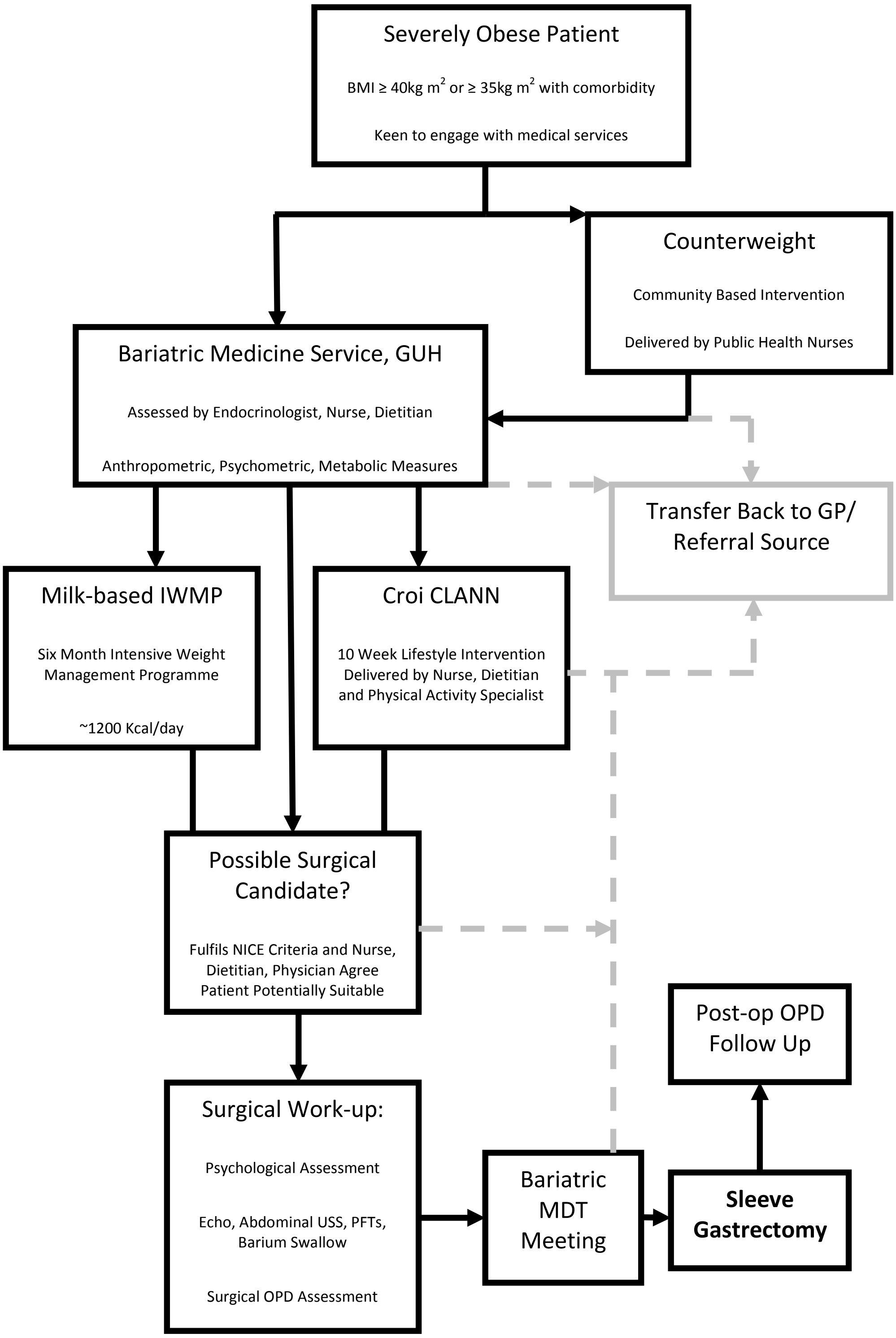
Of particular concern is the potential for different health outcomes as a result of different care pathways – even within Ireland (as opposed to comparing with other countries). For example a longer post-operative follow-up treatment may instigate better compliance among bariatric patients. Also, referring back to a previous point in relation to healthcare incentives; differences that exist in Ireland regarding out-of-pocket expenses may alter the use of services after surgery or affect compliance and hence alter both longer-term effectiveness as well as costs for bariatric surgery.

For example in Ireland in the case of adverse events post-surgery[59], out-of-pocket expenses (for those with no medical card and or a specific PHI plan that covers GP visits) may deter those less well-off patients visiting the GP which in turn may lead to a worsening of the condition whereby these patients present themselves in the acute hospital setting potentially requiring more complex and costly care. Conversely it might be likely that those more

[59] For example, wound infection; leaking from stomach into abdominal cavity [peritonitis]; leaking from staple lines or from Y connection; saline solution leaking from port; marginal ulcers; constipation; staple-line dehiscence; pulmonary problems; deep thrombophlebitis.

affluent would benefit more from bariatric surgery in terms of achieving better health outcomes as a result of more frequent visits with health experts. Thus, the influence that healthcare access mechanisms has on the bariatric care pathways and subsequent health outcomes questions the comparability of other jurisdictions findings to that of Ireland. For example in Australia surgery follow up is covered under Medicare. Similarly in the UK out-of-pocket expenses post-surgery would not arise, the implication of which is that there is no [financial] deterrent for patients to seek help post-surgery. However in the majority of Europe, there is generally little funding for follow up and thus as noted by (O'Brien, 2010) “banding struggles”. Parenthetically this [healthcare access] may be one of the reasons why each country differs in terms of the most commonly practised bariatric procedure.

Figure 21. Bariatric Patient Care Pathway, Galway University Hospital



5.8 Conclusion

Bariatric surgery is deemed to be clinically and cost effective in the countries that report CEA's findings. However the main issue with these findings relates to the uncertainty regarding bariatric surgery long term outcomes and the assumptions therein. Paradoxically, because of the large amount of observational evidence which currently exists, long-term RCTs involving nonsurgical comparators are now unlikely to be performed because of the perception that surgery is superior. Conversely, ongoing refinements of bariatric techniques may cause the results of clinical studies to lag behind the benefits of surgery in the 'real world'. For example, the SOS study (Sjöström et al., 2007) primarily used VBG—which is now largely obsolete, having been replaced by procedures with superior weight loss efficacy such as RYGB.

The heterogeneity of techniques, the existence of different systems of finance and provision, the low throughput, as well as the evident lower priority accorded adult obesity services in general and for bariatric surgery in particular in Ireland in an age of austerity question the transferability of CEA studies and thresholds from other jurisdictions to Ireland. Furthermore, not only does Ireland lag behind in terms of the significantly lower throughput of surgery relative to other countries but the future of bariatric surgery throughput remains uncertain as does the desire of policy makers to increase this throughput. Whilst development of a set of recommendations for authors would be valuable, it was beyond the scope of this chapter to provide specific guidance over and above that provided by others in terms of transferring cost-effectiveness findings (Drummond et al., 2009, Drummond, 1994, Sculpher et al., 2004b) and factors influencing CEA.

Figure 22. Overview of Irish medical services and care pathways for obesity

Source: *Overview of Irish medical services and care pathways for obesity* (unpublished report)

6. Conclusion

6.1 Introduction

This chapter presents a summary of this thesis and highlights some of the main conclusions of the research undertaken, as well as some of the strengths and limitations of the research and potential avenues for future work. Some conclusions from this thesis pertinent to policy are also discussed. Section 6.2 presents a summary of the thesis and the key findings and examines how the research objectives from Chapter one were achieved. Section 6.4 discusses the limitations of the research. Section 6.7 highlights some potential policy implications of the research. The final section presents some concluding remarks.

6.2 Summary of the thesis and key findings

This rising prevalence of obesity will likely have significant economic and social implications, in addition to its more obvious effects on public health. It is important that we as economists measure the economic implications of obesity correctly and also determine the costs of certain social implications, such as that of obesity stigmatisation if public and policy debates around these issues are to be informed. This thesis has examined the use of alternative measures in ascertaining the economic burden of obesity and has also explored some of the lesser documented implications of obesity, such as obesity stigmatisation in the educational setting in Ireland. Furthermore, as the severity of obesity continues to increase it is important that adequate and cost effective strategies are in place to treat this higher end BMI population. In this regard this thesis explored the value that individuals place on obesity treatments and also discusses the cautions that must be undertaken when extrapolating findings from other countries regarding the cost effectiveness of bariatric surgery; given that Ireland has not yet established whether or not this is a cost effective treatment for severe obesity in the Irish setting.

Firstly, as indicated in the findings reported in chapter two - in seeking to measure and understand the relationship between healthcare service use and adiposity it is noted that applying one index of adiposity in isolation may lead to erroneous estimates of the burden on the healthcare system and the distribution of that burden. Using TILDA data, chapter two examined the relationship between alternative measures of adiposity and healthcare service use. Given that both measures, BMI and WTHR were significant predictors of GP, outpatient and aspects of allied service use the findings in this chapter support the consideration of both BMI and WTHR when examining the relationship between healthcare utilisation and adiposity. Furthermore the results showed that in some instances, the prediction of service use varied by gender depending on the measure of adiposity used. Overall the results in chapter two point to the importance of a more nuanced approach to modelling the relationship between service use and obesity than is often evident in the literature.

Whilst using the most accurate measure of adiposity in ascertaining the costs of obesity is important, so too is having knowledge of the value placed on the attributes of the service. In other words, knowledge of the value placed on obesity treatment by the end users- obese individuals. An extensive knowledge of each of these (that is what measure best predicts service use and the value placed on service use) will help inform policy in terms of resource allocation decisions and tailoring treatment programs to individuals' needs and values. With this aim in mind, chapter three utilises the DCE framework to investigate the preferences and WTP that severely obese patients have for alternative hypothetical anti-obesity therapies with differing hypothesised costs, risks and health benefit outlined for each one.

The findings in this chapter indicate that a single strategy for severe obesity treatment is not desirable. For example the results show a large variation regarding individual preferences towards bariatric surgery. On the one hand, the evidence presents a class of individuals who prefer to eschew surgery. This group is more likely to include those who perceive themselves to be in good health and also those who are older. On the other hand, there are those individuals for whom surgery had positive utility. This group are more likely to include those who are female, higher risk taking, within the higher BMI category and have a medical card. Indeed the primary focus of this chapter relates to a specific cohort of individuals -those adults who have reached the severe end of obesity. Beyond the valuation of surgery versus non-surgical approaches to treatment, the study clearly points to the importance of different attributes such as risk reduction and the incorporation of psychological services as aspects of treatment. This was the first study of its type in Ireland and may contain results important to the subsequent design of future services.

Chapter four examines the lesser explored topic of obesity stigmatisation in the primary educational system in Ireland. This is an important topic because the stigmatisation of obese children in early educational institutions can have a detrimental effect in children in later life. It can have a negative impact on educational attainment and subsequent future job prospects. In this chapter, GUI data is used to examine whether a teacher's assessment of their pupil's academic ability was influenced by: the child's; the child's primary caregiver and both child and the child's primary caregiver body shape. The findings from this analysis indicate that there is evidence of obesity stigma among teachers towards the pupils that they teach. This stigma is identified based on teacher's judgements of how well they predict their pupils will perform in Maths and English. In other words whether or not they predict the pupil to obtain a test score that is above or below average. Students that were predicted to obtain an average or below average score were significantly more likely have obese parents/caregivers. It is interesting to note that the parent's obesity status/ BMI that seems to influence teacher's predictions more so than that of the BMI of the actual child that they teach The study found that those children whose primary caregiver is overweight or obese were more likely to be predicted to be in the average and below average quintile for maths and reading compared to those whose primary giver was leaner when other variables were controlled. Given the role of Irish teachers in determining the trajectory of their pupils' performance in exams and lives, these findings are both important and worrisome. While not the focus of this study that prejudice may manifest itself in respect of the child's gender, the marital status and educational attainment of parents is equally worrying. As with the DCE this is the first study of its type in Ireland.

Finally, although the measures of obesity, the values attached to obesity treatment and indeed the assessments of indirect costs such as that of obesity stigma are all used to inform policy; ultimately it is the findings of economic evaluations such as CEA's that influence resource allocation of obesity preventive or treatment mechanisms. In some cases a CEA is not readily available or has not been undertaken in the specific country, for example the cost effectiveness of bariatric surgery has not yet been established in Ireland and so often leads to Irish policy makers extrapolating and inferring CEA findings from other countries for bariatric surgery. Thus the fifth chapter of this thesis provides discussion of the appropriateness of this practise and focuses on what factors might influence the cost effectiveness of bariatric surgery in the Irish healthcare setting; particularly outlining the potential differences that exist in Ireland, such as the Irish healthcare system.

6.3 The contribution of the thesis

The impacts of the obesity epidemic on individual and on public health resources cannot be overstated. This thesis will contribute to our understanding of the cost-effectiveness of bariatric surgery in Ireland; the factors affecting compliance to obesity treatment in terms of the values attached to obesity treatment by obese individuals themselves; the effect of obesity on human capital development (education); and the role of different measures of adiposity in cost of illness studies. Each chapter in this thesis contributes to the health economic literature in its own way.

6.4 Limitations of thesis

6.4.1 Secondary data

There are a number of limitations specific to the analysis in this thesis that should be recognised. They are primarily related to the DCE and are discussed below. However focusing first on the analysis of the secondary data (TILDA and GUI); although TILDA and GUI are both of longitudinal design, the analysis in this thesis uses data from wave one only, thus the cross-sectional design does not allow conclusions on the causal directions of the associations nor does it allow for control of idiosyncratic effects as would be possible with for example a panel approach..

One of the limitations in chapter two (TILDA analysis) relates to the much smaller sample size used for the study in which only those with both adiposity measurements were included, in other words only those who attended the invited health assessment. There may be bias in that by limiting this sample to those who attended the health assessment the analysis may be capturing those who are more concerned with their health or indeed those “worried well” patients who are more likely to utilise health services than, for example, those who do not care for their health.

As per chapter four of this thesis (GUI analysis), the measure used was BMI percentiles; BMI may be the least accurate indicator of body composition and because the height and weight varies dramatically during growth and childhood. This may underestimate or confuse the association between current body composition and expected academic performance during childhood. In this instance however, alternative measures to BMI such as waist circumference measurements were not taken as part of the GUI data collection and were thus unavailable.

6.4.2 Primary data (DCE)

Sample population

With regards to the DCE, a number of limitations warrant discussion not only in terms of the methodology itself but also the survey design. Possibly one of the primary limitations of the owing to the DCE in this thesis is the sample size, which after exluding a number of invalid studies is a relatively small sample size (*n*=157), that said many published studies have applied the DCE methodology to a similar, or even smaller sample size, for example some of which include; n=150 (de Bekker-Grob et al., 2013); *n*=102 (Regier et al., 2012); *n*= 55 (Owen et al., 2010); *n*=110 (Mühlbacher and Bethge, 2013); *n*=129 (Sculpher et al., 2004a); *n*=125 (Haughney et al., 2005) *n*=198 (Yeo et al., 2012) and *n*=165 (Roux et al., 2012).

Also, the sample population was based on the Western region of Ireland (Donegal to Galway), - as opposed to nationally. However whilst this is a small sample size and is not nationally representative, it nonetheless lays the foundations for further research into an area that is relatively under-researched. Very little is documented regarding the severe obese population in Ireland, in terms of the prevelance rates; associated costs and values attached to obesity treatments. However so as to ensure that this sample was somewhat representative of the help seeking severely obese, the descriptive statistics were compared, where possible to other Irish studies. For example, the socio-demographic details in this thesis match those of a recent Irish study (Somerville et al., 2015) which explores poor mental health in the severly obese population using patients atttending Irelands other public weight management clinic.

Indeed the study population selected for this study is advantageous in terms of it being a well-defined population sample. However, this may present some sample bias in that the population are already defined as motivated individuals according to the criterion for referral from the hospital to be considered for program participation, i.e. participants must be motivated to lose weight. That said however one can infer that this population sample are representative of those help-seeking severely obese individuals.

Patient preferences as opposed to the general public

There is a debate in the DCE literature as to whose preferences matter and whose preferences ought to be explored -the general public or the patient. The 1996 Washington Panel on cost-effectiveness in health and medicine provided guidance on methodological issues in the economic evaluation of health care interventions. This panel recommended that it should be the public that value health states, rather than patients, because they represent the taxpayer.

There are valid motives to eliciting patient preferences particularly regarding obesity treatment. In the literature it is speculated that greater compliance with any weight loss initiative is associated with greater weight loss (Wright et al., 2007, Wright et al., 2010, Wadden, 1993, Wadden et al., 1994, Hamilton and Greenway, 2004), and greater weight loss is associated with greater economic benefits (Andreyeva et al., 2004, Collins and Anderson, 1995, Cornier et al., 2002). Because the responsibility for achieving successful weight loss, to a great degree, falls on the shoulders of the individuals attempting weight loss and that their success, in most instances, is related to individuals' willingness and ability to comply with a given program, understanding which factors may influence program choice and compliance is imperative and warrants further inquiry. A DCE can provide a useful tool in gaining insights into the potential factors influencing compliance and adherence to weight loss initiatives, while also providing other useful information such as WTP.

Lexicographic preferences

One of the limitations with DCE's concerns non-attendance to attributes. This happens when respondents do not consider the attributes used to explain scenarios in the choice cards. With reference to lexicographic preferences there are three key issues relevant to this study that was considered at design stage and also at the interpretation of results. Firstly respondents can be prone to exhibit lexicographic preferences where there is correlation among the attributes; or secondly where they consider that an attribute is of relatively high importance thus focusing on a specific attribute for which they have a strong negative preference; or thirdly whereby they place an absolute value on the attribute and refuse to make trade-offs between it and another attribute – this may be due to pre-conceived values or thoughts that the individual may have for that attribute. In this study there was a potential risk that the attribute that describes the method of weight loss could lead to lexicographic preferences in which this attribute might influence respondents' preferences into focusing on one particular level or indeed "protesting" or displaying negative attitudes towards another particular level.

The decision to include the "method of weight loss" attribute in the DCE was carefully considered. Without the inclusion of this [method of obesity treatment] attribute the risk is that the DCE is too difficult for respondents to grasp. Respondents outlined in the focus groups that without the inclusion of the method of obesity treatment they found the DCE 'too abstract', noting that this attribute was an important aspect of obesity treatment to the respondents. A prerequisite for discrete choice models is that the choice set of alternatives must be exhaustive, meaning that the choice set includes all possible alternatives and relevant attributes. Subsequently by not including the method of obesity treatment this might lead to omitted bias in the choice sets. Furthermore, by specifying the method of weight loss this means that the alternative might be more realistic and considering that one of the aims of this DCE is to potentially inform policy with regards the design and implementation of severe obesity, it was deemed appropriate to specify this attribute.

Potential Implausible Combinations

Initially there was concern regarding the credibility of the choice sets presented to respondents from a medical perspective. For example, that an individual who loses the maximum amount of weight [6 stone in this study] might have a correspondingly low reduction in the risk of heart attack [5% in this study]. Subsequently, at the initial design phase restrictions were imposed in the DCE which limited certain attribute-level combinations appearing within the same choice set. These restrictions were tested in the pre-pilot studies such that the choice of a large amount of weight loss [6 stone] appears only with a low risk of heart attack [5%] and also that a large amount of weight loss appears only with bariatric surgery as the method of weight loss in the choice cards. However the pre-pilot studies showed that this imposed too many restrictions on the study and with further consultation with medical expertise it was decided to remove these imposed restrictions. Medical expertise advised that this cohort was *severely* obese and there was every possibility that a severely obese person might lose 6 stone within a 12 month period and [due to other confounding factors such as genetics or smoking] might only have a small reduction in the risk of heart attack; this was also confirmed in the literature (Klem et al., 1997, Curioni and Lourenco, 2005, Anderson et al., 2001, Douketis et al., 2005, Williamson et al., 1992, Jeffery et al., 2004, Christiansen et al., 2007).

Distribution of the cost attribute

An important consideration in DCE's relates to the methodology applied in calculating confidence intervals for WTP estimates and also the models that are used to calculate the WTP estimates. For example there is some debate regarding the appropriateness of calculating WTP estimates from the RPL model. Of particular concern are the assumptions that the RPL model requires regarding the distribution of the cost. Namely, by specifying the cost variable as fixed, (as done in this study) it is assumed that all individuals have the same preference for cost, which may be unreasonable. The treatment of cost parameters as fixed or non-random parameters over sampled populations represents particularly strong assumption in terms of both scale homogeneity (Train and Weeks, 2005) and taste heterogeneity (Hynes et al., 2008).

Some analysts (Campbell et al., 2011) argue that it may be incorrect to assume that all respondents exhibit equal sensitivity in the cost parameter because respondents who are highly sensitive to price may follow a different distribution compared to those who are less price sensitive. However, it may be equally unreasonable to assume that the distribution of preferences for cost as normally distributed. Also, if the cost attribute is modelled as having a random component in the RPL, it would be inappropriate to estimate WTP confidence intervals with parametric procedures such as the delta method. Several alternative techniques have been suggested to address this issue (Hole and Kolstad, 2012). However, no "gold standard" has been established.

6.5 Strengths of thesis

This thesis is novel in that it has investigated a number of research areas that have sparse results to date. This section outlines the strengths of the thesis overall and then focuses on the strengths of the primary data that is the DCE. Firstly the preferences of severely obese individuals for obesity treatments with particular reference to the inclusion of bariatric surgery as a treatment option in the choice cards, where previous studies do not generally include surgery as a treatment option when examining obesity treatments. Another novel topic examined in this thesis relates to obesity stigma and whilst the presence of obesity stigma has been previously documented in the educational sector; the majority of studies focus on stigma according to PE teachers and do not examine teachers in general. In Ireland, this particular study initiates research into a topic that was previously less well known.

Furthermore this thesis adds significantly to the economics literature pertaining to the assessment of costs according to various adiposity measures. Whilst the medical literature has well documented limitations of BMI as an index measure for obesity; the economics literature seems to lag behind. The fact that the findings of this study show not only that alternative measures of adiposity can reveal different findings regarding prediction of service use, but also that the use of alternative measures of adiposity are relevant when examining male or female service use; as indicated by the significance of different measures in predicting different service uses according to gender status. Finally although chapter five does not examine any data per se, it nonetheless opens an important discussion regarding current practises of inferring cost effectiveness findings from other jurisdictions, highlighting the need to take into consideration a number of factors that differ in the Irish healthcare system that may potentially result in different cost effectiveness findings, relative to other jurisdictions.

