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Going the same 'weigh': spousal correlations in obesity in the UK

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Heather Brown*, Arne Risa Hole[$], Jennifer Roberts[$]

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1. Introduction

The UK, along with many developed nations, has seen a significant rise in obesity rates over the last few decades. The Health Survey for England 2008 revealed that 66% of men and 57% of women were obese or overweight (Craig et al, 2008). The causes of obesity are still not completely understood and it is likely that the current obesity epidemic cannot be explained solely by genetic factors. Rising obesity rates have been partially attributed to environmental factors as well as technological change and innovations which have led to a more sedentary lifestyle, increased intake of calorie dense foods and a subsequent energy imbalance (Philipson and Posner 1999, Peters 2003, Jeffery and Utter 2003, Lin et al. 2004).

There is also increasing interest in the extent to which obesity may spread via social networks. This is important from a policy perspective because it sheds light on whether policies to tackle obesity are better targeted at individuals or households, or even better implemented via external organisations such as schools or in the workplace.

Using data on a US adult population, Christakis and Fowler (2007) found that social networks significantly impact on the likelihood of becoming obese. However, Cohen-Cole and Fletcher (2008) claim using data from an adolescent population in the US that after controlling for contextual factors such as the local environment, social networks are no longer a significant determinant of obesity. It is likely that age may impact on the importance of social networks and in addition the influence of social networks may differ by country. This paper attempts to build on the previous work by investigating the mechanisms behind spousal correlations in body mass, using longitudinal data on adults in the United Kingdom. We advance the methodology used in the previous work on body mass by allowing for correlation in unobservables across spouses both via correlation in idiosyncratic errors and time invariant individual effects, after controlling for a number of individual, household, and environmental factors.

To understand spousal[1] correlations in body mass we adopt the Manski (1993) approach used in Christakis and Fowler (2007). Firstly, individuals may choose to marry someone with similar characteristics as described in the theory of assortative matching proposed by Becker (1974). This is analogous to correlated effects in Manski's terminology. Secondly, correlations in body mass between partners may be observed because they share the same environment, or contextual factors. For example, spouses face the same local prices and food choices. This is equivalent to the exogenous effects described by Manski (1993); although the term exogenous is misleading because couples may choose their living environment according to their lifestyle preferences. The important distinction is between the effects of this shared environment and the last factor by which the propensity of an individual to behave in a certain way may vary with the behaviour of their spouse; this is social influence. Similar consumption patterns which develop over the marriage or spousal behaviours and attitude about weight may lead to correlations in body mass. This is what Manski (1993) refers to as

[1] Spouse and partner are used interchangeably to refer to heterosexual couples who are legally married or cohabiting. Same sex couples are not included in our analysis due to small sample sizes in our data.

endogenous effects. These three factors are not necessarily mutually exclusive and all three may contribute to correlations in body mass between spouses.

To investigate these phenomena we use the 2004 and 2006 waves of the British Household Panel Survey (BHPS) to analyse the correlation in body mass between spouses. These two waves are the only ones to date in which information on height and weight is available, enabling calculation of Body Mass Index (BMI). BMI is the standard measure used to assess and grade obesity (World Health Organisation, 2000). BMI is calculated as weight in kilograms divided by height in metres squared. Individuals are classified as obese if their BMI is 30 kg/m^2 or greater, and overweight if their BMI is between 25 and 30 kg/m^2.

We use a number of econometric specifications to shed light on the mechanism behind spousal correlations in BMI. This paper is organised as follows. Section 2 discusses the relevant literature. Section 3 describes the theoretical framework which informs the empirical analysis. Section 4 outlines the data and econometric approach. The results and discussion are presented in Section 5. Finally, Section 6 concludes.

2. Previous Literature

There is an extensive literature examining various areas of spousal correlation, including education (Mare 1991, Pencavel 1998, and Qian 1998), health (Wilson 2002), lifestyle characteristics such as drinking habits (Leonard and Mudar 2003), and smoking patterns (Clark and Etile 2006). However, spousal correlations in BMI have not been widely studied, largely due to a lack of suitable data. Sahn and Younger (2009) look at intra-household BMI as a measure of well-being and inequality in developing countries.

In a similar context to the aims of this paper, Christakis and Fowler (2007) examine how spousal interactions influence the likelihood of becoming obese using US data. Their analysis uses a cohort from the Framingham Heart Study (1971-2003), identifying 5124 core adult respondents (termed ‘egos’), and 12,607 individuals connected to the respondent in some way (termed ‘alters’). Christakis and Fowler (2007) adapt Manski’s (1993) approach to explain social interactions, arguing that correlations in obesity can be determined by: 1) shared individual characteristics; 2) a shared environment; and 3) social influences. They test these hypotheses by analysing the effects of friendship, family, and marital relationships on obesity. Results for married couples indicate that if one spouse became obese the likelihood of the other spouse becoming obese increased by 37%. This effect was found to be relatively symmetrical for men and women.

Cohen-Cole and Fletcher (2008) use US information from the nationally representative Add Health dataset for 12 to 18 year olds in 1994/1995. They attempt to address some of the weaknesses of Christakis and Fowler (2007) by distinguishing between shared environment and social influence through the addition of time invariant environmental factors and time variant school specific factors. They find that shared environment, rather than social influence, explains the majority of the correlation in friends' likelihood of being obese.

Our paper makes a number of important contributions to the literature. Firstly, we focus on spousal correlations in BMI to try and distinguish between shared individual characteristics, social influence and shared environment. Secondly, we use UK data; there are large differences in the built environment and lifestyles in the US and UK which may impact on the results. Thirdly, the majority of the explanatory variables used in the analysis are demand side variables such as individual characteristics, labour market status and health. The economic literature that has examined the causes of obesity (for example Lakdawalla and Philipson 2002, Chou et al. 2004, and Rashad et al. 2006) has primarily focused on supply-side factors. Finally, our econometric approach allows for unobserved individual effects, and correlation between spouses both in these individual effects and in the stochastic error terms from the individual BMI equations; this issue has been neglected in the previous literature on body mass, and here we build on the work of Clarke and Etile (2006) who allow for correlated unobservable effects in their analysis of spousal smoking behaviour.

