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ORIGINAL ARTICLE

The relationship between body mass index and socioeconomic and demographic indicators: evidence from Australia

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Abstract
Objectives This paper explores the association of body mass index (BMI) with socioeconomic and demographic factors using data from the 6th wave of the Household, Income and Labour Dynamics in Australia (HILDA) Survey.
Methods This study applies a stereotype logit model (SLM) to assess 10,875 individuals on the relationship between BMI and socioeconomic and demographic indicators.
Results Aggregate results from the SLM show a positive (and concave) association between age and higher BMI. Further, males are more likely than females to have higher BMI. Higher BMI is positively associated with long-term health problems, reduced prosperity, being married, and being born in Australia and negatively associated with possessing a diploma or above.
Conclusions Results show that there is a positive and concave relationship between age and higher BMI. Further, males tend to have higher BMI as compared to females. Higher BMI is also positively related to long-term health problems, reduced prosperity, being married and being born in Australia. Negative association with BMI is observed on those possessing a diploma and above.

Keywords Obesity · Body mass index · Australia · Socioeconomic status · Stereotype logit model · HILDA survey data

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Introduction

There has been a growing world-wide concern about the increasing number of overweight or obese people, associated with increased risk of incurring various diseases and health conditions. The extent to which a person is overweight or obese is generally described by body mass index (BMI)—a statistical measure that compares a person's weight and height. According to the World Health Organization (WHO) international classification, the principal BMI cut-off points for adults range between 18.50 and 24.99 for normal weight, less than 18.5 for underweight, between 25 and 29.99 for overweight and greater than or equal to 30 for obese.

Assessment using the BMI shows that 53% of the adult population (or around 7.4 million people aged 18 years and above) in Australia was classified as overweight or obese in 2004–2005 (Australian Bureau of Statistics 2008). The report shows that males had a higher rate of overweight and obesity than females and the age–obesity profile was concave. By socioeconomic status (SES), excess weight was negatively associated with the level of education and income. The likelihood of being obese was higher for Australian-born than their foreign-born counterparts; however, with the migrants' length of time in Australia, the likelihood of being obese also increases. The report suggests that the rigorous health checks which migrants undertake to be eligible to migrate is an important reason why most people born overseas are in good health (and thus less overweight or obese) at the time of arrival in Australia. A positive association was also found between overweight or obesity and poor health conditions.

Evidence from other countries shows similar patterns. Quite a large number of studies have found an inverse relationship between obesity and SES, especially among

women. Notably, Sobal and Stunkard's (1989) seminal review showed that, across all industrialized nations, there was a strong inverse relationship between SES and obesity among women. Based on the data from the health survey for England, Wardle et al. (2002) found that obesity risk was greater among men and women with poorer economic circumstances. The inverse association of SES with the prevalence of obesity was also revealed in other industrialized countries (Garn 1986; Gortmaker et al., 1993; Kahn et al., 1991; Sonne-Holm and Sorensen 1986; Van Itallie 1985).

Other studies indicate that BMI displays a concave age profile with a peak overweight/obesity occurring earlier in males, though males are more likely to be overweight or obese compared to females (For e.g., Flegal et al. 2002; Hedley et al. 2004). This implies that women gain weight as they age (Korkeila et al. 1998). The increase in weight with age was also noted by Baum and Rhum (2007).

The inverse relationship between health and BMI was also documented by Brown et al. (2000) for Australia, Zagorsky (2004) for USA and Waidmann et al. (2008) for USA.

By education, a large number of published studies show a negative association between educational attainment and BMI (For instance, Ball and Crawford 2005; Gutierrez-Fisac et al. 2002; Halkjaer et al. 2003; McLaren 2007).

By birthplace, evidence shows that BMI is lower among immigrants than among the natives (Do et al. 2007). In a similar vein, Barcenas et al. (2007) found that, in general, immigrants had a lower risk for obesity compared to natives but noted that an increased risk for obesity was positively associated with an increase in the length of residency among the immigrants.