With reference to the DCE, this was the first to consider the preferences for obesity treatment in Ireland. The overwhelming majority (if not all) of studies regarding obesity treatment preferences have a European, US and/or Australian perspective and while one can infer from these studies, Irelands care pathway is very different to these countries with regards obesity treatment. Ireland differs in terms of the obesity treatments offered, for example as discussed in chapter five of this thesis access to bariatric surgery is somewhat more limited in Ireland relative to other countries.

However that said and as already highlighted there is a paucity of preference studies that incorporate bariatric surgery or its attributes into DCEs when investigating obesity treatment preferences. The importance of this study is that the researcher examines the role that medical cards have in terms of influencing people's preferences. Considering that those with a medical card enjoy free access to health care it follows that one would expect these individuals to be higher users of health services relative to those without medical card. The findings of this study are important in the context of effectively allocating resources, i.e. obesity treatments according to what the end user's preferences are, particularly to those that represent a cost (medical card holders) to the State. The implication being that more efficiently allocated obesity treatments may result in more efficacious obesity treatments, which will have greater economic benefits in the long run.

The DCE was conducted in a ‘real world’ clinical setting. A key strength of this study is that the selection of respondents consisted of a clinically diagnosed well defined population of severely obese individuals. The researcher was able to use data from a clinic database, limiting the use of self-reported data. BMI was calculated using accurately measured rather than self-reported weights and heights thus avoiding miscategorization and under-reporting. Finally, a novel component of this study relates to the data that was collected regarding the risk attitudes of respondents. To the best of our knowledge no other study has sought to include either of these as an interaction term in order to explain the heterogeneity in preferences for obesity treatment.

6.6 Future research

With reference to the DCE, it is recommended that further work be undertaken in the five following directions. As previously mentioned a Safefood report (Heery et al., 2014) sought to explore public opinion on obesity treatment policies. An interesting continuation of this PhD study would be to apply the DCE to the general public and examine their WTP for obesity treatments and or obesity prevention policies relative to other health care treatments or policies, for example cancer care or mental health. Such studies have already been undertaken in America in the context of obesity prevention policies to reduce childhood obesity (Cawley, 2008).

Also this study selected the most relevant attributes by referring to the literature and conducting focus groups and expert interviews. However, this careful procedure does not guarantee that the excluded attributes were irrelevant to patients’ preferences for obesity treatment. There are general criticisms towards this stage (attribute selection) of the DCE, such that DCE development has been criticised for its lack of clarity and transparency in generating attributes (Coast et al., 2012, Coast and Horrocks, 2007). Further research into other attributes that may be important both the public and decision-makers, and their relative importance, is warranted. In addition the pilot work in this study indicated that respondents had difficulty understanding risk. It is recognised that individuals may have attached different risk levels to the different qualitative descriptions. Future work could explore how quantitative risk data can be better described to individuals within a DCE. Another topic regarding weight loss treatments relate to financial incentives including disincentives (for unhealthy behaviour) are well documented in the literature. Although it was not outlined or discussed in the focus groups for this study further research could incorporate a treatment option that included incentives to weight loss and examine what individuals preferences are therein.

Whilst the DCE produced some important findings for policymakers concerned with inducing individuals to adopt healthy lifestyle, a number of potential limitations of the DCE are recognised. The results are based on responses to hypothetical questions. While discrete choice methods are widely used in health economics, an inherent limitation is that respondents are evaluating hypothetical treatments; what respondents declare they will do may be quite different to what they would. To minimise such potential differences, measures were taken to design the hypothetical tasks to be realistic, for instance by centring levels of cost based on focus group findings.

The importance of validating the DCE results using subsequent monitoring and evaluation of policies has been recognised (de Bekker-Grob et al., 2013). A future study might be to follow up this sample and do a valuation of those who have been through surgery and compare them with those who have not had surgery. In this regard the initial sample population identified at GUH attending the weight clinic might prove relevant to examine this.

Indeed future work could explore the external validity of DCE. Given individuals are used to paying for lifestyle interventions, this area offers a potentially fruitful area for future empirical research. Also, considering that this study captured individuals at the beginning of their enrollement to the programme, a future study might include recalling those who completed the programme and dividing this cohort into those who had successful weight loss and those who did not and compare preferences and values therein.

With reference to other topics covered in this thesis, chapter four examined obesity stigma among teachers. An unexpected source of weight stigma toward youth is their parents. A number of studies have examined weight bias in adolescents, and show that parental bias is common. A follow on study from this chapter may be to explore if there is evidence of parental bias among parents among this age group and/or bias among teachers in respect of other age groups. The GUI data includes details regarding how well the parent/caregiver thinks that their child would do in school as well as for other age groups.

A number of studies have also examined the effect that obesity has on actual academic attainment (as oppose to predicted). GUI has details on actual Maths and English test scores and although reports have been published pertaining to this relationship (McCoy et al., 2012, Williams et al., 2011) further analysis could examine the obesity- academic performance relationship in more detail. The difficulty with this is that unless they control for potential prejudice they will add to stigmatization. In addition to this, although these children are not followed until University, it would be interesting to examine what, if any, effect teachers expectations would have on going to University and the courses accepted by these students.

Within the international literature, there is a consensus that standard models might lead to biased results due to for example, reverse causality (for instance, individuals might be obese because they perform poorly in the educational attainment); unobserved heterogeneity (obese children might have lower self-esteem and these unobserved characteristics affect both their weight and educational attainment). In such instances the use of the instrumental variable approach to capture the true causal effect of obesity on predicted test scores or even actual educational attainment might prove useful. Finally with reference to this particular analysis, there is no consensus as to what the most appropriate measure of adiposity is in children the next study might use Z scores alongside percentiles to see if the findings change.

In considering the results presented in chapter two (alternative measures of adiposity), it is worth noting that the magnitude of the effects differ somewhat between the measures which would have implications for cost of illness studies, suggesting that further investigation of these issues is warranted. In addition future research with panel analysis may also be useful to establish how the measures of adiposity interact with service use over time and whether differences emerge between the measures. Furthermore additional analysis could examine whether social class or entitlements have a similar attenuating effect on the role of adiposity in service use.

Finally an obvious recommendation of future research regarding the cost effectiveness of bariatric surgery would be to undertake a CEA of bariatric surgery in Ireland. However, given the limited throughput of this surgery in Ireland at the moment, the practicalities of undertaking this are questionable.

6.7 Key policy implications

From an Irish policymaker's perspective, the analyses in this thesis present a number of pertinent findings. Resource allocation for obesity is a complex matter. Substantial funding is required for the treatment and prevention of obesity and its related comorbidities in all age groups. The allocation of resources depends to an extent on the costs associated with the condition in question- that is how much funding will be required and also on whether or not such intervention is deemed to be cost effective. This thesis provides valuable insight for policy makers on each of these issues.

Currently the economic burden of obesity is assessed primarily according to BMI within the policy arena in Ireland. However, this thesis indicates that this measure may in fact produce erroneous results when examining healthcare utilisation, whereby the findings demonstrate that BMI is not always an accurate indicator of service use. Rather the findings suggest that the use of other measures to complement BMI as a predictor of service use would prove more useful and accurate in predicting costs.

The cost effectiveness of the intervention in question is also a matter of importance for policy making. Currently in Ireland there seems to be a consensus that it is acceptable practice, in the absence of available data or reports, to infer the cost effectiveness findings from other jurisdictions, regardless of the differences that may exist between jurisdictions. However this thesis highlights the perils of doing so, with particular reference to the disparities that exist between different healthcare systems and more importantly between the throughput of bariatric patients. Without any solid CEA of bariatric surgery being undertaken in Ireland it is difficult to ascertain whether or not it would be cost effective in Ireland. With this in mind, chapter five makes the case that in the absence of a CEA there is a need for more transparent and robust system to be in place so as to ensure that the factors that may influence the cost effectiveness between countries is taken into consideration. Currently this is not the case and begs the question of whether or not, given the relatively lesser throughput of patients, bariatric surgery is in fact cost effective in Ireland.

Both the development and findings from the DCE described in this thesis have the potential to inform research in the fields of health economics and patient outcomes. The field of patient preferences is rapidly evolving, with groups like the International Society of Patient Outcomes Research (ISPOR) Patient Preference Methods Working group having recently published a checklist of good research practices for methodologically sound applications of conjoint analysis in health care. The importance of patient experiences are being increasingly recognized (Department of Health, 2005; Coulter, 2005).

According to Ryan (2004), the National Institute for Clinical Excellence (NICE) is under increasing pressure to take account of patients' preferences; furthermore NICE plan to have a patient centred evaluation of technologies in addition to the current assessments of clinical and cost effectiveness (Ryan, 2004). Similarly (McIntosh, 2006a) outlined that future work should explore incorporation of DCE’s into an economic evaluation modelling framework. The DCE in this thesis indicated that a large amount of heterogeneity exits regarding obesity treatment preferences. Considering that compliance to treatment is key for successful obesity treatment, the incorporation of patient preferences when determining cost effective obesity treatment would be beneficial.

In the Irish context we are also seeing a shift towards an increased interest in attitudes towards obesity and obesity treatment from all perspectives. For example, there is ongoing research in Ireland that seeks to assess the attitudes of health professional groups in assessing body weight status (Moorhead et al., 2011). In their study Moorhead et al acknowledge that it is important to address "this [attitudes] apparent knowledge deficit". Another study from Safefood (Heery et al., 2014), reported on the attitudes of the Irish public towards policies to address obesity and noted that *"understanding of public attitudes to policy interventions is important, as it provides a key indicator of the potential effectiveness of interventions and how the public would react to their implementation".* The Safefood report (Heery et al., 2014) did not explore attitudes towards obeisty treatment (focused on obesity prevention policies).

However, as first outlined by Rose and Day (1990), the pioneer of modern preventive medicine as we know it, an effective public health strategy to reverse the increases in body weight seen in the last quarter century will require a two- pronged approach (Rose and Day, 1990). The first involves a whole population approach with interventions aimed at having a small effect in a large number of people, such as taxing sugar sweetened beverages. While the individual effect size is small and thus difficult to quantify in an efficacy analysis (such as a randomised controlled trial), the overall effect on population attributable risk is high (Rose and Day, 1990). In parallel with the whole population approach, a second "high risk" approach is required, in this case targeting individuals with severe obesity using interventions such as bariatric surgery which have a large individual effect that is easy to assess in a trial context but which does not have a significant impact on overall population health. Neither approach will work in isolation.

In the context of obesity treatment, the findings from this DCE will help inform policy in terms of tailoring treatments more specific to individuals' needs and preferences which in turn may positively influence weight loss and program compliance. This is a desirable outcome for many reasons not least because of the previously stated positive benefits for the economy as a whole. In addition WTP findings could be used in a cost-benefit analysis on treatments on obesity treatments. Furthermore, the findings from this study showed from the onset (focus groups and pre-piolet interviews) that access to mental health services as part of an obesity treatment component was important to respondents seeking obesity treatment. Within this context, access to mental health services as part of obesity treatment in Ireland is limited. However, this is not only relevant to Ireland. A UK report *Obesity in the UK: A psychological perspective* outlines that although psychological therapy including Cognitive Behavioural Therapy is mentioned in the NICE (2006) obesity guidelines as the recommended way to address behavioural change through psychological issues associated with obesity, psychological issues are generally not receiving as much attention as sociological and diet issues as ways of tackling this growing epidemic.

Last but certainly not least is the evidence that this thesis produced regarding the indication of obesity stigma in Ireland's primary schools. This could prove detrimental to children experiencing this stigma later in life. This finding is of particular relevance in the context of current policy discussions around screening schoolchildren for childhood obesity. The findings suggest that the implementation of such a scheme may add further to the stigma attached by the child's teacher. Related to this, there may be a need to further educate the educators in terms of self-awareness and how their expectations etc. can impact on the children negatively.

6.8 Closing remarks

In summary this thesis has described some of the economic and social impacts of obesity in childhood and adulthood. It has explored how best to examine health care utilisation in terms of what measure of adiposity might best predict service use. Finally it has sought to quantify the values that severely obese individuals place on obesity treatment, whilst also discussing the appropriateness of inferring cost effectiveness findings for bariatric surgery from other countries. Until we understand more about obesity, these topics and discussions are useful to the field of obesity economics research. Different perspectives on such a complex topic are valuable in broadening thinking on the issue, highlighting uncertainties, and furthering knowledge. Future research is likely to expand on all of the topics described in this dissertation. More sophisticated modelling efforts in the absence of clinical data to evaluate the cost-effectiveness of bariatric surgery, further analysis of the potential for obesity discrimination in schools and its effects on human capital, and more careful consideration of the adiposity measures used to examine the associated costs of obesity will continue to improve our understanding of the economic aspects of obesity.

7. References

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8. Appendices

Appendix one: TILDA sampling frame

The Irish Longitudinal Study on Ageing (TILDA) is a large prospective cohort study examining the social, economic, and health circumstances of 8,175 community-dwelling older adults aged 50 years and older resident in the Republic of Ireland. The sample was generated using a three-stage selection process and the Irish Geodirectory as the sampling frame. The Irish Geodirectory is a comprehensive listing of all addresses in the Republic of Ireland which is compiled by the national post service and ordnance survey Ireland. Subdivisions of district electoral divisions pre-stratified by SES, age, and geographical location served as the primary sampling units. The second stage involved the selection of a random sample of 40 addresses from within each PSU resulting in an initial sample of 25,600 addresses. The third stage involved the recruitment of all members of the household aged 50 years and over. Consequently, the response rate was defined as the proportion of households including an eligible participant from whom an interview was successfully obtained. A response rate of 62.0% was achieved at the household level.

There were three components to the survey. Respondents completed a computer-assisted personal interview (CAPI) (*n* = 8,175) and a separate self-completion paper and pencil module (*n* = 6,915) which collected information that was considered sensitive. All participants were invited to undergo a separate health assessment at one of two national centres using trained nursing staff. In total 5,036 respondents attended the health centre assessment, of which 4,891 provided heart rate measurements, which represents the initial case base for the analysis. A more detailed exposition of study design, sample selection and protocol is available elsewhere (Whelan and Savva, 2013). Broadly speaking assessments took place in a health centre (85.4%) or at participants' homes (15.6%). Participants' height, weight and waist circumference were measured. A single measure of height was taken using a wall-mounted measuring rod while a single measure of weight was taken using an electronic floor scale. BMI was calculated and categorized as normal weight ($18.5 \leq BMI < 25$), overweight ($25 \leq BMI < 30$), obesity class 1 ($30 \leq BMI < 35$) obesity class 2 ($BMI \geq 35$) and obesity class 3 ($BMI \geq 40$) according to WHO recommendations.

Below is a description of the TILDA sample design as extracted from Kenny et al (Kenny et al., 2010). The TILDA pilots were conducted using samples based on the RANSAM system. The pilots were able to provide evidence of the likely levels of non-eligibility (vacant dwellings, institutions wrongly included etc.) and response rates (refusals, non-contacts, etc.). These samples also conformed to the expected pattern of approximately half of the addresses being ineligible because they did not contain a person aged 50 or over. Statistical and resource factors determined the minimum required sample size at 8,000 persons to provide national representation for the TILDA baseline. The target response rate is 60 per cent of eligible households.

This information allowed a two-stage sample design specification as follows:

Stage 1

RANSAM groups the residential addresses in the country into 3,155 first stage units or clusters. These clusters are townlands or aggregations of townlands and range in size from 500 to 1180 addresses. It was decided to select 640 of these clusters, with implicit proportionate stratification of clusters by socio-economic group (3 categories) and geography. Characteristics of the clusters can be inferred from the District Electoral

Divisions of which they are a part, on the basis of the Small Area Population Statistics compiled by the Central Statistics Office. Stratification was achieved by pre-sorting all addresses in the country by socio-economic group (three equal groups on the basis of percentage of the population in the professional/ managerial category) and within socio-economic group by RANSAM's geographical "snake"pattern which orders clusters within county based on a north/south pattern which preserves contiguity. Clusters were selected randomly with a probability of selection proportional to the estimated number of persons aged 50 or over in each cluster.

Stage 2

This stage involved the selection of a probability sample of 50 addresses within each cluster (10 to be held in reserve). The combination of selection probabilities used at the two stages produces an equal probability ("epsem") sample of addresses. All persons aged 50 or over in the selected households (and their spouses or partners of any age) are asked to participate. The addresses are partitioned into two groups: an initial sample list of 25,600 addresses (40 randomly selected from each of the 640 clusters) for immediate issue to the field force and 6,400 addresses (10 randomly selected from each of the 640 clusters) for retention as a reserve list. The reserve list will only be utilised later in the fieldwork process if it appears unlikely that the target sample size will be achieved. If the target sample of 8,000 interviews can be obtained from the initial list, the information from the pilot work suggests that the response rate will be just in excess of 60 per cent. As described, the sample design incorporates stratification, clustering and multi-stage selection. The design results in an equal probability sample of both households containing members of the target population and of persons in the target group. This means that the resulting sample is "epsem" and self-weighting, except for biases caused by non-random variations in response rates. Such biases will be dealt with at analysis stage by means of calibration weights.

Appendix two: Additional modelling results for TILDA analysis

Table 46. Independent marginal effects from bivariate probit results with alternative adiposity measures included for GP & outpatient according to females only

GP (*n* = 3099)															
Model 1: BMI						**Model 2: WTHR**					**Model 3: BMI & WTHR**				
Variable	**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**	
Age	.001	.000	.12	-.000	.003	.001	.000	.18	-.000	.003	.001	.000	.17	-.000	.003
Res. Chronic Conditions	.069	.008	.00	.053	.084	.067	.008	.00	.051	.083	.069	.008	.00	.053	.084
Medical card	.098	.013	.00	.072	.124	.099	.013	.00	.073	.124	.098	.013	.00	.073	.124
PHI	.0084	.0135	.533	-.018	.0356	.0100	.0137	.454	-.016	.0375	.009	.01312	0.47	-.017	.037
Smoke	-.004	.011	.659	-.026	.016	-.007	.011	.50	-.029	.014	-.005	.011	.602	-.027	.016
Third level education	-.002	.014	.893	-.031	.027	-.001	.014	.915	-.030	.027	-.001	.014	.941	-.030	.027

Social isolation measure	.009	.006	.148	-.003	.021	.010	.006	.111	-.002	.022	.009	.006	.140	-.003	.021
BMI	.005	.001	.000	.003	.00						.003	.001	.010	.000	.006
WTHR						.286	.085	.00	.119	.452	.193	.094	.041	.008	.379
Outpatient															
Model 1: BMI						**Model 2: WTHR**					**Model 3: BMI & WTHR**				
Age	-.001	.001	.160	-.003	.000	-.001	.001	.19	-.003	.000	-.001	.001	.198	-.003	.000
Res. Chronic Conditions	.114	.008	.000	.098	.130	.114	.008	.000	.098	.130	.114	.008	.000	.098	.130
Medical card	.055	.023	.016	.010	.100	.055	.023	.01	.010	.100	.055	.023	.016	.010	.100
PHI	.023	.020	.248	-.016	.063	.023	.020	0.25	-.016	.063	.022	.020	0.26	-.017	.063
Smoke	.053	.017	.003	.018	.087	.053	.017	0.003	.018	.087	.054	.017	.00	.019	.088
Third level education	.052	.024	.032	.004428	.101	.052	.024	0.035	.003	.100	.052	.024	.035	.003	.100
Social isolation measure	.007	.010	.455	-.012	.027	.008	.010	0.419	-.011	.028	.007	.010	.449	-.012	.0278
BMI	.005	.001	.010	.001	.008						.003	.002	.070	-.000	.008

WTHR						.139	.130	0.286	-.116	.394	.051	.147	.725	-.236	.339

Table 47. Independent marginal effects from bivariate probit results with alternative adiposity measures included for GP & Outpatient for males only

GP (n=2465)															
Model 1:						**Model 2:**					**Model 3:**				
Variable	**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**	
Age	.004	.001	.00	.002	.006	.004	.001	.00	.002	.006	.004	.001	.00	.002	.00
Res. Chronic Conditions	.071	.009	.00	.053	.088	.072	.009	.00	.054	.090	.071	.009	.00	.053	. 089
Medical card	.080	.017	.00	.047	.114	.080	.017	.00	.047	.114	.080	.017	.00	.047	.113
PHI	.010	.015	.48	-.019	.041	.013	.015	.39	-.017	.044	.012	.015	.42	-.018	.043
Smoke	-.015	.013	.22	-.041	.009	-.017	.013	.18	-.042	.008	-.017	.013	.19	-.042	.008
Third level education	.017	.016	0.28	-.014	.049	.019	.016	.237	-.012	.051	.018	.016	0.24	-.013	.051
Social isolation	.025	.007	.00	.009	.041	.026	.007	.00	.011	.042	.026	.00	.001	.010	.041

measure															
BMI	.006	.001	.00	.003	.009						.004	.002	.06	-.000	.008
WTHR						.409	.100	.00	.212	.605	.270	.137	.05	-.000	.540
<u>Outpatient</u>															
Model 1: BMI						**Model 2: WTHR**					**Model 3: BMI & WTHR**				
Age	..001	.001	0.21	-.000	.004	.001	.001	0.280	-.001	.003	.001	.001	0.29	-.001	.003
Res. Chronic Conditions	.112	.008	0.00	.095	.130	.111	.008	0.00	.094	.1289805	.111	.008	0.00	.094	.129
Medical card	.058	.025	0.02	.008	.108	.058	.025	0.02	.008	.109	.057	.025	0.02	.007463	.108
PHI	-.000	.0225	0.98	-.044	.043	.000	.022	0.98	-.043	.044	.002	.022	0.92	-.042	.046
Smoke	.018	.019	0.35	-.020	.057	.017	.019	0.38	-.021	.056	.016	.019	0.41	-.022	.055
Third level education	.022	.025	0.36	-.026	.072	.025	.025	0.30	-.023	.075	.025	.025	0.31	-.0246	.074
Social isolation measure	.022	.011	0.05	-6.98e-	.0442	.023	.011	0.04	.000	.045	.02	.011	0.03	.001	.045
BMI	.007	.002	0.00	.002	.012						.002	.003	0.381	-.003	.0093
WTHR						.544	.141	0.00	.266	.822	.480	.191	0.01	.105	.855

Table 48. Independent marginal effects from bivariate probit results with alternative adiposity measures included for allied services: males only

