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Estimating the Amount of Overweight and Obesity Related Health-Care Use in the Republic of Ireland Using SLÁN Data*

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Abstract: In Ireland, over half the adult population are now considered to be overweight or obese. This has implications for individuals in terms of their health as well as for the health service in terms of care utilisation. Using SLÁN (2007) data we estimate the impact on use of general practitioner (GP) services, hospital inpatient and hospital day case services of overweight and obesity. Our modelling approach accommodates potential unobserved heterogeneity associated with utilisation of primary and secondary health care. Controlling for a range of socio-demographic variables, we find that overweight and obesity are significant predictors of GP utilisation and obesity is a significant predictor of inpatient episodes. Translating increased utilisation into costs, primary health-care costs are estimated conservatively to be approximately €17 million higher and secondary health-care costs approximately €24 million higher in the Republic of Ireland as a result of overweight and obesity in adults. Given trends, overweight and obesity are likely to present an increasing challenge to the health service in the future that warrant further investigation.

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I INTRODUCTION

Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health (WHO, 2011). Body mass index (BMI) is a simple measure used to identify individuals who are overweight and obese and distinguish them from those who are normal weight or underweight. BMI is defined as a person's weight in kilograms divided by the square of his/her height in metres (kg/m^2). Individuals who have a BMI greater than or equal to 25 are considered to be overweight; individuals with a BMI greater than or equal to 30 are considered to be obese (WHO, 2011). Overweight and obesity have been linked to a range of illnesses. In addition to the 2.8 million deaths linked to overweight and obesity globally, for example, 44 per cent of the diabetes burden, 23 per cent of the ischaemic heart disease burden and between 7 per cent and 41 per cent of the burden of certain cancers have been attributed to overweight and obesity (WHO, 2011).

Since raised BMI is a major risk factor for diseases such as cardiovascular disease, musculoskeletal disorders (such as osteoarthritis) and some cancers (e.g. endometrial, breast and colon) (WHO, 2011) this rise in overweight and obesity is likely to result in increased health-care costs. This is because the chronic diseases that are associated with overweight and obesity give rise to on-going needs that are in turn being met with more complex and expensive pharmaceutical and technological products. Unsurprisingly, perhaps, a substantial body of literature now exists, linking overweight and obesity to increased direct health-care costs. Comparison between studies is difficult because the costs included vary between studies, some including every possible type of health-care costs, some looking only at drug costs or hospital costs. Additionally, as entitlements to publicly funded care varies between countries, various studies highlight the impact this may have on patterns of utilisation across socio-economic groups where the prevalence of obesity and overweight may also vary (Van Doorslaer *et al.*, 2008; Van Doorslaer *et al.*, 2004; Layte and Nolan, 2004, Madden, 2012). This said, we can provide an overview of cost estimates from other developed countries and the methodologies they employ. In the UK, Allender and Rayner (2007) use a population attributable fractions approach applied to National Health Service (NHS) spending data and estimate costs at approximately 4.6 per cent of total NHS spending. Using US health care spending data, Finklestein *et al.* (2003), estimate that overweight accounts for 2.5 per cent and obesity accounts for 2.8 per cent of national health expenditures respectively using medical expenditure panel survey (MEPS) data. In their study they apply regression models, which control for a range of factors such as gender, insurance category, ethnicity, age, region, income, education and marital status, to annual medical spending data including prescription medicines. In a Japanese case-study, Kuriyama *et al.* (2002) estimate that overweight and obesity combined accounts for 3.2 per cent of total health-care expenditure based on a sample of individuals aged between 40 and 79 years. In their study they estimate costs of hospital and physician visits by linking actual charges with national health insurance claim files. In their analysis they adjust for gender, age, smoking status, drinking status and physical activity status. Other studies exploring the relationship between costs and overweight and obesity indicate that the relationship is not monotonic. Lakdawalla *et al.* (2005) for example, in their study of costs for individuals aged 70 years found that overweight individuals had marginally lower health-care costs than individuals of normal weight. In their study they use a simulated modelling approach to estimate the annual health-care costs of an obese individual at \$17,508, compared to \$15,002 for an overweight individual and \$15,131 for a normal weight individual. The differences between the study by Finklestein *et al.* (2003) and Lakdawalla *et al.* (2005) likely reflects differences in the population for which they estimate costs. Finklestein *et al.* (2003) estimate costs for a representative sample of the population while Lakdawalla *et al.* (2005), estimate costs for individuals based on projected expenses starting at the age of 70. Other studies point to a "J shaped" relationship between BMI and health-care costs, with underweight and overweight having higher costs than normal weight individuals, and with costs increasing with increasing BMI (e.g. Nakamura *et al.*, 2007).

Heterogeneity across a range of socio-demographic variables in the relationship between BMI and health-care costs has also been observed. Andreyeva *et al.* (2004) found that women who were moderately obese (obese I) or extremely obese (obese III) had higher health-care costs compared to men in the same groups, while among the severely obese group (obese II) men had higher costs compared to women in their study of individuals aged 54 to 69 years. In their analysis they also control for ethnicity, insurance status, marital status, education levels, income, region, alcohol consumption and smoking status. Finkelstein *et al.* (2008) explored the impact of age, gender and ethnicity on BMI associated health-care costs, controlling for education level, smoking status, insurance status, marital status, census region, population density. Their estimated costs for obese categories (II/III) ranged from \$7,590 for black women to \$25,300 for white women. They also found substantial differences between men and women in their BMI associated lifetime costs. Similarly Wee *et al.* (2005) found that BMI related health-care expenditure rose substantially among white and older adults but not among black adults or those younger than 35 years. They did not, however, find a relationship between BMI and gender. In their US study they examined expenditure data using the MEPS dataset and adjusted their models to control for age, gender, race, education level, type of insurance coverage, region and whether an individual lived in a rural or metropolitan area. They also tested whether controlling for income and smoking status had a bearing on their estimates.

