Short- and Long-Term Effects of Gestational Diabetes Mellitus on the Health Care Cost: Cross-Sectional Comparative Study in the ATLANTIC DIP Cohort

Running head: GDM and health care cost

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Novelty statement

- This paper presents estimates of the impact of Gestational Diabetes Mellitus (GDM) on costs of care in the longer term post pregnancy.
- This paper applies recent IADPSG (International Association of Diabetes and Pregnancy Study Groups) criteria for GDM diagnosis to assess its effect on the maternity care and health care cost post pregnancy.

Abstract

Aims

This paper examines the association between Gestational Diabetes Mellitus (GDM) and costs of care during pregnancy and 2-5 years post pregnancy.

Methods

Health care utilization during pregnancy was measured for a sample of 658 women drawn from the Atlantic Diabetes in Pregnancy (ATLANTIC DIP) network. Health care utilization 2-5 years post pregnancy was assessed for a sub-sample of 348 women via a postal questionnaire. A vector of unit costs was applied to healthcare activity to calculate the costs of care at both time points. Differences in cost for women with GDM compared to those with normal glucose tolerance (NGT) during the pregnancy were examined using univariate and multivariate regression analyses.

Results

GDM was independently associated with an additional €817.60 during pregnancy (€1,192.1 in the GDM group, €511.6 in the NGT group), in the form of additional delivery and neonatal care costs, and an additional €680.50 in annual health care costs 2-5 years after the index pregnancy (€6,252.4 in the GDM group, €5,434.8 in the NGT group).

Conclusions

These results suggest that GDM is associated with increased costs of care during and post pregnancy. They provide indication of the associated cost that can be avoided or reduced by the screening, prevention, and management of GDM in pregnancy. These estimates are useful for further studies which examine the cost and cost effectiveness of such programs.

Introduction

Gestational diabetes mellitus (GDM) is defined as any degree of glucose intolerance with onset or first recognition during pregnancy (1). While international prevalence estimates vary considerably due to differences in definitions and diagnostic test criteria, as well as variations across regions and ethnic groups (2), it is widely accepted that the prevalence of GDM is rising worldwide (1, 3). In Ireland, based on the International Association of Diabetes and Pregnancy Study Groups (IADPSG) diagnostic criteria, GDM is estimated to affect 12.4% of pregnancies (4). The projected rise in prevalence will serve to increase pressures on already resource constrained health systems as the costs of caring for GDM pregnancies are substantial (5-7).

GDM has significant resource use implications during pregnancy and in neonatal period as it is associated with an increased risk of adverse maternal and neonatal pregnancy outcomes (4, 8). A recent Irish study estimated that GDM, diagnosed using World Health Organisation (WHO) 1999 criteria, was associated with a 34% increase in the cost of maternity care (5). In addition, GDM is known to have longer term effects beyond pregnancy. For example, GDM during pregnancy increases the women's future risk of developing type 2 diabetes mellitus by 7.5 times (9, 10). Additionally, there is evidence that children born to GDM mothers are at increased risk of obesity/central adiposity (10-12) and developing glucose intolerance (13). Little is known however about the longer term health care resource utilisation and cost implications of GDM beyond the neonatal period for both women and their children.

The concerns described above have led to an interest in the economic, as well as the health, implications of GDM. This paper adds to the growing economic evidence base by examining the effect of GDM on cost of maternity care and annual health care cost for women in longer term, i.e. two to five years post pregnancy. In contrast to the previous Irish study (5), we use the newer criteria for GDM diagnosis by International Association of Diabetes and Pregnancy

Study Groups (IADPSG), which are currently applied in Ireland (14). The study is based on the combined data from the medical records and a follow up survey for a sample of women, drawn from the Atlantic Diabetes in Pregnancy (ATLANTIC DIP) network. We compare resource utilization and costs of care for women with GDM and those with normal glucose tolerance (NGT) during the index pregnancy, and apply multivariate regression to examine the effect of GDM on costs of care, while controlling for a range of other potentially important cost drivers. Ethical approval for the study was provided by the ethics committees at the participating hospital centres.

Methods

The study is based on the data collected within the framework of the ATLANTIC-DIP collaborative which has been described previously (4). In brief, the ATLANTIC-DIP collaborative is a network of antenatal centres along the Irish Atlantic seaboard serving a population of approximately 500,000 people. This regional area can be considered as broadly representative of the whole population of Ireland (15). Pregnant women who participated in ATLANTIC-DIP form January 2007 to December 2010 were offered a screening at 24–28 weeks' gestation using a 75-g oral glucose tolerance test (OGTT) with fasting, 1-hour, and 2-hour values. Henceforth, we refer to the pregnancy in this period as an *index pregnancy*. In 2012, 658 women participated in a follow up screening programme; at which point women were between 2 and 5 years post the index pregnancy. Of these, 270 had GDM in the index pregnancy and 388 women with NGT in the index pregnancy. The follow up cohort formed the basis for the economic analysis presented in the current study.