3. Theoretical Framework

This paper adopts the framework of Manski (1993) to explain correlated outcomes within a group. Following, Christakis and Fowler (2007) we apply this general framework to examine explanations for spousal correlations in BMI, which fall into three possible categories: 1) shared individual characteristics; 2) social influences and 3) contextual factors.

Hypothesis 1: Shared individual characteristics

Spousal correlations in BMI may be the result of spouses sharing similar individual characteristics which arise due to assortative mating in the marriage market (Becker, 1974). Becker's theory of marriage is based upon the gains of partnership accruing to two rational individuals. Each individual has a set of observable individual characteristics such as body mass and smoking status which signal general preferences over other activities and goods such as eating healthy food, exercising, and socialising. These characteristics can then be combined with the characteristics of potential partners to produce household commodities.

In relation to BMI, three types of assortative mating might arise. Firstly, couples may sort according to variables that indirectly affect BMI, such as education, health, and socioeconomic status. Secondly, body mass can signal preferences for other lifestyle characteristics such as exercise behaviour, diet and alcohol consumption. Contoyannis and Jones (2004) found that healthy and unhealthy lifestyle characteristics tend to cluster in individuals. An individual may then choose a partner who enjoys similar activities to maximise the household production function. It is also possible that BMI may act as an observable signal for less easily observed characteristics such as future health and potential life expectancy. Risk aversion to time spent alone in widowhood will result in preferences for partners whose life expectancy will match one's own (Clark and Etile 2006). Finally, individuals may have direct preferences over appearance and thus match directly on BMI.

Hypothesis 2: Social Influence

Spousal correlations in BMI may arise from sharing common lifestyles that emerge during marriage (as opposed to characteristics that are present pre-marriage, as in assortative mating). For example, spouses are likely to have meals together and buy joint groceries leading to similar food consumption patterns. In addition there may be an element of social learning within marriage where an individual’s BMI may be directly influenced by the behaviours of their spouse. For example, BMI related health problems in one spouse may prompt the partner to try and lose weight. Also, spousal attitudes towards BMI may influence an individual’s attitude towards weight maintenance and the ‘ideal’ weight. Oswald and Powdthavee (2007) theorise about the contagious effects of obesity; if your neighbour becomes obese, it is more socially acceptable for you to gain weight as well. This fits within the general literature relating to local norms (see for example Clark (2003) on unemployment and Luttmer (2005) on wellbeing). Social norms influencing behaviour can be used to explain how if one spouse becomes heavier, the other partner may change their perception of an ‘ideal’ weight causing their weight to increase also.

Hypothesis 3: Shared Environment (Contextual Factors)

Correlations in spousal BMI may also be caused by contextual effects, arising because married individuals share the same environment. Access to outside space, sports facilities, as well as shops and other amenities within walking distance may impact on BMI (Egger and Swinburn 1997). For example, if there are few opportunities for local physical activity, individuals may be less likely to exercise on a regular basis which could lead to weight gain. The number of fast food outlets in the local area may also influence BMI. If cheap unhealthy food is readily available individuals may choose to save time by purchasing food from these outlets rather than consuming healthier time intensive home cooked meals. Jeffery et al. (2006) found that eating at fast-food restaurants was positively associated with BMI; however, proximity to fast-food restaurants was not associated with an increased likelihood of eating at these outlets. The extent to which these factors are seen as exogenous or endogenous depends on whether individuals exercise these preferences in their choice of home location. However, the important theoretical distinction is between these contextual effects and the direct influence of one spouse's behaviour on the other spouse as described in Hypothesis 2.

4. Data and econometric method

We use data from waves 14 and 16 (2004 and 2006) of the British Household Panel Survey (BHPS), the only two waves to date which enable calculation of BMI. The BHPS is an annual longitudinal study which started in 1991 with approximately 5000 nationally representative private households, where individuals aged 16 or older are surveyed. Additional samples of 1500 households for both Scotland and Wales were added in 1999, and 2000 households in Northern Ireland in 2001. The BHPS questionnaire covers a wide range of topics ranging from employment status, wages, various health measures, and education.

For the empirical analysis, we use a sample of couples who remain together during the period 2004-2006, and for whom information on both partners are available. The sample is restricted to individuals of typical working age (18-65). The sample consists of 2927 couples in each wave who have valid height and weight data. While it is possible that this balanced sample is not representative of all couples, since some will separate during the period of analysis, we do not feel this attrition will pose a serious problem over the short period in question.

4.1 Body Mass Index (BMI)

BMI is computed from self-reported height and weight which may be prone to measurement error. A follow up BHPS question reveals that a majority of men and women are 'fairly sure' about their weight measurement. As a validity check, approximately 20% of men and 24% of women respondents in the BHPS are classified as obese (BMI ≥ 30) compared to 24% for both genders in data taken from the Health Survey of England (HSE) 2007, where height and weight measures are obtained by a nurse. Given the similarities in proportions of obese individuals in these samples and the self-declared accuracy of the weight measure, it is likely that measurement error should not significantly impact the results.

The distribution of BMI for men and women is shown in Figures 1a and 1b and summary statistics are in Table 1. Mean BMI for men is 27.2 and for women 26.1, thus mean BMI for both sexes is in the 'overweight' classification (WHO, 2000). 22% of men and 19% of women, have a BMI of more than 30, therefore are classified as obese. Mean BMI increases slightly for both sexes from wave 14 to 16. The raw correlation in partners' BMI is ρ= 0.210 (p = 0.000); the correlation is very similar in waves 14 and 16 (0.212 and 0.207 respectively).

4.2 Econometric method

Three different estimators and a number of different specifications are used to distinguish between the different explanations for spousal correlation in BMI discussed in Section 3. The general specification is shown in equations (1a) and (1b). In most specifications zero restrictions are placed on a number of parameters and these are discussed further below.

$$BMI_{it}^{M} = b^{M} X_{it}^{M} + g^{M} H_{it}^{M} + d^{M} H_{it}^{F} + f^{M} D_{it} + j^{M} D_{it} H_{it}^{F} + J^{M} R_{it} + q^{M} BMI^{F} + v_{it}^{M} \qquad (1a)$$

$$BMI_{it}^{F} = b^{F} X_{it}^{F} + g^{F} H_{it}^{F} + d^{F} H_{it}^{M} + f^{F} D_{it} + j^{F} D_{it} H_{it}^{M} + J^{F} R_{it} + q^{F} BMI^{M} + v_{it}^{F} \qquad (1b)$$

The *M* and *F* superscripts denote male and female spouse respectively; variables are observed for individual *i* and time *t*. The dependent variable is *BMI* in kg/m^{2}; in some specifications spouse *BMI* is also included as an explanatory variable. *X* is a vector of individual characteristics which includes age in years, age squared, presence of pre-school age children, highest educational attainment, employment status and the log of household income[2].