Previous work in Ireland has sought to establish the impact of obesity on health-care costs. Using 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. They found that over the study period there was a 45 per cent 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 €4.4 million in 1997, rising to €13.3 million 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. Furthermore the study did not rely on an objective measure of obesity such as BMI which may be viewed as problematic. The National Taskforce for Obesity (2005) estimated the direct costs of obesity at €70 million in 2002 for Ireland. They apply a cost methodology employed in England to Ireland to estimate costs which includes the costs of drugs, GP visits and hospital contacts. In general they find that the largest component of costs is associated with drug use followed by hospital visits.

Within a context of rising obesity levels in Ireland, this paper seeks to establish the relationship between BMI, health-care utilisation and the associated health-care costs for the Republic of Ireland. We use data collected from the SLÁN 2007 survey to estimate the additional utilisation associated with overweight and obesity on GP and hospital health-care services relative to individuals of normal weight. SLÁN 2007 is used as it permits a more detailed socio-demographic characterisation of the individual than would be possible using data from hospital discharge records. SLÁN moreover provides a nationally representative sample, and contains data on utilisation of GP as well as hospital services. Importantly it also contained the reported BMI of respondents.

While many studies in the international literature that employ a modelling approach, control for a range of socio-economic factors as noted above, many do not explicitly control for the health status of individuals. In general the relationship between BMI and health-care consumption is complex. In particular since high BMI tends to be a contributory factor for certain health conditions, the endogeneity means that trying to disentangle the health-care impacts of high BMI from the health conditions that it contributes to is difficult. In our analysis, we therefore present a number of alternative modelling specifications that differ in the treatment of individuals' health status and examine how this impacts on our estimated findings for the BMI categories.

The remainder of the paper is outlined as follows, in Section II the econometric methods are detailed, in Section III the SLÁN survey and variables used in the analysis are discussed, in Section IV the results of the econometric analysis are presented and in Section V the key findings, study limitations and areas for further work are set out.

II METHODOLOGY

In SLÁN health-care use in respect of GP and day case services is captured using a series of dichotomous variables that identify whether or not use occurred in specified time period. While hospital inpatient length of stay is measured as a count within a specified time period, for consistency we estimate an econometric model of health-care utilisation in which the dependent variable is dichotomous. In this case we assume that utilisation of a particular health-care service is the unobserved latent counterpart of the observed variable, captured in the survey

$$y_i{}^* = x_i' \beta_i + \varepsilon_i \tag{1}$$

Only y_i is observed which equals 1 if $y_i^* > 0$ implying that a person chooses to visit a particular health-care service in this case in the previous year and 0 otherwise; x_i is a vector explanatory variables that include BMI and the other socio-demographic characteristics. Importantly in the Irish context these include medical card status and access to private health insurance both of which have been shown in a range of other studies to impact on health-care utilisation (Madden *et al.*, 2005; Nolan and Nolan, 2008; Walsh *et al.* 2011). We include each chronic condition, reported in SLÁN, separately to allow for the possibility that each may not contribute equally to the use of services. As a final control variable we include self-assessed health status. β_i represents the coefficients to be estimated in the model and ε_i represents the error term.

Three aspects of health care are modelled: visits to the GP, visits to the hospital as an inpatient and visits to the hospital for a day procedure. A seemingly unrelated probit model is used to accommodate potentially correlated errors between the health-care services: as it is possible that underlying latent characteristics that drive an individual to visit their GP could also potentially affect whether they attend hospital, it is important to accommodate these in the model used. For example, a person who is anxious regarding their health – the worried well – may be more likely to attend the GP and be referred by the GP to hospital than would be suggested by the estimated model. (The converse would apply to their counterpart, the unworried sick.) Hence, a positive correlation in errors between utilisation of the two health-care services may be expected. (McGregor and O'Neill, 2007) It is also possible that again individual concerns (or apathy) regarding health may lead to a positive correlation in errors between inpatient and day procedure services. Equally, it is conceivable that if inpatient and day procedure services act as substitutes to each other a negative correlation in errors may exist.

Under a seemingly unrelated probit model it is possible to accommodate potential unobserved heterogeneity between utilisation of different health-care services. In this case we can assume that a generic health-care service (for example, GP visits) is identified by a binary variable y_1^* and that a second generic health-care service (for example, hospital inpatient visits) is denoted by a binary variable y_2^*. In this case the first model becomes:

$$y_1^* = x_1'\beta_1 + \varepsilon_1 \text{ where } y_1 = 1 \text{ if } y_1^* > 0, 0 \text{ otherwise} \quad (2)$$

The second model becomes:

$$y_2^* = x_2'\beta_2 + \varepsilon_2 \text{ where } y_2 = 1 \text{ if } y_2^* > 0, 0 \text{ otherwise} \quad (3)$$

where the explanatory variables in the two equations may be the same or different (Greene, 1997). The error structure captures the potential correlation between utilisation of both health-care services, which following Greene (1997) can be described as:

$$\left(\begin{matrix}\varepsilon_1 \\ \varepsilon_2\end{matrix}\middle| \; x_1, x_2\right) \sim N\left[\begin{pmatrix}0 \\ 0\end{pmatrix}, \begin{pmatrix}1 & \rho \\ \rho & 1\end{pmatrix}\right] \quad (4)$$

