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Exploring the Relationship Between Education and Obesity

by
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An epidemic of obesity has been developing in virtually all OECD countries over the last 30 years. Existing evidence provides a strong suggestion that such an epidemic has affected certain social groups more than others. In particular, a better education appears to be associated with a lower likelihood of obesity, especially among women. This paper sheds light on the nature and the strength of the correlation between education and obesity. Analyses of health survey data from Australia, Canada, England, and Korea were undertaken with the aim of exploring this relationship. Social gradients in obesity were assessed across the entire education spectrum, overall and in different population sub-groups. Furthermore, investigations testing for mediation effects and for the causal nature of the links observed were undertaken to better understand the underlying mechanisms of the relationship between education and obesity.

JEL classification: I12, I21

Keywords: obesity, education, social disparities, mediation effect

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Overweight and obesity rates have been increasing sharply over recent decades in all industrialised countries, as well as in many lower-income countries. The rise in obesity has reached epidemic proportions, with over 1 billion adults worldwide estimated to be overweight and at least 300 million of those considered to be clinically obese (WHO, 2003). The circumstances in which people have been leading their lives over the past 20-30 years, including physical, social and economic environments, have exerted powerful influences on their overall calorie intake, on the composition of their diets and on the frequency and intensity of physical activity at work, at home and during leisure time. On the other hand, changing individual attitudes, reflecting the long-term influences of improved education and socio-economic status (SES) have countered to some extent environmental influences.

Many OECD countries have been concerned not only about the pace of the increase in overweight and obesity, but also about inequalities in their distribution across social groups, particularly by level of education, socio-economic status and ethnic background. Inequalities across social groups appear to be particularly large in women (Wardle *et al.*, 2002; Branca *et al.*, 2007). Acting on the mechanisms that make individuals who are poorly educated and in disadvantaged socio-economic circumstances so vulnerable to obesity, and those at the other end of the socio-economic spectrum much more able to handle *obesogenic* environments, is of great importance not just as a way of redressing existing inequalities, but also because of its potential effect on overall social welfare. The current distribution of obesity appears particularly undesirable, as it is likely to perpetuate the vicious circle linking obesity and disadvantage by intergenerational transmission.

Research has produced ample evidence of the individual labour market returns of education. Economists have shown much interest in the estimation of the causal effect of education on wages and economic growth (see Card 2001, for a comprehensive review of the literature) but only recently has work begun to investigate the non–monetary returns of schooling (see McMahon, 2004 for a review). Empirical studies, for example, suggest that education has a positive impact on health and well-being (Wolfe and Haveman 2002; Lleras-Muney 2005), particularly in poorer countries (Cutler and Lleras-Muney, 2006), reduces crime (Lochner and Moretti 2004) and water and air pollution (Appiah and McMahon 2002). The finding that education has positive externalities provides a rationale for government intervention.

However, the causal nature of the link between education and health is still subject to a certain degree of scrutiny, and the precise mechanisms through which education may affect health are not yet fully understood. Lifestyles may be one of the keys to understanding such a relationship, as they are often significantly influenced by education and, at the same time, they contribute to health and longevity by affecting the probability of developing a wide range of diseases. Obesity is a close marker of important aspects of individual lifestyles, such as diet and physical activity, and is also an important risk factor for major chronic diseases, such as diabetes, heart disease, stroke and certain cancers. Obesity is also associated with negative labour market outcomes, in term of both wages and employment, particularly for women (Cawley, 2004; Brunello *et al.*, 2006).

The aim of this paper is to provide new evidence concerning the relationship between education and obesity and contribute to understand the nature of such relationship and its implications for health and education policy. The empirical analyses on education and obesity undertaken by the OECD focus on four countries: Australia, Canada, England and Korea. Data from health surveys regularly undertaken in the four countries were used in a range of analyses, in pursuit of the following specific objectives:

1. To explore the correlation between body mass index, and obesity, on one hand, and formal education, expressed in terms of years spent in full-time education, on the other, controlling for possible confounding factors. The main goal of this analysis is to determine whether the intensity of the relationship between education and obesity is constant, or whether it shows increasing or decreasing strength at either end of the education spectrum.
2. To assess the extent to which the correlations identified may reflect the influences of factors associated with individual education, such as socio-economic status and the level of education of household members.
3. To assess the extent to which the correlations identified may reflect causal links between education and obesity.
4. To explore what conceptual model of the role of education as a determinant of health is most consistently supported by the findings concerning the correlation between obesity and aspects of individual and group education.

Box 1. **Data description**

The analyses reported in this paper are based on individual-level national health surveys covering four OECD countries: Australia, Canada, England and Korea. Data sources include the Australian National Health Survey (NHS) 1989-2005, the Canadian National Population Health Survey–cross-section (NPHS) and the Canadian Community Health Survey (CCHS) 1995-2005, the Health Survey for England (HSE) 1991-2005 and the Korean National Health and Nutrition Examination Survey (KNHANES) 1998-2005. All available survey waves were pooled for each survey. Since the focus of the analyses was the relationship between obesity and education, survey samples were restricted to individuals in the age range 25-64 who were supposed to have completed their full time education, and for whom the body mass index is a useful proxy for health risk. Body mass index (BMI) was calculated as weight in kilograms divided by square height in meters. Obesity and overweight status were then derived as BMI greater than 30 and 25.

The analyses were conducted by applying the same models to all countries' data, in order to facilitate comparisons across countries. However, differences in data and survey methods sometimes make it difficult to achieve complete consistency. For instance, data on height and weight were measured by examination in England and Korea while they were self-reported in the other two countries. The education variable was obviously a critical one, and the format of this variable varied across countries. We created a variable reflecting the numbers of years spent by each individual in full-time education using all the information available in each dataset on years of schooling and educational attainment. For consistency, we grouped together individuals with no education and those with the lowest level of education, as these two groups were not always separated in the available datasets. A certain degree of heterogeneity was also present in relation to the socio-economic status (SES) variable, as occupation-based social class was reported in the English data, while equivalised household income was available in Australia, Canada and Korea. Individuals were allocated to income quintiles in Australia and Korea, and to income groups based on fixed income ranges in Canada. Finally, an ethnicity variable was available in England, while proxies were used in Canada (minority status) and Australia (migrant status). No such variable was available in Korea. Tables of descriptive statistics are presented in Annex A1.

1. Existing evidence on the relationship between education and obesity

The existing evidence concerning the relationship between education and obesity is relatively limited, as the main focus of most research has been more broadly on the links between socio-economic factors and health status, or longevity, with a smaller number of studies focusing on lifestyles and on obesity in particular. The evidence available, covering a number of OECD countries, generally shows strong associations between education and obesity. However, there have been only few studies that have investigated the causal effects of education on obesity, and these studies have reported mixed results.

Cutler and Lleras-Muney (2006) found that those with more years of schooling are less likely to smoke, drink a lot, to be overweight or obese or to use illegal drugs. Similarly, the better educated are more likely to exercise and to obtain preventive care such as flu shots, vaccines, mammograms, pap smears and colonoscopies. They also found the relationship between education and health appears to be non-linear for obesity, with increasing effects of additional years of schooling. A review by Grossman and Kaestner concluded that years of formal schooling is the most important correlate of good health (Grossman *et al.*, 1997). Cross-sectional estimates from a study of twins conducted by Webbink *et al.* (2008), also confirms the negative relationship between education and the probability of being overweight. By looking at differences between the sexes within a study of socio-economic factors and obesity, Yoon *et al.* (2006) found that income, rather than education, had a greater effect on BMI and waist circumference in men, whereas higher levels of education for women resulted in lower BMI and waist circumference.

The correlation between education and health may reflect three possible types of relationships: *a)* a causal link running from increased education to improved health, *b)* a reverse causal link, indicating that better health leads to greater education; or *c)* an absence of a causal relationship between education and health, which appear to be correlated because of possible unobserved factors affecting both health (or obesity) and education in the same direction. The three pathways are not mutually exclusive, of course, and some combination of the three is likely to provide the most plausible explanation of the strong correlations consistently found across countries between education and health, or obesity. Cutler and Lleras-Muney (2006) argue that children in poor health obtain less schooling and because of this they are also more likely to be unhealthy adults. Similarly, evidence on longitudinal data shows that becoming overweight during the first four years in school is a significant risk factor for adverse school outcomes in girls (Datar and Sturm, 2006). Unobserved factors possibly contributing to the third pathway identified may include family background, genetic traits or other individual differences, such as ability to delay gratification. These factors may explain why the more educated are also healthier. Cutler and Lleras-Muney (2006) found that even controlling for some of these factors, the effect of education on health generally remains large and significant. Although there is evidence to support the hypothesis that the direction of causality is from more schooling to better health (Grossman, 2000), when overall health status or longevity are the outcomes of interest, there are few studies shedding light on the causal nature of the relationship between education and obesity specifically. Results from Lundborg (2008) suggest that a causal effect of education on health exists, but found no evidence that lifestyle factors such as smoking and obesity contribute to the health/education gradient. Natural experiments where policy changes are implemented that directly affect the number of years of mandatory schooling, can provide an indication of the causal nature of the link between education and obesity. Arendt (2005) used changes in compulsory education laws in

Denmark and found inconclusive results regarding the effect of education on BMI. However, Spasojevic, (2003) using a similar estimation strategy for Sweden found that additional years of education have a causal effect on maintaining a healthy body mass index. Clark and Royer (2008) focused on an educational reform implemented in England in 1947, which increased the minimum compulsory schooling age in the country, from 14 to 15. They found that cohorts affected by the law display only slightly improved long-run health outcomes and their findings did not support a causal link between education and obesity. Brunello *et al.* (2009) used compulsory school reforms implemented in European countries after the Second World War to investigate the causal effect of education on the BMI and the incidence of overweight and obesity among European females. They showed that years of schooling have a protective effect on BMI. On US data, Grabner (2009) used the variation caused by state-specific compulsory schooling laws between 1914 and 1978 as an instrument for education, and found a strong and statistically-significant negative effect of additional schooling on BMI, effect especially pronounced in females.

Michael Grossman's demand for a health model, developed in the 1980s, hypothesised that "schooling raises a person's knowledge about the production relationship and therefore increases his or her ability to select a healthy diet, avoid unhealthy habits and make efficient use of medical care" (Kemna, 1987). Educated individuals make better use of health-related information than those who are less educated. Education provides individuals with better access to information and improved critical thinking skills. Speakman *et al.* (2005) hypothesised that the lack of education about energy content of food may contribute to the effects of social class on obesity. Results from their study show that on average, non-obese individuals in the lower social class group have better food knowledge than those who are obese in the same group. However non-obese subjects in all groups overestimate food energy in alcoholic beverages and snack foods indicating poorer knowledge of the energy content of these foods. Lack of information could also affect one's own perception of their body mass. Research has shown that over time more overweight individuals are under-perceiving their body mass compared with people with normal weight (Haas, 2008). It is possible that more highly-educated people have the knowledge to develop healthy lifestyles and have more awareness of the health risks associated with being obese (Yoon, 2006). The more educated are more likely to choose healthy lifestyles; however, it has been shown that the highly educated choose healthier behaviours than individuals who are highly knowledgeable about the consequences of those behaviours (Kenkel, 1991). This could indicate that the effect of education on obesity is driven by different mechanisms, and not just by information and knowledge about healthy lifestyles.

Exploring the link between education and obesity is important, as this may lead to the development of appropriate education-based policies to counteract recent trends in obesity and related chronic diseases. For example, if the findings reported by Cutler and Lleras-Muney (2006) showing increased effects of additional years of schooling for those who are better educated were confirmed by further analyses, these would provide support for education policies aimed at promoting higher education, as these would produce greater health returns.

2. Policy and institutional environment

Policies aimed at counteracting the negative effects of obesity through the education system can be of two main types: policies focusing on the educational environment, aimed at promoting healthier lifestyles by exposing children to healthier environments and by providing health education; and policies aimed at encouraging higher levels of general education. Although the relationship between years of schooling, or educational attainment, and health outcomes is well established, most of the policies encountered to improve health by promoting lifestyle changes have focused on educating the population about healthier lifestyles as opposed to providing more general education. Each of the four countries examined in this study have implemented policies to strengthen "healthy living" education within schools, with the aim of achieving better health outcomes.

Australia has developed National Goals for Schooling in the Twenty-First Century, to which authorities across governmental jurisdictions refer to provide young Australians with the best possible educational outcomes and improve the quality of schooling nationally. The Active School Curriculum/ Building a Healthy Active Australia through the Department of Health and Ageing aims to provide young people with the skills to embrace an active lifestyle by introducing them to a range of physical activities. All state and territory governments and non-government education authorities have committed to providing in their curriculum at least two hours of physical activity each school week for primary and junior secondary school children under the Schools Assistance Act 2004. Also, the Australian Social Inclusion Agenda of the Australian Labour Party recommended that more young people from disadvantaged backgrounds complete 12 years of schooling and go on to further education and training.

In Canada, due to the vast geographical dispersion of the population, many policies relating to health and education are conducted at the provincial/territorial level. Nova Scotia, for example, implemented the Annapolis Valley Health Promoting Schools programme in seven elementary schools, with preliminary results indicating that those schools which implemented the programme had significantly lower rates of overweight and obese students. The British Columbia Children's Hospital and the University of British Columbia implemented a programme called "Healthy Buddies" to empower elementary school children to live healthier lives by providing them with knowledge about health and physical activity. Results from the programme have shown that students had an increase in their healthy-living knowledge and BMI and less weight gain than students who were not in the programme. In Quebec the "Take care of your health!" programme delivered by ACTI-MENU (a health promotion organisation) aimed to provide employees with information and support risk factor reduction. Evaluation of the programme revealed that participants were more likely to report more frequent physical activity and better nutritional practices and absenteeism declined by 28% and turnover by 54%.