It is predicted that the likelihood of obesity is positively associated with decreased net worth (Zagorsky 2004). Material deprivation is also found to be positively associated with higher BMI and prevalence of obesity (Cubbin et al. 2001; Ellaway et al. 1997; Van Lenthe and Mackenbach 2002). A positive association of obesity with people outside the labor force is found by Jose et al. (2004). McLaren (2007) and Butcher and Park (2008) have also revealed a negative association of obesity with employment.

Further, a study by Ball et al. (2004) concludes that young women who are obese were more dissatisfied with both their professional and social activities. Their findings also show that weight status is longitudinally associated with aspirations and life satisfaction. They further hypothesize that being obese may have a lasting effect on a young woman's life satisfaction and future aspirations.

The aim of this study is to empirically investigate the association between BMI and socioeconomic and demographic characteristics using a stereotype logit model (SLM). This model is more parsimonious than the models for ordinal or multinomial outcomes due to its product representation in terms of a common parameter that corresponds to each scores of the dependent variable. For ordered outcomes, the SLM allows more flexibility than the proportional odds model in capturing subjective ordinal scaling (such as the BMI scale) which is not a discrete version of some continuous variable. Further, the SLM is more flexible than the ordinal logit model because it does not require the proportional odds assumption. Apart from showing a more appropriate statistical method, the rationale for this study is the attempt to control many variables that influence BMI.

Methods

Data for this study are taken from the HILDA (Household, Income and Labour Dynamics in Australia) Survey. This survey was initiated, and is funded by the Australian Government through the Department of Families, Housing, Community Service and Indigenous Affairs. Responsibility for the design and management of the survey rests with the Melbourne Institute of Applied Economics and Social Research (University of Melbourne).

The HILDA Survey is a household-based panel study which began in 2001. It collects information about economic and subjective well-being, labor market dynamics and family dynamics. It is Australia's only large-scale nationally representative longitudinal household survey which interviews the same households and individuals each year. Survey response rates are high. Of the 13,969 individuals initially interviewed in wave 1, 10,085 were reinterviewed in wave 6. Of the 3,406 individuals interviewed between waves 2 and 5, 1,975 were reinterviewed in wave 6. In addition to this, 845 individuals were first interviewed in wave 6. Overall, the number of individuals interviewed in wave 6 was 12,095 (=10,085 + 1,975 + 845).

To check whether there is bias due to non-response the original data o are divided into two groups, one includes individuals without BMI scores and the other contains individuals with BMI scores. The original data set contains around 14% of individuals without BMI scores. Reasons for this are due to not returning self-completion questionnaire or implausible value coding or not stating their height and/or weight. The guideline considered to identify the existence of potential non-response bias is comparisons of respondents with and without BMI scores across subgroups using available sample frame characteristics, and finally performing *t* test (for the continuous variable 'age' and chi-square test of independent for the rest of the independent variables. Test results show that there is no significant difference between the two groups, implying non-existence of non-response bias.

For the first time in wave 6 of the HILDA Survey respondents were asked about their height and weight, thus, enabling to derive BMI scores and then categorize into four groups (underweight, normal, overweight or obese). The definitions of the BMI groups are consistent with the international classification.

This study is restricted to people aged 15 years and over. After checking for inconsistencies in the data and removing individuals with incomplete answers the sample size is reduced from 11,080 to 10,875, of which around 54% were either overweight or obese. Observations that are excluded from the sample due to incomplete answers are compared with those included in the sample and no sample selection bias is found.

The widely used method of analysis for ordinary nature of dependent variable is ordered logit/probit regression. This method, however, is not appropriate because it usually violates an important assumption called parallel regression assumption.[1] In this paper, the assumption was tested using Stata's *brant* command and the overall result (Chi-square 390.46, $p < 0.000$) indicated that the assumption was not tenable. As an alternative a stereotype logit model (SLM)—a model that does not require a parallel regression assumption—is utilized. The stereotype ordered regression model, which is proposed by Anderson (1984), is a compromise between allowing the coefficients for each independent variable to vary by outcome category and restricting them to be identical across all outcomes (Long and Freese 2006).