Model 1: Probit model: Model 1: BMI Only: (*n* =2466)						Probit model: Model 2: WTHR Only: (*n* =2466)					Probit model: Model 3: BMI & WTHR Males: (*n* =2466)				
Variable	**Marg Effects (P>|z|)**	**Std. Err.**	**z**	**95% Conf. Interval**		**Marg Effects (P>|z|)**	**Std. Err.**	**z**	**95% Conf. Interval**		**Marg Effects (P>|z|)**	**Std. Err.**	**z**	**95% Conf. Interval**	
Age	.005 (.00)	.000	5.7	.003	.00	.004 (.00)	000	5.69	.00	.006	.005	.000	.82	- .003	.006
Residual morbidities BMI	.036 (.00)	.004	8.27	.027	.045										
Residual WTHR						.036 (.00)	.004	8.36	.027	.045					
Residual Chronic											.035	.004	8.15	.027	. .044

Conditions											(0.0)				
Medical Card	.070 (.00)	.015	4.49	.039	.101	.070 (.00)	.0156904	4.51	.0400475	.101553	.070 (.00)	.015	4.49	.039	.101
PHI	-.043 (.00)	.013	- 3.13	-.070	-.016	-.0438 (.00)	.014	- 3.13	-.071	-.016	-.042 (.00)	.013	- 3.08	-.070	-.015
Smoke	-.008 (.48)	.012	- 0.71	-.033	.015	-.007 (.54)	.012	- 0.60	-.032	.016	-.007 (.54)	. .012	- 0.61	-.032	.016
Third level education	.008 (.61)	.017	0.51	-.024	.042	.009 (0.56)	.017	0.57	-.023	.043	.009 (0.59)	.017	0.53	-.024	.042
Social isolation measure	-.0100 (0.139)	.006	- 1.48	-.023	.003	-.008 (0.23)	.006	- 1.20	-.021	.005	-.008 (0.20)	.006	- 1.28	-.021	.004

BMI	.003 (.00)	.001	2.72	.001	.006						.002 (.14)	.001	1.46	-.000	.006
WTHR						.242 (.00)	.088	2.75	.069	.415	.151 (.19)	.117	1.30	-.077	.381

Table 49. Independent marginal effects from bivariate probit results with alternative adiposity measures included for allied services: females only

GP visits: females : Number of obs = 3099															
Model 1: BMI						Model 2: WTHR					Model 3: BMI & WTHR				
Variable	Marg Effects	Std. Err.	P>|z|	95% Conf. Interval		Marg Effects	Std. Err.	P>|z|	95% Conf. Interval		Marg Effects	Std. Err.	P>|z|	95% Conf. Interval	
Age	.001	.000	0.15	-.0005	.003	.001	.000	0.23	-.000	.002	.001	.000	0.21	-.000	.002
Res. Chronic Conditions	.070	.008	0.00	.054	.086	.068	.008	0.00	.052	.084	.070	.008	0.00	.054	.086
Medical card	.098	.0130	0.00	.073	.124	.099	.012	0.00	.074	.124	.099	.012	0.00	.073	.124

PHI	.013	.014	0.35	-.014	.040	.014	.014	0.30	-.013	.042	.014	.014	0.31	-.013	.041
Smoke	-.006	.011	0.56	-.028	.015	-.008	.011	0.43	-.030	.013	-.006	.011	0.54	-.028	.015
Third level education	-.009	.015	0.54	-.039	.020	-.006	.015	0.64	-.036	.022	-.006	.014	0.66	-.035	.022
Social isolation measure	.009	.006	0.15	-.003	.021	.009	.006	0.15	-.003	.021	.008	.006	0.20	-.0043	.020
BMI	.020	.0053	0.00	.009	.032						.004	.001	0.00	.001	.007
WTHR						.302	.085	0.00	.134	.470	.202	.096	0.03	.014	.391
Allied services															
Model 1: BMI						**Model 2: WTHR**					**Model 3: BMI & WTHR**				
Age	.0063	.0006	0.00	.005	.0085	.006	.000	0.00	.004	.007	.0062	.0001	0.00	.004	.0084
Res. Chronic Conditions	.0369	.004	0.00	.027	.046	.037	.004	0.00	.028	.047	.037	.004	0.00	.027	.046
Medical	.091	.015	0.00	.060	.122	.092	.015	0.00	.061	.123	.091	.015	0.00	.061	.122

card															
PHI	-.014	.013	0.26	-.040	.011	-.015	.013	0.23	-.041	.010	-.014	.013	0.28	-.040	.011
Smoke	.010	.011	0.36	-.012	.034	.008	.011	0.46	-.014	.032	.009	.011	0.42	-.013	.032
Third level education	-.002	.018	0.88	-.038	.033	-.002	.0184	0.90	-.038	.034	-.002	.018	0.89	-.038	.033
Social isolation measure	-.007	.006	0.28	-.020	.005	-.007	.006	0.28	-.020	.005	-.006	.006	0.32	-.019	.006
BMI	.017	005	0.00	.006	.028						.002	.001	0.13	-.000	.004
WTHR						.128	.083	0.12	-.034	.292	.091	.095	0.33	-.095	.277

Table 50. Independent marginal effects from probit results with alternative adiposity measures included for Dietician service

Model 1: GENERAL						Model 2: MALES					Model 3: FEMALES				
Number of obs = 5570						Number of obs = 2466					Number of obs = 3104				
Variable	**Marg Effects (P>|z|)**	**Std. Err.**	**z**	**95% Conf. Interval**		**Marg Effects (P>|z|)**	**Std. Err.**	**z**	**95% Conf. Interval**		**Marg Effects (P>|z|)**	**Std. Err.**	**z**	**95% Conf. Interval**	
Age	-.000 (0.25)	.000	- 1.13	-.000	.000	-.000 (0.34)	.000	- 0.94	-.000	.000	-.000 (0.51)	.000	-0.66	-.000	.000
sex	.002 (0.53)	.003	0.62	-.004	.009										
Medical card	.008 (0.02)	.003	2.26	.001	.015	.010 (0.11)	.006	1.59	-.002	.023	.006 (0.11)	.004	1.59	-.001	.0147
PHI	-. (0.65)	.003	.45	-.007	.004	-.000 (0.87)	.005	- 0.15	-.011	.009	-.002 (0.55)	.003	-0.59	-.009	. 0057
Smoke	-.006 (0.07)	.003	-2.0	-.012	-.000	-.008 (0.14)	.0058	-1.4	-.0181	.002	-.005 (0.08)	.003	-1.7	-.012	.000
Third level education	.004 (0.37)	.005	0.89	-.005	.014	.008 (0.31)	.008	1.01	-.007	.024	.000 (.96)	.005	0.04	-.011	.011
Social	.000	.001	0.07	-.002	.003	.000	.002	0.28	-.004	.005	-.000	.001	-0.30	-.004	.002

isolation measure	(0.94)					(0.78)					(.76)				
Residual of all comorbidities	.005 (0.00)	.001	5.57	.003	.007	.006 (0.00)	.001	4.24	.003	.010	.005 (0.00)	.001	3.69	.002	.007
BMI	.000 (0.53)	.000	0.62	-.000	.001	.000 (0.32)	.000	0.99	-.000	.002	-.000 (0.82)	.000	-0.23	-.001	.000
WTHR	.085 (0.00)	.024	3.44	.036	.134	.122 (0.07)	.045	2.70	.033	.211	.056 (.07)	.031	1.81	-.004	.117

Table 51. Independent marginal effects from biprobit results using BMI &WTHR measures together for GP & Chiropody service

Males & females combined (n=5564)						**Females only (n=3099)**				
GP										
Variable	**Marg Effects**	**Std. Err.**	**Z**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**Z**	**95% Conf. Interval**	
Age	.002 (0.00)	.000	3.54	.001	.003	.001 (0.19)	.000	1.30	-.000	.003
sex	.030 (0.00)	.011	2.63	.007	.053					
Res. Chronic Conditions	.070 (0.00)	.006	11.74	.058	.082	.070 (0.00)	.008	8.67	.054	.085
Medical card	.091 (0.00)	.010	8.92	.071	.111	.099 (0.00)	.012	7.67	.074	.125
PHI	.013 (0.188)	.010	1.32	-.006	.034	.014 (0.31)	.014	1.01	-.013	.042
Smoke	-.008	.008	-1.01	-.025	.008	-.007	.011	-0.64	-.029	.014

	(0.31)					(0.51)				
Third level education	.008 (0.46)	.010	0.76	-.013	.029	-.006 (0.68)	.014	-0.40	-.035	.023
Social isolation measure	.017 (0.00)	.005	3.58	.008	.027	.008 (0.18)	.006	1.31	-.004	.021
BMI	.004 (0.00)	.001	3.27	.001	.006	.004 (0.00)	.001	2.65	.001	.007
WTHR	.228 (0.00)	.076	2.99	.078	.378	.208 (0.03)	.096	2.17	.019	.396

<u>Chiropody</u>

Variable	**Marg Effects**	**Std. Err**	**Z**	**95% Conf. Interval**		**Marg Effects**	**Std. Err**	**Z**	**95% Conf. Interval**	
Age	.003 (0.00)	.000	8.38	.002	.0046	.004 (0.00)	.000	6.90	.003	.005
Sex	.021 (0.00)	.005	3.66	.009	.032					
Res. Chronic Conditions	.0099 (0.00)	.001	5.63	.006	.013	.010 (0.00)	.002	4.00	.005	.016
Medical card	.028 (0.00)	.005	5.07	.017	.0398	.033 (0.00)	.008	4.14	.017	.0494

PHI	-.001 (0.76)	.005	-0.30	-.012	.008	-.009 (0.24)	.007	-1.17	-.024	.006
Smoke	-.002 (0.66)	.005	-0.44	-.012	.007	.000 (0.90)	.007	0.11	-.013	.014
Third level education	-.000 (0.97)	.007	-0.03	-.015	.014	-.015 (0.13)	.010	-1.51	-.036	.004
Social isolation measure	-.001 (0.53)	.002	-0.61	-.007	.003	-.000 (0.90)	.004	-0.12	-.00	.007
BMI	.001 (0.02)	.000	2.18	.000	.002	.001 (0.03)	.000	2.16	.00	.003
WTHR	.08 (0.03)	.040	2.08	.004	.163	-.036 (0.49)	.054	-0.68	-.143	.069

Table 52. Independent marginal effects from probit results using BMI &WTHR measures together for Chiropody service for males only

Males only (*n* = 2466)					
Variable	**Marg Effects (P>|z|)**	**Std. Err.**	**Z**	**95% Conf. Interval**	
Age	.003 (0.00)	.000	4.73	.001	.004
Res. Chronic Conditions	.008 (0.00)	.002	4.07	.004	.012
Medical card	.022 (0.00)	.007	3.04	.008	.037
PHI	.007 (0.00)	.006	1.06	-.006	.020
Smoke	-.006 (0.41)	.007	-0.81	-.020	.008
Third level education	.011 (0.26)	.010	1.11	-.009	.033
Social isolation measure	-.003 (0.36)	.003	-0.91	-.011	.004
BMI	.000	.001	0.07	-.002	.002

	(0.94)				
WTHR	.253 (0.000)	.064	3.91	.126	.38
*Findings from the probit analysis were as follows Probit Pseudo R2 = 0.2272 Prob > chi2 = 0.0000 Log pseudolikelihood = -259.5098					

Table 53. Independent marginal effects from biprobit results using BMI &WTHR measures together for GP and public health nurse for males and females combined

Males and females combined (*n* = 5564)										
	GP					Public health nurse				
Variable	Marg Effects	Std. Err.	z	95% Conf. Interval		Marg Effects	Std. Err.	z	95% Conf. Interval	
Age	.002 (0.00)	.000	3.55	.001	.003	.003 (0.00)	.000	7.36	.002	.004
Sex	.030 (0.00)	.011	2.57	.007	.053	.014 (0.04)	.007	2.02	.000	.028
Res. Chronic Conditions	.070 (0.00)	.006	11.73	.058	.082	.015 (0.00)	.001	7.72	.011	.019
Medical card	.091 (0.00)	.010	8.87	.071	.111	-.012 (0.00)	.006	5.73	.024	.049
PHI	.013 (0.18)	.010	1.26	-.006	.034	.011 (0.03)	.006	-2.12	-.024	-.000
Smoke	-.008 (0.31)	.008	-1.00	-.025	.008	-.000 (0.03)	.005	2.07	.000	.022

Third level education	.008 (0.44)	.010	0.76	-.013	.029	-.000 (0.95)	.008	-0.01	-.017	.017
Social isolation measure	.017 (0.00)	.005	3.55	.008	.027	-.006 (0.03)	.003	-2.07	-.012	-.000
BMI	.004 (0.001)	.001	3.25	.001	.006	-.000 (0.49)	.000	-0.68	-.002	.000
WTHR	.228 (0.003)	.076	2.96	.078	.378	.101 (0.03)	.048	2.07	.005	.197

Table 54. Separate Independent marginal effects for males and females from probit results using BMI &WTHR measures together for public health nurse

	Males only (n=2466)					Females only (n=3104)				
Variable	**Marg Effects**	**Std. Err.**	**Z**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**Z**	**95% Conf. Interval**	
Age	.002 (0.00)	.000	4.45	.001	.004	.003 (0.00)	.000	5.92	.002	.005
Res. Chronic Conditions	.016 (0.00)	.002	6.38	.011	.021	.013 (0.00)	.002	4.59	.007	.019
Medical card	.038 (0.00)	.008	4.34	.021	.056	.035 (0.00)	.009	3.92	.017	.053
PHI	-.016 (0.05)	.008	-1.93	-.033	.000	-.010 (0.20)	.008	-1.26	-.027	.005
Smoke	.005 (0.48)	.008	0.70	-.010	.022	.015 (0.04)	.007	2.06	.000	.030
Third level education	-.006 (0.58)	.011	-0.55	-.028	.016	.006 (0.62)	.0131796	0.50	-.019	.032
Social isolation measure	-.006	.004	-1.30	-.015	.003	-.005	.004	-1.36	-.014	.002

	(0.19)					(0.17)				
BMI	-.000 (0.89)	.001 (0.05)	-0.13	-.002	.002	-.000 (0.83)	.000	-0.21	-.002	.001
WTHR	.008 (0.90)	.073	0.12	-.136	.153	.150 (0.02)	.065	2.31	.023	.278
*Findings from the probit analysis were as follows: Probit: Wald chi2(13) = 139.01 Prob > chi2 = 0.0000 Pseudo R2 = 0.2447 Log pseudolikelihood = -332.61949						*Findings from the probit analysis were as follows: Probit: Wald chi2(13) = 199.84 Prob > chi2 = 0.0000 Pseudo R2 = 0.2163 Log pseudolikelihood = -491.63556				

Table 55. Independent marginal effects from probit results using BMI &WTHR measures together for home-help services for males and females combined

	Males and Females (*n*=5570)					**Males only (*n*= 2466)**					**Females only (*n*=3104)**				
Variable	**Marg Effects**	**Std. Err.**	**z**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**z**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**z**	**95% Conf. Interval**	
Age	.004 (0.00)	.000	8.28	.003	.005	.002 (0.0)	.000	4.13	.001	.004	.005 (0.000)	.000	7.40	.003	.006
Sex	.012 (0.01)	.004	2.53	.002	.022										
Residual Chronic Conditions	.007 (0.00)	.001	5.88	.005	.010	.004 (0.0)	.001	3.18	.001	.007	.009 (0.00)	.002	4.90	.005	.013
Medical card	.010 (0.03)	.005	2.13	.000	.020	.011 (0.03)	.005	2.15	.001	.022	.008 (0.27)	.008	1.10	-.006	.024
PHI	-.005 (0.15)	.004	-1.44	-.013	.002	-.003 (0.46)	005	-0.74	-.0138	.006	-.007 (0.25)	.006	-1.15	-.019	.004
Smoke	-.006 (0.119)	.004	-1.56	-.0147	.001	-.010 (0.081)	.005	-1.75	-.022	.001	-.003 (0.576)	.005	-0.56	-.014	.007
Third level education	-.007 (0.17)	.005	-1.37	-.018	.003	-.001 (0.80)	.006	-0.25	-.015	.011	-.012 (0.14)	.008	-1.46	-.029	.004

Social isolation measure	-.008 (0.00)	.002	- 3.82	-.012	-.004	-.008 (0.00)	.002	- 2.99	-.013	-.002	-.007 (0.03)	.003	- 2.47	-.014	-.001
BMI	.000 (0.05)	.000	0.58	-.000	.001	-.000 (0.47)	.000	- 0.72	-.002	.001	.000 (0.27)	.000	1.09	-.000	.002
WTHR	.0249 (0.078)	.0318	0.78	-.037	.087	.090 (.05)	.047	1.90	-.003	.183	-.017 (0.70)	.045	- 0.38	-.105	.071
*Findings from the probit analysis were as follows: Wald chi2(14) = 298.32 Prob > chi2 = 0.0000 Pseudo R^2 = 0.3316						*Findings from the probit analysis were as follows: Wald chi2(13) = 146.52 Prob > chi2 = 0.0000 Pseudo R^2 = 0.3105					*Findings from the probit analysis were as follows: Wald chi2(13) = 212.12 Prob > chi2 = 0.0000 Pseudo R^2 = 0.3441				

Table 56. Biprobit model GP: Outpatient for males

GP visits: Number of obs = 2465															
Model 1: BMI						**Model 2: WTHR**					**Model 3: BMI & WTHR**				
Wald chi2(22) = 397.36						**Wald chi2(22) = 407.53**					**Wald chi2(26) = 409.34**				
Prob > chi2 = 0.0000						**Prob > chi2 = 0.0000**					**Prob > chi2 = 0.0000**				
Log pseudolikelihood = -2372.9789						**Log pseudolikelihood = -2372.4036**					**Log pseudolikelihood = -2370.5012**				
GP															
Variable	**Coef.**	**Std. Err.**	**z**	**95% Conf. Interval**		**Coef.**	**Std. Err.**	**Z**	**95% Conf. Interval**		**Coef.**	**Std. Err.**	**Z**	**95% Conf. Interval**	
Age	.042	.064	0.66	-.083	.169	.035	.064	0.54	-.091	.161	.034	.064	0.54	-.091	.161

	(0.50)					(0.58)					(0.58)				
Age^2	-.000 (0.75)	.000	-0.32	-.001	.000	-.000 (0.82)	.000	-0.22	-.001	.000	-.000 (0.83)	.000	-0.21	-.001	.000
Residual of chronic conditions											.308 (0.00)	.036	8.53	.237	.379
Residual of all											-.048 (0.00)	.011	-4.03	-.071	-.024
Residual morbidities BMI	.315 (0.00)	.037	8.47	.242	.388										
Residual morbidities #c.resmorb_bmi	-.0439 (0.00)	.0122	-3.60	- .0679	- .020										
Residual WTHR						.306 (0.00)	.035	8.58	.236	.376	-1.072 (0.91)	10.319	-0.10	-21.297	19.153

Residual WTHR #c.res_WTHR						-.049245 (0.00)	.0117999	-4.17	-.0723723	-.0261177	1.305697 (0.80)	5.33588	0.24	-9.152436	11.76383
Medical card	.4507 (0.00)	.1029	4.38	.248	.652	.450 (0.00)	.102	4.38	.248	.651	.449 (0.00)	.102	4.37	.247	.6505
PHI[60]	.056 (0.47)	.079	0.71	-.0993	.212	.068 (0.39)	.080	0.85	-.088	.225	.064 (0.42)	.080	0.80	-.092	.221
Smoke	-.083 (0.23)	.069	-1.20	-.219	.052	-.091 (0.18)	.069	-1.31	-.227	.044	-.089 (0.19)	.069	-1.29	-.226	.046
Third level education	.094 (0.29)	.090	1.05	-.082	.270	.103 (0.25)	.0904	1.14	-.073	.2808208	.101 (0.26)	.090	1.12	-.0758	.2791
Social isolation measure	.133 (0.01)	.041	3.18	.051	.215	.103 (0.01)	.041	3.35	.0582	.222	.137 (0.01)	.041	3.27	.054	.219

[60] Private health insurance

BMI	.008 (0.91)	.075	0.11	-.139	.155						-.041 (0.60)	.080	-0.52	-.199	.116
BMI^2	.000 (0.71)	.001	0.37	-.002	.002						.001 (0.40)	.001	0.83	-.001	.003
Constant	-1.86	2.26	-0.82	-6.30	2.57	-1.11 (0.82)	5.124	-0.22	-11.16	8.92	-.871 (0.86)	5.107	-0.17	-.199	.116
Outpatient															
Age	.134 (0.00)	.045	2.98	.045	.222	.129 (0.00)	.045	2.87	.041	.218	.127 (0.00)	.045	2.83	.039	.216
Age^2	-.001 (0.00)	.000	-2.92	-.001	-.000	-.000 (0.00)	.000	-2.83	-.001	-.000	-.000 (0.00)	.000	-2.78	-.001	-.000
Residual morbidities BMI	.311 (0.00)	.026	11.68	.259	.363										

Residual morbidities BMI #c.resmorb_BMI	-.0343 (0.00)	.009	-3.48	-.053	- .014										
Residual WTHR						.301 (0.00)	.025	11.83	.251	.351					
Residual WTHR #c.res_WTHR						-.034 (0.00)	.009	-3.44	-.053	-.014					
res_all											.303 (0.00)	.0258	11.78	.253	.354
c.res_all#c.res_all											-.035 (0.00)	.009	-3.57	-.055	-.015
Medical card	.160 (0.02)	.070	2.29	.023	.298	.161 (0.021)	.070	2.30	.024	.299	.159 (0.02)	.070	2.27	.021	.297

PHI[61]	-.001 (0.98)	.062	-0.02	-.124	.121	.000 (0.98)	.062	0.01	-.122	.124	.005 (.29)	.063	0.09	-.117	.129
Smoke	.051 (0.35)	.055	0.92	-.057	.159	.048 (0.38)	.055	0.88	-.060	.157	.045 (0.41)	.055	0.82	-.063	.154
Third level education	.063 (0.36)	.069	0.91	-.073	.199	.071 (0.30)	.069	1.03	-.065	.201	.070 (0.31)	.069	1.01	-.066	.207
Social isolation measure	.061 (0.05)	.031	1.95	-.000	.123	.064 (0.04)	.03	2.04	.002	.126	.065 (0.03)	.031	2.07	.003	.127
WTHR					- 2.48	-2.48 (0.72)	7.10	-0.35	-16.40	11.44	1.97 (0.80)	7.84	0.25	-13.39	17.35
Residual WTHR #c.WTHR						2.078 (0.572)	3.675	0.57	-5.11	9.270314	-.332 (0.93)	4.02	-0.08	-8.21	7.559