Where ρ captures the correlation in the error terms between utilisation of the two health-care services. A positive value for ρ is consistent with the interpretation of unobserved heterogeneity related to anxiety regarding health. A negative value for ρ is consistent with the interpretation that factors that drive utilisation of one health-care service may make a person less likely to use another health-care service. While our analysis allows correlation between GP and inpatient stays and inpatient stays and day procedure visits, it is equally conceivable that correlation in errors may occur across the three health-care services. Hence, our analysis could be modelled using a trivariate specification which allows correlation between GP visits, inpatient stays and day procedure visits rather than two bivariate specifications. Here we present only the results from bivariate specifications rather than the trivariate specification. This approach is adopted because the computation of marginal effects under the trivariate specification is more involved (as is the interpretation of results) than in the bivariate case and in comparisons of signs and significance of coefficient estimates (as well as their magnitude) in trivariate and bivariate models we did not find any significant differences.[1]

In general the relationship between BMI and health care is complex. BMI has been shown to indirectly impact upon a person's health because it is a risk factor for a number of other health conditions such as, for example, cardiovascular disease, diabetes and certain cancers. As a result the potential increased utilisation for higher BMI categories likely reflects the impact of BMI on whether a person develops a health condition as a result of being either overweight or obese. To highlight this potential endogeneity of BMI with certain chronic health conditions, we present the results from a further econometric specification. In this case we model the impact of health using a number of chronic conditions (recorded in the survey) on health-care utilisation after removing the impact of BMI on the number of conditions (which we name as chronic conditions residual). This is intended to capture the impact on health-care utilisation of health, when the BMI related impact is separated out.[2]

III DATA

As noted in this paper we use data collected from SLÁN 2007, which 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 health care. In particular respondents were asked to indicate on a categorical scale when the last time they visited the GP for their own health

[1] The trivariate model requires the maximisation of the simulated maximum likelihood whereas the bivariate specification requires the maximisation of the maximum likelihood. Calculation of marginal effects as presented in Table 3 is not supported by standard software packages for the trivariate model. The trivariate specification was based on 500 Halton draws with subsequent comparison of coefficients' signs and significance with those obtained from the bivariate specification.

[2] The residual term is estimated by a count data model of the number of chronic conditions with the BMI categories as regressors. The differences between the predicted and actual number of counts is used as the residual.

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.[3]

BMI was used to categorise individuals as underweight, normal weight overweight and obese in the survey.[4] The utilisation of each group relative to those who were classed as normal weight based on their BMI category was analysed. The purpose of using categorical variables is in part to make our results comparable to the international literature. We also tested models with continuous BMI included in the regression, along with BMI squared and BMI cubed and we did not find that this lead to a significantly better model fit. We also include dummy variables to indicate whether an individual had a medical card or private medical insurance. We controlled for a range of other variables representing various socio-demographics of the individuals surveyed. These included age (divided into a series of categories), household income (also categorised), marital status, gender and employment status.[5,6]

3.1 *Results*

Table 1 presents the definition of variables that are included in the econometric models along with the percentage of respondents who are in each category. As shown the obese category is broken down to identify separately individuals who have moderate obesity (obese I), severe obesity (obese II) and extreme or morbid obesity (obesity III). In terms of the other variables, quite a sizeable proportion of the sample, approximately 37 per cent, have access to a medical card and the majority of individuals have private health insurance.

[3] For a subsample of SLÁN respondents' independently measured height and weight was captured. To identify whether our results were biased by using self-reported measures we ran some model specifications where we replaced self-reported with measured BMI, for the subsample of respondents' in which we have both BMI measures. We found that the results were not significantly different from each other. As a result, we use the self-reported BMI measure in our analysis as it gives us a much larger sample size (Measured BMI was taken for less than one-fifth of the sample).

[4] We acknowledge that there has been criticism of BMI as a measure of obesity because it cannot distinguish between fat and other mass such as muscle and bone (see Burkhauser and Cawley, 2008 for a discussion). Despite this it remains by necessity the most commonly used measure to establish overweight and obesity in the literature.

[5] We do not enter age as a continuous variable since we only have data on which age category an individual falls into. This is also the case for the income variable.

[6] We exclude from our analysis females who have given birth in the previous year. This is the common approach taken in the literature as pregnant women are more likely to have raised BMI as a result of being pregnant.

Table 1: *Variable Definitions and Summary Percentages* for Independent Variables*