The rating scales used to measure individuals' BMI are not a discrete version of some continuous variable. These observable scale categories are prone to errors because there is no underlying variable that directly links to the ordered response categories. According to Anderson (1984), response variables that are intrinsically ordinal (truly discrete) are *judged* or *assessed* variables and thus the scores assigned for categorization loose stereotypes. To avoid this, he introduced another model known as the stereotype model (see Appendix for a stereotype logit model explanation).

The stereotype logistic model assumes that categories are distinguishable one from the other. In other words, the estimated weights for each scale category should not be equal. This assumption was tested using a likelihood-ratio test and the result indicates that the categories are distinguishable and, thus, the set of predictors are able to differentiate between a pair of outcome categories. Another assumption is that the dependent categories can be ordered, but the ordering is not necessarily the same as how the outcome categories are numbered. This assumption was also tested and the results show that the one-dimensional stereotype logistic model orders the categories of the outcome, but the order does not need to correspond to how the outcome has been numbered.

[1] For ordinal logit model, the assumption is known as the proportional odds assumption. This assumption implies that the impact of x_i is constant across all possible values of y_i.

Results

As illustrated in Table 1, descriptive statistics are presented for the variables included in the model. The mean age of respondents was 44 years and around 47% were females. On average, 66% of respondents were employed, 68% owned their own home or other resident, 27% were getting interest (more than $100), 25% were receiving income from dividends, 28% had taken a loan, 26% had long-term health conditions, disability or impairment, 31% had earned at least a diploma and 79% were born in Australia. The mean overall life satisfaction score of respondents was 7.9 and their mean level of prosperity given current needs and financial responsibilities was 3.2.

The proportion of females being overweight was less than that of males and, relatively, there were more underweight and of normal weight females than males (see Table 2). This is consistent with other findings. For instance, in a study that attempts to relate gender with obesity, Hedley et al. (2004) report that men are more likely to be overweight than women, but women are more likely to be obese. From Table 3, we observe that the proportion of individuals being overweight or obese increases with age and then decreases. Such a relationship indicates the existence of a concave age–BMI profile.

Figures presented in Table 4 show results of the test of the association of each covariate with outcome and factor change in odds of being obese relative to being underweight, of normal weight or overweight. As presented in column 5 of Table 4, results of the test of association (using Spearman's rank correlation coefficient) reveal that the strength of association between BMI scores and covariates such as age, home, married and long-term health problems is significantly high. The odds of being obese relative to other BMI categories are positively associated with age but at a decreasing rate. The coefficients for age and age square show that the peak obesity occurs at 55 years of age. For males, the odds of being obese versus of normal weight increase by a factor of 1.68 compared to females. Married people have greater odds of being obese. The odds of being obese are higher for people born in Australia relative to those born overseas. Possessing at least a diploma as opposed to being without post-secondary education decreases the odds of being obese. Having at least a diploma decreases the odds of being obese versus of normal weight by a factor of 0.736. There is a positive

Table 1 Descriptive statistics on personal characteristics, labor force status, geographical location by State/Territory, income and wealth indicators, education and satisfaction level, Australia, 2006, HILDA Survey

