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For richer, for poorer: the relationship between adolescent obesity and future household economic prosperity

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Key words: adolescent; childhood; obesity; household income; socioeconomic status

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Abstract

Adolescent obesity not only has serious long-term health implications, but also the potential to lead to a socioeconomic trajectory of lower earnings and household income. However, the magnitude and mechanisms of such outcomes across the life course are poorly understood. Using birth cohort data from the British National Child Development Study (1958 to 2008), we examined the relationship between adolescent obesity (at age 16) and future household income, employment, wages, marriage and spousal earnings when individuals were in their 30s, 40s and 50s. We additionally investigated the role of obesity persistence from childhood (age 11) through to adulthood (age 33). After adjusting for a rich set of childhood characteristics, compared to normal weight, obesity at age 16 was associated with significantly lower levels of future household income for women (by approximately 14%), but not men. This household income penalty was greater for women with obesity in both childhood and adulthood. The household income penalty for women appeared to be driven by a lower likelihood of marriage and lower spousal earnings for those who were married, and not by their own wage penalty in the labour market. The spousal earnings penalty occurred even when obesity did not persist into adulthood.

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1. Introduction

About one in three young adolescents in England have overweight or obesity [1] and are at an increased risk of serious health problems in the short run and later in adulthood [2]. They are also more likely to face lower earnings and household income trajectories [3]. However, the magnitude and mechanisms of economic outcomes across the life course are poorly understood.

Adolescent obesity may influence adult economic prosperity in a number of ways. First, it may affect the acquisition of human capital – an individual's knowledge, skills and attributes that enable an individual to be productive. Cognitive skills (e.g. problem solving and critical thinking) and socioemotional skills (e.g. self-esteem and social skills) are important for academic achievement, high school completion, employment and wages [4, 5]. Recent evidence suggests that after accounting for socioeconomic background, and child and school characteristics, childhood obesity may hinder the development of cognitive skills [6-8] and socioemotional skills [9, 10]. One possible individual-level mechanism is childhood health problems, which can lead to absences from school or interfere with concentration and learning through fatigue and stress. Societal-level mechanisms may also be at play: weight stigma and bullying may affect the development of skills by affecting self-confidence and self-esteem, or by negatively biasing teacher assessments [11].

Second, adolescent obesity may affect adult economic prosperity through an increased risk of adult obesity [12, 13], which has been shown to reduce employment opportunities [14, 15] and wages [16-20] after controlling for family socioeconomic background, individual traits and other unobserved confounders. This labour market penalty associated with obesity is typically larger and more consistently demonstrated for women than men [21]. It has been hypothesised that the penalties in the labour market may be due to, at an individual level, lower self-esteem [22, 23]; or at a societal level, discrimination in the hiring and promotion of workers with obesity [24]. These mechanisms, among others, can impair the employment prospects for individuals with obesity. Third, obesity may influence future household income through opportunities for marriage and the contribution of spousal earnings. It has been shown that women with obesity are less likely to be married or accepted by men into cohabiting relationships or marriage [25, 26].

Findings from a limited number of studies suggest that adolescent obesity is associated with lower household income [3, 17] and wages [27, 28] in young adulthood (up to 31y), particularly for women. What remains unclear, however, is whether these penalties extend

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beyond early adulthood and into middle-age. Such information is important in understanding the economic consequences of adolescent obesity over the life course.

This study contributes to the existing literature in several ways. We utilised the 1958 British Cohort Study to examine the relationship between adolescent obesity and economic prosperity between one's 30s and 50s. Our analysis across multiple time points in adulthood enabled us to examine whether a relationship exists across adulthood, rather than appearing spuriously at one point. We carefully controlled for a range of potential confounders, particularly relating to the child's socioeconomic background, which may determine both obesity status (e.g. through social influences and access to healthy diets) [29] and later economic prosperity [30]. We explored possible mechanisms, including opportunities in the labour and marriage markets, and we further investigated the roles of educational attainment, health and self-efficacy. Additionally, we investigated whether obesity persistence is important in determining adult economic prosperity.

2. Study design

2.1 National Child Development Study (NCDS)

The NCDS follows 17,413 individuals born in England, Scotland, and Wales in 1958. Rich data on their health and socioeconomic circumstances, among other information, have been collected from birth. Childhood information was collected from parents, teachers and medical examiners; in adulthood, information was collected primarily from the cohort members. Despite considerable attrition across five decades of follow-up, with just over 50% of the original birth cohort present at 50y, we show in supplementary analyses (Appendix B) that our main findings are robust to the presence of non-random attrition.

Parental consent was obtained for all childhood surveys, and individual consent was obtained for all adult surveys. Ethical approval was sought from 2000 onwards from the London Multicentre Research Ethics Committees, United Kingdom. This study was exempt from ethical approval by the Monash University Human Research Ethics Committee.

2.2 Adulthood economic prosperity

Household income was our main measure of economic prosperity as it is arguably a more comprehensive measure of economic resources available to the individual [31]. It was the weekly sum of all self-reported income (net of taxes), including own and spousal earnings, benefits, and pension. We examined this at 33y, 42y, and 50y, in 1991, 2000, and 2008 –

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adjusted to 2005 prices (GBP). The natural logarithm of income was used in all regressions. To understand the relative importance of income from the labour and marriage markets, we also examined the following outcome measures: employment (1=employed/self-employed; 0=otherwise), log hourly wages for employed respondents, married (1=married/in a cohabiting partnership; 0=otherwise) and log weekly spousal earnings for married respondents.