Maternity care utilization and respective costs were estimated for the full sample of 658 women based on the medical records. The postal questionnaire was administered to all women at follow up and contained a range of questions relating to healthcare service usage in the previous year, health related quality of life, and socioeconomic characteristics. In total, 348 or 52.9% of women responded to the questionnaire: 235 of these women had NGT and 113 had GDM in the index pregnancy. Non-responders (n=310) were on average one year younger than the responders, but also more often were obese, primiparous, possessed medical card, and came from the study site A. These differences, though significant, were not of a great magnitude. The results of the comparison between responders and non-responders are available from the authors on request.

Costs of care during pregnancy focused on maternity care utilization and comprised of two main elements: childbirth and neonatal care. Resource use data were obtained from the ATLANTIC DIP database. The records contained the mode of delivery (spontaneous vaginal, assisted vaginal, elective caesarean section, or emergency caesarean section), and admissions to a neonatal intensive care unit. A vector of unit costs, estimated from the Irish Casemix dataset (16) and presented in 2012 € prices, was applied to value individual resource activity and calculate the total maternity care cost during pregnancy (see Table A1 in Appendix A).

Costs of care post pregnancy focused on utilization of health care services over a period of one year (2-5 years after the index pregnancy). The detailed list of the health care service and pharmaceuticals was informed by the clinical expertise in the study team. As above, a vector of unit costs was applied to value individual resource activity and to calculate the total annual cost of health care post pregnancy (see Table A1 in Appendix A). The unit cost estimates were calculated based on the methodological guidance for the conduct of health technology assessment in Ireland (17), applying the HSE salary scales (18), the Monthly Index of Medical Specialities (19), and the Irish Casemix Programme (16).

A series of univariate analyses were undertaken to examine whether the GDM and NGT cohorts differed with respect to the characteristics, resource use and costs of care. This consisted of independent two-sided t-tests for continuous variables, χ^2 tests for binary variables, Kendall's τ(tau)-b correlation (consistent with the results of Mann-Whitney test) for the ordinal variables. For the nominal variables, formal Cramer's V criterion was applied, though in this case we rely upon qualitative differences.

Univariate testing was applied to compare the total costs of care for GDM and NGT groups: (i) cost of maternity care; and (ii) annual cost of health care utilisation 2-5 years post pregnancy. Both parametric (two-sided t-test) and non-parametric (Mann-Whitney) were applied due to skewed nature of the cost data. For the health care cost post pregnancy, a similar analysis was conducted to examine the impact on their components: (a) those obviously related to diabetes care, i.e. diabetes nurse specialist, dietician, diabetes day centre, insulin, diabetes medicines, and blood sugar tests; and (b) those not directly related to diabetes care, i.e. primary care specialist services, hospital services, outpatient services, and pharmaceuticals usage. It should be noted, however, that the latter group might still include care utilization related to glucose tolerance, but we have no means of distinguishing it from the other use. Finally, the detailed comparisons in each individual resource item utilization and cost between the GDM and NGT groups are presented in Appendix B with the explanation of statistical testing applied.

For the multivariate analyses of the total cost variables, separate generalized linear models (GLM) assuming a Gamma family distribution and a log link were applied. This method has been shown to be appropriate for the analysis of cost data which are skewed (20). In both cases, the objective of the analysis was to estimate the effect of a GDM IADPSG diagnosis on the total cost of care. To estimate the effect of the GDM in each case, linear predictions

from a pooled regression model, using the method of recycled predictions (21) was employed, holding other covariates and factors at the whole sample average levels.

The regression models were estimated controlling for a range of other clinical and socioeconomic characteristics which may be potentially important cost drivers. In particular, body mass index (BMI), age, primiparity, delivery week, previous miscarriage, income and medical card status were included in the maternity care cost models. For modelling the annual health care cost post pregnancy, a broader set of covariates was selected. In addition to those already described, indicator variables for subsequent miscarriages, lifestyle characteristics, specifically relating to alcohol consumption, tobacco use, and regular exercise (at least 30 min a day), and medical card status (entitlement to free GP care) were included.