[2] Some of the elements of *X* are measured at the household level (for example household income), hence will not vary for M and F, but for ease of exposition *X* is described as a vector of individual characteristics.

Education, which is usually determined before marriage, acts as an important signal to potential partners. The empirical literature has mostly found positive assortative mating on education (Mare 1991, Pencavel 1998, and Qian 1998). If higher levels of education increase health knowledge, it is possible that those with more education may be more likely to engage in weight maintaining activities, after controlling for individual time preferences. Dependent children will influence how parents allocate their time between market work, non-market work, and leisure. Numerous studies have found that the number of children significantly impacts on how much time parents devote to exercise (Verhoef and Love 1992, Strenfeld et al. 1999, and Cody and Lee 1999). Employment status will affect how much time is spent participating in active leisure or home production such as cooking meals. Chou et al. (2004) hypothesised that the rise in female labour supply since the 1970s, coupled with the growing availability of restaurants and other alternative sources of cheap food increased the likelihood of being obese.

H is a vector of health variables comprising a set of dummy variables for the presence of twelve specific health problems (see Appendix 1). There are two separate health variable vectors, one for own health and one for spouse health. If an individual chooses a spouse based upon lifestyle characteristics that influence health and BMI, such as preferences for exercise, eating healthy food, and smoking status it is likely that spouses' health will be correlated and this may indirectly influence individual BMI (see Wilson 2002). There is substantial evidence from the medical literature (for example, Must et al. 1999, Mokdad et al. 2003, and WHO 2006) that increasing BMI is associated with higher morbidity. Thus, it is likely that those with a higher BMI are more likely to be in poor health, hence there is simultaneous causation between health and BMI.

D is a variable measuring duration of marriage in years. *D.H* is a vector of dummy variables representing the interaction of marriage duration with spouse health problems. These two variables help us to consider the influence of social learning. *R* is set of dummy variables denoting region of residence; this is an attempt to control for supply side factors. *v* is the error term.

A complete list of the variables used in this analysis are presented in Appendix A and descriptive statistics for all variables are shown in Table 1.

The three estimators are as follows.

Model A: a seemingly unrelated regression (SUR) allowing for correlation of the errors (v_{it}) from the male and female equations (1a and 1b). For this model q is always restricted to zero i.e. spouse BMI does not appear as an explanatory variable.

Model B: individual RE models estimated separately for males and females. This model does not allow for correlation of the errors across males and females, however q is not restricted to zero so spouse BMI is included as an explanatory variable. The errors from each equation are decomposed into an individual specific time invariant random effect (RE) $m_{i,}$, plus an idiosyncratic error term e_{it} as shown in equation (1c).

$$v_{it}^{M(F)} = m_i^{M(F)} + e_{it}^{M(F)} \qquad (1c)$$

Model C: This is the most general specification, a SUR model with RE, which decomposes the error as in (1c), and allows for correlation in both idiosyncratic errors (e_{it}) and individual effects (m_{it}) across males and females. As is the case for Model A, for this model q is always restricted to zero. All of the models are estimated via maximum likelihood using the *xtreg* and *xtmixed* estimators in STATA v10.

For each model we also estimate specifications with six different subsets of explanatory variables: (1) A basic specification including only a vector of individual characteristics X; (2) as (1) plus a vector of own health variables (H); (3) as (2) plus a vector of spouse health variables (H^F in 1a and H^M in 1b); (4) as (3) plus a variable for duration of marriage (D); (5) as (3) plus a vector of dummy variables representing the interaction of marriage duration with spouse health problems ($D.H$); (6) all the above the above are estimated with and without regional dummy variables (R).

For each specification Models A and B are tested as restrictions on Model C using a likelihood ratio test. Relating these specifications to the three hypotheses outlined in Section 3, firstly Clark and Etile (2006) explain that the type of information exchange implied by social influences is difficult to measure, and show that correlated information can be allowed for by using correlated errors (i.e. correlated unobserved contemporaneous shocks) in individual male and female BMI equations, such as in Model A. Allowing for correlated stochastic errors is also interpreted as allowing for shared unobserved behaviours such as the propensity to exercise or eat unhealthy food. In addition to this, in our uncorrelated estimators we include spouse BMI directly as an explanatory variable and we also test for social learning by including partner health and duration of marriage variables in an individual's BMI equation.

In Model B individual effects are allowed for, if these are important then there are unobserved time invariant effects on BMI after conditioning on our observed variables. The implication of assortative mating is that the matching occurs on individual characteristics that are present prior to marriage. As Clark and Etile (2006) point out, this implies correlated random effects in male and female BMI equations. Allowing for correlated individual effects can also be thought of as controlling for selection into partnerships. Model C allows for the individual effects to be correlated across spouses, and if this is significant it is evidence of assortative matching leading to correlation in BMI. If the errors in Model C are also correlated this is evidence that social influences and/or contextual factors, beyond those we observe, also lead to correlation in BMI.

It is important to note that it is difficult empirically to distinguish between contextual factors and unobserved endogenous effects, so in practice Hypotheses 2 and 3 are difficult to separate. As Cohen-Cole and Fletcher (2008) explain

> "without detailed information on individual characteristics, choices, preferences and environment, it is difficult to discern whether two friends' simultaneous weight gain is attributable to their friendship or to an exposure of a common environmental factor" (p. 1384).

We accept this point but also argue that the distinction between the two effects is somewhat philosophical; the fact that two people are subject to a common environment may be an implicit result of their relationship i.e. of shared preferences or behaviours. Empirically, our emphasise will be on the demand-side but we can allow for these contextual (supply-side) factors by accounting for local geographic effects in male and female BMI equations. Correlation in time invariant contextual effects is also allowed for by the inclusion of random effects in Model C.