2.3 Obesity

We focused on obesity status at 16y (in 1974) because adolescence has been identified as a critical period for the development and persistence of obesity [32]. Obesity status in adulthood at 33y (in 1991) was additionally used to explore the role of obesity persistence from adolescence into adulthood. Here, individuals were grouped into four categories: persistent obesity (obesity at both 16y and 33y), non-persistent obesity (obesity at 16y but not 33y), adult-onset obesity (obesity at 33y but not 16y), and without obesity at 16y and 33y (reference category). Obesity in childhood at 11y (in 1969) was used in another specification to examine whether obesity persistence beginning in childhood was associated with worse economic penalties. Here, we maintained the above categories but split the persistent obesity group into: a) persistent obesity from childhood (obesity at 11y, 16y and 33y), and b) persistent obesity from adolescence (obesity at 16y and 33y, but not 11y).

Obesity status was measured using body mass index (BMI) (kg/m^2), calculated from interviewer-measured height and weight at 11y, 16y and 33y. At 11y and 16y, individuals were classified as having obesity if BMI≥90th percentile of the study cohort (by gender). We further classified individuals as overweight (80th percentile≤BMI<90th percentile), normal (10th percentile≥BMI<80th percentile) and underweight (BMI<10th percentile). Normal weight was the reference category.[1] For adults, BMI≥30 kg/m^2 indicated obesity. Appendix A shows the mean BMI at 16y and 33y by BMI categories when respondents were 16y. Adolescents with obesity had higher BMI at 33y than their counterparts without obesity. At 33y, 10.5% of men and 11.8% of women had obesity.

[1] These BMI cut-offs were considered more appropriate than modern international cut-offs due to the much smaller proportion of children in this 1958 cohort who were obese (only about 1.5% at 11y and 16y according to cut-offs from Cole et al. [33]). When using these international cut-offs [33, 34], our main findings were either very similar or showed an even stronger relationship between obesity and adult outcomes.

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2.4 Covariates

In all regressions we adjusted for covariates that may influence both childhood obesity and human capital development, as these may confound the relationship between obesity and future economic outcomes. To this end we considered several family background characteristics [30, 35]: mother's smoking status while pregnant and an indicator for low birthweight (<2.5kg) were included to account for early effects on health and development. To account for parents' investments in childhood health and development, mother's age, mother's marital status at child's birth, whether English was usually spoken at home, father's social class at birth, parents' weekly earnings and whether the child was the family's eldest child were included. Means of these variables by obesity status at 16y are shown in Appendix A.

In robustness analyses, we also adjusted for additional child characteristics: health, cognitive ability and socioemotional difficulties at 11y. These were excluded from main analyses as they are associated with potential pathways through which obesity may affect adult economic prosperity. Other adult characteristics, including educational attainment (based on grades and number of passes in secondary education qualifications i.e. O- and A-Level examinations), physical health (self-assessed general health), mental wellbeing (Malaise Inventory, capturing perceived emotional disturbance and somatic symptoms) and self-efficacy (belief in one's ability to succeed in specific situations, i.e. usually "get what I want out of life", "have a free choice and control over my life", and "can run my life more or less as I want to") were excluded from the main analysis, but examined in supplementary analyses investigating potential pathways.

2.5 Empirical approach

We estimated the relationship between adolescent obesity and adult economic prosperity using ordinary least squares (OLS) regression. In models that examined the probability of marriage in adulthood, we employed probit regressions and present the marginal effects of each obesity category. Due to previous studies showing gender differences in economic outcomes associated with obesity [3, 16, 17], models were estimated separately by gender. In specifications that explored the effects of obesity persistence, obesity status at 16y was replaced with obesity persistence variables (Section 2.3). In all models, we tested for statistical significance at the 5% level. In robustness models, we used Coarsened Exact Matching [36] to balance the potential

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confounders prior to the OLS regressions. This enabled background differences between adolescents with and without obesity to be matched non-parametrically.[2]

3.0 Results

3.1 Descriptive statistics

Figure 1 illustrates the mean household income across adulthood by whether the respondent had obesity or normal weight at 16y. For men (A), household incomes were statistically similar between groups. However, for women (B), compared with normal weight, obesity at 16y was associated with a lower household income trajectory; average household incomes were significantly lower at 33y, 42y, and 50y.

Table 1 shows, by obesity status at 16y, mean weekly household income along with other outcomes, averaged across 33y, 42y, and 50y. Adult women with obesity at 16y had an average weekly household income of £391, which is £74 (16%) less than that of women of normal weight. A significant difference of £44 (9%) was also found between overweight and normal weight. The likelihood of employment was not significantly different between women with obesity and normal weight, but hourly wages (for the employed), likelihood of marriage, and spousal earnings (for the married) were all significantly lower for women with obesity at 16y. These suggest that an economic penalty exists for women with obesity in adolescence. Similarly, economic penalties were evident for women who were overweight or underweight at 16y, but these were generally smaller and not always statistically significant. For men, average weekly household income was not significantly different between those who had obesity and those of normal weight. Overall, there was no clear relationship between obesity at 16y and adult male economic outcomes, even when estimated separately for the different ages.

3.2 Adult household income

Given the associations in Table 1, we further investigated the relationships at each adult time-point for women but not for men.[3] Panel A of Table 2 shows OLS coefficient estimates for obesity status at 16y for household income at 33y (Column 1), 42y (Column 2) and 50y (Column 3). Holding childhood covariates constant, compared to normal weight, obesity at 16y

[2] We matched on low birth weight, mother's marital status, mother's smoking status, mother's age at birth, father's social class and father's income. We pruned 3, 6 and 3 unmatched individuals at age 33, 42 and 50.
[3] For males, the fully-adjusted estimates for adolescent obesity were also insignificant for all economic outcomes at all adult ages.