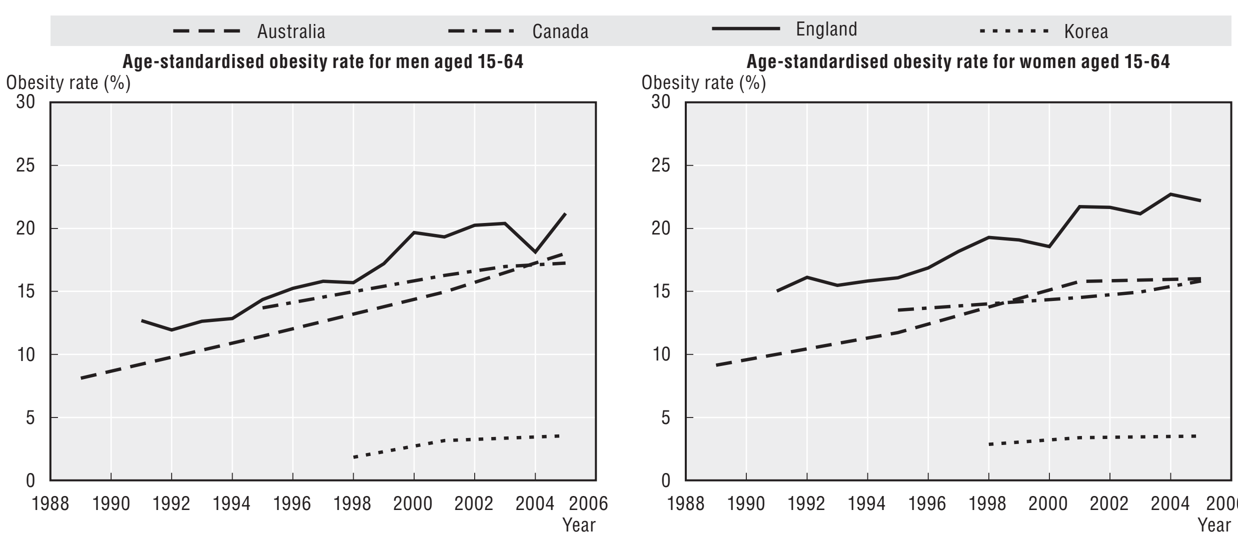
As part of the National Health Promotion Act, Korea established national policies aimed at enhancing people's health through health education, disease prevention, nutrition improvement and the practice of healthy lifestyles. The Health Plan 2010 aims at improving the nutritional status of the population and a part of this was the revision and dissemination of dietary guidelines, enforcing mandatory nutrition labelling and providing information to groups deemed vulnerable such as the elderly and young children. Part of this strategy is to develop the plan in line with educational, political, economic and organisational means. The Health Plan 2010 includes activities focusing on the development of nutritious diets, development of obesity prevention and management programmes and physical activity campaigns.

"Healthy Weight, Healthy Lives: A Cross-Government Strategy for England" is a project which targets children for healthy growth and healthy weight. Funded through the Department of Health, this strategy aims to reduce the proportion of overweight and obese children back to the levels found in 2000 by 2020. The NHS (National Health Service) has strategies aimed at offering public advice and support to those who already have weight problems through weight management programmes, NHS websites, as well as by developing the ability of health-service staff to deal with issues of excess weight. Additionally, strategies exist in England to combat obesity through the promotion of healthier food choices, by limiting food advertising to children and working with the food industry to reduce salt, sugar and fat in foods; as well as strategies such as "Walking into Health" to build physical activity into the lives of the whole population and "Active England" aimed at promoting non-sport physical activity.

3. General trends in obesity in the four countries

The distribution of BMI in the four countries concerned has been shifting in a characteristic fashion over the past few decades, as illustrated in Sassi *et al.*, 2009. In particular, as in most OECD countries, a sizable share of the normal weight population has been progressively gaining weight, moving towards the pre-obese category first, then progressively towards obesity and, in some cases, morbid obesity (BMI>40). A visible increase in the percentage of the population that is obese was recorded for both men and women, across all four countries (Figure 1). However, a significant difference in trends between genders is observed in Korea, where the relative distribution of females over the BMI categories remained relatively stable between 1998 and 2005, while a 10% decrease in the normal weight category was observed in men, followed by a 9% increase in the pre-obese category and a 2% increase in the obese category. On the other hand, in 2005 Korea had only 4% of its population obese, on average, compared with 25% in England, 18% in Australia and 17% in Canada. In the latter three countries the percentage of overweight men is significantly higher than that of women. In Canada, the majority of men were overweight in all survey years, and the same has been true in England since 1995.

Figure 1. **Trends in age-standardised obesity rates in Australia, Canada, England and Korea**



Source: Authors' estimates using 2005 OECD standard population.

Box 2. **Methods**

Differences in obesity rates among population groups with different levels of education were first analysed using logistic regression models controlling for a range of covariates, including gender, age, ethnicity, socio-economic status and survey year (Figure 2 and Annex A2). An interaction term between education and gender was also included in the regression model for the purpose of assessing differences between the two genders in the relationship between education and obesity (Figures 4 to 6, and Annex A3). The relationship between education and obesity in different ethnic groups was similarly explored through an interaction term between years of education and ethnicity (minority status in Canada, migrant status in Australia). The relationship between BMI and education was analysed using ordinary least squares regression models including the same covariates listed above (Figure 3 and Annex A2). All analyses were conducted using Stata 10.

Obesity rates, as well as BMI levels, by years of education were reported in separate graphs for different population groups. The linearity of the relationship between education and obesity and BMI was assessed visually, based on those graphs.

The effects of the clustering of individuals into households or geographical areas were studied using multilevel statistical models, also known as hierarchical linear models, random effects models or nested models (see Annex A4). Multilevel analyses concerned England and Korea, data which are based on household structure. Two-level random-intercept models, using households as higher-level units of aggregation, were tested on samples of people aged 25-64, living in a household comprising at least two members. It was not possible to perform this analysis on Australian and Canadian data, since the relevant surveys do not have a household structure.

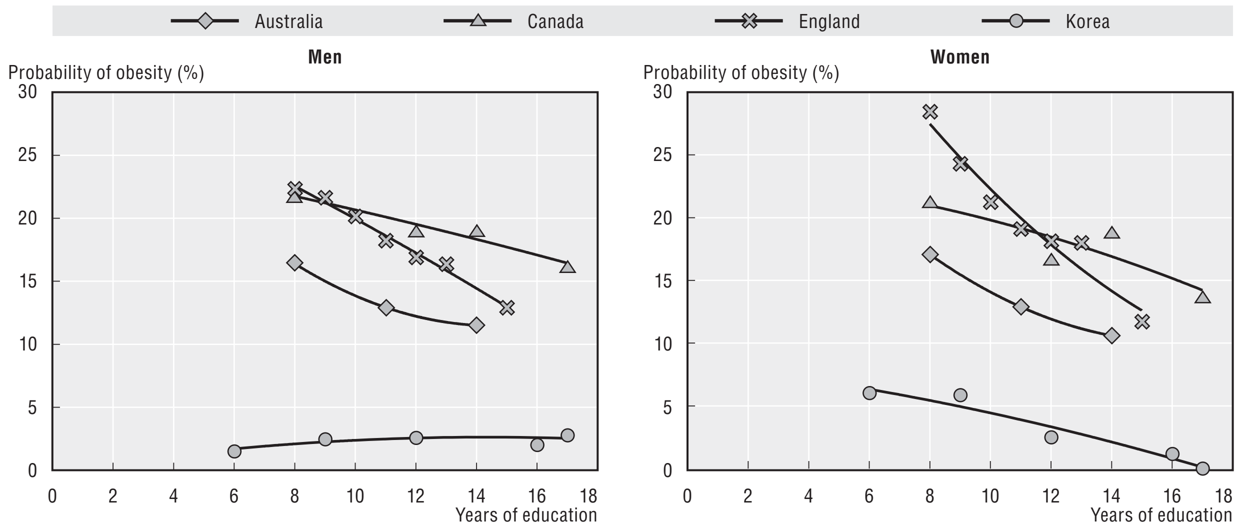
4. Is the strength of the correlation between education and obesity constant across the entire education spectrum, overall and in different population sub-groups?

Figure 2 shows the relationship between education and obesity for each gender in the four countries. Obesity rates in Figure 2 and BMI levels in Figure 3 are regression estimates adjusted for age, gender, and socio-economic status. Full results are presented in Annex A2. The relationship is negatively sloped in all cases except in Korean men, indicating that each additional year of education is consistently associated with a lower chance of being obese in Australia, Canada and England, as well as in Korean women. For Korean men, no conclusive results could be obtained as none of the coefficients for education were significant in the regression analysis, possibly due to the relatively small number of individuals who are obese in the country.

The patterns shown in Figure 2 suggest that the relationship between obesity and years of education may be considered broadly linear, *i.e.* of a constant strength across the entire education spectrum. However, results for England and Canada might suggest that the effect of further years of education tends to decrease progressively when approaching completion of upper secondary education (13-14 years of schooling), and then increase again sharply in individuals who complete tertiary education. A similar effect was also found for men in Australia, based on 2001 and 2005 data, which provided more detailed information on years of education relative to other editions of the same survey.

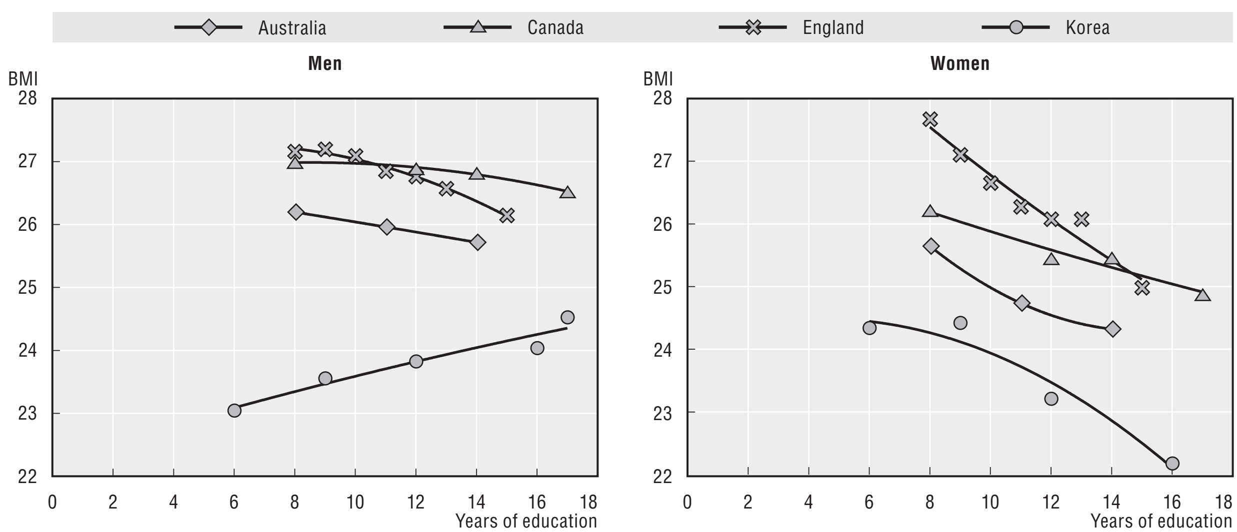
When the relationship between average BMI and education is observed, as in Figure 3, the conclusions are similar to what was previously discussed. No clear and consistent deviation is observed from a linear pattern in the four countries examined. Again Korean men represent an exception, as they display a positively sloped relationship, which seems substantially more marked than in Figure 2, where the link between education and obesity was examined.

Figure 2. **Relationship between obesity and years of education**



Source: Authors' estimates from logistic regression, see Annex A2.

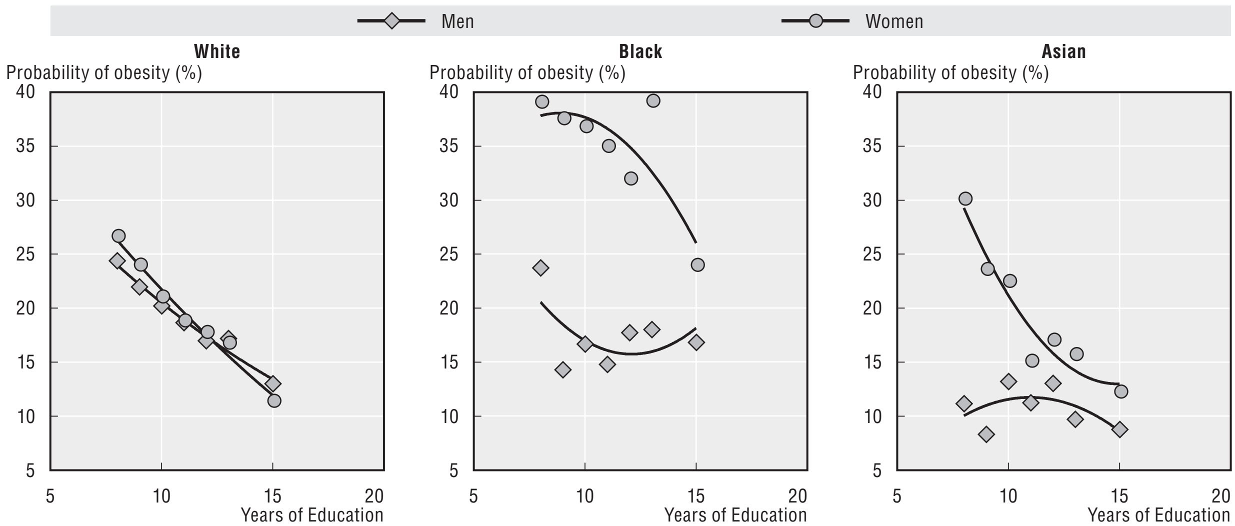
Figure 3. **Relationship between BMI and years of education**



Source: Authors' estimates from linear regression, see Annex A2.