Variables	Absolute number	Percentage
Personal characteristics		
Age (mean and standard deviation)	44.1899	18.0805
Gender (female omitted case)	5,143	47.29
Married (not married omitted case)	5,535	50.90
Born in Australia (born overseas omitted case)	8,624	79.30
Long term health problems (no long term health problems omitted case)	2,833	26.05
Labor force status		
Employed	7,146	65.71
Unemployed	339	3.12
Not in the labor force (omitted case)	3,390	31.17
Geographical location by State/Territory		
New South Wales	3,105	28.55
Victoria (omitted case)	2,716	24.97
Queensland	2,294	21.09
South Australia	1,029	9.46
Western Australia	1,091	10.03
Tasmania	349	3.21
Northern Territory	69	0.63
Australian Capital Territory	222	2.04
Income and wealth indicators		
Government benefit (no government benefit omitted case)	1,894	17.42
Interest (not getting interest omitted case)	2,927	26.91
Dividends (not receiving dividends omitted case)	2,719	25.00
Rent (not getting income from rent omitted case)	1,283	11.80
Home (not owned their own home or other resident omitted case)	7,381	67.87
Savings habits (no savings habits omitted case)	7,986	74.43
Loan (not taking any loan omitted case)	3,040	27.95
Prosperity (a scale of 1–5, mean and standard deviation)	3.1755	0.7925
Education		
Diploma or above	3,327	30.59
Certificate	2,309	21.23
No post-secondary education (omitted case)	5,239	48.17
Satisfaction level		
Overall life satisfaction (a scale of 0–10, mean and standard deviation)	7.9113	1.4402

In the original HILDA Survey data set variables related to savings habits, education and marital status had 5, 9 and 6 categories, respectively, however, for simplicity; they are converted into 2, 3 and 2 categories, respectively. For the variable prosperity and overall life satisfaction higher scores indicate very poor and totally satisfied, respectively

Table 2 Body mass index by gender, Australia, 2006, HILDA Survey

BMI category	Male (%)	Female (%)	Total (%)
Underweight	106 (2.06)	239 (4.17)	345 (3.17)
Normal weight	1,914 (37.22)	2,709 (47.26)	4,623 (42.51)
Overweight	2,058 (40.02)	1,572 (27.42)	3,630 (33.38)
Obese	1,065 (20.71)	1,212 (21.14)	2,277 (20.94)
Total	5,143 (100)	5,732 (100)	10,875 (100)

Source: authors' calculation

association between obesity and long-term health problems. As overall life satisfaction increases, the odds of being obese also increase. The odds of being obese increase as individuals' prosperity level decreases. People who get interest income are less likely to be obese, whereas those taking out loans are more likely to be obese. This indicates that financially well-off people have the money to buy healthier food and hence less likely to be obese.

Separate regression analyses by gender reveal few exceptions. As can be observed in Table 5 the decrease in factor change in odds of being obese with employment and interest income is evident only among females. A positive association between being obese and higher level of life satisfaction is only found among males. Relatively, the positive association between being born in Australia and obesity is greater for females than males. The effect of geographical location is more pronounced for females. The

Table 3 Body mass index by age groups (between 15 and 75+), Australia, 2006, HILDA Survey

BMI category	15–34 (%)	35–54 (%)	55–74 (%)	75+ (%)
Underweight	211 (5.88)	70 (1.69)	41 (1.67)	23 (3.29)
Normal weight	1,947 (54.22)	1,574 (38.06)	788 (32.19)	314 (44.86)
Overweight	935 (26.04)	1,444 (34.91)	992 (40.52)	259 (37.00)
Obese	498 (13.87)	1,048 (25.34)	627 (25.61)	104 (14.86)
Total	3591 (100)	4,136 (100)	2,448 (100)	700 (100)

Source: authors' calculation

Table 4 Factor change in odds (for personal characteristics, labor force status, geographical location, income and wealth indicators, education and satisfaction levels) by body mass index (omitted category is obese), Australia, 2006, HILDA Survey

