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### Heaviness, health and happiness

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## Title Page

### **Heaviness, Health and Happiness: A Cross-Sectional Study of 163,066 UK Biobank Participants.**

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## **Abstract**

### **Background**

Obesity is known to increase the risk of many diseases and reduce overall quality of life. This study examines the relationship with self-reported health (SRH) and happiness.

### **Methods**

We conducted a cross-sectional study of the 163,066 UK Biobank participants who completed the happiness rating. The association between adiposity and SRH and happiness was examined using logistic regression. SRH was defined as good (excellent, good), or poor (fair, poor). Self-reported happiness was defined as happy (extremely, very, moderately) or unhappy (moderately, very, extremely).

### **Results**

Poor health was reported by 44,457 (27.3%) participants. The adjusted odds ratios (OR) for poor health were 3.86, 2.92, 2.60 and 6.41 for the highest, compared with lowest, deciles of body mass index, waist circumference, waist to hip ratio and body fat percent, respectively. The associations were stronger in men ( $p < 0.001$ ). Overall, 7,511 (4.6%) participants felt unhappy, and only class III obese participants were more likely to feel unhappy (adjusted OR 1.33, 95% CI 1.15, 1.53,  $p < 0.001$ ) but the associations differed by sex ( $p < 0.001$ ). Among women, there was a significant association between unhappiness and all levels of obesity. By contrast, only class III obese men had significantly increased risk and overweight and class I obese men were less likely to be unhappy.

### **Conclusion**

Obesity impacts adversely on happiness as well as health, but the association with unhappiness disappeared after adjustment for self-reported health, indicating this may be mediated by health.

Compared with obese men, obese women are less likely to report poor health but more likely to feel unhappy.

### **What is already known**

Obesity is associated with reduced physical health-related quality of life (HRQoL) in both men and women. By contrast, there are sex differences in mental health such that obesity is associated with reduced mental health in women only and overweight men have better mental health. Quality of life has been the subject of many studies but there is a paucity of studies on unhappiness.

### **What this study adds**

Adiposity was significantly associated with poor overall health, with a clear dose relationship across all the anthropometric measures used (BMI, waist circumference, waist to hip ratio and body fat percent), in both men and women. The association was stronger in men than women. Overweight men were more likely to report being happy, and only morbidly obese men were at higher risk of reporting unhappiness, compared to men of normal-weight. By contrast, among women, all classes of obesity were associated with unhappiness, compared with women of normal-weight. However, after adjustment for self-reported health, the association between adiposity and unhappiness was no longer apparent, suggesting that this association may be mediated by health.

### **Policy implications**

Interventions effective at combating obesity have the potential to improve perceived health as well as avoiding adverse clinical outcomes.

## **Main text**

### **Introduction**

Historically, the main focus of healthcare has been the avoidance of preventable mortality. As life-expectancy has increased, attention has focused on the need to improve health, as well as longevity. WHO definition of health encompasses mental and social, as well as physical, wellbeing<sup>1</sup> but, when self-reporting health, people give greater emphasis to physical well-being than psychological well-being.<sup>2</sup> Poor self-reported health (SRH) predicts mortality over 2-13 years follow-up overall,<sup>3</sup> but the association is significantly stronger in men.<sup>4</sup> This has been attributed to women considering a wider range of health-related factors and non-health-related factors in the process of assessing their own health.<sup>4</sup> Psychological well-being itself comprises several components, including happiness (hedonic well-being) and life satisfaction (eudaimonic well-being). In the United Kingdom, 38% of people who reported poor health had high levels of life satisfaction, and 20% of those who reported good health had low life satisfaction.<sup>5</sup> Therefore, it is important that study results pertaining to one construct are not inappropriately generalised to another.

High levels of adiposity are associated with many diseases including hypertension,<sup>6</sup> stroke,<sup>7</sup> coronary heart disease,<sup>8</sup> diabetes<sup>9</sup> and arthritis.<sup>10</sup> Evidence is increasing that obesity may also impact adversely on psychosocial well-being. There are conflicting results regarding the association between obesity and poor SRH. Some studies have reported significant associations<sup>11;12</sup> while others have reported no<sup>13</sup> or very weak associations.<sup>14</sup> A recent study from the USA that found no association hypothesised that a shift to the right in the Body Mass Index (BMI) distribution of the general population had changed societal perspectives of what constituted normal weight.<sup>14</sup> Previous studies on obesity have tended to use measures of health-related quality of life (HRQoL) which encompass both physical and psychosocial

wellbeing. In recent studies, we demonstrated that obesity was associated with significantly reduced overall HRQoL, irrespective of the presence of comorbid conditions.<sup>15</sup> The physical component of HRQoL was reduced in both overweight and obese adults with evidence of a dose relationship.<sup>16;17</sup> By contrast, the mental component of HRQoL was reduced only among class III obese ( $\geq 40$  kg/m<sup>2</sup>), individuals and was increased among overweight adults.<sup>17</sup> On sub-group analyses it was also clear that the overall reduction in the mental component among class III obese was present in women only.<sup>18</sup>

While BMI remains the measure of choice for most researchers, there is also growing evidence that favours other anthropometric measurements such as waist circumference (WC), waist to hip ratio (WHR) and body fat percentage (BF%).<sup>19</sup> Studies have reported association between WC, WHR and perceived stress, and higher levels of stress-dependent cortisol.<sup>20</sup> In some recent studies, abnormally high BF% is significantly associated with poor mental health and well-being.<sup>21</sup> Obesity can lead to stigma and discrimination.<sup>22</sup> Compared with men, women are more likely to be judged based on physical appearance. Therefore, it is plausible that obesity will be associated with unhappiness, especially among women. The aim of this study was to explore the relationship between adiposity (objectively measured by BMI, WC, WHR and BF%), SRH and unhappiness among a large sample of UK middle-aged population.

## Methods

### Data source

UK Biobank is a large, prospective cohort study of 502,682 residents of the United Kingdom, aged between 40 and 69 years.<sup>23;24</sup> The cohort provides one of the largest resources worldwide to study the genetic, environmental and lifestyle factors that cause or prevent disease in middle and older age.<sup>25</sup> Recruitment was undertaken over a 4-year period from 2006 to 2010, but the rating on self-reported happiness was only included in the last two years of recruitment. In due course, follow-up information will be obtained via record linkage to routine health and administrative databases. This cross-sectional study was undertaken using the baseline data on those participants who completed the happiness rating.

### Data collection

Participants attended one of 22 centres located across the United Kingdom. They completed a touch screen questionnaire that collected information on demographics (including age, sex, ethnicity, employment status and postcode of residence), health-related behaviours (including smoking status and alcohol consumption), doctor-diagnosed comorbidity (cardiovascular disease, hypertension, diabetes and cancer), overall health rating and happiness. Trained clinic staff used standard operating procedures to record physical measurements; including height, weight, waist and hip circumference and BF% (measured by bioimpedance). After removal of shoes and heavy outer clothing, weight and BF% were measured using the Tanita BC-418MA body composition analyser. Height, without shoes, was measured using the Seca 202 device. The Wessex non-stretchable sprung tape was used to measure WC at the level of the umbilicus and hip circumference at the widest point. WHR was derived by dividing WC by hip

circumference and BMI was derived by dividing weight (measured in kilograms) by the square of height (measured in metres).

### Definitions

BMI was categorised into underweight ( $<18.5 \text{ kg/m}^2$ ), normal weight ( $18.5\text{-}24.9 \text{ kg/m}^2$ ), overweight ( $25.0\text{-}29.9 \text{ kg/m}^2$ ), class I obese ( $30.0\text{-}34.9 \text{ kg/m}^2$ ), class II obese ( $35.0\text{-}39.9 \text{ kg/m}^2$ ) and class III obese ( $\geq 40 \text{ kg/m}^2$ ), using standard cut-point.<sup>26</sup> Among men, WC was categorised into normal weight ( $<94 \text{ cm}$ ), overweight ( $94\text{-}101 \text{ cm}$ ), and obese ( $\geq 102 \text{ cm}$ ). The equivalent cut-off values for women were  $<80$ ,  $80\text{-}87$  and  $\geq 88 \text{ cm}$  respectively.

Among men, WHR was categorised into normal weight ( $<0.90$ ), overweight ( $0.90\text{-}0.99$ ) and obese ( $\geq 1$ ). Among women, the equivalent cut-off values were  $<0.80$ ,  $0.80\text{-}0.84$  and  $\geq 0.85$  respectively.<sup>27</sup> BF% was dichotomised into normal weight (defined as  $\leq 25\%$  for men and  $\leq 32\%$  for women) and obese (defined as  $>25\%$  for men and  $>32\%$  for women).<sup>28</sup>

Smoking status, level of alcohol consumption, ethnic group and employment status were self-reported. Townsend deprivation index is an area-based measure of socioeconomic status and is derived from aggregated information collected in the census on: car ownership; overcrowding; owner-occupation and unemployment.<sup>29</sup> The score includes both positive and negative values, with positive values indicating higher levels of deprivation. The presence of comorbidity was based on self-report of a physician diagnosis. Overall health was self-classified, and based on response to the question “In general, how would you rate your overall health; excellent, good, fair or poor? In this study, we collapsed these into two categories, one comprising excellent and good that we labelled good, and a second comprising fair and poor that we labelled poor. Overall happiness was self-reported, and based on response to the



question: “In general, how happy are you; extremely happy, very happy, moderately happy, moderately unhappy, very unhappy or extremely unhappy?” In this study, we collapsed these into two categories: happy (extremely happy, very happy, moderately happy) and unhappy (moderately unhappy, very unhappy or extremely unhappy). UK Biobank used validated questionnaires, particularly for lifestyle factors, socioeconomic status and general health.<sup>25</sup>

This study was approved by the NHS National Research Ethics Service (17 June 2011, Ref 11/NW/0382). Written consent was obtained, including consent to collect baseline data, to obtain follow-up information via linkage to medical records, and to collect and analyse blood and urine samples. Participants agreed that, except for some measurements obtained during the visits, none of their results would be provided to them and they will not benefit from any future commercial developments.