The relationship between obesity and education was observed in different sub-groups along dimensions reflecting ethnicity or minority status (Figures 4 to 6). Obesity rates presented in Figures 4 to 6 are estimates adjusted for age, gender, and socio-economic status. Full results are presented in Annex A3. Three ethnic groups were identified in England (White, Black, Asian), while binary variables were used in Canada and Australia to denote, respectively, ethnic minority status and migrant status. The slope of the correlation between education and obesity is broadly similar in women, across all ethnic groups, although Black women display significantly higher obesity rates than others. It is difficult to assess whether the different patterns observed in Black and Asian women, suggesting a concave relationship between education and obesity in the former and a

Figure 4. **Relationship between obesity and years of education by ethnicity groups in England**

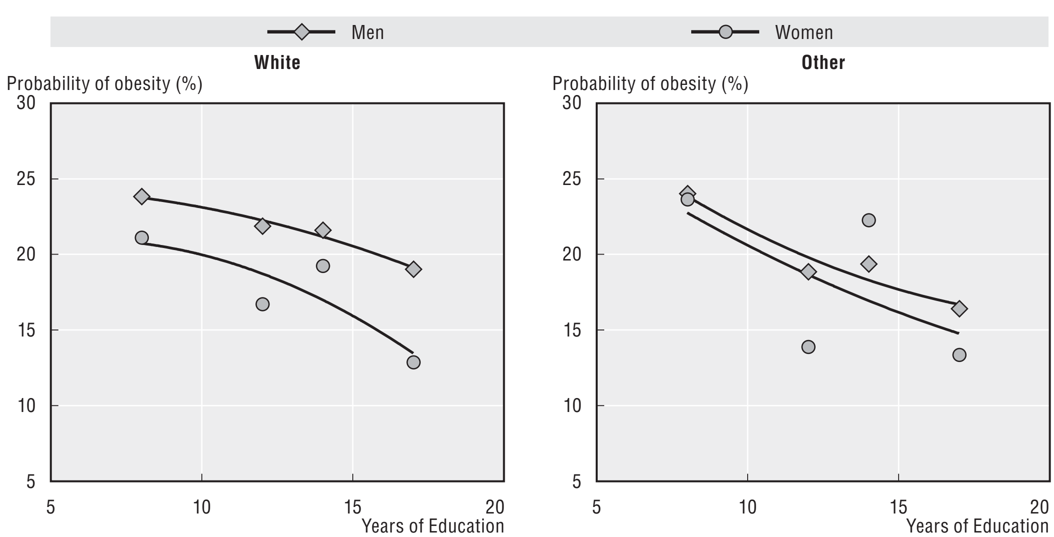


Source: Authors' estimates from logistic regression, see Annex A3.

convex relationship in the latter, reflects a true difference in the impact of education in the two groups. However, this interpretation of concavity and convexity on few data points should be taken with caution, as it is sensitive to outliers. This finding demands a larger and more detailed investigation. Education appears to be much more weakly correlated with obesity in Black and Asian men, although the least educated among Black men are substantially more likely to be obese than their more educated counterparts.

In Canada, individuals who belong to ethnic minority groups are less likely to be obese than White majority individuals. The relationship between obesity and education level is negatively sloped in both men and women, regardless of minority status, as illustrated in Figure 5.

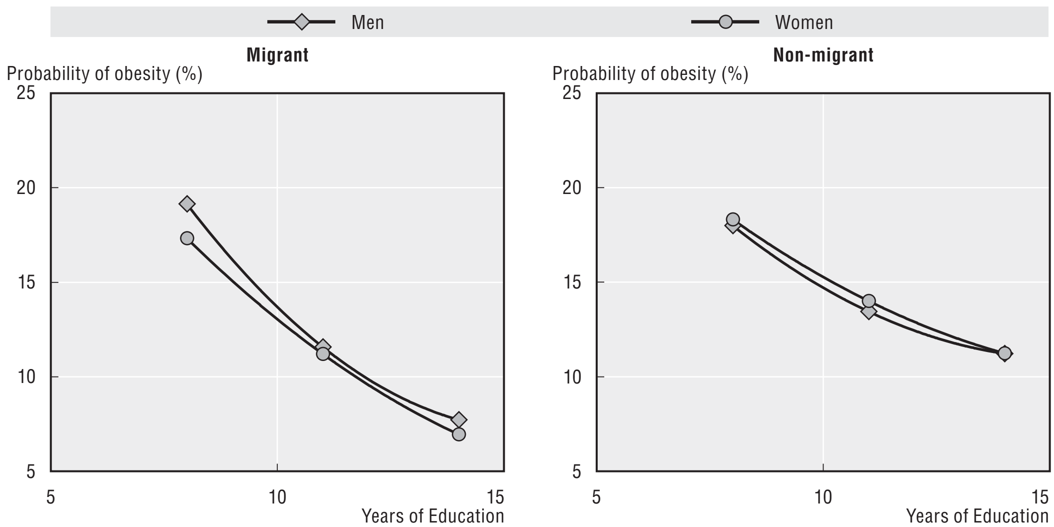
Figure 5. **Relationship between obesity and years of education by minority status in Canada**



Source: Authors' estimates from logistic regression, see Annex A3.

The analysis of the correlation between obesity and education in Australia does not show significant differences by migrant status, as illustrated in Figure 6.

Figure 6. **Relationship between obesity and years of education by migrant groups in Australia**



Source: Authors' estimates from logistic regression, see Annex A3.

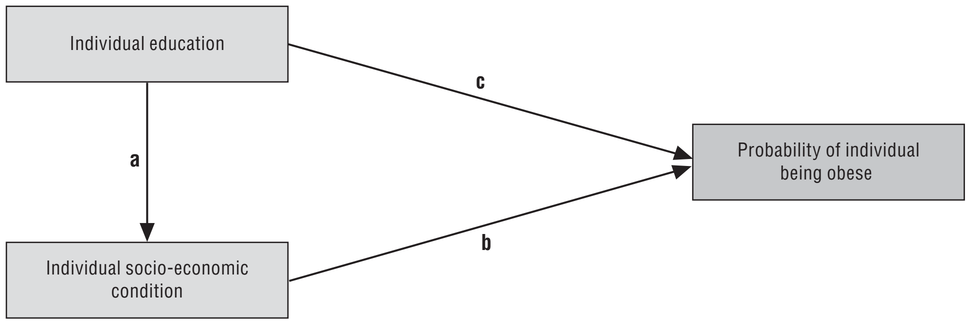
In addition, regression analyses presented in Annexes A2 and A3 were adjusted for socio-economic status. Obesity tends to be more prevalent in disadvantaged socio-economic groups, and inequalities are consistently larger in women than in men. A more detailed analysis of social inequalities in obesity is presented in a separate study (Devaux and Sassi, 2011).

5. Does the relationship between education and obesity reflect the role of other factors associated with individual education?

Several factors associated with individual education may potentially have an influence on the correlation observed between education and BMI/obesity. In particular, we studied the influence of individual socio-economic status and of the education level of household members.

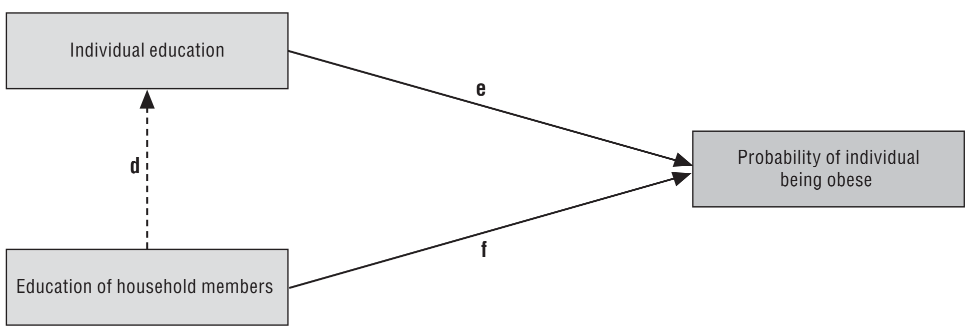
In addition to its direct effect on the likelihood of obesity, individual education may also have an indirect effect, mediated by individual socio-economic status. Figure 7 describes the hypothesised ***mediation effect***. Individual education contributes to determining individual socio-economic status *(a)*, which in turn has an influence on the likelihood of obesity *(b)*. Such mediated effect adds to the direct effect of education on obesity[1] *(c)*. In order to test for the existence of the hypothesised mediation effect, a series of logistic regression models were developed with and without controlling for the socio-economic status covariate, to assess possible variations in the coefficients of the individual education variable. Results are consistent with a slight mediation role played by socio-economic status in the relationship between education and obesity since odds ratios of obesity according to education level change slightly towards a unitary value, when the role of socio-economic status is accounted for (Sassi *et al.*, 2009). However, it should be noted that this empirical strategy does not account for a potential reverse causality in the relationships outlined in Figure 7 (*a*, *b* and *c*).

Figure 7. **Indirect effect of individual education through individual socio-economic status**



A further analysis focused on the education of household members, which might have a direct influence on the likelihood of an individual being obese, *i.e.* it may have a ***concurrent effect*** to that of individual education (relationships *e* and *f* in Figure 8). In principle, individual education may also act as a mediator of the household education effect on obesity (*d* and *e* in Figure 8). However, the analysis focused on the former (concurrent) effect of the education of household members.

Figure 8. **Indirect effect of education of household members**



The concurrent effect of household education could bias estimates of the effect of individual education on obesity. The education of household members could be, indeed, viewed as an omitted variable that would bias the model's coefficients. So, to test for this concurrent effect, regression models with and without this covariable were computed. This analysis is limited to England and Korea, the two countries for which household-based surveys are available. Multilevel logistic models were used to account for household structure (see Annex A4 for details of methods used). The education of household members is defined as the years of education of the spouse of the head of household and, when the latter was not available, as the years of education of the head of household.[2]

Odds ratios for the probability of being obese in England are displayed in Table 1. Model 1 is a multilevel logistic model without controls for the level of education of household member, whereas model 2 accounts for the education of household members. Differences among households explain about one fifth of the total variance in the likelihood of obesity (see the intra-class correlation coefficient *Rho*, in Table 1). It is worth noting that household education is negatively correlated to obesity status (odds ratio < 1) with significant values when years of education are above 11. Comparison of model 2 with model 1 shows that there seems to be a small concurrent effect of household education on obesity, which adds to the effect of individual education, since odds ratios of obesity according to individual education become smaller and closer to 1.

Table 1. **Odds ratios and significance for the probability of obesity in England**

England	Model 1: without controls		Model 2: with controls for household education	
	Odds Ratios	*Significance*	Odds Ratios	*Significance*
Age	1.070	***	1.073	***
Age squared	0.999	***	0.999	***
Year of survey	1.065	***	1.067	***
Women	1.441	***	1.381	***
Years of education – Men				
8	ref.		ref.	
9	0.937		0.967	
10	0.860	**	0.916	
11	0.767	***	0.859	*
12	0.703	***	0.798	**
13	0.671	***	0.796	***
15	0.522	***	0.636	***
Years of education – Women				
8	ref.		ref.	
9	0.746	***	0.784	***
10	0.630	***	0.697	***
11	0.552	***	0.664	***
12	0.514	***	0.615	***
13	0.505	***	0.648	***
15	0.304	***	0.390	***
Ethnicity				
White	ref.		ref.	
Black	1.714	***	1.729	***
Asian	0.738	***	0.734	***
Socio-economic status				
highest	ref.		ref.	
middle-high	1.252	***	1.253	***
middle	1.199	***	1.192	***
middle-low	1.347	***	1.337	***
lowest	1.481	***	1.466	***
Years of education of household				
8			ref.	
9			0.951	
10			0.893	
11			0.812	**
12			0.819	**
13			0.752	***
15			0.749	***
Observations	102 051		100 202	
Log-likelihood	–49 860.1		–48 867.7	
Rho	0.195	***	0.196	***

Note: *** means significant at 1%, ** at 5%, * at 10%.
Source: Cross-sectional survey data from *Health Survey for England 1991-2005*. Authors' calculations.

Table 2 shows the results of the corresponding analysis for Korea. In this case, differences among households explain about 7% of the total variance in the likelihood of obesity (see intra-class correlation in Table 2). In both models, odds ratios for men are not significantly different from 1, although the strength of the correlation between obesity and individual education is somewhat diminished in model 2, similarly to what was observed in England. On the other hand, the correlation between individual education and obesity appears marginally strengthened when accounting for household education in women, contrary to expectations. However, the absence of a statistically significant correlation between household education and obesity prevents from drawing any conclusions on the role of the latter in Korea.

Table 2. **Odds ratios and significance for the probability of obesity in Korea**

Korea	Model 1: without controls		Model 2: with controls for household education	
	Odds Ratios	*Significance*	Odds Ratios	*Significance*
Age	0.961		0.965	
Age squared	1.000		1.000	
Year of survey	1.070	***	1.071	***
Women	3.871	***	3.759	***
Years of education – Men				
6	ref.		ref.	
9	1.551		1.385	
12	1.582		1.439	
16	1.438		1.123	
17	1.810		1.209	
Years of education – Women				
6	ref.		ref.	
9	0.959		0.795	
12	0.408	***	0.394	***
16	0.189	***	0.152	***
Socio-economic status				
highest	ref.		ref.	
middle-high	0.971		0.940	
middle	1.006		0.991	
middle-low	1.040		1.059	
lowest	1.203		1.215	
Years of education of household				
6			ref.	
9			1.181	
12			1.053	
16			1.320	
17			2.281	
Observations	15 441		15 199	
Log-likelihood	–2 039.7		–1 998.8	
Rho	0.077		0.073	

Note: *** means significant at 1%, ** at 5%, * at 10%.
Source: Cross-sectional survey data from KNHANES 1998-2005. Authors' calculations.