Steps were also taken to address two potential sources of imbalance in the regression models: that relating to differing patterns to servce use and costs across the four hospital sites (A, B, C, and D), and that relating to the difference in the time between delivery and follow up which ranged from between 2 and 5 years. We explicitly address these issues by introducing indicators for the study site and time after delivery. Finally, as GDM status is related to the other clinical and socioeconomic characteristics included in the full multivariate regression models (2, 22), the independent effect of GDM might be a biased predictive estimate at the population or group level, though it is a good estimate for an individual level prediction. Therefore, we also present separately the results for a reduced model specification, estimating the GDM effect, controlling for the effect of the study site and time after delivery. Statistical significance was explored at three levels (0.05, 0.01, and 0.001).

Results

Summary statistics for the characteristics of both the original sample and the follow up sample, and the differences between the GDM and the NGT groups, are presented in Table 1. At both time points, women with GDM were more likely to have had a higher BMI. Women with GDM were also more likely to have an earlier delivery. There are certain imbalances in the selection from the study sites at both time points. This is more prominent in the follow up sample. Women with GDM were more likely to be past smokers, but had similar current smoking rates. Additionally, women with NGT were more likely to have entered the follow up study in the 4^{th} and 5^{th} year post delivery, with very few in the 2^{nd} or 3^{rd} year.

The results from the univariate cost analyses are presented in Table 2. A more detailed analysis of the differences in individual resource use and costs are presented in Appendix B. The results indicate that both the total cost of maternity care and the total annual cost of health care post pregnancy were substantially and significantly higher for the GDM group compared to the NGT group. GDM was associated with an excess of €1,549.56 per patient in costs of care during pregnancy and €411.31 per patient in annual health care costs post pregnancy.

In the case of the maternity costs, the differential between the GDM and NGT groups was caused by the higher likelihood for the GDM group of elective caesarean section (relative risk 1.83), emergency caesarean section (relative risk 1.69), and neonatal unit admissions (relative risk 1.61). In the case of post pregnancy costs, the differential in annual health care cost was a combined effect across multiple resource elements. Notably, €256.58 of this difference was attributed to the increased cost of hospital and emergency services and €63.83 to outpatient day centre visits (see Appendix B). Expenses directly related to diabetes care constituted €51.51 in the difference between the NGT and GDM groups. In particular, women with GDM were more likely to attend a diabetes specialist nurse, dietician, visit a diabetes day centre, use insulin and other glucose lowering agents, and blood glucose testing. Women with

GDM were less likely to use primary care, physiotherapy and optician services, but were more likely use psychologist services. Finally, the difference in the total cost of pharmaceuticals was not significant.

The results of the multivariate regression analyses for the total cost of maternity care analysis are presented in Table 3. Based on the full regression model, a GDM pregnancy was associated with an increase in maternity care costs of €817.60 relative to a NGT pregnancy. In the reduced model specification, this difference increases to €1,490.10. In addition to GDM, increased BMI at booking visit, primiparity, and premature delivery were associated with significantly higher maternity care costs. It is also notable that for hospital site B, the cost of maternity care was significantly higher than in other sites.

The results of the multivariate regression analysis of total annual cost of health care post pregnancy are presented in Table 4. A GDM case was associated with an increase in health care costs of €680.50 relative to a NGT case. This increased marginally to €708.70 in the reduced model specification. Notably, the use of alcohol and exercising 30 min a day were associated with reduced health care costs. Interestingly, we found no significant association between costs of care and BMI, smoking status, medical card status, age or subsequent miscarriage. The study site imbalance was also present in the longer term analysis, with hospital site D associated with significantly lower costs of care.

Discussion

This study investigated the effect GDM, diagnosed using the IADPSG criteria, on the cost of maternity care and the annual cost of health care 2-5 years post pregnancy. To do so, we compared costs of care estimates for a sample of women with GDM during pregnancy to a

sample of women with NGT during pregnancy. Our results indicate that GDM was associated with significantly higher total costs of care: with a €817.60 increase in maternity care costs during pregnancy and a €680.50 increase in annual health care costs 2-5 years post pregnancy. These should be considered as independent effects, applicable for the individual level predictions. At a group level, one should also account for differences in the background characteristic inherent to women with GDM.

In the maternity care cost analysis, the cost increase attributable to GDM was associated with more frequent elective and emergency caesarean sections rates, and a greater need for neonatal unit admissions. The longer term care cost increases were attributed primarily to increased hospital, accident and emergency, and outpatient service use that are not directly related to diabetes care. At follow up, women with GDM also consumed more diabetes related services including diabetes specialist nurse, dietician and diabetes day centre visits, insulin, glucose lowering agents, and blood glucose testing. This was to be expected given that GDM is associated with an increased future risk of impaired glucose tolerance and type 2 diabetes (9, 10).

