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Going the same 'weigh': Spousal correlations in Obesity in the UK

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Abstract:
The obesity epidemic has received widespread media and research attention. However, the social phenomenon of obesity is still not well understood. Data from the British Household Panel Survey show positive and significant correlations in spousal body mass index (BMI). This paper explores the three mechanisms of matching on the marriage market, social learning, and shared environment to explain this correlation. We apply a novel method of testing for social learning by focusing on how the addition of individual and partner health and marriage length affects the correlation in spousal BMI. Results show the importance of matching in the marriage market in explaining correlated BMI outcomes. There is significant correlation in partner BMI even after controlling for own health, spouse health, marriage length, and regional effects suggesting evidence of a social influence. However, it does not appear to be a learning effect as spouse health and marriage length are insignificant.

I. 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, where the impacts can be amplified. The latest public health guidance from the National Institute for Health and Clinical Excellence (NICE) in the UK stresses the importance of taking a community level approach to tacking obesity[1].

There are a growing number of studies investigating a social network effect in obesity (Christakis and Fowler 2007, Kano 2008[2], Trogden et al. 2008, and Halliday and Kwak 2009, Clark and Etile 2011). This paper attempts to build on the previous work investigating the mechanisms behind spousal correlations in body mass, using longitudinal data on adults from 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. This is the first paper to model the relationship between health and relationship length as a mechanism explaining partner correlations in weight. Around 60 per cent of adults in the UK are married or live as a couple, therefore a better understanding of body mass transmission in these households can be of substantial value to policy makers.

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[1] http://guidance.nice.org.uk/PH42

[2]

To understand spousal[3] correlations in body mass we adopt the Manski (1993) approach. 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, food choices, and opportunities for exercise. Manski calls these exogenous effects although the term exogenous is misleading because (to some extent) 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 refers to as 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). These two waves are the only ones which include information on height and weight, thus 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 role of individual and partner health in general and obesity related health co-morbidities specifically as a mechanism explaining 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.

[3] 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.

II. 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).

Christakis and Fowler (2007), Kano (2008) and Clark and Etile (2011) have explored peer effects in spousal obesity outcomes from an economic perspective. Christakis and Fowler (2007) examine how spousal interactions influence the likelihood of becoming obese using 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) also 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. The large peer effect suggests that obesity interventions targeted at one partner would impact on the weight of the other partner.

Kano (2008) focuses on controlling for individual and partner propensity to be obese and matching on these unobserved time constant characteristics to isolate peer effects in partner obesity outcomes. He employs a dynamic bivariate probit model to data from years 1999-2005 of the Panel Study of Income Dynamics. Kano finds evidence of matching on unobservable time constant factors related to obesity and a negative relationship between a wife's obesity in the previous period and her husband's likelihood of being obese. If the wife was obese in the previous period it decreases the likelihood that her partner will be obese by 4%. Peer effects of obesity were not found from men to women. These results contradict the findings from Christakis and Fowler (2007) suggesting that there would be no spillover effects from an obesity intervention targeted at one partner or if the policy is targeted at women, her partner may even gain weight.

Clark and Etile (2011) explore the role of utility measured by life satisfaction from individual and partner BMI, as a mechanism for explaining correlated BMI outcomes in couples. They employ least squares and semi-parametric techniques to data from the German Socio-Economic Panel. Gender asymmetries are found. An overweight woman married to a healthy weight man does not have a reduction in well-being if she becomes obese if her husband also becomes overweight, whilst she has a reduction in well-being if her partner remains a healthy weight. Whereas overweight men have the highest level of satisfaction when their partner is not overweight and obese men have the highest level of satisfaction when their partner is also obese. These findings point to a scenario where an individual chooses their optimal weight, maximising their utility, based upon observing their partner's weight. Optimal weight may change over time as one's partner's weight changes.

The variation in findings between these three studies is partially dependent upon the model estimated, dataset used, and mechanism focused on (assortative mating in Kano (2008) and life satisfaction in Clark and Etile (2011)). The disagreement in the importance of peer effects in couples, underlying mechanisms, and effects of gender highlight gaps in the literature. Our paper makes a number of important contributions to the literature on understanding the mechanisms explaining correlated BMI outcomes in couples. Firstly, we focus on the role of health and specific health conditions as an observable matching signal and as a learning mechanism by exploring how health interacts with relationship length. This area has not been explored in the previous literature and has important policy implications as the majority of the costs of obesity stem from the negative health effects of carrying excess weight. 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, such as the availability of fast food. Our analysis focuses on demand side variables such as individual characteristics, labour market status and health, providing a different perspective on the determinants of obesity. 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 providing an efficient model specification.

