The impact of GP supply on body mass index

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Summary

Background: There is conflicting evidence on the impact of primary care on obesity. The aim of this paper is to investigate whether primary care (GP supply) is associated with lower body mass index (BMI) using mixed level (area and individual) data for England.
Methods: Individual level BMI is regressed against health authority (HA) level GP supply (whole-time equivalent GPs per 1,000 population) plus individual and HA level covariates. We use OLS, 2SLS and mixed level IV models to examine the endogeneity of BMI and GP supply. Instruments are area level house prices and area population age structure weighted by age related capitation rates.
Findings: GP supply is endogenous. Compared to the OLS models, IV models show a much larger negative and statistically significant effect on BMI. Typically a 10% increase in GP supply is associated with a mean reduction in BMI of around 1 kg/m^2 (around 4% of mean BMI).
Interpretation: This study provides some evidence that better primary care in the form of reduced list sizes per GP can improve the management of obesity.

1. Background

Obesity is a rapidly growing health problem that affects an increasing number of countries worldwide (WHO 1998). In England in 1980 six per cent of males and eight per cent of females in England were obese; by 2003 the prevalence had trebled to 21 per cent and 24 per cent, respectively (Department of Health 2003). The growth in obesity is a serious cause for concern because as well as being a debilitating condition in its own right, obesity is an important risk factor for a number of major diseases including coronary heart disease, type II diabetes, osteoarthritis, hypertension and stroke (NHLBI 1998).

In the UK the treatment and prevention of obesity takes place mainly in primary care (National Audit Office 2001), though evidence on the effectiveness of this is sparse and mixed. Some commentators have argued that primary care interventions can reduce obesity. Finer (2003) suggests that the Counterweight Programme, for example, is effective in reducing the burden of obesity in the community (Finer 2003; Broom and Haslam 2004; Counterweight Project Team 2004a, 2004b; http://www.counterweight.org). On the other hand, a recent RCT found that offering practice teams a short training course in obesity management had little effect on patient weight (Moore et al, 2003). There have been few randomised controlled trials of primary care policies to reduce obesity (Harvey et al 1999). The House of Commons Health Committee argued that local GPs provide a unique resource for obesity management, but expressed concern that there is only limited prescribing of cost-effective obesity drugs, that specialist obesity services were commonly closed due to lack of funds, and that GPs and other primary care workers often prioritised other targets ahead of obesity (House of Commons Health Committee, 2004).

The aim of our paper is to use observational data to provide additional evidence on whether primary care interventions can reduce obesity. We do so by using very rich multi-level (individual and area) data to investigate whether, other things equal, individuals in Health Authorities with more GPs per head of population are less obese in the sense of having a lower Body Mass Index (BMI).

The approach we adopt is similar to that used in other multi-level studies to examine the overall effect of primary care on health. For example, Shi and Starfield (2000) found that individuals were more likely to report good health if they lived in states with more primary care physicians per capita, after controlling for gender, age, ethnicity, employment, wages, deprivation, heath insurance, physical health and smoking. The data were from a 1996 sample of 58,000 respondents clustered in 60 communities. Shi, Starfield, Politzer and Regan (2002) used the same data source but in addition made use of responses to questions about accessibility of primary care, interpersonal care and continuity of care. The results were similar to Shi and Starfield (2000) in that better primary care was found to be associated with better physical and mental health after controlling for a wide range of covariates.

This literature has been with concerned with general health rather than obesity and has not taken account of the endogeneity of primary care supply and health. We analyse the impact of the supply of GPs on individual BMI by regressing individual level BMI against Health Authority (HA) level GP supply and a large set of individual and HA level covariates. In our baseline model, like those most of those in the literature, we use OLS. The major problem with this approach is endogeneity: GP supply may be associated with unobserved factors which are also associated with BMI. Other things equal, GPs like to live and work in "nice" areas and such areas have unobserved characteristics which lead them to have populations with lower BMI. This could lead to a positive estimated effect of GPs on BMI even if GP supply has no true effect. On the other hand, there may be a negative bias. GP location decisions are also affected by the GP remuneration system. Some types of payment are related to the mix of types of patient and the composition of the patient population varies across areas. Examples include capitation payments related to the age of patients and their deprivation levels, fee per item payments for such things as night visits and flu vaccinations for high risk groups, and payments for meeting quality targets. Thus it is possible that there may be higher rewards per patient in areas with a greater mean BMI. Moreover until 2001 GPs' location decisions were regulated by the Medical Practices Committee which attempted to restrict entry to areas with a high ratio of GPs to population. Hence it is possible that GP supply could be positively or negatively associated with BMI whether or not GP supply has an impact on BMI.