Gillespie et al (5) found that GDM, diagnosed using WHO 1999 criteria, was associated with a 34% increase in the maternity care cost per case in Ireland. Our equivalent estimate, based on IADPSG criteria, is a 14% increase in the cost per case. This substantially lower estimate reflects the broader IADPSG criteria which, while increasing the overall prevalence, have also widened the GDM cohort to include less risky and less resource intensive cases. This notwithstanding, we further highlight the economic burden that GDM poses on maternity care services. Moreover, our paper highlights, for the first time, the significant effects on GDM for health care resource use and costs beyond the pregnancy. These results give an indication of cost savings, both in the short and long term, which may arise from

interventions that go to prevent the onset of GDM in pregnancy or its consequences post pregnancy.

There is a possibility that the diagnosis of GDM may "medicalise" a pregnancy, leading to higher resource usage and associated costs (23). The benefits of identifying GDM and providing appropriate treatment must be weighed against the increased costs of doing so, especially in women with less severe indications for intervention. In our study, given the observed structure of the excess care utilization among women with GDM it is unlikely that the cost increase is due to unnecessary medicalisation.

The analysis in this paper is subject to several limitations. While the study sample is generally representative of the population at large in the region, it is important to note that those who refused or did not attend for an OGTT during pregnancy were excluded from the follow up analysis. Notably, these women were statistically different those who attended (slightly younger, more likely to be obese, or hold medical card). It is likely, therefore, that the women with worse health status were not included in the follow up analysis. The GDM group made up 33% of the total study sample, compared to national prevalence of 12.4% of all pregnancies (4). The overrepresentation of GDM cases was a feature of the study design; however, it may create an imbalance and reduce the reliability of the obtained pooled regression effects estimates at the population level. Furthermore, while the cost estimates presented are specific to the Irish setting, the patterns of service use and costs, as they are related to need, are likely to hold for other countries where GDM is diagnosed and managed in the same manner.

There is a greater level of uncertainty around the estimate of the cost increase in the long term. Firstly, data on resource use at follow up was reported by patients via the postal questionnaire and is thereby open the possibility of recall bias. Other questions relating to lifestyle might yield biased answers due to social desirability bias. However, we do not

expect these biases to be systematic or related to the GDM status. It is also observed that health care costs were systematically lower in one of the study sites. Moreover, we observed a possible sampling bias in that women with NGT came into the study later after pregnancy than women with GDM. However, we controlled for these effects in all the versions of the models. On that basis, the presence of the significant difference appears reliable, although this should be confirmed in better matched groups with larger sample sizes.

In conclusion, this study estimates that GDM, diagnosed using the IADPSG criteria, is associated with increased cost of maternity care and 2-5 years post pregnancy. The analysis provides information that will be useful to future research which seeks to examine questions of costs and cost effectiveness in relation to GDM prevention, screening or treatment. It gives a clear indication of the cost associated with the diagnosis of GDM. Furthermore, the study contributes to the international literature in this area by providing data on these as they arise in an Irish setting.

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Conflict of interest

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Table 1 Descriptive statistics of the study sample as measured at the index pregnancy