6. Do the data provide evidence of the causal nature of the link between education and obesity?

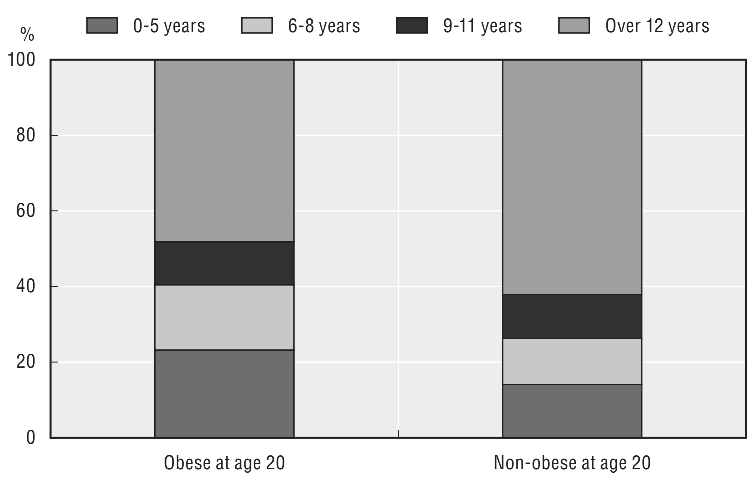
When exploring the cross-sectional relationship between obesity and education, it is difficult to interpret the direction of the causal link between the two variables. In addition, the correlations identified might be affected by the omission of relevant variables in the analysis.

The existence of a reverse causal effect (obesity in young age determines the level of educational achievement of an individual) is supported by the findings of several studies.

Sargent and Blanchflower (1994), using panel data, showed an inverse relationship between obesity at age 16 and earnings at 23 in young women. Gortmaker *et al.* (1993) found that women who were overweight in childhood completed fewer years of school. Crosnoe and Muller (2004) found that students at risk of obesity achieved worse outcomes in schools characterised by higher romantic activity, lower mean BMI or lower rate of athletic participation, than they did in schools lower in romantic activity, higher in mean BMI or higher in athletic participation.

Since no suitable instrument for education was identified in the available survey data, nor could be linked from external sources, it was not possible to address endogeneity issues satisfactorily in the analysis. However, an attempt to explore the direction of the causal link between education and obesity was made possible by data from an additional country, France.[3] The data from *Enquête Décennale Santé 2002-2003* provides information on body weight at age 20, which was taken to reflect **obesity status at school age**. The data shows that being "obese at age 20" is positively and significantly correlated with obesity in adulthood (correlation 0.177) and is negatively and significantly correlated with the number of years spent in education (correlation –0.035). Figure 9 shows that those who were obese at age 20 have significantly lower levels of educational attainment than those who were not obese, suggesting a potential for reverse causality in the relationship between education and obesity.

Figure 9. **Distribution of years of education according to obesity status at age 20**



Source: French data from *Enquête Décennale Santé 2002-03*; Authors' calculations.

In order to assess the influence of such potential reverse causal effect on the observed correlation between education and adult obesity, the results of two regression analyses assessing factors associated with adult obesity were compared, in one the "obesity at age 20" variable was included as an additional covariate (Table 3). Comparing Model 1 (without control) and Model 2 (with control) is a way of assessing whether the strength of the association between education and obesity is affected by a potential reverse causality. Odds ratios of obesity relative to education for women are virtually identical in both models, while small changes are observed in odds ratios for men. This comparison suggests that a reverse causal effect is unlikely to have a significant influence on the strength of the correlation observed between education and adult obesity. However, there remains an issue of potential recall bias concerning body weight at age 20, as suggested by the fact that individuals tended to report round numbers (*e.g.* 60, or 65 kg).

Table 3. **Odds ratios for obesity in adulthood in France (age range 25-64)**

France	Model 1: without control for obesity at age 20		Model 2: with control for obesity at age 20	
	Odds Ratios	*Significance*	Odds Ratios	*Significance*
Age	1.13	***	1.14	***
Age squared	1.00	***	1.00	***
Women	1.26	**	1.31	**
Years of education – Men				
0-5 years	ref.		ref.	
6-8 years	0.93		0.98	
9-11 years	0.75	**	0.79	
over 12 years	0.85	*	0.90	
Years of education – Women				
0-5 years	ref.		ref.	
6-8 years	0.84	*	0.83	*
9-11 years	0.54	***	0.54	***
over 12 years	0.52	***	0.53	***
Obese at age 20			15.53	***
Occupation (SES)				
Blue collar workers	ref.		ref.	
Craftsmen	0.82	**	0.81	**
Farmers	0.88		0.84	
Clerks	0.82	***	0.82	***
Intermediate professions	0.65	***	0.66	***
Managers, Professionals	0.42	***	0.43	***
Working status				
Working	ref.		ref.	
Not working	1.29	***	1.29	***

Note: *** means significant at 1%, ** at 5%, * at 10%.
Source: French data from *Enquête Décennale Santé 2002-03*. Authors' calculations.

7. What theoretical model of the influence of education on social outcomes is supported by the data?

As a final step in our empirical analysis, we assessed which of the absolute, relative and cumulative conceptual models of the outcomes of education proposed by Campbell (2006) is empirically supported by the data.

Table 4 indicates that better educated individuals are less likely to be obese than their less educated counterparts in all of the countries considered. This result can be viewed as evidence in support of the absolute effect of education model, mirroring evidence in the literature on the importance of individual level education for health status and health behaviours. However, after accounting for individual level education, those who are exposed to better educated environments in Australia, Canada and England are significantly more likely to be obese. This finding supports the relative model of the effects of education, which appears to play a larger role than the absolute model in explaining the distribution of obesity across social groups. The educational environment estimate is not significant in Korea which gives evidence for the absolute model.

The relative effect could operate through several pathways. One pathway that is consistent with both the absolute and the relative models is that linking social position to

Box 3. **The absolute, relative and cumulative models**

The relationship between education and obesity may be interpreted according to various models/hypotheses, which involve alternative mechanisms. Three such models were conceptualised by Campbell (2006) as follows.

The **absolute model** implies that the probability that individuals will be obese depends on their level of education. According to this model, education may reduce the probability that an individual will be obese both by increasing the stock of information available to the individual concerning the health risks associated with unhealthy lifestyles, and by improving their ability to understand and handle such information. When the effects of education are in line with the predictions of the absolute model, policies which successfully promote education and learning and increase the average educational attainment of a population will have the effect of decreasing obesity rates. While our hypothesis is that the absolute model of education generally leads to lower rates of obesity through increased education, the absolute effect of education might also be negative. If education increases wages, and therefore increases the opportunity cost of leisure time, an educated individual's propensity to engage in leisure time physical activity or home meal preparation will likely be reduced.

The **relative model** implies that education serves as a marker of social status and an individuals' level of education relative to their peers, or relative to the prevailing level of education in the relevant social environment, is what affects the probability that they will be obese. This model implies that a generalised increase in the level of education of an entire community may not alter individual outcomes, unless the relative position of individuals within that community changes as a result.

The **cumulative model** rests on the idea that the impact of individual education on obesity is consistent with, and additive to, the impact of the level of education of other members of the same community. Therefore, the likelihood that an individual may become obese depends both on the individual's own level of education and on the level of education of other community members.

To test the above models, logistic regression analyses of the likelihood of obesity were run on the four countries' data using a similar approach to that proposed by Campbell (2006) in his analysis of civic and social engagement as an outcome of education. Regression models included, in addition to the control variables gender and age, two measures of education: the number of years of education completed by the individual respondent (education level) and the mean level of education completed by members of the same age cohort within the same country (educational environment). In order to calculate the educational environment variable, four 10-year birth cohort groups were devised: 1941-50, 1951-60, 1961-70, 1971-80. Mean education levels within each cohort were standardised using the 2005 national distributions of levels of education (lower secondary; upper secondary; tertiary education) by age group, available in *Education at a Glance 2007* (OECD, 2007). Findings of a statistically-significant and strong negative effect of individual level education on obesity would provide support for the absolute model. A correlation between educational environment and obesity could be interpreted as evidence of a relative effect of education, especially if the correlation is stronger than that between individual education and obesity. Findings indicating that individual education is correlated with obesity and the educational environment variable is inversely correlated with obesity would lend support to the cumulative model, especially if the latter correlation were stronger than the former (Campbell, 2006).

Table 4. **Odds ratios and significance for likelihood of obesity when controlling for cohort education level**

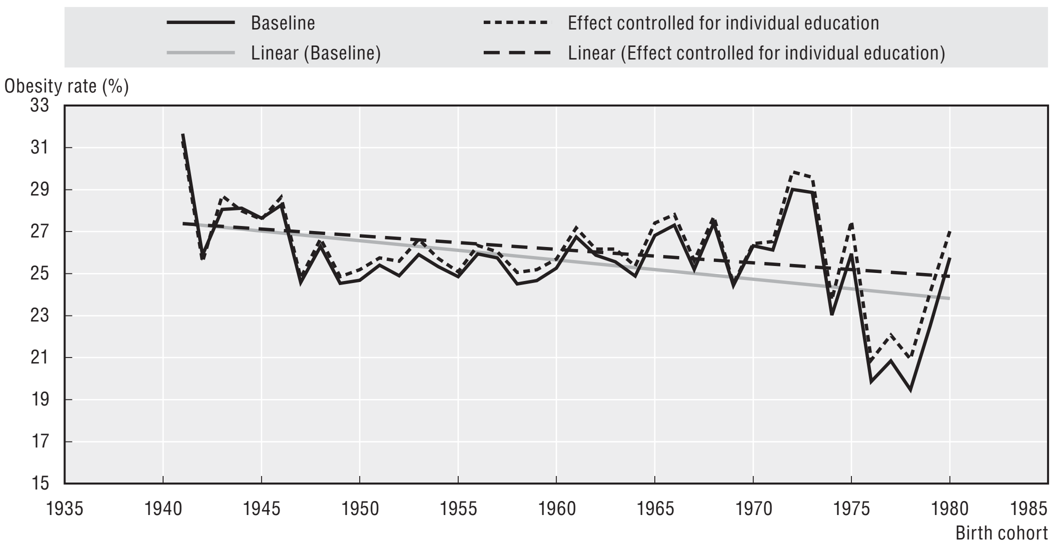
	Australia	Canada	England	Korea
Age	1.060***	1.026***	1.157***	0.992
Age squared			0.999***	1.000
Women	0.859***	0.808***	1.138***	1.179
Individual education	0.912***	0.959***	0.913***	0.921***
Educational environment	3.347***	1.184***	2.015***	0.989
Socio-economic status				
highest	ref.	ref.	ref.	ref.
middle-high	1.179***	1.099***	1.232***	0.946
middle	1.158***	1.104***	1.221***	0.912
middle-low	1.531***	1.106**	1.397***	1.057
lowest	1.365***	1.189***	1.488***	1.200
Ethnicity				
White			ref.	
Black			1.675***	
Asian			0.780***	

In Australia and Canada age squared is not available as the age variable is categorical; we use mid-age of each category. *** means significant at 1%, ** at 5%, * at 10%.
Source: Authors' calculations based on national survey data.

stress levels and eventually to health outcomes. Evidence has been gathered that individuals who have a lower social position are exposed to higher levels of perceived stress, because of a lower degree of control over their jobs and their life circumstances and because of a less satisfactory balance between efforts and rewards (Siegrist and Marmot, 2004). This is associated with a reduced ability to handle environmental pressures and often translates into less healthy lifestyles, obesity, chronic diseases and premature mortality (Brunner *et al*, 2007; Chandola *et al*., 2008). A second pathway which typically reflects features of the relative model of the effects of education is linked to a higher demand for health inputs that are associated with a healthy weight, *e.g.* gym and health club memberships, by those who have higher levels of education and occupy higher social positions. In communities where the average level of education is higher, demand for such inputs, and consequently the price of those inputs, are also likely to be higher, hindering access to the same resources for the less educated and less well-off.

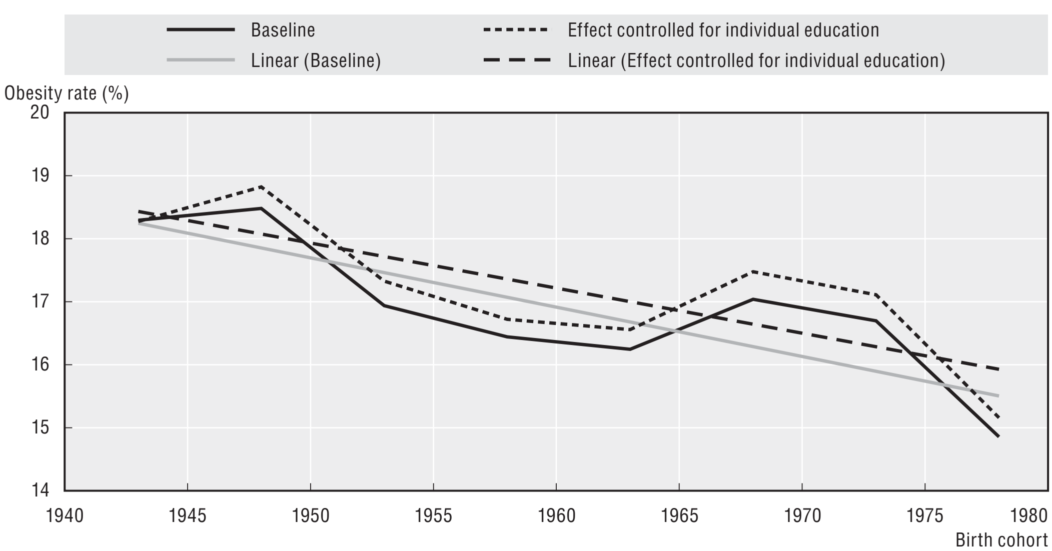
A further analysis was carried out to test for a possible effect of individual education on obesity, consistent with the *absolute* model discussed above. The analysis exploited age-period-cohort models of obesity developed by Sassi *et al* (2009) with the aim of disentangling the effects of the three time-related factors (individual age, period of observation and birth cohort) on the likelihood of obesity. The findings of the main analysis showed negatively sloped cohort effects, suggesting that individuals born in more recent cohorts, other things being equal (including age), have a lower probability of being obese than individuals born in earlier cohorts, with a possible flattening of the cohort effect curve for the most recent cohorts. Here, these models were completed by adding a control for individual education, for the purpose of testing whether improvements in education over time may account for at least part of the negatively sloped cohort effects observed in the main analysis, *i.e.* whether a higher level of education may partly explain why individuals born in more recent cohorts have a lower probability of being obese. The age-period-cohort model used in the analyses is the one proposed by Yang, Fu and Land (2004), based on a robust estimator (intrinsic estimator) which does not require the identification of constraints on the parameter vector by using prior information. The intrinsic estimator method (Fu, 2000; Knight and Fu, 2000; Fu and Hall, 2004; Fu and Rohan, 2004) considers an orthogonal decomposition of the parameter space into a null space for the singular design matrix and a non-null space, where the intrinsic estimator is obtained by the Moore-Penrose generalised inverse. Analyses were carried out on data from Canada and England. Obesity rates in Korea are too low for this analysis to produce meaningful results, and Australian data were not directly accessible at the individual level.