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was associated with about 14% lower household incomes at each adult time-point considered. Unlike obesity, overweight or underweight was not strongly associated with adult household income, although coefficients were consistently negative.

Panel B examines whether the household income penalty depended on obesity persisting from adolescence into adulthood. Coefficient estimates for persistent obesity (4.6% of the sample at 33y, N=123), non-persistent obesity (5.2%, N=139), and adult-onset obesity (7.2%, N=192) showed that compared to women without obesity at either adolescence or adulthood, women with persistent obesity experienced a much larger penalty, especially in later adulthood. For example, by 42y, women with persistent obesity had 34% lower household incomes. Adult-onset obesity was also independently associated with lower adult household incomes, but this effect was modest in comparison to persistent obesity, and only statistically significant at age 42y.

Panel C presents estimates of the persistent obesity group, split by whether they had obesity at 11y. These suggest that the penalty associated with obesity persistence was driven by individuals with obesity in childhood. The household income penalty for women with persistent obesity from childhood to adulthood (2.4% of the sample) was about twice as large as the penalty for those with obesity only in adolescence and adulthood.

3.3 Wages

In Columns (4)-(6) of Table 2 we examined labour market penalties among women. Regression estimates demonstrated no significant association between adolescent obesity and adult employment at any adult age, consistent with Table 1; we therefore focused on whether wage penalties existed among the employed. After adjusting for childhood covariates, adolescent obesity was associated with a 6.5% wage penalty at 33y, but not at 42y or 50y. Taking into account persistence of obesity (Panel B), adolescent obesity was not significantly associated with lower wages at any age. Even when persistence of childhood obesity was considered (Panel C), there was little relationship between adolescent obesity and adult labour market outcomes. In contrast to the weak association between adolescent obesity and future wages, adult-onset obesity was associated with 8-12% lower wages across adulthood, compared with not having obesity in either adolescence or adulthood.

3.4 Marriage and spousal earnings

Table 3 examined success in the marriage market among women: Columns (1)-(3) of Panel A show marginal effects for adolescent BMI categories on the probability of marriage across

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adulthood, after controlling for childhood covariates. Women with obesity at 16y were about 5 percentage points less likely to be married at each adult age. Panel B shows that the marriage penalty depended on obesity persisting into adulthood – persistent obesity was significantly associated with around a 7-percentage-point lower probability of marriage across adulthood, particularly at 42y and 50y. When the persistence of obesity from earlier in childhood was considered, marriage penalties were generally slightly larger for individuals with obesity from 11y (Panel C), although these estimates were only marginally significant (*p*s<0.1).

We investigated the relationship between adolescent obesity and spousal earnings among those who married (78% of the sample across the adult ages). Columns (4)-(6) of Table 3 show coefficient estimates for log earnings of the respondent's partner if married at 33y, 42y and 50y. Panel A shows that compared with female adolescents of normal weight, female adolescents with obesity tended to partner with individuals who earned significantly less, (ranging from about 13% at 33y to 18% at 42y and 50y). Panels B and C further reveal that the penalties arose for adolescents with obesity, regardless of their childhood or adulthood obesity status.

3.5 Robustness checks and possible mechanisms

When we balanced the covariates between adolescents with and without obesity using Coarsened Exact Matching [36] prior to the OLS regressions, we obtained very similar regression estimates to our main results.[4] This suggests that the main estimates from adjusted OLS models sufficiently accounted for differences in observed background characteristics (Section 2.5) by adolescent obesity status.

Table 4 displays results of the main regressions with the inclusion of childhood health, cognitive ability and socioemotional skills, as captured at 11y. The estimated effect of adolescent obesity on household income reduced by 18-32% and the significance dropped to the 10% level, suggesting these characteristics played an important role in the relationship between adolescent obesity and adult household income. Cognitive ability had the largest influence, followed by socioemotional skills and finally physical health. Estimates for wages also reduced when these characteristics were included, and was no longer significant at 33y. In contrast, associations for marriage and spousal income appeared robust to the inclusion of these

[4] In OLS regressions of household income at age 33, 42 and 50, the coefficient for obesity at age 16 was -0.140, -0.133 and -0.142 respectively, all statistically significant (*p*s<0.05)

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childhood characteristics, with minimal changes to the significance or size of coefficients across adulthood.

To further investigate whether marriage market penalties were a likely pathway through which adolescent obesity relates to reduced household income among women, we included marriage and spousal earnings (for the married) as separate covariates in supplementary models of household income. The coefficient for adolescent obesity reduced considerably across adulthood (by 23-26% when marital status was included, and by 40-85% when spousal earnings was included) and was no longer significant, except at 33y. Similarly large reductions in the persistent obesity coefficients occurred when these variables were included. In contrast, when wages (for the employed) were included as a covariate in the household income models, penalties for adolescent obesity and persistent obesity showed little change in size and remained statistically significant at 42y and 50y.

Possible mechanisms for why adolescent obesity was associated with marriage and spousal earnings penalties were explored by including adult educational attainment, mental wellbeing, general health and self-efficacy (separately and together). Appendix Table A2 shows the marriage and spousal earnings penalties associated with adolescent obesity held with the inclusion of covariates measuring these potential pathways.