### Statistical Analyses

Differences in the characteristics of participants by SRH and happiness were analysed using the  $\chi^2$  test for categorical data,  $\chi^2$  test for trend for ordinal data, and Wilcoxon rank-sum test for Townsend score (non-normally distributed). We examined the associations between anthropometric measurements (BMI, WC, WHR and BF%) and SRH and happiness using univariate and multivariate logistic regression models. Results are presented as odds ratio (OR) and 95% confidence intervals. In the latter, we adjusted for the potential confounding effects of age, sex, socioeconomic and employment status, ethnic group, smoking status, frequency of alcohol consumption and presence of comorbidity. We tested whether there were statistically significant interactions by applying likelihood ratio test between anthropometric measurements and both sex; conducting subgroup analyses accordingly. All statistical analyses were performed using Stata version 12.1 (StataCorp, College Station, Texas). Statistical significance was defined as  $p < 0.05$ .

## Results

Of the 502,682 UK Biobank participants, 163,066 (32.4%) were recruited following inclusion of a happiness rating and were, therefore, eligible for inclusion in this study. Their mean BMI was 27.4 (SD 4.8) (men 27.8 (SD 4.2); women 27.1 (SD 5.2)). Overall, the mean age was 57 years (SD 8 years), and 74,177 (45.5%) were men.

### Self-reported health

Overall, 44,457 (27.3%) participants classified themselves as being in poor health. Compared to those with good SRH, those with poor SRH were more likely to be women, obese, deprived, unemployed, non-white, smoked and reported comorbidity, but consumed less alcohol and were not significantly different in terms of age (Table 1). There was a J-shaped relationship between several anthropometric measures and poor SRH in both men (Figure 1), and women (Figure 2). On both univariate and multivariate logistic regression analysis, there were significant associations between all anthropometric measures and SRH (all  $p < 0.001$ ) (Table 2). In relation to BMI category, those participants who were classified as underweight, overweight or obese (class I, II or III) had significantly increased odds of having poor SRH in comparison with normal weight participants with evidence of a dose relationship among participants with above-normal BMI (Table 2). Similarly, individuals classified as overweight or obese based on the other measures had significantly higher odds of poor SRH compared with individuals of normal-weight, with higher odds for obese than overweight. There was a significant interaction with gender ( $p < 0.001$ ). Sub-group analyses by sex demonstrated that the overall patterns of association were common to both men and women, but the odds ratios associated with class II and III obesity tended to be higher in men (Table 2).

When the logistic regression analyses were re-run entering the anthropometric measures as sex-specific deciles, the adjusted odds ratios in both sexes showed the same J shaped relationships (Supplementary Figures 1&2) observed for the crude frequencies (Figures 1&2). Men and women in the highest deciles of BMI, WHR and WC had fourfold to sixfold higher odds of poor SRH. The magnitude of association with BF% was much greater in men than women. Being in the top decile of BF% increased the odds of poor SRH ninefold in men (adjusted OR 8.99, 95% CI 5.58, 14.49,  $p<0.001$ ) (Supplementary Figure 1) but only threefold in women (adjusted OR 3.33, 95% CI 3.09, 3.59,  $p<0.001$ ) (Supplementary Figure 2).

### Self-reported happiness

Overall, 7,511 (4.6%) participants reported feeling unhappy. Compared to those with good self-reported happiness, those with poor self-reported happiness were more likely to be women, obese, deprived, unemployed, non-white, smoked and reported comorbidity, but consumed less alcohol and were not significantly different in terms of age (Table 1). In both men (Figure 1) and women (Figure 2), the odds of being unhappy were higher in only the highest deciles of adiposity. There was a significant interaction with gender ( $p<0.001$ ) but not with ethnicity ( $p=0.366$ ). On logistic regression analysis, women who were obese, based on BMI, were more likely to be unhappy (Table 3). Adjustment for the potential confounding effects attenuated the associations but they remained statistically significant (class III obese adjusted OR 1.38, 95% CI 1.16, 1.65,  $p<0.001$ ) (Table 3). BF% was less discriminatory. Men only had significantly higher odds of unhappiness if they were class III obese (adjusted OR 1.29, 95% CI 1.03, 1.63,  $p=0.029$ ), and overweight and class I obese men were significantly less likely to be unhappy than men of normal weight (Table 3).

Overall, of the 44,457 participants with self-reported poor health, 39,869 (89.7%) were happy and, of the 7,511 participants who felt unhappy, 2,923 (38.9%) reported good health. After adjustment for SRH,

obesity was no longer associated with a significantly increased risk of unhappiness (Supplementary Table 1). In women, being underweight was associated with increased odds of being unhappy even after adjusting for potential confounders including comorbidity (Table 3). But when the analyses were stratified according to whether or not participants reported themselves as healthy, underweight women who reported themselves to be healthy were no longer significantly more likely to be unhappy (adjusted OR 1.39, 95% CI 0.86, 2.24,  $p=0.181$ ) (Supplementary Table 2a) whereas unhealthy underweight women were still more likely to feel unhappy (adjusted OR 1.70, 95% CI 1.14, 2.53,  $p=0.009$ ) (Supplementary Table 2b). Among men, there was a significant univariate association between being underweight and unhappy but this was no longer significant following adjustment for potential confounders (Table 3).

## Discussion

In this study we sought to investigate the relationship between obesity, health and happiness using a large cross-sectional study of the UK general population. We found that there was no association between happiness and self-reported good health which suggests that the general population may primarily define their health in terms of physical, rather than psychosocial, wellbeing. Overweight and obese individuals were significantly more likely to report poor overall health than individuals, of normal weight, even after adjustment for potential confounders, and irrespective of the anthropometric measure used. The association varied by sex such that obesity increased the odds of poor self-rated health in men more than in women. By contrast, obesity increased the odds of unhappiness in women more than men. Overweight and class I obese men were more likely to report being happy than men of normal weight, and men only reported feeling unhappy if they were severely obese. By contrast women reported unhappiness at lower levels of obesity. The significant association between obesity and unhappiness was lost following adjustment for SRH suggesting that the association may be mediated by health. Being underweight may occur as a result of ill-health, and underweight women were only at increased risk of unhappiness if they also reported themselves as unhealthy.

Self-reported poor health is a stronger predictor of mortality among men.<sup>3</sup> Our findings suggested that the association between poor SRH and obesity was also stronger in men. Both may be due to sex differences in the range of factors considered when self-reporting health.<sup>4</sup> Existing evidence is mixed as to whether SRH is poorer in overweight and obese individuals. Studies have reported different results across countries.<sup>11;14;30</sup> Poor SRH was more prevalent in the UK than other European countries, particularly in men.<sup>30</sup> By contrast, poor mental health was more prevalent in women in all the European countries studied.<sup>30</sup> There is a paucity of UK studies on the association between body weight and SRH, but our

findings of higher poor SRH among overweight and obese individuals are in line with published international studies.<sup>12;31</sup>

The sex differences we observed in the relationship between adiposity and happiness are consistent with the previous studies that have examined overall quality of life; as is the finding of greater happiness among overweight men. We previously reported sex differences in the relationship between BMI and mental health in a cross-sectional study of more than 37,000 Scottish adults.<sup>18</sup> Being overweight was associated with better mental health in men only and obesity was associated with significantly worse mental health in women only. Greeno et al reported an association between obesity and reduced life satisfaction in women only.<sup>32</sup> Obese men had significantly higher life satisfaction.<sup>32</sup> In a recent meta-analysis, health related quality of life was significantly reduced in class III obese adults and improved in overweight adults.<sup>17</sup>

Health is an important determinant of well-being and happiness; but it is not the only determinant. Electronic and print media promote thin and muscular models and are becoming increasingly unrepresentative of the general population in which more than 65% of individuals are either overweight or obese. Portrayal of these models as the ideal can promote negative body image and disordered eating.<sup>33</sup> Several studies have reported more discriminatory societal attitudes towards obesity in women than men.<sup>34</sup> Obesity-related stigma begins very early in life, as young as three years of age, and persists through childhood and adolescence into adult and later life.<sup>22</sup> There is evidence of discrimination in recruitment, education, news and the media.<sup>35</sup> Recurrent stigma, prejudice and discrimination could result in chronic psychological stress, reduced mental health and overall happiness.