Variable	*Definition*	*Percentage*
Underweight	1 if underweight (15-18.49 kg/m^2), 0 otherwise	2.1
Normal weight	Base category, normal weight (18.5-24.99 kg/m^2),	47.7
Overweight	1 if overweight (25-29.99 kg/m^2), 0 otherwise	35.6
Obese grade I	1 if obese grade 1 (30-34.99 kg/m^2), 0 otherwise	10.8
Obese grade II	1 if obese grade 2 (35-39.99 kg/m^2), 0 otherwise	2.8
Obese grade III	1 if obese grade 3 (40 kg/m^2 plus), 0 otherwise	1.0
Full Medical Card	1 if full medical card holder, 0 otherwise	34.0
GP Only Medical Card	1 if GP only medical card holder, 0 otherwise	3.0
No Medical Card	Base category	63.0
Private Insurance	1 if has private insurance, 0 otherwise	53.0
No Private Health Insurance	Base category	47.0
Age 18-24	Base category	10.1
Age 25-34	1 if aged 25-34, 0 otherwise	19.3
Age 35-44	1 if aged 35-44, 0 otherwise	20.9
Age 45-54	1 if aged 45-54, 0 otherwise	16.6
Age 55-64	1 if aged 55-64, 0 otherwise	14.1
Age 65 plus	1 if aged 65 plus, 0 otherwise	19.0
Male	1 if male, 0 otherwise	42.2
Female	Base category	57.8
Single	1 if single, 0 otherwise	28.7
Separated/divorced	1 if separated or divorced, 0 otherwise	6.09
Widowed	1 if widowed, 0 otherwise	8.8
Married/Cohabiting	Base Category	56.4
Primary Education Only	Base Category	18.0
Lower Secondary	1 if highest level of education is junior certificate, 0 otherwise	20.0
Higher Secondary	1 if highest level of education is leaving certificate, 0 otherwise	25.0
Third Level	1 if highest level of education is post leaving certificate qualification, 0 otherwise	37.0
Income €10,000	1 if income is below €9,999 euro, 0 otherwise	5.07
Income €20,000	Base Category, income €10,000-€19,999	20.0
Income €30,000	1 if income is between €20,000-€29,999, 0 otherwise	17.8
Income €40,000	1 if income is between €30,000 -€39,999, 0 otherwise	16.1
Income €50,000	1 if income is between €40,000 -€49,999, 0 otherwise	15.2
Income €50,000	plus 1 if income equals €50,000 or above, 0 otherwise	25.9
Smoker	1 if a smoker, 0 otherwise	26.9
Non-Smoker	Base Category	73.1
Working	1 if working, 0 otherwise	57.0
Unemployed	1 if unemployed, activity seeking employment	3.00

Table 1: *Variable Definitions and Summary Percentages* for Independent Variables (contd.)*

Variable	*Definition*	*Percentage*
Not activity seeking employment	(Base category-this represents a composite variable which includes students, people on training schemes, the long-term sick or disabled, homemakers, retired and other)	40.0

*Percentages are rounded.

As the focus of this paper is in exploring health-care utilisation across different categories of BMI it is useful to highlight the percentage breakdown of utilisation by BMI category before presenting the econometric results. Table 2 presents the patterns of utilisation across the three health-care services explored in this paper. For the utilisation of health care each service was broken down into a binary variable of whether the respondent used that particular service in the previous 12 months.

Table 2: *Health-Care Utilisation by BMI Category*

	GP %	*Inpatient* %	*Day Case* %
Underweight	80.2	20.1	6.3
Normal Weight	74.6	8.9	8.0
Overweight	77.6	9.1	9.2
Obese Class I	82.2	9.3	8.9
Obese Class II	84.7	14.7	10.1
Obese Class III	88.7	14.5	13.0
Overall number of individuals in SLÁN reporting using these services in previous 12 month period	7,891 individuals	975 individuals	862 individuals

Quite a large proportion of the sample indicated that they had visited a GP in the previous 12 months. As expected, the proportion of individuals using hospital services is much lower. Bivariate analyses of visitation rates by BMI categories, show that for the various health-care services, individuals who are overweight or obese tend to be consistently more likely to use the services compared to normal weight individuals. The underweight category tends also to have higher utilisation particularly for hospital inpatient stays.

In Table 3 we present the average marginal effects for the models. While inpatient stays are included in both bivariate models, we present the marginal effects for inpatient stays from the model with GP visits only. The reason for this is that the coefficients for inpatient stays in the bivariate probit models are not significantly different from each other.

From Table 3 it is evident that overweight and obesity categories I and III are significant, suggesting that individuals that are in these BMI categories have a significantly higher probability of visiting the GP. For this model the marginal effect for the obese category III is not significant. This could be the result of the small number of individuals in this BMI category. It could also be related to the fact that collinearity between this BMI category and the health conditions are impacting the significance of this variable.

While the results with respect to other variables included in this function are not the focus of this paper, it is noteworthy that they are consistent with expectations in terms of the signs and significance of estimated marginal effects and with the findings of others. Medical card holders and people with private health insurance are significantly more likely to visit their GP than those who do not have the enhanced access these confer. Men are significantly less likely to visit than women, single, widowed or separated individuals are also less likely to visit the GP compared to married or cohabiting individuals. Each of these can be interpreted in terms of the differential opportunity cost of time for the category concerned, and/or in the case of marital status in terms of the "pester power" of a partner and again are consistent with intuition. As expected older people are more likely to visit the doctor, individuals with a second or third level education are also significantly more likely to visit the GP compared to individuals who have primary education only. Income was not statistically significant, except for the higher income categories which are significant at the 10 per cent level. The non-significance of many of the income categories could be due to a positive correlation between income and other variables included in the models such as private insurance, medical card status and education.