Variable	Underweight	Normal weight	Overweight	Correlation coefficient
Personal characteristics				
Age	1.281 (1.241–1.322)	1.163 (1.140–1.185)	1.031 (1.015–1.046)	0.197*
Age square	0.998 (0.997–0.998)	0.999 (0.998–0.999)	1.000 (1.000–1.000)	0.197*
Gender	2.343 (2.000–2.745)	1.680 (1.539–1.833)	1.109 (1.060–1.160)	0.092*
Married	1.428 (1.208–1.688)	1.243 (1.125–1.373)	1.044 (1.016–1.074)	0.143*
Born in Australia	1.629 (1.364–1.947)	1.346 (1.208–1.501)	1.061 (1.024–1.100)	0.016
Long term health problems	1.559 (1.297–1.874)	1.311 (1.170–1.468)	1.056 (1.018–1.094)	0.110*
Labor force status				
Employed	0.903 (0.740–1.103)	0.940 (0.832–1.062)	0.988 (0.963–1.013)	−0.019
Unemployed	0.954 (0.622–1.463)	0.972 (0.749–1.261)	0.994 (0.944–1.047)	−0.023**
Geographical location				
New South Wales	1.106 (0.916–1.334)	1.063 (0.948–1.192)	1.012 (0.989–1.036)	0.003
Queensland	1.049 (0.855–1.286)	1.029 (0.909–1.166)	1.006 (0.981–1.031)	0.004
South Australia	1.270 (0.974–1.655)	1.157 (0.984–1.359)	1.030 (0.994–1.066)	0.020**
Western Australia	1.223 (0.945–1.583)	1.131 (0.966–1.323)	1.025 (0.991–1.060)	0.008
Tasmania	1.117 (0.739–1.688)	1.070 (0.831–1.376)	1.014 (0.963–1.066)	0.011
Northern Territory	0.679 (0.289–1.596)	0.790 (0.469–1.330)	0.954 (0.858–1.061)	−0.018
Australian Central Territory	1.135 (0.691–1.865)	1.080 (0.799–1.461)	1.016 (0.956–1.079)	−0.014
Income and wealth indicators				
Government benefit	1.017 (0.829–1.247)	1.010 (0.892–1.144)	1.002 (0.978–1.027)	0.033*
Interest	0.796 (0.667–0.949)	0.870 (0.782–0.968)	0.973 (0.948–0.998)	−0.008
Dividends	0.889 (0.745–1.060)	0.931 (0.836–1.036)	0.986 (0.964–1.008)	0.020*
Rent	0.837 (0.668–1.583)	0.897 (0.783–1.028)	0.979 (0.951–1.007)	0.015
Home	1.081 (0.873–1.338)	1.049 (0.921–1.194)	1.010 (0.984–1.036)	0.156*
Savings habits	0.980 (0.827–1.162)	0.988 (0.891–1.096)	0.998 (0.977–1.018)	−0.049*
Loan	1.385(1.173–1.636)	1.220 (1.103–1.349)	1.040 (1.013–1.068)	0.006
Prosperity	1.283 (1.158–1.421)	1.164 (1.093–1.239)	1.031 (1.012–1.050)	0.093*
Education				
Diploma or above	0.605 (0.507–0.723)	0.736 (0.661–0.820)	0.941 (0.907–0.976)	−0.045*
Certificate	0.961 (0.796–1.161)	0.976 (0.870–1.095)	0.995 (0.972–1.018)	0.070*
Satisfaction level				
Overall life satisfaction	1,073 (1.091–1.130)	1.044 (1.011–1.078)	1.001 (1.001–1.016)	−0.015
Log likelihood	−12,056.458	−12,056.458	12,056.458	
Wald Chi-square (26)	446.89*	641.97*	23.88*	
Sample size	10,875			

Figures in bracket are 95% confidence intervals

* and ** denote 1 and 5% level of significance, respectively

Table 5 Factor change in odds (for age, marital status, regions, and various socioeconomic indicators) by gender (omitted category is obese), Australia, 2006, HILDA Survey