It is possible when modelling BMI in equations (1a) and 1b) that some of the explanatory variables will be endogenous due simultaneous causation and/or unobserved effects that influence both the dependent and explanatory variables. This will lead to an upward bias in the estimated effects of the endogenous variable on BMI. For example, the medical literature (Must et al. 1999, Mokdad et al. 2003, WHO 2006) shows a clear link between obesity and health suggesting that health and BMI may be endogenously related. We attempt to ameliorate these endogeneity problems by including a rich set of conditioning variables as well as individual effects. We also estimate models with and without own health in order to investigate the effects on the remaining coefficient estimates. In addition, our focus is not on the causal effect of the explanatory variables on BMI, but rather it is on the correlation between spouse BMI, and whether or not this remains depending on the choice of conditioning variables, and also whether these correlations can be attributed to correlated errors or individual effects.

5. Results and discussion

For ease of exposition we do not report the results for the regional dummy variables. All of the specifications 1. to 5. described in section 5. are estimated with and without a set of seventeen regional dummies, where inner and outer London are the excluded category. Most of the dummy variables have insignificant coefficient estimates, however Wales, Northern Ireland and in some cases Scotland, have a positive and significant coefficient in both male and female equations suggesting higher mean BMI in these regions; this significance remains even after we have conditioned on all other observed effects. Exclusion of the regional dummies has virtually no effect on the coefficient estimates of the included variables, so in the results reported in Tables 2 to 4, regional dummy variables are included but not reported.

Looking across Tables 2 to 4 there are a number of points to note. Firstly, wherever correlated errors are allowed (corr_e in Models A and C) this correlation is positive and significant suggesting social influence as a cause of correlation is spouse BMI. Secondly, where equations have individual random effects these are significant and account for more than 90% (ρ for Models B and C) of the overall variance in m_i and e_{it} from equation (1c). Thirdly, in Model C, which allows for the individual effects to be correlated, this correlation is positive and significant (corr_u), suggesting positive assortative matching. Finally, where spouse BMI is included as an explanatory variable (all versions of Model B), this is positive and significant; the effect of spouse BMI is slightly larger for females than males.

Table 2 reports the results of the baseline specification 1., containing only individual characteristics (*X*). For men, age and age squared are significant suggesting a non-linear relationship with BMI initially increasing (up to around age 55 to 65 years) and then decreasing. Also being employed is associated with lower BMI. These individual characteristics remain significant across all of the specifications reported here. For women, education is significant in Model A, with all levels being associated with lower BMI, compared to the baseline of no qualifications. Only degree level education remains significant once individual effects are introduced in Models B and C. Having pre-school age children is also associated with lower BMI in Model A but again this effect goes when individual effects are introduced.

Table 3 also includes own health (*H* in specification 2.) For men having a problem with the *heart or blood pressure* and having *diabetes* are both associated with higher BMI; suffering from *anxiety and depression* and *migraine* are both associated with lower BMI. These effects remain across all three Models A to C, although the size of the effects is reduced in Models B and C which include individual random effects. Problems with *arms, legs and hands* are significant in Model A but this disappears when individual effects are included. For women, problems with *chest and breathing, heart or blood pressure, diabetes* and *epilepsy* are all associated with higher BMI across all three models, and again the quantitative importance is reduced when individual effects are included.

Table 4 also includes spouse health problems ($H^{M(F)}$ in specification 3.); the effects of own health remain largely unaffected by the inclusion of spouse health. For men, Model A suggests that the spouse having problems with *heart or blood pressure* and *diabetes* are associated with higher BMI, but these effects disappear when individual effects are included in Models B and C. However, the spouse having problems with *sight* is associated with higher BMI in men across all three models. For women, three spouse health problems are significant in Model A but these all disappear when individual effects are included in Models B and C, thus spouse health problems appear to have no effect on BMI in women.

In addition to the results shown here specifications 4. and 5. were also estimated in order to investigate the potential effects of social learning, but the results are not reported. In 4. a variable for duration of marriage (*D*) is included as well as own health and spouse health. This is significant (and negative) only for men in Model A; it disappears when individual effects are included and is never significant for women. In 5. we interact marriage duration with spouse health problems, while also conditioning on own health and spouse health. For men significant interactions between marriage duration and spouse health problems with *heart or blood pressure, anxiety and depression* and *diabetes* are found in Model A, but once individual effects are included the only interaction that remains significant is that with *anxiety and depression;* this is positive suggesting that once we condition on own health and spouse health, longer marriage to a spouse with anxiety and depression is associated with higher BMI in men. None of the interactions are significant for women.

As discussed in Section 4 criticisms can be made regarding the potential endogeneity of own health in these equations. Comparison of Tables 2 and 3 show that the coefficients on the other explanatory variables are robust to the inclusion/exclusion of own health, and while the quantitative importance of the own health variables is reduced by the inclusion of individual effects, the statistically significant variables remain unchanged. Those health problems known to be associated with obesity such as heart problems, blood pressure and diabetes are significant, for both men and women. Our focus is on the correlation between spouse BMI, and this remains after conditioning on a full set of individual characteristics, own health, spouse health, regional dummies, marriage duration and unobserved individual effects. LR test results show that the restrictions implied by Models A and B do not hold. The preferred model is Model C which allows for individual random effects, correlated random effects and correlated errors.

Our ability to test hypotheses around social earning is limited by only having data on two years and by not knowing an individual's BMI prior to marriage; if we had more waves of the BHPS with height and weight information we could condition on baseline BMI for each spouse and still include individual effects in the models. Nevertheless, our analysis does shed some light on the mechanisms behind spousal correlations in BMI. Firstly, individual effects are important and are strongly correlated between spouses suggesting that there is assortative mating in the marriage market; or at the least that part of the correlation between spouse BMI is present before we observe the couples in our data. The correlation of individual effects is present after controlling for variables that indirectly affect BMI, such as education, health, and socioeconomic status (proxied with education, employment status and household income), thus suggesting that matching may be directly on BMI due to aesthetic preferences, or because BMI is signalling preferences for other lifestyle characteristics and less easily observed characteristics such as future health and potential life expectancy, and matching is on these factors.