III. Theoretical Framework

This paper adopts the framework of Manski (1993) to explain correlated outcomes within a group. The theoretical model focuses on how health and BMI influence matching in the marriage market and if observing partner's health status in general and specific health conditions explain social learning leading to correlated BMI outcomes.

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 social 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 here is between these contextual effects and the direct influence of one spouse's behaviour on the other spouse as described in Hypothesis 2.

IV. 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 of the survey which collected information on height and weight for calculating BMI. The BHPS is an annual longitudinal study which started in 1991 and ended in 2008 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. In the unbalanced dataset, approximately 98% of couples that are observed together in 2004 are still together in 2006 suggesting that our sample should be fairly representative of couples in the dataset[4].

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 $\geq$ 30) compared to 24% for both genders in data taken from the Health Survey of England 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 in this sample, 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).

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 (1*a*) and (1*b*). In most specifications restrictions are placed on a number of parameters and these are discussed further below.

[4] This percentage does not include couples that separate from their partner and both individuals are lost to the sample. One individual needs to remain in the sample to determine if there was a change in their marital status between waves 14 and 16.

$$BMI_{it}^{M} = \beta^{M} X_{it}^{M} + \gamma^{M} H_{it}^{M} + \delta^{M} H_{it}^{F} + \phi^{M} D_{it} + \varphi^{M} D_{it} H_{it}^{F} + \vartheta^{M} R_{it} + \theta^{M} BMI^{F} + v_{it}^{M} \qquad (1a)$$

$$BMI_{it}^{F} = \beta^{F} X_{it}^{F} + \gamma^{F} H_{it}^{F} + \delta^{F} H_{it}^{M} + \phi^{F} D_{it} + \varphi^{F} D_{it} H_{it}^{M} + \vartheta^{F} R_{it} + \theta^{F} BMI^{M} + v_{it}^{F} \qquad (1b)$$

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[5].

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 1994, 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

[5] 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.

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 length of marriage in years. *D.H* is a vector of dummy variables representing the interaction of marriage duration with spouse health problems. The relationship between marriage length and health will allow us to test if there is any evidence of the impact of health being compounded by marriage length indicating the possibility of social learning. *R* is set of dummy variables denoting region of residence; this is an attempt to control for supply side factors such as the availability of fast food. *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 (1*a* and 1*b*). For this model θ 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 θ 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) $\mu_{i,}$, plus an idiosyncratic error term ε_{it} as shown in equation (1*c*).

$$v_{it}^{M(F)} = \mu_i^{M(F)} + \varepsilon_{it}^{M(F)} \quad (1c)$$

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 (ε_{it}) and individual effects (μ_{it}) across males and females. As is the case for Model A, for this model θ is always restricted to zero. All of the models are estimated via maximum likelihood using the *xtreg* and *xtmixed* commands 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 specifications are estimated with and without regional dummy variables (R).

Model specifications A-C are non-nested. Therefore, to compare across model specifications and help choose the most appropriate model specification the Bayesian Information Criteria (BIC) and Akaike's Information Criteria (AIC) are calculated for each model. 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 emphasis 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 to 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.

V. Results and discussion

For ease of exposition we do not report the results for the regional dummy variables. All of the specifications (1) to (6) described in section 4.2 are estimated with and without a set of seventeen regional dummies, where London (inner and outer) is 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 in 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 μ_i and ε_{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, and 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, if one's spouse has problems with *sight* this 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 length 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 length 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, the longer one is married to an individual with anxiety and depression the greater the likelihood of having a 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 variables with statistically significant coefficients 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.

Both the BIC and AIC criteria suggest overall that Model B is the best fitting model; pointing towards individual effects and partner choice as important factors in explaining correlated BMI outcomes in couples. Explicitly modelling partner BMI may help improve the fit of the model.

Our ability to test hypotheses around social learning is limited by only having data two years apart 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, 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.

In addition we have strong evidence of correlated errors even after own health, spouse health, regional effects and marriage duration are taken 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 suggesting 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.

VI. 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 with which to investigate these issues. This paper investigates three mechanisms: 1) matching in the marriage market; 2) social influence; and 3) the shared environment; focusing on how health in general and specific health conditions may contribute to both matching and social influence resulting in correlated BMI outcomes in couples. 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 because we allow for correlation in the observable components of spouse BMI.

