Midlife Health Inequalities in Britain and US: Comparison of Two Nationally Representative Cohorts

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Abstract

International comparisons typically show worse health in the US compared to the UK as measured by life expectancy and health at older ages. Less is known about comparative health in midlife, a time when health deterioration is emerging and may foreshadow chronic disease at older ages. Better understanding of US-UK differences in socioeconomic inequalities in health can also shed light on how different sociopolitical contexts shape health and disparities throughout the life course.

We compare harmonised measures of smoking status, alcohol consumption, body mass index, self-rated health, cholesterol, blood pressure, and glycated haemoglobin (HbA1c) using population-weighted modified Poisson regression in the 1970 British Cohort Study (BCS70) in Britain (N= 9,665) and the National Longitudinal Study of Adolescent to Adult Health (Add Health) in the US (N=12,297), when cohort members were aged 34-46 and 32-42, respectively. Additionally, we test modification of associations by parental education level in adolescence, and own education level and income in midlife.

US adults had worse health in midlife particularly as measured by heavy drinking, obesity, high blood pressure and unhealthy cholesterol levels. Self-rated health and smoking were the only outcomes with lower risk in the US. We found smaller educational inequalities in midlife health in Britain compared to the US.

US adults are in worse cardiometabolic health than their British counterparts, even in their 30s and 40s. Smaller SEP inequalities in midlife health in the UK may reflect differences in access to health care, welfare systems, or other environmental risk factors.

Background

International comparisons typically show worse health in the US compared to England as measured by mortality and health at older ages [1-4]. A comparison of the English Longitudinal Study of Aging (ELSA) in the England and the Health and Retirement Survey (HRS) in the US found older adults in the US were less healthy based on measures of self-reported chronic disease, including levels of diabetes, hypertension, heart disease, myocardial infarction, stroke, lung disease, and cancer [2]. Adults in the US have higher average body mass index (BMI) than those in England, with a higher prevalence of extreme obesity [4]. However, adults in England scored worse on several health behaviors, including cooccurrence of smoking, alcohol consumption, low physical activity and obesity, and were less likely to present with no behavioral risk factors at all [1].

Previous comparisons of health in the US and UK have focused on ages 50 and over based on harmonized international surveys of ageing [5]. Younger midlife ages are often overlooked, particularly in life course research where there is a tendency to focus on early or later life [6]. There is growing recognition of midlife as an important time in the life course that sets the stage for later life health and aging, before chronic disease and disability starts to emerge [7]. Midlife marks the start of functional decline, with changes in physical health, cognitive functioning, and mental health [7]. Moreover, midlife mortality has been rising in the US over the last several decades [8] and the UK more recently [9], and has been linked to an increase in “deaths of despair” [10].

Many health outcomes follow social gradients, in both the US and UK [3], in that individuals living with greater disadvantage typically have worse health than more advantaged counterparts. In both England and the US, education, income, and wealth inequalities in health exist for adults in their 50’s and 60s across multiple conditions, including diabetes, hypertension, heart disease, myocardial infarction, stroke and chronic lung diseases [3]. In both countries, behavioral risk factors (work, marriage, obesity, exercise, and smoking) help to explain some of these social gradients, but a sizeable proportion of these differences remains unaccounted for, indicative of the many and multiple mechanisms through which social (dis)advantages operate [3].

There has also been growing interest in adopting a life course approach to investigate health inequalities, such as examining the relation between socioeconomic position (SEP) in early life and health outcomes in adulthood. For example, in the UK, there was a 43% increased risk of having more than one long term health condition in midlife, for individuals from the poorest families in childhood (compared to what?) [11]. Similarly in the US, low childhood SEP was associated with a higher mean number of chronic conditions in older adulthood, which was partly explained by lower adult SEP [12].

While socioeconomic gradients in health are not unique to either the US or UK, the magnitude of these gradients is likely shaped by social, political, and economic contexts. Therefore, international comparisons are useful in identifying possible contextual drivers of population health. Observed differences between the US and England have previously been attributed to factors such as cost of healthcare [2], differences in income benefit systems [2, 3], and differences in local environments and neighborhoods [13].

However, the determinants of population health and inequalities may differ for adults in midlife compared to older age, particularly considering different benefit systems [3]. For example, in England there was less evidence of an income gradient in health among older adults (70-80), an age group for which there is a substantial pension benefit that is independent of work and income history [3]. It is possible that we may also expect to see differences between the UK and US for associations between early life SEP and midlife health, as the healthcare and financial benefits available for children differ, and importantly in the UK are largely independent from family circumstances.

Following previous trends, it may be expected that health in midlife would be worse in the US compared to Britain (England, Wales and Scotland). However, the health of cohorts born since the 1970s in Britain has typically been worse than generations that preceded them. For example, the 1970 British Cohort study (BCS70) has higher prevalence of obesity, psychological distress and multimorbidity than cohorts born in 1946 and 1958 at comparable ages [14-16]. While we expect to find significant socioeconomic gradients for health outcomes in midlife in both Britain and the US – for both childhood and current SEP – the magnitude of these health inequalities is likely to be affected by countries' sociopolitical contexts, such as the more generous welfare system in Britain compared to the US.

To address these gaps, we compare behavioral risk factors, anthropometry, and biomarkers of health in midlife of two nationally representative cohorts in the US, the National Longitudinal Study of Adolescent to Adult Health (Add Health), and in Britain, BCS70. Additionally, we explore moderation of associations by early life SEP, current SEP, and sex. We hypothesize that the health of the US cohort, Add Health, will be worse than that of the British cohort, BCS70, and that inequalities with SEP will be larger.

Methods

Data Sets

BCS70 is an ongoing nationally representative birth cohort of roughly 17,000 individuals born one week in April in 1970 in Britain (England, Wales and Scotland) [17]. Cohort members have been followed up ten times since birth, with the most recent pre-COVID-19 data collection taking place in 2016 when cohort members were aged 46. The tenth sweep in BCS70 was a biomedical sweep and collected multiple measures not previously collected, such as blood samples. The current analysis uses data from sweeps eight to ten, when cohort members were aged 34, 42 and 46, respectively. Achieved sample sizes for these sweeps were 9,665 (age 34), 9,841 (age 42) and 8,581 (age 46).

Add Health is a nationally representative cohort of approximately 20,000 individuals in the US who were enrolled in grades 7 – 12 (ages 12 to 18 years old) in 1994 to 1995 [18]. The cohort has been followed up in four additional waves since Wave I, with the most recent Wave V taking place in 2016–18 when cohort members were aged 32 to 42 years old. The current analysis uses data from Wave V

(N=12,297). In addition to self-reported data in the full sample, at Wave V a number of biomedical measures were collected on a subsample of participants (N=5,381).

Variables

Multiple health behaviors, physical measures and biomarkers were analyzed: smoking status; alcohol consumption; body mass index (BMI); self-rated health; cholesterol; blood pressure (BP); and glycated hemoglobin (HbA1c). In BCS70, smoking status and alcohol consumption were considered at age 34, self-rated health was considered at age 42, and all remaining measures were considered at age 46. For Add Health, all measures were taken from Wave V when cohort members were aged between 32 and 42. Each outcome was converted to a binary variable using the cut-offs shown **Supplementary Methods Table S1**.

