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The Intergenerational Transmission of Mental and Physical Health in the United Kingdom*

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Abstract

We estimate intergenerational health persistence in the United Kingdom using Quality Adjusted Life Years (QALY), a broad measure of health derived from the SF-12 Survey. We estimate that both the rank-rank slope and the intergenerational health association (IHA) are 0.21. We use components of the SF-12 to create mental and physical health indices and find that mental health is at least as persistent across generations as physical health. Importantly, parents' mental health is much more strongly associated with children's health than parents' physical health indicating that mental health might be a more important transmission channel. Finally, we construct an overall measure of welfare that combines income and health, and estimate a rank-rank association of 0.31. This is considerably lower than a comparable estimate of 0.43 for the US, suggesting greater mobility of overall welfare in the UK than the US.

Key Words: intergenerational health mobility, mental health, physical health, United Kingdom

JEL Classification: J62, I14

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One of the most salient questions among social scientists is the extent to which there is equality of opportunity across various societies. A large literature has emerged using estimates of intergenerational persistence in various measures of socioeconomic status across many countries to address this question. A country with a very high degree of intergenerational persistence and, hence, a low degree of mobility might be indicative of a society with less opportunity. In such societies there may be a particularly important role for policies that enhance opportunities for long-term socioeconomic success.

Most studies of intergenerational mobility have focused on income, education, and occupation. However, in recent years a new strand of the literature has begun to consider the intergenerational transmission of health. This is an important development as health status is a critical component of human welfare (Jones and Klenow, 2016) as well as human capital (Grossman, 1972). Moreover, childhood health also strongly influences adult economic outcomes (Case et al., 2005). Consequently, intergenerational transmission of health status also has ramifications for the transmission of economic status across generations.

Recent work by Halliday et al. (2021) (henceforth "HMW") considers intergenerational mobility with respect to self-reported health status (SRHS) in the US using the Panel Study of Income Dynamics (PSID).[1] SRHS provides a broad-based measure of health that is indicative of how health shapes quality of life. In addition, HMW show how SRHS can be combined with income to produce a broader measure of social welfare and document intergenerational persistence in this proxy for social welfare.

We build upon on HMW in several important ways. First, we examine intergener-

[1]See HMW for a detailed discussion of the previous literature on intergenerational mobility in health. A number of studies have examined intergenerational associations in very specific health outcomes such as birth weight (e.g. Currie and Moretti (2007)), mental health (Johnston et al., 2013); smoking (Darden and Gilleskie, 2016); longevity (e.g. Lach et al. (2008); Hong and Park (2016); Lindahl et al. (2016)), and asthma (Thompson, 2017). Other studies of intergenerational transmission in SRHS include Kim et al. (2015), Pascual and Cantarero (2009), Fletcher and Jajtner (2019) and Graeber (2020). Andersen (2019) uses administrative data in Denmark and a principal components model to study intergenerational transmission in health. A related study by Attanasio et al. (2020) estimates intergenerational persistence in non-cognitive skills.

ational health mobility in the UK using a broad-based measure of health which to our knowledge has not been previously done.[2] Adding evidence from another country with an entirely different institutional setting is useful for gaining further insight into the factors that affect health mobility.

Second, we use a richer set of information on self reported health status than HMW, who rely on just one question on general health status. In contrast, we combine a variety of health questions covering different aspects of health into one measure.

Third, we use a unified framework for examining several domains of health including mental and physical health and consider how each component affects overall health mobility. Mental health has been relatively less studied but a number of studies suggest that it plays an important role in determining socioeconomic success.[3] We directly compare the relative roles of physical and mental health in intergenerational health transmission.

Fourth, like HMW, we consider the relative importance of both parent income and parent health in determining children's outcomes. We also combine the two aspects of socioeconomic status to estimate mobility in one overall measure of social welfare.

Our data combines the British Household Panel Survey (BHPS) and the UK Household Longitudinal Survey (UKLS), which are nationally representative panels spanning the years 1990 to 2018. Our main estimates derive from the Short Form 12 (SF-12), a 12-question health survey. Importantly, we fully utilize use the SF-12 to construct a Quality Adjusted Life Year, or QALY, using the methods developed by Brazier et al. (2002). In contrast, HMW only use the first question in the SF-12 to create a QALY.

We use two measures of intergenerational persistence. First, we estimate the inter-

[2]Studies that estimate intergenerational mobility using broad-based measures of health outside of the US include Kim et al. (2015) (Indonesia), Pascual and Cantarero (2009) (Spain), Andersen (2019) (Denmark), and Graeber (2020) (Germany).

