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# The impact of mental wellbeing on obesity in Great Britain

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**Background:** A number of studies have estimated the impact of mental wellbeing on obesity. The findings are ambiguous and have generally not accounted for the endogeneity of mental wellbeing.
**Aim:** To investigate the causal effect of mental wellbeing on obesity.
**Data:** Data for the analysis were taken from the British Household Panel Study (BHPS; 2006-07; n=8011).
**Methods:** We regress obesity measures (body mass index [BMI], BMI>30kg/$m^2$) against mental wellbeing plus covariates. Mental wellbeing is measured using the General Health Questionnaire (GHQ-12), treated as a binary variable (GHQ-12 >3). We use instrumental variables (IV) regression and IV probit models to account for the endogeneity of mental wellbeing. The instruments are household overcrowding and area psychological wellbeing. We estimate separate models for men and women.
**Results:** We find little evidence that mental wellbeing affects obesity in men. In women there is evidence that GHQ-12 >3 increases obesity**.**
**Conclusion:** Our study supports the view that in women psychological problems affect obesity.

## Background

Obesity is increasing on an epidemic scale in the developed world, and its associated morbidity and mortality pose one of the greatest health challenges of the 21st century. About one quarter of the English population was classified as obese in 2005 (Health Survey for England, 2005) and two thirds were overweight or obese. Obesity is a major problem because the clinical and financial consequences are serious. There has been an extensive research on

the physiological causes of obesity. It has also already been recognised that weight has social, cultural and socioeconomic determinants (Veenstra et al 2005).

The prevalence of mental health disorders in the UK has also increased over the past several decades. According to recent estimates mixed anxiety and depression is the most common mental health disorder in Britain with almost 9% of people meeting the criteria for a positive diagnosis.

There is some limited evidence that mental illness causes obesity. The mechanisms involved are thought to vary from person to person but include biological, socio-demographic, and psychological factors (Keck et al, 2002). On the one hand, psychological problems may cause weight *loss* (DiPietro, Anda and Williamson, 1992), possibly because people with such problems consume fewer calories. On the other hand, psychological problems may be associated with weight *gain* as people consume more calories and undertake less physical activity when anxious and stressed. This finding is thought to be particularly strong among women (Carpenter, Hasin, Allison, & Faith, 2000; McElroy et al., 2002; McElroy et al., 2004; Baldassano, 2006; Istavan et al. 1992; Strine et al. 2008).

While there is some evidence of a relationship between mental wellbeing and obesity the direction of causality and effect is unclear. There are a number of possibilities:

1. Psychological problems cause weight loss and therefore reduce obesity.
2. People under psychological stress may overeat, and/or eat relatively unhealthy foods and/or undertake less exercise; in this case psychological problems may cause weight gain and increase obesity.
3. Obesity causes psychological distress.
4. Obesity improves psychological health, e.g., due to the "Jolly fat" hypothesis (Crisp and McGuinness, 1976).
5. There are unobserved variables (e.g., genetic factors) that are correlated with both psychological wellbeing and obesity.

The focus in this paper is on the first two of these possibilities. But empirical analysis of this relationship may be contaminated by the other effects. Hence, the aim of the paper is to identify the causal effect of psychological wellbeing on obesity and to produce unbiased estimates that are not contaminated by the other effects listed above. We use instrumental variables (IV) regression in an attempt to address this issue.

## Data and variables

*Data sources*

The data source used in the analysis is the British Household Panel Survey (BHPS). The BHPS is an annual panel survey covering a random sample of about 10,000 individuals in more than 5,000 households. The first wave of BHPS took place in 1991. The same individuals are followed and re-interviewed in each subsequent wave. If individuals leave their original households to form a new one, all adult members of the new households are also interviewed. The BHPS contains detailed information on individual and household demographics, health, job related characteristics, values and finances on an annual basis. Obesity data are reported in the BHPS in waves 14 (September 2004–May 2005) and wave 16 (September 2006–April 2007). In this paper we focus on the sample of individuals from wave 16.