A small number of previous studies have examined the association between level of adiposity and SRH and happiness. To our knowledge, this is the first study to examine the relationship across the full

spectrum from underweight to class III obese, and use multiple anthropometric measurements. Use of UK Biobank provided a large sample of middle-aged and old-aged individuals recruited from the general population. We were able to adjust for a series of potential confounders, but as with any observational study, residual confounding is always possible. Many studies have used only BMI which is a poor measure of adiposity in muscular individuals. Having access to three other measures of adiposity (WC, WHR and BF%) enabled us to corroborate our findings using BMI. We were able to demonstrate interactions by sex and to undertake subgroup analyses accordingly. As with any cross-sectional study, it was not possible to establish a temporal relationship and exclude reverse causation. Obesity may predispose to unhappiness. Conversely, unhappiness may lead to over-eating. A longitudinal study reported that after 5 years of follow-up, obesity, predicted unhappiness (OR 1.70) and depression (OR 2.16), but depression did not predict obesity.<sup>36;37</sup> Conversely, another study reported that baseline depressive symptoms influenced future adiposity but initial adiposity did not influence future depressive symptoms.<sup>38</sup> One weakness of this study is to have used a rating scale of happiness that has been rarely used. However, some previous studies which have used a similar happiness question using the full range of categories from extremely happy to extremely unhappy.<sup>39;40</sup> Less than 10% of invited people participated in UK Biobank. It is representative of the UK population in terms of breakdown for age, sex, ethnicity and socioeconomic status, but may not be representative in terms of other parameters. Our overall prevalence of 66% for overweight or obese (42% and 24% respectively) corresponds closely with national statistics.<sup>41;42</sup> The 27% prevalence for poor SRH observed in our study and mean score of 2.177 are higher than the UK figures (9.1% and 1.196 respectively) reported in WHO's "2002 World Health Survey"<sup>43</sup> but this difference is likely to be due, in part, to WHO survey participants being younger (mean age of 45 years compared with 57 years in UK Biobank) since our figures are commensurate with UK national figures.<sup>44</sup> Inclusion was restricted to participants who had completed the happiness question. They were more likely to be older ( $p<0.001$ ), and deprived ( $p<0.001$ ) than participants who did not complete the happiness question, but were not significantly different in terms of sex ( $p=0.855$ ).

## Conclusions

High levels of adiposity are associated with unhappiness as well as poor health. Compared with obese men, obese women are less likely to report poor health but more likely to report unhappiness. However, after adjustment for self-reported health the association between adiposity and unhappiness is lost, suggesting that this association may be mediated by health. This study further supports the existing evidence that there is an association between adiposity and subjective well-being, particularly perceived health, regardless of the anthropometric measurements used, and independent of various potential confounders, including comorbidity. These findings emphasise the need for individual and community-level interventions to reverse the increasing trend of obesity because it is a risk to mental, as well as physical, well-being.



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## **Competing interests**

None declared.

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## **Contributors' statement**

All authors contributed to conception and design. ZUH and DFM analysed the data. All authors agreed what analyses were required and interpreted the results ZUH wrote the first draft. All authors revised the manuscript and approved the final version and takes full responsibility for the manuscript.

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**Figure 1 Frequency (%) of self-reported poor health and unhappiness by measures of adiposity in Men.**

**Figure 2 Frequency (%) of self-reported poor health and unhappiness by measures of adiposity in Women.**

**Supplementary Figure 1 Adjusted odds ratio of self-reported poor health and unhappiness by measures of adiposity in Men.**

**Supplementary Figure 2 Adjusted odds ratio of self-reported poor health and unhappiness by measures of adiposity in Women.**

Table 1 Characteristics of the participants by self-reported health and happiness.

	Self-reported General Health			Self-reported overall Happiness		
	Good N= 118,609 N (%)	Poor N= 44,457 N (%)	P-value	Happy N=155,555 N (%)	Unhappy N=7,511 N (%)	P-value
<b>Sex</b>						
Women	66,600 (56.15)	22,289 (50.14)	<0.001	85,105 (54.71)	3784 (50.38)	<0.001
Men	52,009 (43.85)	22,168 (49.86)		70,450 (45.29)	3727 (49.62)	
<b>Age (years)</b>						
39-49	26,985 (22.75)	10,167 (22.87)	0.134	34,714 (22.32)	2,438 (32.46)	<0.001
50-60	42,930 (36.19)	16,274 (36.61)		56,076 (36.05)	3,128 (41.65)	
61-72	48,694 (41.05)	18,016 (40.52)		64,765 (41.63)	1,945 (25.90)	
<b>BMI category</b>						
Underweight	555 (0.47)	241 (0.54)	<0.001	729 (0.47)	67 (0.89)	<0.001
Normal-weight	43,995 (37.09)	9,284 (20.88)		50,873 (32.70)	2,406 (32.03)	
Overweight	51,983 (43.83)	17,067 (38.39)		66,216 (42.57)	2,834 (37.73)	
Class I obese	17,249 (14.54)	11,432 (25.71)		27,213 (17.49)	1,468 (19.54)	
Class II obese	3,837 (3.23)	4,294 (9.66)		7,665 (4.93)	466 (6.20)	
Class III obese	990 (0.83)	2,139 (4.81)		2,859 (1.84)	270 (3.59)	
<b>WC category</b>						
Normal-weight	53,223 (44.87)	11,257 (25.32)	<0.001	61,636 (39.62)	2,844 (37.86)	<0.001
Overweight	32,791 (27.65)	10,787 (24.26)		41,781 (26.86)	1,797 (23.92)	
Obese	32,595 (27.48)	22,413 (50.42)		52,138 (33.52)	2,870 (38.21)	
<b>WHR category</b>						
Normal-weight	47,874 (40.36)	10,293 (23.15)	<0.001	55,681 (35.80)	2,486 (33.10)	<0.001
Overweight	46,689 (39.36)	18,472 (41.55)		62,219 (40.00)	2,942 (39.17)	
Obese	24,046 (20.27)	15,692 (35.30)		37,655 (24.21)	2,083 (27.73)	
<b>%BF category</b>						
Normal-weight	45,812 (38.62)	10,479 (23.57)	<0.001	53,582 (34.45)	2,709 (36.07)	0.003
Obese	72,797 (61.38)	33,978 (76.43)		101,973 (65.55)	4,802 (63.93)	
<b>‡Townsend score, median (IQR)</b>	-2.07 (3.85)	-1.08(4.78)	<0.001	-1.87 (4.08)	-0.64 (5.05)	<0.001
<b>Employment status</b>						
In paid employment	69,946 (58.97)	22,014 (49.52)	<0.001	87,868 (56.49)	4,092 (54.48)	<0.001
Retired	41,330 (34.85)	15,531 (34.93)		55,225 (35.50)	1,636 (21.78)	
Look after home	3,517 (2.97)	1,354 (3.05)		4,589 (2.95)	282 (3.75)	
Unemployed/ unpaid	2,761 (2.33)	1,697 (3.82)		3,953 (2.54)	505 (6.72)	
Not working (sick/disable)	704 (0.59)	3,740 (8.41)		3,478 (2.24)	966 (12.86)	
Only student status	351 (0.30)	121 (0.27)		442 (0.28)	30 (0.40)	
<b>Ethnicity</b>						
White	110,390 (93.07)	39,330 (88.47)	<0.001	143,128 ( 92.01)	6,592 (87.76)	<0.001
Mixed	822 (0.69)	394 (0.89)		1,137 (0.73)	79 (1.05)	
Asian/Asian British	3,111 (2.62)	2,255 (2.62)		4,991 (3.21)	375 (4.99)	
Black/Black British	2,641 (2.23)	1,562 (3.51)		3,927 (2.52)	276 (3.67)	



Chinese	413 (0.35)	197 (0.44)		569 (0.37)	41 (0.55)	
Other	1,232 (1.04)	719 (1.62)		1,803 (1.16)	148 (1.97)	
<b>Alcohol consumption</b>						
Daily	25,677 (21.65)	7,563 (17.01)	<0.001	31,720 (20.39)	1,520 (20.24 )	<0.001
3-4 times/week	28,685 (24.18)	7,880 (17.72)		35,292 (22.69)	1,273 (16.95)	
1-2 times/week	30,600 (25.80)	10,492 (23.60)		39,502 (25.39)	1,590 (21.17)	
1-2 times/month	13,041 (10.99)	5,517 (12.41)		17,624 (11.33)	934 (12.44)	
Special occasions only	12,394 (10.45)	7,321 (16.47)		18,506 (11.90)	1,209 (16.10)	
Never	8,212 (6.92)	5,684 (12.79)		12,911 (8.30)	985 (13.11)	
<b>Smoking status</b>						
Never	68,702 (57.92)	21,696 (48.80)	<0.001	86,586 (55.66)	3,812 (50.75)	<0.001
Previous	40,452 (34.11)	16,039 (36.08)		54,113 (34.79)	2,378 (31.66)	
Current	9,455 (7.97)	6,722 (15.12)		14,856 (9.55)	1,321 (17.59)	
<b>Comorbidity</b>						
No	82,923 (69.91)	20,394 (45.87)	<0.001	98,717 (63.46)	4,600 (61.24)	<0.001
Yes	35,686 (30.09)	24,063 (54.13)		56,838 (36.54)	2,911 (38.76)	

‡ Townsend score, a measure of socio-economic status; a negative score represents greater affluence. P-value;  $\chi^2$  test for categorical data and  $\chi^2$  test for trend for ordinal data, Wilcoxon rank-sum test for Townsend score (non normally distributed). **BMI**: body mass index category ( $\text{kg}/\text{m}^2$ ); underweight ( $<18.5$ ), normal-weight ( $18.5$ - $24.9$ ), overweight ( $25$ - $29.9$ ), class I obese ( $30$ - $34$ ), class II obese ( $35$ - $39$ ), and class III obese ( $>40$ ), **WC**: Waist Circumference category (cm) men/women; normal-weight ( $<94$ / $<80$ ), overweight ( $94$ - $101$ / $80$ - $87$ ), obese ( $\geq 102$ / $\geq 88$ ), **WHR**: Waist-to-hip ratio category men/women; normal-weight ( $<0.90$ / $<0.80$ ), overweight ( $0.90$ - $0.99$ / $0.80$ - $0.84$ ), obese ( $\geq 1$ / $\geq 0.85$ ), **BF**: Body fat (%) men/women; normal-weight ( $\leq 25$ / $\leq 32$ ), obese ( $>25$ / $>32$ ). Comorbidity (CVD, hypertension, diabetes and cancer)

**Table 2** Logistic regression analysis of the participant characteristics associated with having poor self-reported health.