4.0 Discussion

While a large literature has examined the labour market consequences of adult obesity [14, 16], relatively little attention has been given to long-term effects of childhood and adolescent obesity on adult economic prosperity. This study used the 1958 British Cohort Study to investigate the long-term relationship between adolescent obesity and future household income, employment, wages, marriage and spousal income. We uniquely examined adult economic prosperity when cohort members were in their 30s, 40s and 50s, and explored whether economic penalties depended on whether obesity status persisted from earlier in childhood and into adulthood. Additional strengths of this study were the use of measured height and weight to calculate BMI, along with rich childhood and at-birth information in regression models to isolate the effect of youth obesity.

After controlling for circumstances in childhood, we found that obesity at 16y was associated with about 14% lower adult household incomes at 33y, 42y and 50y, for women but not men. The household income penalty was greatest for adolescents with obesity who also had obesity in childhood (11y) and adulthood (33y). This suggests that the penalty operated largely through the persistence of obesity into adulthood and highlights the importance of not only

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obesity during adolescence but also earlier in childhood. Women with persistent obesity had, on average, a higher BMI in adulthood (mean of 36.4 kg/m^2 at 33y) compared with women with adult-onset obesity (33.4 kg/m^2) or non-persistent obesity (25.8 kg/m^2). Our significant finding for a household income penalty for women with adolescent obesity corresponds with previous studies that used data from the United States National Longitudinal Survey of Youth (NLSY) to investigate relationships between late adolescent obesity (16-24y) and socioeconomic outcomes just seven years later (23-31y) [3, 17].

Among women, adolescent obesity was only weakly associated with lower own wages (and only at 33y), suggesting that the labour market was not the primary mechanism for economic penalties related to adolescent obesity. Our study demonstrated the importance of examining the wage penalty in later adulthood; previous studies that only examined this relationship during early adulthood captured only part of the picture. We showed that adult-onset obesity was particularly detrimental for own wages, supporting previous findings of associations between adult obesity and wages [16, 37]. Further research is needed to understand why wage penalties fell predominantly on women with adult-onset, rather than persistent, obesity.

In contrast to the weak labour market penalty, adolescent obesity was strongly associated with a lower probability of marriage, and for those who marry, lower spousal earnings throughout adulthood. Marriage and spousal earnings explained a large proportion of the relationship between adolescent obesity and lower household incomes. Averett and Korenman [17] similarly found that the economic deficit in young adulthood associated with obesity among American women (born 1958-65) was largely driven by differences in the marriage market, not the labour market. It is noteworthy that we obtained similar findings in a 1958 British cohort and showed that the pattern extended into one's 40s and 50s. While the marriage penalty appeared to be driven by women with persistent obesity, we found that the spousal earnings penalty among married women were large for women whose obesity did not persist from adolescence to adulthood (as well as those with persistent obesity), suggesting that obesity during adolescence has a particularly strong association with spousal earnings in adulthood. For this sample of married women, having non-persistent obesity was also associated with household income penalties in adulthood. Our supplementary models showed that neither educational attainment nor health or self-efficacy explained the marriage market penalties. Other characteristics that we were unable to measure, such as attractiveness [38], self-esteem [22] and social skills [10] may offer possible explanations [22].

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The gender inequality in the economic penalties associated with obesity is consistent with a culture that places a greater importance on thinness and attractiveness for women than for men, and an unrealistic ideal thinness for women; these can contribute to gender differences in appearance self-esteem [39]. Recent evidence also suggests that the social and emotional consequences of obesity in childhood differ for girls and boys [10]. Additionally, there are gender differences in the importance of physical attractiveness and thinness in a prospective partner (men value it more) [40] and in the value of marriage (women value it more) [25], which may explain the larger marriage market penalties associated with obesity for women than for men. To mitigate the economic penalties associated with adolescent obesity, further research is needed to better understand the sociological and individual factors that most strongly influence this relationship.

In contrast to our study and others from the United States and Britain that found no association between adolescent obesity and economic outcomes for men [27, 41], Lundborg et al. [28] found that among men from the Swedish military enlistment (born 1966-1979), obesity at 18y was associated with 18% lower earnings at 28y-38y, compared with normal weight. This difference in findings highlights the importance of investigating the economic penalties associated with obesity in different settings and across different cohorts.

We acknowledge here several limitations of this study. Although we accounted for a rich set of confounders in childhood, and showed that covariates in our models were balanced between adolescents with and without obesity, we cannot interpret our estimates as causal. Given the very small sample of siblings/twins in the cohort, we were unable to use sibling fixed-effects as in Averett and Korenman [17] to rule out other fixed unobserved factors not captured by our covariates, but it is encouraging that we found qualitatively similar results to their OLS estimates with the NLSY. We also recognise that household income and other economic outcomes used were self-reported and may be subject to measurement error.

Finally, while a long time-span is necessary to examine the relationship between childhood obesity and adult circumstances, this inevitably means that children in our study lived in different times from the children of today. There have been changes in gender roles and a normalisation of overweight and obesity, which may affect the generalisability of our results to contemporary children. However, evidence suggests that the stigmatisation of obesity by children has increased since the 1960's [42] and the value placed on physical attractiveness in a potential spouse has also increased over the last half-century for both sexes [43]. Therefore, it is unclear how generalizable our results are to contemporary adolescents with obesity.