*Obesity*

The dependent variable is based on individual BMI, which is based on self-reported weight and height, obtained during the individual interview. The measurements were not always given in the same units; weight was reported in either kg or lbs, and height was reported in either inches or cm. We converted all weight measurements into kg and all height measurements into metres. From these data we compute two obesity measures. The first is BMI measured as a linear term as weight in kilogrammes divided by height in metres squared ($kg/m^2$). The second is a binary variable taking the value 1 if the individual has a BMI>30 $kg/m^2$ and 0 otherwise.

*Psychological wellbeing*

To measure psychological well-being we use the General Health Questionnaire (GHQ-12) score developed by Golderg and Williams (1988). The GHQ-12 score is a reliable measure for psychological well-being and mental disorders. The GHQ-12 was originally designed for use in general practice settings as a screening tool and cannot be used to diagnose specific psychiatric problems. The GHQ-12 is designed to be self-administered and was included in the self completion booklet for informants aged 65 and over. It is based on answers to 12 questions on concentration, sleep loss due to worry, perception of role, capability in decision making, whether constantly under strain, perception of problems in overcoming difficulties,

enjoyment day to day activities, ability to face problems, loss of confidence, self-worth, general happiness and whether suffering depression. Each of the 12 questions has a four point response scale for the presence of symptoms, which are scored bimodally (i.e., symptom present: 'not at al'=0, 'no more than usual'=0, 'more than usual'=1, 'much more than usual'=1). The scores for each item are summed and an overall score from 0–12 is calculated, with higher values indicating greater psychological distress. A threshold score of four or more on the GHQ-12 has been used to identify informants with a potential psychiatric disorder (and references to informants with a 'high' GHQ12 score refer to those with scores at this threshold level). (Health Survey for England, 2005)

*Covariates*

We include a number of covariates from the BHPS. At the individual level we include: age (as a cubic function); annual income (measured in UK£); socioeconomic group in present job (7 categories); educational attainment (8 categories); smoking status (current smoker, yes/no); alchohol or drug problem (yes/no); ethnic group (6 categories); legal marital status (5 categories); month of interview (7 categories). We estimate separate models for men and women.

At the area level we include area mean annual income, % people in the area with no qualifications, and % people with very poor self-assessed general health. These variables were constructed by collapsing individual level values of annual income, no qualifications and very poor self-assessed general health in the BHPS sample by region/metropolitan area of residence (19 values) to produce a dataset of mean values at the area level. The area level dataset was then merged with the individual level BHPS data by respondents' area of residence. The mean number of sample observations per area (range) was 678 (168–2407).

**Analysis**

We run the following models:

1. We regress BMI against GHQ-12 score >3 plus the covariates separately for men and women using OLS.
2. We regress BMI>30 kg/$m^2$ against GHQ-12 score >3 plus the covariates separately for men and women using a probit model.

3. We repeat the first set of models using an IV regression procedure to account for the endogeneity of mental wellbeing. At the first stage we use OLS to regress GHQ-12 score >3 against an instrumental variable plus the covariates. We then compute the linear prediction of the psychological wellbeing measure for every observation using this model and at the second stage regress BMI against the predicted psychological wellbeing measure plus the covariates using OLS. The standard errors in this model are computed asymptotically.
4. We repeat the second set of models with an IV probit procedure using a conditional maximum likelihood estimator that estimates jointly both stages of the IV procedure (the relationship between the psychological wellbeing measure and the IV, and BMI>30 kg/$m^2$ and the predicted psychological wellbeing variable), both conditional on the covariates. The standard errors in this model are also computed asymptotically.
5. We regress BMI against the 12 components of the GHQ-12, measured as binary variables. The binary variables take the value 1 if the respondent records either of the two least favourable responses for that component, and 0 otherwise. These models are estimated using OLS, and we estimate two versions, for both men and women. In the first version all the GHQ-12 variables are added at the same time in a single model; in the second version they are added separately in 12 different models.
6. We repeat the previous analysis using BMI>30 kg/$m^2$ as the dependent variable, using probit models.
7. We regress BMI against the 12 components of the GHQ-12 using a similar IV procedure to the one outlined above. We were unable to find 12 different instruments for the GHQ-12 components and so we run this model 12 times, once for each component.
8. We repeat the previous analysis using BMI>30 kg/$m^2$ as the dependent variable, using IV probit models and a similar procedure to the one described above.