For chronic diseases (e.g., diabetes) measured by biomarkers (e.g., HbA1c), we distinguish between the biomarker alone, and "any" indication of the disease. For the latter, we supplemented the biomarkers by additionally drawing on medication use for specific conditions (e.g., diabetic medication), therefore indicating a positive disease diagnosis. Full details of the harmonization of measures are shown in **Methods S2 (Supplementary Material).**

Three measures of SEP were used: parental education measured in childhood; own education measured in adulthood; and income measured in adulthood. For parental education, measures were taken at Wave 1 (ages 11 to 19) in Add Health and Sweep 4 (age 16) in BCS70. For own education and income, measures were taken from Wave 5 in Add Health (ages 32 to 42) and from sweeps 7 (age 34) and sweep 9 (age 42) in BCS70, with the age used in BCS70 dependent on the respective outcome. In both cohorts, parental education was grouped as: 1) neither parent has a university degree (i.e., four-year or Bachelors); 2) at least one parent has a university degree. Own education was grouped as; 1) No university degree; 2) Degree-level educated. In both cohorts, own income was grouped into approximate "fifths" from the lowest income fifth to the highest income fifths. Full details on the harmonization across the cohorts are provided in **Methods S2.**

BCS70 is largely homogenous in terms of race/ethnicity, with the majority of the cohort identifying as White. Therefore, it was not possible to include race/ethnicity as a variable in analysis with BCS70. In Add Health, race/ethnicity was measured at Wave I, and for purpose of the current analysis, restricted to non-Hispanic White to aid comparison with BCS70.

In BCS70 at the "age 46" biomedical sweep, which took place across 3 years, and in Add Health at Wave V, age was recorded in years, up to the date of interview. For the remaining BCS70 sweeps, age was included as a dummy variable, as 34 and 42 years of age respectively. Sex was measured from birth in BCS70, and from Wave I in Add Health, and reported as either male or female.

Statistical Analysis

Modified Poisson regression was used to obtain relative risk estimates (i.e., risk ratios [RR]) and corresponding 95% confidence intervals (95% CI) using Stata V17, though we focus on comparing marginal estimates, as detailed below. In Model 1, a dummy variable for the country (Britain or US) was created and included as the independent variable, and age was controlled for. Model 1 was run in both pooled and sex-stratified samples. As BCS70 is ethnically homogenous, the main analysis was conducted limiting the Add Health sample to those who were non-Hispanic White. In sensitivity analysis, Model 1 was run using the full, racially/ethnically heterogenous, sample in Add Health.

Model 2 explored modification of associations by early life SEP (parental education) and current adult SEP (education and household income), including interaction terms between the country and SEP measure. For ease of interpretation, RR estimates are presented as adjusted predicted marginal estimates of prevalence for each country and/or for each country at each level of SEP, estimated at the observed values of covariates (and results were nearly identical when covariates were held at their means). A Wald test was used to determine whether country differences are significant. For household income we focus on whether the difference between the lowest and highest fifth relative to the middle fifth is significantly different. We also control for household size when analyzing household income.

Model 3 conducts an informal mediation analysis to determine whether there are country differences in the relationship between childhood SEP and adult health outcomes after controlling for adult education and adult household income. Supplementary analysis also ran model 3 stratified by sex.

Complex Survey Design and Non-Response Weights

Add Health uses a complex, stratified sampling strategy as previously described elsewhere [18], thus maintaining the national representativeness of the data. Add Health also includes survey weights that account for non-representativeness among adults providing biomarker samples.

To ensure the complex survey design and non-response was accounted for in analysis, non-response weights were developed in BCS70 at each age, using multiple imputation. The full method used to develop non-response weights, and methods used to apply complex survey characteristics, is shown in **Supplementary Material (Methods S3 & S4).**

Results

Model 1 – Comparison of health indicators between Britain and the US

Midlife adults in the US typically had worse health than in Britain (Figure 1). Adults in the US were more likely to have higher blood pressure and cholesterol, both measured with and accounting for taking medication (“any”). They were also more likely to be heavy drinkers (0.121 [95%CI: 0.110, 0.131] vs 0.052 [95%CI: 0.047, 0.058]) and to be classified as obese (0.405 [95%CI: 0.384, 0.426] vs 0.345 [95%CI: 0.332, 0.358]). However, British adults were more likely to be regular smokers (0.279 [95%CI: 0.268, 0.290] vs 0.214 [95%CI: 0.195, 0.234]) and to have poor self-rated health (0.183 [95% CI: 0.172, 0.194] vs 0.122 [95%CI: 0.108, 0.136]) than adults in the US.

In both Britain and the US, men typically had worse health outcomes, apart from self-rated health and obesity. In the US, no sex differences were observed for smoking and diabetes. In the US, the male health disadvantage was greater than the UK for heavy drinking, high cholesterol and high blood pressure (both biomarkers and “any”). In the UK, there was a bigger male disadvantage for smoking behavior compared to the US.

Model 2 – Socioeconomic inequalities in midlife health between Britain and the US

Socioeconomic inequalities in midlife health were stronger for adult SEP compared to childhood SEP in both Britain and the US (Figure 2). The probability of being a regular smoker and reporting poor self-rated health was higher for individuals in the bottom compared to the top income fifth, and for those without a degree compared to degree-holding people. There were, however, very few differences in the probability of heavy drinking by SEP.

In both Britain and the US there was a small SEP gradient in hypertension and cholesterol markers, but this was only significant in the US for adulthood education. There was no difference between middle- and low-income groups in the probability of obesity in Britain (Panel C, 0.366 [95%CI: 0.334, 0.397] vs. 0.358 [95%CI: 0.320, 0.396]), but there was a difference between the highest and lowest income fifths. However, in the US there was a stronger income gradient for obesity (Panel C, low: 0.501 [95%CI: 0.454, 0.549], middle: 0.425 [95%CI: 0.390, 0.459], top: 0.236 [95%CI: 0.199, 0.273]). Both countries had gradients by education, which were stronger for participants' own rather than parent's education level.

Model 3 – The long arm of childhood in Britain and the US

Model 3 examined associations between childhood SEP and adult health, accounting for the effect of adult SEP through adjustment (Figure 3). Compared with Figure 2 Panel A, the association of childhood SEP and most health outcomes was attenuated by adult SEP, though this pattern was stronger for Britain than for the US. For example, when accounting for adult SEP, the probability of smoking in Britain in midlife was nearly identical for individuals with or without degree-holding parents, whilst differences remained in the US.

This result was similar when looking at males and females separately **(Supplementary Material),** although among men, the inequality for HbA1c or "any" diabetes appeared larger in Britain than the US following adjustment for Adult SEP.

Sensitivity Analysis

When using the full, racially/ethnically heterogenous, Add Health sample, results were similar to the main analysis. The exception to this being "any" diabetes, which was significantly higher in the US as compared to Britain. In general, the gap between the two countries was smaller when looking at heavy drinking, smoking, and self-rated health, but larger among obesity, hypertension, dyslipidemia, and hyperglycemia. We also checked that results were consistent when limiting our measure of obesity to those respondents with clinically assessed – rather than self-reported – height and weight in Add Health. While the overall prevalence of obesity was higher in the US based on clinically assessed measures, the substantive conclusions were unchanged.

Discussion

Our analyses identified a US disadvantage in health in midlife, similar to that observed in older ages [1-4]. The health disadvantage is particularly clear for heavy drinking, obesity, high blood pressure and unhealthy cholesterol levels. Smoking and self-rated health are the only outcomes for which Britain performs worse than the US. Further, our results demonstrate that socioeconomic inequalities are typically wider in the US, where health differences between the most and least advantaged are larger. For some outcomes, such as smoking, and to a lesser extent obesity and diabetes, this is because being advantaged in the US confers greater protection, and being disadvantaged confers greater risk, than the equivalent in Britain. For other outcomes, such as hypertension and cholesterol, those in the most advantaged position in the US do similarly or worse than those in the most disadvantaged position in Britian. Socioeconomic inequalities in health are typically wider for respondent's adult SEP rather than their parent's SEP in both the US and Britain. Most of the association with parental SEP is mediated by adult SEP.