The results suggest evidence of 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 related to observing changes in partner health status.

The important role of shared individual characteristics or matching on the marriage market influencing the correlation in partner BMI suggests that future work should look at the role of lifestyle characteristics and BMI on marriage formation to confirm the findings from this research and other related studies (Kano 2008). These findings suggest that policies and interventions targeted at household behaviour change may be an effective way to reduce obesity.

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Figure 1a: Distribution of BMI – Men

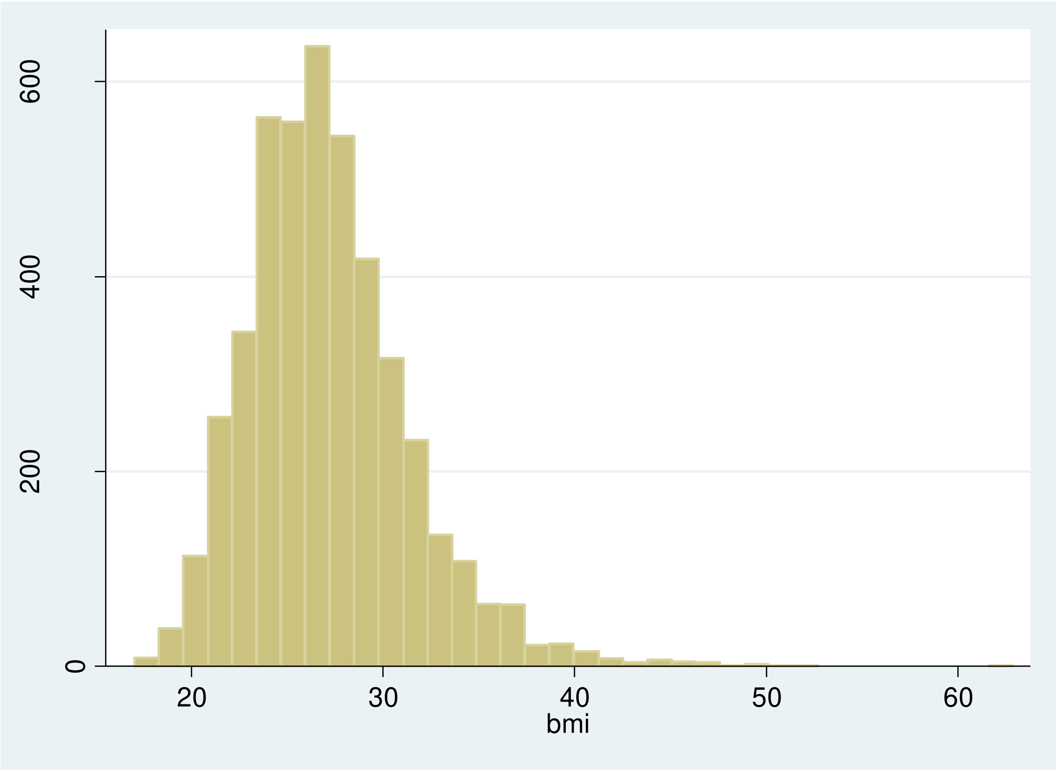

Figure 1b: Distribution of BMI – Women

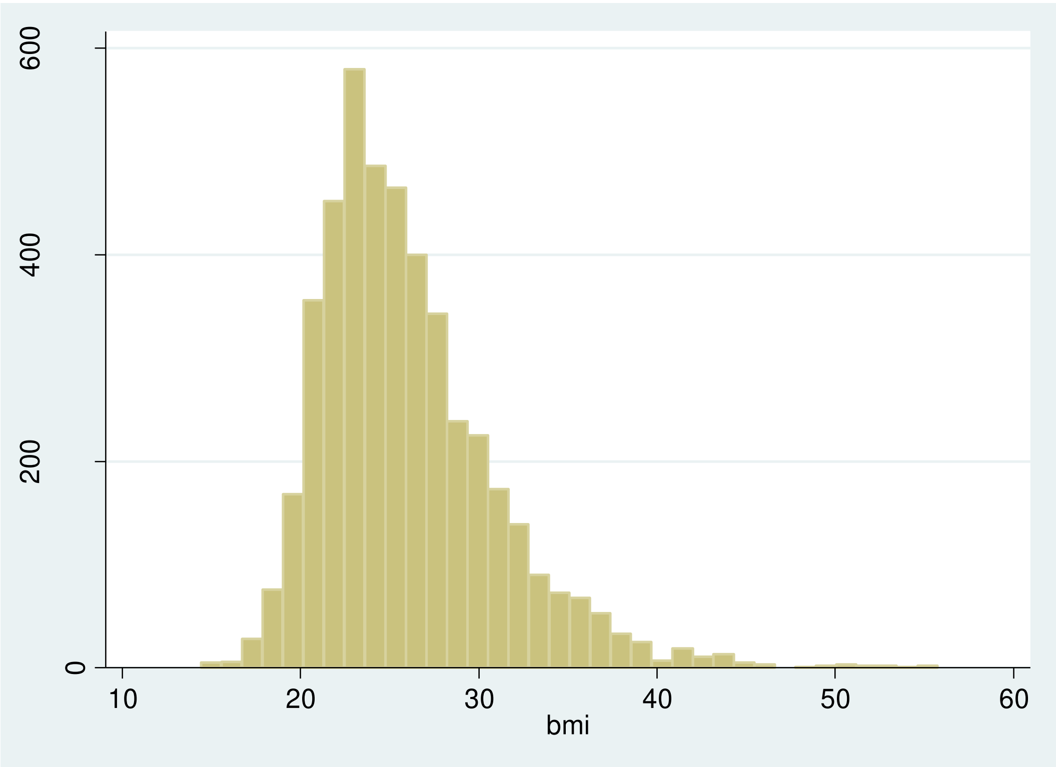

Table 1: Descriptive Statistics

	Men	Women
BMI	27.25 (4.27)	26.08 (5.16)
Age	44.17 (9.98)	42.42 (9.89)
Preschool kids	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
Log HH income	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 length	11.27 (10.20)	11.27 (10.20)

Notes: BMI is measured in kg/m^2, household income is measured in 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		-14245.722		-14312.015		-16929.638		-14245.722		-14312.015	
AIC	33893.276		28531.444		28592.100		33893.276		28531.444		28592.100	
BIC	33994.726		28650.777		28759.480		33994.726		28650.777		28759.480	
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:

[a] Regional dummies are included but not reported (see Appendix 1).

[b] Variables in bold are significant at the 5% level. M and F represent men and women respectively.

[c](A) SUR with no RE. (B) Single equation model with RE. (C) SUR with random effects.

[d] AIC is the Akaike Information Criteria test and BIC is the Bayesian Information Criteria test

[e] corr_u is the correlation between the individual (random) effects (u_i) for men and women.