		Overall				Men				Women			
		Univariate		Multivariate		Univariate		Multivariate		Univariate		Multivariate	
N = Overall (Men, Women)		Odds Ratio (95% CI)	P- value	Odds Ratio (95% CI)	P- value	Odds Ratio (95% CI)	P- value	Odds Ratio (95% CI)	P- value	Odds Ratio (95% CI)	P- value	Odds Ratio (95% CI)	P- value
<b>BMI category</b>													
Underweight	796 (162, 634)	2.06 (1.77, 2.40)	<0.001	1.67 (1.41, 1.97)	<0.001	3.64 (2.67, 4.97)	<0.001	2.43 (1.72, 3.45)	<0.001	1.85 (1.54,2.21)	<0.001	1.49 (1.22, 1.81)	<0.001
Normal-weight	53,279 (18,486, 34,793)	1	-	1	-	1	-	1	-	1	-	1	-
Overweight	69,050 (36,650, 32,400)	1.56 (1.51, 1.60)	<0.001	1.40 (1.35, 1.44)	<0.001	1.34 (1.29, 1.40)	<0.001	1.29 (1.23, 1.35)	<0.001	1.63 (1.57, 1.70)	<0.001	1.47 (1.42, 1.54)	<0.001
Class I obese	28,681 (14,680, 14,001)	3.14(3.04, 3.24)	<0.001	2.49 (2.40, 2.58)	<0.001	2.76 (2.63, 2.90)	<0.001	2.32 (2.20, 2.45)	<0.001	3.26 (3.12, 3.41)	<0.001	2.58 (2.46, 2.70)	<0.001
Class II obese	8,131 (3,222, 4,909)	5.30 (5.05, 5.57)	<0.001	3.82 (3.63, 4.03)	<0.001	5.22 (4.83, 5.65)	<0.001	3.86 (3.55, 4.19)	<0.001	5.29 (4.97, 5.64)	<0.001	3.75 (3.50, 4.01)	<0.001
Class III obese	3,129 (977, 2,152)	10.24 (9.47, 11.08)	<0.001	6.45 (5.94, 7.02)	<0.001	11.44 (9.86, 13.28)	<0.001	7.38 (6.31, 8.63)	<0.001	10.15 (9.25, 11.15)	<0.001	6.13 (5.55, 6.77)	<0.001
<b>Waist circumference</b>													
Normal-weight	64,480 (30,330, 34,150)	1	-	1	-	1	-	1	-	1	-	1	-
Overweight	43,578 (21,339, 22,239)	1.56 (1.51, 1.60)	<0.001	1.47 (1.42, 1.51)	<0.001	1.57 (1.51, 1.64)	<0.001	1.50 (1.43, 1.56)	<0.001	1.52 (1.46, 1.59)	<0.001	1.42 (1.35, 1.48)	<0.001
Obese	55,008 (22,508, 32,500)	3.25 (3.17, 3.34)	<0.001	2.68 (2.60, 2.76)	<0.001	3.28 (3.16, 3.41)	<0.001	2.71 (2.60, 2.83)	<0.001	3.38 (3.26, 3.51)	<0.001	2.60 (2.49, 2.70)	<0.001
<b>Waist to hip ratio</b>													
Normal-weight	58,167 (20,900, 37,267)	1	-	1	-	1	-	1	-	1	-	1	-
Overweight	65,161 (42,433, 22,728 )	1.84 (1.79, 1.89)	<0.001	1.51 (1.46, 1.55)	<0.001	2.01 (1.93, 2.10)	<0.001	1.79 (1.72, 1.87)	<0.001	1.52 (1.46, 1.58)	<0.001	1.34 (1.29, 1.40)	<0.001
Obese	39,738 (10,844, 28,894)	3.04 (2.95, 3.13)	<0.001	2.34 (2.27, 2.42)	<0.001	4.77 (4.53, 5.02)	<0.001	3.48 (3.29, 3.68)	<0.001	2.54 (2.45, 2.64)	<0.001	1.90 (1.83, 1.98)	<0.001
<b>Body fat Percent</b>													
Normal-weight	56,291 (34,588, 21,703)	1	-	1	-	1	-	1	-	1	-	1	-
Obese	10,6775 (39,589, 67,186)	2.04 (1.99, 2.09)	<0.001	1.98 (1.92, 2.03)	<0.001	2.30 (2.22, 2.37)	<0.001	2.0 (1.93, 2.07)	<0.001	2.24 (2.15, 2.33)	<0.001	1.93 (1.85, 2.02)	<0.001

CI; Confidence Interval, adjusted by age, sex, socio-economic status, employment, ethnicity, alcohol consumption, smoking and comorbidity (CVD, hypertension, diabetes and cancer).

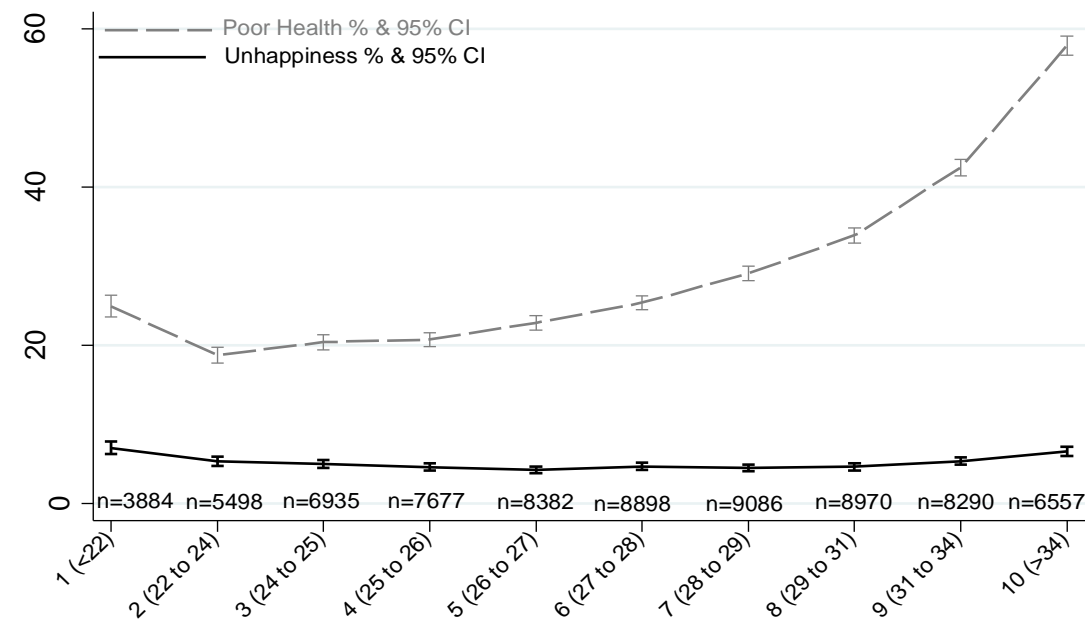
**Table 3** Logistic regression analysis of the participant characteristics associated with self-reported Unhappiness.