Our finding that hypertension and cholesterol are higher in the US compared to the UK confirms previous research, which showed that high blood pressure and cardiovascular disease were higher among US adults at older ages [2, 4]. However, the finding that alcohol consumption in midlife is higher among the US population compared to the UK population is a novel finding, and contrary to Banks et al [2] who found heavy drinking was more common among older adults in the UK. Moreover, previous work in older adults found co-occurrence of multiple risk behaviors, including alcohol consumption and smoking, was more likely among individuals in the UK than the US [1]. This finding may be consistent with recent increased mortality due to alcoholism, suicide, or drug use in midlife in the US [10]. , It's also possible that this result reflects different definitions of "heavy drinking" used in the US compared to Britain, where the US definition is based on number of drinks rather than units. It is possible that British adults in midlife drink more units overall but are less likely to exceed the heavy drinking threshold adopted in the UK.

For several outcomes, we find that e the most advantaged respondents in the US have equal or worse health compared the most disadvantaged in Britain. This may reflect different sociopolitical contexts between the two countries. The US and UK health care systems differ substantially [19], and might help to explain part of the US disadvantage. For example, the UK has the National Health Service (NHS) where healthcare is universally available and free at the point of access. In the US, healthcare is largely covered by private health insurance, Medicare or through an individual's own finances, and prescription costs are often high.

Past work has suggested that relatively "universal" access to healthcare at older ages in the US through Medicare has helped to explain its better international standing in mortality and morbidity for medically amenable causes of death in the 65+ age range [20]. Moreover, comparisons of income gradients at older ages (70-80 years of age) between England and the US found no income gradient in health in England, whilst they existed in the US. The authors explained this finding through a more generous benefit system for older adults in England, where below the median income, retirement benefits are largely consistent and unrelated to historic income [3].

It is also possible that these differences between the US and Britain reflect broader inequalities affecting health across the life course Societies with a high level of inequality perform worse in international comparisons across a range of indicators, including health [21]. Both the US and UK have relatively high levels of inequality compared to peer countries, but the US still fairs worse in terms of measures of income inequality than Britain [22]. This impact of national level inequalities relates especially to the present study's finding of worse health in the US, even among the most advantaged groups. The unique combination of high inequality and weak welfare state in the US may prove particularly harmful across all groups in society.

Our study finds evidence of "the long arm of childhood" where the impact of childhood disadvantage can be seen on midlife health, with those whose parents did not have a university degree more likely to have worse health. However, through informal mediation analysis we show that in both the US and Britain, the participants own SEP in adulthood can explain much of the inequality in health in midlife, although this trend is slightly stronger in Britain than the US. It is previously documented that SEP tracks across the life course, with social mobility in both countries low [23, 24], therefore the attenuation of associations is not unexpected, and is consistent with previous work [25].

Strengths and Limitations

The current research utilizes data from two nationally representative cohort studies in the UK and US, exploring differences in health based on a wide range of outcomes, including biomarkers and objectively measured anthropometry. Although BCS70 is representative of the population at time of recruitment, there is little racial/ethnic diversity in BCS70, and the majority of the cohort is White. Therefore, it was not possible to make adjustment for race/ethnicity, and instead a sensitivity analysis was conducted limiting Add Health to non-Hispanic Whites to aid comparability. For biomedical measures, the age at which measures were collected do not fully overlap between Add Health and BCS70. However, adjustment for age was included in models.

Another strength of this work was the extensive harmonization of measures, to ensure comparability of two cohorts. This included development of weights in BCS70, allowing for comparative analysis that accounts for the complex survey design in Add Health. However, as is the case with harmonization, for some measures there may still be differences in the ways in which they were measured. Moreover, a number of measures were not designed to be harmonized (e.g., alcohol consumption as described above), and this is more problematic for subjective measures of health, such as smoking, drinking and self-rated health. This work therefore highlights a need for integration of harmonized longitudinal cross-country studies, including at younger ages, given the success of these efforts at older ages, particularly with respect to disability and cognitive decline.

Conclusion

Although our study cannot identify the direct causes of differences in health inequalities, in demonstrating the larger health inequalities in the US compared to Britain our study reaffirms the importance of sociopolitical contexts for social inequalities in health. We particularly emphasize the population health significance of welfare support for the *most disadvantaged* members of society, which can attenuate the negative health effects of individual level disadvantages related to education and income. Moreover, the overall level of socioeconomic inequality in a country is also likely to influence health inequalities, independent of the circumstances of individuals. The greater inequality in the US, combined with lower welfare provisions compared to Britain, may prove to be particularly detrimental for health inequalities. National efforts to improve welfare provisions for those in the most vulnerable social position and circumstances may alleviate the effect of existing inequalities as well as reduce the extent to which inequalities in childhood have a scarring effect on adult health.

Tables and Figures

Figure 1 - Comparison of health indicators between Britain and the US

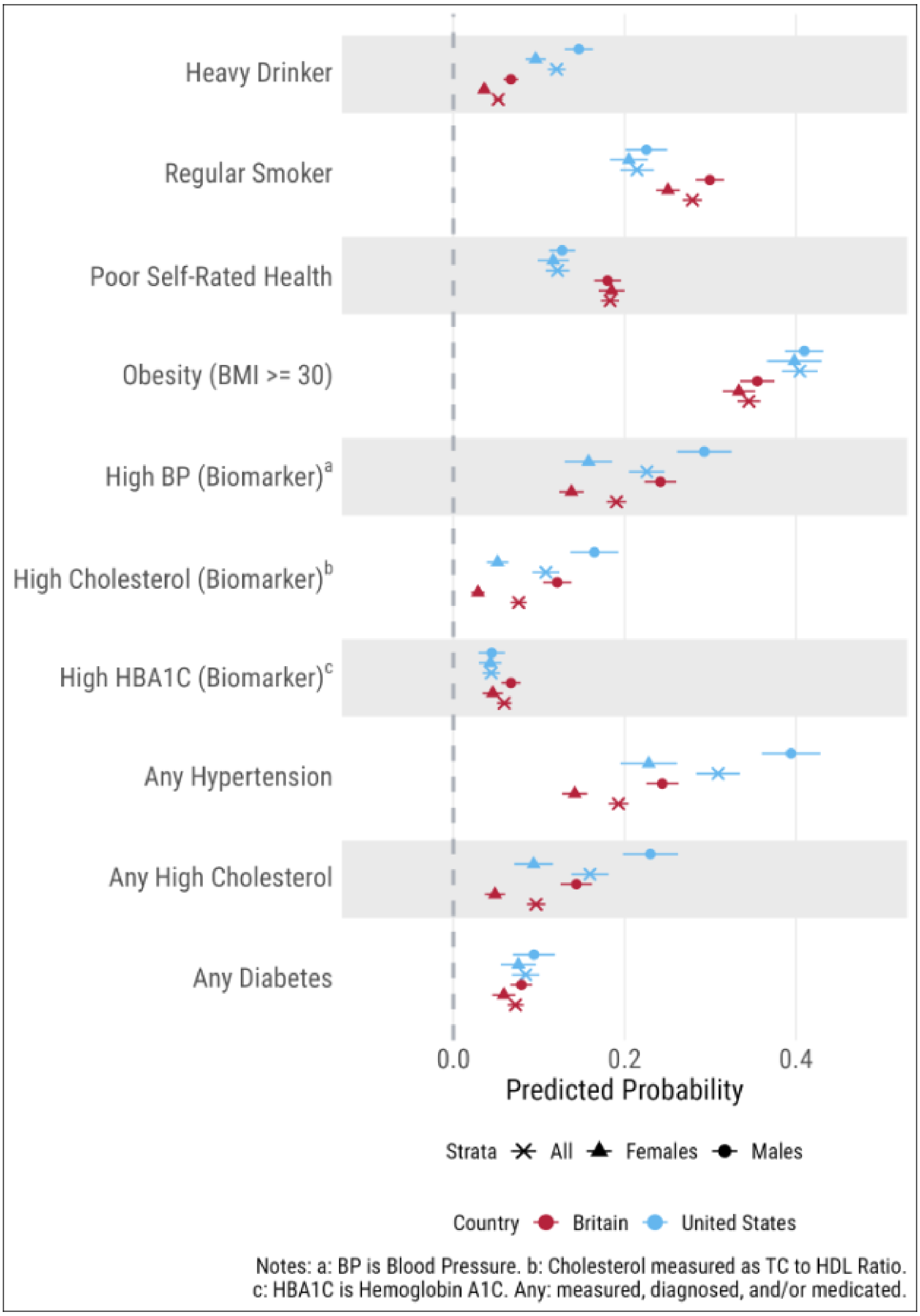


Figure 2 – Socioeconomic inequalities in midlife health between Britain and the US