Variable	Female			Male		
	Underweight	Normal weight	Overweight	Underweight	Normal weight	Overweight
Age	1.254 (1.204–1.307)	1.177 (1.148–1.207)	1.070 (1.048–1.092)	1.362 (1.290–1.439)	1.189 (1.154–1.226)	1.039 (1.016–1.063)
Age square	0.998 (0.998–0.998)	0.999 (0.998–0.999)	0.999 (0.999–1.000)	0.997 (0.997–0.998)	0.998 (0.998–0.999)	1.000 (0.999–1.000)
Married	1.292 (1.047–1.594)	1.203 (1.037–1.394)	1.079 (1.013–1.150)	1.687 (1.258–2.261)	1.340 (1.142–1.572)	1.067 (1.016–1.121)
Born in Australia	1.889 (1.497–2.383)	1.581 (1.343–1.861)	1.208 (1.113–1.312)	1.394 (1.037–1.874)	1.205 (1.020–1.423)	1.04 (0.996–1.090)
Long term health problems	1.854 (1.475–2.330)	1.560 (1.327–1.834)	1.202 (1.106–1.305)	1.393 (1.024–1.894)	1.204 (1.011–1.434)	1.042 (0.994–1.093)
Employed	0.726 (0.576–0.915)	0.794 (0.671–0.940)	0.909 (0.845–0.978)	1.212 (0.827–1.775)	1.114 (0.901–1.376)	1.024 (0.977–1.074)
Unemployed	0.957 (0.540–1.695)	0.969 (0.641–1.463)	0.987 (0.833–1.170)	1.317 (0.665–2.608)	1.167 (0.796–1.709)	1.035 (0.949–1.129)
New South Wales	1.028 (0.808–1.308)	1.020 (0.858–1.214)	1.008 (0.938–1.083)	1.296 (0.945–1.778)	1.156 (0.969–1.379)	1.033 (0.990–1.078)
Queensland	1.080 (0.831–1.403)	1.057 (0.875–1.277)	1.023 (0.946–1.107)	1.120 (0.797–1.572)	1.065 (0.880–1.289)	1.014 (0.971–1.059)
South Australia	1.34 (0.961–1.888)	1.239 (0.972–1.579)	1.093 (0.986–1.211)	1.214 (0.784–1.877)	1.115 (0.873–1.422)	1.024 (0.969–1.083)
Western Australia	1.272 (0.910–1.779)	1.189 (0.935–1.513)	1.074 (0.971–1.188)	1.134 (0.745–1.726)	1.073 (0.848–1.358)	1.016 (0.963–1.071)
Tasmania	1.286 (0.767–2.156)	1.199 (0.826–1.740)	1.078 (0.922–1.260)	1.088 0.540–2.192)	1.048 (0.708–1.552)	1.011 (0.926–1.103)
Northern Territory	0.249 (0.069–0.903)	0.267 (0.144–0.937)	0.661 (0.442–0.990)	2.396 (0.511–11.236)	1.631 (0.689–3.864)	1.115 (0.915–1.355)
Australian Central Territory	0.904 (0.464–1.762)	0.930 (0.574–1.505)	0.970 (0.795–1.184)	1.414 (0.626–3.196)	1.214 (0.768–1.918)	1.044 (0.940–1.160)
Government benefit	1.082 (0.848–1.386)	1.058 (0.888–1.261)	1.024 (0.952–1.101)	0.832 (0.573–1.208)	0.902 (0.733–1.110)	0.977 (0.931–1.026)
Interest	0.735 (0.585–0.923)	0.801 (0.681–0.943)	0.913 (0.850–0.980)	0.873 (0.651–1.170)	0.927 (0.786–1.092)	0.983 (0.946–1.022)
Dividends	0.860 (0.685–1.078)	0.897 (0.762–1.056)	0.956 (0.892–1.024)	0.887 (0.663–1.188)	0.935 (0.794–1.102)	0.985 (0.949–1.023)
Rent	0.806 (0.601–1.081)	0.856 (0.693–1.057)	0.938 (0.859–1.024)	0.839 (0.576–1.220)	0.906 (0.735–1.117)	0.978 (0.932–1.027)
Home	0.761 (0.584–0.992)	0.823 (0.678–0.996)	0.922 (0.848–1.003)	1.625 (1.127–2.343)	1.312 (1.073–1.606)	1.062 (1.009–1.119)
Savings habits	0.921 (0.743–1.143)	0.943 (0.806–1.102)	0.976 (0.915–1.041)	0.987 (0.742–1.313)	0.993 (0.846–1.164)	0.998 (0.964–1.034)
Loan	1.228 (0.988–1.527)	1.160 (0.992–1.355)	1.063 (0.996–1.135)	1.580 (1.199–2.081)	1.292 (1.109–1.504)	1.059 (1.012–1.108)
Prosperity	1.269 (1.111–1.449)	1.187 (1.080–1.305)	1.074 (1.029–1.120)	1.297 (1.096–1.535)	1.157 (1.051–1.273)	1.033 (1.004–1.062)
Diploma or above	0.621 (0.498–0.774)	0.709 (0.607–0.829)	0.868 (0.807–0.933)	0.572 (0.418–0.781)	0.731 (0.614–0.871)	0.933 (0.881–0.987)
Certificate	1.022 (0.788–1.324)	1.016 (0.842–1.224)	1.006 (0.932–1.087)	0.892 (0.663–1.201)	0.938 (0.794–1.108)	0.986 (0.949–1.024)
Overall life satisfaction	1.045 (0.980–1.115)	1.032 (0.985–1.082)	1.013 (0.994–1.033)	1.137 (1.040–1.244)	1.075 (1.023–1.129)	1.016 (1.003–1.030)
Log likelihood	−6,424.426	−6,424.4262	6,424.4262	−5,526.282	−5,526.282	−5,526.282
Wald Chi-square (25)	213.80*	378.70*	57.18*	209.85*	320.67*	15.55*
Sample size	5,732			5,143		