[61] Private health insurance

BMI	-.064 (0.28)	.060	-1.07	-.182	.053						-.117 (0.08)	.067	-1.74	-.25	.015
BMI^2	.001 (0.14)	.001	1.46	-.000	.003						.002 (0.05)	.00	1.95	-7.91	.004
_cons	-4.12 (0.01)		-2.47	-7.39	- .855	-4.10 (0.26)	3.66	-1.12	-11.30	3.08	-4.54 (0.22)	3.72	-1.22	-11.84	2.75
Rho	.393 (0.00)	.048	8.16	.29	.487	.39 (0.00)	.048	8.09	.296	.485	.391 (0.00)	.048	8.09	.296	.48
rho	.374	.041		.290	.452	.372	.041		.287	.450	.372	.041		.288	.451

Table 57. Biprobit model GP: Outpatient for females

Model 1: Bi Probit model: Model 1: BMI Only: (*n* = 3099)						BiProbit model: Model 2: WTHR Only: (*n* = 3099					BiProbit model: Model 3: BMI & WTHR Males: (*n* = 3099)				
Wald chi2(22) = 440.98						Wald chi2(22) = 443.77					**Wald chi2(26) = 447.05**				
Prob > chi2 = 0.0000						rob > chi2 = 0.0000					**Prob > chi2 = 0.0000**				
Log pseudolikelihood = -2924.4099						Log pseudolikelihood = -2925.3019					**Log pseudolikelihood = -2922.2621**				
Variable	**Coef. (P>|z|)**	**Std. Err.**	**z**	**95% Conf. Interval**		**Coef. (P>|z|)**	**Std. Err.**	**z**	**95% Conf. Interval**		**Coef. (P>|z|)**	**Std. Err.**	**z**	**95% Conf. Interval**	
Age	.0463 (0.39)	.054	0.85	-.060	.153	.044 (0.41)	.054	0.82	-.062	.152	.043 (0.42)	.0548066	0.80	-.063	.151
Age^2	-.000	.000	-0.74	-.001	.000	-.000	.000	-0.73	-.001	.000	-.000	.000		-.001	.000

	(0.46)					(0.46)					(0.48)				
Residual morbidities BMI	.357 (0.00)	.035	9.97	.287	.428										
Residual morbidities BMI #c.resmorb_bmi	-.035 (0.08)	.020	-1.75	-.075	.004										
Residual WTHR						.359 (0.00)	.036	9.90	.287	.430					
Residual WTHR #c.res_WTHR						-.029 (0.222)	.024	-1.22	-.076	.017					
res_all											.361 (0.00)	.036	9.97	.290	.432
c.res_all#c.res_all											-.037 (0.06)	.020	-1.84	-.077	.002

Medical card	.625 (0.00)	.091	6.84	.445	.804	.629 (0.00)	.091	6.88	.450	.808	.627 (0.00)	.091	6.87	.448	.806
PHI	.049 (0.52)	.07	0.63	-.104	.203	.059 (0.44)	.078	0.76	-.093	.212	.056 (0.47)	.078	0.72	-.097	.210
Smoke	-.028 (0.65)	.064	-0.44	-.153765	.0972456	-.043 (0.49)	.0638089	-0.68	-.168	.0819634	-.0335628 (0.601)	.064	-0.52	-.159402	.092
Third level education	-.011 (0.89)	085	-0.14	-.178	.155	-.009 (0.91)	.0847	-0.11	-.175	.156	-.006 (0.94)	.084	-0.07	-.172	.160
Social isolation measure	.05 (0.14)	.037	1.45	-.018	.126	.059 (0.11)	.037	1.59	-.013	.132	.053 (0.14)	.037	1.45	-.018	.126
BMI	.121 (0.01)	.048	2.53	.027	.215						.082 (0.10)	.050	1.62	-.016	.181

BMI^2	-.001 (0.04)	.000	-2.02	-.003	-.000						-.001 (0.18)	.000	-1.32	-.002	.000
WTHR						7.83 (0.22)	6.43	1.22	-4.785	20.44	6.49 (0.32)	6.60	0.98	-6.45	19.44
$WTHR^2$						-3.67 (0.32)	3.73	-0.98	-10.99	3.65	-3.19 (0.40)	3.82	-0.84	-10.68	4.30
Constant	-2.71 (0.13)	1.80	-1.50	-6.24	.82	-4.58 (0.15)	3.19	-1.43	-10.84	1.68	-5.16 (0.11)	3.24	-1.59	-11.52	1.19
Visoutpat															
Age	.067 (0.07)	.037	1.81	-.005	.139	.068 (0.06)	.037	1.85	-.004	.141	.069 (0.06)	.037	1.86	-.003	.141
Age^2	-.000	.000	-1.99	-.001	-9.13e-	-.000	.000	-2.02	-.001	-.000	-.000	.000	-2.04	-.00	-.000

	(0.04)					(0.04)			1		(0.04)				
Residual morbidities BMI	.312 (0.000)	.025	12.40	.263	.362										
Residual morbidities BMI #c.resmorb_bmi	-.020 (0.04)	.010	-2.00	-.040	-.000										
Residual WTHR						.318 (0.00)	.026	12.24	.267	.369					
Residual WTHR #c.res_WTHR						-.022 (0.02)	.010	-2.21	-.042	-.002					
res_all											.315 (0.00)	.026	12.10	.264	.3670
c.res_all#c.res_all											-.020 (0.04)	.010	-1.99	-.041	-.000

Medical card	.150 (0.01)	.061	2.43	.028	.271	.149 (0.01)	.061	2.42	.028	.27	.149 (0.01)	.061	2.42	.028	.271
PHI	.064 (0.24)	.056	1.15	-.045	.174	.063 (0.25)	.056	-.046	.173		.062 (0.26)	.05	1.11		
Smoke	.143 (0.03)	.047	3.01	.050	.237	.144 (0.03)	.047	.050	.237		.146 (0.00)	.048	3.06		
Third level education	.142 (0.03)	.066	2.14	.012	.273	.140 (0.03)	.066	.010	.271		.140 (0.03)	.066	2.11		
Social isolation measure	.020 (0.45)	.027	0.75	-.033	.075	.022 (0.41)	.027	-.032	.076		.021 (0.45)	.027	0.76		
BMI	.015 (0.71)	.040	0.37	-.064	.094						.011 (0.78)	.042	0.27		
BMI^2	-.000 (0.97)	.000	-0.03	-.001	.001						-.000 (0.98)	.000	-0.01	-.001	.001

WTHR						-7.18 (0.16)	5.22	-1.38	-17.43	3.05	-7.20 (0.17)	5.30	-1.36	-17.60	3.187
$WTHR^2$						4.42 (0.14)	3.01	1.47	-1.47	10.32	4.29 (0.15)	3.04	1.41	-1.66	10.25
Constant	-2.68 (0.03)	1.300	-2.07	-5.23	-.137	.528 (0.83)	2.51	0.21	-4.39	5.45	.314 (0.90)	2.52	0.12	-4.64	5.27
athrho	.424 (0.00)	.045	9.33	.335	.513	.426 (0.00)	.04	9.36	.33	.51	.42 (0.00)	.04	9.32	.335	.514
rho	.400	.038		.323	.472	.402	.038		.324	.474	.401	.038		.323	.473
Wald test of rho=0: chi2(1) = 87.0165 Prob > chi2 = 0.0000						Wald test of rho=0: chi2(1) = 87.5361 Prob > chi2 = 0.0000					Wald test of rho=0: chi2(1) = 86.8432 Prob > chi2 = 0.0000				

Table 58. Marginal effects GP and outpatient

GP visits: Number of obs = 5564															
Model 1: BMI						**Model 2: WTHR**					**Model 3: BMI & WTHR**				
Variable	**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**	
Age	.002	.000	0.00	.001	.004	.002	.000	0.00	.001	.003	.002	.000	0.00	.001	.003
Female	.017	.008	0.04	.000	.034	.031	.011	0.00	.009	.053	.028	.011	0.01	.006	.051
Res. Chronic Conditions	.069	.006	0.00	.057	.081	.069	.000	0.00	.057	.081	.069	.006	0.00	.057	.08
Medical	.100	.012	0.00	.075	.124	.099	.012	0.00	.075	.124	.091	.010	0.00	.071	.112

card															
PHI[62]	.0100	.010	0.32	-.009	.030	.011	.010	0.24	-.007	.031	.011	.010	0.27	-.008	.031
Smoke	-.007	.008	0.36	-.024	.008	-.010	.008	0.23	-.026	.006	-.008	.008	0.29	-.025	.007
Third level education	.010	.011	0.37	-.012	.032	.010	.011	0.35	-.011	.032	.010	.010	0.33	-.010	.031
Social isolation measure	.017	.005	0.00	.007	.027	.018	.005	0.00	.008	.028	.017	.005	0.00	.007	.027
BMI	.003	.001	0.00	.001	.005						.004	.001	0.00	.001	.006
WTHR						.192	.065	0.00	.064	.320	.218	.076	0.00	.069	.368
Outpatient															
Age	-.000	.000	0.69	-.00	.00	-.000	.000	0.70	-.002	.001	-.000	.000	0.71	-.002	.001
Female	.021	.013	0.10	-.004	.0478	.030	.016	0.06	-.002	.062	.030	.016	0.07 6	-.003	.063

[62] Private health insurance

Res. Chronic Conditions	.113	.006	0.00	.101	.124	.112	.006	0.00	.100	.124	.112	.006	0.00	.100	.124
Medical card	.057	.006	0.00	.024	.090	.056	.016	0.00	.023	.089	.057	.017	0.00	.023	.090
PHI	.013	.015	0.39	-.0168	.042	.013	.015	0.37	-.016	.043	.013	.015	0.36	-.015	.043
Smoke	.041	.013	0.00	.016	.067	.041	.013	0.00	.015	.067	.041	.013	0.00	.015	.067
Third level education	.040	.017	0.02	.006	.075	.041	.017	0.01	.007	.075	.041	.017	0.02	.006	.075
Social isolation measure	.0143	.007	0.05	-.000	.029	.015	.007	0.04	.000	.029	.015	.007	0.04	.000	.029
BMI	.0008	.0014	0.60	-.0021	.0037						.0035	.0013	0.04	.0007	.006
WTHR						.074	.096	0.44	-.115	.263	.230	.112	0.04	.008	.451

Table 59 Biprobit model GP: Inpatient using both measures of adiposity

GP visits:												
Model 3: BMI & WTHR for both males and females					**Model 2: WTHR & WTHR for males only**				**Model 3: BMI & WTHR forfemales only**			
Number of obs = 5564					Number of obs = 2465				Number of obs = 3099			
Log pseudolikelihood = -3794.831					Log pseudolikelihood = -1726.093				Log pseudolikelihood = -2052.9048			
Wald chi2(28) = 610.82					Wald chi2(26) = 295.61				Wald chi2(26) = 339.90			
Prob > chi2 = 0.0000					Prob > chi2 = 0.0000				Prob > chi2 = 0.0000			
GP												
Variable	**Coef.** (**P>|z|**)	**Std. Err.**	**z**	**95% Conf. Interval**	**Coef.** (**P>|z|**)	**Std. Err.**	**Z**	**95% Conf. Interval**	**Coef.** (**P>|z|**)	**Std. Err.**	**Z**	**95% Conf. Interval**

Age	.024 (0.56)	.041	0.58	-.057	.105	.012 (0.84)	.064	0.20	-.113	.139	.040 (0.45)	.055	0.74	-.066	.148
Sex	.161 (0.01)	.063	2.54	.036	.285										
Age^2	-.000 (0.79)	.000	-0.26	-.000	.000	.000 (0.88)	.000	0.15	-.000	.001	-.000 (0.51)	.000	-0.65	-.001	.000
res_all	.340 (0.00)	.025	13.23	.28	.390	.314 (0.00)	.036	8.69	.243	.385	.368 (0.00)	.036	10.05	.296	.4400
c.res_all#c.res_all	-.038 (0.00)	.012	-3.07	-.062	-.013	-.045 (0.00)	.012	-3.66	-.069	-.021	-.036 (0.09)	.021	-1.65	-.079	.006
Medical card	.548 (0.00)	.067	8.09	.415	.681	.441 (0.00)	.102	4.32	.241	.641	.636 (0.00)	.091	6.96	.457	.815
PHI	.069 (0.22)	.056	1.23	-.041	.179	.058 (0.47)	.080	0.72	-.100	.216	.074 (0.34)	.079	0.94	-.081	.229

Smoke	-.048 (0.30)	.047	-1.03	-.141	.044	-.075 (0.28)	.069	-1.08	-.212	.061	-.045 (0.47)	.064	- 0.71	-.172	.081
Third level education	.041 (0.50)	.061	0.67	-.079	.162	.103 (0.25)	.09132 92	1.14	-.075	.282	-.042 (0.61)	.084	- 0.50	- .20811 91	.122
Social isolation measure	.097 (0.00)	.02	3.51	.042	.151	.142 (0.00)	.041	3.43	.061	.224	.048 (0.19)	.037	1.31	-.024	.121
BMI	.044 (0.29)	.042	1.05	-.038	.128	-.042 (0.60)	.082	-0.52	-.204	.118	.084 (0.09)	.050	1.67	-.014	.184
BMI^2	-.000 (0.56)	.000	-0.58	-.001	.000	.00 (0.41)	.001	0.81	.003	.003	-.0011 (0.17)	.000	- 1.35	-.002	.000
WTHR	.858 (0.837)	4.16	0.21	-.001	9.01	.761 (0.94)	10.093	0.08	20.546	20.54	6.60 (0.31)	6.59	1.00	-6.31	19.52
$WTHR^2$	.203	2.2927	0.09	-4.284	4.692	.375	5.207	0.07	10.575	10.57	-3.237	3.809	- 0.85	- 10.703	4.225

	(0.92)					(0.942)					(0.39)				
Constant	-2.25 (0.31)	2.24	-1.01	-6.665	2.146	-1.088 (0.82)	4.98	-0.22	8.67	8.67	-5.154 (0.11)	3.25	-1.59	-11.52	1.217
Inpatient															
Age	.059 (.09)	.035	1.67	-.010	.130	.037 (0.50)	.056	0.66	-.073	.147	.073 (0.11)	.047	1.56	-.018	.165
Sex	.021 (0.71)	.058	0.36	-.093	.136										
Age^2	-.000 (0.1)	.000	-1.56	-.000	.000	-.000 (0.52)	.00	-0.63	-.001	.000	-.000 (0.15)	.000	-1.43	-.001	.000
res_all	.185 (0.00)	.023	7.90	.139	.23	.197 (0.00)	.03	6.18	.13	.26	.17 (0.00)	.034	5.02	.105	.24
c.res_all#c.res_all	-.008 (0.29)	.007	-1.04	-.023	.007	-.00 (0.37)		-0.89	-.031	.011	-.007 (0.52)	.011	-0.64	-.029	.0151

Medical card	.194 (0.00)	.057	3.38	.081	.306	.215 (0.01)	.010	2.44	.042	.389	.183 (0.01)	.075	2.43	.035	.332
PHI	.071 (0.17)	.052	1.37	-.030	.173	.013 (0.86)	.079	0.16	-.143	.169	.116 (0.09)	.068	1.69	-.018	.252
Smoke	.057 (0.21)	.046	1.25	-.032	.148	-.027 (0.69)	.070	-0.39	-.164	.109	.125 (0.04)	.061	2.04	.005	.246
Third level education	.008 (0.89)	.063	0.13	-.117	.132	.075 (0.39)	.089	0.84	-.099	.249	-.049 (0.58)	.091	- 0.54	-.229	.129
Social isolation measure	.019 (0.46)	.025	0.74	-.031	.069	.033 (0.377)	.038	0.88	-.041	.109	.007	.035 (0.83)	0.21	-.061	.076
BMI	-.016 (0.70)	.043	- 0.37	-.101	.068	-.085 (0.2)	.079	-1.07	-.242	.070	.020	.053 (0.70)	0.38	-.083	.124
BMI^2	.000	.000	0.55	-.000	.001	.00152 75	.001 2869	1.19	-.0009949	.004 0498	-.00023	.0008688 (0.791)	- 0.26	- .00193	.001472 9

						(0.23)								29	
WTHR	4.17	4.204	0.99	-4.06	12.41	2.36 (0.80)	9.63	0.24	-16.52	21.25	22.98	8.72 (0.00)	2.63	5.87	40.095
$WTHR^2$	-1.87	2.29	-0.82	-6.36	2.62	-.633 (0.89)	4.91	-0.13	-10.26748	9.00	-12.98	5.02 (0.01)	-2.58	-22.82	-3.134
Constant	-5.52	2.24	-2.47	-9.92	-1.13	-3.08 (0.50)	4.62	-0.67	-12.1	5.98	-14.447	4.11 (0.00)	-3.51	-22.50	-6.37
Athro	.342 (0.00)	.052	6.52	.239	.445	.366	.078	4.67	.212	.520	.327	.070	4.66		
rho	.329	.046		.235	.418	.350	.068		.209	.477	.316	.063		.189	.465
Wald test of rho=0: chi2(1) = 42.5534 Prob > chi2 = 0.0000						Wald test of rho=0: chi2(1) = 21.7765 Prob > chi2 = 0.0000					Wald test of rho=0: chi2(1) = 21.674 Prob > chi2 = 0.0000				

Table 60. GP and inpatient marginal effects

GP visits: Number of obs = 5564															
Model 1: BMI						**Model 2: WTHR**					**Model 3: BMI & WTHR**				
Variable	**Marg Effects**	**Std .Err**	**P>|z|**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**	
Age	.002	.000	0.00	.001	.004	.002	.000	0.00	.001	.003	.002	.000	0.00	.001	.003
sex	.018	.008	0.04	.000	.035	.032	.011	0.00	.010	.054	.029	.011	0.01	.006	.052
Res. Chronic Conditions	.070	.006	0.00	.057	.082	.069	.006	0.00	.057	.081	.069	.006	0.00	.058	.081
Medical	.100	.012	0.00	.076	.124	.099	.012	0.00	.075	.123	.091	.010		.071	.111

card															
PHI	.011	.010	0.26	-.008	.031	.013	.010	0.19	-.006	.033	.012	.010	0.22	-.007	.033
smoke	-.007	.008	0.37	-.024	.009	-.009	.008	0.24	-.026	.006	-.008	.008	0.30	-.025	.007
Third level education	.006	.011	0.55	-.015	.028	.007	.011	0.52	-.014	.029	.007	.010	0.49	-.013	.028
Social isolation measure	.017	.005	0.00	.007	.027	.018	.005	0.00	.008	.028	.017	.005	0.00	.007	.027
BMI	.003	.001	0.00	.001	.005						.004	.001	0.00	.001	.006
WTHR						.193	.065	0.00	.065	.321	.221	.076	0.00	.072	.371
Inpatient															

Age	.000	.000	0.09	-.000	.002	.000	.000	0.12	-.000	.001	.000	.000	0.12	-.000	.00
Sex	-.004	.009	0.62	-.022	.013	.004	.011	0.68	-.0173	.026	.004	.011	0.71	-.018	.026
Res. Chronic Conditions	.035	.003	0.00	.027	.042	.034	.003	0.00	.027	.042	.035	.003	0.00	.027	.042
Medical card	.037	.011	0.00	.016	.059	.037	.011	0.00	.015	.059	.038	.011	0.00	.015	.061
PHI	.013	.010	0.19	-.006	.032	.013	.010	0.17	-.006	.033	.013	.009	0.16	-.005	.033
Smoke	.012	.009	0.17	-.005	.030	.011	.009	0.21	-.006	.028	.011	.008	0.21	-.006	.028
Degree	.001	.012	0.92	-.022	.025	.001	.012	0.88	-.022	.025	.001	.012	0.89	-.022	.025
Social isolation measure	.003	.005	0.49	-.006	.013	.003	.005	0.45	-.006	.013	.003	.005	0.46	-.006	.013

BMI	.000	.000	0.35	-.001	.002						.0012	.001	0.295	-.001	.003
WTHR						.101	.062	0.10	-.021	.224	.148	.073	0.04	.004	.292

Table 61. Independent marginal effects from bivariate probit results with alternative adiposity measures included for GP & Inpatient -females

GP visits: Number of obs = 3099															
Model 1: BMI						**Model 2: WTHR**					**Model 3: BMI & WTHR**				
Variable	**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**	
Age	.001	.000	0.15	-.000	.003	.00	.000	0.21	-.000	.003	.001	.000	0.203	-.000	.003
Res. Chronic Conditions	.001	.008	0.00	.05364	.085	.068	.008	0.00	.051	.084	.069	.008	0.00	.053	.085
Medical card	.099	.013	.00	.073	.124	.099	.013	0.00	.074	.125	.099	.013	0.00	.074	.125
PHI	.011	.014	.39	-.015	.039	.013	.0144	0.33	-.013	.040	.012	.014	0.35	-.014	.040

Smoke	-.006	.011	.53	-.028	.014	-.009	.011	0.38	-.031	.012	-.007	.011	0.48	-.029	.014
Third level education	-.008	015	0.57	-.038	.021	-.007	.015	0.59	-.037	.021	-.007	.014	0.61	-.004	.021
Social isolation measure	.008	.006	0.19	-.004	.020	.009	.006	0.14	-.003	.022	.008	.006	0.19	-.00	.020
BMI	.005	.001	0.00	.0032	.008						.004	.001	0.00	.001	.007
WTHR						.296	.085	0.00	.128	.464	.199	.095	0.03	.012	.385
inpatient															
Model 1: BMI						**Model 2: WTHR**					**Model 3: BMI & WTHR**				
Age	.001	.000	0.05	-.000	.002	.001	.000	0.08	-.000	.002	.001	.000	0.08	-.000	002
Res. Chronic Condition	.032	.005	0.00	.022	.042	.031	.005	0.00	.021	.042	.032	.005	0.00	.021	.042

s															
Medical card	.034	.0149	0.02	.005	.064	.035	.014	0.01	.006	.065	.035	.0149	0.07	.006	.065
PHI	.021	.012	0.09	-.003	.046	.022	.012	0.08	-.002	.047	.022	.012	0.08	-.003	.047
Smoke	.025	.011	0.03	.002	.048	.023	.011	0.04	.000	.046	.024	.011	0.042	.000	.047
Third level education	-.010	.016	0.549	-.043	.022	-.009	.016	0.57	-.042	.023	-.009	.016	0.58	-.042	.023
Social isolation measure	.001	.006	0.82	-.011	.014	.001	.00	0.80	-.01	.014	.001	.006	0.83	-.0117	.014
BMI	.002	.001	0.046	.000	.004	.148	.080	0.06	-.008	.306	.001	.001	0.322	-.001	.004
WTHR											.114	.090	0.204	-.062	.291