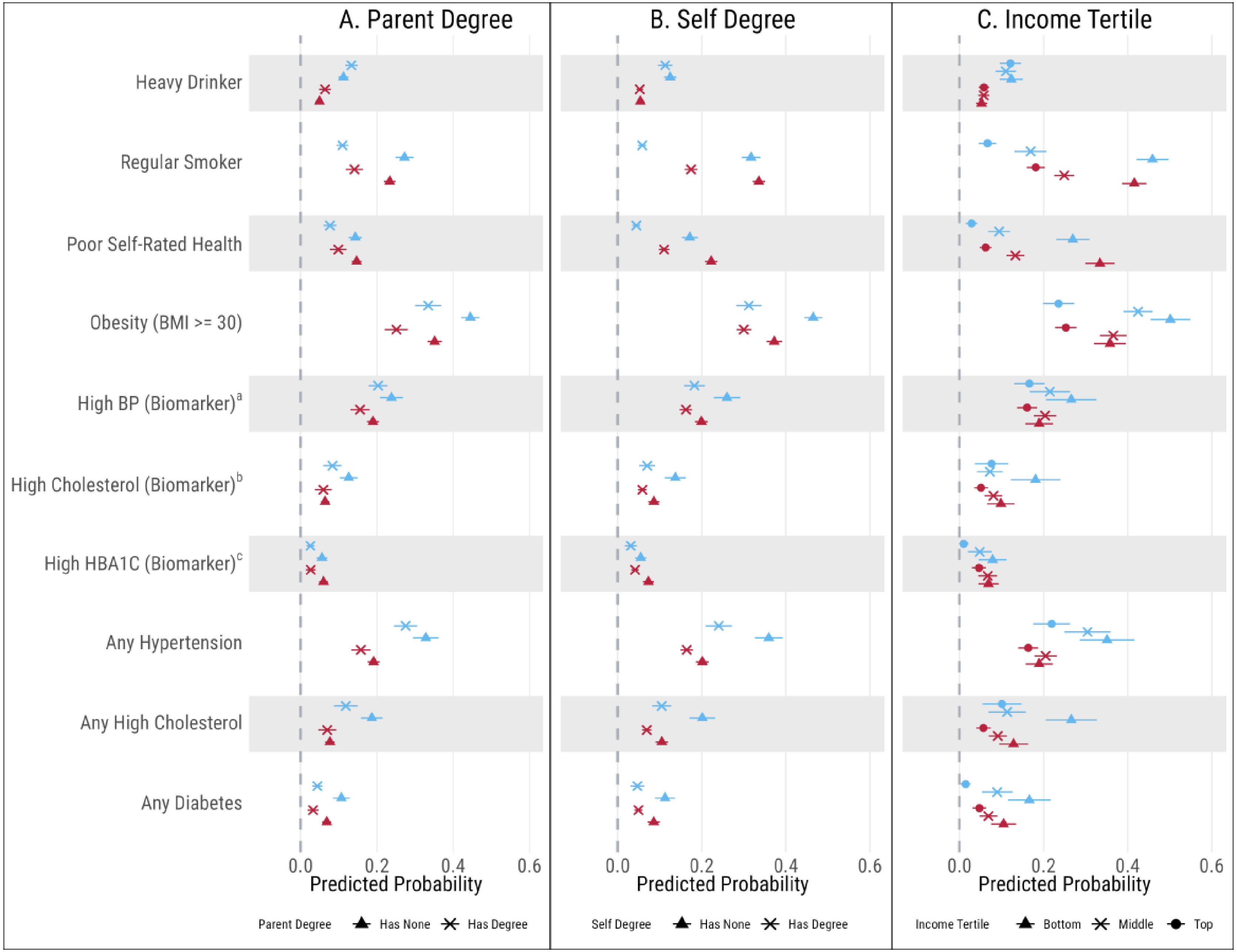
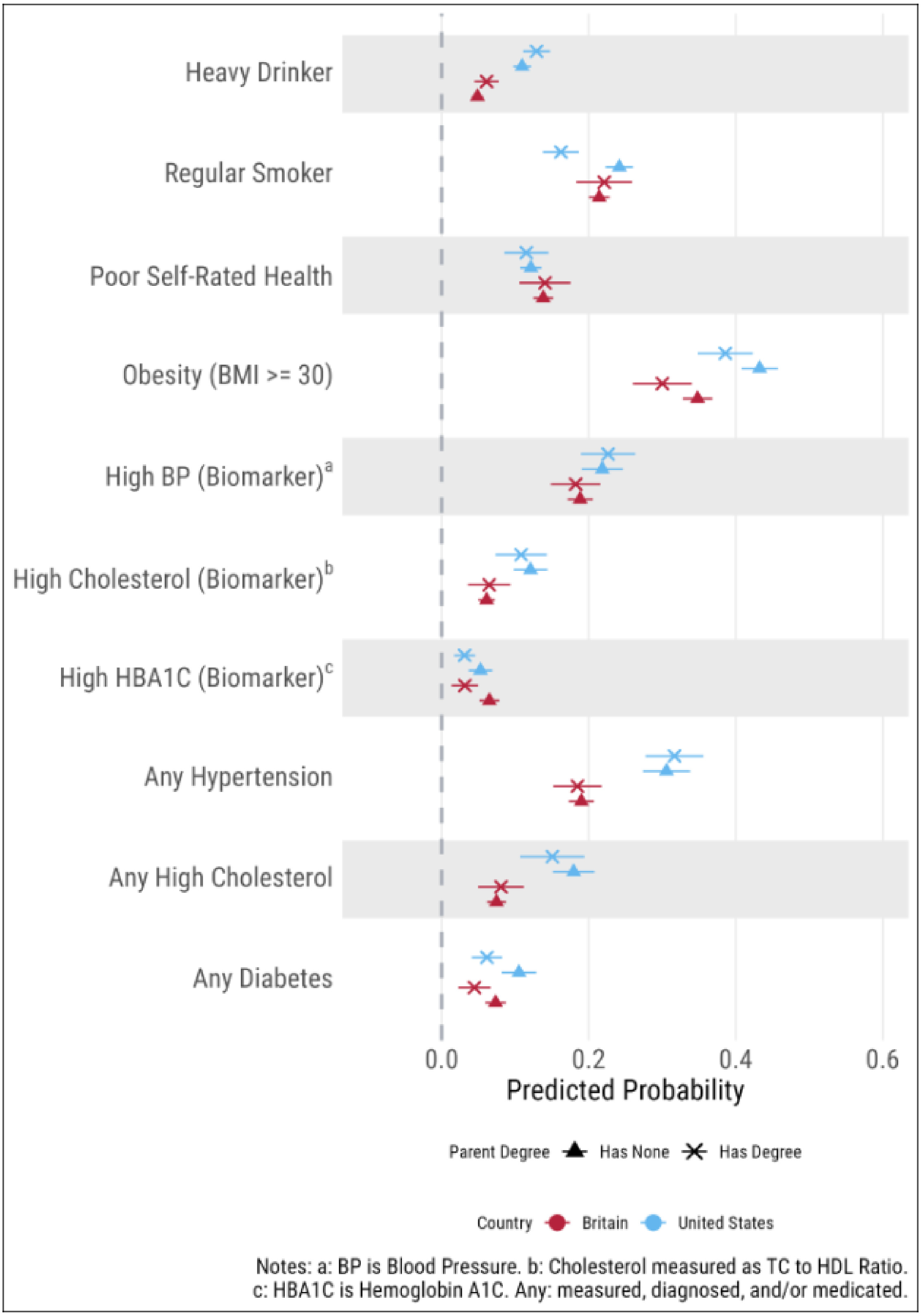