Figure 10. **Negative cohort effect with/without controls for education level in England**



Source: Authors' calculation based on national survey data.

Figure 11. **Negative cohort effect with/without controls for education level in Canada**



Source: Authors' calculation based on national survey data.

An age-period-cohort analysis allowed to disentangle the impact of the three time-related effects on obesity. The findings of such analysis (reported in Sassi *et al*., 2009) show declining cohort effects in Canada, England and, to a lesser degree, in Korea (no APC analysis could be undertaken on Australian data). After inclusion of individual education as a covariate in the regression models for the two countries with more pronounced cohort effects, trends in cohort effects become more flat (Figures 10 and 11). This means that part of the reduction in the likelihood of obesity in younger birth cohorts is explained by their higher degrees of educational attainment achieved by individuals in the same cohorts, which is consistent with the absolute model of the effects of education on obesity.

8. Conclusions

A range of analyses of health survey data from Australia, Canada, England and Korea were undertaken with the aim of exploring the relationship between education and obesity. The findings of these analyses show a broadly linear relationship between the number of years spent in full-time education and the probability of obesity, with most educated individuals displaying lower rates of the condition (the only exception being men in Korea). This suggests that the strength of the correlation between education and obesity is approximately constant throughout the education spectrum. Increasing education at any point along that spectrum would be expected to reduce obesity to a similar degree, if the causal nature of the link between education and obesity had been established.

The education gradient in obesity is stronger in women than in men. Differences between genders are minor in Australia and Canada, more pronounced in England and major in Korea. The gradient has not meaningfully changed over the time periods covered by the health survey data available for our study. However, there is at least some evidence that over longer periods of time more educated individuals have been less likely to be become obese than their less educated counterparts, suggesting that education produces its influence on obesity only in the long term.

The causal nature of the link between education and obesity has not yet been proven with certainty. Our own attempt to use a natural experiment, involving a school reform which increased the minimum compulsory schooling age in England by one year in 1973, failed to establish a causal link. However, using data from France we were able to ascertain that the direction of causality appears to run mostly from education to obesity, as the strength of the association is only minimally affected when accounting for reduced educational opportunities for those who are obese in young age. Most of the effect of education on obesity is direct. Small components of the overall effect of education on obesity are mediated by an improved socio-economic status linked to higher levels of education, and by a higher level of education of other family members, associated with an individual's own level of education.

The positive effect of education on obesity is likely to be determined by at least three factors: *a)* greater access to health-related information and improved ability to handle such information; *b)* clearer perception of the risks associated with lifestyle choices; and, *c)* improved self-control and consistency of preferences over time. However, it is not just the absolute level of education achieved by an individual that matters, but also how such a level of education compares with that of the individual's peers. The higher the individual's education relative to his or her peers, the lower is the probability of the individual being obese. The latter effect may be due to different levels of perceived stress experienced by individuals in different social positions, and by different coping mechanisms. Access to resources required to maintain a healthy weight may also be driven by an individual's position in the social hierarchy.

The findings reported in this paper concerning the relationship between education and obesity are consistent with those reported in a number of other studies, notably Spasojevic (2003), Arendt (2005), Kenkel *et al*. (2006), Cutler and Lleras-Muney (2006), Sánchez-Vaznaugh *et al.* (2009). Several of the above studies showed a strong education gradient in BMI or obesity, with the better educated, especially if women, less likely to be overweight or obese. We found similar evidence in all of the four countries examined, with the largest differences between genders in Korea, the only country in which an inverse gradient (more education associated with higher obesity rates) was observed in men. This used to be a common pattern in many countries early in the 20^{th} century, and it is possible that some countries which still display relatively low obesity rates, like Korea, still retain that feature as a sign of the slower transition they have been experiencing in the weight distribution across population groups. Cutler and Lleras-Muney (2006) also found that the gradient in obesity was steeper in whites than in ethnic minorities. In our study, a detailed analysis by ethnic group could be undertaken using data from England, which showed substantially milder education gradients in obesity for minority men, relative to white men, but similar gradients in women of different ethnic backgrounds.

It should be noted that BMI was measured in England and Korea, but self-reported in Canada and Australia. The use of self-reported data may potentially cause bias in the results, as a number of people tend to report incorrectly their height and weight. However, there is no clear evidence that self-report bias may vary among individuals with different levels of education. Therefore, the correlations reported in this paper may not be affected in a major way by this potential limitation. Also, BMI is not an accurate measure of body fat, or body composition. For instance, those with a substantial muscular mass because of intense physical activity may have a high BMI but a low risk for chronic diseases. However, BMI is a widely reported measure which has proven to be particularly useful in population-level analyses. There is evidence that the link between BMI and the associated health risks is different in Asian populations, suggesting that lower BMI thresholds should be used in the latter to identify individuals who are overweight or obese. In the present study we applied the same thresholds in all countries.

The analyses presented in this paper were based on cross-sectional health survey data, which provide a very detailed source of information on the health and health-related behaviour of the respective populations, but at the same time present a number of limitations, especially in the assessment of the causal nature of the link between education and obesity. Individual education was defined as the number of years spent in full-time education, although this was available in a discrete form and interpolations were required. No information was available on the quality and contents of the education received, which are also likely to influence health and health-related behaviour in adult life.

9. Policy Implications

Establishing the causal nature of links between obesity and policy levers that could potentially be used to curb the current epidemic is essential for effective policies to be designed and implemented. If changes in education could be expected to influence health-related behaviours and obesity rates in a population, this might strengthen the case for educational policies aimed, for instance, at increasing compulsory schooling age or increasing enrolment in higher education. Our analysis in Table 4 provides an estimate of the size of such effect. Increasing education by one year in the whole population would decrease the overall obesity rate by 4% in Canada, and up to 9% in England. Cutler and Lleras-Muney (2006), with reference to the broader health effects of education, argued that if a causal link were proven, education subsidies might be desirable. These would promote higher levels of education for a larger share of the population and correspondingly improve population health. Grossman and Kaestner (1997) argued that education policies directed at disadvantaged groups might reduce some of the existing health disparities. Although the evidence currently available, including some of the findings of our study, provides strong suggestions that at least part of the correlation between education and obesity is of a causal nature, conclusive proof of this does not yet exist.

Health education programmes aimed at promoting healthy lifestyles might in principle generate similar effects to those associated with school education by providing relevant information. However, Speakman *et al.* (2005) argue that these campaigns are likely to be ineffective "if people in lower social strata already know what foods have high energy contents, but fail to act on this information", suggesting that health promotion would mostly help those who have a higher level of education. However, very limited empirical evidence exists concerning the effects of health education programmes, and virtually none is available on differences in effectiveness between socio-economic groups. Haas (2008) suggested that more funding should not be spent on public health education campaigns while clear evidence of the effectiveness of such programmes does not exist.

Whether through formal schooling or health promotion campaigns, education may play a role in tackling overweight and obesity. Policy makers need to consider what levels of evidence should be deemed sufficient to prompt action, and how efficiency and equity objectives should be balanced in tackling obesity. Education policies aimed at increasing formal schooling include a flexible range of policies, which may be targeted at specific age and socio-economic groups. We showed that the strength of the link between education and obesity is approximately constant throughout the education spectrum, which means that similar gains could be achieved in terms of reduction of obesity rates by increasing educational attainment for early school leavers as well as for those who spend the longest in full time education. However, policies targeting early school leavers would likely improve equity by focusing on individuals who are more likely to belong to disadvantaged socio-economic groups. Similar results could be achieved by improving access to education, *e.g.* through financial incentives, for disadvantaged groups.

Notes

1. The assumption on the direction of the causal link from the former to the latter is further discussed later in the paper.
2. We tested whether this distinction in the construction of the variable had an effect on obesity status by introducing a control dummy variable, but it was not significant.
3. A second test for the causal nature of the link between education and obesity was carried out using data from the Health Survey for England in a sort of natural experiment, assessing the impact of the educational reform introduced in England in 1973, which increased the minimum compulsory schooling age from 15 to 16 years. Clark and Royer (2008) used this approach with reference to an earlier educational reform implemented in England in 1947, which also increased the minimum compulsory schooling age in the country, from 14 to 15. They found that cohorts affected by the law display only slightly improved long-run health outcomes and their findings did not support a

causal link between education and obesity. Our results consistently indicated an absence of change in the likelihood of obesity in the cohorts affected by the educational reform, relative to previous cohorts. This finding does not necessarily indicate that the link between education and obesity is not of a causal nature. Rather, it may suggest that school reforms leading to small changes in minimum compulsory schooling age do not provide sufficiently strong means for implementing an instrumental variables approach.

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ANNEX A1

Data Description Tables

Table A1.1. **Australia – National Health Survey**

Australia		1989			1995			2001			2005		
		Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total
Total frequency		12 499	12 490	24 989	10 932	10 904	21 836	4 744	5 164	9 908	5 348	5 590	10 938
Age group	25-39	16.5%	16.7%	16.6%	15.3%	15.6%	15.4%	11.4%	12.8%	12.1%	12.4%	12.9%	12.7%
	30-34	16.2%	16.5%	16.4%	15.9%	16.1%	16.0%	13.9%	15.1%	14.4%	14.4%	15.0%	14.7%
	35-39	15.1%	15.4%	15.2%	15.2%	15.6%	15.4%	14.9%	15.4%	15.1%	13.9%	14.4%	14.1%
	40-44	14.6%	14.5%	14.5%	14.0%	14.0%	14.0%	15.2%	14.3%	14.8%	14.4%	14.6%	14.5%
	45-49	11.7%	11.1%	11.4%	12.9%	13.1%	13.0%	13.3%	13.2%	13.2%	13.2%	13.2%	13.2%
	50-54	9.4%	9.2%	9.3%	10.7%	10.1%	10.4%	13.1%	12.1%	12.6%	11.6%	11.3%	11.5%
	55-59	8.3%	8.2%	8.2%	8.7%	8.0%	8.4%	10.1%	9.3%	9.7%	11.3%	10.3%	10.8%
	60-64	8.2%	8.5%	8.3%	7.4%	7.4%	7.4%	8.2%	7.8%	8.0%	8.8%	8.2%	8.5%
Equivalized income	upper	31.6%	26.9%	29.3%	30.0%	26.0%	28.0%	31.3%	25.7%	28.6%	30.4%	24.4%	27.5%
	upper middle	25.6%	23.6%	24.6%	23.6%	22.3%	23.0%	22.5%	21.9%	22.2%	24.4%	21.0%	22.8%
	middle	20.0%	19.5%	19.8%	18.8%	18.5%	18.7%	19.4%	19.2%	19.3%	19.8%	21.1%	20.4%
	lower middle	13.9%	17.4%	15.6%	12.7%	16.5%	14.6%	12.9%	16.0%	14.4%	14.5%	17.1%	15.8%
	lower	8.9%	12.6%	10.7%	15.0%	16.6%	15.8%	13.9%	17.1%	15.5%	10.9%	16.4%	13.6%
Migrant	yes	31.2%	29.2%	30.2%	29.8%	29.2%	29.5%	29.2%	28.9%	29.1%	28.4%	28.9%	28.7%
	no	68.8%	70.8%	69.8%	70.2%	70.8%	70.5%	70.8%	71.1%	70.9%	71.6%	71.1%	71.3%
Obese	no	90.8%	89.6%	90.2%	86.4%	86.5%	86.4%	82.8%	81.8%	82.3%	78.1%	81.6%	79.8%
	yes	9.2%	10.4%	9.8%	13.6%	13.5%	13.6%	17.2%	18.2%	17.7%	21.9%	18.4%	20.2%
Overweight	no	51.3%	67.0%	59.0%	43.8%	60.7%	52.0%	37.9%	55.7%	46.6%	32.2%	53.0%	42.3%
	yes	48.7%	33.0%	41.0%	56.2%	39.3%	48.0%	62.1%	44.3%	53.4%	67.8%	47.0%	57.7%
BMI classification	underweight	1.1%	5.1%	3.1%	0.9%	3.7%	2.3%	0.8%	3.4%	2.1%	0.5%	3.0%	1.7%
	normal	50.1%	61.9%	55.9%	42.9%	57.0%	49.8%	37.2%	52.2%	44.5%	31.7%	50.0%	40.6%
	overweight	39.5%	22.6%	31.2%	42.6%	25.7%	34.4%	44.8%	26.2%	35.7%	45.9%	28.6%	37.5%
	obese	9.2%	10.4%	9.8%	13.6%	13.5%	13.6%	17.2%	18.2%	17.7%	21.9%	18.4%	20.2%
Years of education	0-8	17.8%	17.9%	17.9%	13.8%	13.2%	13.5%	10.0%	8.3%	9.2%	6.7%	5.4%	6.1%
	9-11	65.8%	70.2%	68.0%	67.1%	71.2%	69.1%	67.6%	72.1%	69.8%	45.6%	44.0%	44.8%
	over 12	16.4%	11.9%	14.2%	19.2%	15.6%	17.4%	22.4%	19.6%	21.0%	47.7%	50.6%	49.1%