		At the index pregnancy (n=658)				2-5 years after the index pregnancy (n=348)			
		NGT (n=388)	GDM (n=270)	Difference testing		NGT (n=235)	GDM (n=113)	Difference testing	
		N (%)	N (%)	stat.	P	N (%)	N (%)	stat.	P
Age, years	mean (st.err.)	34.2 (0.26)	34.0 (0.30)	t-t -0.19	0.628	39.1 (0.30)	38.1 (0.43)	t-t -0.98	0.066
Income level, €	<20,000	54 (16.2%)	41 (19.0%)	τ-b -0.02	0.592	30 (14.6%)	16 (17.2%)	τ-b 0.03	0.554
	20,000-29,999	71 (21.3%)	46 (21.3%)			45 (22.0%)	17 (18.3%)		
	30,000-39,999	59 (17.7%)	40 (18.5%)			36 (17.6%)	15 (16.1%)		
	40,000-49,000	72 (21.6%)	34 (15.7%)			47 (22.9%)	16 (17.2%)		
	50,000+	78 (23.4%)	55 (25.5%)			47 (22.9%)	29 (31.2%)		
Body mass index	Norm./under.	118 (36.1%)	41 (16.9%)	τ-b **0.30**	**0.000**	120 (51.1%)	35 (31.3%)	τ-b **0.21**	**0.000**
	Overweight	131 (40.1%)	65 (26.9%)			83 (35.3%)	43 (38.4%)		
	Obese	78 (23.9%)	136 (56.2%)			32 (13.6%)	34 (30.4%)		
Miscarriages		114 (29.4%)	81 (30.0%)	RR 1.02	0.864	20 (9.1%)	13 (11.6%)	RR 1.28	0.469
Primiparous	yes	139 (36.4%)	106 (39.3%)	RR 1.08	0.455				
Delivery term	<36 weeks	14 (3.7%)	20 (7.4%)	τ-b **-0.18**	**0.000**				
	36-38 weeks	68 (17.8%)	83 (30.7%)						
	≥39 weeks	299 (78.5%)	167 (61.9%)						
Time after delivery	year 2					5 (2.1%)	32 (28.3%)	τ-b **-0.35**	**0.000**
	year 3					21 (8.9%)	23 (20.4%)		
	year 4					104 (44.3%)	34 (30.1%)		
	year 5					105 (44.7%)	24 (21.2%)		
Alcohol	yes					154 (65.5%)	61 (56.0%)	RR 0.85	0.105
Smoking status	past					70 (29.8%)	44 (38.9%)	V 0.09	*n.a.*
	current					30 (12.8%)	14 (12.4%)		
	never					135 (57.4%)	55 (48.7%)		
Exercise 30 min a day						201 (85.5%)	103 (91.2%)	RR 1.07	0.110
Medical card	yes					85 (36.5%)	43 (38.1%)	RR 1.04	0.776
Study site	site A	236 (60.8%)	135 (50.0%)	V 0.17	*n.a.*	133 (56.6%)	41 (36.3%)	V 0.09	*n.a.*
	site B	58 (14.9%)	27 (10.0%)			40 (17.0%)	9 (8.0%)		
	site C	59 (15.2%)	68 (25.2%)			38 (16.2%)	33 (29.2%)		
	site D	35 (9.0%)	40 (14.8%)			24 (10.2%)	30 (26.5%)		

n.a. not applicable; GDM – gestational diabetes mellitus; NGT – normal glucose tolerance;
t-t – t-test; τ-b – tau-b; RR – relative risk; V – Cramer's V

Table 2 Mean annual health care cost and differences in cost in GDM and NGT groups

		Group mean annual cost, €				Test of difference	
		Pooled	**NGT**	**GDM**	**Difference**	**t-test**	**M-W**
Total maternal cost	mean	5,802.35	5,153.08	6,702.64	1,549.56	**0.000**	**0.000**
	(st.err.)	(160.88)	(192.38)	(267.04)	(320.53)		
	N	642	373	269			
Total cost 2 to 5 years after delivery	mean	764.78	632.67	1 043.98	411.31	**0.037**	**0.006**
	(st.err.)	(92.10)	(105.63)	(177.48)	(196.14)		
	N	302	205	97			
Diabetes related services and pharmaceuticals	mean	40.67	24.12	75.63	51.51	**0.043**	**0.000**
	(st.err.)	(11.11)	(12.52)	(21.95)	(23.64)		
Costs not related to diabetes care directly:							
Primary care services	mean	170.16	164.13	182.91	18.79	0.420	0.106
	(st.err.)	(10.86)	(13.59)	(17.87)	(23.27)		
Medical specialists' services	mean	36.53	32.36	45.34	12.98	0.507	**0.015**
	(st.err.)	(6.73)	(4.13)	(19.08)	(14.41)		
Outpatient day center	mean	94.02	73.52	137.35	63.83	**0.048**	**0.025**
	(st.err.)	(12.36)	(11.20)	(29.98)	(26.25)		
Hospital services (A&E, day case and night stay)	mean	402.89	320.48	577.06	256.58	0.131	**0.056**
	(st.err.)	(79.25)	(92.62)	(149.38)	(169.35)		
Non-diabetic medicines	mean	20.51	18.06	25.69	7.63	0.461	0.555
	(st.err.)	(4.82)	(5.80)	(8.67)	(10.33)		

* In this table only the full cases are reported, i.e. those who have all cost elements non-missing. This is made for the compatibility of the individual elements of the total cost. The total of the means of individual elements is equal to the mean total cost in this case. The summary statistics and the difference of means tests for the full sub-groups yields similar results.