		Overall				Men				Women			
		Univariate		Multivariate		Univariate		Multivariate		Univariate		Multivariate	
		N= Overall (Men, women)	Odds Ratio (95% CI)	P- value	Odds Ratio (95% CI)	P- value	Odds Ratio (95% CI)	P- value	Odds Ratio (95% CI)	P- value	Odds Ratio (95% CI)	P- value	
BMI category													
Underweight	796 (162, 634)	1.94 (1.51, 2.50)	<0.001	1.44 (1.11, 1.88)	0.006	1.74 (1.02, 2.97)	0.043	0.93 (0.53, 1.63)	0.798	2.16 (1.62, 2.89)	<0.001	1.73 (1.28, 2.33)	<0.001
Normal-weight	53,279 (18,486, 34,793)	1	-	1	-	1	-	1	-	1	-	1	-
Overweight	69,050 (36,650, 32,400)	0.90 (0.86, 0.96)	<0.001	0.89 (0.84, 0.94)	<0.001	0.79 (0.73, 0.86)	<0.001	0.83 (0.77, 0.90)	<0.001	0.94 (0.87, 1.01)	0.105	0.94 (0.87, 1.02)	0.137
Class I obese	28,681 (14,680, 14,001)	1.14 (1.07, 1.22)	<0.001	1.02 (0.95, 1.09)	0.576	0.94 (0.85, 1.04)	0.21	0.89 (0.81, 0.99)	0.029	1.27 (1.16, 1.40)	<0.001	1.15 (1.05, 1.27)	0.004
Class II obese	8,131 (3,222, 4,909)	1.29 (1.16, 1.42)	<0.001	1.03 (0.93, 1.15)	0.536	1.10 (0.94, 1.29)	0.221	0.91 (0.77, 1.07)	0.245	1.41 (1.23, 1.61)	<0.001	1.15 (1.00, 1.32)	0.057
Class III obese	3,129 (977, 2,152)	2.0 (1.75, 2.28)	<0.001	1.33 (1.15, 1.53)	<0.001	1.88 (1.51, 2.34)	<0.001	1.29 (1.03, 1.63)	0.029	2.11 (1.79, 2.49)	<0.001	1.38 (1.16, 1.65)	<0.001
Waist circumference													
Normal-weight	64,480 (30,330, 34,150)	1	-	1	-	1	-	1	-	1	-	1	-
Overweight	43,578 (21,339, 22,239)	0.93 (0.88, 0.99)	0.022	0.96 (0.90, 1.02)	0.218	0.92 (0.84, 0.99)	0.036	0.96 (0.88, 1.05)	0.366	0.94 (0.86, 1.03)	0.193	0.96 (0.88, 1.05)	0.381
Obese	55,008 (22,508, 32,500)	1.19 (1.13, 1.26)	<0.001	1.11 (1.05, 1.17)	<0.001	1.15 (1.07, 1.24)	<0.001	1.09 (1.01, 1.19)	0.037	1.26 (1.17, 1.36)	<0.001	1.12 (1.04, 1.22)	0.004
Waist to hip ratio													
Normal-weight	58,167 (20,900, 37,267)	1	-	1	-	1	-	1	-			1	-
Overweight	65,161 (42,433, 22,728)	1.06 (1.0, 1.12)	0.039	0.99 (0.93, 1.05)	0.732	1.0 (0.92, 1.07)	0.9	1.01 (0.93, 1.10)	0.791	1.0 (0.92, 1.09)	0.958	0.97 (0.89, 1.06)	0.507
Obese	39,738 (10,844, 28,894)	1.24 (1.17, 1.32)	<0.001	1.14 (1.07, 1.21)	<0.001	1.29 (1.17, 1.43)	<0.001	1.16 (1.04, 1.29)	0.008	1.25 (1.16, 1.35)	<0.001	1.12 (1.03, 1.21)	0.006
Body fat Percent													
Normal-weight	56,291 (34,588, 21,703)	1	-	1	-	1	-	1	-	1	-	1	-
Obese	10,6775 (39,589, 67,186)	0.93 (0.89, 0.97)	0.004	0.98 (0.93, 1.04)	0.535	0.98 (0.92, 1.05)	0.541	0.98 (0.91, 1.05)	0.505	0.96 (0.89, 1.03)	0.26	0.96 (0.89, 1.04)	0.298

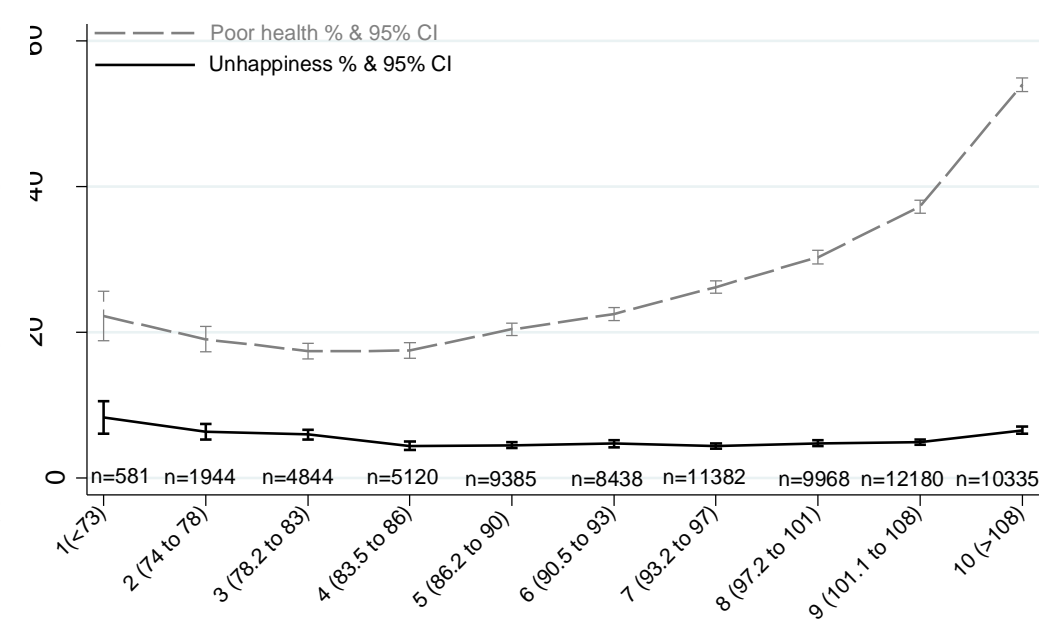
CI; Confidence Interval, adjusted by age, sex, socio-economic status, employment, ethnicity, alcohol consumption, smoking and comorbidity (CVD, hypertension, diabetes and cancer

**Figure 1 Frequency (%) of self-reported poor health and unhappiness by measures of adiposity in Men.**

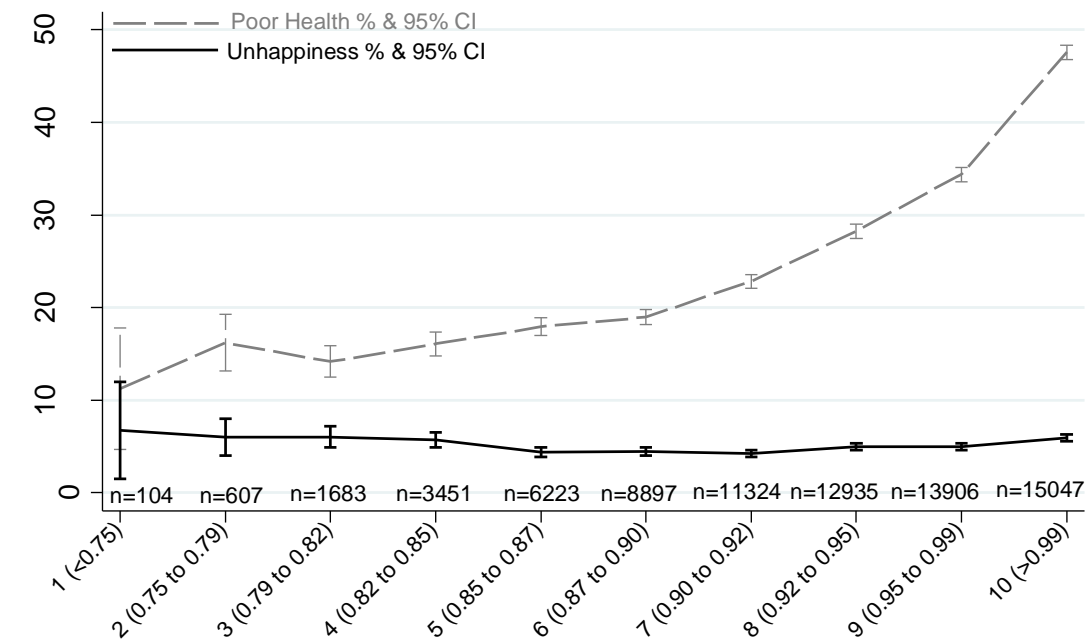
**a. Body Mass Index deciles (kg/m<sup>2</sup>)**