For hospital services as noted functions were estimated for day and inpatient stays. In terms of inpatient stays the marginal effect representing the underweight category respectively is positive and significant. The finding for the underweight BMI category is not surprising given the raw utilisation figures outlined in Table 2 – and may indicate that these represent a group for whom low weight is indicative of an underlying illness (such as cancer for example). Similarly the results show that whilst those individuals with a higher BMI have a higher propensity to visit the GP, the relationship with hospital inpatient stays is weaker. Again, this result is consistent with intuition in the sense that only when health conditions that may be associated

Table 3: *Seemingly Unrelated Bivariate Probit Models for Health-Care Utilisation**

Variables	*GP Visits*	*Inpatient*	*Day Case*	*Variables cont'd*	*GP Visits*	*Inpatient*	*Day Case*
Underweight	0.003	0.056	–0.026	Age 25-34	–0.005	–0.002	–0.021
	(0.21)	(2.04)**	(1.33)		(0.31)	(0.16)	(1.67)*
Overweight	0.022	–0.011	0.005	Age 35-44	–0.016	0.014	–0.031
	(2.19)**	(1.41)	(0.78)		(0.87)	(0.87)	(2.50)***
Obese I	0.047	–0.011	–0.000	Age 45-54	–0.005	0.004	–0.009
	(3.20)***	(1.18)	(0.05)		(0.27)	(0.26)	(0.63)
Obese II	0.061	0.018	–0.004	Age 55-64	0.071	0.024	–0.005
	(2.29)**	(0.93)	(0.25)		(3.65)***	(1.28)	(0.32)
Obese III	0.043	–0.04	0.019	Age 65 plus	0.096	0.024	–0.012
	(0.78)	(-1.86)*	(0.50)		(4.56)***	(1.28)	(0.78)
Full Medical Card	0.107	0.025	0.021	Smoker	–0.005	0.015	–0.011
	(8.28)***	(2.50)***	(1.94)*		(0.51)	(1.99)**	(1.40)
GP Medical Card	0.052	0.004	0.023	Asthma	0.068	0.018	–0.015
	(2.02)**	(0.22)	(1.00)		(3.53)***	(1.35)	(1.22)
Health Insurance	0.061	0.011	0.026	Bronchitis	0.116	0.017	–0.009
	(5.60)***	(1.32)	(3.36)***		(3.50)***	(1.01)	(0.51)
Income €10,000	0.018	0.035	–0.003	Heart Attack	0.115	0.137	–0.018
	(0.71)	(1.99)**	(0.23)		(1.76)*	(3.10)***	(0.62)
Income €30,000	0.011	0.015	–0.001	Angina	0.136	0.017	0.049
	(0.70)	(1.38)	(0.18)		(3.52)***	(0.92)	(1.82)*
Income €40,000	0.005	0.007	0.004	Stroke	0.015	0.188	–0.034
	(0.28)	(0.55)	(0.32)		(0.21)	(3.60)***	(1.29)
Income €50,000	0.031	0.026	0.007	Rheumatoid Arthritis	0.039	–0.004	0.016
	(1.68)*	(1.76)*	(0.52)		(1.65)*	(0.40)	(1.17)
Income €50,000 Plus	0.031	0.011	0.009	Osteoarthritis	0.072	0.011	0.000
	(1.72)*	(0.77)	(0.69)		(2.73)***	(0.86)	(0.04)
Lower Secondary	0.036	0.019	0.008	Back Pain	0.097	0.016	0.025
	(1.99)**	(1.71)*	(0.69)		(8.31)***	(1.94)	(2.68)***

Table 3: *Seemingly Unrelated Bivariate Probit Models for Health-Care Utilisation* (contd.)*

Variables	*GP Visits*	*Inpatient*	*Day Case*	*Variables cont'd*	*GP Visits*	*Inpatient*	*Day Case*
Higher Secondary	0.035	0.011	0.005	Diabetes	0.147	0.018	–0.009
	(1.96)**	(0.98)	(0.46)		(6.10)***	(1.10)	(0.55)
Third Level	0.044	0.011	0.016	Cancer	0.155	0.264	0.048
	(2.55)***	(0.96)	(1.36)		(3.58)***	(5.81)***	(1.51)
Employed	–0.013	–0.009	0.004	Urinary problems	0.117	0.027	0.019
	(1.66)*	(1.07)	(0.5)		(3.69)***	(1.61)	(1.03)
Unemployed	–0.001	0.017	0.009	Anxiety	0.091	0.004	0.013
	(0.05)	(0.85)	(0.40)		(4.19)***	(0.37)	(0.95)
Male	–0.102	0.0009	–0.013	Depression	0.071	0.004	0.011
	(10.09)***	(0.13)	(1.90)*		(2.93)***	(0.33)	(0.72)
Single	–0.035	–0.006	–0.007	Excellent Health	–0.161	-0.098	–0.047
	(2.80)***	(0.80)	(0.80)		(6.31)***	(13.35)***	(4.73)***
Separated/Divorced	–0.041	–0.005	0.027	Very good health	–0.119	–0.101	–0.038
	(1.89)*	(0.41)	(1.72)*		(5.46)***	(10.85)***	(3.60)***
Widowed	–0.063	-0.017	–0.032	Good health	–0.064	–0.067	–0.0168
	(2.48)***	(1.58)	(3.01)***		(2.90)***	(8.21)***	(1.65)*
Number of observations		7,203				7,232	
Log-Likelihood (GP, Inpatient)		–5,213.74		(Inpatient, Outpatient)		–3,948.83	
ρ		0.352				–0.516	
		(9.02)***				(11.14)***	

*Estimates presented are average marginal effects. Estimates in brackets are absolute z-statistics.
*** denotes significance at the 1 per cent level; ** denotes significance at the 5 per cent level;* denotes significance at the 10 per cent level.

with overweight or obesity are sufficiently serious, will the sufferer be permitted to access hospital inpatient care. Fewer of the other independent variables appear significant for hospital inpatient stays compared to the GP visits. Again this is consistent with intuition and likely reflects the greater role accorded to the referring or admitting physician in the decision to access inpatient care than the respondent whose characteristics are explicitly modelled. A perhaps surprising finding is that private insurance is not a significant determinant of inpatient stays. While this may appear counter-intuitive, it may be that while private health insurance does not increase the likelihood of a person accessing care, it could impact on the speed with which care is accessed, which is not observable to us.