Figure 3 – The long arm of childhood in Britain and the US



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Supplementary Methods S1: Outcome cut-offs used in BCS70 and Add Health

Supplementary Methods Table 1. *Description of health behavior, anthropometry and biomarker outcomes and the cut-offs used in BCS70 and Add Health*

Outcomes	**Cut-off used**
Smoking	Regular smoker versus occasional smoker, past smoker or never smoked
Alcohol consumption [A]	Heavy drinker (Men): > 50 units a week/15 drinks a week Heavy drinker (Women): >35 units a week/8 drinks a week
Self-rated health	Described health as poor or fair versus those described as good or excellent
BMI [B]: Obese	Obesity: >=30 kg/m^2
Cholesterol: Total/HDL ratio	Unhealthy Levels: >=6
Glycated hemoglobin: HbA1c	Diabetes: 6.1% (>= 43.2 mmol/Mol)
Blood Pressure	Hypertension: Systolic >=140, Diastolic >=90 [C]

Supplementary *Table 1 Footnote:* *[A] Heavy drinking was measured as units per week in BCS70, and number of alcoholic drinks per week in Add Health. [B] Body Mass Index (BMI) was derived from objectively measured height and weight in both cohorts but supplemented with self-reported height and weight where nurse/examiner measured was unavailable. [C] Respondents were classified as having hypertension if either systolic or diastolic blood pressure was above the cut-off.*

Supplementary Methods S2: Harmonization of measures between Add Health and BCS70

Smoking

In Add Health, respondents were asked in wave 5 how many days out of the last thirty days they had smoked cigarettes, with possible responses ranging from 0 to 30 days.

In BCS70, respondents were asked at age 34 to identify on a card whether they would say that they had “never smoked cigarettes”, that they “used to smoke cigarettes but don’t at all now”, that they “smoke cigarettes occasionally but not every day”, or that they “smoke cigarettes every day”.

Using these answers to these questions, we identified current cigarette smokers and those who did not currently smoke cigarettes (see below, Supplementary Methods Table 2).

Supplementary Methods Table 2. *Categorization of smokers by responses in Add Health and BCS70.*

	BCS70	**Add Health**
Current regular smoker.	“Smoke cigarettes every day”	In the last 30 days, smoked cigarettes on 30 days
Does not currently regularly smoke cigarettes.	“Smoke cigarettes occasionally but not every day” **OR** “Never smoked cigarettes” **OR** “Used to smoke cigarettes but don’t at all now”	In the last 30 days, smoked cigarettes on <30 days

Alcohol consumption

For alcohol consumption, a binary variable was created to indicate heavy drinking (0=no, 1=yes). In BCS70, cohort members responded to their drinking habits at age 34, and heavy drinking in the UK was defined according to the National Institute for Health and Care Excellence (NICE. Diagnosis, assessment and Management of Harmful Drinking and Alcohol Dependence. In: National Clinical Practice Guideline 115; 2009.), with heavy drinking in men consuming more than 50 alcohol units a week, and in women more than 35 alcohol units a week. In Add health, cohort members reported on their drinking habits at age 33-43 (wave 5) and heavy drinking in the US was defined according to the Centers for Disease Control and Prevention (CDC. https://www.cdc.gov/alcohol/faqs.htm), with heavy drinking in men consuming 15 drinks or more a week, and in women 8 drinks or more a week.

For BCS, the variables used to create the heavy drinking index were self-reported measures of how many units of beer, spirits, wine, alcopops and sherry the cohort member had within the last seven days, which were recoded and combined into the number of alcohol units per week (based on which the heavy drinking variable was generated according to the official guidelines).

For Add health, the variables included were how many days per month the cohort member drinks, as well as how many drinks the cohort member has each time they drink, which were recoded and combined to reflect the number of drinks per week (based on which the heavy drinking variable was generated according to the official guidelines).

Self-rated health

In BCS70 at age 42, participants were asked to describe if their health was 1) Excellent; 2) Very good; 3) Good; 4) Fair; and 5) Poor. Cohort members were then grouped into those who described their health as "Excellent/Very Good/Good" and "Fair/Poor". The same grouping was used in Add Health at Wave V.

BMI: Obesity

In BCS70 at age 46, weight in kilograms (kg) was collected through Tanita BF-522W scales. The scales can accurately measure up to 130kg, and only those whose weight was unlikely to exceed this amount were weighed. Height was measured by nurses using a portable Leicester stadiometer following standard protocol. Cohort members also self-reported height and weight.

Body mass index (BMI) was derived by dividing nurse measured weight in KG by nurse measured height in meters (m) squared (kg/m^2). Where nurse measured BMI could not be derived, BMI using self-reported height and weight was derived instead using the same method (n= 1,081), and supplemented the nurse measured BMI (n= 7,413). Individuals with a BMI exceeding or equal to 30 kg/m^2 were categorized as obese, whilst individuals with a BMI lower than this threshold were categorized as not obese.

Likewise, in Add Health at Wave V weight and height were also collected at time of examination among the subset of respondents participating in the biomarker specimen collection (n=5,377). Add Health provides users with both calculated BMI and categorized BMI for these respondents, using the same 30 kg/m^2 threshold for obesity. Supplementary information on individuals' BMI was obtained from self-reported height and weight (n=6,839), which is asked of all respondents in the survey component of the data collection.

Cholesterol: Total/HDL ratio

In BCS70, cohort members provided a blood test at age 46 and total cholesterol and HDL cholesterol were measured. Cohort members were categorized as having high cholesterol (hyperlipidemia) if the ratio of total cholesterol to HDL cholesterol exceeded 6.

Additionally at age 46, nurses looked at medical records of a subset of the sample and reported medications being used by the cohort members, including lipid regulating medication. If cohort members were using lipid regulating medication but there total/HDL ratio was “healthy”, they were reclassified as having high cholesterol.

In Add Health, cohort members provided a blood test at ages 33-43 (varying across members) and total cholesterol and HDL cholesterol were measured. The same cut-off of having a total cholesterol to HDL cholesterol ratio greater than 6 was used to categorize hyperlipidemia.

Additionally, Add Health respondents provided self-reported information on their medication use, including lipid regulating medication. This information was collected in both the in-home survey (respondents who first reported receiving a diagnosis for hyperlipidemia were then asked if they take medication for their condition) and as part of the in-home examination for a subset of the sample (respondents were asked about what medications they take, which were then classified by Add Health staff). If respondents reported taking medication in response to either question, they were classified as having high cholesterol.

Glycated hemoglobin: HbA1c

In BCS70, glycated hemoglobin was measured when cohort members provided a blood test at age 46 and were classified into those with diabetes if HbA1c levels exceeded 6.1% (>= 43.2 mmol/Mol). Similar to the approach for cholesterol, those using diabetic medication as identified by nurses, were reclassified as having diabetes even if HbA1c levels were below the diabetic threshold.