[3]Lundborg et al. (2014) show that mental health in adolescence is strongly predictive of economic outcomes later in the life-course. Biasi et al. (2020) provide plausibly causal evidence that access to medication for bipolar disorder leads to large improvements in labor market earnings. Johnston et al. (2013) shows that maternal mental health appears to have significant intergenerational effects on children's health and other outcomes.

generational health association (IHA) which is simply the regression coefficient from regressing the child QALY on the parent QALY. This captures the rate of regression to the mean and can be used to gauge how long it takes for differences across families to dissipate. Second, we convert our QALYs to ranks and estimate the rank-rank slope, or the Spearman correlation. This provides a measure of positional mobility and also offers a standardized way to compare coefficients across different dimensions of socioeconomic status (e.g. income, education, health).

For both measures, we estimate intergenerational persistence to be 0.21 suggesting a high degree of intergenerational mobility in health in the UK. When we use a comparable measure of the QALY as that used by HMW for the US, our estimates are very similar, suggesting similar rates of intergenerational health persistence in the two countries.[4]

When we separate mental health from physical health, we find that the IHA in mental health is 0.22 and the IHA in physical health is 0.17. The rank-rank estimates are virtually the same (0.20 for mental health and 0.21 for physical health). Thus, while there is a greater degree of intergenerational transmission of mental health than physical health when measured in health units, persistence appears to be roughly similar in terms of ranks.

With respect to gender, we observe larger persistence estimates when we use mothers rather than fathers but see little difference by child gender. This is consistent with previous studies including HMW.

We also estimate models where we include both parental health measures simultaneously and find that all of the parental health association loads on to the mental health component. This suggests that mental health constitutes a more important transmission channel than physical health.

In addition, we consider the interplay between parent income and health in determining

[4]Specifically, using just the general health question to construct a QALY, as in HMW, we estimate an IHA of 0.25 and a rank-rank estimate of 0.24. HMW's estimate for the US are 0.23 and 0.26

children's outcomes. We do this by adding parent income rank along with parent health rank in rank-rank specifications of both child health and income. We find that including parent income rank plays a relatively modest role in explaining child health rank and similarly that parent health rank has a small contribution in explaining child income rank. Nevertheless, combining both parent rank measures slightly increases the explanatory power of these regressions and illustrates the independent role of each of these aspects of parental socioeconomic status.

Furthermore, we convert our QALY measure into a monetary metric, which allows us to construct an overall measure of welfare that combines both income and health. We estimate the rank-rank slope in welfare to be 0.32 in the UK. This is a fair bit lower than the comparable estimate of 0.43 for the US found by HMW and suggests that the UK has greater mobility by this broader measure of socioeconomic status.

Finally, we consider heterogeneity in health mobility by parent education and race. Overall, the differences are not statistically significant given our sample sizes, but there are some interesting patterns that may be worth examining in future work. For example, we find that the rank-rank relationship in physical health is virtually identical among both low and higher educated parents but that that there is a flatter rank-rank relationship in mental health among lesser educated parents.

The balance of this paper is organized as follows. In the next section, we discuss the data that we use. This is followed by a brief discussion of the methods. After this, we discuss our results. Finally, we conclude.

1 Data

We combine data from the British Household Panel Survey (BHPS) and the UK Household Longitudinal Survey (UKLS) (University of Essex, Institute for Social and Economic Research, 2020). The BHPS includes 18 rounds spanning 1991 to 2009 and approximately

10,000 households per year. The BHPS was replaced by the UKHLS in 2009 and includes roughly 40,000 households per year. Beginning in the second round, the UKHLS integrated about 6,000 households from the BHPS. Currently, nine waves of the UKHLS are available to researchers.[5] In total, the BHPS/UKHLS has been running annually for 26 years making it the longest running annual longitudinal social research study in the world.[6] Entire households typically participate in the BHPS/UKHLS with members ages 10-15 filling out youth questionnaires and members 16 and older filling out the adult questionnaires. The surveys are representative of the population of the United Kingdom. We restrict the analysis to children 25 years of age or older.[7]

For our main analysis, we use the Short Form 12 Survey (SF-12) to construct three health measures.[8] First, using the algorithm provided by Brazier et al. (2002), we use all 12 questions in the SF-12 to construct a Quality Adjusted Life Year or "QALY".[9] The SF-12 includes a question on general health status that is widely collected in many surveys such as the PSID and is often referred to as "Self-reported Health Status" (SRHS). SRHS has been validated as a strong predictor of mortality and hospitalization (DeSalvo et al., 2005; Wang et al., 2018). HMW use SRHS to contruct their version of the QALY.[10] However, our QALY also incorporates information from the other health questions including those on mental and physical health.