With respect to hospital day cases, positive and significant coefficients were recorded for individuals with full medical card as well as for individuals with private health insurance. Most other explanatory variables were not significant including the various BMI categories. This suggests BMI is not a significant predictor of utilisation of hospital day cases generally, which is confirmed by findings from a Wald test on the BMI dummies. In terms of socio-demographic variables, separated/divorced individuals are significantly more likely (at the 10 per cent level) to attend hospital for a day procedures, whereas widowed individuals are significantly less likely, compared to individuals who are married or cohabiting. Individuals who fall into the age category 35-44 years are significantly less likely to attend hospital for a day procedure compared to the youngest age cohort (18-24), similarly individuals aged between 25-34 are significantly less likely at the 10 per cent level to attend for a hospital day case compared to the youngest individuals. Men are also significantly less likely to attend for a hospital day procedure at the 10 per cent level compared to women. The non-significance of many of the socio-demographic variables including the BMI categories means that the utilisation of hospital day procedures are somewhat difficult to predict based on these variables. The insignificance of these marginal effects (and BMI in particular) could reflect the heterogeneity among day case procedures. That is, what is treated as a day procedure may better reflect aspects of service provision – what can and is treated as a day procedure – rather than aspects of service need and thus BMI or other need related characteristics.

Across the three health-care services, we observe significant relationships between the health conditions and the use of services. This is particularly evident for GP services whilst the relationship with day case procedures is much weaker. In addition, as expected, individuals with better self-reported health are less likely to use health-care services compared to individuals who report their health to be either fair or poor (the baseline). The correlation coefficient ρ is positive and significant between GP and inpatient visits suggesting that underlying latent factors that drive a person to visit a GP also positively influence their attendance at hospital as an inpatient. For the hospital inpatient and hospital day procedure, the correlation coefficient is negative and significant. This suggests that underlying factors that lead to a person attending hospital as an inpatient are associated with them being less likely to attend for a day procedure. As noted this could relate to some substitutability between the two hospital services.

3.2 *Alternative Model Specification for Chronic Health Conditions*

While Table 3 highlights the results of BMI on health-care utilisation controlling for a range of variables including each chronic health condition and self-assessed health, Table 4 presents the marginal effects from a model specification where we include the residual from a model where the count of chronic conditions is regressed on BMI rather than each chronic condition directly and self-assessed health is not included. The purpose of this is to model the impact of BMI on health-care utilisation when the collinearity between BMI and the chronic health condition is removed. In the interests of brevity, we only present the results for the coefficients on the BMI dummies and the chronic conditions residual and not the other socio-demographic variables.

Table 4: *Bivariate Probit Models with Residual On Chronic Conditions*

Variable	*GP Visits*	*Inpatient*	*Day Case*
Underweight	0.014	0.059	–0.028
	(0.43)	(3.09) ***	(1.12)
Overweight	0.051	–0.004	0.007
	(5.05) ***	(0.61)	(1.06)
Obese I	0.099	–0.001	0.005
	(6.03) ***	(-0.11)	(0.48)
Obese II	0.17	0.039	0.014
	(5.23)***	(2.17) **	(0.73)
Obese III	0.196	0.017	0.034
	(3.02)***	(0.53)	(1.08)
Chronic Condition Residual	0.130	0.027	0.014
	(17.2) ***	(12.83) ***	(6.92) ***
Log likelihood (GP, inpatient)	–5,363.83	Log likelihood (Day procedure, inpatient)	–4,207.25

Estimates presented are marginal effects. Estimates in brackets are absolute z-statistics.
*** denotes significance at the 1 per cent level; ** denotes significance at the 5 per cent level;* denotes significance at the 10 per cent level.

Table 4 highlights the impact of including the residual on the count of chronic conditions on the relationship between BMI and health-care utilisation. The most obvious difference between this specification and that presented in Table 3 is that obese category III is found to significantly impact on the utilisation of GP services while obese category II is found to be a significant predictor of hospital impatient stays. This suggests that some of the BMI related impact on health-care utilisation may be captured within the chronic conditions in our earlier specification. Indeed, some of the conditions, such as diabetes and cancer, have a direct causal link with high BMI which means that trying to disentangle their impacts is difficult when they are included directly in the model.

IV RESULTS WITH BMI AND SOCIO-DEMOGRAPHIC INTERACTIONS

In additional analyses we explored potential differences in utilisation within BMI categories associated with various socio-demographic variables. Table 5 presents the marginal effects for a model in which we include interaction terms between the higher BMI categories with age and gender.[7] For the age category we only included the interactions between the oldest age category (age 65 plus) and the higher BMI categories. We attempted to include interactions between all the age categories, presented in Table 5, and the higher BMI categories, however many of these were not significant. For the gender variable we include the separate marginal effects of being male and female on the BMI related impact of health-care utilisation. For our age variable we include the marginal impact of being over 65 years versus being less than 65 on the BMI related impact of health-care utilisation While the other socio-demographic variables were included in the model with interactions, we do not present their results in Table 5 as they do not differ substantially from their values presented in Table 4. (The results are from a model with the residual of chronic health added as an explanatory variable rather than from the specification included in Table 3.)

[7] Age and Gender were chosen as most evidence in the literature points to heterogeneity in utilisation by BMI based on these socio-demographic variables. Ethnicity has also been shown to be important in studies, particularly in the US. However, the Irish population has a much higher homogeneous population and, therefore, ethnicity was not considered in the models.