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This study demonstrated that obesity in childhood and adolescence was associated with less favourable socioeconomic outcomes throughout adulthood, particularly for women. Such negative consequences can have a substantial impact on the future wellbeing of children and adolescents, yet are rarely accounted for in economic evaluations. In order to measure the benefits of obesity prevention programs more holistically, future economic evaluations should work towards capturing the socioeconomic, in addition to health, consequences across the lifespan that are due to obesity in children and adolescents.

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Conflicts of interest: None

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Data sharing: The NCDS is available to the scientific community. Please refer to the Centre for Longitudinal Studies, Institute of Education: http://www.cls.ioe.ac.uk/default.aspx

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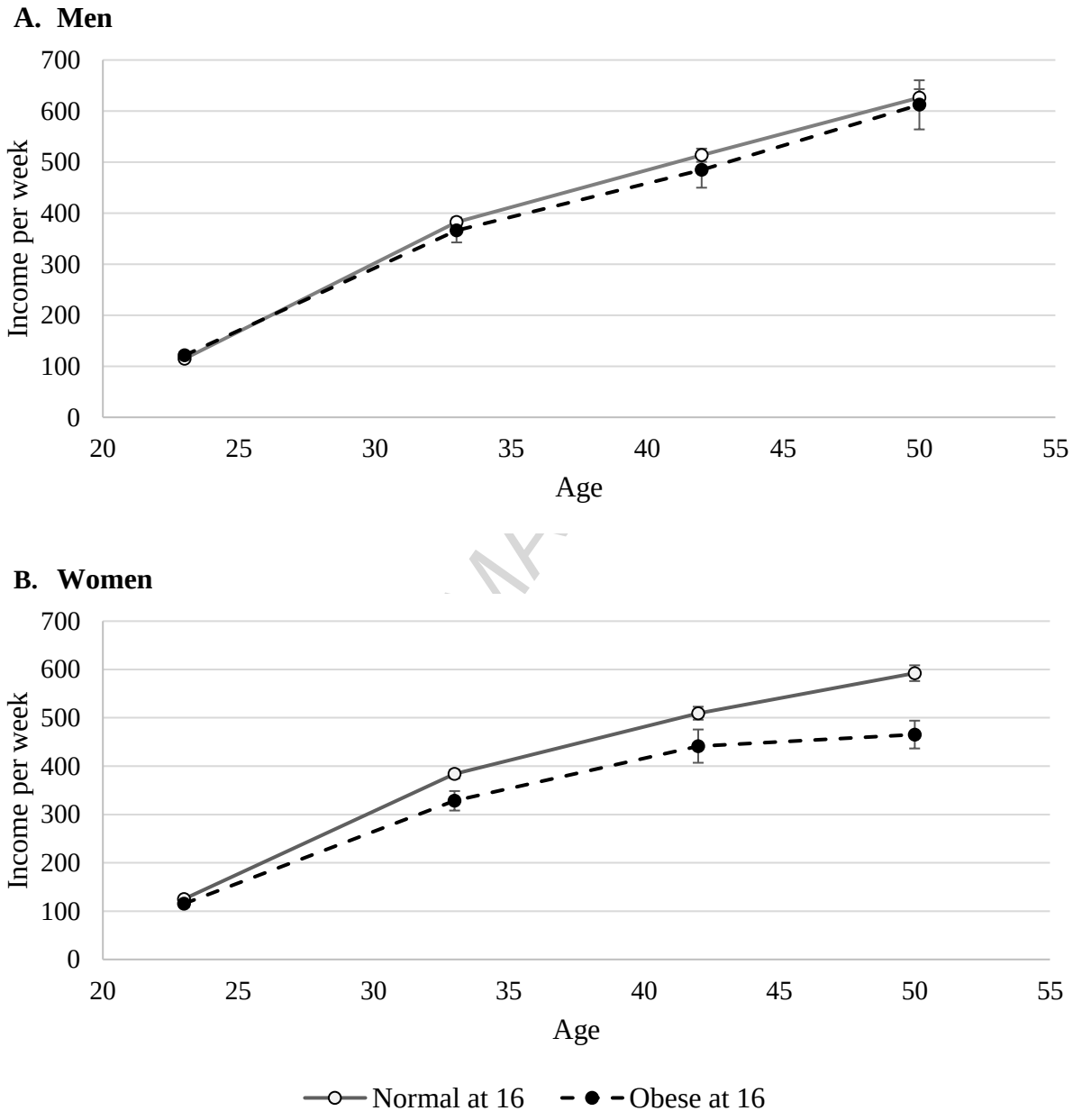
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Figure 1. Mean household income across adulthood by obesity status at age 16



Notes: Data came from the British NCDS. Age 16 obesity status was measured in 1974. Household income was measured at age 23, 33, 42 and 50 in 1981, 1991, 2000 and 2008 respectively (adjusted to 2005 GBP). Bars indicate the 95% confidence interval. Underweight and overweight excluded from the figure to reduce clutter, but the trajectories for these individuals were between individuals with obesity and normal weight.