A test of association of each covariate with outcome variable is done and found that for the male subgroup the strength of association between BMI scores and covariates such as home, age, married and long-term health problems is significantly higher. For female subgroup the strength of association is significantly higher with covariates age, home, married and prosperity

Figures in bracket are 95% confidence intervals

* denotes 1% level of significance

association between obesity and home ownership is positive for males and negative for females.

To perform a sensitivity analysis predicted probabilities were computed for both the stereotype and multinomial logit models and then correlated. Test results show that the probabilities are highly but not perfectly correlated across the two models, providing some support that the constraints imposed by the SLM hold. For the whole sample, as well as for the separate groups by gender the highest correlation between the predicted probabilities of the two models is found in the normal weight category (with 98, 99 and 97% correlation for the whole sample, for the males and the females, respectively). With 69% the lowest correlation is found in the underweight category for females.

Further, goodness-of-fit test was performed for each model and results of the Bayesian information criterion (BIC) show that for the whole sample and for the separate samples by males and females the BIC value for the SLM is greater than the BIC value for the multinomial model by 352.1, 464.1, and 487.7, respectively, in absolute terms. This indicates that the SLM is preferred over the multinomial model.

Discussion

Globally, obesity is fast becoming a major health problem, raising societal costs. Given the paramount importance of this phenomenon, there is a growing literature that investigates the relationship between BMI, socio-economic status and demographic characteristics in an attempt to understand the demographic and socio-economic forces impacting weight. This study, by applying a stereotype ordered regression model, contributes to existing literature by incorporating various socio-economic and demographic variables including age, prosperity, overall life satisfaction, interest and dividend income, home ownership, academic qualification, and geographical location.

Similar to the findings of other studies (for instance, Flegal et al. 2002; Hedley et al. 2004), our study shows that males tend to have higher BMI when compared to females. This paper also shows that there is a positive association between age and the prevalence of high BMI but at a decreasing rate. Although previous literature report a positive relationship between gain in weight and aging, they do not indicate at what rate the gain in weight is observed over time.