Table 5: *BMI with Socio-Demographic Interactions for Health-Care Utilisation*

Variables	*GP*	*Inpatient*	*Day Case*
Male	–0.093	0.010	–0.010
	(9.52)***	(1.09)	(1.58)
Overweight	0.053	–0.004	0.006
	(5.35)***	(0.62)	(0.83)
Obese I	0.092	0.00	0.007
	(6.87)***	(0.01)	(0.61)
Obese II	0.138	0.047**	0.014
	(7.41)***	(1.96)	(0.68)
Obese III	0.158	0.019	0.009
	(5.44) ***	(0.77)	–0.31
Overweight Male	0.077	–0.008	0.021
	(5.03)***	(0.71)	(1.99)**
Overweight Female	0.031	–0.001	–0.005
	(2.61)***	(0.18)	(0.57)
Obese I Male	0.121	–0.021	0.001
	(6.18)***	(1.37)	(0.09)
Obese I Female	0.077	0.015	0.013
	(4.09)***	(0.94)	(0.84)
Obese II Male	0.196	0.023	0.004
	(7.40)***	(0.71)	(0.14)
Obese II Female	0.092	0.065	0.029
	(3.35)***	(1.95)*	(0.97)
Obese III Male	0.226	–0.101	–0.081
	(4.86)***	(18.67)***	(16.31)***
Obese III Female	0.110	0.039	0.083
	(2.74)***	(0.91)	(1.54)
Age 65 Plus	0.074	0.039	–0.08
	(3.43)***	(1.86)*	(0.49)
Overweight and Aged over 65 years	0.029	–0.053	0.013
	(–1.27)	(3.29)***	(0.93)
Overweight and Aged under 65 years	0.057	0.011	0.004
	(5.24)***	(1.25)	(0.47)
Obese I and Aged over 65 years	0.061	–0.072	–0.002
	(1.81)*	(3.47)***	(0.09)
Obese I and Aged under 65 years	0.097	0.023	0.001
	(7.02)***	(1.71)*	(0.76)
Obese II and Aged over 65 years	0.077	0.021	0.026
	(1.36)	(0.39)	(0.50)
Obese II and Aged under 65 years	0.148	0.060	0.011
	(7.55)***	(2.10)**	(0.48)
Obese III and Aged over 65 years	0.003	–0.126	0.134
	(0.93)	(7.46)***	(1.30)

Table 5: *BMI with Socio-Demographic Interactions for Health-Care Utilisation (contd.)*

Variables	*GP*	*Inpatient*	*Day Case*
Obese III and Aged under 65 years	0.180 (6.59)***	0.014 (0.44)	–0.023 (0.83)
Log likelihood (GP, inpatient)	–5,343.22	Log likelihood (Day procedure, inpatient)	–4,184.98

Estimates presented are marginal effects. Estimates in brackets are absolute z-statistics.
*** denotes significance at the 1 per cent level; ** denotes significance at the 5 per cent level;* denotes significance at the 10 per cent level.

In Table 5 we examine heterogeneity across gender and age using interaction terms. We find that men with higher BMIs have a higher probability of visiting the GP compared to women who fall into the equivalent higher BMI category. For the inpatient and day case visits we observe significant differences between obese III men and obese III women. Additionally for day cases, we observe a significant difference between overweight men and overweight women. Exploring the marginal effects for inpatient visits we find that individuals who are over 65 years who have a high BMI have a statistically lower utilisation of inpatient services relative to younger individuals with the corresponding BMI category (the only exception is for the obese II category where we did not find a significant difference between older and younger individuals who are in this BMI category). In respect to day cases we do not find significant differences between younger and older individuals who are overweight and obese in their use of this health-care service.

4.1 *Direct Health-Care Costs of Overweight and Obesity in Ireland*

It is possible to use the marginal effects presented to estimate the cost of overweight and obesity on these aspects of health-care use in the Republic of Ireland. Typically in the literature, frequency of visits are used to form the basis of cost estimation, however, this was not collected in SLÁN for all aspects of care. In consequence, the cost estimates presented below are likely to be somewhat crude. Nevertheless, if we take the average number of GP visits reported in the *Quarterly National Household Survey* Q3 2007, which averaged at 2.8 visits in 2007 (CSO, 2008), and use the unit health service costs reported in Glynn *et al.* (2011), which is estimated at €50 for a GP visit and €5,030 for a hospital inpatient visit, it is possible to combine these with marginal effects to estimate expected incremental costs. To estimate GP costs we use the following formula:

GP costs = ME_{BMI} *unit cost*average number visits* proportion Irish population indicated in SLÁN who are in that BMI category.

Table 6: *Estimated Costs of Overweight and Obesity on Health-Care Services in Ireland*

	Model with Chronic Conditions and Self-Assessed Health		*Model with Residual on Chronic Conditions*	
	GP	*Inpatient*	*GP*	*Inpatient*
Overweight	€4,071,155 CI: €370,182.2 – €7,772,127		€9,621,882 CI: €6,082,772–€13,160,991	
Obese I	€2,671,958 CI: €930,469.6 – €4,413,445		€5,011,917 CI: €3,642,275–€6,381,553	
Obese II	€942,579 CI: €43,752.18 – €1,841,406		€1,950,618 CI: €1,440,715–€2,460,520	€23,982,589 CI: €3,706,199–€47,594,507
Obese III			€638,284.20 CI: €403,436.2–€873,131.9	

CI= 95 per cent confidence intervals.