To test and control for endogeneity we use instrumental variables (IVs). This relies on finding instruments for GP supply – observable characteristics that affect GP supply conditional on the covariates, and are not correlated with unobserved factors affecting individual BMI. Using two area-based instruments we estimate two-stage last squares (2SLS) and mixed level IV models to analyse the impact of GP supply on BMI.

2. Data and variables

2.1. Data sources

The main data source is the core sample of the Health Survey for England (HSE) 2000. The HSE is a nationally representative survey of individuals aged two years and over living in England. A new sample is drawn each year and respondents are interviewed on a range of core topics including demographic and socio-economic indicators, general health and psychosocial indicators, and use of health services. Additionally, there is a follow up visit by a nurse at which various physiological measurements are taken, including height and weight.

HA area level GP supply variables were constructed using the General Medical Services (GMS) database held by the National Primary Care Research and Development Centre (NPCRDC).[1] The database is a summary of data relating to GPs, their patients, partnerships and services for each registered general practice in England and Wales. A wide range of information is collected including the age and sex breakdown for each registered practice population, details of practice organisation such as staffing, list size, GP characteristics and details of service provision. We use data for six years from 1995-2000.

Additional area level data were assembled from three sources. First, we use the Allocation of Resources to English Areas (AREA) dataset for comprehensive data on deprivation and accessibility to health care services at the local authority (LA) ward level across England for the period 1996-2000 (Sutton et al., 2002; Gravelle et al., 2003). LA level data on crime rates in 2000 were obtained from the Neighbourhood Statistics branch of the Office for National Statistics,[2] and LA data on house prices for 2000 were obtained from the Land Registry.[3] The LA area level data were first converted to HA level based on 2001 HA boundaries. There were 95 HAs in England with a mean population of 515,517 residents (range 168,873 to 1,050,626). Mean values of the variables for each HA were computed based on the proportion of each LA

[1] http://www.primary-care-db.org.uk/
[2] http://www.neighbourhood.statistics.gov.uk/home.asp
[3] http://www.landreg.gov.uk/propertyprice/interactive/ppr_ualbs.asp

ward's population resident within the HA. The HA data were then linked to the individuals in the HSE sample via their recorded HA of residence.

2.2. BMI and GP supply

The dependent variable is BMI, measured as each HSE respondent's weight in kilogrammes divided by their height in metres squared (kg/m^2). This is computed from the height and weight measures obtained during the nurse visit. Thus BMI is not based on self reported height and weight, reducing the likelihood of systematic measurement error.

GP supply is computed at the HA level. The GMS data were first cleaned by removing all GPs in Wales, and all GPs working in practices with 100 patients or fewer. GP supply is measured for each year 1995-2000 as the number of WTE unrestricted principals or equivalents per 1,000 registered patients in each HA.

2.3. Covariates

We include a large number of other explanatory variables, grouped in three categories. (a) Individual demographic variables were gender, age, age squared and age cubed, plus interactions between age and gender. We also include ethnicity (nine categories), marital status (five categories), the number of infants living in the household aged zero or one year (three categories) and the number of children aged 2 to 15 year living in the household (seven categories). (b) Individual socioeconomic variables include equivalised household income, social class of the head of the household (eight categories based on the Registrar General's classification), the highest educational level achieved (seven categories), car ownership (four categories) and housing tenure (five categories). (c) Area level variables (forty six in all) include measures of deprivation, mainly from the Indices of Deprivation 2000 (ID2000). These include the proportion of the population receiving job seekers' allowance; the percentage of the population aged 17 or over not going to higher education; the proportion of attendance allowance claimants over 60 years; the proportion of income support claimants over 60 years; the proportion and standardised rate of incapacity benefit/severe disability allowance claimants; and the proportion and standardised rate of attendance allowance/severe disability allowance claimants (DTLR, 2000). We also had data on area crime rates, (separate rates for violent offences, sexual offences, robbery, burglary from a dwelling, theft of a motor vehicle, and theft from a motor vehicle) and twenty seven indictors measuring accessibility to health care in terms of waiting times for hospital services (acute, maternity, mental health, private health care, and outpatient services), the number of beds at local hospitals, distance to local hospitals, and the number of staff at local hospitals.