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Table 1. Mean economic outcomes across adulthood by age 16 obesity status

Age 16 obesity status category	Obese	Overweight	Normal	Underweight
Men				
Household income (£/week)	445.23	447.29	463.08	441.39
Employed	0.87	0.92	0.90	0.89
Hourly wage (£/hour)	8.26	8.26	8.50	8.21
Married	0.77	0.78	0.79	0.68**
Spousal earnings (£/week)	121.34	116.75	133.21	153.14*
Sample	264	270	1866	280
Women				
Household income (£/week)	390.83**	421.17**	464.65	440.83
Employed	0.78	0.73*	0.76	0.74
Hourly wage (£/hour)	6.12**	6.64	6.72	6.51
Married	0.74*	0.76	0.80	0.79
Spousal earnings (£/week)	243.72**	300.32	323.97	321.31
Sample	284	295	1991	284

Notes: BMI=Body mass index. Data came from the British NCDS. Sample based on regressing age 33 household income on age 16 obesity (in 1974). Adulthood socioeconomic outcomes were averaged across ages 33 (in 1991), 42 (in 2000), and 50 (in 2008) for individuals with ≥1 observation across these waves. Income/wage/earnings were net of taxes and based on 2005 price levels in Great Britain. For every outcome variable three two-group *t*-tests were conducted to examine whether the obese, overweight, and underweight categories differed significantly from the normal weight category. $^{*}p<0.05$,$^{**}p<0.01$. Mean hourly wages were only calculated for those employed and mean spousal earnings were only calculated for those married/cohabiting, leading to slightly smaller sample sizes than those reported.

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Table 2. Regression estimates of obesity status for log household income and log wages across adulthood for women

	Household income			Hourly wages		
	(1) Age 33	(2) Age 42	(3) Age 50	(4) Age 33	(5) Age 42	(6) Age 50
(A) *Adolescent BMI status*						
Obese	-0.145*	-0.138*	-0.139*	-0.065*	-0.050	-0.011
	(0.064)	(0.061)	(0.058)	(0.027)	(0.030)	(0.029)
Overweight	-0.032	-0.034	-0.180*	-0.049	-0.034	0.002
	(0.048)	(0.042)	(0.085)	(0.026)	(0.032)	(0.029)
Underweight	-0.069	-0.086	-0.210	-0.017	-0.059	-0.012
	(0.068)	(0.059)	(0.111)	(0.025)	(0.032)	(0.029)
N	2854	2915	2361	2145	2580	2313
(B) *Adolescent & adult obesity status*						
Adolescent & adult	-0.152	-0.335*	-0.279*	-0.071	-0.056	-0.004
	(0.083)	(0.132)	(0.113)	(0.041)	(0.042)	(0.045)
Non-persistent	-0.048	-0.025	0.026	-0.056	-0.059	-0.037
	(0.077)	(0.056)	(0.065)	(0.033)	(0.045)	(0.039)
Adult onset	-0.083	-0.159**	-0.113	-0.124**	-0.125**	-0.083*
	(0.063)	(0.049)	(0.063)	(0.027)	(0.044)	(0.034)
N	2681	2505	2018	2031	2226	2000
(C) *Persistence from childhood*						
Adolescent & adult & childhood	-0.233	-0.433*	-0.394*	-0.070	-0.010	0.074
	(0.142)	(0.194)	(0.195)	(0.050)	(0.061)	(0.063)
Adolescent & adult & not childhood	-0.062	-0.219	-0.156	-0.072	-0.114*	-0.085
	(0.073)	(0.170)	(0.103)	(0.068)	(0.054)	(0.059)
Non-persistent	-0.051	-0.024	0.027	-0.057	-0.058	-0.038
	(0.077)	(0.057)	(0.065)	(0.033)	(0.045)	(0.039)
Adult onset	-0.084	-0.158**	-0.112	-0.124**	-0.124**	-0.083*
	(0.063)	(0.049)	(0.063)	(0.027)	(0.044)	(0.034)
N	2681	2505	2018	2031	2226	2000

Notes: Figures are OLS coefficients (robust standard errors). All covariates detailed in Section 2.4 and Appendix A were included: whether child was first born in the family; whether below 2.5kg at birth; father's social class, mother's marital status, and mother's age (below 21y, 21y-30y, or above 30y) at the time of birth; whether mother smoked during pregnancy; whether English was usually spoken at home; and father's and mother's weekly earnings. Regressions for wages additionally included an indicator for working part-time (<30 hours per week). Normal weight was the reference category for Panel A. Not obese at either age was the reference category for Panels B and C. Data came from the British NCDS. Obesity status was measured in 1969 (age 11), 1974 (age 16) and 1991 (age 33). Outcomes measured in 1991 (age 33), 2000 (age 42) and 2008 (age 50). $^{*}p<0.05$,$^{**}p<0.01$

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Table 3. Regression estimates of obesity status for probability of marriage and log spousal earnings for women

	Marriage			Spousal earnings		
	(1) Age 33	(2) Age 42	(3) Age 50	(4) Age 33	(5) Age 42	(6) Age 50
(A) *Age 16 status*						
Obese	-0.047*	-0.051*	-0.056*	-0.125**	-0.183**	-0.184**
	(0.020)	(0.021)	(0.023)	(0.030)	(0.040)	(0.041)
Overweight	-0.036	-0.011	-0.012	-0.066*	-0.062	-0.110*
	(0.020)	(0.021)	(0.024)	(0.030)	(0.045)	(0.046)
Underweight	0.013	0.004	-0.003	-0.055	-0.062	0.024
	(0.022)	(0.023)	(0.025)	(0.033)	(0.051)	(0.052)
N	3733	3772	3294	2070	2227	1572
(B) *Adolescent & adult obesity status*						
Adolescent & adult	-0.051	-0.074*	-0.074*	-0.129**	-0.177**	-0.153*
	(0.030)	(0.032)	(0.036)	(0.045)	(0.052)	(0.063)
Non-persistent	-0.026	-0.011	-0.021	-0.100*	-0.170**	-0.157**
	(0.028)	(0.030)	(0.032)	(0.041)	(0.061)	(0.054)
Adult onset	-0.019	-0.049	-0.035	-0.066	-0.089	-0.179*
	(0.030)	(0.032)	(0.034)	(0.041)	(0.058)	(0.078)
N	3510	3207	2803	1927	1926	1366
(C) *Persistence from childhood*						
Adolescent & adult	-0.067	-0.073	-0.091	-0.153	-0.250**	-0.132
& childhood	(0.041)	(0.044)	(0.048)	(0.080)	(0.084)	(0.105)
Adolescent & adult	-0.033	-0.074	-0.056	-0.109*	-0.106	-0.169*
& not childhood	(0.043)	(0.045)	(0.051)	(0.048)	(0.059)	(0.076)
Non-persistent	-0.026	-0.011	-0.021	-0.100*	-0.171**	-0.158**
	(0.028)	(0.030)	(0.032)	(0.041)	(0.061)	(0.054)
Adult onset	-0.019	-0.049	-0.035	-0.066	-0.090	-0.180*
	(0.025)	(0.026)	(0.030)	(0.041)	(0.058)	(0.078)
N	3510	3207	2803	1927	1926	1366