Our second measure is an index of physical health that is based on five questions in the SF-12. These relate to limitations on activities of daily living and work due to problems with physical health.[11] Each question has a series of responses that vary in their severity

[5] See more on the surveys here: https://www.understandingsociety.ac.uk

[6] While the PSID has been running since 1968, it has been biannual since 1997.

[7] This latter limitation, for the QALY sample, excludes 9,035 of the 14,327 (63.1%) children, 4,769 of 8,522 (56.0%) of mothers, and 2,927 of the 5,259 (55.7%) of fathers.

[8] The SF-12 is a shorter version of the 36-item SF-36. Jenkinson et al. (1997) showed that morbidity measurements from the SF-12 and SF-36 are very similar.

[9] SF-12 variables are available in all rounds of the UKHLS and rounds 9 and 14 of the BHPS.

[10] The question asked is "In general, would you say your health is excellent, very good, good, fair, or poor." The responses are then coded as a categorical variable.

[11] See Appendix Table A1.

that range from one to five for three questions and one to three for two questions. The responses to the questions are normalized so that higher numbers correspond to better health. We rescale each outcome from one to 100. Then, we average these values for an individual-year specific physical health index (PI). Finally, we average these across years to obtain the PI index. If one or more of the five underlying questions has a missing answer, we set PI to be missing for the individual.

Our third measure is a mental health index (MI) that uses a different set of five questions in the SF-12. These questions assess the degree to which mental health problems interfere with activities of daily living or work, energy levels, and whether respondents report feelings of depression or tranquility. All five questions have response values that range from one to five. MI varies between zero and 100 with higher values corresponding to better mental health.

We constructed the PI and MI over using SF-12's regularly applied Physical Component Summary (PCS) and Mental Component Summary (MCS) for two reasons. First, both PCS and MCS include as one of their components the general health question, SRHS (Lacson et al., 2010). To avoid mechanically created correlations between mental, physical, and overall health, we exclude the overall health measure from our mental and physical indices, MI and PI. Secondly, the question "During the past 4 weeks, how much of the time has your physical or emotional problems interfered with your social activities [...]?" is originally included in MCS only, designating it as strictly a mental component. We find the question somewhat more ambiguous regarding whether it speaks to physical or mental problems, and opt to not use it in either of our constructed measures.

Previous studies have emphasized the value of using long time averages to better capture latent health status (Halliday et al., 2020, 2021). This is analogous to the income mobility literature where more years of income better approximate permanent or lifetime income, otherwise estimates suffer from attenuation bias (Solon, 1992; Mazumder, 2005). HMW show that reliable estimates of the IHA can be obtained by using about four to five years of health status for the parents.[12]

In addition to our main measure of the QALY, we also create a version of the QALY based only on the general health question following the methodology in HMW. This allows us to produce estimates for the UK that are an "apples to apples" comparison to the US estimates produced by HMW. We refer to that persistence estimator as SRHS. Furthermore, for a few exercises we also create a version of the SRHS variable that follows the same methodology as the MI and PI to create an index that takes on values between 0 and 100. This allows us to compare the information in the SRHS to the MI and PI using an identical methodology. We refer to this index as "SRHS100."

For our heterogeneity analysis we use two categories of education.[13] The first includes those who have only attained a General Certificate of Secondary Education (GCSE) but no further educational credential. The second group includes those who have completed their A-levels (equivalent to a high school degree) or who have a tertiary education degree. For race, we split the sample into two groups. One contains white and white British respondents while the other includes Black and Black British, Asian and Asian British (BAME) respondents.[14]

We report summary statistics in Table 1. For the child generation, we have a sample size of 5,292 and the mean QALY is 77.1. The average MI is 76.7 and the average PI is 90.2. We have an average of 3.7 different annual reports of health in the child generation.

Turning to the parent generation, we have about 2,300 fathers and 3,800 mothers. Importantly, we have over five years of measurement for the parents suggesting that there should be minimal attenuation bias in our estimations. Not surprisingly, parents report worse health than children for all three measures and mothers report being in worse health than fathers which is an established result in the demography literature (e.g. Case and

[12] Halliday et al. (2020) also show that the bias from estimating linear models (as opposed to an ordered non-linear model) is very small for rank-based estimates.

[13] We limit our analysis to 2 categories to obtain meaningful sample sizes for each group.

[14] We don't include in the heterogeneity analysis due to low sample size the categories mixed race, traveler, and those choosing the response category "other."