Table 62. Independent marginal effects from bivariate probit results with alternative adiposity measures included for GP & Inpatient -males

GP visits: Number of obs = 2465															
Model 1: BMI						**Model 2: WTHR**					**Model 3: BMI & WTHR**				
Variable	**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**		**Marg Effects**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**	
Age	.004	.001	0.00	.002	.006	.004	.001	0.00	.001	.006	.004	.001	0.00	.001	.006
Res. Chronic Conditions	.071	.009	0.00	.053	.089	.072	.009	0.00	.054	.090	.072	.009	0.00	.054	.089
Medical card	.078	.016	0.00	.045	.112	.079	.016	0.00	.046	.112	.078	.016	0.00	.045	.111
PHI	.009	.015	0.53	-.020	.040	.011	.015	0.45	.046	.042	.011	.015	0.47	-.019	.042

Smoke	-.012	-.012	0.32	-.038	.012	-.014	.013	0.27	-.019	.011	-.014	.013	0.27	-.040	.011
Third level education	.017	.017	0.27	-.014	.050	.019	.016	0.23	-.040	.051	.019	.016	0.24	-.012	.051
Social isolation measure	.026	.026	0.00	.011	.041	.027	.007	0.00	.012	.043	.027	.007	0.00	.011	.042
BMI	.006	.006	0.00	.003	.009						.003	.002	0.09	-.000	.008
WTHR						.408	.101	0.00	.210	.606	.282	.138	0.04	.010	.553
inpatient															
Model 1: BMI						**Model 2: WTHR**					**Model 3: BMI & WTHR**				
Age	.000	.000	0.58	-.001	.00	.000	.000	0.66	-.001	.002	.000	.000	0.662	-.001	.0021
Res. Chronic Conditions	.038	.005	0.00	.027	.049	.038	.005	0.00	.027	.049	.038	.005	0.000	.027	.049
Medical card	.043	.018	0.01	.008	.079	.044	.018	0.01	.008	.079	.043	.018	0.017	.007	.079

PHI	.0013	.015	0.93	-.029	. 031	.001	.015	0.90	-.028	.032	.002	.015	0.869	-.028	.033
Smoke	-.004	.013	0.74	-.031	.022	-.004	.013	0.72	-.032	.022	-.005	.013	0.69	-.032	.021
Third level education	.013	.018	0.45	-.022	.049	.015	.018	0.40	-.020	.051	.015	018	0.41	-.020	.051
Social isolation measure	.005	.007	0.43	-.008	.020	.006	.007	0.39	-.008	.021	.006	.007	0.37	-.008	.021
BMI	.002	.001	0.08	-.000	.006						.000	.002	0.73	-.003	.0051
WTHR						.233	.097	0.01	.041	.425	.223	.132	0.09	-.036	.4825

Table 63. Probit model GP: Allied services for males

Model 1: Probit model: Model 1: BMI Only: (*n* =2466)						Probit model: Model 2: WTHR Only: (*n* =2466)					Probit model: Model 3: BMI & WTHR Males: (*n* =2466)				
Log pseudolikelihood = -684.24175						Log pseudolikelihood = -681.24924					Log pseudolikelihood = -680.42471				
Wald chi2(11) = 288.72						Wald chi2(11) = 302.09					Wald chi2(13) = 302.58				
Prob > chi2 = 0.0000						Prob > chi2 = 0.0000					Prob > chi2 = 0.0000				
Pseudo R2 = 0.2007						Pseudo R2 = 0.2042					Pseudo R2 = 0.2052				
Variable	**Coef. (P>|z|)**	**Std. Err.**	**z**	**95% Conf. Interval**		**Coef. (P>|z|)**	**Std. Err.**	**z**	**95% Conf. Interval**		**Coef. (P>|z|)**	**Std. Err.**	**z**	**95% Conf. Interval**	
Age	-.224 (.00)	.061	-3.65	-.345	-.103	-.227 (.00)	.061	-3.71	-.347	-.107	-.227 (.00)	.061	-3.72	-.347	-.107
Age^2	.001	.000	4.09	.000	.002	.001	.000	4.1	.001	.002	.001	.000	4.1	.001	.002

	(.00)					(.00)					(.00)				
Residual morbidities BMI	.255 (.00)	.038	6.68	.180	.330								6.79		
Residual morbidities BMI #c.resmorb_bmi	-.013 (0.23)	.011	-1.18	-.036	.009								-1.30		
Residual WTHR						.256 (.00)	.036	7.02	.185	.328					
Residual WTHR #c.res_WTHR						-.017 (0.15)	.011	-1.43	-.039	.006					
res_all											.251	.037	6.79	.178	.324

											(0.192)				
c.res_all#c.res _all											-.015 (0.19)	.011	4.61	-.038	. .007
Medical card	.456 (.00)	.098	4.63	.263	.649	.458 (.00)	.098	4.63	.264	.652	.456 (.00)	.099	- 0.62	.262	.650
PHI	-.277 (.01)	.085	-3.23	-.445	-.108	-.281 (.00)	.087	- 3.23	-.452	-.110	-.281 (0.001)	.087	0.54	-.452	-.110
Smoke	-.058 (0.476)	.0813 923	-0.71	-.217	.101	-.049 (0.54)	.081	- 0.61	-.209	.110	-.049 (0.54)	.081	- 1.27	-.209	.110
Third level education	.056 (0.60)	.109	0.52	-.157	.270	.063 (0.561)	.109	0.58	-.150	.277	.063 (0.56)	.109	- 1.02	-.150	.277902 9
Social isolation measure	-.066 (0.14)	.044	-1.47	-.154	.021	-.053 (0.00)	.045	- 1.19	-.142	.034	-.053 (0.22)	.045	1.30	-.142	.0344
BMI	-.116	.070	-1.65	-.255	.022						-.0841	.0835	-	-.248	.0798

	(.09)										(0.31)		1.02		
BMI^2	.002 (0.03)	.001	2.07	.000	.004						.001 (0.19)	.001	1.30	-.000	.004
WTHR						-26.54 (.00)	8.94	- 2.97	-44.08	-9.00	-23.69 (.01)	10.01	- 2.37	-43.31	-4.07
$WTHR^2$						14.45 (0.00)	4.55	3.17	5.51	23.38	12.6 (.01)	5.04	2.51	2.79	22.56
Constant	6.50 (.04)	2.27	2.86	2.04	10.97	17.38 (.00)	4.91	3.54	7.751	27.01	17.23 (.00)	4.91	3.42	7.37	27.10

Table 64. BiProbit model GP: Allied services for females

Model 1: Probit model: Model 1: BMI Only: (*n* =3099)						Probit model: Model 2: WTHR Only: (*n* =3099					Probit model: Model 3: BMI & WTHR (*n* 3099)				
Log pseudolikelihood = -2016.7751						Log pseudolikelihood = -2019.7518					Log pseudolikelihood = -2015.2979				
Wald chi2(22) = 637.54						Wald chi2(11) = 642.18					Wald chi2(26) = 642.14				
Prob > chi2 = 0.0000						Prob > chi2 = 0.0000					Prob > chi2 = 0.0000				
GP															
Variable	**Coef. (P>|z|)**	**Std. Err.**	**z**	**95% Conf. Interval**		**Coef. (P>|z|)**	**Std. Err.**	**z**	**95% Conf. Interval**		**Coef. (P>|z|)**	**Std. Err.**	**z**	**95% Conf. Interval**	
Age	.036 (.50)	.055	0.66	-.071	.144	.034 (.529)	.055	0.63	-.073	.143	.033 (.543)	.055	0.61	-.074	.142

Age^2	-.000 (0.580)	.000	-0.55	-.001	.000	-.000 (0.588)	.000	- 0.54	-.001	.000	-.000 (.606)	.000	- 0.52	-.001	.0001
Residual morbidities BMI	.367 (0.00)	.036	10.1	.296	.438										
Residual morbidities BMI #c.resmorb_bmi	-.033 (0.123)	.021	-1.54	-.075	.00959										
Residual WTHR						.368 (.00)	.036	10.1 5	.297	.4397					
Residual WTHR #c.res_WTHR						-.027 (.26)	.025	- 1.10	-.077	.021					
res_all											.371	.036	10.1 8	.299	.442

											(.000)				
c.res_all#c.res_all											-.035 (0.094)	.021	- 1.68	-.077	.006
Medical card	.632 (0.000)	.091	6.95	.454	.811	.634	.090	6.98	.456	.812	.634 (0.000)	.090	6.98	.456	.812
PHI	.074 (0.352)	.079	0.93	-.081	.229	.082	.079	1.05	-.072	.237	.080 (0.309)	.07957 71	1.02	-.075	.236
Smoke	-.033 (0.603)	.064	-0.52	-.159	.092	-.050	.064 -	- 0.78	-.176	.075	-.039 (.544)	.064	- 0.61	-.165	.087
Third level education	-.043 (0.611)	.084	-0.51	-.209	.123	-.039	.084	- 0.47	-.205	.126	-.037 (0.662)	.084	- 0.44	-.203	.1290
Social isolation measure	.047 (0.202)	.037	1.28	-.025	.120	.053	.037	1.42	-.019	.126	.047 (0.201)	.037	1.28	-.025	.1206
BMI	.123 (.011)	.048	2.55	.028	.217						.0827 (.105)	.051	1.62	-.0172	.182

<table>
<tr><td>BMI^2</td><td>-.001
(.044)</td><td>.000</td><td>-2.01</td><td>-.003</td><td>-.000</td><td></td><td></td><td></td><td></td><td></td><td>-.001
(.195)</td><td>.000</td><td>-
1.30</td><td>-.002</td><td>.000</td></tr>
<tr><td>WTHR</td><td></td><td></td><td></td><td></td><td></td><td>8.23</td><td>6.44</td><td>1.28</td><td>-4.38</td><td>20.8</td><td>6.80
(0.303)</td><td>6.61</td><td>1.03</td><td>-6.15</td><td>19.7</td></tr>
<tr><td>WTHR^2</td><td></td><td></td><td></td><td></td><td></td><td>-3.85</td><td>3.73</td><td>-
1.03</td><td>-
11.17</td><td>3.47</td><td>-3.34
(0.382)</td><td>3.82</td><td>-
0.88</td><td>-10.8</td><td>4.14</td></tr>
<tr><td>Constant</td><td>-2.44
(0.176)</td><td>1.803</td><td>-1.35</td><td>-5.97</td><td>1.09</td><td>-4.46</td><td>3.23</td><td>-
1.38</td><td>-
10.81</td><td>1.87</td><td>-5.01
(0.126)</td><td>3.27</td><td>-
1.53</td><td>-11.43</td><td>1.41</td></tr>
<tr><td colspan="16">Allied services</td></tr>
<tr><td>Variable</td><td>Coef.
(P>|z|)</td><td>Std.
Err.</td><td>z</td><td colspan="2">95% Conf.
Interval</td><td>Coef.
(P>|z|)</td><td>Std.
Err.</td><td>z</td><td colspan="2">95% Conf.
Interval</td><td>Coef.
(P>|z|)</td><td>Std.
Err.</td><td>z</td><td colspan="2">95% Conf.
Interval</td></tr>
<tr><td>Age</td><td>-.162
(.001)</td><td>.047</td><td>-3.43</td><td>-.255</td><td>-.069</td><td>-.161
(.001)</td><td>.047</td><td>-
3.42</td><td>-.254</td><td>-.069</td><td>-.164
(.001)</td><td>.047</td><td>-
3.47</td><td>-.257</td><td>-.071</td></tr>
</table>

Age^2	.001 (0.000)	.0003	4.12	.000	.002	.001 (0.000)	.000	4.10	.000	.002	.001 (0.000)	.000	4.15	.000	.002
Residual morbidities BMI	.202 (0.000)	.033	6.04	.136	.268				.136	.274					
Residual morbidities BMI #c.resmorb_bmi	-.003 (0.742)	.010	-0.33	-.024	.017										
Residual WTHR						.205 (0.00)	.035	5.81	-.024	.019					
Residual WTHR #c.res_WTHR						-.002 (.82)	.010	- 0.23	.323	.632					
res_all											.203	.034	5.84	.134	.271

											(0.00) .				
c.res_all#c.res_all											-.003 (0.71)	.010	- 0.36	-.025	.017
Medical card	.473 (0.00)	.078	6.02	.319	.628	.477 (0.00)	.078	6.07	.323	.6320	.474 (0.00)	.078	6.03	.3200	.628
PHI	-.076 (0.270)	.069	-1.10	-.213	.059	-.083 (0.232)	.069	- 1.20	-.220	.053	-.074 (0.28)	.069	- 1.07	-.211	.062
Smoke	.053 (0.400)	.063	0.84	-.071	.178	.046 (0.467)	.063	0.73	-.078	.171	.050 (0.42)	.063	0.79	-.0745	.176
Third level education	-.014 (0.888)	.099	-0.14	-.209	.181	-.012 (0.904)	.099	- 0.12	-.207	.183	-.012 (0.89)	.099	- 0.13	-.208	.182
Social isolation measure	-.0352 (0.323)	.035	-0.99	-.105	.034	-.038 (0.286)	.035	- 1.07	- .107	.031	-.035 (0.32)	.035	- 0.98	-.104	.034
BMI	-.046	.048	-0.96	-.141	.048						-.065	.051	-	-.167	.0362

	(0.339)										(0.206)		1.26		93
BMI^2	.001 (0.174)	.000	1.36	-.000	.002						.00171 (0.110)	.000842	1.60	-.000	.002
WTHR						4.81 (0.510)	7.30	0.66	-9.49	19.12	5.48 (0.460)	7.42	0.74	-9.07	20.048
$WTHR^2$						-2.38 (0.567)	4.15	-0.57	-10.52	5.76	-2.88 (0.492)	4.20	-0.69	-11.134	5.35
Constant	3.29 (0.047)	1.66	1.98	.036	6.563	.518 (0.883)	3.529	0.15	-6.39	7.43	1.12 (0.752)	3.54	0.32	-5.82	8.06
Athrho	.241 (0.001)	.071	3.37	.101	.381	.242 (0.001)	.071	3.39	.1022	.383	.240 (.001)	.071	3.35	.099	.380
rho	.236	.067		.100	.364	.237	.067				.235	.067		.0995	.363

Wald test of rho=0: chi2(1) = 11.358 Prob > chi2 = 0.0008	Wald test of rho=0: chi2(1) = 11.4746 Prob > chi2 = 0.0007	Wald test of rho=0: chi2(1) = 11.2489 Prob > chi2 = 0.0008

Appendix three: GUI data- additional information

Growing Up in Ireland tracks the development of two cohorts of children, one aged nine years and one aged nine months. Growing Up in Ireland was commissioned in April 2006. It is funded by the Department of Health and Children through the Office of the Minister for Children and Youth Affairs, in association with the Department of Social and Family Affairs and the Central Statistics Office. The principal objective of Growing Up in Ireland – the National Longitudinal Study of Children is to describe the lives of Irish children, to establish what is typical and normal as well as what is atypical and problematic. The Study will focus on a broad range of child outcomes with a view to documenting how well children in Ireland are doing in relation to a number of key child outcomes.

The sample of 8,570 nine-year-old children and their families was generated through the primary school system. A representative sample of 910 schools participated in the study – from the national total of 3,200 Primary schools. The sample of children and their families was then randomly generated from within those schools. At the school level a rate of 82% was achieved. At the level of the household (i.e. eligible child selected within the school) a total of 57% of children and their families consented to participate in the study.

The following questionnaires were completed in the school:

1. Principal's questionnaire – recording details on the school, its resources, its management and its ethos
2. Teacher-on-self questionnaire – recording demographic details on the teacher himself/herself
3. Teacher-on-child questionnaire – recording details on each Study Child and his/her performance in school

4. Drumcondra English and Maths tests – academic performance tests sat by all children participating in the study

5. Piers-Harris 2, self-concept questionnaire – a self-completion instrument recording information on the child's self-concept across a number of domains.

On completion of the school-based phase of the project interviewers visited the families of the nine-year olds in their homes and administered the following core questionnaires to the Study Child and his/her caregivers:

1. Primary Caregiver – core questionnaire
2. Primary Caregiver – sensitive self-completion module
3. Spouse/partner of Primary Caregiver – core questionnaire
4. Spouse/partner of Primary Caregiver – sensitive self-completion module
5. Child core questionnaire
6. Child sensitive modules
7. A one-day time-use diary for the Study Child. In addition to the above, the family was also asked to provide contact information for non-resident parents and other caregivers who delivered at least eight hours of care to the nine-year-old Study Child on a regular basis. This regular caregiving could be delivered in either a domestic or institutional setting (the latter including, for example, an after-school facility). This contact information was used by the Study Team to administer (on a postal basis) short self-completion questionnaires to non-resident parents and/or carers who provided either home-based or centre-based care on a regular basis. In the course of the household interview the interviewer also recorded the height and weight of the Study Child and the Primary and Secondary caregivers (the latter where relevant).

Table 65. Marginal effect for predicted maths test score [BMI as continuous]

Predicted average maths test score	dy/dx (St. error)	z	P>|z|	[95% Conf. Interval]	
Females	-.0545438 (.0137646)	-3.96	0.000	-.0815219	-.0275656
Parents BMI	-.005948 (.0014213)	-4.18	0.000	-.0087337	-.0031623
Catholic	-.0095 (.0307744)	-0.31	0.758	-.0698168	.0508168
Marital status (Married and living with husband / wife is reference)					
Married and separated from husband / wife	.0383027 (.0309915)	1.24	0.216	-.0224395	.0990449
Divorced	.1229806 (.0623489)	1.97	0.049	.000779	.2451822
Widowed	-.1034285 (.0871409)	-1.19	0.235	-.2742215	.0673646
Never married	-.0506167 (.0232845)	-2.17	0.030	-.0962536	-.0049798
Equivalised Household Annual Income Quintiles Base Lowest (€503.7783- €10530.65)					
1st €10534.48 - €14610.27	.0184157 (.024511)	0.75	0.452	-.029625	.0664563
2nd €14637.58 - €18797.37	.0040922 (.0239022)	0.17	0.864	-.0427552	.0509396
3rd €18814.07 - €25046.98	.050744 (.0255225)	1.99	0.047	.0007209	.1007672
Highest €25060.24- €223115.6	.0426927 (.0255701)	1.67	0.095	-.0074238	.0928091

Actual maths test score	.0111591 (.0004287)	26.03	0.000	.0103189	.0119992
Parents Education (None or primary is the reference)					
Lower Sec	.0448496 (.0445207)	1.01	0.314	-.0424094	.1321086
Hi Sec/TechVoc/UppSec+Tech/Voc	.0571514 (.0413993)	1.38	0.167	-.0239897	.1382925
Non Degree	.0872815 (.0422281)	2.07	0.039	.0045159	.1700471
Primary Degree	.1375242 (.0430131)	3.20	0.001	.0532201	.2218284
Postgrad	.1468811 (.0474663)	3.09	0.002	.053849	.2399133
Child's BMI	-.001291 (.0022588)	-0.57	0.568	-.005718	.0031361
late year	.0240727 (.0135679)	1.77	0.076	-.0025199	.0506653

Table 66. Marginal effect for predicted reading test score [BMI as continuous]

Predicted average maths test score	**dy/dx (St. error)**	**z**	**P>|z|**	**[95% Conf. Interval]**	
Females	.0480638	3.17	0.002		
Parents BMI	-.0044028	-3.04	0.002		
Catholic	.0075363	0.26	0.793		
Marital status (Married and living with husband / wife is reference)					
Married and separated from husband / wife	-.0164254 (.0339531)	-0.48	0.629		
Divorced	.0336799 (.055581)	0.61	0.545		
Widowed	-.0520394 (.0913837)	-0.57	0.569		
Never married	-.0549955 (.0258658)	-2.13	0.033		
Equivalised Household Annual Income Quintiles Base Lowest (€503.7783- €10530.65)					
1st €10534.48 - €14610.27	.0308046 (.0282157)	1.09	0.275	-.0244972	.0861065
2nd €14637.58 - €18797.37	.0015005 (.025498)	0.06	0.953	-.0484747	.0514757
3rd €18814.07 - €25046.98	.0607913 (.0264631)	2.30	0.022	.0089245	.1126581
Highest €25060.24- €223115.6	.0536391 (.0271762)	1.97	0.048	.0003747	.1069035
Actual reading test score	.0143347 (.0005406)	26.52	0.000	.0132751	.0153942
Parents Education (None or primary is the reference)					

Lower Sec	.0078111 (.055082)	0.14	0.887	-.1001476	.1157698
Hi Sec/TechVoc/UppSec+Tech/Voc	.0074825 (.0516497)	0.14	0.885	-.0937489	.108714
Non Degree	.0281135 (.0532983)	0.53	0.598	-.0763492	.1325762
Primary Degree	.0712181 (.0543011)	1.31	0.190	-.03521	.1776462
Postgrad	.1036474 (.0572161)	1.81	0.070	-.008494	.2157889
Child's BMI	-.000806 (.0023585)	-0.34	0.733	-.0054286	.0038166
late year	-.0149974 (.0147196)	-1.02	0.308	-.0438473	.0138525

Table 67. Marginal effect for predicted maths test score with childs BMI included (along with parent/caregiver)

Predicted average maths test score	dy/dx (St. error)	z	P>|z|	[95% Conf. Interval]	
Females	-.0427499 (.0139154)	-3.07	0.002	-.0700236	-.0154763
Primary caregiver BMI (reference case is normal weight)					
Overweight and obese	-.0341358 (.0139212)	-2.45	0.014	-.0614208	-.0068508
Child BMI (reference case is normal weight)					
Overweight and obese	-.0291721 (.0152513)	-1.91	0.056	-.059064	.0007199
Marital status (reference case is married and living with husband / wife)					
Married and separated from husband / wife	.0463302 (.0318374)	1.46	0.146	-.0160699	.1087304
Divorced	.0888232 (.0613137)	1.45	0.147	-.0313495	.208996
widowed	-.1193694 (.0852793)	-1.40	0.162	-.2865137	.0477749
Never married	-.0591558 (.022716)	-2.60	0.009	-.1036784	-.0146332
Equivalised Household Annual Income Quintiles Reference case is lowest quintile (€503.7783- €10530.65)					
1st €10534.48 - €14610.27	.035614 (.0249744)	1.43	0.154	-.013335	.0845629
2nd €14637.58 - €18797.37	.0152204 (.0245511)	0.62	0.535	-.0328989	.0633397
3rd €18814.07 - €25046.98	.0525994	1.99	0.047	.0007892	.1044096