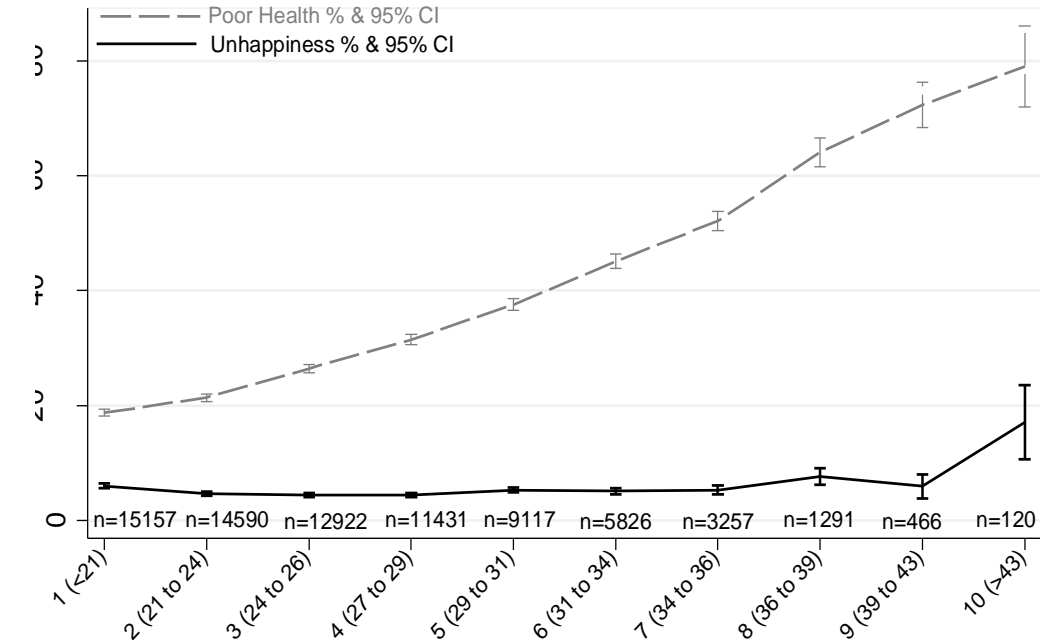
**b. Waist Circumference deciles (cm)**



**c. Waist-to-hip ratio deciles**

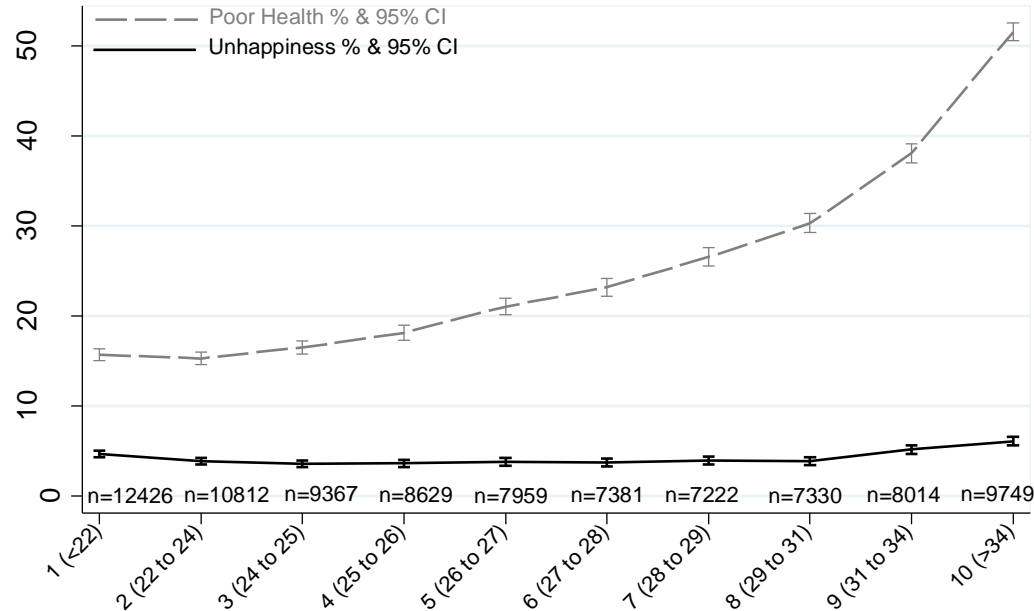


**d. Body fat% deciles**

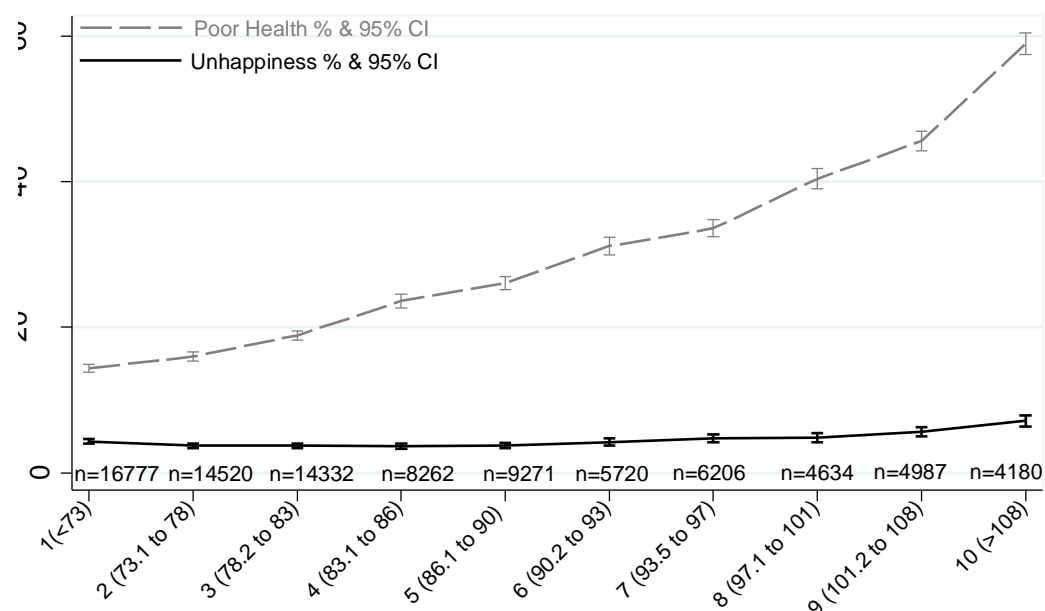


**Figure 2 Frequency (%) of self-reported poor health and unhappiness by measures of adiposity in Women.**

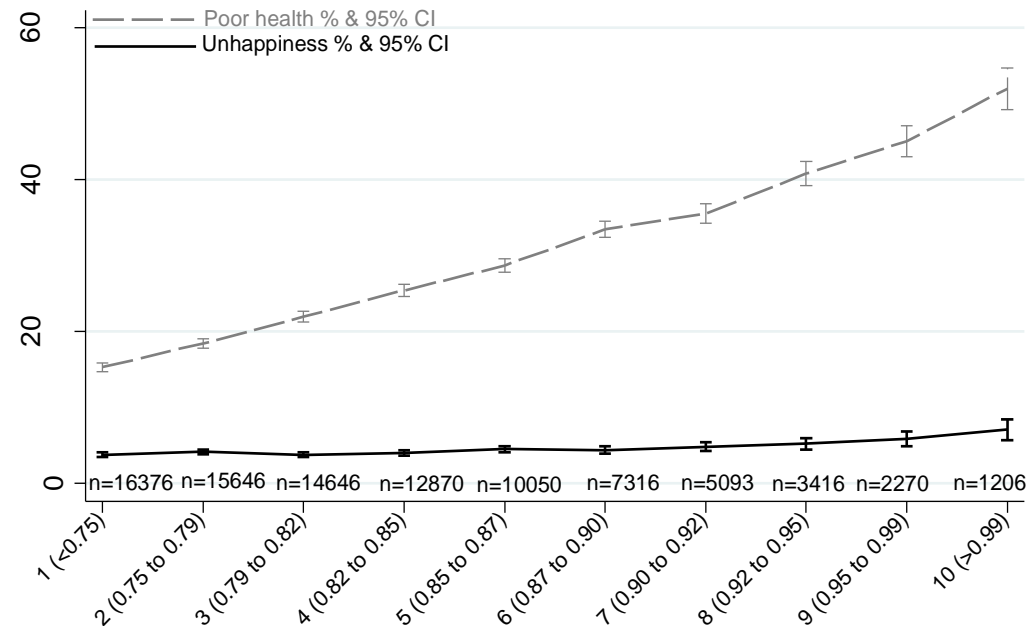
**a. Body Mass Index deciles (kg/m<sup>2</sup>)**