Table 3 Results of the regression analysis of the maternal cost (generalized linear regression, log link, Gamma distribution family)

Maternal cost – dependent variable		Full model		Reduced model	
		Coef.	(St.Err.)	Coef.	(St.Err.)
GDM	Yes (positive)	0.140	(0.07)*	0.253	(0.06)***
Income, €	<20,000	*ref.*		-	
	20,000-29,999	-0.052	(0.10)	-	
	30,000-39,999	-0.156	(0.10)	-	
	40,0000-49,0000	0.021	(0.10)	-	
	50,000+	0.031	(0.10)	-	
Body mass index at booking	Norm./Underw.	*ref.*		-	
	Overweight	0.266	(0.08)***	-	
	Obese	0.321	(0.08)***	-	
Age at delivery	years	0.010	(0.01)	-	
Miscarriages	yes	0.049	(0.07)	-	
Primaparous	yes	0.169	(0.07)*	-	
Delivery term	<36 weeks	0.443	(0.16)**	-	
	[36-39)weeks	*ref.*		-	
	>= 39 weeks	-0.176	(0.08)*	-	
Site effect	site A	*ref.*		*ref.*	
	site B	0.386	(0.09)***	0.313	(0.08)***
	site C	0.154	(0.09)	0.120	(0.07)
	site D	-0.064	(0.11)	0.028	(0.09)
Constant		7.975	(0.25)***	8.480	(0.04)***
Prediction of the cost, €					
NGT group		5,434.8	(81.70)	5,174.4	(23.04)
GDM group		6,252.4	(93.99)	6,664.5	(29.68)
Difference		817.6	(12.29)	1,490.1	(6.64)
Model fit					
N. of obs.		461		642	
Loglikelihood		-4,433.3		-6,196.5	
P (chi2)		0.000		0.000	
BIC		-2,572.6		-3,860.4	

* $p<0.05$; ** $p<0.01$; *** $p<0.001$,

NGT – normal glucose tolerance, GDM – gestational diabetes mellitus

Table 4 Results of the regression analysis of the annual health care cost 2 to 5 years after the index pregnancy (generalized linear regression, log link, Gamma distribution family)

		Full model		Reduced model	
		Coef.	(St.Err.)	Coef.	(St.Err.)
GDM	Yes (positive)	0.846	(0.29)**	0.787	(0.31)*
Income, €	<20,000 = ref.	*ref.*		-	
	20,000-29,999	0.264	(0.38)	-	
	30,000-39,999	-1.141	(0.37)**	-	
	40,0000-49,0000	-0.715	(0.40)	-	
	50,000+	-0.306	(0.36)	-	
Body mass index	Norm./Underw.	*ref.*		-	
	Overweight	0.092	(0.25)	-	
	Obese	0.373	(0.36)	-	
Age		-0.003	(0.03)	-	
Subsequent miscarriages		0.011	(0.38)	-	
Time after delivery	2 years	*ref.*		*ref.*	
	3 years	-0.225	(0.48)	0.324	(0.55)
	4 years	0.610	(0.40)	0.624	(0.44)
	5 years	0.138	(0.42)	0.202	(0.46)
Consumes alcohol		-0.514	(0.25)*	-	
Smoking status	Past smoker	0.151	(0.27)	-	
	Current smoker	0.243	(0.35)	-	
	Never smoked	*ref.*		-	
Exercises 30 min a day		-0.765	(0.34)*	-	
Medical Card	Yes	-0.265	(0.29)	-	
Center effect	site A	*ref.*		*ref.*	
	site B	0.518	(0.40)	0.530	(0.37)
	site C	0.100	(0.30)	-0.048	(0.36)
	site D	-0.761	(0.38)*	-0.865	(0.37)*
Constant		7.128	(1.23)***	5.998	(0.44)***
Prediction of the cost, €					
NGT group		511.6	(25.41)	592.4	(15.50)
GDM group		1,192.1	(59.20)	1,301.1	(34.04)
Difference		680.5	(33.80)	708.7	(18.54)
Model fit					
N. of obs.		234		302	
Log-likelihood		-1,698.1		-2,274.0	
P (chi2)		0.000		0.030	
BIC		-849.7		-1167.5	