In the IV models we instrument psychological well-being measures using two instruments, and we run three sets of IV models, using both instruments separately and together. The first instrument is a household overcrowding measure, calculated as the number of bedrooms per person in the household. Higher values of this variable indicate less overcrowding. We expect this variable to be significantly related to psychological wellbeing. A recent report on the impact of household overcrowding on health and education (Office of the Prime Minister

Report, May 2004) provides evidence of positive association between overcrowding and mental health, especially in women.

The second instrument is area mean GHQ-12 score, calculated in a similar fashion to the area covariates described above. There is evidence that area deprivation affects psychological wellbeing (Office of the Prime Minister Report, May 2004). But area deprivation would not be an appropriate instrument because it may also be correlated directly with individual obesity. Hence, by using area psychological wellbeing as an instrument, but also controlling for area deprivation (area mean income, area educational attainment [% with no qualifications] and area health [% reported very poor self-assessed general health], as described above), we aim to isolate the component of area deprivation that affects individual psychological wellbeing but does not affect individual obesity directly. Conditional on the individual and area covariates, we expect that area psychological wellbeing measures are significantly and positively correlated with individual psychological wellbeing, and that the instrument is unlikely to be correlated with the error terms in the obesity equations.

We also experimented with using change of marital status over the last year as an instrument. Bruce and Kim (1992) report that major depression is three times higher among men who have been separated or divorced compared to stably married and single men and women. In all the IV models this variable was not significantly correlated with psychological wellbeing conditional on the covariates (excluding marital status) and so it was not included in the final models.

We test for exogeneity using auxiliary regressions (Davidson and MacKinnon, 1993; Smith and Blundell, 1986). We regress the obesity measures against the GHQ-12 variables and the covariates also including the residual term from the first stage GHQ-12 equations described above. The null hypothesis is that the coefficient on the residual term equals zero. If it is significantly different from zero then, under the maintained assumption that the instruments are valid, the psychological wellbeing measures are endogenous and the IV estimates are preferred. If we fail to reject the null hypothesis then, assuming the instruments are valid, it is not possible to identify any endogeneity problems with respect to GHQ-12 and the non-IV estimates are preferred (Baum, Schaffer and Stillman, 2003).

To maximise the sample size we included observations with missing values of the covariates. Missing values for income (<3% of the sample) were assigned the mean value. For binary and categorical variables, missing values were assigned to the omitted category. To allow for the possibility that items were not missing at random we included dummy variables for all imputed items to indicate item non response.

In all models we report robust standard errors and BHPS cross-section sample weights are used to weight observations in all the models.

**Results**

The total sample size in the 2006-07 BHPS is 15,248. Excluding pregnant women, individuals under the age of 16 years old, and those with missing BMI values we end up with a sample size of 8011 (4,112 men and 3,899 women). The mean BMI (SD) in the sample is 26.7 kg/$m^2$ (4.7 kg/$m^2$) for men and 27.6 kg/$m^2$ (5.4 kg/$m^2$) for women (Table 1). Eighteen percent of men are obese in the sample, compared with 28% women (Figure 1). Fifteen percent of men have GHQ-12 score >3, compared with 24% women .

GHQ-12 score >3 has a positive partial correlation with BMI and BMI>30kg/$m^2$ in both men and women (Tables 2 and 3). The association in males is non-significant for BMI and significant for BMI>30kg/$m^2$. In females GHQ-12 score >3 is significantly associated with both obesity measures.

In terms of the IV results, in men the household overcrowding variable was not a significant predictor of GHQ-12 score >3 and so these results are not reported. In the models using the area psychological wellbeing variable the effect, GHQ-12 score >3 has a positive but non-significant effect on the obesity measures. We fail to reject the exogeneity of psychological wellbeing in these models.

In women there is some evidence in the IV models that GHQ-12 score >3 is significantly and positively associated with obesity when using household overcrowding as the instrument. In the models where area psychological wellbeing is an instrument the effect is non-significant. In these models we fail to reject the exogeneity of psychological wellbeing, indicating that the non-IV models are preferred.