2.4. Instruments

We instrument GP supply using two HA level variables. The first candidate for an observable area characteristic likely to affect GP supply but unlikely to influence BMI directly conditional on the covariates is an index of house prices. These should affect the decision of GPs to locate in an area but are unlikely to be correlated with individual BMI directly, after controlling for other area characteristics such as deprivation and crime and the rich set of individual level covariates in the BMI regression model. A priori we expect a negative partial correlation between house prices and GP supply. After experimenting with combinations of the price of detached, semi-detached, terraced houses, and flats prices, we use the area semi-detached house price as it was the most significant predictor of GP supply conditional on the covariates.

The second instrument is the age-related capitation payment per head of population. GPs receive capitation fees which increase with the age of the patient for each patient on their list. The age bands are 0-64; 65-74; and, 75+. Age related capitation payments are a major component of GP income in England. We expect to find more GPs in areas where the population generate higher age-related capitation payments – that is, in areas where a higher proportion of the population are elderly, other things being equal. Although age may be correlated with BMI at individual level, we include individual age in the individual level BMI regression. It is difficult to think of any reason why the health of an individual patient, given their age and all the other individual and area factors included as covariates, should be correlated with the age structure of the area. The weighted average age-related capitation payment per person in area a in year t is computed as

$$\sum_{k=1}^{3} \frac{N_{ka}}{N_a} Q_{kt} \qquad (1)$$

where N_{ka} is the number of people in HA a in age band k, and Q_{kt} is the capitation payment for age band k in year t. The values of $Q_{.kt}$ were obtained for each year from 1995 to 2000 from the Statement of fees and Allowances Payable to General Medical Practitioners in England and Wales (Department of Health 2000). The proportion of the HA population in each age band was obtained for 2000 from the AREA dataset.

3. Estimation

3.1. Regression models

In the baseline non-IV models we use OLS to regress BMI against GP supply and the covariates. In the IV models we use two alternative approaches: (a) we estimate a GP supply equation at the individual level, regressing GP supply in each year against the two instruments plus the individual and area covariates. This yields predicted GP supply for each individual in each year and individuals in each area may have different predicted supplies. In the second stage individual BMI is regressed against individual predicted GP supply plus the individual and area covariates, with appropriate correction of the standard errors in the second stage. (b) In the second approach the first stage GP supply equation is estimated at the HA level to produce a predicted GP supply measure which is the same for all individuals in the HA. The second stage BMI equation is estimated at the individual level using OLS, and includes individual and area covariates as well as the HA predicted GP supply. The first approach is the standard 2SLS model. The second we label a 'mixed level IV' approach.

3.2. Modelling strategy

For each of the three modelling strategies (OLS, 2SLS, mixed level IV) we report six separate regressions, examining the effect on obesity in 2000 of the separate impact of GP supply measured in each year over the six year period 1995-2000, plus the covariates. In total we therefore report results for 3*6 = 18 BMI regressions.

3.3. Sample size and sampling issues

The total core sample size in the HSE in 2000 is 9,920. Excluding females who are pregnant (82 observations), and all individuals less than 18 years of age (2,159 observations), reduces the sample to 7,679. 920 of these observations are excluded because they have invalid BMI measures (due to "Height/weight/BMI not useable", 122 respondents, "Height/weight refused", 417 respondents, "Height/weight attempted but not obtained", 99 respondents, and "Height/weight not attempted", 282 respondents). This reduces the number of observations in the final estimation sample to 6,759.

In the 2000 core sample of the HSE the samples of children but not adults were deliberately boosted to include greater numbers of children. Since adult respondents were not over or under sampled each observation in the individual level models has a weight of unity in the regressions. Population weights are used in all HA models.

Following Moulton (1990), who demonstrates the pitfalls in failing to control for within area dependence when estimating the effects of area level variables on individual level outcomes, we adjust the standard errors in the individual level models to control for HA level clustering. This applies to the OLS models, both stages of the 2SLS models and the second stage of the mixed level IV models.