* $p<0.05$; ** $p<0.01$; *** $p<0.001$,

NGT – normal glucose tolerance; GDM – gestational diabetes mellitus

Appendix A

Table A1 Unit cost assigned to the resource utilization

Resource	Unit	Unit cost, € (2012)	Source/ Methodology
Maternal care			
Neonatal unit admission	n	8,145.25	Casemix unit, DOHC (16)
Mode of delivery:			
spontaneous vaginal	n	2,615.18	
assisted vaginal	n	3,894.10	
elective caesarean	n	6,527.67	
emergency caesarean	n	8,134.43	
Health care at follow-up			
Service prices			
GP visit	visit	50	HSE Salary Scales (18) 12 min consultation
Practice Nurse visit	visit	12	HSE Salary Scales (18) 15 min consultation
Public Health Nurse visit	visit	26	HSE Salary Scales (18), HIQA (17)
Diabetes Specialist Nurse visit	visit	26	
Dietician visit	visit	23	
Chiropodist visit	visit	23	
Physiotherapist visit	visit	23	
Occupational Therapist visit	visit	23	
Optician visit	visit	23	
Social Worker visit	visit	23	
Psychologist visit	visit	23	
Outpatient Clinic visits	visit	141	Casemix unit, DOHC (16)
Diabetes Day Care Centre visits	visit	141	
A&E visit	visit	268	
Day-case Hospital Admission	admission	665	
Inpatient Hospital Admission	night	770	
Pharmaceuticals			
Insulin	int. unit	0.023	MIMS Ireland (19)
Diabetic (oral glucose agent)			
metformin	mg	0.000056	
sulphonylurea	mg	0.002	
Cholesterol: statin 10	mg	0.039	
Aspirin: salicylate	mg	0.00057	
Blood sugar test			
lancet+strip+glucomter(aloc)	1 test	0.521	
Smoking cessation			
inhaler	day	3.570	
tabs/lozenges	day	1.578	
patch	day	1.657	
Blood pressure			
average: ACE inhibitor, angiotensin II antagonist, Ca++ antagonist	mg	0.0372	
Anti-depressants (exact name)	mg	0.0029 - 0.0796	

Appendix B Comparison of the annual utilization of the health care resources, and the cost elements in the NGT and GDM groups

We applied univariate analyses to test the difference between the groups in the consumption of individual resource items. First, the relative risk of using each resource item for GDM group over NGT group was assessed. At the second stage, many of the resource elements had very low numbers of users which precluded the use of formal statistical testing of differences in positive use between the study groups. Instead, formal parametric (two sided t-test) and non-parametric (Mann-Whitney) testing was applied to the cost of each individual resource item, including zero cost. The analyses for the maternal care utilization and cost are presented in Table B1, and for the annual health care utilization and cost two to five years after the index pregnancy – in Table B2.

Table B1. As for maternity care, the women with GDM are more likely to have neonatal unit admissions (1.61 times), and to have elective or emergency caesarean section (1.83 and 1.69 times respectively). This results in significantly higher cost of both neonatal care and delivery.

Table B2. In the GDM group, women are more likely to visit diabetic specialist nurse (10.59 times), psychologist (2.89 times), and diabetes day centre (3.74 times) than the women in the NGT group. They are also more likely to use oral glucose agents (6.32 times) and blood sugar tests (4.56 times). At the same time, women from the GDM group are less likely to visit a physiotherapist or an optician (relative risks 0.36 and 0.5 respectively). In the GDM group, there are also tendencies at the verge of significance to be more likely to visit dietician, outpatient day centre, be admitted to the hospital, and use insulin. It is hard to make conclusions about visits of occupational therapist, insulin and cholesterol drug consumption due to very small groups of users. Additionally, none of the women in GDM group (was) visited (by) a social worker or used aspirin, whereas women in NGT group did.

In terms of cost, women with GDM spend significantly more on diabetic specialist nurse, psychologist, diabetes day centre visits, and blood sugar tests. There are also tendencies not far from significance levels to spend more on GP services, dietician, outpatient day centre, inpatient hospital stays, and oral glucose agents. On the other hand, women with GDM tend to spend less on public health nurse, physiotherapist, optician, and to not use aspirin.

Table B1 Maternal care utilization

	Users				**Risk ratio of use***		**Mean positive use**			**Mean cost, €** (incl. zero cost)			**t-test**	**M-W**
	NGT		**GDM**											
	N	***(%)***	**N**	***(%)***	**RR**	**p-v**	**NGT**	**GDM**	**Diff**	**NGT**	**GDM**	**Diff**	**p-v**	**p-v**
Neonatal Unit, admissions	52	(13.6%)	59	(21.9%)	**1.61**	**0.006**	-	-	-	1,109	1,787	678	**0.005**	**0.006**
Mode of delivery										4,013	4,912	900	**0.000**	**0.000**
spontaneous vaginal	229	(60.6%)	116	(43.0%)	**0.71**	**0.000**	-	-	-					
assisted vaginal	47	(12.4%)	25	(9.3%)	0.74	0.209	-	-	-					
elective caesarean	59	(15.6%)	77	(28.5%)	**1.83**	**0.000**	-	-	-					
emergency caesarean	43	(11.4%)	52	(19.3%)	**1.69**	**0.006**	-	-	-					

* Risk ratio of resource utilization for GDM group over NGT group; GDM – gestational diabetes mellitus, NGT – normal glucose tolerance.