In Add Health, cohort members provided a blood test at ages 33-43 (varying across members) and were classified into those with diabetes based on the same HbA1c cut-off as in BCS70. As with high cholesterol, diabetic medication use was assessed in the in-home survey and examination, wherein either response led to respondents being classified as having diabetes.

Blood Pressure

At age 46 in BCS70 three blood pressure readings for systolic and diastolic blood pressure were collected. The mean was taken across the three readings, and a single blood pressure variable was derived if either the systolic or diastolic value exceeded their given threshold (Systolic >=140, Diastolic >=90). Individuals who were also reported by nurses to be taking medication for “hypertension or heart failure” at age 46 were reclassified to have high blood pressure (hypertension). Similar to other biomarkers, cohort members were also reclassified based on medication use if they did not have a blood pressure reading.

In Add Health, cohort members received a blood pressure reading for systolic and diastolic blood pressure. As with BCS70, the mean was taken across the three readings and a single blood pressure variable was derived if either the systolic or diastolic value exceed the aforementioned threshold. Once again, self-reported medication use in the in-home survey and examination portions of the survey was used to assess hypertension not captured by the blood pressure reading. Specifically, respondents were asked about hypertension and heart failure medication, separately, in the in-home survey; this was complemented by an Add Health derived indicator of antihypertensive medication use based on the examination questionnaire. Medication use related to hypertension and/or heart failure across these two sets of measures led to respondents being reclassified as having high blood pressure.

Childhood SEP: Parental Education

In BCS70, parental education was collected at age 16 through the family-follow up form, administered either by a health visitor during a home visit, or by self-completion sent in the post to be completed by the parent(s). The form ascertained if the mother, father, both parents or neither parent had the following qualifications: 1) trade apprenticeship or other occupational training; 2) O levels or equivalent (CSE/C&G etc); 3) A level or equivalent (OND/ONC/C&G); 4) nurse (SEN or SRN); 5) teacher (certificate of education or equivalent); 6) degree, diploma, or member of professional institute; 7) other qualification(s); 8) no qualifications; 9) Qualifications of parents not known. From this, the highest education level of the mother and father were derived separately, and then combined to indicate if: 1) at least one parent has a degree or equivalent; or, 2) neither parent has a degree.

In Add Health, parental education was collected at Wave 1 when cohort members were aged 11-19. Both the cohort member and the parents were asked for the mother and fathers' highest level of completed education. Responses were regrouped into those who 1) had a degree or equivalent (either "Graduated from college/university" or "Professional training beyond 4-year college"), and 2) no degree or equivalent (all other responses). Similar to BCS70, qualifications were combined between parents using the parent reported qualifications, to indicate if either parent had a university degree or if neither parent did. This was then supplemented with the cohort members response in the cohort member questionnaire, where parents own report of highest qualification was missing.

Adulthood SEP: Own Education

In BCS70, own education was assessed at age 34 and 42 by asking cohort members to report all academic and vocational qualifications obtained since their last interview. These were grouped into the National Vocational Qualification (NVQ) groupings of NVQ level 1-5 as derived by the BCS70 survey team, and a variable for Highest NVQ level from an academic or vocational qualification at the respective sweep was derived using prior survey data (for further details, please see: https://cls.ucl.ac.uk/wp-content/uploads/2018/06/Deriving-highest-qualification-in-NCDS-and-BCS70.pdf).

For the present analysis, using the deposited derived variable for Highest NVQ level from an academic or vocational qualification, a new binary variable was derived grouping highest education level into 1) has a degree (e.g., NVQ level 4 & 5) and 2) does not have a degree (No qualification and NVQ level 1-3).

In Add Health, education of the cohort member was taken at Wave 5 when cohort members were age 33-43. Cohort members were asked to report their highest educational qualification achieved to date, and this was used to group cohort members into those who 1) have a degree (any response from the following: “completed college (bachelor's degree)", "some graduate school", "completed a master's degree", "some graduate training beyond a master's degree", "completed a doctoral degree", "some post baccalaureate professional education (such as law school, medical school, nursing)" and "completed a post baccalaureate professional degree (such as law, medicine, nursing)") and 2) those who do not have a degree (all other responses).

Adulthood SEP: Household Income

Income was assessed at ages 34 and 42 through the employment and family income questionnaire, which ascertained multiple sources of income as well as employment status for both the main respondent and partner. Household income was derived from the main respondent’s income, the partners income and any income from benefits or other sources whilst taking into account employment status. Full code and methodology for derivation of the income variable will be deposited with the UK data service as a later date. This was then equivalised into fifths, resulting in five groups from the lowest income fifth to the highest income fifth.

In Add Health household income was taken from Wave 5 when cohort members were age 33-43. Cohort members were asked “What was the total household income before taxes and deductions in the last calendar year for all household members who contribute to household expenses?” and responded by indicating which income band they fell in, out of 13 bands ranging from “less than $5,000” to “$200,000 or more”. To allow comparability with BCS70, these were then regrouped into approximate fifths, with roughly 20% of the respondents falling into each group. However, because these fifths were being regrouped from banded categories, the proportion in each fifth ranged from 17.16% to 24.74%.

Ethnicity

BCS70 is nationally representative at the time of birth, which has resulted in BCS70 being a predominantly ethnically homogenous cohort, due to few non-white babies being born in Britain at the time of recruitment. Therefore, ethnicity is not considered in BCS70.

In Add Health, ethnicity was measured at Wave I, and grouped as non-Hispanic White, Hispanic or Spanish/Latino, Black or African American, American Indian or Native American and Asian or Pacific Islander. For the current analysis, we distinguish between non-White and non-Hispanic White participants to aid comparison with BCS70.

Age

In BCS70, age was recorded in years, up to the date of interview at the biomedical sweep at age 46, as data collection took place across 3 years, and therefore cohort members were aged between 45 and 48 at time of data collection. For age recorded at sweep 7 and sweep 9, age was included as a dummy variable, as 34 years of age and 42 years of age respectively. In Add Health, age was recorded in years at the time of data collection.

Supplementary Methods S3: Weight Derivation Method in BCS70

Supplementary Methods Table S3i. *Variables used in weight derivation at each age in BCS70.*

Variable used to derive weight	Weight Age 46		Weight Age 42		Weight Age 34	
	Age Taken	**Variable name**	**Age Taken**	**Variable name**	**Age Taken**	**Variable name**
Sex	Birth	sex	Birth	sex	Birth	sex
Parental Social Class	Birth	BD1PSOC	Birth	BD1PSOC	Birth	BD1PSOC
Number of rooms in house	5	e228a	5	e228a	5	e228a
Cognitive ability	10	cog_10 *	10	cog_10*	10	cog_10 *
Malaise Score	16	BD4MAL	16	BD4MAL	16	BD4MAL
Voting	42	B9SCQ6	34	b7vote01	29	vote97
Membership in social/political/sport organisations	42	org_42 *	34	org_34 *	29	org_29 *
Educational Qualification	42	BD9HNVQ	38	BD8HNVQ	29	HINVQ00
Economic Activity (Whether in employment)	42	BD9ECACT	38	b8Econ02	29	econact
Partnership Status (Whether currently or previously married)	42	BD9MS	38	b8ms	29	marstat2
Psychological distress (Malaise score)	42	BD9MAL	34	BD7MAL	29	BD6MAL
BMI	42	BD9BMI	34	bd7bmi	29	bmi29 *
Self-rated Health	42	B9HLTHGN	38	b8hlthgn	29	hlthgen
Smoking Status	42	B9SMOKIG	38	bd8smoke	29	smoking
Social Capital/support (how frequently meets family or friends)	42	B09FAMFREMT *	34	bd7vfrnd	29	outalone
Social Capital/support (whether people around would be willing to listen to problems)	42	B9LISTEN	Not Available	-	Not Available	-
Income	42 29	hh_inc42* hh_inc29 *	38	hh_inc38 *	29	hh_inc29 *
Indicator of non-response in all previous sweeps	42	OUTCME0_nr_cum42	38	OUTCME0_nr_cum38	29	OUTCME0_nr_cum29