The HSE sample had missing values for the income variable (16% had missing values), and the ethnicity, social class, education, and car ownership variables (all < 1%). To maximise the sample size we impute missing values for these variables. In the case of income missing values were imputed using the linear prediction from a regression of the variable on the other covariates. For the remaining binary and categorical variables missing values are assigned to the omitted category. To allow for the possibility that items are not missing at random we include dummy variables for all imputed items to indicate item non response. We use this approach in preference to other methods for dealing with missing data, such as hotdecking, because in the sample items may not be missing at random. If the dummy variable is insignificant non-responders' employment is affected in the same way as the responders by the imputed variable and the imputation has increased sample size without biasing results. If the dummy variable is significant then responders and non-responders are affected in different ways by the variable and inclusion of the missing item dummy variable enables estimation of an effect for responders that is not contaminated by the imputation for non responders.

4. Results

4.1. Descriptive statistics

Table 1 contains population weighted health authority level summary statistics for WTE GPs per 1,000 patients over the period 1995 to 2000. From the top panel, in each year the mean value is similar, with around 0.5 WTE GPs per 1,000 registered persons, or one WTE GP for every 2,000 people. The similarity in the distributions suggests that GP supply varied little over the period. The bottom panel of Table 1 shows that the measures are highly positively correlated, and the correlation coefficient is statistically significant.

The sample distribution of BMI is in Table 2 and histograms for male and female BMI are in Figure 1. The mean BMI in the sample is 27 kg/m^2. Only 34% of the sample has a BMI within the range normally considered to be healthy (20 to 25 kg/m^2), while 22% and 6% meet the standard definitions of obesity (BMI over 30 kg/m^2) and morbid obesity (BMI over 35 kg/m^2), respectively. The mode BMI category is overweight (25 to 30 kg/m^2), containing 40% of the sample.

4.2. GP supply equations

The key results from the GP supply equations are in Table 3 which reports the coefficients and the individual and joint significance of the two instruments on GP supply in each year conditional on the covariates. The top panel shows the results from the individual level analysis used in the first stage of the 2SLS models. The bottom panel shows the results from the area level analysis used in the mixed level IV models. In all cases the instruments have the expected sign (mean age-related capitation payments have a positive impact on GP supply and house prices have a negative effect), and are individually and jointly significant. The coefficients are of a similar order of magnitude in the two sets of models, though their significance is greater in the individual level analyses. This is unsurprising given the number covariates and the relatively small sample size in the area level models.

4.3. BMI equations – impact of GP supply

The key results from the BMI equations are in Table 4. The coefficients on the GP supply variable and the related t-statistics/z-scores are reported. The elasticity of BMI with respect to changes in GP supply is also presented, computed at the sample mean.[4] The table also reports the explanatory power of the OLS models and the second stage of the mixed level IV models. In the 2SLS models we report the results of Hansen J tests of overidentifying restrictions (a p-value < 0.05 casts doubt on the validity of the instruments) and Hausman F tests for exogeneity (a p-value < 0.05 indicates that IV estimators should be used in preference to OLS estimators).

Conditional on the covariates, the non-IV results indicate that GP supply has a negative but generally weakly significant effect on BMI (the coefficients are significantly different from zero at the 5% level when the absolute value of the t value or z score exceeds 1.9, and at the 10% level when it exceeds 1.6). In contrast, the IV models (2SLS and mixed level IV) show a negative and significant effect in all cases. The overidentifying restrictions tests indicate that, insofar as it can be tested empirically, the instruments are not correlated with the error term in the BMI equation. The exogeneity tests indicate that IV models should be preferred to the non-IV models.

There is little variation in the coefficients on the GP supply variable and their statistical significance across years. Presumably this is due to the fact the GP supply varied little over the time period considered, as evidenced from Table 1.

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[4] The estimated BMI equation is of the form $y_i = \delta g_i + \beta x_i$ where *y* is BMI, *g* is GP supply, *x* is a set of other covariates, δ and β are estimated coefficients, and *i* indexes individuals. The elasticity is $(dy/dg)g/y = \delta g/y$, which is estimated at the sample mean values of *g* and *y*.

In terms of the magnitude of effect in the IV models, the elasticities indicate that a 10% increase in GP supply is correlated with a 3.6%–4.7% decrease in BMI in the 2SLS models, depending on the year, and a 3.6%-4.8% decrease in the mixed level IV models. Note the similarity in the magnitude of effect between the two IV approaches. At the sample mean values, the elasticities translate into a mean reduction in BMI of around 1 kg/m^2 (≈26.838*0.04) following a 10% increase in GP supply.