Other variables that have a negative association with obesity are: individuals who earn interest income, people who are prosperous, and individuals who at least have diploma. These findings are supported by prior literature.

As found in earlier literature, positive association with high BMI is observed on individuals who: (a) have long-term health problems and (b) report higher levels of overall life satisfaction. Our findings further show that there is a positive relationship between high BMI and being married and having loans; findings which have not been reported previously. In addition, this study further contributes to current literature by showing that compared to those born abroad; Australian born individuals tend to have high BMI.

Further regression analyses by gender gives a broader insight on the relationship between BMI and SES. For females, there is a negative association between being employed and earning income in the form of interest and prevalence of obesity. For males, obesity is positively associated with high levels of overall life satisfaction. These findings are largely supported by earlier research.

BMI as a measure of population prevalence of overweight and obesity has certain limitations. BMI does not account for differences in muscle mass or in the distribution of body fat (Baum and Rhum 2007). It also does not take into account age, gender, ethnicity and occupation (Deurenberg et al. 1991; Dietz and Robinson 1998). Nevertheless, BMI is considered to be the most appropriate measure and remains the global system to measure adiposity given its greatest merit. It is simple, rapid, inexpensive (Baum and Rhum 2007) and readily available (Dietz and Robinson 1998). Moreover, measures of height and weight, and therefore BMI, provide a more accurate measure of fatness in populations than other direct measures of adiposity (Deurenberg et al. 1991; Dietz and Robinson 1998).

Conflict of interest The authors declare that they have no competing interests.

Appendix: Explanation of a stereotype logit model

Consider a BMI outcome variable Y with c ordered categorical outcomes y_i denoted by $i = 1, 2, \ldots, c$, and let X_1, X_2, …, X_p denote a set of p covariates. The ordinal polytomous regression model can be written as:

$$\Pr(Y = y_i|X_1, X_2, \ldots, X_p) = \frac{\exp(\alpha_i + \beta_{i1}X_1 + \beta_{i2}X_2 + \ldots + \beta_{ip}X_p)}{\sum_{i=1}^{c} \exp(\alpha_i + \beta_{i1}X_1 + \beta_{i2}X_2 + \ldots + \beta_{ip}X_p)} \quad (1)$$

where $\alpha_c = 0$ and $\beta_{ck} = 0 (k = 1, 2, \ldots, p)$ to assure identifiability. The log-probability ratios for equation (1) are formed by comparing each response category (y_i) with a reference category (y_c). Assuming the first category as the reference category, the log-probability ratio can be expressed as follows:

$$\log\left[\frac{\Pr(Y = y_i|X_1, X_2, \ldots X_p)}{\Pr(Y = y_1|X_1, X_2, \ldots X_p)}\right] = \alpha_i + \beta_{i1}X_1 + \beta_{i2}X_2 + \ldots + \beta_{ip}X_p \quad (2)$$

where $i = 2$ to c.

The regression coefficient β_{ip} for the pth covariate X_p corresponds to the log-probability ratio comparing $(Y = y_i)$ versus $(Y = y_1)$ for a unit increase in X_p. From the above equation we note that the ordinal nature is not accounted for in any way. To build the ordinality into the model, Anderson (1984) imposed the relationship $\beta_{ik} = \phi\beta_k$, where β_k is a list of new parameters and the ϕ_i values can be thought of as the scores attached to the response y_i. By substituting $\beta_{ik} = \phi\beta_k$ into equation (2) a stereotype model can be written as:

$$\log\left[\frac{\Pr(Y = y_i|X_1, X_2, \ldots X_p)}{\Pr(Y = y_1|X_1, X_2, \ldots X_p)}\right] = \alpha_i + \phi_i(\beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_{ip} X_p) \quad (3)$$

A stereotype model determines a set of parameters $\{\phi_i\}$ for the dependent variable and a single parameter β_k for each covariate.

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