	(.0264342)				
Highest €25060.24- €223115.6	.0496485 (.0258165)	1.92	0.054	-.0009509	.100248
Actual maths test score	.0110725 (.0004271)	25.92	0.000	.0102354	.0119097
Education					
Lower Sec	-.0208334 (.0423329)	-0.49	0.623	-.1038044	.0621376
Hi Sec/TechVoc/UppSec+Tech/Voc	.0094794 (.0392951)	0.24	0.809	-.0675377	.0864964
Non Degree	.0362997 (.0405424)	0.90	0.371	-.0431619	.1157614
Primary Degree	.0835663 (.0415711)	2.01	0.044	.0020884	.1650442
Postgrad	.0958629 (.0459054)	2.09	0.037	.0058899	.1858359
late year	.0144845 (.0137826)	1.05	0.293	-.0125289	.0414979
This table is the marginal effects according to a probit regression. Probit regression details are as follows;					

Table 68. Marginal effect for predicted reading test score with child's BMI included (along with parent/caregiver)

Predicted average reading test score	**dy/dx (St. error)**	**z**	**P>|z|**	**[95% Conf. Interval]**	
Females	.0554114 (.015258)	3.63	0.000	.0255064	.0853164
Parents BMI	-.0311632 (.0145143)	-2.15	0.032	-.0596107	-.0027157
Marital status (Married and living with husband / wife is reference)					
Married and separated from husband / wife	-.0348775 (.0337591)	-1.03	0.302	-.1010441	.0312891
Divorced	.0349216 (.0555242)	0.63	0.529	-.0739039	.143747
Widowed	-.014784 (.0944401)	-0.16	0.876	-.1998831	.1703152
Never married	-.0654167 (.0248573)	-2.63	0.008	-.1141361	-.0166972
Equivalised Household Annual Income Quintiles Base Lowest (€503.7783- €10530.65)					
1st €10534.48 - €14610.27	.0347492 (.0275037)	1.26	0.206	-.019157	.0886553
2nd €14637.58 - €18797.37	.0131473 (.0252196)	0.52	0.602	-.0362823	.0625768
3rd €18814.07 - €25046.98	.0637355 (.026704)	2.39	0.017	.0113967	.1160744
Highest €25060.24- €223115.6	.0536915 (.0268422)	2.00	0.045	.0010817	.1063013
Actual reading test score	.0144612 (.000542)	26.68	0.000	.013399	.0155234
Parents Education (None or					

primary is the reference)					
Lower Sec	-.0308171 (.0477458)	-0.65	0.519	-.1243972	.062763
Hi Sec/TechVoc/UppSec+Tech/Voc	-.0324028 (.0447661)	-0.72	0.469	-.1201427	.055337
Non Degree	-.0092803 (.0465919)	-0.20	0.842	-.1005988	.0820382
Primary Degree	.0405578 (.0473218)	0.86	0.391	-.0521913	.1333069
Postgrad	.0666657 (.0508272)	1.31	0.190	-.0329538	.1662851
Child’s BMI	-.0098782 (.0158265)	-0.62	0.533	-.0408975	.021141
late year	-.0182898 (.0151442)	-1.21	0.227	-.0479719	.0113924

Table 69. Marginal effect for predicted maths test score with child's BMI only

Predicted average maths test score	dy/dx (St. error)	z	P>|z|	[95% Conf. Interval]	
Females	-.0458778 (.0152333)	-3.01	0.003	-.0757344	-.0160211
Childs BMI	-.0287982 (.0166976)	-1.72	0.085	-.0615248	.0039284
Marital status (Married and living with husband / wife is reference)					
Married and separated from husband / wife	.0071522 (.0888511)	0.08	0.936	-.1669929	.1812972
Divorced	-.0378261 (.114994)	-0.33	0.742	-.2632102	.187558
Never married	-.0580549 (.0361907)	-1.60	0.109	-.1289873	.0128775
Equivalised Household Annual Income Quintiles Base Lowest (€503.7783- €10530.65)					
1st €10534.48 - €14610.27	.0172616 (.0298232)	0.58	0.563	-.0411909	.075714
2nd €14637.58 - €18797.37	-.0100004 (.0279183)	-0.36	0.720	-.0647192	.0447184
3rd €18814.07 - €25046.98	.0389477 (.0291439)	1.34	0.181	-.0181733	.0960686
Highest €25060.24- €223115.6	.0375546 (.029723)	1.26	0.206	-.0207014	.0958105
Actual maths test score	.0115845 (.000466)	24.86	0.000	.0106711	.0124979
Parents Education (None or primary is the reference)					
Lower Sec	.0358194	0.92	0.356	-	.1118478

	(.0387908)			.0402091	
Hi Sec/TechVoc/UppSec+Tech/Voc	.0805641 (.0384123)	2.10	0.036	.0052774	.1558508
Non Degree	.0714563 (.0394784)	1.81	0.070	-.00592	.1488325
Primary Degree	.1035877 (.0411753)	4.30	0.000	.098699	.264109
Postgrad	.181404 (.0421972)	4.30	0.000	.098699	.264109
late year	.0265311 (.015495)	1.71	0.087	- .0038386	.0569008

Table 70. Marginal effect for predicted reading test score with child's BMI only

Predicted average maths test score	**dy/dx (St. error)**	**z**	**P>|z|**	**[95% Conf. Interval]**	
Females	.0627394 (.0165137)	3.80	0.000	.0303731	.0951056
Childs BMI	-.0175559 (.0174198)	-1.01	0.314	-.051698	.0165862
Marital status (Married and living with husband / wife is reference)					
Married and separated from husband / wife	-.0686066 (.0840774)	-0.82	0.415	- .2333952	.0961821
Divorced	0381225 (.1250739)	0.30	0.761	- .2070179	.283263
Never married	-.0588006 (.0394403)	-1.49	0.136	- .1361022	.018501
Equivalised Household Annual Income Quintiles Base Lowest (€503.7783- €10530.65)					
1st €10534.48 - €14610.27	.0709045 (.032881)	2.16	0.031	.0064588	.1353502
2nd €14637.58 - €18797.37	.0320341 (.0296183)	1.08	0.279	- .0260167	.0900848
3rd €18814.07 - €25046.98	.0933545 (.0307889)	3.03	0.002	.0330094	.1536996
Highest €25060.24- €223115.6	.0820022 (.030813)	2.66	0.008	.0216099	.1423946
Actual reading test score	.0147678 (.0006207)	23.79	0.000	.0135512	.0159845
Parents Education (None or					

primary is the reference)					
Lower Sec	.0807729 (.0411107)	1.96	0.049	.0001975	.1613483
Hi Sec/TechVoc/UppSec+Tech/Voc	.1054975 (.0416354)	2.53	0.011	.0238936	.1871014
Non Degree	.1234473 (.0432683)	2.85	0.004	.038643	.2082517
Primary Degree	.13271 (.0434814)	3.05	0.002	.0474879	.2179321
Postgrad	.1730019 (.0457112)	3.78	0.000	.0834095	.2625943
late year	-.0144357 (.016621)	-0.87	0.385	-.0470123	.0181409

Appendix four: DCE questionnaire

Using discrete choice experiment to elicit the preferences for obesity treatment

Survey 2012-2013

Preamble

Hello, my name is Michelle Queally and I am carrying out an administered interview as part of my PhD Research in collaboration with Galway University Hospital and the National University of Ireland Galway regarding people's preferences towards obesity treatment. The purpose of this survey is to find out what your preferences are for obesity treatment. The questionnaire will take you about 35-40 minutes and you should find it interesting. Thank you for taking part in this survey. Ethics approval has been granted for this study by the Galway Research Ethics Board. All information will be treated confidentially.

The following is the structure of this survey (you do not have to answer any questions that you do not want to)

Section A	Attitude towards obesity treatment in Ireland
Section B	General Health
Section C	Probability tutorial and risk attitude
Section D	Choice cards
Section E	Post choice card questions
Section F	Socioeconomic status
Section G	Health care utilisation

SECTION A: ATTITUDE TOWARDS OBESITY TREATMENT

Allocating funds for treating obesity is just one area of Government healthcare spending. In this section of the questionnaire we would like to ask you about your opinions regarding Government spending on obesity treatment in Ireland- relative to other healthcare spending areas.

I would now like to ask you what level of priority you feel Government spending on obesity *should be given* relative to other Government health spending areas.

Looking at the show card, please indicate the extent to which you think Government spending on obesity is less of a priority or more of a priority than each of the below Government spending areas. For example, relative to Government spending on mental health - if you feel Government spending on obesity is of least importance then you circle 1. If you feel Government spending is of more/most importance relative to mental health, you circle 4 and 5 respectively. By circling 3 you feel that Government spending is of equal importance between mental health and obesity. Please circle the appropriate number according to your own opinion.

	Government spending on treating obesity is less of a priority than…. ⟷ Government spending on treating obesity is more of a priority than….				
Mental health	1	2	3	4	5
Elderly care	1	2	3	4	5
Disability	1	2	3	4	5
Paediatric care	1	2	3	4	5
Cancer Care	1	2	3	4	5

SECTION B: QUESTIONS ABOUT YOUR HEALTH

In this section we are interested to know about your general health. Please tick your response to each question in the box accordingly.

1. How would you describe your own health state in general? By placing a tick in one box in each group below, please indicate which statement best describes your own health state in general.

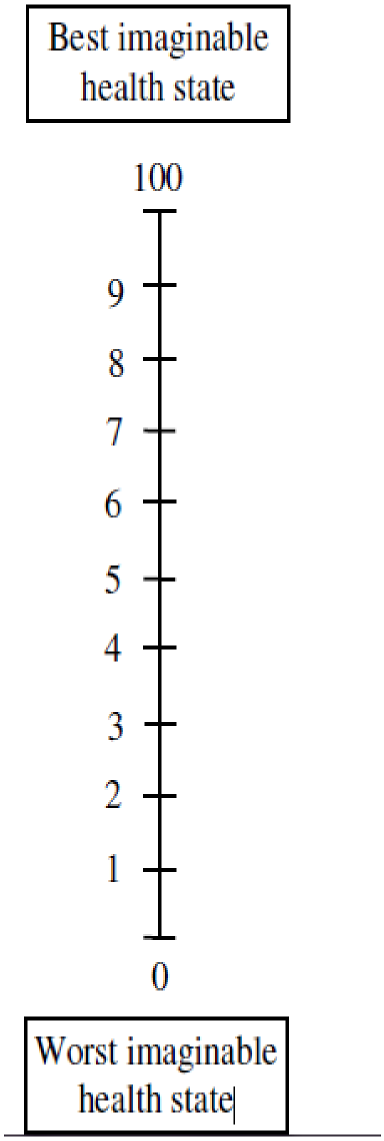
Mobility
I have no problems in walking about [ ]
I have some problems in walking about [ ]
I am confined to bed [ ]

Self-care
I have no problems with self-care [ ]
I have some problems with washing and dressing myself [ ]
I am unable to wash and dress myself [ ]

Usual activities (e.g. work, study, housework, family or leisure activities)
I have no problems with performing my usual activities [ ]
I have some problems with performing my usual activities [ ]
I am unable to perform my usual activities [ ]

Pain/discomfort
I have no pain/discomfort [ ]
I have moderate pain/discomfort [ ]
I have extreme pain/discomfort [ ]

Anxiety/depression
I am not anxious or depressed [ ]
I am moderately anxious or depressed [ ]
I am extremely anxious or depressed [ ]



The best health state you can imagine is marked 100 and the worst sate you can imagine is 0.
We would like you to indicate on this scale how good or bad your own health state is today you're your opinion. Please do this by drawing a circle to whichever point on the scale indicates how good or bad your health state is.

2. What is your height (to your best knowledge?) Please circle

Feet and Inches	Inches	Centimetres
4ft 0in	48	122
4ft 1in	49	124
4ft 2in	50	127
4ft 3in	51	130
4ft 4in	52	132
4ft 5in	53	135
4ft 6in	54	137
4ft 7in	55	140
4ft 8in	56	142
4ft 9in	57	145
4ft 10in	58	147
4ft 11in	59	150
5ft 0in	60	152
5ft 1in	61	155
5ft 2in	62	157
5ft 3in	63	160
5ft 4in	64	163
5ft 5in	65	165
5ft 6in	66	168
5ft 7in	67	170
5ft 8in	68	173
5ft 9in	69	175
5ft 10in	70	178
5ft 11in	71	180
6ft 0in	72	183
6ft 1in	73	185
6ft 2in	74	188
6ft 3in	75	191
6ft 4in	76	193
6ft 5in	77	196
6ft 6in	78	198
6ft 7in	79	201
6ft 8in	80	203
6ft 9in	81	206
6ft 10in	82	208
6ft 11in	83	211
7ft 0in	84	213

3. What is your weight (to your best knowledge, please write below?

_____stones _____pounds (or _____kilos)

4. Do you know what your BMI is?

Yes	[ ]
No	[ ]

If so please state what your BMI is

____

5. What age were you at onset of obesity

From a child	[ ]
Under 20	[ ]
21-30	[ ]
31-40	[ ]
41-50	[ ]
51-60	[ ]
61-70	[ ]
71-80	[ ]

6. **Has a doctor ever told you that you have any of the following conditions? Please tick the appropriate box to show which condition that you have been told that you have.**

Type 2 diabetes [ ]
(There is not enough insulin being produced)

Type 1 diabetes [ ]
(The body is not producing insulin)

Hypertension [ ]
(High blood pressure)

Dyslipidaemia [ ]
(E.g. cholesterol and/or fat in the blood)

Sleep Apnoea [ ]
(Pauses in breathing or instances of very low breathing during sleep)

Depression [ ]
(A state of low mood and aversion to activity that can affect a person's thoughts, behaviour, feelings and sense of well-being)

Anxiety [ ]
(Anxiety is an unpleasant state of inner turmoil, often accompanied by nervous behaviour, such as pacing back and forth, somatic complaints and rumination)

Don't know [ ]

Other [ ]

7. **Have you ever suffered from a heart attack?**

Yes [ ]
No [ ]

8. **How many prescribed medications are you currently on?**

[ ]

9. Do you smoke?

Yes	[ ]
No, I quit	[ ]
No	[ ]

10. How often have you dieted over the past 3 months?

Not often	[ ]
Regularly	[ ]
Never	[ ]
Extremely often	[ ]

11. During the last week, how many hours did you spend on each of the following activities?

Walking, including walking to work, shopping, for pleasure etc

None	[ ]
Some but less than 60 minutes	[ ]
60 minutes but less than 180 minutes	[ ]
180 minutes or more	[ ]
Don’t know	[ ]

12. During the last week, how many hours did you spend on each of the following activities? Physical exercise such as swimming, jogging, aerobics, football, tennis, gym workout etc.

None	[ ]
Some but less than 60 minutes	[ ]
60 minutes but less than 180 minutes	[ ]
180 minutes or more	[ ]
Don’t know	[ ]

13. What is your main reason for not undertaking any dieting/ physical exercise?

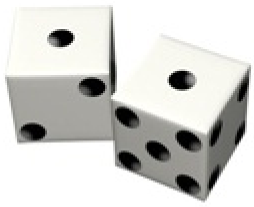
Time	[ ]
Effort	[ ]
Injury	[ ]
Money	[ ]
Weather	[ ]
Lack of support (specify Family/friends/partner/services)	[ ]
Physical Incapacity	[ ]
Laziness	[ ]
Low mood	[ ]
Depression	[ ]
Paranoia *(Afraid of what others might think)*	[ ]
Don’t know	[ ]
Not Applicable	[ ]
Other	[ ]

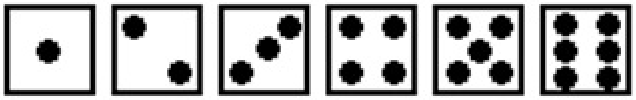
SECTION C: PROBABILITY AND RISK TUTORIAL

Now we will explain to you the meaning of probability

If we flip a coin, the probability to obtain a head is 50%

If we throw a dice the probability of obtaining any number is one over six

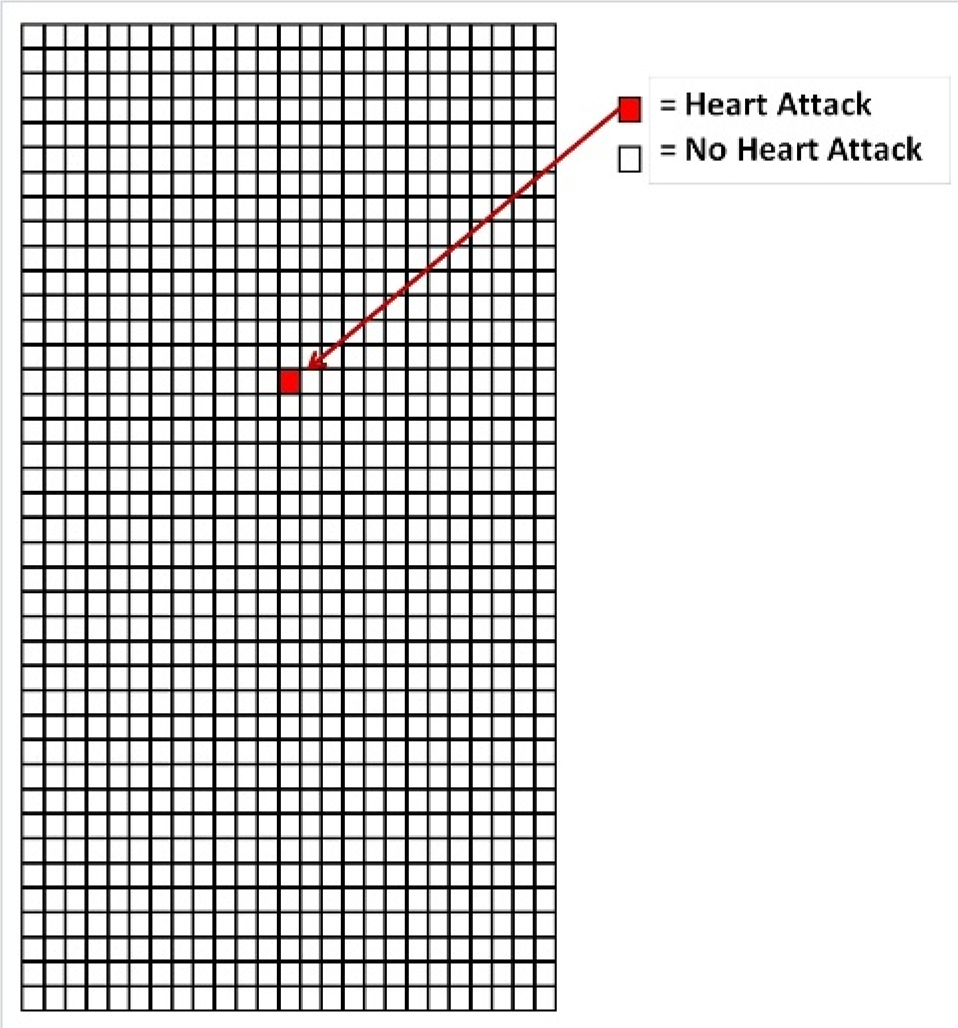




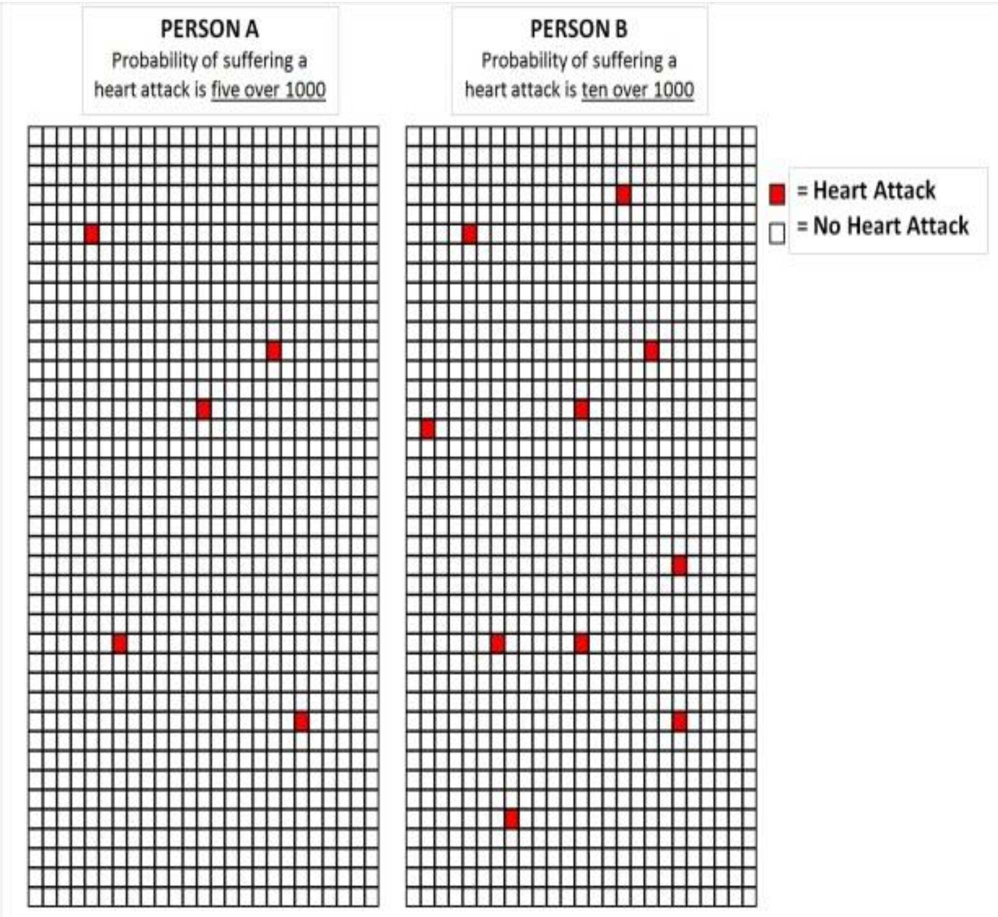
If we are betting in roulette with 36 numbers, the chance to win is 1 over 36. For instance, the chance to win by betting on 16 will be 1 over 36

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30
31	32	33	34	35	36

Now let's talk about the probability of suffering a heart attack.
The following diagram represents a 1 out of a 1,000 chance of suffering a heart attack.