In addition we have strong evidence of correlated errors even after own health, spouse health, regional effects and marriage duration are taking into account. This suggests that social influence is also contributing to correlations in spouse BMI. This influence does not seem to arise from direct social learning via spouse health problems. For women, spouse health has no effect in any of our models. For men, some obesity related health problems in their spouse, such as heart and blood pressure problems and diabetes do influence own BMI (positively) but these effects disappear once individual effects are included. This suggests that, rather than contributing to social learning, spouse health is correlated directly. Further attempts to investigate social influence by including marriage duration again provide no evidence for social learning as marriage duration has no effect on the results.

In relation to contextual or supply-side effects we limit our attention to regional identifiers. These are largely insignificant, although there is some evidence for higher mean BMI in Wales, Scotland and Northern Ireland compared to the baseline of inner and outer London. The correlation in individual effects and errors remain once regional effects are taken into account suggest that this correlation is not driven by supply-side factors. The fact that regional dummies are not strongly significant suggests that contextual effects are not important once we have conditioned on our other observed effects.

6. Conclusion

Social factors play an important role in explaining the obesity epidemic facing many countries. Social interactions are likely to influence behaviour related to weight. Married partners living in the same household are an ideal group to look at how social interactions impact on household BMI outcomes. This paper investigates three mechanisms, shared individual effects, social influence, and the shared environment to explain why spouses' BMI may be correlated. A number of econometric specifications are used to test these hypotheses. The analysis allows for correlation in both the idiosyncratic errors and the individual effects across husband and wives. This methodology builds on previous work (Christakis and Fowler 2007 and Cohen-Cole and Fletcher 2008) because we allow for correlation in the observable components of spouse BMI.

Results suggest a social influence independent of the shared environment on the correlation in spousal BMI. There is strong evidence of shared individual effects influencing BMI outcomes for married couples suggesting positive assortative mating along lifestyle characteristics related to weight. Correlation in the idiosyncratic error terms in the spouses equations are positive and significant even after controlling for own health, spouse health, regional effects and marriage duration. Given the insignificance of spouse health and marriage duration this does not seem to imply social learning.

The important role of shared individual characteristics influencing the correlation in spousal BMI suggests that future work should look at the role of lifestyle characteristics and BMI on marriage formation. These findings suggest that policies targeted at household behaviour may be an effective way to target obesity rates.

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Figure 1a: Distribution of BMI – Men