For the non-significant marginal effects we do not estimate the costs and hence for the hospital categories in particular, no additional costs are estimated from the model with each of the chronic conditions and self-assessed health. Computing the costs for primary health care from the model with the residual on the chronic conditions we can see that this leads to an estimated total excess cost in primary health care of overweight and obesity of €17,222,700 (CI: €11,569,198–€22,876,196). For the hospital inpatient stays we use a similar formula, however we use the average unit cost for a hospital inpatient stay which takes into account the average number of nights spent in hospital. Based on this calculation the estimated cost of obesity related hospital inpatient care is €23,982,589 (CI: €3,706,199–€47,594,507). For the first model the mean value for GP costs tends to be lower for the higher BMI categories under this model. This suggests that collinearity between the BMI categories and chronic health conditions, which reflect the complex relationship between overweight and obesity and some of the chronic health conditions, may be creating downward pressure on our cost estimates. This is particularly evident in the case of hospital related costs. We must acknowledge that in the case of GP services, the three models tend to produce quite large confidence intervals for the costs associated with the overweight and obesity.

V SUMMARY AND CONCLUSIONS

This paper has analysed the impact of overweight and obesity on utilisation of both primary and secondary health care in the Republic of Ireland and derived an estimate of the additional cost associated with this. The impact of a number of other socio-demographic factors including access to medical cards and private insurance were also included to control for their impact on utilisation. In general our analyses highlighted the complex relationship between BMI and chronic health conditions. As noted BMI is endogeneous to certain serious health conditions, which is likely to result in greater need for health care. However, without a valid instrument it is very difficult to disentangle this impact. As a result we presented two model specifications which differ in their treatment of chronic health conditions. In one of these we include a residual on the number of chronic conditions, with the BMI related effect removed, on health-care utilisation.

Based on the results from the model specification with the residual of chronic conditions included we found that being overweight or belonging to any of the three obese categories led to a higher probability of visiting the GP in the previous year. For hospital utilisation, the pattern was not as clear cut. In the model specifications, we found that only individuals who fall into the severe obese category (Obese II) had a higher probability of attending the hospital as an inpatient. Potentially the non-significance of the extreme obese category (Obese III) reflects the small number of individuals in the sample who fall into this category and is thus an artefact of the data. It could though also be explained in terms of the ability of individuals' who are morbidly obese to tolerate health-care interventions and thus the use of services associated with them or a reluctance on the part of the service to engage with morbidly obese individuals until they have lost weight. For the hospital day procedure category we found no significant relationship between BMI and utilisation of this health-care service. This could reflect the fact that visits to hospital for a day procedure likely reflects aspects of service delivery – what can and is delivered in this manner rather than need per se. The findings highlight the impact that trends in overweight and obesity may have for the health service and the disproportionate impact these may have on GP services in particular. For our model in which each chronic condition is entered directly (Table 3) we found that the Obese Category III variable was not a significant predictor of GP utilisation and we found no significant relationship between any of the higher BMI categories and hospital utilisation. This suggests that some of the BMI related effects may be captured directly within the chronic health conditions and self-assessed health measure. We believe future work in this area would benefit from exploring these issues directly, potentially using an instrumental variable approach.

We found observed heterogeneity in utilisation among the higher BMI categories related to gender and older age. In addition, in terms of the obesity categories, we found some differences in terms of the significance of the interactions, so that for some of the obese categories and for some of the health-care services the interactions were significant while for others they were not. Findings in respect of other variables, private insurance, medical card status and several socio-demographic variables, similarly echo those of other authors who have examined utilisation patterns in Ireland (e.g. Madden *et al.*, 2005, Nolan and Nolan, 2008). That we found a positive and statistically significant relationship between GP visits and hospital inpatient stays and a significant and negative relationship between inpatient and day case services echoes the findings of McGregor and O'Neill (2007).

We acknowledge a number of potential limitations of this study. First, BMI in this study is based on self-reported measures of height and weight. As previously noted this could be biased if individuals systematically misreport their BMI status. However we do not consider this to be an issue on the basis of analyses of measured and self-reported BMI for the subsample where both measures are available. (Restricting the analysis to this reduced sample was not pursued here given the smaller sample size and the consequent impact on standard errors.) Second, we accept that the measures of utilisation used here are crude, being dichotomous in nature. Similarly, the measures used to generate health-care related costs are somewhat crude. Given that SLÁN does not collect information on frequency of usage for the GP and hospital day procedure cases our ability to model utilisation more precisely was limited. Similarly, in respect of costs, while we could attempt to increase the precision of estimates used by, for example, exploring the literature for information on length of stays associated with obesity related illnesses, the data available in SLÁN would still require us to make assumptions on the purpose of visits that would be open to question.

Notwithstanding these limitations and in line with the international literature we found additional health-care costs associated with overweight and obesity in the Republic of Ireland; more substantial than had been previously estimated for Ireland (Vellinga *et al.,* 2008). Given the limitations noted, as well as the absence from our calculations of various other health and social care services – prescribed and over the counter medicines, outpatient care, community care, long-term care etc. – and of young people from the survey (Layte and McCrory, 2011), the estimates produced here should be viewed very much as tentative lower bound estimates of the impact of obesity and overweight on health-care costs in Ireland. As recent trends highlight an increasing incidence of overweight and obesity, the results do though serve to underscore the importance of further work in this area given the likely implications for health-care budgets. In particular, and aside from the poorer health individuals who are overweight or obese may experience (and indeed the costs to society in terms of lost productivity associated with avoidable mortality and morbidity), these findings suggest that obesity presents a major economic as well as public health issue, that warrants greater attention.

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