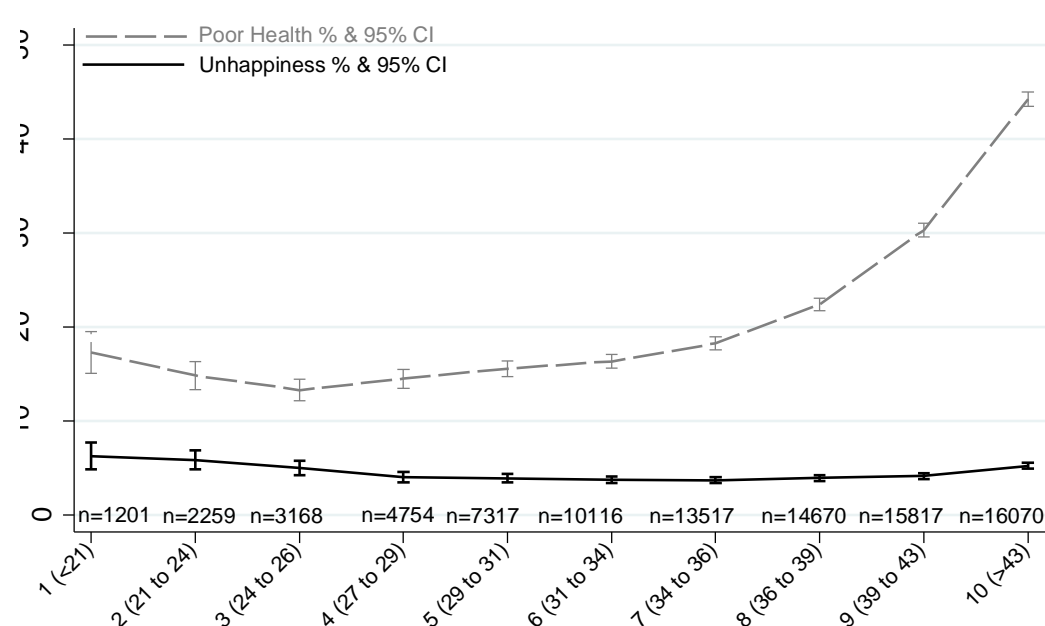
**b. Waist Circumference deciles (cm)**



**c. Waist-to-hip ratio deciles**

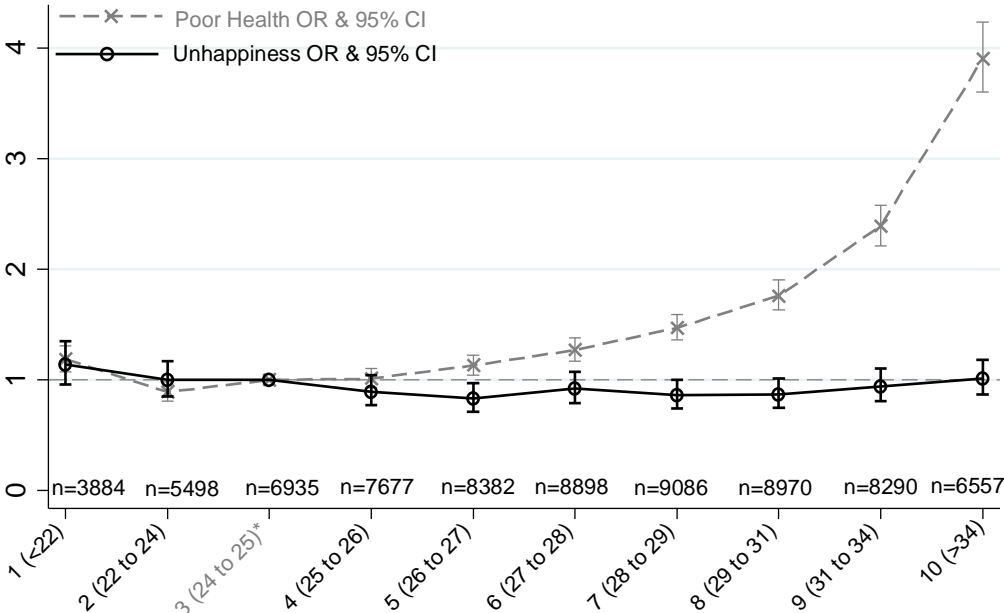


**d. Body fat% deciles**

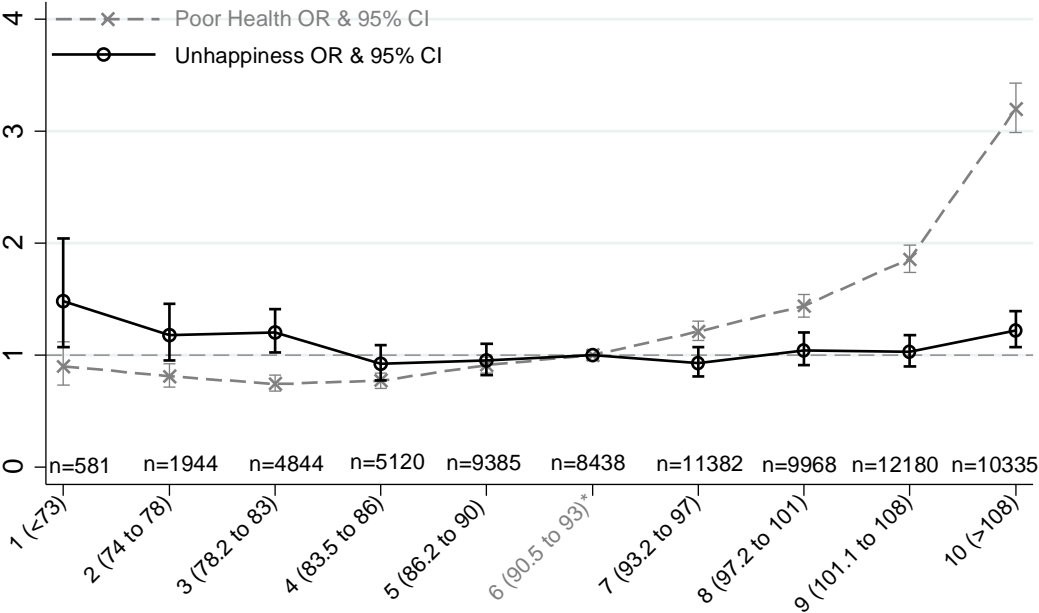


**Supplementary Figure 1 Adjusted odds ratio of self-reported poor health and unhappiness by measures of adiposity in Men.**

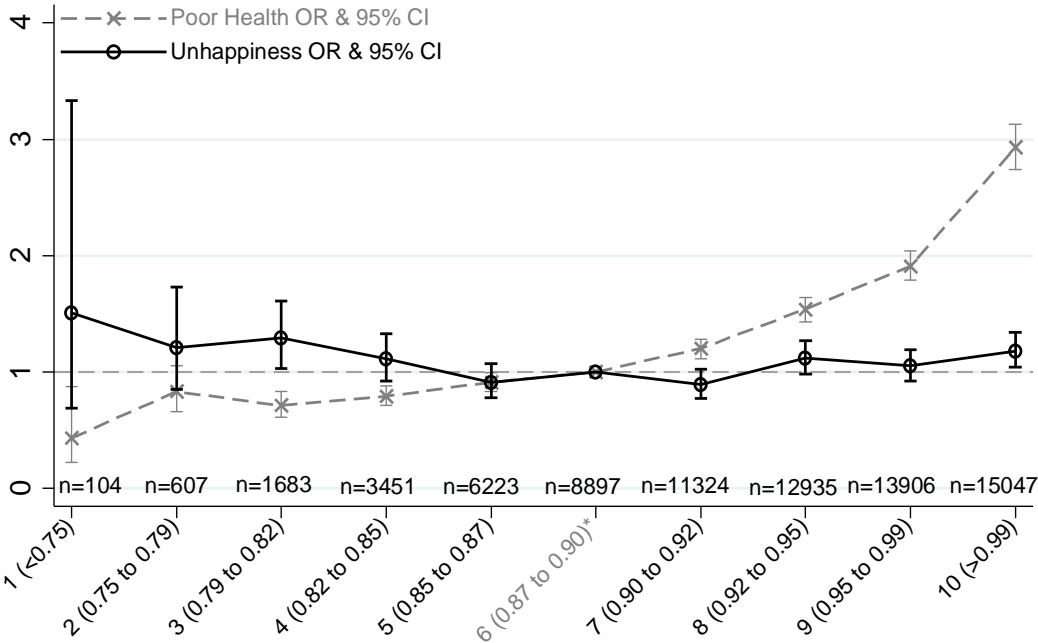
**a. Body Mass Index deciles (reference group\* 24 to 25kg/m<sup>2</sup>)**



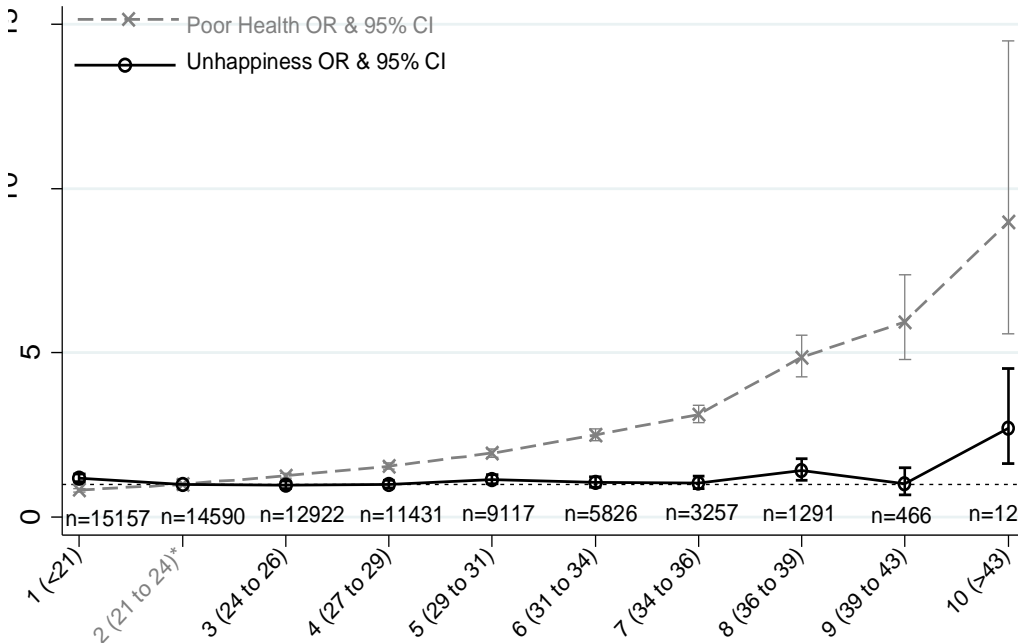
**b. Waist Circumference deciles (reference group\* 90.5 to 93cm)**



**c. Waist to hip ratio deciles (reference group\* 0.87 to 0.90)**



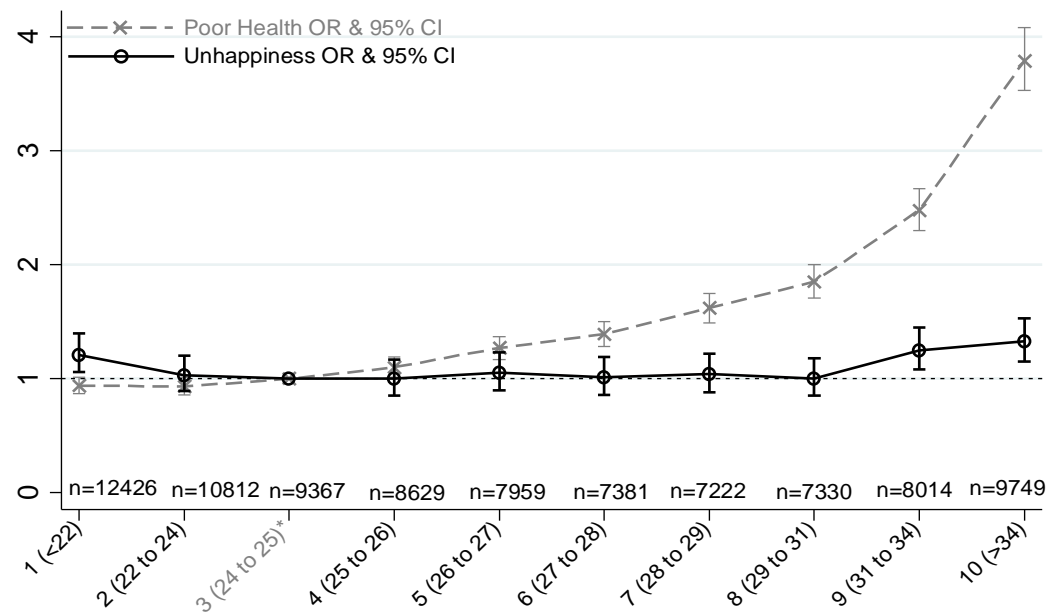
**d. Body fat % deciles (reference group\* 21 to 24%)**