We also estimated the impact of GHQ-12 components on obesity. In every case, in the IV models we failed to reject the exogeneity of psychological wellbeing and so we only report the non-IV models here. When the components were added simultaneously (Table 6) few of the components are significant. This may be due to multicollinearity between the different components. When the variables are tested in separate models (Table 7), three of the components are statistically significant in the models for men (four in the BMI>30kg/$m^2$ models). In women seven or eight of the components are significant predictors. Hence, the impact of psychological wellbeing on obesity in women would appear to be driven by a number of components of psychological wellbeing.

**Discussion**

Using a nationally representative health survey with rich information on individuals and socioeconomic variables we find some evidence to support the view that psychological wellbeing is positively correlated with obesity in women. The effect in men appears to be much weaker. Analysis of the components of the GHQ-12 score in women suggest that the positive relationship is driven by a number of elements, including ability to concentrate, feelings of playing a useful part in things, ability to face problems, losing confidence in self and thinking of self as worthless. We generally fail to reject the exogeneity of psychological wellbeing, though this does depend on the instruments used.

A potential weakness of our study is that our IVs are invalid if they are correlated with the obesity measures. We use household overcrowding and area psychological wellbeing as instruments. While these are plausible instruments for individual psychological wellbeing, this is maintained rather than proven; any use of IVs rests on the uncheckable assumption that, conditional on the covariates, the instruments are uncorrelated with unobservable factors affecting the dependent variable.

There is conflicting evidence of psychological wellbeing on obesity. Our study provides support for the view that people, especially women, who have psychological problems are more likely to be obese.

The results presented in this paper are preliminary. In future work we intend to investigate the impact of psychological wellbeing on obesity using additional datasets (e.g., the Health Survey for England) in order to investigate the robustness of our results. Obesity and GHQ-12 scores are currently reported in two waves of the BHPS and therefore we also intend to repeat our analysis in the future using the BHPS data in a panel data setting.

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**Table 1. Sample means and standard deviations**

| | Men | | Women | |
|---|---|---|---|---|
| | **Mean** | **Std.Dev.** | **Mean** | **Std.Dev.** |
| **Obesity measures** | | | | |
| BMI ($kg/m^2$) | 26.696 | 4.643 | 27.669 | 5.392 |
| BMI >30$kg/m^2$ | 0.183 | 0.387 | 0.278 | 0.448 |
| **Psychological wellbeing measures** | | | | |
| GHQ-12 score >3 | 0.146 | 0.353 | 0.244 | 0.429 |
| Able to concentrate | 0.137 | 0.344 | 0.213 | 0.410 |
| Lost sleep over worry | 0.137 | 0.344 | 0.226 | 0.418 |
| Felt playing useful part in things | 0.100 | 0.300 | 0.143 | 0.349 |
| Felt capable of making decisions | 0.073 | 0.259 | 0.116 | 0.319 |
| Felt constantly under strain | 0.217 | 0.412 | 0.297 | 0.457 |
| Felt couldn't overcome difficulties | 0.108 | 0.310 | 0.175 | 0.380 |
| Able to enjoy day- to day activities | 0.155 | 0.362 | 0.203 | 0.402 |
| Been able to face problems | 0.081 | 0.273 | 0.144 | 0.352 |
| Been feeling unhappy and depressed | 0.167 | 0.374 | 0.244 | 0.429 |
| Been loosing confidence in self | 0.101 | 0.302 | 0.182 | 0.386 |
| Been thinking of self as worthless | 0.051 | 0.221 | 0.100 | 0.300 |
| Been feeling reasonably happy | 0.104 | 0.306 | 0.151 | 0.358 |
| **Age** | | | | |
| Age/100 | 0.468 | 0.181 | 0.500 | 0.182 |
| Age squared | 0.252 | 0.179 | 0.283 | 0.188 |
| Age cubed | 0.149 | 0.151 | 0.176 | 0.162 |
| **Instruments** | | | | |
| Overcrowding (bedrooms per person) | 2.036 | 1.085 | 2.139 | 1.161 |
| Area GHQ-12 score | 1.874 | 0.190 | 1.874 | 0.192 |
| **Annual Income** | | | | |
| Annual income | 19818.7 | 16204.87 | 12393 | 10174.3 |
| Missing annual income | 0.021 | 0.142 | 0.015 | 0.122 |
| **Socioeconomic group, present job** | | | | |
| Professional | 0.055 | 0.228 | 0.019 | 0.136 |
| Managerial | 0.273 | 0.445 | 0.256 | 0.437 |
| Semi-skilled non manual | 0.115 | 0.319 | 0.239 | 0.427 |
| manual | 0.233 | 0.422 | 0.059 | 0.236 |
| Skilled | 0.126 | 0.332 | 0.121 | 0.326 |
| Non-skilled | 0.034 | 0.181 | 0.039 | 0.195 |
| Not working/missing | 0.160 | 0.367 | 0.266 | 0.442 |
| **Educational qualifications** | | | | |
| Higher degree | 0.034 | 0.182 | 0.223 | 0.148 |
| Degree | 0.124 | 0.330 | 0.102 | 0.302 |
| Higher Education | 0.306 | 0.461 | 0.271 | 0.444 |
| GCSE | 0.281 | 0.449 | 0.272 | 0.445 |
| CSE | 0.028 | 0.166 | 0.024 | 0.154 |
| Other qualification | 0.042 | 0.200 | 0.059 | 0.236 |
| No qualification | 0.162 | 0.368 | 0.235 | 0.423 |
| Missing qualifications | 0.021 | 0.143 | 0.014 | 0.119 |