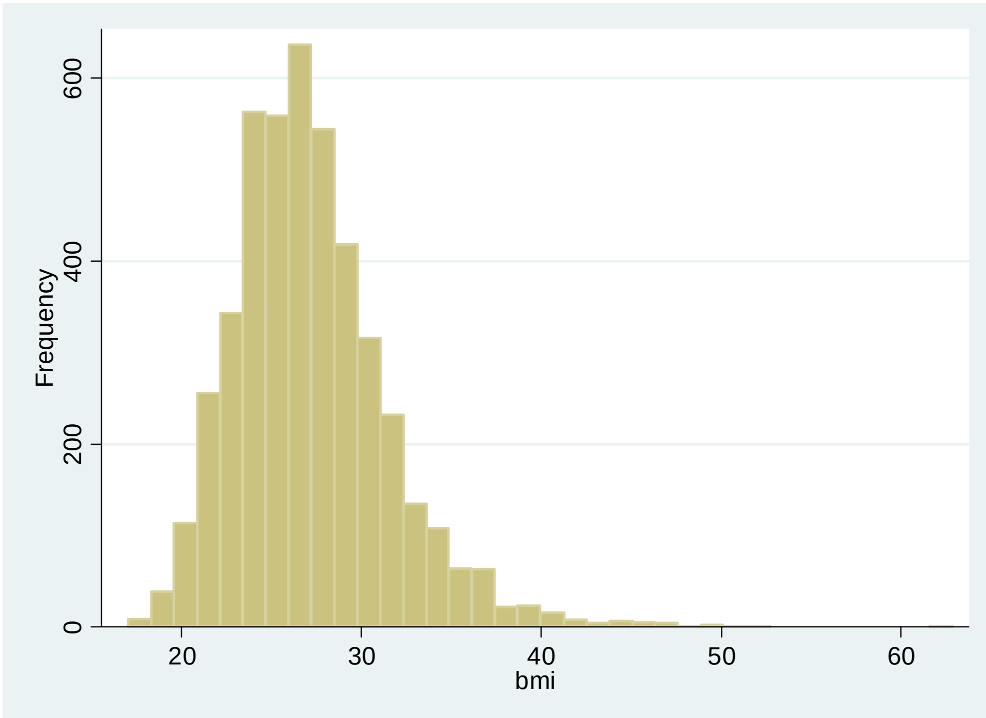

Figure 1b: Distribution of BMI – Women

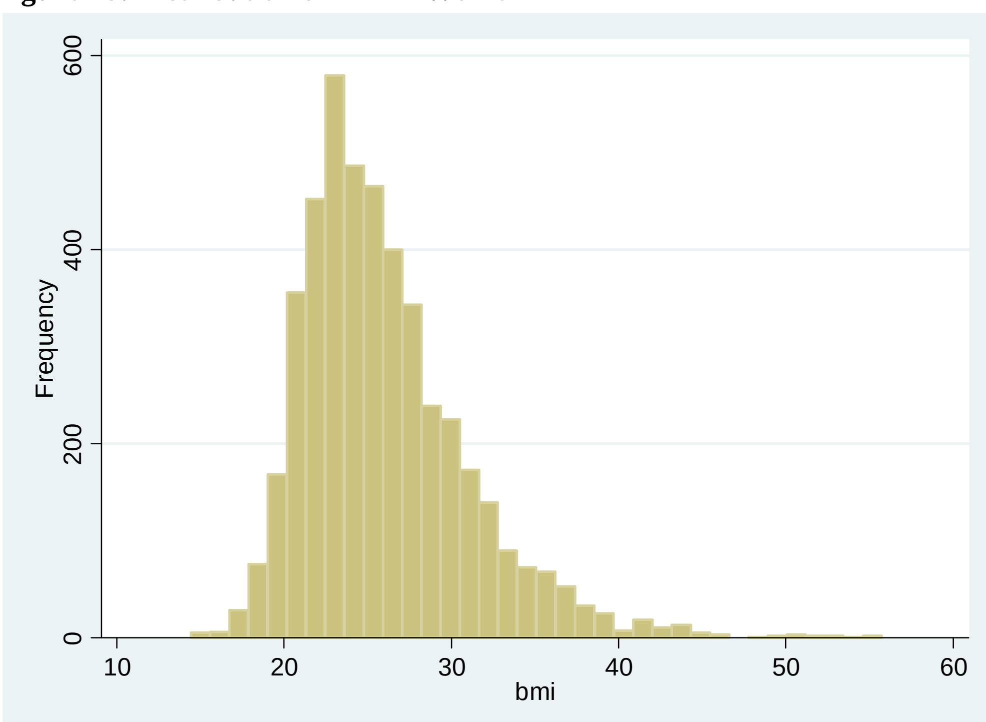

Table 1: Descriptive Statistics

	Men	Women
bmi	27.25 (4.27)	26.08 (5.16)
age	44.17 (9.98)	42.42 (9.89)
preschoolkids	0.15	0.15
employed	0.93	0.76
O level	0.31	0.39
A level	0.34	0.24
Degree	0.15	0.15
loghhincome	10.49 (0.57)	10.49 (0.57)
Health Problems:		
Arms, Legs, Hands	0.21	0.22
Sight	0.03	0.03
Hearing	0.07	0.04
Skin/Allergy	0.09	0.14
Chest/Breathing	0.10	0.11
Heart/Blood Pressure	0.12	0.10
Stomach/Digestion	0.07	0.08
Diabetes	0.04	0.02
Anxiety/Depression	0.04	0.10
Epilepsy	0.01	0.01
Migraine	0.04	0.12
Other	0.04	0.08
marriage duration	11.27 (10.20)	11.27 (10.20)

Notes: BMI is measured in kg/m^2, household income is measure GBP, age and marriage duration are measured in years. Standard deviations are in parenthesis. All other variables are measured in percentages.

Table 2: Baseline specification 1. with individual characteristics

	MEN						WOMEN					
BMI	(A) M		(B) M		(C) M		(A) W		(B) W		(C) W	
Age	**0.258**	**(0.066)**	**0.268**	**(0.0673)**	**0.275**	**(0.068)**	0.096	(0.078)	0.026	(0.078)	0.071	(0.079)
Age Squared	**-0.002**	**(0.001)**	**-0.002**	**(0.001)**	**-0.002**	**(0.001)**	-0.001	(0.001)	0.0003	(0.001)	-0.00003	(0.001)
Preschool Kids	-0.168	(0.241)	0.091	(0.132)	0.097	(0.133)	**-0.676**	**(0.297)**	-0.003	(0.156)	0.014	(0.156)
O-Level	0.218	(0.235)	0.393	(0.308)	0.397	(0.307)	**-0.626**	**(0.265)**	-0.575	(0.352)	-0.543	(0.352)
A-Level	-0.002	(0.231)	0.174	(0.295)	0.180	(0.295)	**-0.762**	**(0.294)**	-0.569	(0.379)	-0.566	(0.379)
Degree	-0.388	(0.286)	-0.142	(0.359)	-0.161	(0.359)	**-1.644**	**(0.338)**	**-1.403**	**(0.419)**	**-1.370**	**(0.420)**
Employed	**-1.250**	**(0.314)**	**-0.835**	**(0.214)**	**-0.824**	**(0.214)**	-0.468	(0.234)	-0.095	(0.168)	-0.116	(0.168)
Log HH Income	0.140	(0.150)	0.050	(0.084)	0.036	(0.084)	-0.420	(0.179)	-0.111	(0.098)	-0.110	(0.098)
Spouse BMI			**0.128**	**(0.015)**					**0.178**	**(0.022)**		
n	2886		2886		2886		2886		2886		2886	
Log Likelihood	-16929.638		-6882.523		-14312.015		-16929.638		-7363.199		-14312.015	
$P(\chi^2>0)$ v. (iii)	**5235.246**		**-14792.164**				**5235.246**		**-13830.39**			
ρ			**0.916**	**(0.004)**	**0.918**	**(0.004)**			**0.921**	**(0.004)**	**0.924**	**(0.004)**
corr_u					**0.199**	**(0.027)**					**0.199**	**(0.027)**
corr_e	**0.343**	**(0.039)**			**0.110**	**(0.029)**	**0.343**	**(0.039)**			**0.110**	**(0.029)**

Notes: Regional dummies are included but not reported (see Appendix 1).
Variables in bold are significant at the 5% level. M and F represent men and women respectively.
(i) SUR with no RE. (ii) Single equation model with RE. (iii) SUR with random effects.
$P(\chi^2>0)$ is a LR test of that model versus model (iii).
corr_u is the correlation between the individual (random) effects (u_i) for men and women.
corr-e is the correlation between the idiosyncratic errors terms (e_i) for men and women.
ρ is fraction of the variance in e_i and u_i, due to u_i

Table 3: Specification 2. with own health.