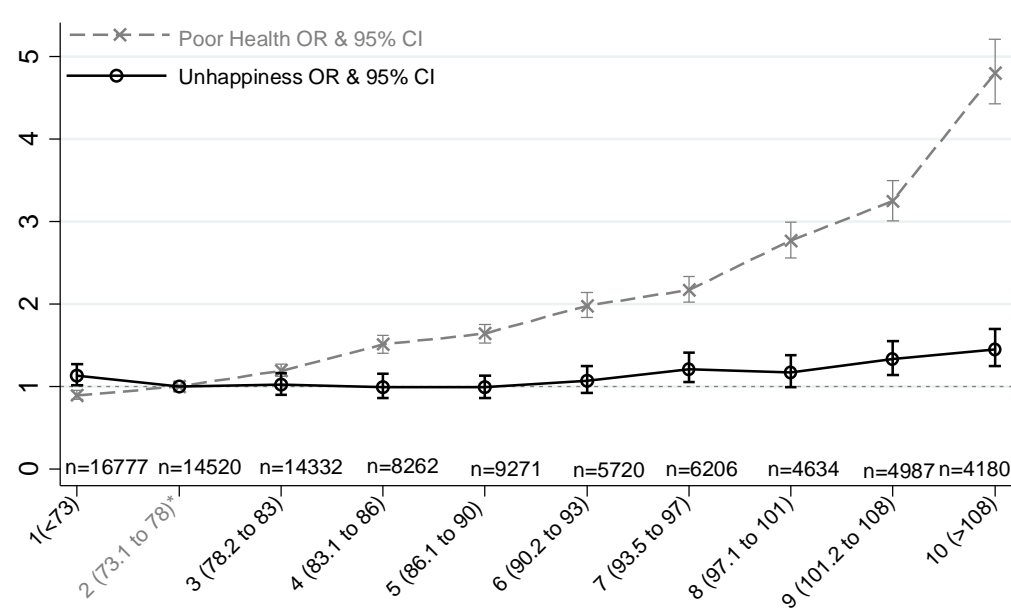
OR; Odds ratio, CI; confidence interval, Adjusted by age, socio-economic status, employment, ethnicity, alcohol consumption, smoking, and comorbidity (CVD, hypertension, diabetes and cancer).

**Supplementary Figure 2 Adjusted odds ratio of self-reported poor health and unhappiness by measures of adiposity in Women.**

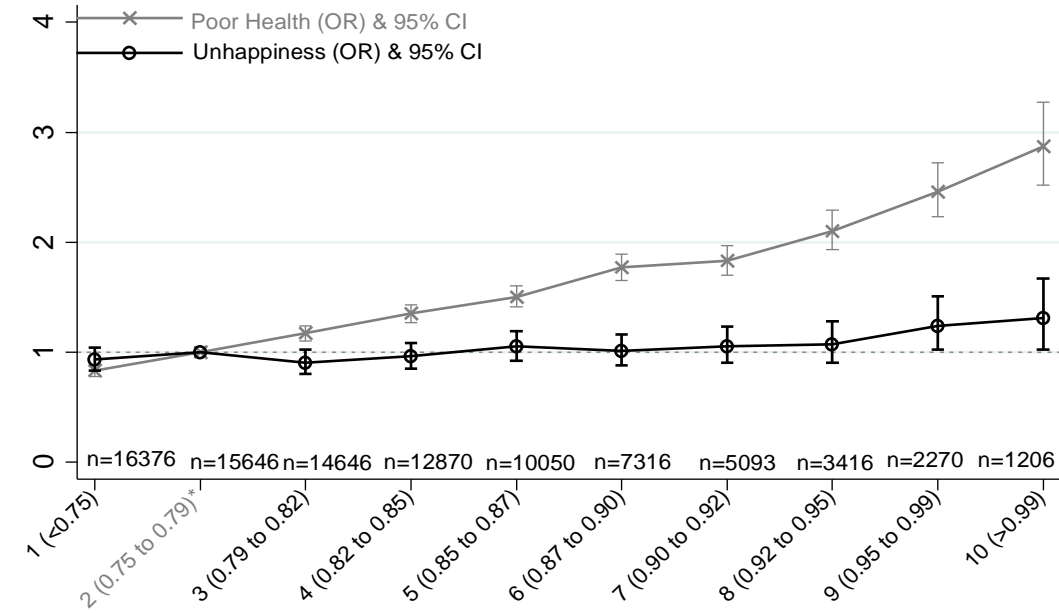
**a. Body Mass Index deciles (reference group\* 24 to 25kg/m<sup>2</sup>)**



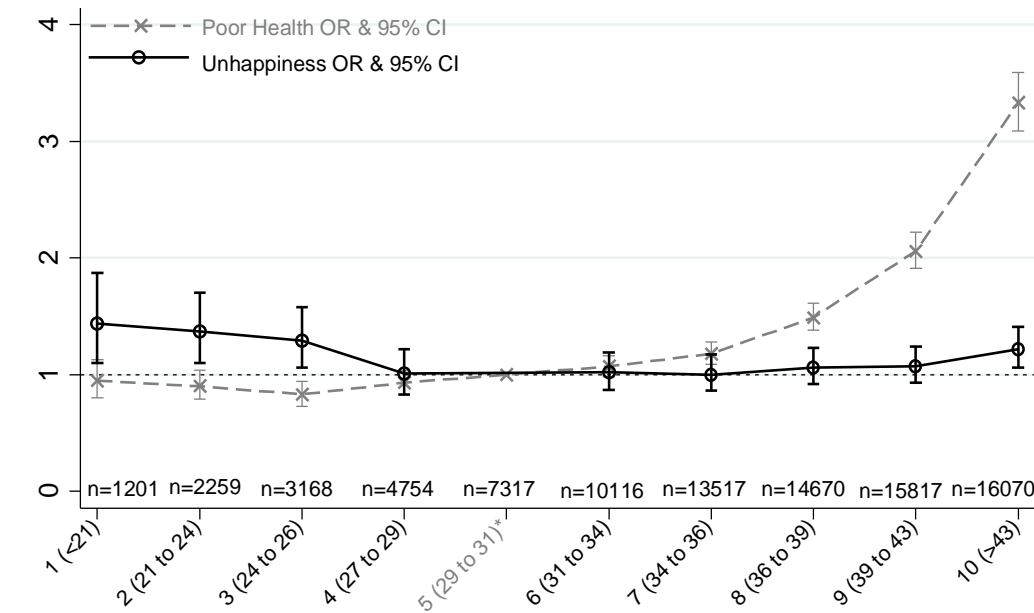
**b. Waist Circumference deciles (reference group\* 73 to 78cm)**



**c. Waist to hip ratio deciles (reference group\* 0.75 to 0.79)**



**d. Body fat % deciles (reference group\* 29 to 31%)**



OR; Odds ratio, CI; confidence interval, Adjusted by age, socio-economic status, employment, ethnicity, alcohol consumption, smoking, and comorbidity (CVD, hypertension, diabetes and cancer)

**Supplementary Table 1** Logistic Multivariate regression analysis of the body mass index (BMI) associated with self-reported Unhappiness after adjustment for Self-reported health, in addition to the other potential confounding factors.

	Odds Ratio (95% CI)	P-value
<b>BMI category</b>		
Underweight	1.24 (0.94, 1.62)	0.123
Normal-weight	1	-
Overweight	0.81 (0.77, 0.86)	<0.001
Class I obese	0.78 (0.73, 0.84)	<0.001
Class II obese	0.71 (0.64, 0.79)	<0.001
Class III obese	0.84 (0.73, 0.97)	0.015

CI; Confidence Interval, adjusted by age, sex, socio-economic status, employment, ethnicity, alcohol consumption, smoking, comorbidity and self-reported health.



**Supplementary Table 2** Logistic regression analysis of the women body mass index (BMI) associated with self-reported Unhappiness after stratification by Self-reported health.

a. Self-reported good health women

	Odds ratio (95% CI)	P-value
<b>BMI category</b>		
Underweight	1.39 (0.86,2.25)	0.181
Normal-weight	1	-
Overweight	0.82 (0.72, 0.91)	<0.001
Class I obese	0.87 (0.74, 1.03)	0.100
Class II obese	0.77 (0.58, 1.03)	0.075
Class III obese	0.75 (0.46, 1.23)	0.254

b. Self-reported poor health women

	Odds ratio(95% CI)	P-value
<b>BMI category</b>		
Underweight	1.70 (1.14,2.53)	0.009
Normal-weight	1	-
Overweight	0.85 (0.75, 0.95)	0.005
Class I obese	0.84 (0.74, 0.95)	0.007
Class II obese	0.75 (0.63, 0.89)	0.001
Class III obese	0.85 (0.70, 1.03)	0.098

CI; Confidence Interval, adjusted by age, socio-economic status, employment, ethnicity, alcohol consumption, smoking, comorbidity