Table A1.2. **Canada – Canadian National Population Health Survey 1995 and Canadian Community Health Survey 2001-2005**

Canada		1995			2001			2003			2005		
		Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total
Total frequency		5 009	5 560	10 569	35 044	36 852	71 896	33 154	34 911	68 065	33 471	35 495	68 966
Age group	25-39	13.9%	12.6%	13.2%	12.0%	11.5%	11.8%	12.0%	11.4%	11.7%	11.8%	11.6%	11.7%
	30-34	16.3%	17.5%	16.9%	13.3%	12.5%	12.9%	11.9%	12.0%	12.0%	11.7%	11.8%	11.7%
	35-39	17.1%	16.4%	16.8%	15.6%	15.9%	15.7%	15.0%	14.8%	14.9%	13.3%	13.1%	13.2%
	40-44	14.8%	14.7%	14.7%	16.5%	16.5%	16.5%	16.6%	16.4%	16.5%	16.4%	16.0%	16.2%
	45-49	13.2%	12.0%	12.6%	14.0%	14.7%	14.4%	13.6%	14.2%	13.9%	14.3%	14.9%	14.6%
	50-54	10.2%	9.9%	10.0%	12.2%	12.4%	12.3%	12.4%	12.8%	12.6%	12.5%	13.3%	12.9%
	55-59	7.7%	8.8%	8.2%	9.4%	9.2%	9.3%	10.6%	10.6%	10.6%	11.2%	10.9%	11.1%
	60-64	7.0%	8.1%	7.5%	7.0%	7.4%	7.2%	7.8%	7.8%	7.8%	8.8%	8.4%	8.6%
Equivalized income	upper	19.9%	16.5%	18.2%	37.7%	31.8%	34.8%	45.0%	37.7%	41.5%	54.2%	47.6%	51.0%
	upper middle	41.1%	37.9%	39.5%	37.1%	36.6%	36.8%	34.2%	35.9%	35.0%	26.0%	27.1%	26.6%
	middle	25.6%	28.3%	26.9%	17.1%	20.2%	18.6%	14.6%	17.7%	16.1%	12.9%	15.9%	14.4%
	lower middle	8.8%	11.4%	10.1%	4.8%	7.3%	6.0%	3.8%	5.6%	4.7%	3.0%	4.1%	3.5%
	lower	4.7%	5.9%	5.3%	3.3%	4.1%	3.7%	2.4%	3.0%	2.7%	3.9%	5.3%	4.5%
Minority	no				86.0%	85.9%	86.0%	84.3%	85.3%	84.8%	83.6%	84.0%	83.8%
	yes				14.0%	14.1%	14.0%	15.7%	14.7%	15.2%	16.4%	16.0%	16.2%
Obese	no	85.9%	86.1%	86.0%	82.5%	84.8%	83.6%	82.1%	84.2%	83.1%	81.2%	83.8%	82.5%
	yes	14.1%	13.9%	14.0%	17.5%	15.2%	16.4%	17.9%	15.8%	16.9%	18.8%	16.2%	17.5%
Overweight	no	39.0%	59.2%	49.0%	40.4%	57.4%	48.7%	38.5%	57.0%	47.5%	37.7%	56.4%	46.7%
	yes	61.0%	40.8%	51.0%	59.6%	42.6%	51.3%	61.5%	43.0%	52.5%	62.3%	43.6%	53.3%
BMI classification	underweight	0.5%	2.6%	1.5%	0.9%	3.4%	2.1%	0.7%	3.1%	1.9%	0.7%	3.5%	2.0%
	normal	38.5%	56.6%	47.4%	39.5%	53.9%	46.6%	37.8%	54.0%	45.6%	37.1%	52.9%	44.7%
	overweight	46.9%	27.0%	37.1%	42.1%	27.5%	34.9%	43.6%	27.1%	35.6%	43.5%	27.5%	35.7%
	obese	14.1%	13.9%	14.0%	17.5%	15.2%	16.4%	17.9%	15.8%	16.9%	18.8%	16.2%	17.5%
Years of education	8	21.6%	21.1%	21.4%	18.1%	16.8%	17.4%	14.1%	13.3%	13.7%	12.4%	10.7%	11.6%
	12	14.9%	18.4%	16.6%	18.2%	21.3%	19.7%	18.0%	19.6%	18.7%	14.8%	15.8%	15.3%
	14	23.7%	25.0%	24.3%	6.9%	7.3%	7.1%	6.3%	6.6%	6.5%	7.1%	6.7%	6.9%
	17	39.8%	35.5%	37.7%	56.9%	54.6%	55.8%	61.6%	60.5%	61.1%	65.7%	66.8%	66.3%

Table A1.3. **Korea – Korean National Health and Examination Survey**

Korea		1998			2001			2005		
		Men	Women	Total	Men	Women	Total	Men	Women	Total
Total frequency		2 941	3 396	6 337	2 179	2 706	4 885	1 822	2 398	4 220
Age group	25-39	13.6%	14.4%	14.0%	11.7%	12.7%	12.3%	8.3%	9.0%	8.7%
	30-34	15.4%	15.4%	15.4%	15.4%	16.0%	15.7%	13.7%	15.1%	14.5%
	35-39	16.0%	15.3%	15.6%	16.3%	16.6%	16.5%	13.3%	14.9%	14.2%
	40-44	15.3%	14.3%	14.7%	16.4%	16.6%	16.5%	15.3%	16.3%	15.9%
	45-49	11.1%	10.9%	11.0%	13.3%	11.7%	12.4%	17.0%	14.3%	15.5%
	50-54	9.9%	9.6%	9.7%	8.6%	9.4%	9.0%	10.4%	11.2%	10.8%
	55-59	9.6%	10.6%	10.1%	10.1%	8.4%	9.1%	11.9%	9.7%	10.6%
	60-64	9.1%	9.6%	9.4%	8.2%	8.6%	8.4%	10.2%	9.4%	9.7%
Equivalized income	upper	20.5%	25.6%	23.3%	22.7%	28.7%	26.0%	22.7%	27.4%	25.4%
	upper middle	21.8%	21.6%	21.7%	19.4%	18.7%	19.0%	21.5%	19.9%	20.6%
	middle	21.9%	19.1%	20.4%	22.9%	19.7%	21.1%	20.9%	18.6%	19.6%
	lower middle	20.4%	18.6%	19.4%	20.3%	18.7%	19.4%	20.4%	18.7%	19.5%
	lower	15.4%	15.0%	15.2%	14.7%	14.3%	14.5%	14.4%	15.4%	15.0%
Obese	no	98.2%	96.7%	97.4%	97.4%	96.5%	96.9%	96.8%	96.1%	96.4%
	yes	1.8%	3.3%	2.6%	2.6%	3.5%	3.1%	3.2%	3.9%	3.6%
Overweight	no	72.2%	70.8%	71.4%	65.5%	70.9%	68.5%	61.6%	70.4%	66.6%
	yes	27.8%	29.2%	28.6%	34.5%	29.1%	31.5%	38.4%	29.6%	33.4%
BMI classification	underweight	3.2%	3.8%	3.5%	2.2%	4.7%	3.6%	2.7%	4.1%	3.5%
	normal	68.9%	67.0%	67.9%	63.3%	66.1%	64.9%	58.9%	66.2%	63.1%
	overweight	26.1%	25.9%	26.0%	31.9%	25.6%	28.4%	35.2%	25.8%	29.8%
	obese	1.8%	3.3%	2.6%	2.6%	3.5%	3.1%	3.2%	3.9%	3.6%
Years of education	6	16.8%	31.5%	24.7%	10.5%	21.0%	16.3%	9.9%	20.3%	15.8%
	9	15.5%	17.5%	16.6%	14.0%	15.4%	14.8%	12.6%	14.1%	13.4%
	12	40.2%	35.5%	37.7%	39.0%	41.9%	40.6%	37.7%	39.8%	38.9%
	16	24.2%	14.7%	19.1%	31.3%	20.7%	25.4%	35.0%	24.1%	28.8%
	17	3.2%	0.8%	1.9%	5.2%	1.1%	2.9%	4.8%	1.8%	3.1%

Table A1.4. **England – Health Survey for England**

England		1991			1992			1993			1994			1995			1996			1997			1998		
		Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total
Total Frequency		937	1 046	1983	1 162	1 242	2 404	5 000	5 364	10 364	4 557	5 073	9 630	4 536	5 108	9 644	4 734	5 303	10 037	2 514	2 867	5 381	4 484	5 221	9 705
Age group	25-39	14.8%	13.4%	14.1%	15.6%	15.3%	15.4%	14.2%	14.1%	14.2%	14.0%	14.3%	14.1%	12.1%	13.6%	12.9%	12.1%	12.7%	12.5%	13.1%	12.6%	12.8%	12.3%	12.4%	12.4%
	30-34	14.6%	15.5%	15.1%	12.0%	12.9%	12.5%	14.3%	14.6%	14.4%	15.3%	15.0%	15.1%	15.6%	15.2%	15.4%	14.3%	14.7%	14.6%	13.9%	14.9%	14.4%	14.6%	14.4%	14.5%
	35-39	13.1%	12.4%	12.8%	13.6%	14.1%	13.9%	13.1%	13.9%	13.5%	15.1%	14.7%	14.9%	15.1%	13.6%	14.3%	13.9%	14.7%	14.3%	13.9%	13.2%	13.5%	14.4%	14.7%	14.6%
	40-44	14.3%	15.2%	14.8%	14.3%	14.2%	14.2%	12.9%	13.2%	13.0%	12.4%	12.8%	12.6%	13.0%	12.9%	13.0%	13.9%	12.8%	13.4%	13.6%	13.5%	13.5%	12.3%	12.4%	12.4%
	45-49	12.3%	11.5%	11.9%	14.0%	12.0%	13.0%	14.3%	13.6%	13.9%	12.7%	13.5%	13.1%	12.4%	12.9%	12.7%	14.1%	13.7%	13.9%	13.6%	13.9%	13.8%	13.4%	12.6%	13.0%
	50-54	10.0%	10.5%	10.3%	10.8%	10.8%	10.8%	10.6%	10.8%	10.7%	10.4%	10.3%	10.3%	11.4%	11.6%	11.6%	12.0%	12.1%	12.0%	12.1%	12.6%	12.4%	12.8%	13.4%	13.1%
	55-59	10.1%	10.5%	10.3%	9.2%	9.4%	9.3%	10.7%	9.9%	10.3%	9.8%	9.5%	9.7%	10.2%	10.5%	10.4%	9.6%	9.4%	9.5%	10.1%	9.8%	10.0%	9.7%	9.8%	9.8%
	60-64	10.7%	11.0%	10.8%	10.5%	11.4%	10.9%	9.9%	10.0%	9.9%	10.4%	9.9%	10.1%	10.1%	9.6%	9.8%	10.1%	9.8%	9.9%	9.7%	9.5%	9.6%	10.4%	10.3%	10.3%
Socioeconomic status	upper	7.6%	1.8%	4.5%	8.6%	1.8%	5.1%	10.0%	2.4%	6.0%	8.3%	2.3%	5.1%	8.4%	1.9%	5.0%	7.5%	2.2%	4.7%	8.0%	2.3%	5.0%	7.2%	2.4%	4.7%
	upper middle	32.9%	26.6%	29.6%	30.3%	25.7%	27.9%	30.3%	26.6%	28.4%	29.6%	26.3%	27.9%	31.1%	25.6%	28.2%	32.3%	25.9%	29.0%	31.3%	25.3%	28.1%	31.8%	25.6%	28.5%
	middle	40.8%	42.9%	41.9%	43.3%	47.8%	45.6%	43.9%	44.1%	44.0%	43.2%	44.0%	43.6%	42.7%	46.4%	44.6%	42.8%	45.0%	43.9%	42.4%	45.3%	43.9%	42.6%	44.3%	43.5%
	lower middle	14.3%	18.5%	16.5%	13.3%	15.8%	14.6%	11.7%	18.8%	15.4%	13.8%	19.8%	17.0%	13.1%	19.0%	16.2%	12.7%	19.7%	16.4%	14.7%	19.9%	17.5%	13.6%	19.7%	16.9%
	lower	4.5%	10.2%	7.5%	4.5%	8.9%	6.8%	4.1%	8.1%	6.2%	5.0%	7.6%	6.4%	4.7%	7.2%	6.0%	4.7%	7.2%	6.0%	3.6%	7.2%	5.5%	4.7%	7.9%	6.4%
Ethnicity	White	95.8%	96.1%	96.0%	95.3%	96.1%	95.7%	95.2%	95.3%	95.3%	95.2%	95.4%	95.3%	95.4%	95.6%	95.5%	94.6%	94.8%	94.7%	94.3%	94.8%	94.6%	95.0%	95.4%	95.2%
	Black	2.0%	2.0%	2.0%	1.2%	1.7%	1.5%	1.8%	2.0%	1.9%	1.4%	2.1%	1.7%	1.3%	1.6%	1.5%	1.8%	2.2%	2.0%	1.7%	1.9%	1.8%	2.1%	1.9%	2.0%
	Asian	2.1%	1.9%	2.0%	3.5%	2.2%	2.8%	3.0%	2.7%	2.9%	3.4%	2.5%	2.9%	3.3%	2.8%	3.0%	3.6%	3.0%	3.3%	4.1%	3.3%	3.6%	2.9%	2.7%	2.8%
Obese	no	85.5%	82.6%	84.0%	86.0%	82.0%	83.9%	85.3%	82.7%	83.9%	85.0%	82.3%	83.6%	83.1%	81.8%	82.4%	81.8%	80.9%	81.3%	81.0%	79.3%	80.1%	81.2%	78.3%	79.6%
	yes	14.5%	17.4%	16.0%	14.0%	18.0%	16.1%	14.7%	17.3%	16.1%	15.0%	17.7%	16.4%	16.9%	18.2%	17.6%	18.2%	19.1%	18.7%	19.0%	20.7%	19.9%	18.8%	21.7%	20.4%
Overweight	no	42.7%	54.2%	48.8%	39.9%	53.5%	47.0%	38.3%	50.9%	44.8%	38.6%	51.2%	45.3%	36.8%	49.2%	43.4%	34.4%	47.0%	41.0%	33.4%	46.9%	40.6%	33.0%	45.5%	39.7%
	yes	57.3%	45.8%	51.2%	60.1%	46.5%	53.0%	61.7%	49.1%	55.2%	61.4%	48.8%	54.7%	63.2%	50.8%	56.6%	65.6%	53.0%	59.0%	66.6%	53.1%	59.4%	67.0%	54.5%	60.3%
BMI classification	under-weight	1.2%	2.0%	1.6%	0.9%	2.0%	1.5%	0.7%	1.4%	1.1%	0.6%	1.6%	1.1%	0.7%	1.4%	1.0%	0.6%	1.2%	0.9%	0.3%	1.5%	0.9%	0.6%	1.2%	0.9%
	normal	41.5%	52.2%	47.2%	39.1%	51.5%	45.5%	37.5%	49.5%	43.7%	38.1%	49.6%	44.2%	36.2%	47.8%	42.3%	33.8%	45.9%	40.2%	33.1%	45.4%	39.6%	32.4%	44.3%	38.8%
	overweight	42.8%	28.4%	35.2%	46.0%	28.5%	37.0%	47.0%	31.8%	39.1%	46.4%	31.1%	38.3%	46.3%	32.6%	39.0%	47.4%	33.9%	40.3%	47.6%	32.4%	39.5%	48.2%	32.8%	39.9%
	obese	14.5%	17.4%	16.0%	14.0%	18.0%	16.1%	14.7%	17.3%	16.1%	15.0%	17.7%	16.4%	16.9%	18.2%	17.6%	18.2%	19.1%	18.7%	19.0%	20.7%	19.9%	18.8%	21.7%	20.4%
Years of education	8	11.4%	12.0%	11.7%	10.2%	9.3%	9.7%	8.5%	8.2%	8.3%	7.5%	6.8%	7.1%	6.7%	5.5%	6.1%	5.0%	5.2%	5.1%	3.7%	4.4%	4.1%	2.8%	2.8%	2.8%
	9	30.6%	29.3%	29.9%	28.4%	29.9%	29.2%	27.7%	29.2%	28.5%	25.2%	27.8%	26.5%	27.3%	29.1%	28.2%	26.8%	26.7%	26.7%	26.0%	29.1%	27.6%	27.8%	27.1%	27.4%
	10	27.2%	26.9%	27.0%	28.8%	28.8%	28.8%	29.4%	27.7%	28.5%	31.6%	28.4%	29.9%	30.6%	29.3%	29.9%	31.8%	31.4%	31.6%	31.5%	30.1%	30.7%	32.2%	31.8%	32.0%
	11	7.7%	9.3%	8.5%	7.0%	9.2%	8.1%	7.5%	8.7%	8.1%	7.5%	10.0%	8.8%	8.1%	10.0%	9.1%	7.5%	10.1%	8.8%	7.9%	9.4%	8.7%	7.5%	9.4%	8.5%
	12	5.1%	10.0%	7.7%	6.7%	10.0%	8.4%	7.2%	9.4%	8.3%	7.5%	10.2%	8.9%	7.5%	10.0%	8.8%	7.3%	9.3%	8.3%	8.5%	10.1%	9.4%	7.1%	11.0%	9.2%
	13	5.7%	6.8%	6.3%	7.7%	6.0%	6.8%	6.9%	8.9%	8.0%	8.3%	8.2%	8.2%	19.8%	16.0%	17.8%	21.4%	17.3%	19.2%	8.5%	7.1%	7.7%	8.4%	8.0%	8.2%
	15	12.3%	5.8%	8.9%	11.3%	6.8%	8.9%	12.9%	7.8%	10.3%	12.5%	8.7%	10.5%	0.1%	0.1%	0.1%	0.2%	0.1%	0.1%	14.0%	9.8%	11.8%	14.1%	9.8%	11.8%