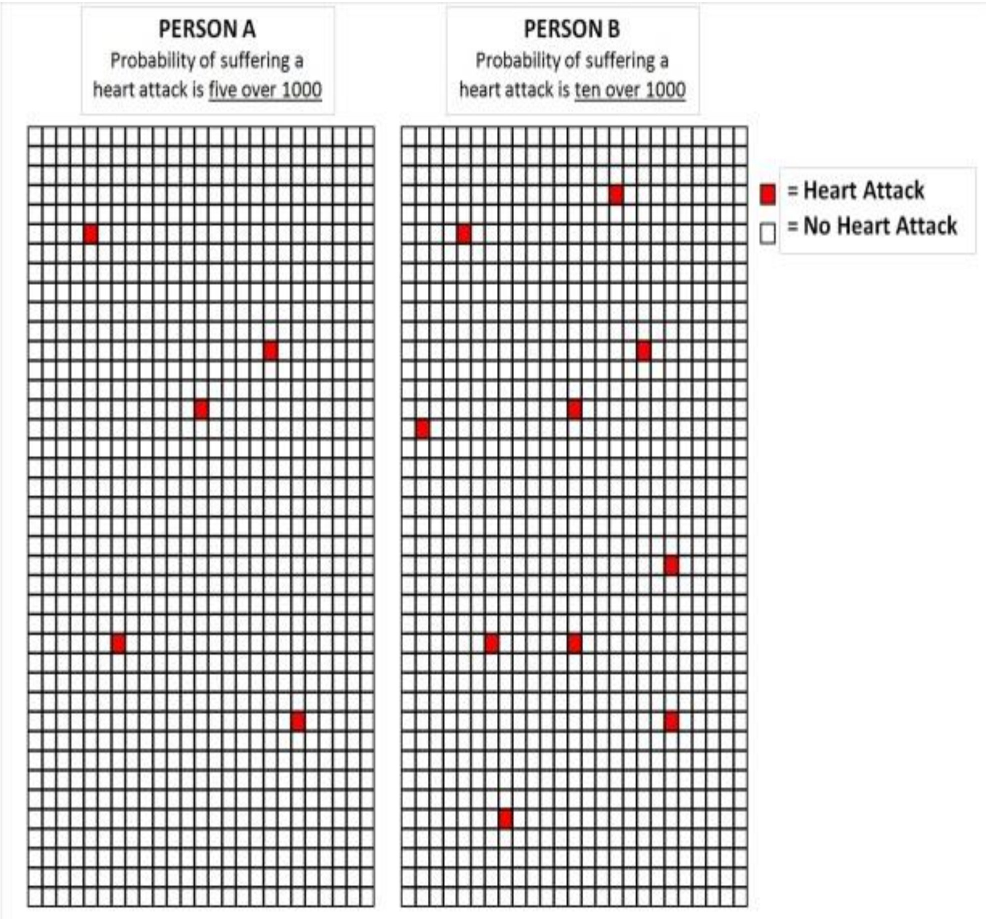
1. **For instance, consider the following example of the risk of two people. Of these two persons, who has more probabilities of having a heart attack in the next ten years? (Tick the right answer in the box below)**



Person A [ ]
Person B [ ]

2. **Who of these two persons would you prefer to be? (Tick the right answer)**

Person A



Person A [ ]
Person B [ ]

RISK ATTITUDE

1. **Would you describe yourself as someone who tries to avoid risks (risk-averse) or as someone who is willing to take risks (risk-prone)?**

   *Please answer on a scale from 0 to 10, where **0** means **risk-averse** and **10** means **risk-prone**.*

Risk-averse — Risk-prone

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

0 1 2 3 4 5 6 7 8 9 10

2. **How would you describe yourself: Do you generally think things over for a long time before acting – in other words, are you not impulsive at all? Or do you generally act without thinking things over for long, in other words, are you very impulsive?**

   *Please answer on a scale from 0 to 10, where **0** means **not at all impulsive** and **10** means **very impulsive***

.

Not at all impulsive — Very impulsive

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

0 1 2 3 4 5 6 7 8 9 10

SECTION D: CHOICE CARDS

In the following choice cards we are presenting you with hypothetical obesity treatment options. Each obesity treatment is described by its characteristics (referred to as attributes). We are asking you to take into account all of the characteristics/attributes of each treatment option as described below and to pick which treatment option that you would choose. Each treatment comes with a cost. We ask you to consider what your own budget constraint.

We will present you with 12 choice cards which look like the choice card on page 12 (SHOW CHOICE CARD ON PAGE 12 TO RESPONDANT). Once you get started on the choice cards you cannot look back. You will have the choice between three options of weight loss treatment.

Option A and Option B will vary in terms of the amount of weight you could possible loose, the reduction in the risk of fatal heart attack, the method in which you lose the weight and also the access to support services such as Psychological services.

Option C is the same throughout the survey. This is like an opt- out option. You can choose this option if you do not like what option A or option B has to offer in terms of weight loss, access to psychological services or the method or you cannot afford option A or option B. By choosing this option (Option C) you are stating that you would prefer not to engage in any of the weight loss treatments presented here. There is no cost associated with this option C, however there is also no weight loss associated with this option and a high risk of fatal heart attack.

Now let me describe and explain the characteristics or attributes that describe each treatment option

1. **Amount of weight loss in 12 months**: This is the amount of weight that you would potentially loose over a 12 month period. The levels of weight loss are as follows;
2 stone/12.70kg
4 stone/25.40kg
6 stone/38.10kg

2. **Risk of fatal heart attack over a 10 year period (resulting in death)**

The risks presented in this survey are <u>not</u> individual specific health risks.

The heart attack risk refers to the risk of having a fatal heart attack which will result in your death over the next 10 years. In this survey the risk of fatal heart attack varies from 5% 10% 15% 20% 25%. A 5% risk of heart attack represents a lower risk of fatal heart attack than 25%. Option C states that you have a 30% risk of fatal heart attack; this option has the highest risk heart attack, because essentially you are not undertaking any weight loss treatment if you choose option C. By choosing option C in this survey, you have a 30% chance of getting a fatal heart attack. By choosing option A or B you are lowering this risk of fatal heart attack by undertaking a weight loss treatment.

3. **Method of weight loss**

<u>Diet & lifestyle modification</u>
This includes calorie control and increased physical activity up to 30 minutes per day. A diet rich in vegetables, fruits, fibre-rich whole grains, lean meats and poultry, fish and low in saturated and *trans* fats, cholesterol, sodium and added sugars. Modifying your daily routines can also affect your expenses, as different foods have different prices.

<u>Bariatric surgery (</u>Sleeve gastrectomy)
Sleeve gastrectomy is a surgical weight-loss procedure in which the stomach is reduced to about 25% of its original size, by surgical removal of a large portion of the stomach. The result is a sleeve or tube like structure. The procedure permanently reduces the size of the stomach, although there could be some dilatation of the stomach later on in life. The procedure is generally performed laparoscopically and is irreversible. As with all types of surgery- there are risks involved. Immediately after bariatric surgery, the patient is on a very restricted diet for a number of weeks.

Drug therapy plus diet & lifestyle modification

This is diet and lifestyle programme alongside a drug therapy. Orlistat (Xenical), which reduces intestinal fat absorption by inhibiting an enzyme called lipase in the pancreas. It is intended for use in conjunction with a healthcare provider-supervised reduced-calorie diet.

4. **Cost**

Each of the treatments will come with additional cost to you. This cost will be paid for by means of a monthly contribution to a health fund, regardless of whether or not you have a medical card of private health insurance. Therefore when answering the question please take into account how much you *can afford* to pay. If the options are too expensive then you can simply choose option D, which will not involve any obesity treatment and therefore cost you nothing. The cost to you ranges from €20, €30, €40, €50, €65, and €85 per month.

5. **Psychological services**

Each treatment option either will or will not provide access to psychological services, whereby you would have access to visit a psychologist once a month.

Before we begin here is an example of a choice card you will be facing in this questionnaire

In this choice card we are offering you three options of a weight loss treatment. Each option is described by its attributes and levels as per left hand side of the table. For example if you choose option A you would lose 2 stone weight, your heart attack risk would be reduced from 30% to 15%. It would cost you €50 per month. You would not have any access to Psychological services and the method in which you would lose the weight is via drug therapy alongside diet and lifestyle modification changes. If you choose option B you would loose6 stone weight, your heart attack risk would be reduced from 30% to 12%. It would cost you €20 per month. You would have any access to Psychological services and the method in which you would lose the weight is via diet and lifestyle modification changes. If you choose option C – this option represents a no weight loss treatment. It will cost you nothing, no access to psychological services and there will be no weight loss- you will have a 30% risk of fatal heart attack

Sample choice card

	Option A	Option B	Option C
Amount of weight loss in 12 months	2 stone /12.7kg	6 stone/ 38.10kg	0%
Risk of heart attack/stroke over a 10 year period	15%	12%	30%
Cost (per month)	€50	€20	€0
Psychological services	No	Yes	No
Method of Weight loss	Drug therapy plus diet & lifestyle modification	Diet & lifestyle modification	No weight loss programme
Please tick the one option you prefer **best**.	□	□	□

You will now be presented with a series of similar choice cards and on each choice card you will see three options like the sample card shown above. I would like you pick which option on each choice card that you would choose.

There are no wrong or right answers. We are just interested in your opinion.

Have you any questions relating to this task?

Choice Card 1

	Option A	**Option B**	**Option C**
Amount of weight loss in 12 months	4 stone	4 stone	0 stone
Risk of heart attack over a 10 year period	20%	15%	30%
Cost (per month)	€40	€50	€0
Psychological services	Yes	No	No
Method of weight loss	Diet & lifestyle modification	Bariatric surgery (Sleeve gastrectomy)	No weight loss programme
Please tick the one option you prefer **best**.	□	□	□

Choice Card 2

	Option A	**Option B**	**Option C**
Amount of weight loss in 12 months	2 stone	6 stone	0 stone
Risk of heart attack over a 10 year period	15%	15%	30%
Cost (per month)	€40	€50	€0
Psychological services	Yes	No	No
Method of weight loss	Diet & lifestyle modification	Bariatric surgery (Sleeve gastrectomy)	No weight loss programme
Please tick the one option you prefer **best**.	□	□	□

Choice Card 3

	Option A	**Option B**	**Option C**
Amount of weight loss in 12 months	6 stone	2 stone	0 stone
Risk of heart attack over a 10 year period	10%	15%	30%
Cost (per month)	€20	€85	€0
Psychological services	No	Yes	No
Method of weight loss	Drug therapy plus diet & lifestyle modification	Diet & lifestyle modification	No weight loss programme
Please tick the one option you prefer **best**.	□	□	□

Choice Card 4

	Option A	**Option B**	**Option C**
Amount of weight loss in 12 months	6 stone	2 stone	0 stone
Risk of heart attack over a 10 year period	25%	10%	30%
Cost (per month)	€65	€30	€0
Psychological services	Yes	No	No
Method of weight loss	Diet & lifestyle modification	Bariatric surgery (Sleeve gastrectomy)	No weight loss programme
Please tick the one option you prefer **best**.	□	□	□

Choice Card 5

	Option A	**Option B**	**Option C**
Amount of weight loss in 12 months	4 stone	4stone	0 stone
Risk of heart attack over a 10 year period	10%	20%	30%
Cost (per month)	€30	€65	€0
Psychological services	No	Yes	No
Method of weight loss	Diet & lifestyle modification	Bariatric surgery (Sleeve gastrectomy)	No weight loss programme
Please tick the one option you prefer **best**.	□	□	□

Choice Card 6

	Option A	**Option B**	**Option C**
Amount of weight loss in 12 months	2 stone	6 stone	0 stone
Risk of heart attack over a 10 year period	5%	20%	30%
Cost (per month)	€85	€20	€0
Psychological services	Yes	No	No
Method of weight loss	Drug therapy plus diet & lifestyle modification	Diet & lifestyle modification	No weight loss programme
Please tick the one option you prefer **best**.	□	□	□

Choice Card 7

	Option A	**Option B**	**Option C**
Amount of weight loss in 12 months	6 stone	2stone	0 stone
Risk of heart attack over a 10 year period	15%	10%	30%
Cost (per month)	€50	€40	€0
Psychological services	No	Yes	No
Method of weight loss	Bariatric surgery (Sleeve gastrectomy)	Drug therapy plus diet & lifestyle modification	No weight loss programme
Please tick the one option you prefer **best**.	□	□	□

Choice Card 8

	Option A	**Option B**	**Option C**
Amount of weight loss in 12 months	2 stone	6 stone	0 stone
Risk of heart attack over a 10 year period	25%	5%	30%
Cost (per month)	€30	€65	€0
Psychological services	Yes	No	No
Method of weight loss	Drug therapy plus diet & lifestyle modification	Diet & lifestyle modification	No weight loss programme
Please tick the one option you prefer **best**.	□	□	□

Choice Card 9

	Option A	**Option B**	**Option C**
Amount of weight loss in 12 months	4 stone	4 stone	0 stone
Risk of heart attack over a 10 year period	20%	10%	30%
Cost (per month)	€85	€20	€0
Psychological services	No	Yes	No
Method of weight loss	Drug therapy plus diet & lifestyle modification	Bariatric surgery (Sleeve gastrectomy)	No weight loss programme
Please tick the one option you prefer **best**.	□	□	□

Choice Card 10

	Option A	**Option B**	**Option C**
Amount of weight loss in 12 months	2 stone	6 stone	0 stone
Risk of heart attack over a 10 year period	15%	15%	30%
Cost (per month)	€20	€85	€0
Psychological services	Yes	No	No
Method of weight loss	Bariatric surgery (Sleeve gastrectomy)	Diet & lifestyle modification	No weight loss programme
Please tick the one option you prefer **best**.	□	□	□

Choice Card 11

	Option A	**Option B**	**Option C**
Amount of weight loss in 12 months	4 stone	4 stone	0 stone
Risk of heart attack over a 10 year period	10%	15%	30%
Cost (per month)	€65	€30	€0
Psychological services	No	Yes	No
Method of weight loss	Bariatric surgery (Sleeve gastrectomy)	Diet & lifestyle modification	No weight loss programme
Please tick the one option you prefer **best**.	□	□	□

Choice Card 12

	Option A	Option B	Option C
Amount of weight loss in 12 months	6 stone	2 stone	0 stone
Risk of heart attack over a 10 year period	5%	25%	30%
Cost (per month)	€40	€50	€0
Psychological services	No	Yes	No
Method of weight loss	Bariatric surgery (Sleeve gastrectomy)	Drug therapy plus diet & lifestyle modification	No weight loss programme
Please tick the one option you prefer **best**.	□	□	□

SECTION E: POST CHOICE CARD QUESTIONS

1. Did you ignore any attributes?

Yes [ ]
No [ ]

2. Can you please tick the box as to which attribute you ignored?

1 Amount of weight loss in 12 months	[ ]
2. Risk of fatal heart attack/stroke over a 10 year period	[ ]
3. Cost (per month)	[ ]
4. Access to psychological services	[ ]
5. Method of weight loss	[ ]

3. How confident were you when making your decisions?

Not very confident	[ ]
Somewhat confident	[ ]
Fairly confident	[ ]
Confident	[ ]
Very Confident	[ ]

4. When making your decisions did you consider all of the different attributes when making your choices?

Yes [ ]
No [ ]

5. What attributes are most important to you?(Rank 1st to last, for example, 1 2 3 4 5)

Amount of weight loss in 12 months	[ ]
Risk of fatal heart attack/stroke over a 10 year period	[ ]
Cost (per month)	[ ]
Access to psychological services	[ ]

Method of weight loss [ ]

6. What is your attitude towards bariatric surgery?

Would like to avoid it [ ]
Would like to undergo it [ ]
Not sure what I think of it – need more information [ ]
Would do it as a very last resort [ ]

7. **If you choose option C (no weight loss treatment) in the choice cards - why did you choose this option?**

Can't afford it [ ]
Can't afford it but would if I could afford it [ ]
I don't believe that I can achieve this [ ]
These improvements are not important to me [ ]
Other [ ]

8. What is the MAXIMUM amount of money that you would be willing to pay each month for 12 month duration for a reduction in your risk of developing diabetes? Please bear in mind that your contribution would reduce what you have left to spend on other things.

SECTION F: SOCIOECONOMIC CHARACTERISTICS OF PARTICIPANT

1. Gender

Male [ ]
Female [ ]

2. What is your date of birth?

____/____/_____/

Under 20 [ ]
21-30 [ ]
31-40 [ ]
41-50 [ ]
51-60 [ ]
61-64 [ ]
65+ [ ]

3. What is your relationship status?

Living with partner [ ]
Living with parents or parent [ ]
Married [ ]
Widowed [ ]
Divorced or separated [ ]
Single [ ]
Other [ ]

4. What is your highest level of education completed?

3rd level university or college or equivalent
[ ]
Intermediate between secondary level and university (e.g. technical training)
[ ]
Upper Secondary school (Leaving Certificate)
[ ]
Lower Secondary school (Junior Certificate)
[ ]

Lower Primary school only (or less)

[ ]

Other

[ ]

5. Which of the following best describes your employment status?

Unemployed [ ]

Employed full time [ ]

Employed Part time [ ]

Student Full time [ ]

Student part time [ ]

Retired [ ]

Disabled/ unable to work due to health reasons [ ]

Homemaker [ ]

6. What is your total income per year (whether from employment, pensions, state benefits, investments or any other source) before the deduction of tax? PLEASE DETAIL YOUR HOUSEHOLD INCOME.

Per week	**Per Year**	**Household**
Less than €150	Less than €7,800	
€150- €299	€7,800 - €15,599	
€300- €449	€15,600- €23 399	
€450 - €599	€23,400- €31, 199	
€600- €899	€31,200- €46,799	
€900- €1,199	€46,800- €62, 399	
€1,200- €1,499	€62,400- €77, 999	
€1,500- €2,249	€78,000- €116,999	
€2,250 and over	€117,000 and over	
No Answer		

7. Do you have Private Health Insurance?

Yes [ ]
No [ ]

8. Do you have a Medical Card?

Yes [ ]
No [ ]

SECTION G: HEALTH CARE UTILISATION OF RESPONDENT

1. **Have you had surgery in the past 12 months?**

Yes [ ]
No [ ]

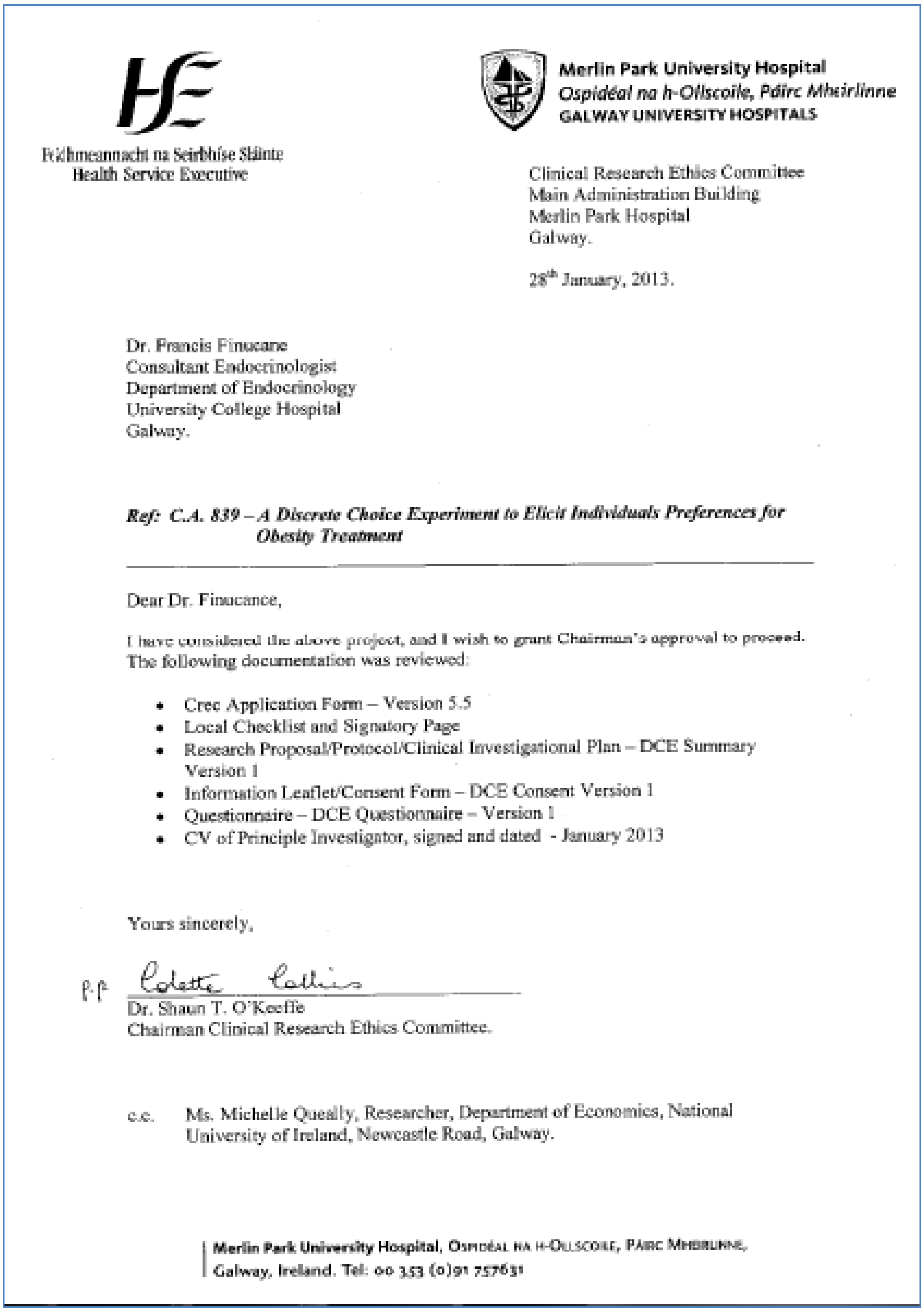
If so what type, please specify (e.g. heart, knee)

TYPE		FREQUENCY OF USE
COMMUNITY CARE	**Have you used this service in the past 12 months**	**If yes, approximately how <u>many visits</u> of <u>how often</u> did you use this service**
General Practitioner (GP)	□No □Yes → (Please tick)	
Practise Nurse	□ No □Yes → (Please tick)	
Public Health Nurse	□ No □Yes → (Please tick)	
Diabetes Services	□ No □Yes → (Please tick)	
Chiropody Services	□ No □Yes → (Please tick)	
Occupational	□ No □Yes →	

Therapist	(Please tick)	
Optician Services	□ No □Yes → (Please tick)	
Dietician Services	□ No □Yes → (Please tick)	
Counselling Services	□ No □Yes → (Please tick)	
Other	□ No □Yes → (Please identify)	
HOSPITAL CARE	**Have you used this service in the past 12 months**	**If yes, approximately how many visits of how often did you use this service**
Outpatient clinic	□ No □Yes → (Please identify)	
Diabetes Day Care Centre	□ No □Yes → (Please identify)	
Accident and Emergency	□ No □Yes → (Please identify)	
In patients Hospital Admissions	□ No □Yes → (If yes please specify how many day	

	admissions and how many night admissions)	

Appendix five : Ethics approval



Feidhmeannacht na Seirbhíse Sláinte
Health Service Executive

Merlin Park University Hospital
Ospidéal na h-Ollscoile, Páirc Mheirlinne
GALWAY UNIVERSITY HOSPITALS

Clinical Research Ethics Committee
Main Administration Building
Merlin Park Hospital
Galway.