| | | | | |
|---|---|---|---|---|
| **Current smoker** | 0.228 | 0.419 | 0.224 | 0.417 |
| **Alcohol or drug problem** | 0.006 | 0.079 | 0.004 | 0.068 |
| **Ethnicity** | | | | |
| White | 0.957 | 0.203 | 0.962 | 0.192 |
| Black | 0.005 | 0.075 | 0.001 | 0.0734 |
| Asian | 0.011 | 0.106 | 0.014 | 0.117 |
| Chinese | 0.000 | 0.027 | 0.001 | 0.034 |
| Other ethnicity | 0.001 | 0.073 | 0.006 | 0.079 |
| Missing ethnicity | 0.020 | 0.140 | 0.011 | 0.105 |
| **Legal marital status** | | | | |
| Married | 0.589 | 0.492 | 0.522 | 0.499 |
| Separated | 0.013 | 0.114 | 0.017 | 0.129 |
| Divorced | 0.058 | 0.233 | 0.104 | 0.304 |
| Widowed | 0.036 | 0.187 | 0.123 | 0.329 |
| Never married | 0.296 | 0.457 | 0.227 | 0.418 |
| **Month of Interview** | | | | |
| January | 0.025 | 0.158 | 0.021 | 0.142 |
| February | 0.003 | 0.057 | 0.004 | 0.067 |
| March | 0.002 | 0.047 | 0.004 | 0.061 |
| September | 0.488 | 0.499 | 0.535 | 0.498 |
| October | 0.329 | 0.469 | 0.297 | 0.457 |
| November | 0.122 | 0.327 | 0.115 | 0.319 |
| December | 0.029 | 0.169 | 0.023 | 0.152 |
| **Area level variables** | | | | |
| Mean income | 15732.43 | 1715.49 | 15727.28 | 1706.32 |
| Prop. no educational qualifications | 0.185 | 0.050 | 0.186 | 0.051 |
| Prop. very poor self-assessed health | 0.021 | 0.007 | 0.021 | 0.006 |

**Table 2. Impact of GHQ-12 score >3 on BMI and BMI>30 kg/m$^2$ in men**

| **Impact of GHQ-12 score >3 on BMI** | | | | |
|---|---|---|---|---|
| | **OLS** | **2SLS 1** | **2SLS 2** | **2SLS 3** |
| **GHQ-12 >3** | 0.266 | N/A | 7.497 | N/A |
| *N* | 4112 | | 4112 | |
| $R^2$ | | | | |
| t | 0.087 | | 1.59 | |
| F-test | | | 10.14(0.001) | |
| Endogeneity test: $\chi 2$ [p-value] | | | 2.95(0.08) | |
| **Impact of GHQ-12 score >3 on BMI>30 kg/m$^2$** | | | | |
| | **Probit** | **IV probit 1** | **IV probit 2** | **IV probit 3** |
| **GHQ-12 >3** | 0.156** | N/A | 0.681 | N/A |
| *N* | 4122 | | 4122 | |
| Pseudo $R^2$ | 0.053 | | | |
| z | 2.28 | | 0.49 | |
| F-test | | | 10.14(0.001) | |
| Exogeneity test: $\chi 2$ [p-value] | | | 0.14(0.71) | |