	MEN						WOMEN					
BMI	(A) M		(B) M		(C) M		(A) W		(B) W		(C) W	
Age	**0.300**	**(0.065)**	**0.295**	**(0.067)**	**0.302**	**(0.067)**	0.111	(0.076)	0.032	(0.078)	0.075	(0.078)
Age Squared	**-0.003**	**(0.001)**	**-0.003**	**(0.001)**	**-0.003**	**(0.001)**	-0.001	(0.001)	0.0002	(0.001)	-0.0002	(0.001)
Preschool Kids	-0.144	(0.236)	0.092	(0.131)	0.097	(0.132)	-0.474	(0.290)	-0.014	(0.157)	0.003	(0.157)
O-Level	0.210	(0.230)	0.418	(0.303)	0.415	(0.304)	**-0.584**	**(0.261)**	-0.511	(0.347)	-0.497	(0.348)
A-Level	-0.044	(0.227)	0.198	(0.291)	0.191	(0.292)	**-0.756**	**(0.289)**	-0.506	(0.375)	-0.513	(0.376)
Degree	-0.296	(0.282)	-0.077	(0.355)	-0.116	(0.355)	**-1.551**	**(0.332)**	**-1.287**	**(0.415)**	**-1.280**	**(0.416)**
Employed	**-0.784**	**(0.330)**	**-0.828**	**(0.217)**	**0.830**	**(0.217)**	0.069	(0.239)	-0.015	(0.170)	-0.040	(0.168)
Log HH Income	0.152	(0.147)	0.039	(0.083)	0.025	(0.083)	-0.332	(0.175)	-0.116	(0.098)	-0.115	(0.099)
Health problems:												
Arms, Legs, Hands	**0.706**	**(0.194)**	0.138	(0.104)	0.136	(0.103)	0.583	(0.230)	0.130	(0.122)	0.136	(0.122)
Sight	0.138	(0.433)	-0.175	(0.221)	-0.163	(0.221)	-1.200	(0.567)	-0.319	(0.250)	-0.300	(0.250)
Hearing	-0.067	(0.312)	0.170	(0.190)	0.167	(0.189)	-0.068	(0.486)	-0.171	(0.357)	-0.169	(0.304)
Skin/Allergy	0.234	(0.262)	0.231	(0.150)	0.236	(0.149)	0.250	(0.268)	0.017	(0.164)	0.018	(0.164)
Chest/Breathing	0.187	(0.258)	0.221	(0.168)	0.223	(0.168)	**1.628**	**(0.302)**	**0.600**	**(0.203)**	**0.586**	**(0.202)**
Heart/Blood Pressure	**2.260**	**(0.251)**	**0.726**	**(0.148)**	**0.718**	**(0.147)**	**1.601**	**(0.316)**	**0.572**	**(0.189)**	**0.566**	**(0.188)**
Stomach/Digestion	0.052	(0.312)	0.083	(0.164)	0.091	(0.164)	0.211	(0.354)	-0.018	(0.177)	-0.019	(0.177)
Diabetes	**1.970**	**(0.421)**	**1.009**	**(0.334)**	**0.993**	**(0.333)**	**4.023**	**(0.704)**	**1.342**	**(0.516)**	**1.296**	**(0.514)**
Anxiety/Depression	-0.986	(0.406)	**-0.521**	**(0.198)**	-0.515	(0.199)	0.104	(0.323)	0.189	(0.176)	0.181	(0.174)
Epilepsy	-0.115	(0.829)	0.618	(0.752)	0.648	(0.753)	**3.573**	**(0.901)**	**2.443**	**(1.050)**	**2.439**	**(1.050)**
Migraine	-0.117	(0.398)	**-0.591**	**(0.207)**	**-0.593**	**(0.207)**	0.234	(0.281)	0.083	(0.162)	-0.004	(0.160)
Other	0.104	(0.408)	-0.116	(0.198)	-1.110	(0.120)	0.369	(0.342)	0.062	(0.163)	0.067	(0.163)
Spouse BMI			**0.127**	**(0.016)**					**0.174**	**(0.021)**		
n	2886		2886		2886		2886		2886		2886	
Log Likelihood	-16790.435		-6854.488		-14265.392		-16790.435		-7345.928		-14265.392	
P(χ^2>0) v. (iii)	**5050.086**		**-14755.126**				**5050.086**		**-13775.656**			
ρ			**0.915**	**(0.004)**	**0.917**	**(0.004)**			**0.918**	**(0.004)**	**0.921**	**(0.004)**
corr_u					**0.186**	**(0.027)**					**0.186**	**(0.027)**
corr_e	**0.285**	**(0.038)**			**0.117**	**(0.029)**	**0.285**	**(0.038)**			**0.117**	**(0.029)**

See Notes to Table 2.

Table 4: Specification 3. with individual characteristics, own health and spouse health.