Table 1: Summary Statistics

	All Children	Fathers	Mothers
QALY (Scale: 0 to 100)			
Age	31.84	60.76	58.76
	(8.39)	(9.29)	(10.51)
Overall Score	77.08	76.46	72.75
	(11.68)	(12.94)	(13.10)
Years of Health Measurement	3.72	5.29	5.47
	(2.49)	(2.59)	(2.52)
MI (Scale: 0 to 100)			
Age	31.84	60.75	58.76
	(8.39)	(9.29)	(10.51)
Overall Score	76.70	78.82	74.49
	(13.33)	(13.34)	(14.03)
Years of Health Measurement	3.73	5.30	5.49
	(2.49)	(2.60)	(2.51)
PI (Scale: 0 to 100)			
Age	31.84	60.76	58.77
	(8.39)	(9.29)	(10.51)
Overall Score	90.22	81.59	77.87
	(13.56)	(18.96)	(20.48)
Years of Health Measurement	3.72	5.28	5.47
	(2.49)	(2.59)	(2.51)
N	5,292	2,329	3,750

Note: Averages are reported. Standard deviations are in parentheses. This sample includes children who have at least one health measurement observation above the age of 25 in all three health measures and are matched to at least one parent with at least one health measurement observation above the age of 25 for all three health measures. Age is the averaged for all available health measures.

Paxson (2005)).

In addition to the three subjective health indices constructed from the SF-12, we also experimented with data on biomarkers which were collected in two survey waves.[15] Unfortunately, biomarkers are only available for a very small subsample of individuals and only one reading per individual was collected yielding very imprecise estimates. For interested readers, we show intergenerational persistence results using biomarkers in the

[15] The underlying data on biomarkers is described in Appendix A6.

Appendix. We do use them, however, in an exercise below to show how these objective measures correlate with our subjective health measures.

Specifically, following Schanzenbach et al. (2016), we construct an index by calculating the within-gender z-score for each variable (where positive z-scores indicate better health) and then aggregate these z-scores for each individual.[16] We also constructed a "stress" index comprised of four biomarkers that indicate stress and/or inflammation.[17] This is sometimes referred to as allostatic load (e.g. Chandola and Zhang (2018)).

To provide some idea of how our different health measures relate to one another, Table 2 presents a correlation matrix of five of our measures which include the SRHS100, PI, MI, the Biomarker index and the Stress index.[18] We do not use the QALY for this exercise because it is comprised of the questions used to calculate the MI and PI and thus would be mechanically correlated. We also use the SRHS100 rather than SRHS so that it is constructed in the same way as the MI and PI.

Looking at the first column we find that the PI is the measure most strongly correlated with SRHS100, with a correlation of 0.71. The MI is also strongly correlated with SRHS with a correlation of 0.59. The two biomarker indices are much less correlated with SRHS with correlations of 0.31 and 0.22. We also find that the MI and PI have a quite strong correlation of 0.64.

In Figure 1, we show that the correlations of PI and MI with SRHS100 peak between the ages of 50 and 60. We also find that the age profile of the correlation of SRHS100 with MI is much flatter than the correlation of SRHS100 with PI. This suggests that the MI is more uniformly informative of general health over the life-course than PI. A possible explanation for this pattern is that physical health conditions (e.g. chronic disease) may

[16] We do this separately by gender as some biomarkers (e.g. testosterone) should be interpreted differently for each gender.

[17] These include C-reactive protein (CRP), Clauss Fibrinogen, Cytomegalovirus IgG, and Cytomegalovirus IgM.

[18] See the same matrix for the complete UKHLS, exhibiting similar corelations as our sample, in Table A3 in the Appendix.

Table 2: Correlation Matrix of Health Measures

Analysis Sample	SRHS100	PI	MI	Biomarker	Stress
SRHS100	1.00				
PI	0.71	1.00			
MI	0.59	0.64	1.00		
Biomarker	0.31	0.31	0.14	1.00	
Stress	0.22	0.25	0.13	0.59	1.00

N=4,543 This matrix represents the correlation between each pair-wise combination of five time-averaged health measures: Subjective Health (SRHS100), physical health index (PI), and mental health index (MI). The sample includes children and parents who had non-missing values for the specified pair of measures.

take longer to manifest, on average, than mental health conditions which can manifest earlier in life.

In Figure A2, we show how the level and variability of our main health measures change over the lifecycle. We find that the PI gradually declines with age and becomes more variable which is consistent with Deaton and Paxson (1998). In contrast the level and variability of the MI is much more constant. The patterns in the QALY, not surprisingly, falls somewhere between the two.