All the covariates are included in all the models.
N/A: the household overcrowding instrument was not significant in the first stage.
2SLS: two stage least squares, IV: instrumental variables, ***p<0.01, **p<0.05, *p<0.1
IV model 1: instrument is household overcrowding variable (bedrooms per person)
IV model 2: instrument is area level GHQ-12 score
IV model 3: instrument is household overcrowding variable plus area level GHQ-12 score variable

**Table 3. Impact of GHQ-12 score >3 on BMI and BMI>30 kg/m$^2$ in women**

| **Impact of GHQ-12 score >3 on BMI** | | | | |
|---|---|---|---|---|
| | **OLS** | **2SLS 1** | **2SLS 2** | **2SLS 3** |
| **GHQ-12 >3** | 0.415* | 16.114** | -2.774 | 3.501 |
| *N* | 3899 | 3876 | 3899 | 3876 |
| $R^2$ | 0.077 | | | |
| t | 1.83 | 2.08 | -0.83 | 1.21 |
| F-test | | 6.78(0.00) | 14.61(0.00) | 10.75(0.00) |
| Endogeneity test : $\chi 2$ [p-value] | | 11.105(0.00) | 0.95(0.329) | 1.278(0.258) |
| **Impact of GHQ-12 score >3 on BMI>30 kg/m$^2$** | | | | |
| | **Probit** | **IV probit 1** | **IV probit 2** | **IV probit 3** |
| **GHQ-12 >3** | 0.109** | 1.94*** | -0.988 | 0.407 |
| *N* | 3899 | 3876 | 3899 | 3876 |
| Pseudo $R^2$ | 0.041 | | | |
| z | 1.96 | 5.02 | -1.55 | 0.37 |
| F-test | | 6.78(0.00) | 14.61(0.00) | 10.75(0.00) |
| Exogeneity test: $\chi 2$ [p-value] | | 5.54(0.018) | 2.20(0.136) | 0.07(0.794) |

All the covariates are included in all the models.
2SLS: two stage least squares, IV: instrumental variables, ***p<0.01, **p<0.05, *p<0.1
IV model 1: instrument is household overcrowding variable (bedrooms per person)
IV model 2: instrument is area level GHQ-12 score
IV model 3: instrument is household overcrowding variable plus area level GHQ-12 score variable

**Table 6. Impact of GHQ-12 score components on BMI (all GHQ-12 score components added simultaneously)**

| | Men | | Women | |
|---|---|---|---|---|
| | **Coef.** | **t/z** | **Coef.** | **t/z** |
| ***Impact of GHQ-12 score components on BMI*** | | | | |
| Able to concentrate | -0.127 | -0.50 | 0.091 | 0.33 |
| Lost sleep over worry | -0.260 | -0.98 | 0.242 | 0.85 |
| Felt playing useful part in things | 0.763** | 2.52 | 0.408 | 1.21 |
| Felt capable of making decisions | -0.839** | -2.23 | -0.453 | -1.17 |
| Felt constantly under strain | -0.009 | -0.04 | -0.205 | -0.75 |
| Felt couldn't overcome difficulties | -0.018 | -0.06 | 0.143 | 0.38 |
| Able to enjoy day-to-day activities | 0.204 | 0.79 | 0.124 | 0.40 |
| Been able to face problems | 0.265 | 0.45 | 0.524 | 1.35 |
| Been feeling unhappy and depressed | -0.184 | -0.67 | -0.419 | -1.39 |
| Been losing confidence in self | 0.430 | 1.35 | 0.234 | 0.71 |
| Been thinking of self as worthless | 0.348 | 0.76 | 1.012** | 2.36 |
| Been feeling reasonably happy | 0.063 | 0.17 | -0.401 | -1.06 |
| ***Impact of GHQ-12 score components on BMI>30kg/m$^2$*** | | | | |
| Able to concentrate | -0.079 | -0.91 | 0.022 | 0.30 |
| Lost sleep over worry | -0.116 | -1.34 | -0.004 | -0.06 |
| Felt playing useful part in things | 0.158 | 1.64 | 0.079 | 0.93 |
| Felt capable of making decisions | -0.215* | -1.72 | -0.014 | -0.15 |
| Felt constantly under strain | -0.011 | -0.14 | -0.013 | -0.18 |
| Felt couldn't overcome difficulties | -0.039 | -0.40 | 0.121 | 1.38 |
| Able to enjoy day-to-day activities | 0.102 | 1.20 | 0.087 | 1.12 |
| Been able to face problems | 0.034 | 0.29 | 0.072 | 0.73 |
| Been feeling unhappy and depressed | 0.062 | 0.66 | -0.155* | -1.84 |
| Been losing confidence in self | 0.054 | 0.50 | 0.055 | 0.61 |
| Been thinking of self as worthless | 0.268 | 1.97* | 0.086 | 0.77 |
| Been feeling reasonably happy | 0.001 | 0.01 | -0.038 | -0.39 |