Supplementary Methods Table S3i. Footnote. ** Derived from other variables in the dataset. Please see table below.*

Supplementary Methods Table S3ii. *Variables and methods used to create derived variables for weights.*

Derived Variable	Variables Derived From	Method
cog_10	"BCS10simG1" to "BCS10simG21", "BCS10word1" to "BCS10word37", "BCS10digit1" to "BCS10digit34", "BCS10mat1" to "BCS10mat28" ,"PLCT1" to "PLCT103", "i4101" to "i4164", BD3MATHS	Principle component analysis – variable for cognitive ability will be deposited with UK data service.
org_42	"B9SCQ8A" to "B9SCQ8P"	Involvement in different types of organisations was combined across the variables, to indicate numbers of organisations involved in (0, 1, 2 or more).
org_34	"b7fintr1" to "b7fintr7"	Involvement in different types of organisations was combined across the variables, to indicate numbers of organisations involved in (0, 1, 2 or more).
org_29	"orgever1" to "orgever7"	Involvement in different types of organisations was combined across the variables, to indicate numbers of organisations involved in (0, 1, 2 or more).
bmi29	wtstone2, wtpound2, wtkilos2, htmetre2, htcms2, htfeet2, htinche2	Where necessary, weight was converted to kg, height was converted to m, and from this BMI was calculated (BMI = weight (kg)/ weight(m)^2
B09FAMFREMT	B9FREMT, B9FAMTDR, B9FAMMT	Frequency of meeting friends or family was combined across variables (never/rarely, fairly frequently, very frequently).
hh_inc42	Multiple income and employment related variables at age 42.	Full method to create standardised household income will be published when deposited with UK Data Service.
hh_inc38	Multiple income and employment related variables at age 38.	Full method to create standardised household income will be published when deposited with UK Data Service.
hh_inc29	Multiple income and employment related variables at age 29.	Full method to create standardised household income will be published when deposited with UK Data Service.

Weight Derivation Method

Weights were derived for the target population at each sweep, which was those cohort members who were alive and living in the UK at the point of data collection.

Multiple imputation was used to generate weights, to ensure that it was possible to include all cohort members in the weight-derivation process, by imputing the variables indicated in Methods Table S3 (excluding the indicators of non-response in all previous sweeps, as well as response to the current sweep, which were complete variables). Multiple imputation was run under the assumption of missing at random, obtaining 5 imputations each, and combined using Rubin's rule. Multiple imputation was done separately for the weight at each age.

Following imputation, logistic regression was used to predict likelihood of responding to the present sweep, using the variables indicated in methods Table 3. Using the regression output, probability of responding was predicted, and inverse probability weights were generated.

Weights at each age were then truncated to the value of 10 in order to prevent extreme weights exerting undue influence. The weights were then rescaled to the respective sweeps.

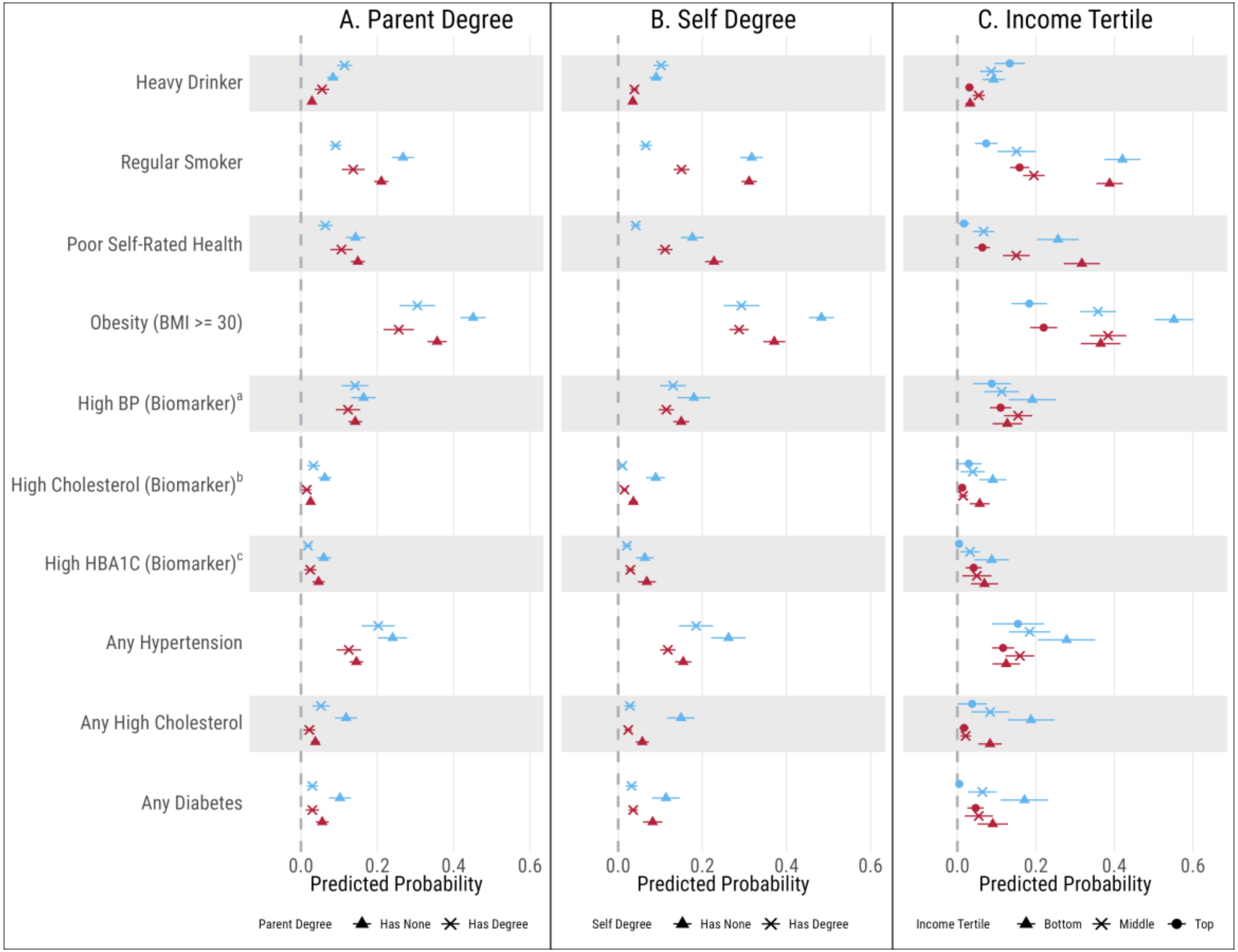
Supplementary Methods S4: Methods used to apply complex survey design across studies.

Add Health uses a complex, stratified sampling strategy that accounts for the region, urbanicity, size, type, and racial composition of schools from which students were recruited, thus maintaining the national representativeness of the data. The Add Health data set therefore includes a primary sampling unit (PSU) value for each participant, and a strata variable. Add Health also includes survey weights that account for non-representativeness among adults providing biomarker samples.