4.4. BMI equations – impact of the covariates

Table 5 presents coefficients on selected covariates from one of the BMI regressions – the mixed level IV model with GP supply in 2000 plus the full set of covariates. Results in the other BMI regressions are very similar. Age has a non-linear effect on BMI in both sexes. Figure 2 plots predicted BMI against age for both sexes using the coefficients in Table 5. Conditional on the other covariates, there is an inverse U-shape between BMI and age for both males and females. For males BMI and age are positively correlated up to around 50 years of age and negatively correlated thereafter. For females the turning point occurs at around 60 years of age.

Income has a negative effect but insignificant on BMI. Relative to the professional classes, other social classes have on average a higher BMI, with a significant effect in the semi-skilled manual group. Those who are less well educated are found to have significantly higher BMI, with the biggest effect in those with no qualifications. Some Black groups have significantly higher BMI than Whites, while those in Indian, Pakistani, Bangladeshi and Chinese groups have lower BMI, all else equal. Individuals who are married, separated or widowed have higher BMI than those who are single. The coefficients on the other variables not reported in the table are in the main insignificant.

5. Concluding remarks

In this paper we investigate the impact of GP supply on BMI in England. We use a regression based approach and data containing a rich set of individual and area variables. Using IVs to control for endogeneity we find that GP supply has a statistically significant and negative effect on BMI: on average, a 10% increase in GP supply (around 2,500 WTE GPs at current levels) is associated with a mean reduction in BMI of around 1 kg/m^2.

The impact of GP supply in the IV models is more negative than in the non-IV models, which suggests that unobserved heterogeneity leads to an underestimation of the negative effect of GP supply on BMI. This indicates that there are omitted variables that are positively correlated with both GP supply and BMI. For example, it may be that GPs are influenced by financial incentives that encourage them to locate in areas which have high BMI.

There are some limitations to our study. Although we find evidence of a negative relationship between GP supply and BMI we cannot provide any information on the precise mechanisms by which increases in GP supply might reduce BMI. Do GPs have more time to spend on the management of obese patients? Do they change their methods of management? Is increased provision of GPs merely a proxy for increased provision of other members of the primary care team, such as nurses and dieticians, who may have more impact on BMI. Data limitations preclude us from investigating these issues: the HSE asks respondents about their use of GP services only in the previous two week period and does not contain information on the quality of services provided. The GMS GP workforce census has little reliable information about skill mix in general practices.

There is conflicting evidence of the impact of primary care on obesity. The above limitations notwithstanding, this study provides some support for the view that primary care provision can affect the management of obesity.

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Table 1. Summary statistics on the GP supply measures

	1995	1996	1997	1998	1999	2000
Distributions						
Observations	95	95	95	95	95	95
Mean	0.503	0.500	0.502	0.502	0.505	0.501
Std. Dev.	0.033	0.034	0.034	0.034	0.030	0.033
Minimum	0.432	0.432	0.430	0.436	0.449	0.431
1st percentile	0.432	0.432	0.442	0.443	0.449	0.446
5th percentile	0.461	0.451	0.451	0.455	0.468	0.454
10th percentile	0.465	0.464	0.456	0.460	0.472	0.460
25th percentile	0.480	0.476	0.481	0.481	0.484	0.481
Median	0.498	0.497	0.496	0.496	0.500	0.495
75th percentile	0.523	0.522	0.517	0.517	0.519	0.517
90th percentile	0.548	0.548	0.556	0.555	0.559	0.553
95th percentile	0.567	0.567	0.569	0.573	0.566	0.567
99th percentile	0.591	0.593	0.592	0.587	0.578	0.580
Maximum	0.591	0.593	0.595	0.594	0.598	0.596
Correlation coefficients						
1996	0.982*	1.000				
1997	0.964*	0.979*	1.000			
1998	0.952*	0.969*	0.986*	1.000		
1999	0.899*	0.911*	0.921*	0.933*	1.000	
2000	0.932*	0.942*	0.955*	0.966*	0.918*	1.000

* $p<0.00001$

Table 2. Summary statistics on the obesity measures (observations = 6,759)

Variable	Mean	Std. Dev.
BMI (kg/m^2)	26.838	4.903
BMI < 20	0.045	0.208
20 ≤ BMI < 25	0.343	0.475
25 ≤ BMI < 30	0.395	0.489
30 ≤ BMI < 35	0.156	0.363
35 ≤ BMI < 40	0.045	0.207
BMI ≥ 30	0.217	0.412
BMI ≥ 35	0.060	0.238
BMI ≥ 40	0.016	0.124