Table A1.4. **England – Health Survey for England** *(cont.)*

England		1999			2000			2001			2002			2003			2004			2005		
		Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total
Total Frequency		2 190	2 494	4 684	2 186	2 520	4 706	4 261	4 976	9 237	1971	2 531	4 502	4 025	4 745	8 770	3 027	3 689	6 716	1950	2 342	4 292
Age group	25-39	11.4%	10.2%	10.7%	11.0%	11.5%	11.3%	10.4%	10.7%	10.6%	10.2%	11.7%	11.0%	9.6%	9.3%	9.4%	11.5%	12.4%	12.0%	8.8%	10.0%	9.5%
	30-34	13.8%	14.8%	14.3%	15.2%	14.4%	14.7%	13.4%	12.7%	13.0%	12.3%	14.0%	13.3%	12.8%	12.3%	12.6%	15.8%	13.6%	14.6%	13.5%	11.3%	12.3%
	35-39	15.2%	15.4%	15.3%	15.0%	15.8%	15.4%	14.8%	15.6%	15.2%	15.4%	17.8%	16.7%	13.9%	15.1%	14.5%	15.2%	15.3%	15.3%	12.9%	12.9%	12.9%
	40-44	12.4%	13.8%	13.2%	13.8%	14.1%	14.0%	13.3%	13.8%	13.6%	15.6%	13.4%	14.4%	14.3%	14.7%	14.5%	14.9%	15.7%	15.3%	11.9%	14.9%	13.6%
	45-49	12.9%	12.1%	12.4%	10.7%	11.9%	11.3%	12.1%	12.3%	12.2%	11.6%	11.1%	11.3%	11.9%	11.9%	11.9%	11.7%	12.4%	12.1%	13.6%	14.1%	13.9%
	50-54	13.2%	15.2%	14.2%	12.9%	12.7%	12.8%	13.8%	13.9%	13.8%	12.2%	11.8%	12.0%	12.6%	11.7%	12.1%	11.3%	10.8%	11.0%	13.4%	11.9%	12.6%
	55-59	11.5%	8.9%	10.1%	11.6%	10.7%	11.1%	12.1%	11.6%	11.8%	12.1%	11.6%	11.8%	13.9%	14.2%	14.1%	9.8%	9.8%	9.8%	13.6%	13.3%	13.4%
	60-64	9.7%	9.6%	9.7%	9.8%	9.0%	9.4%	10.1%	9.4%	9.7%	10.5%	8.7%	9.5%	10.9%	10.9%	10.9%	9.8%	10.0%	9.9%	12.2%	11.6%	11.8%
Socioeconomic status	upper	9.4%	2.1%	5.5%	7.8%	2.1%	4.8%	7.8%	2.7%	5.0%	9.1%	3.6%	6.0%	8.4%	3.3%	5.6%	7.4%	4.1%	5.6%	8.6%	3.5%	5.8%
	upper middle	31.6%	26.9%	29.1%	32.4%	30.1%	31.2%	33.2%	29.8%	31.4%	32.1%	30.6%	31.3%	33.6%	32.5%	33.0%	32.0%	31.6%	31.8%	35.5%	33.7%	34.6%
	middle	43.6%	45.9%	44.8%	42.6%	43.1%	42.9%	41.4%	42.1%	41.8%	41.7%	41.8%	41.8%	41.0%	39.7%	40.3%	40.2%	37.6%	38.8%	39.1%	40.3%	39.7%
	lower middle	12.4%	18.6%	15.7%	13.2%	17.9%	15.7%	13.4%	19.7%	16.8%	13.5%	19.0%	16.6%	13.3%	19.2%	16.5%	16.4%	21.6%	19.3%	12.4%	17.5%	15.2%
	lower	3.0%	6.5%	4.8%	4.0%	6.7%	5.5%	4.2%	5.7%	5.0%	3.5%	4.9%	4.3%	3.7%	5.2%	4.5%	4.0%	5.0%	4.5%	4.4%	5.0%	4.7%
Ethnicity	White	94.2%	94.9%	94.6%	94.2%	94.4%	94.3%	94.8%	95.0%	94.9%	94.1%	94.1%	94.1%	93.6%	94.0%	93.8%	58.3%	60.9%	59.8%	93.6%	93.9%	93.8%
	Black	1.6%	1.7%	1.7%	1.4%	1.7%	1.6%	1.4%	1.8%	1.6%	1.4%	2.1%	1.8%	1.9%	2.0%	2.0%	13.2%	14.3%	13.8%	1.1%	1.8%	1.5%
	Asian	4.1%	3.4%	3.8%	4.4%	3.9%	4.1%	3.8%	3.2%	3.5%	4.5%	3.9%	4.1%	4.5%	4.0%	4.2%	28.4%	24.8%	26.4%	5.2%	4.3%	4.7%
Obese	no	79.7%	78.2%	78.9%	77.3%	78.8%	78.1%	77.2%	75.2%	76.2%	76.0%	76.0%	76.0%	75.7%	76.2%	76.0%	78.4%	74.2%	76.1%	74.2%	74.5%	74.3%
	yes	20.3%	21.8%	21.1%	22.7%	21.2%	21.9%	22.8%	24.8%	23.8%	24.0%	24.0%	24.0%	24.3%	23.8%	24.0%	21.6%	25.8%	23.9%	25.8%	25.5%	25.7%
Overweight	no	33.1%	44.8%	39.3%	29.2%	45.9%	38.1%	28.5%	42.7%	36.2%	29.5%	42.5%	36.8%	28.8%	42.6%	36.3%	33.3%	39.7%	36.8%	28.5%	41.8%	35.7%
	yes	66.9%	55.2%	60.7%	70.8%	54.1%	61.9%	71.5%	57.3%	63.8%	70.5%	57.5%	63.2%	71.2%	57.4%	63.7%	66.7%	60.3%	63.2%	71.5%	58.2%	64.3%
BMI classification	under-weight	0.7%	1.1%	0.9%	0.5%	1.3%	0.9%	0.6%	1.1%	0.9%	0.7%	1.1%	0.9%	0.6%	1.1%	0.9%	0.9%	1.2%	1.1%	0.3%	1.0%	0.7%
	normal	32.4%	43.7%	38.4%	28.6%	44.6%	37.2%	28.0%	41.6%	35.3%	28.8%	41.4%	35.9%	28.3%	41.5%	35.4%	32.4%	38.4%	35.7%	28.3%	40.7%	35.1%
	overweight	46.6%	33.4%	39.6%	48.1%	33.0%	40.0%	48.7%	32.5%	40.0%	46.5%	33.5%	39.2%	46.8%	33.6%	39.7%	45.1%	34.5%	39.3%	45.6%	32.7%	38.6%
	obese	20.3%	21.8%	21.1%	22.7%	21.2%	21.9%	22.8%	24.8%	23.8%	24.0%	24.0%	24.0%	24.3%	23.8%	24.0%	21.6%	25.8%	23.9%	25.8%	25.5%	25.7%
Years of education	8	3.2%	2.8%	3.0%	3.2%	2.3%	2.8%	2.6%	2.2%	2.4%	2.4%	1.8%	2.0%	2.4%	1.9%	2.1%	3.9%	5.4%	4.7%	2.2%	1.6%	1.9%
	9	26.2%	26.9%	26.6%	24.1%	21.1%	22.5%	23.2%	23.7%	23.4%	22.0%	22.0%	22.0%	21.4%	21.7%	21.6%	14.7%	15.7%	15.3%	20.0%	19.8%	19.9%
	10	32.3%	31.2%	31.7%	30.6%	32.4%	31.6%	31.9%	32.1%	32.0%	32.8%	29.7%	31.1%	32.4%	30.9%	31.6%	25.4%	25.0%	25.2%	30.6%	30.8%	30.7%
	11	6.7%	10.1%	8.5%	8.2%	9.4%	8.9%	7.8%	9.9%	9.0%	7.5%	9.7%	8.7%	7.2%	9.7%	8.5%	7.8%	9.8%	8.9%	7.6%	10.7%	9.3%
	12	7.7%	10.0%	8.9%	7.2%	11.7%	9.6%	8.1%	11.3%	9.8%	8.7%	11.8%	10.4%	8.8%	11.4%	10.2%	9.1%	11.6%	10.5%	8.9%	11.6%	10.3%
	13	8.6%	8.3%	8.5%	10.7%	10.6%	10.6%	10.0%	9.7%	9.8%	10.1%	11.2%	10.7%	10.1%	10.5%	10.3%	16.4%	14.8%	15.5%	11.2%	9.1%	10.0%
	15	15.2%	10.7%	12.8%	15.9%	12.4%	14.0%	16.4%	11.2%	13.6%	16.5%	13.8%	15.0%	17.7%	13.9%	15.6%	22.7%	17.7%	20.0%	19.6%	16.5%	17.9%

ANNEX A2

Regression Analysis Related to Estimates in Figures 2 and 3

Logistic regression was used to estimate the likelihood of obesity associated with different lengths of time in education for both genders.