28th January, 2013.

Dr. Francis Finucane
Consultant Endocrinologist
Department of Endocrinology
University College Hospital
Galway.

Ref: C.A. 839 – A Discrete Choice Experiment to Elicit Individuals Preferences for Obesity Treatment

Dear Dr. Finucance,

I have considered the above project, and I wish to grant Chairman's approval to proceed. The following documentation was reviewed:

- Crec Application Form – Version 5.5
- Local Checklist and Signatory Page
- Research Proposal/Protocol/Clinical Investigational Plan – DCE Summary Version 1
- Information Leaflet/Consent Form – DCE Consent Version 1
- Questionnaire – DCE Questionnaire – Version 1
- CV of Principle Investigator, signed and dated - January 2013

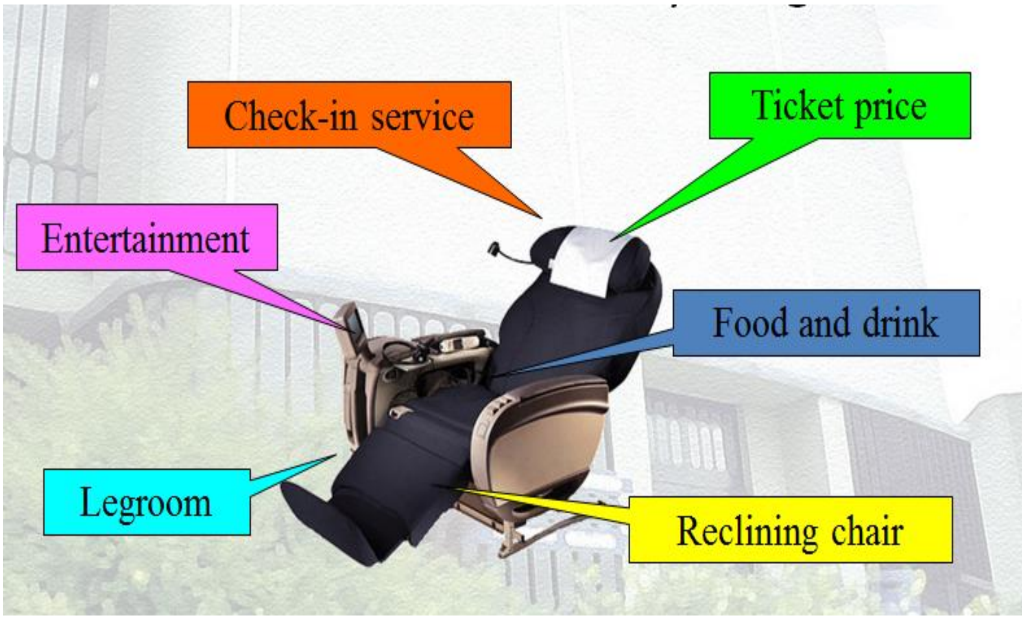
Yours sincerely,

p.p. Colette Collins
Dr. Shaun T. O'Keeffe
Chairman Clinical Research Ethics Committee.

c.c. Ms. Michelle Queally, Researcher, Department of Economics, National University of Ireland, Newcastle Road, Galway.

Merlin Park University Hospital, Ospidéal na h-Ollscoile, Páirc Mheirlinne, Galway, Ireland. Tel: 00 353 (0)91 757631

Appendix six: Focus group material



Appendix seven: Other considerations of the DCE at design and analysis stage

This appendix describes other aspects of a DCE that were considered to be important at the design and analysis stage of a DCE.

Considerations at design stage

Attribute coding

Studies that explore the coding of attributes in DCEs are less prevalent, particularly within the health literature. However, there are a few recent studies that discuss this aspect of DCE. For example, a study that examined effects coding (Hasan-Basri and Karim, 2013) stated that some DCE studies which have qualitative attributes are coded with effect coding (Kemperman et al., 2000) (Oh et al., 2007) and or dummy coding (Rolfe and Bennett, 2009). In the earlier health economic literature, attributes in DCEs with qualitative levels were reported as typically been handled by a number of dummy coded variables (Bech and Gyrd-Hansen, 2005).

In this study there is a categorical attribute 'method of weight loss' which is described using three levels; 'diet and lifestyle modification' (D&LM), 'drug therapy alongside D&LM' and 'bariatric surgery'. In this DCE, D&LM is the reference category. Initially this attribute was coded using dummy coding, which was then coded using effects coding. This section shows the estimated parameter values using the two forms of coding. Additionally effects coding calculation technique for WTP differs slightly to that of dummy coding. This section will provide an overview of this.

A characteristic of dummy coding is that the estimated β coefficient is correlated with the intercept β0, which, in this study is the 'status quo' coefficient. The status quo reflects respondents' current situation. Dummy coding can introduce an identification problem whereby the utility associated with the Lth level, [diet and lifestyle modification] of the attribute cannot be separated from other elements of utility incorporated in the intercept term [status quo]. Table 72 below shows the estimated parameter values across all of the attributes using the conditional logit (CL) model. As expected, Table 72 shows that the attribute which was effects coded produces slightly different coefficient values. This attribute 'method of weight loss' described as "drug therapy alongside D&LM" and "bariatric surgery" (diet and lifestyle as the reference category). The estimated parameter values for these two levels represent a change in utility relative to diet and lifestyle modification as an obesity treatment.

Table 71. Conditional logit results using effects and dummy coding

	Dummy Coding		**Effects Coding**	
Variable	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
Weight loss	0.12334***	0.02042	0.12335***	0.02042
Risk of fatal heart attack	-0.02626***	0.00554	-0.02623***	0.00554
Access to psychological services	0.29399***	0.05448	0.29383***	0.05448
Drug therapy alongside D&LM	0.08626	0.06746	-0.22732***	0.04126

Bariatric surgery	-0.85299***	0.07603	-0.54010***	0.04595
Cost	-0.00835***	0.00123	-0.00835***	0.00123
Status quo	-1.82177***	16282	-1.50907***	16446
Log likelihood function	-1525.28364		-1525.22213	
	Normalized	Unnormalized	Normalized	Unnormalized
AIC	1.62663	3064.56728	1.62656	3064.44425
Bayes IC	1.64722	3103.35534	1.62659	3064.50395
Note: ***, **, * ==> Significance at 1%, 5%, 10% level				

Calculating WTP for effects coded attributes

The WTP calculations for both effects and dummy coded attributes are presented in Table 73. Prior to showing WTP calculations for effects coded attributes, below outlines WTP calculations for dummy coded attributes based on the output from Table 72;

Dummy coding:

Drug therapy alongside D&LM: 0.08626

Bariatric surgery: -0.85299

Baseline level: 0

Marginal WTP, a change from the baseline level (D&LM) to:

Drug therapy alongside D&LM (0.08626) / (-0.00835) = €10.33

Bariatric surgery: (-0.85299)/ (-0.00835) = €102.15

Status quo (SQ) -1.82185/ (-0.00835) = €218.16

WTP for effects coded calculations

Drugs; Level 1: 0.22732

Surgery ‘Level 2: -0.54010

Therefore, baseline level = (0.22732+ (-0.54010))* -1 = 0.31278

For WTP, recall that WTP is the value someone is willing to pay for a marginal change in the attribute.

The marginal change between level 1 and the baseline is 0.22732– (0.31278) = -0.08546

The marginal change between level 2 and the baseline is -0.54010– (0.31278) = -0.85288

The marginal change between SQ and the baseline is -1.50907– (0.31278) = -1.82185

Then for cost coefficient of -0.00835, the marginal WTP for a move from the baseline level to:

Drug therapy alongside D&LM: -0.08546/ (-0.00835)= €10.23

Bariatric surgery: -0.85288/ (-0.00835) = €102.14

Status quo: -1.82185/ (-0.00835) = €218.18

Table 72. WTP calculations

Attribute	WTP Dummy Coding	WTP Effects Coding
Amount of weight loss	€14.77***	€14.77
Risk of fatal heart attack	€-3.14***	-€3.14
Access to psychological services	€35.20***	€35.19
Drug therapy	€-10.33	€10.23
Bariatric surgery	€-102.15***	-€102.14
Status quo	€-218.17***	-€218.17

Considerations at data collection stage

As with all primary data collection, there is a risk of introducing bias, some of which include non-response bias, interviewer bias, and information bias.

Non response **bias**

Non response bias can occur when individuals who respond to a survey systematically differ from non-respondents (Champ et al., 2003) for example, individuals with particularly strong feelings toward the good in question may be more willing to commit time to the questionnaire. Nonresponse bias is almost impossible to eliminate completely, but there are a few ways to ensure that it is avoided as much as possible. Non-response bias can be prevented by achieving high response rates (≥80% by convention) . We therefore aimed for high response rates. The researcher invited the target population to participate after delievering a brief presentation of the research in a group setting. Potential participants were approached while in a group attending a lecture on healthy eating, which was held at the local community building. It was thought that this [group behaviour and motivation] might help increase response rates as oppose to approaching indivudals seperatly.

In order to reduce non response bias there are also some tasks that can be completed prior to data collection that will facilitate the attempts to reduce nonresponse bias throughout the survey process (Krenzke et al., 2005). For this study nonresponse patterns from similar DCE surveys were studied. This gave insights into why people decided not to participate in their study, which may lead to identifying outcome-related reasons for nonresponse. For example a language barrier was sometimes a reason for non-participation. Subsequently a full understanding and written knowledge of the English language was an inclusion criterion for this study. Although that said, even with this inclusion criterion a number of completed DCE surveys were excluded from analysis in this study due to language barrier; see Chapter four for further details. An English language assessment prior to participation may have been a good idea here; however because of the small sample size and the majority of participants been Irish it was not felt worthwhile- but this could prove useful in a larger study. In a further attempt to reduce non response bias in this survey the researcher pre-tested the survey to ensure it ran smoothly and that all questions were understood. The survey format and medium followed what was the preferred means for the target group- as per focus group findings. Finally confidentially was ensured throughout the survey which can reduce the non-response bias (Krenzke et al., 2005).

Interviewer bias

There are three major sources of such bias: the interviewer (who may, for example, have prejudices or ask leading questions); the respondent (who may wish to lie or evade questions); and the actual interview situation itself (especially the physical and social setting). In order to minimise bias, the researcher only read out introductory and explanatory sections of the DCE and did not ask any of the questions. We also ensured, where possible, that all studies were conducted in the same physical setting (CROI community building), apart from five studies which due to participants inability to attend were conducted elsewhere. These studies were checked for any evidence of bias and subsequently did not show any.

One of the issues that arose in the pre-pilot studies was the view held by respondents that the interviewer formed part of the team delivering the lifestyle program and respondents were thus reluctant or afraid to provide full information in case that it affected their right to continue participating in the Intervention. In order to overcome this, a short passage was read out at the start of each survey to clearly outline that this was part of an independent research project and that the survey information was kept in the strictest of confidence.

Information bias

All stated preference methods rely on surveys in order to elicit valuations. As such, responses to valuation questions are likely to be influenced by what information is presented (Bergstrom et al., 1990, Whitehead and Blomquist, 1991). In order to reduce information bias the questionnaire favoured closed, precise questions and avoid open-ended questions. We also ensured that the surveys were piloted in order to improve and refine the study. The researcher used standardised interviewers' techniques through (informal) training (with the questionnaire) to explain the survey in the same way to each respondent. The DCE was explained by reading a standard information box which was on the questionnaire. This ensured the DCE was explained to each respondent in the same way with the same information presented. Given the small sample size and the fact that the same person conducted the interviews for all of the surveys, interviewer bias was possibly at a minimum relative to other larger studies of this kind.

Considerations at data analysis stage

Missing data

In this DCE all of the choice cards were completed by respondents therefore the non-completion of choice cards was not an issue in this survey. However in the socioeconomic section of the questionnaire, there was missing data regarding the income of respondents. For household income, approximately 8% of respondents refused to answer. The data was modelled to include and exclude these respondents, which made no real difference to the estimated coefficients.

Treatment of potential protest responses

A common problem in stated preference studies is that some respondents might cast their responses to signal disapproval of the question rather than giving the response that best reflect their preferences. Or, for example respondents might choose the ‘status-quo’ option not as a reflection of their true preference to remain at status quo, rather as an easier option. In this study a total of seven respondents chose the opt-out option. Table 74 below shows the output from the conditional logit including and excluding these seven respondents. Table 75 also shows the WTP calculations including and excluding these seven respondents. As can be seen there is very little difference across the models by excluding or including these respondents.

Table 73. Comparison of results of those who choose the status quo option (CL model)

	Including all respondents Conditional logit	Including those who opted for SQ respondents Conditional logit
Variable	**Coefficient** **(Std. error)**	**Coefficient** **(Std. error)**
Weight loss	.12335*** 0.02042	.13024*** (.02101)
Risk heart	-0.02623*** .00554	-.02852*** (.00574)
Psyc services	.29383*** .05448	.32377*** (.05577)
Drug therapy	.22732*** .04126	.18276*** (.04299)
Surgery	-.54010*** .04595	-.52682*** (.04667)
Cost	-.00835*** .00123	-.00780*** (.00125)

Constant[SQ]	-1.50907***		-1.70790*** . (18012)	
LL	-1525.22213		-1400.18878	
	Normalized	UnNormalized	Normalized	Unnormalized
AIC	1.62656	3064.44425	1.25409	2362.71281
Bayes IC	1.62659	3064.50395	1.28939	2429.20664

Table 74. Comparison of WTP estimates of those who choose the status quo option

	WTP CL All respondents	**WTP CL Excluding Status quo respondents**
Weight loss	14.7723***	16.7046***
Risk of fatal heart attack	-3.14168***	-3.65794***
Access to psyc services	35.1883***	41.5282***
Drug therapy	27.2233***	23.4418***
Bariatric surgery	-64.6813***	-67.5714***

Follow up questions

After the completion of the choice task, questions aimed at retrieving information on the respondents' reasons for answering the choice sets in the way that they did were presented. This was done, as shown in the figures below by including a ranking exercise in which the respondent was asked to rank the attributes by their importance on a Likert scale. Although this ranking exercise does not provide information about the respondents willingness to trade one attribute off for another (i.e. the results cannot be interpreted as cardinal utilities); it does inform the researcher as to whether or not the relative weighting of the attributes in the DCE is plausible. Below shows the findings of the Likert scale used in the DCE, in which "1" infers that the respondent thought that the particular attribute in question was the most important to them and "5" meaning that they felt it was the least important to them.

Figure 23. Ranking of the attribute ‘method of weight loss’

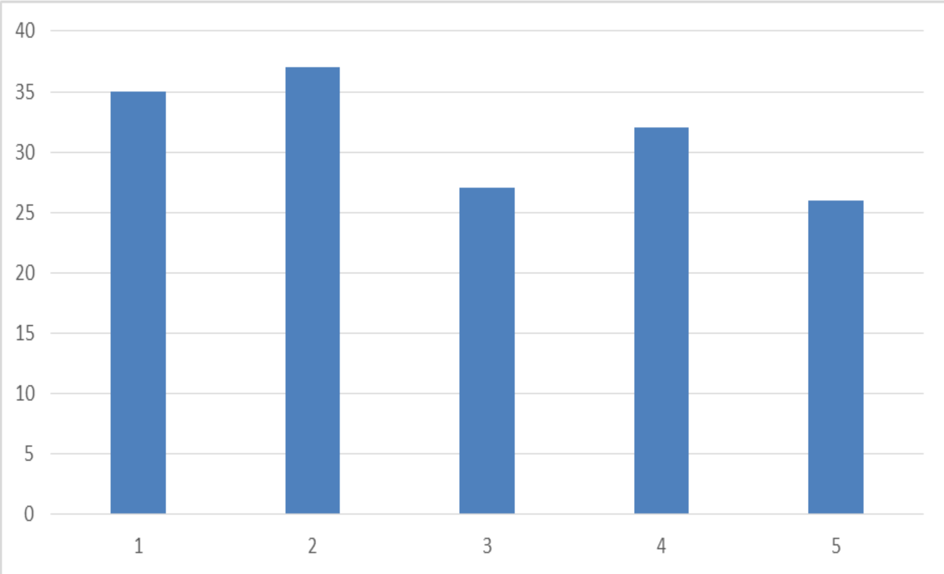


Figure 24. Ranking of the attribute ‘risk of fatal heart attack’

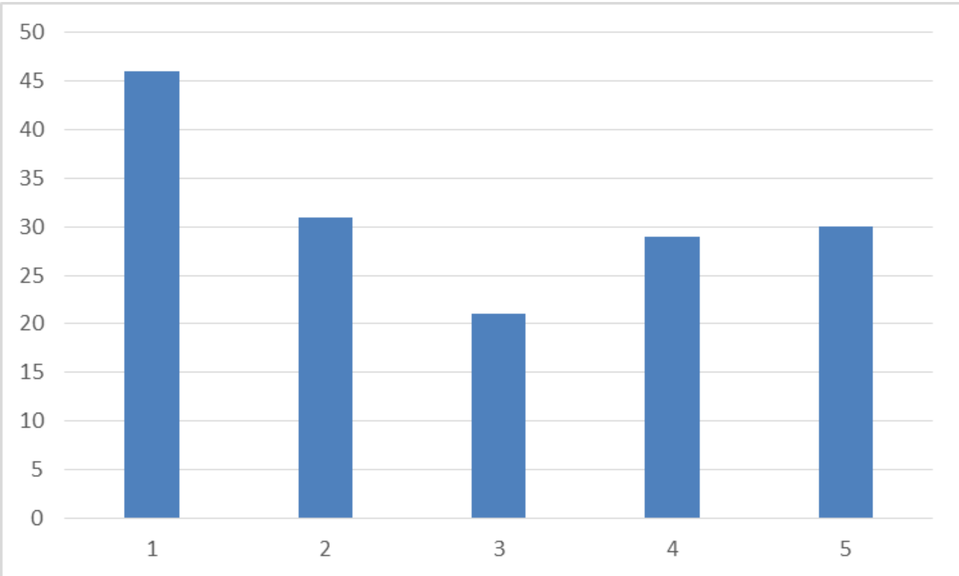


Figure 25. Ranking of the attribute ‘access to psychological services’

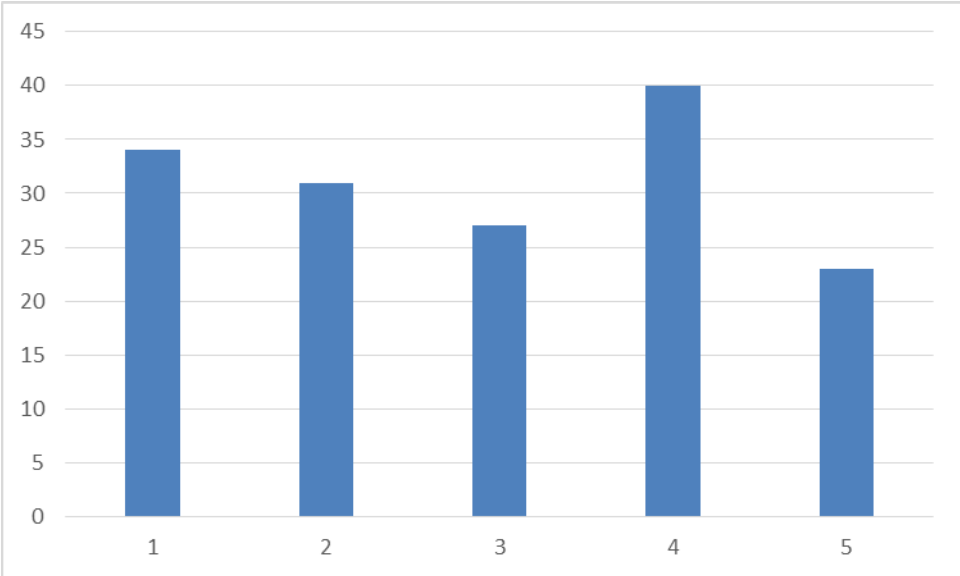


Figure 26. Ranking of the attribute ‘method of weight loss’

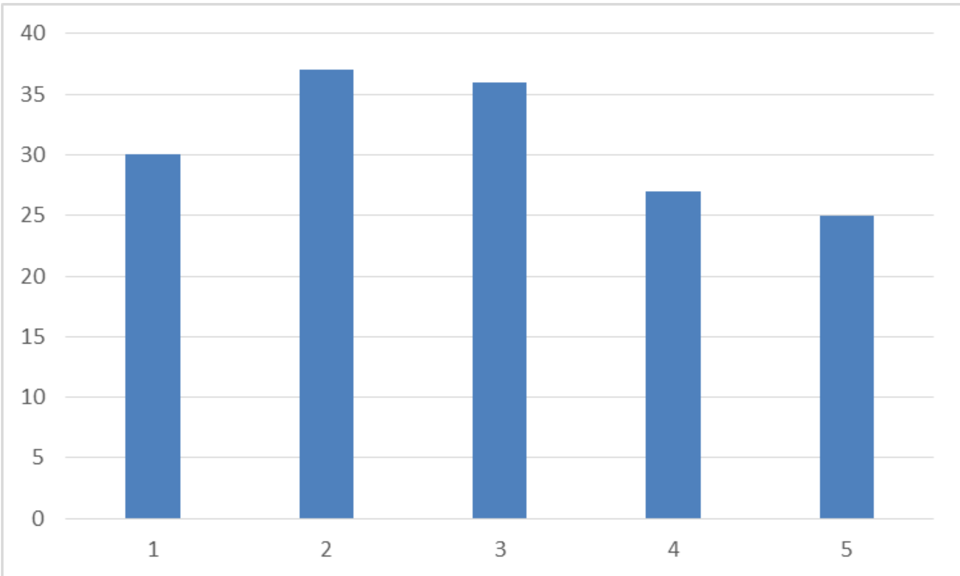


Figure 27. Ranking of the attribute 'cost'