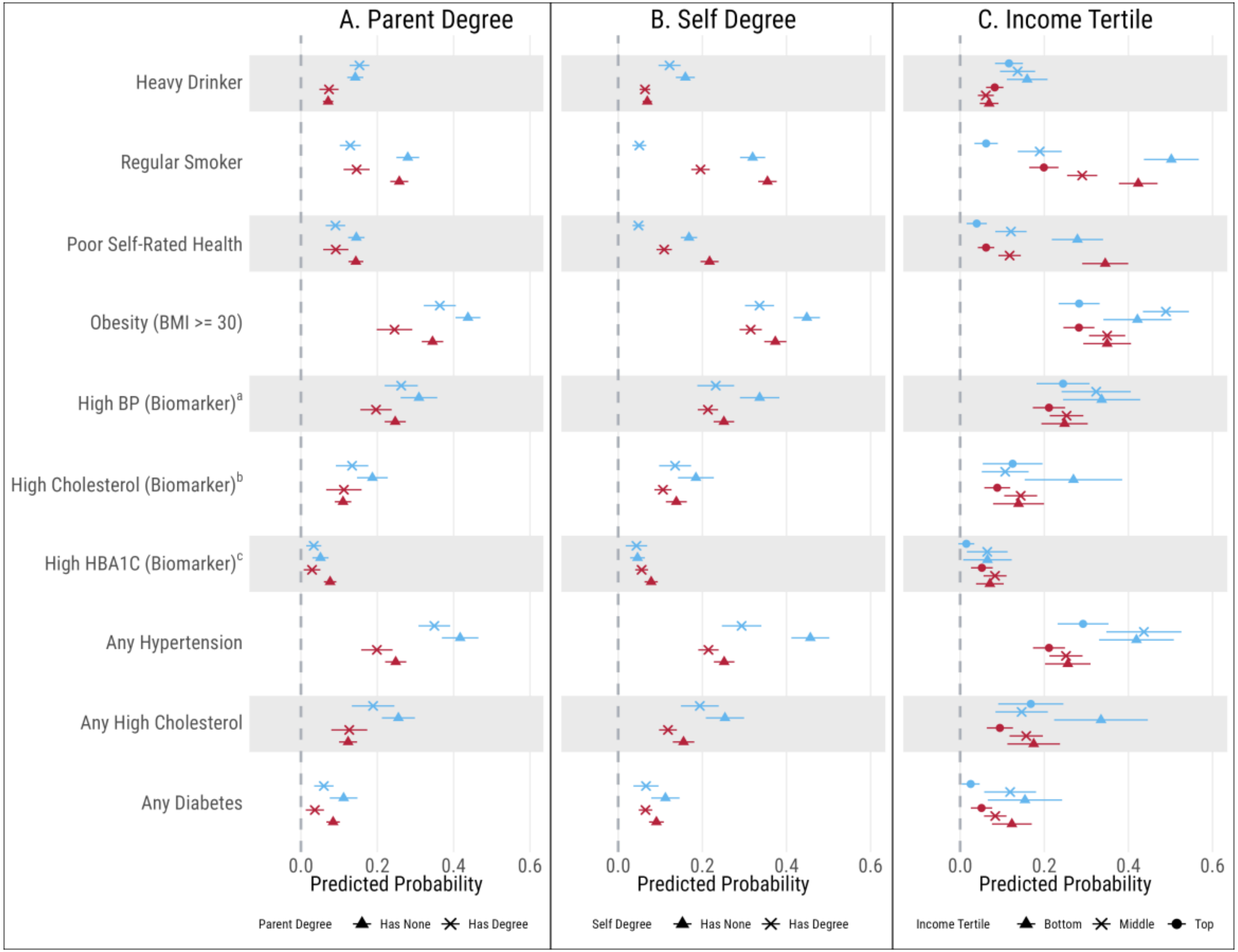
To allow inclusion of the complex survey design in Add Health when analysing data across the two data sets, dummy PSU and strata were created in BCS70. In BCS70, a unique primary sampling unit (PSU) value was assigned to each cohort member that differed to those used in Add Health, a constant strata value was created across the cohort that also differed to those used in Add Health therefore allowing use of the complex survey characteristics in Add Health in the pooled analysis.

Supplementary Results S1: Sex-stratified analysis - Model 2 in females (figure 1a) and males (figure 1b).

Supplementary Figure 1a. Analytic Model 2 in females only

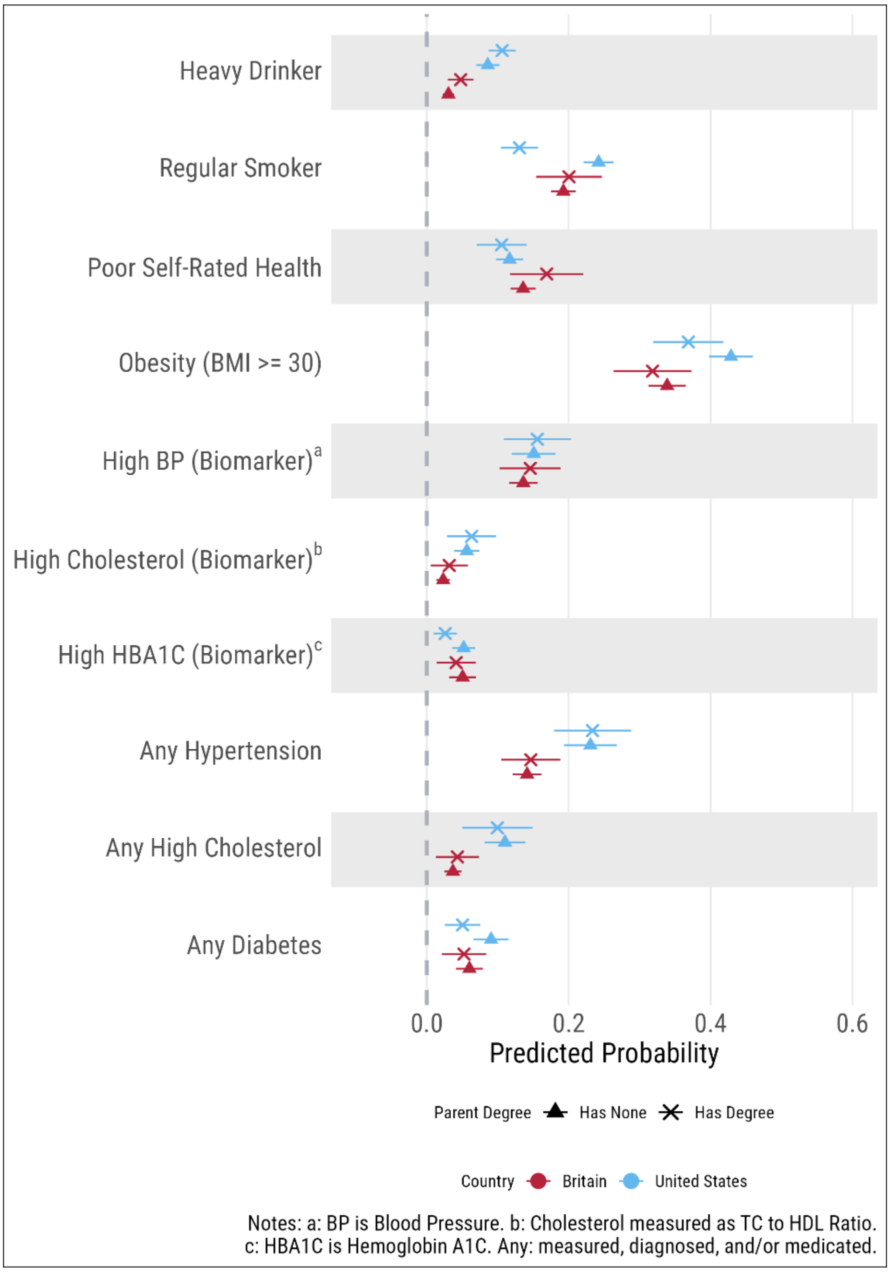


Supplementary Figure 1b. Analytic Model 2 in males only



Supplementary Results S2: Sex-stratified analysis - Model 3 in females (figure 2a) and males (figure 2b).

Supplementary Figure 2a. Analytic Model 3 in females only



Supplementary Figure 2a. Analytic Model 3 in males only