Australia	Dependant variable: obesity status	
	Odds ratios	*Significance*
Age		
25-29	ref.	
30-34	1.287	***
35-39	1.325	***
40-44	1.450	***
45-49	1.717	***
50-54	1.752	***
55-59	1.604	***
60-64	1.536	***
Year of survey	1.062	***
Women	1.027	
Years of education – Men		
8	ref.	
12	0.738	***
14	0.568	***
Years of education – Women		
8	ref.	
12	0.700	***
14	0.462	***
Socio-economic status		
highest	ref.	
middle-high	1.157	***
middle	1.132	***
middle-low	1.517	***
lowest	1.381	***
Obs.	67 671	
Prob > chi2	0.000	
Pseudo R2	0.032	

Canada	Dependant variable: obesity status	
	Odds ratios	*Significance*
Age		
25-29	ref.	
30-34	1.091	*
35-39	1.140	***
40-44	1.180	***
45-49	1.391	***
50-54	1.538	***
55-59	1.543	***
60-64	1.490	***
Year of survey	1.039	***
Women	0.956	
Years of education – Men		
8	ref.	
12	0.848	***
14	0.867	**
17	0.709	***
Years of education – Women		
8	ref.	
12	0.754	***
14	0.896	
17	0.599	***
Socio-economic status		
highest	ref.	
middle-high	1.141	***
middle	1.136	***
middle-low	1.151	***
lowest	1.207	***
Obs.	219 496	
Prob > chi2	0.000	
Pseudo R2	0.0124	

England	Dependant variable: obesity status	
	Odds ratios	*Significance*
Age	1.064***	
Age squared	0.999***	
Year of survey	1.058***	
Women	1.368***	
Years of education – Men		
8	ref.	
9	0.956	
10	0.882**	
11	0.788***	
12	0.726***	
13	0.706***	
15	0.558***	
Years of education – Women		
8	ref.	
9	0.792***	
10	0.677***	
11	0.599***	
12	0.565***	
13	0.558***	
15	0.353***	
Socio-economic status		
highest	ref.	
middle-high	1.235***	
middle	1.199***	
middle-low	1.347***	
lowest	1.440***	
Obs.	104 143	
Prob > chi2	0.000	
Pseudo R2	0.0266	

Korea	Dependant variable: obesity status	
	Odds ratios	*Significance*
Age	0.973	
Age square	1.000	
Year of survey	1.066***	
Women	3.968***	
Years of education – Men		
6	ref.	
9	1.601	
12	1.649	
16	1.509	
17	1.909	
Years of education – Women		
6	ref.	
9	1.007	
12	0.418***	
16	0.195***	
17	1.3E-07***	
Socio-economic status		
highest	ref.	
middle-high	0.967	
middle	1.001	
middle-low	1.055	
lowest	1.217	
Obs.	15 242	
Prob > chi2	0.000	
Pseudo R2	0.026	

Linear regression was used to estimate BMI level associated with different lengths of time in education for both genders.

Australia	Dependant variable: BMI	
	Estimates	*Significance*
Age		
25-29	ref.	
30-34	0.523	***
35-39	0.695	***
40-44	1.006	***
45-49	1.422	***
50-54	1.575	***
55-59	1.575	***
60-64	1.454	***
Year of survey	0.123	***
Women	–0.554	***
Years of education - Men		
8	ref.	
12	–0.351	***
14	–0.883	***
Years of education - Women		
8	ref.	
12	0.239	***
14	0.867	***
Socio-economic status		
highest	ref.	
middle-high	0.184	***
middle	0.143	**
middle-low	0.538	***
lowest	0.254	***
Obs.	67 671	
Prob > F	0.000	
Pseudo R2	0.0709	

Canada	Dependant variable: BMI	
	Estimates	*Significance*
Age		
25-29	ref.	
30-34	0.496	***
35-39	0.651	***
40-44	0.847	***
45-49	1.303	***
50-54	1.638	***
55-59	1.733	***
60-64	1.552	***
Year of survey	0.078	***
Women	–0.749	***
Years of education - Men		
8	ref.	
12	–0.128	
14	–0.140	
17	–0.506	***
Years of education - Women		
8	ref.	
12	–0.801	***
14	–0.725	***
17	–1.398	***
Socio-economic status		
highest	ref.	
middle-high	0.148	***
middle	0.057	
middle-low	0.036	
lowest	–0.091	
Obs.	219 496	
Prob > F	0.000	
Pseudo R2	0.0514	

England	Dependant variable: BMI	
	Estimates	*Significance*
Age	0.183***	
Age squared	–0.001***	
Year of survey	0.120***	
Women	0.503***	
Years of education - Men		
8	ref.	
9	0.027	
10	–0.071	
11	–0.312**	
12	–0.390***	
13	–0.569***	
15	–0.948***	
Years of education - Women		
8	ref.	
9	–0.603***	
10	–1.028***	
11	–1.401***	
12	–1.598***	
13	–1.622***	
15	–2.647***	
Socio-economic status		
highest	ref.	
middle-high	0.332***	
middle	0.196***	
middle-low	0.434***	
lowest	0.467***	
Obs.	104 143	
Prob > F	0.000	
Pseudo R2	0.0503	

Korea	Dependant variable: BMI	
	Estimates	*Significance*
Age	0.223***	
Age square	–0.002***	
Year of survey	0.065***	
Women	1.300***	
Years of education - Men		
6	ref.	
9	0.487***	
12	0.739***	
16	0.922***	
17	1.379***	
Years of education - Women		
6	ref.	
9	0.042	
12	–1.167***	
16	–2.223***	
17	–2.584***	
Socio-economic status		
highest	ref.	
middle-high	–0.184**	
middle	–0.104	
middle-low	–0.124	
lowest	–0.294***	
Obs.	15 704	
Prob > F	0.000	
Pseudo R2	0.0806	

ANNEX A3

Regression Analysis Related to Estimates in Figures 4 to 6

Logistic regression was used to estimate the likelihood of obesity associated with different lengths of time in education for both genders and by ethnicity/minority status.

Table A3.1. **Australia**

Australia – men	Dependant variable: obesity status		Australia – women	Dependant variable: obesity status	
	Odds ratios	*Significance*		Odds ratios	*Significance*
Age			**Age**		
25-29	ref.		25-29	ref.	
30-34	1.259	**	30-34	1.369	***
35-39	1.396	***	35-39	1.347	***
40-44	1.559	***	40-44	1.479	***
45-49	1.715	***	45-49	1.927	***
50-54	1.735	***	50-54	1.998	***
55-59	1.475	***	55-59	1.969	***
60-64	1.435	***	60-64	1.841	***
Year of survey	1.070	***	Year of survey	1.050	***
Years of education – Migrant			**Years of education – Migrant**		
8	ref.		8	ref.	
12	0.580	***	12	0.675	***
14	0.373	***	14	0.408	***
Years of education – Non-migrant			**Years of education – Non-migrant**		
8	ref.		8	ref.	
12	0.693	*	12	0.878	
14	0.576	***	14	0.729	***
Socio-economic status			**Socio-economic status**		
highest	ref.		highest	ref.	
middle-high	1.115	*	middle-high	1.247	***
middle	0.973		middle	1.409	***
middle-low	1.389	***	middle-low	1.784	***
lowest	1.170	**	lowest	1.760	***
Obs.	33 523		Obs.	34 148	
Prob > chi2	0.000		Prob > chi2	0.000	
Pseudo R2	0.0357		Pseudo R2	0.0367	

Table A3.2. **Canada**

Canada – men	Dependant variable: obesity status	
	Odds ratios	*Significance*
Age		
25-29	ref.	
30-34	1.222	***
35-39	1.203	***
40-44	1.197	***
45-49	1.366	***
50-54	1.471	***
55-59	1.475	***
60-64	1.323	***
Year of survey	1.030	***
Years of education – Non-minority		
8	ref.	
12	0.880	***
14	0.869	***
17	0.735	***
Years of education – Minority		
8	ref.	
12	0.639	***
14	0.761	***
17	0.467	***
Socio-economic status		
highest	ref.	
middle-high	0.988	
middle	0.941	**
middle-low	0.944	
lowest	0.875	***
Obs.	101 113	
Prob > chi2	0.000	
Pseudo R2	0.0075	

Canada – women	Dependant variable: obesity status	
	Odds ratios	*Significance*
Age		
25-29	ref.	
30-34	1.193	***
35-39	1.160	***
40-44	1.210	***
45-49	1.441	***
50-54	1.689	***
55-59	1.646	***
60-64	1.474	***
Year of survey	1.053	***
Years of education – Non-minority		
8	ref.	
12	0.823	***
14	0.843	***
17	0.739	***
Years of education – Minority		
8	ref.	
12	0.529	***
14	0.926	
17	0.549	***
Socio-economic status		
highest	ref.	
middle-high	1.323	***
middle	1.554	***
middle-low	1.825	***
lowest	1.821	***
Obs.	106 698	
Prob > chi2	0.000	
Pseudo R2	0.0179	

Table A3.3. **England**

England – men	Dependant variable: obesity status	
	Odds ratios	*Significance*
Age	1.089	***
Age squared	0.999	***
Year of survey	1.067	***
Years of education – White		
8	ref.	
9	0.869	**
10	0.781	***
11	0.701	***
12	0.626	***
13	0.640	***
15	0.471	***
Years of education – Black		
8	ref.	
9	0.517	***
10	0.618	***
11	0.537	**
12	0.664	
13	0.677	**
15	0.634	**
Years of education – Asian		
8	ref.	
9	0.517	***
10	1.169	***
11	0.970	***
12	1.153	***
13	0.826	***
15	0.762	***
Socio-economic status		
highest	ref.	
middle-high	1.220	***
middle	1.185	***
middle-low	1.135	**
lowest	1.022	
Obs.	48 558	
Prob > chi2	0.000	
Pseudo R2	0.0261	

England – women	Dependant variable: obesity status	
	Odds ratios	*Significance*
Age	1.042	***
Age squared	1.000	***
Year of survey	1.050	***
Years of education – White		
8	ref.	
9	0.886	**
10	0.774	***
11	0.696	***
12	0.656	***
13	0.615	***
15	0.414	***
Years of education – Black		
8	ref.	
9	1.631	***
10	1.650	***
11	1.582	***
12	1.396	**
13	1.862	***
15	0.984	
Years of education – Asian		
8	ref.	
9	1.631	
10	1.142	
11	0.704	***
12	0.831	***
13	0.762	***
15	0.615	***
Socio-economic status		
highest	ref.	
middle-high	1.378	***
middle	1.347	***
middle-low	1.682	***
lowest	1.930	***
Obs.	55 585	
Prob > chi2	0.000	
Pseudo R2	0.0312	

ANNEX A4

Multilevel models

This methodological annex gives a description of the multilevel model.

Let y_i be the value of the response variable Y for the individual i, and X_1 an independent covariate in a simple univariate model, the single-level regression equation for the individual i is given by:

$$y_i = \beta_0 + \beta_1 x_{1i} + e_i \quad (1)$$

where β_0 is the intercept, β_1 the regression coefficient and the individual-level residuals e_i with $e_i \sim N(0, \sigma_e^2)$.

In order to evaluate the significance of a higher order aggregation of individuals in n groups on the single values y_i, the regression model in (1) can be written as:

$$y_{ij} = \beta_{0j} + \beta_1 j x_{1ij} + e_{ij} \quad (2)$$

where $j = 1,\ldots, n$ refers to the level-2 units (groups) and $i = 1,\ldots, N$, to the level-1 units (individuals).

The model in equation (2) is called *random intercept model* when the intercept β_0 in (1) becomes a random variable depending on the group j, that is:

$$\beta_{0j} + \beta_0 + u_{0j} \quad (3)$$

with $u_{0j} \sim N(0, \sigma_{u0}^2)$ as group-level residuals. When considering also the regression coefficient β_1 as a random variable such as:

$$\beta_{1j} + \beta_1 + u_{1j} \quad (4)$$

with $u_{1j} \sim N(0, \sigma_{u1}^2)$ and $cov(u_{0j},u_{1j}) = \sigma_{u01}$, the model in equation (2) is called *random coefficient model* and can be written in the form:

$$y_{ij} = \beta_0 + \beta_1 x_{1ij} + (u_{0j} + u_{1j} x_{1ij} + e_{ij}) \quad (5)$$

In equation (5) the response variable y_{ij} has been expressed as the sum of a fixed part and a random part within the brackets, where the covariate x_{1ij} in the random part of the model is usually substituted by z_{1ij} to make the distinction with the covariates in the fixed part. In model (5) both intercept and regression coefficients vary from group to group, so as to explain the effect of the group's aggregation on the Y variable. The individual-level residuals e_{ij} are assumed to be independent from the group-level residuals u_{0j} and u_{1j}.

The *intra level-2 unit correlation* in random intercept models is given by:

$$\rho = \frac{\sigma_{u0}^2}{\sigma_{u0}^2 + \sigma_e^2} \quad (6)$$

and measures the proportion of the total variance which is between-groups. The same correlation index in case of random coefficient models equals:

$$\rho = \frac{\sigma_{u0}^2 + 2\sigma_{01} z_{1ij} + \sigma_{u1}^2 z_{1ij}^2}{\sigma_{u0}^2 + 2\sigma_{01} z_{1ij} + \sigma_{u1}^2 z_{1ij}^2 + \sigma_e^2} \quad (7)$$

The existence of a non-zero intra-group correlation indicates that traditional estimation procedures used in multiple regressions, such as ordinary least squares, are not correct. For this reason, estimation methods for multilevel models include generalised least square techniques (Goldstein, 1986), Fisher scoring algorithm (Longford, 1987) or the expectation-maximisation algorithm (Raudenbush and Bryk, 1986). The simple 2-level random coefficient model in (5) can be further extended by introducing more explanatory variables at either the individual or the group levels. Moreover, the number of nested levels can be increased when considering more aggregation stages.

In this case y_{ij} is a discrete response, the model is a hierarchical logistic model and the random intercept model is:

$$y_{ij} = \beta_0 + \beta_1 x_{1i} + (u_{0j} + e_{ij}) \quad (8)$$

with e_{ij} having logistic distribution and the individual-level variance σ^2_e is equal to $\pi^2/3$. So, the intra-class correlation is (with σ^2_{u0} the group-level variance):

$$\rho = \frac{\sigma_{u0}^2}{\sigma_{u0}^2 + \frac{\pi^2}{3}} \quad (9)$$