All the covariates are included in all the models. ***p<0.01, **p<0.05, *p<0.1

**Table 7. Impact of GHQ-12 score components on BMI (GHQ-12 score components added separately in different models)**

| | Men | | Women | |
|---|---|---|---|---|
| | **Coef.** | **t/z** | **Coef.** | **t/z** |
| ***Impact of GHQ-12 score components on BMI*** | | | | |
| Able to concentrate | 0.088 | 0.38 | 0.427* | 1.83 |
| Lost sleep over worry | -0.057 | -0.24 | 0.396* | 1.70 |
| Felt playing useful part in things | 0.668** | 2.36 | 0.738*** | 2.60 |
| Felt capable of making decisions | -0.151 | -0.51 | 0.369 | 1.24 |
| Felt constantly under strain | 0.073 | 0.39 | 0.182 | 0.85 |
| Felt couldn't overcome difficulties | 0.168 | 0.65 | 0.522** | 2.11 |
| Able to enjoy day-to-day activities | 0.306 | 1.35 | 0.457* | 1.87 |
| Been able to face problems | 0.350 | 0.91 | 0.748*** | 2.60 |
| Been feeling unhappy and depressed | 0.134 | 0.60 | 0.147 | 0.65 |
| Been losing confidence in self | 0.518* | 1.90 | 0.675*** | 2.73 |
| Been thinking of self as worthless | 0.645* | 1.70 | 0.178** | 3.61 |
| Been feeling reasonably happy | 0.326 | 1.11 | 0.292 | 1.09 |
| ***Impact of GHQ-12 score components on BMI>30kg/m$^2$*** | | | | |
| Able to concentrate | 0.010 | 0.14 | 0.115** | 2.00 |
| Lost sleep over worry | -0.035 | -0.49 | 0.071 | 1.23 |
| Felt playing useful part in things | 0.165** | 2.07 | 0.169** | 2.56 |
| Felt capable of making decisions | -0.026 | -0.28 | 0.144* | 2.04 |
| Felt constantly under strain | 0.031 | 0.50 | 0.074 | 1.38 |
| Felt couldn't overcome difficulties | 0.049 | 0.64 | 0.177 | 2.83 |
| Able to enjoy day-to-day activities | 0.123* | 1.83 | 0.152** | 2.54 |
| Been able to face problems | 0.105 | 1.19 | 0.174*** | 2.61 |
| Been feeling unhappy and depressed | 0.100 | 1.53 | 0.025 | 0.44 |
| Been losing confidence in self | 0.147* | 1.84 | 0.151** | 2.43 |
| Been thinking of self as worthless | 0.293*** | 2.80 | 0.200** | 2.59 |
| Been feeling reasonably happy | 0.116 | 1.48 | 0.097 | 1.48 |

All the covariates are included in all the models. ***p<0.01, **p<0.05, *p<0.1

**Figure 1. Sample distribution of BMI**