Notes: All covariates detailed in Section 2.4 and Appendix A were included: whether child was first born in the family; whether below 2.5kg at birth; father's social class, mother's marital status, and mother's age (below 21y, 21y-30y, or above 30y) at the time of birth; whether mother smoked during pregnancy; whether English was usually spoken at home; and father's and mother's weekly earnings. Probit regressions were used to model marriage; figures are marginal effects (robust standard errors). Regressions for spousal earnings (for the married) included an indicator for the partner working part-time; figures are OLS coefficients (robust standard errors). Normal weight was the reference category for Panel A. Not obese at either age was the reference category for Panels B and C. Data came from the British NCDS. Obesity status was measured in 1969 (age 11), 1974 (age 16) and 1991 (age 33). Outcomes measured in 1991 (age 33), 2000 (age 42) and 2008 (age 50). $^{*}p<0.05$,$^{**}p<0.01$

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Table 4. Robustness of regression estimates of age 16 obesity for all outcomes across adulthood for women

	Age 33		Age 42		Age 50	
	(1) Base	(2) Child controls	(3) Base	(4) Child controls	(5) Base	(6) Child controls
Household income						
Obese at 16	-0.145*	-0.107	-0.138*	-0.112	-0.139*	-0.096
	(0.064)	(0.063)	(0.061)	(0.062)	(0.058)	(0.056)
N	2854	2854	2915	2915	2361	2361
Hourly wages						
Obese at 16	-0.065*	-0.046	-0.050	-0.035	-0.011	0.010
	(0.027)	(0.025)	(0.030)	(0.029)	(0.029)	(0.028)
N	2145	2145	2580	2580	2313	2313
Marriage						
Obese at 16	-0.047*	-0.039	-0.051*	-0.047*	-0.056*	-0.049*
	(0.020)	(0.020)	(0.021)	(0.021)	(0.023)	(0.023)
N	3733	3733	3772	3772	3294	3294
Spousal earnings						
Obese at 16	-0.125**	-0.115**	-0.183**	-0.172**	-0.184**	-0.162**
	(0.030)	(0.030)	(0.040)	(0.040)	(0.041)	(0.041)
N	2070	2070	2227	2227	1572	1572

Notes: Figures are OLS coefficients (robust standard errors). Overweight and underweight indicators not shown for brevity. (1), (3) and (5) Base followed the regression estimates from Panel A of Tables 2 and 3 (included all main covariates). (2), (4) and (6) Child controls included all main covariates plus: an indicator for major physical health problems from medical examinations at age 11; the general cognitive ability total score at age 11; and socioemotional difficulties from the Bristol Social Adjustment Guide score at age 11 (teacher-reported). To maintain sample size, missing values were imputed as zero and indicators for those respondents with missing values were included in the models. Data came from the British NCDS. Obesity status was measured in 1974 (age 16). Outcomes measured in 1991 (age 33), 2000 (age 42) and 2008 (age 50). $^{*}p<0.05$,$^{**}p<0.01$

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APPENDIX A

Table A1. Mean BMI and key covariates by age 16 obesity status

	Men				Women			
	Obese	Over-weight	Nor-mal	Under-weight	Obese	Over-weight	Nor-mal	Under-weight
BMI at 16	26.15	22.58	19.61	16.54	27.38	23.70	20.30	16.84
BMI at 33	29.79	27.51	24.98	22.43	30.76	26.85	23.72	21.19
Childhood covariate								
First-born [a]	0.30	0.36	0.34	0.38	0.32	0.37	0.33	0.36
Below 2.5kg at birth	0.03	0.03	0.05	0.07	0.05	0.07	0.07	0.11
Father's social class								
I Professional	0.02	0.04	0.06	0.04	0.03	0.04	0.04	0.05
II Managerial and technical	0.10	0.14	0.13	0.13	0.08	0.14	0.14	0.11
III Skilled, non-manual	0.08	0.10	0.12	0.11	0.08	0.08	0.10	0.08
III Skilled, manual	0.51	0.48	0.49	0.47	0.55	0.44	0.49	0.51
IV Partly skilled	0.14	0.13	0.11	0.11	0.12	0.16	0.11	0.12
V Unskilled	0.09	0.05	0.07	0.08	0.08	0.08	0.07	0.08
No father/other	0.06	0.06	0.04	0.04	0.05	0.05	0.04	0.04
Mother married	0.97	0.97	0.98	0.96	0.95	0.97	0.97	0.96
Mother smoked while pregnant	0.39	0.34	0.31	0.28	0.42	0.34	0.30	0.30
Mother's age at birth								
Below age 21	0.08	0.10	0.08	0.11	0.09	0.09	0.09	0.09
Ages 21 to 30	0.55	0.64	0.65	0.65	0.58	0.61	0.63	0.66
Above age 30	0.38	0.25	0.28	0.24	0.33	0.29	0.28	0.25
English usually spoken at home [a]	0.86	0.86	0.86	0.86	0.87	0.83	0.85	0.88
Father's earnings (£/week) [b]	29.08	30.39	29.51	30.36	26.37	29.14	30.18	29.16
Mother's earnings (£/week) [b]	8.04	9.30	8.31	8.13	9.13	7.90	8.71	7.88
Sample	264	270	1866	280	284	295	1991	284