	MEN						WOMEN					
BMI	(A) M		(B) M		(C) M		(A W		(B) W		(C W	
Age	**0.306**	**(0.064)**	**0.297**	**(0.067)**	**0.306**	**(0.068)**	0.111	(0.076)	0.096	(0.079)	0.091	(0.079)
Age Squared	**-0.003**	**(0.001)**	**-0.003**	**(0.001)**	**-0.003**	**(0.001)**	-0.001	(0.001)	-0.0005	(0.001)	-0.004	(0.001)
Preschool Kids	-0.110	(0.235)	0.108	(0.133)	0.109	(0.133)	-0.458	(0.298)	0.012	(0.158)	00.19	(0.158)
O-Level	0.188	(0.228)	0.333	(0.307)	0.411	(0.303)	-0.488	(0.260)	0.552	(0.353)	-0.500	(0.348)
A-Level	-0.37	(0.225)	0.077	(0.295)	0.190	(0.291)	-0.662	(0.288)	-0.620	(0.380)	-0.500	(0.375)
Degree	-0.277	(0.279)	-0.343	(0.358)	-0.104	(0.354)	**-1.430**	**(0.332)**	**-1.280**	**(0.415)**	**-1.272**	**(0.415)**
Employed	-0.530	(0.331)	**-0.819**	**(0.217)**	**-0.818**	**(0.217)**	0.149	(0.238)	-0.081	(0.170)	-0.020	(0.169)
Log HH Income	0.216	(0.146)	0.038	(0.084)	0.033	(0.084)	-0.226	(0.176)	-0.092	(0.100)	-0.103	(0.099)
Health probs: Arms, Legs, Hands	**0.786**	**(0.194)**	0.134	(0.105)	0.134	(0.104)	0.502	(0.232)	0.141	(0.122)	0.146	(0.123)
Sight	-0.80	(0.194)	-0.211	(0.226)	-0.209	(0.226)	-0.916	(0.575)	-0.310	(0.256)	-0.315	(0.255)
Hearing	-0.10	(0.314)	0.179	(0.191)	0.174	(0.190)	0.003	(0.489)	-0.164	(0.308)	-0.162	(0.308)
Skin/Allergy	-0.002	(0.262)	0.225	(0.151)	0.223	(0.151)	0.227	(0.269)	0.030	(0.165)	0.026	(0.165)
Chest/Breathing	0.145	(0.259)	0.218	(0.170)	0.219	(0.170)	**1.709**	**(0.305)**	**0.583**	**(0.205)**	**0.594**	**(0.206)**
Heart/BP	**2.158**	**(0.252)**	**0.703**	**(0.148)**	**0.690**	**(0.149)**	**1.656**	**(0.319)**	**0.546**	**(0.190)**	**0.575**	**(0.191)**
Stomach/Digestion	-0.040	(0.313)	0.091	(0.167)	0.093	(0.166)	0.151	(0.356)	-0.133	(0.179)	-0.014	(0.179)
Diabetes	**2.131**	**(0.423)**	**0.992**	**(0.334)**	**1.042**	**(0.337)**	**4.474**	**(0.713)**	**1.366**	**(0.518)**	**1.435**	**(0.520)**
Anxiety/Depression	-0.810	(0.406)	**-0.535**	**(0.199)**	**-0.510**	**(0.201)**	-0.034	(0.326)	0.157	(0.176)	0.161	(0.176)
Epilepsy	-0.362	(0.831)	0.634	(0.759)	0.648	(0.759)	**3.549**	**(0.908)**	**2.436**	**(1.048)**	**2.582**	**(1.061)**
Migraine	-0.189	(0.399)	**-0.581**	**(0.207)**	**-0.602**	**(0.209)**	0.215	(0.284)	0.013	(0.162)	0.008	(0.162)
Other	0.019	(0.410)	-0.153	(0.200)	-0.149	(0.200)	0.386	(0.345)	0.083	(0.165)	0.085	(0.165)
Spouse Health: Arms, Legs, Hands	-0.236	(0.191)	0.024	(0.104)	0.022	(1.044)	**0.523**	**(0.231)**	0.108	(0.123)	0.106	(0.122)
Sight	**1.376**	**(0.478)**	**0.508**	**(0.216)**	**0.473**	**(0.218)**	0.155	(0.526)	0.449	(0.265)	0.446	(0.265)
Hearing	-0.332	(0.407)	-0.261	(0.262)	-0.256	(0.262)	0.793	(0.377)	0.098	(0.224)	0.102	(0.223)
Skin/Allergy	0.139	(0.223)	0.088	(0.105)	0.080	(0.140)	-0.233	(0.316)	0.010	(0.177)	0.012	(0.177)
Chest/Breathing	0.614	(0.256)	0.121	(0.176)	0.106	(0.175)	0.136	(0.311)	0.145	(0.200)	0.150	(0.200)
Heart/BP	**1.004**	**(0.264)**	0.268	(0.162)	0.257	(0.162)	0.362	(0.300)	-0.037	(0.175)	-0.054	(0.175)
Stomach/Digestion	0.098	(0.296)	0.056	(0.153)	0.050	(0.153)	0.088	(0.377)	0.158	(0.195)	0.160	(0.195)
Diabetes	**2.642**	**(0.593)**	0.750	(0.443)	0.703	(0.440)	**1.253**	**(0.508)**	0.566	(0.397)	0.543	(0.396)
Anxiety/Depression	-0.0194	(0.267)	0.092	(0.150)	0.092	(0.150)	**1.339**	**(0.480)**	0.254	(0.235)	0.257	(0.234)
Epilepsy	0.894	(0.753)	0.844	(0.890)	0.824	(0.889)	-0.597	(0.997)	0.134	(0.897)	0.155	(0.897)
Migraine	0.332	(0.236)	0.140	(0.138)	0.136	(0.138)	-0.781	(0.479)	-0.195	(0.224)	-0.199	(0.244)
Other	0.349	(0.286)	0.160	(0.140)	0.155	(0.140)	-0.162	(0.492)	-0.050	(0.234)	-0.052	(0.234)
Spouse BMI			**0.125**	**(0.016)**					**0.174**	**(0.022)**		
n	2886		2886		2886		2886		2886		2886	
Log Likelihood	-16736.530		-6847.755		-14252.17		-16736.530		-7341.382		-14252.17	
P(χ^2>0) v. (iii)	**61977.400**		**-14745.419**				**61977.400**		**-13758.92**			
ρ			**0.914**	**(0.004)**	**0.916**	**(0.004)**			**0.918**	**(0.004)**	**0.920**	**(0.004)**
corr_u					**0.178**	**(0.027)**					**0.178**	**(0.027)**
corr_e	**0.283**	**(0.037)**			**0.126**	**(0.029)**	**0.283**	**(0.037)**			**0.126**	**(0.029)**

See Notes to Table 2.

Appendix A: Variable Labels and Definitions

Variable Name	Description
BMI	Body Mass Index: weight measured in kilograms divided by height measured in meters squared
Spouse BMI	Spouse BMI
	0=No qualifications (Base Category)
ed_deg	1=Higher or First Degree
ed_alevel	1=HND, HNC, teaching, or A-level
ed_olevel	1=CSE or O level
	0=Very Poor/Poor (Base Category)
sahfair	1=Fair
sahgood	1=Good
sahex	1=Excellent
	0=Spouse Very Poor/Poor (Base Category)
sahfair_s	1=Spouse Fair
sahgood_s	1=Spouse Good
sahex_s	1=Spouse Excellent
	0- Family Care, Long Term Sick/Disabled, or Unemployed (Base Category)
jbemp	1-Employed/Self-Employed
age	Age in years
agesq	Age squared
	0=No children in household aged 0-4 years (Base Category)
preschoolkids	1=Children in household age 0-4
ln_hhinc	Log of Annual household income/household size
	0=No problems mentioned
hlprba	1=Health problems: arms, legs, hands, etc
hlprbb	1=Health problems: sight
hlprbc	1=Health problems: hearing
hlprbd	1=Health problems: skin conditions/allergy
hlprbe	1=Health problems: chest/breathing
hlprbf	1=Health problems: heart/blood pressure
hlprbg	1=Health problems: stomach or digestion
hlprbh	1=Health problems: diabetes
hlprbi	1=Health problems: anxiety, depression, etc
hlprbk	1=Health problems: epilepsy
hlprbl	1=Health problems: migraine
hlprbz	1=Other health problems
marriage_duration	Number of years married/cohabiting
	0-Inner and Outer London
region2 though 18	1=Rest of South East, South West, East Anglia, East Midlands, West Midlands Conurbation, Rest of West Midlands, Greater Manchester, Merseyside, Rest of Northwest, South Yorkshire, West Yorkshire, Rest of Yorkshire and Humberside, Tyne and Wear, Rest of North, Wales, Scotland, and Northern Ireland