Table 3. The impact of the instruments on GP supply

	1995		1996		1997		1998		1999		2000	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Individual level analysis [1]												
Mean age-related capitation payment	0.089	5.60	0.102	6.83	0.107	7.49	0.100	6.55	0.078	5.83	0.070	4.79
Semi-detached house price / 100,000	-0.010	-3.47	-0.010	-3.50	-0.013	-3.87	-0.014	-3.70	-0.017	-4.89	-0.012	-4.08
F-test instruments = 0 [p-value]	22.34 [<0.001]		33.00 [<0.001]		41.69 [<0.001]		32.04 [<0.001]		36.07 [<0.001]		19.61 [<0.001]	
N	6,759		6,759		6,759		6,759		6,759		6,759	
R^2	0.9103		0.9099		0.9087		0.8893		0.8648		0.8638	
Area level analysis [2]												
Mean age-related capitation payment	0.088	3.84	0.097	4.15	0.103	4.51	0.094	3.80	0.074	3.31	0.065	2.75
Semi-detached house price / 100,000	-0.010	-1.98	-0.010	-1.89	-0.012	-2.34	-0.013	-2.25	-0.017	-2.96	-0.012	-1.95
F-test instruments = 0 [p-value]	9.07 [<0.001]		10.11 [<0.001]		12.53 [<0.001]		9.46 [<0.001]		9.52 [<0.001]		5.50 [0.007]	
N	95		95		95		95		95		95	
R^2	0.9102		0.9061		0.9034		0.8840		0.8587		0.8593	

[1] Individual level covariates are also included for age, gender, income, car ownership, social class of head of household, educational attainment, ethnic group, marital status, housing tenure, number infants 0 to 1 years in household, number children 2 to 15 years in household, and item non-response. Area level covariates are also included that measure crime rates, deprivation, and the supply of health services. In all the models the standard errors are adjusted for area level clustering.

[2] Area level covariates are also included that measure crime rates, deprivation, and the supply of health services.

Table 4. The impact of GP supply on BMI (kg/m^2)

	OLS				2SLS					Mixed level IV			
GP supply	Coef.	t	Elast.	R^2	Coef	z	Elast.	Hansen J test [p-value]	Hausman F-test [p-value]	Coef.	t	Elast.	R^2
1995	-2.665	-0.75	-0.050	0.0923	-25.303	-2.73	-0.476	1.23 [0.27]	7.43 [0.01]	-26.025	-3.48	-0.489	0.0932
1996	-5.584	-1.70	-0.105	0.0925	-22.024	-3.04	-0.413	1.06 [0.30]	5.82 [0.02]	-23.543	-3.58	-0.441	0.0933
1997	-6.100	-1.93	-0.115	0.0926	-19.463	-3.08	-0.365	1.69 [0.19]	5.36 [0.02]	-20.350	-3.48	-0.382	0.0932
1998	-5.493	-1.91	-0.103	0.0925	-19.547	-3.03	-0.368	2.1 [0.15]	4.77 [0.03]	-20.829	-3.36	-0.391	0.0932
1999	-4.702	-1.54	-0.089	0.0925	-19.106	-2.78	-0.361	3.3 [0.07]	4.55 [0.03]	-19.384	-2.81	-0.366	0.0930
2000	-5.420	-1.61	-0.102	0.0925	-23.337	-2.85	-0.438	2.27 [0.13]	4.51 [0.03]	-24.548	-3.14	-0.460	0.0931

The number of observations in every model is 6,759.

In all the models individual level covariates are also included for age, gender, income, car ownership, social class of head of household, educational attainment, ethnic group, marital status, housing tenure, number infants 0 to 1 years in household, number children 2 to 15 years in household, and item non-response. Area level covariates are also included that measure crime rates, deprivation, and the supply of health services.

In all the models the standard errors are adjusted for area level clustering.