Table B2 Annual health care utilization 2-5 years after delivery

	Users				Risk ratio of use*		Mean positive use			Mean cost, € (incl. zero cost)			t-test	M-W
	NGT		GDM											
	N	*(%)*	N	*(%)*	RR	p-v	NGT	GDM	Diff	NGT	GDM	Diff	p-v	p-v
Specialists														
GP visits	194	(83.3%)	99	(88.4%)	1.06	0.186	3.8	4.4	0.6	157.68	193.26	35.58	0.066	0.124
Practice nurse visits	72	(31.3%)	40	(36.4%)	1.16	0.348	1.9	2.1	0.3	7.06	9.33	2.26	0.242	0.253
Public health nurse visits	27	(11.6%)	9	(8.4%)	0.72	0.377	2.1	1.3	-0.8	6.44	2.92	-3.52	0.310	**0.047**
Diabetic specialist nurse visits	2	(0.9%)	10	(9.1%)	**10.59**	**0.002**	4.5	4.0	-0.5	1.00	9.36	8.36	**0.000**	**0.043**
Dietician visits	6	(2.6%)	7	(6.4%)	2.47	0.097	2.7	2.7	0.0	1.62	3.94	2.32	0.087	0.167
Chiropodist visits	9	(3.9%)	8	(7.3%)	1.87	0.187	1.6	1.8	0.2	1.45	3.07	1.62	0.178	0.209
Physiotherapist visits	35	(15.0%)	6	(5.5%)	**0.36**	**0.018**	4.3	7.3	3.0	14.81	9.20	-5.61	**0.013**	0.321
Occupational therapist visits	6	(2.6%)	1	(0.9%)	0.35	0.333	3.3	4.5	1.2	1.97	0.94	-1.03	0.314	0.424
Optician visits	71	(30.6%)	17	(15.3%)	**0.50**	**0.005**	1.2	1.1	-0.1	8.60	4.03	-4.58	**0.002**	**0.001**
Social Worker visits	2	(0.9%)	0	(0.0%)	0.00	0.988	1.5	0.0	-1.5	0.30	0.00	-0.30	0.333	0.359
Psychologist visits	8	(3.4%)	11	(9.9%)	**2.89**	**0.019**	6.5	13.1	6.6	5.14	29.94	24.81	**0.013**	0.065
Hospitalizations														
Outpatient day centre visits	62	(26.7%)	38	(35.5%)	1.33	0.095	2.2	3.2	1.0	83.04	160.09	77.05	0.101	0.072
Diabetes day centre visits	5	(2.3%)	9	(8.5%)	**3.74**	**0.016**	3.4	2.0	-1.4	10.90	23.94	13.05	**0.010**	0.201
Accidents & emergency unit admissions	24	(10.5%)	14	(13.1%)	1.25	0.482	1.4	1.4	0.0	39.65	49.06	9.41	0.471	0.533
Day case hospital admissions	19	(8.3%)	9	(8.1%)	0.98	0.953	1.3	1.3	0.1	69.33	71.89	2.56	0.969	0.933
Inpatient hospital stay	22	(9.6%)	18	(16.2%)	1.69	0.078	3.7	4.1	0.4	272.48	513.33	240.86	0.063	0.115
Pharmaceuticals														
Insulin, units	2	(0.9%)	3	(3.6%)	**4.22**	0.095	4.2	7.0	2.8	0.82	4.37	3.55	0.175	0.362
Diabetic medicines, in mg	2	(0.9%)	6	(5.4%)	**6.32**	**0.023**	22.0	162.6	140.6	0.25	1.72	1.48	**0.009**	0.174
Cholesterol medicines, in mg	3	(1.3%)	1	(0.9%)	0.71	0.762	1.4	0.2	-1.2	0.68	0.07	-0.60	0.758	0.326
Blood Pressure medicines, in mg	7	(3.0%)	5	(4.5%)	1.51	0.476	1.7	2.2	0.5	1.85	3.60	1.75	0.471	0.417
Aspirin, in mg	16	(6.8%)	0	(0.0%)	0.00	0.986	11.7	0.0	-11.7	0.46	0.00	-0.46	**0.005**	**0.024**
Smoking Cessation medicines, in days	7	(3.0%)	5	(4.5%)	1.51	0.471	48.1	40.6	-7.5	2.63	3.55	0.92	0.478	0.643
Anti-Depressants, in mg	12	(5.1%)	10	(9.0%)	1.76	0.173	11.9	13.1	1.3	11.45	16.40	4.95	0.128	0.562
Blood Sugar Tests, number	7	(3.0%)	15	(13.6%)	**4.56**	**0.001**	0.6	0.6	0.0	9.99	42.82	32.83	**0.000**	**0.029**

* Risk ratio of resource utilization for GDM group over NGT group; GDM – gestational diabetes mellitus, NGT – normal glucose tolerance.