Notes: BMI=Body mass index. Data came from the British NCDS. Obesity status was measured in 1974 (age 16). Sample based on regressing age 33 household income on age 16 obesity. Childhood covariates were all measured at birth (in 1958), except whether English was spoken at home which was measured at age 11 (in 1969); and parental earnings which were measured when respondents are age 16. Father's social class was based on Registrar General's Social Classes assigned in 1951. Parental earnings were recorded in the form of 12 brackets ranging from £0-£4 to ≥£60; means were calculated from the bracket midpoints and retained at 1974 GBP price levels.

[a] To avoid loss of observations, missing values were imputed as zero. When included in regressions, an indicator for respondents with missing values was additionally included.

[b] Missing values imputed as zero if the cohort member had no father or if father/mother did not work, otherwise imputed as the social class average. When included in regressions, an indicator for respondents with missing values was additionally included.

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Table A2. Robustness of regression estimates of age 16 obesity for marriage market outcomes for women at age 42 – including potential mechanisms

Age 42 outcomes	(1) Base	(2) Educ	(3) Educ years	(4) Health 23	(5) Mental 23	(6) Health 33	(7) Mental 33	(8) Self-Efficacy
Marriage								
	-0.047*	-0.045*	-0.047*	-0.045*	-0.047*	-0.046*	-0.046*	-0.041*
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
N	3772	3772	3772	3772	3772	3772	3772	3772
Spousal earnings								
	-0.172**	-0.166**	-0.161**	-0.166**	-0.171**	-0.167**	-0.172**	-0.164**
	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)
N	2227	2227	2227	2227	2227	2227	2227	2227

Notes: Data came from the British NCDS. Obesity status was measured in 1974 (age 16). Outcomes measured in 2000 (age 42). Figures are OLS coefficients (robust standard errors) for obesity at age 16. Overweight and underweight indicators not shown for brevity. (1) Base followed the regressions from Column 4 of Table 4 (included extra child controls); (2) included an educational attainment variable (ranging from 0 to 12) from administrative data, reflecting performance in O- and A-Level examinations at ages 16 and 18; (3) captured age left full-time education; (4) and (6) included 4 indicators of general self-assessed health (excellent, good, fair, and poor) measured at age 23 (in 1981) and 33 (in 1991) respectively; (5) and (7) included Malaise Inventory score (24 items) which measured perceived emotional disturbances and somatic symptoms, at age 23 and 33 respectively; (8) included total general self-efficacy score measured at age 33 (based on three items i.e. usually "get what I want out of life", "have a free choice and control over my life", and "can run my life more or less as I want to"). If all additional covariates from (2) to (8) were included, the obesity at 16 coefficient (SE) was -0.040 (0.021) for marriage and -0.153** (0.040) for spousal earnings. $^{*}p<0.05$,$^{**}p<0.01$

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APPENDIX B

Testing for Attrition

Given our working sample comprised only approximately 30% of the original birth cohort; we explored the data for any obesity-related attrition that may have biased our main estimates. We employed two tests, based on analyses conducted by Frijters et al. [44]. First we estimated three separate probit attrition models for each gender, regressing a binary indicator for whether the individual was present in the estimation sample on all child covariates plus a) age 16 obesity status variables, or b) the obesity persistence from childhood variables, or c) the obesity persistence into adulthood variables. Being the first-born, father's social class, mother's marital status, and having a younger mother appeared to predict attrition among men but not women. Importantly, we found that all obesity status variables do not significantly predict attrition from our working sample.

Our second test involved a Heckman sample selection model to control for omission from the working sample when estimating the effects of age 16 obesity on adult household income. This model assumed that certain unobserved variables influencing household income were correlated with those influencing nonresponse. We imposed certain restrictions on this correlation instead of exclusion restrictions, given there were no clear valid 'instruments' in the dataset. We adjusted the values of this correlation to .2, .4, .6, and .8; thereby assessing the sensitivity of the estimates to attrition. Results from estimating these four Heckman models indicate that our main findings from this regression were robust: using specification (2) in Table 2 Panel A as an example, the effect of age 16 obesity remained significant between -0.146 and -0.156 when the correlation was adjusted between the four values (as a comparison, the OLS estimate without accounting for the correlation was -0.145). These tests suggest that our main findings were robust to the presence of any non-random attrition.

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For richer, for poorer: the relationship between adolescent obesity and future household economic prosperity

Highlights

- Female adolescents with obesity have lower household incomes across adulthood.
- This is likely due to penalties in the marriage market, not the labour market.
- Obesity in adolescence is linked with life-long social and economic consequences.

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