Table 5. The impact of selected covariates on BMI (kg/m^2)

Covariates	Coef.	t
GP supply (2000)	-24.548	-3.14
Age/100	44.702	5.03
Age/100 squared	-67.412	-3.78
Age/100 cubed	29.462	2.65
Female	3.369	1.66
Female*Age/100	-33.125	-2.49
Female*Age/100 squared	74.503	2.76
Female*Age/100 cubed	-47.265	-2.75
Income/100,000	-0.396	-1.1
Social class of head of household [1]		
II Managerial/technical	0.023	0.09
IIIn Skilled non-manual	0.169	0.52
IIIm Skilled manual	0.347	1.11
IV Semi-skilled manual	0.691	2.18
V Unskilled manual	0.556	1.24
Other	0.848	1.76
Education [2]		
Higher education less than a degree	0.452	1.92
A level or equivalent	0.339	1.51
GCSE or equivalent	0.480	2.26
CSE or equivalent	0.574	1.92
Other qualification	0.291	0.91
No qualification	0.843	3.29
Ethnic group [3]		
Black Caribbean	1.644	3.2
Black African	-0.730	-0.75
Indian	-1.078	-3.42
Pakistani	-1.081	-1.99
Bangladeshi	-2.277	-3.79
Chinese	-2.240	-2.63
Other non-white ethnic group	-0.081	-0.2
Marital status [4]		
Married	1.158	5.72
Separated	0.850	1.87
Divorced	0.368	1.26
Widowed	1.145	3.73
Observations	6,759	
R^2	0.0931	

[1] The omitted category is I Professional. [2] The omitted category is Degree. [3] The omitted category is White. [4] The omitted category is Single.

Individual level covariates are also included for housing tenure, car ownership, number infants 0 to 1 years in household, number children 2 to 15 years in household, and item non-response. Area level covariates are also included that measure crime rates, deprivation, and the supply of health services.

Figure 1. Distribution of BMI (kg/m^2) for males and females

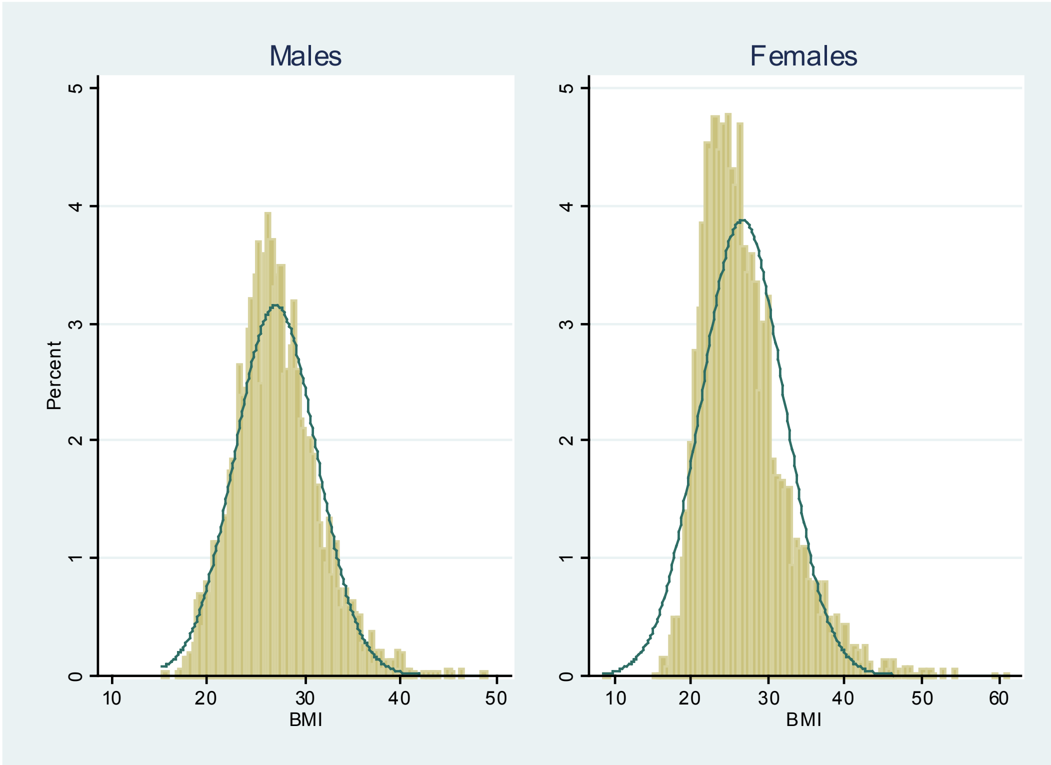

Figure 2. Conditional impact of age on BMI (kg/m^2)