[f] corr-e is the correlation between the idiosyncratic errors terms (e_i) for men and women.

[g] 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		-14200.416		-14265.392		-16790.435		-14200.416		-14265.392	
AIC	33496.870		28488.832		28446.784		33496.870		28488.832		28446.784	
BIC	33915.510		28751.408		28865.424		33915.510		28751.408		28865.424	
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)**

*Notes: S*ee 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		-14189.137		-14252.170		-16736.530		-14189.137		-14252.170	
AIC	33341.060		28514.274		28732.340		33341.060		28514.274		28732.340	
BIC	33998.923		28920.073		29030.203		33998.923		28920.073		29030.203	
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)**

*Notes: S*ee 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)
Degree	1=Higher or First Degree
A-Level	1=HND, HNC, teaching, or A-level
O-Level	1=CSE or O level
	0- Family Care, Long Term Sick/Disabled, or Unemployed (Base Category)
Employed	1-Employed/Self-Employed
Age	Age in years
Age squared	Age squared
Preschool kids	0=No children in household aged 0-4 years (Base Category)
	1=Children in household age 0-4
Log HH income	Log of Annual household income/household size
Health Problems:	0=No problems mentioned (Base category for all health problem dummies)
Arms, Legs, Hands	1=Health problems: arms, legs, hands, etc
Sight	1=Health problems: sight
Hearing	1=Health problems: hearing
Skin/Allergy	1=Health problems: skin conditions/allergy
Chest/Breathing	1=Health problems: chest/breathing
Heart/BP	1=Health problems: heart/blood pressure
Stomach/Digestion	1=Health problems: stomach or digestion
Diabetes	1=Health problems: diabetes
Anxiety/Depression	1=Health problems: anxiety, depression, etc
Epilepsy	1=Health problems: epilepsy
Migraine	1=Health problems: migraine
Other	1=Other health problems
Marriage length	Number of years married/cohabiting
Region	0-Inner and Outer London 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