2 Methodology

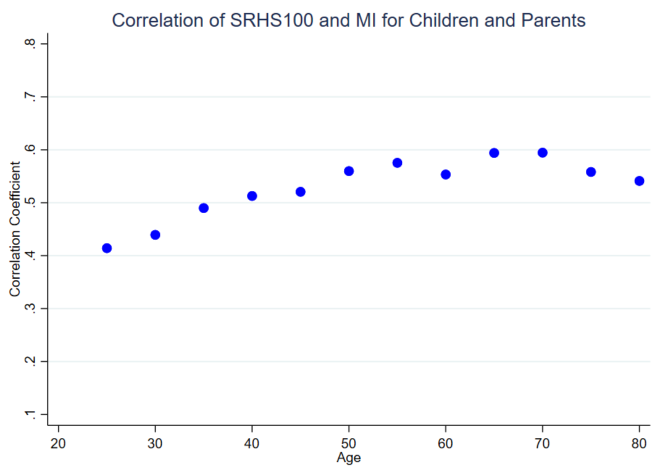
We use standard methods from the literature (e.g. Yule (1919); Solon (1992); Mazumder (2005); Halliday et al. (2021)) to estimate intergenerational persistence in health in which we regress children's health on parents' health. Specifically, we estimate the following linear model:

$$y_i^C = \alpha + \beta y_i^P + X_i\theta + \epsilon_i$$

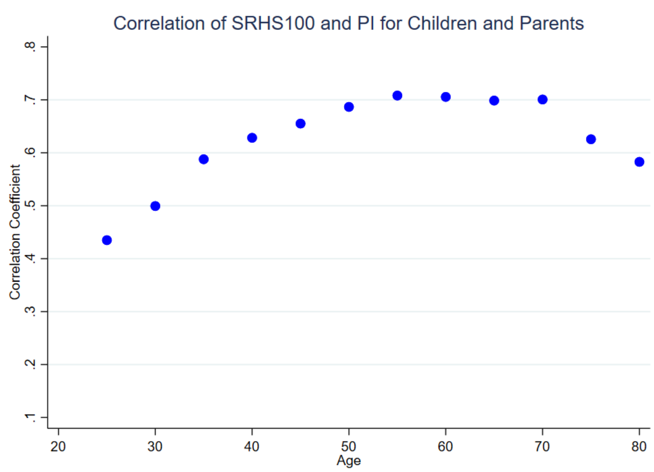
where y_i^C and y_i^P denote measurements of the health status of the child and the parent and X_i includes a parsimonious set of control variables including parent age and child

Figure 1: Correlations Between SRHS100 and PI and MI Across The Lifecycle

Panel A: Correlation Between SRHS100 and PI by Age



Panel B: Correlation Between SRHS100 and MI by Age



This displays the correlation of SRHS100 and PI/MI of individuals who are within the same 5-year age span with ages above 80 bucketed together. The sample includes children and parents who had non-missing health observations for both health outcomes.

age (averaged over all the years that the individual was in the panel), a quadratic in the ages of the parents and the children, and a dummy variable indicating if one parent's health outcome is missing. When y_i^C and y_i^P are averages of the health measurements for both generations, β is the Intergenerational Health Association (IHA). The IHA measures the extent to which parental health status persists across generations. Conversely, $1 - \beta$ measures generational mobility or how quickly health reverts to its mean. We calculate the IHA using the different health domains discussed in the previous section. In addition to the IHA, another commonly used set of mobility measures in this literature are based on rank-rank regressions. The rank-rank slope, which is mathematically equivalent to the Spearman correlation, provides an estimate of positional mobility. The expected rank of children conditional on parent rank (e.g. at the 25th or 75th percentile) can be used to assess differences across population subgroups or for distinguishing upwards and downwards mobility patterns. Rank mobility estimates are computed by estimating a model like equation (1) except with y_i^C and y_i^P representing the rank of the child and parent's age-adjusted health within a particular group. For models where we only consider sons or daughters (mothers or fathers), the reference group is sons or daughters (mothers or fathers). We also computed "all parent" and "all children" rank measures.[19]

3 Results

3.1 Intergenerational Health Association

We begin by presenting estimates of the IHA in Table 3. Columns 1 through 3 show the estimates for QALYs, the physical health index (PI), and the mental health index (MI),

[19]For the "all parent" measurement, we pooled the observations of mothers and fathers and regressed the parent health measure on a quadratic in age interacted with parent type (mother or father), indicators for missing mother and father, and fraction of the parent health observations in that family that is from the mother. The age- and gender-adjusted parent health measure is the residual. We then take the percentile rank of this measure. We employed a similar procedure for the "all children" measurement.

respectively. The rows show the estimates by the type of parent-child pair. The first row contains estimates of the IHA using the average of both parents and pooling all children. We treat this as the baseline estimate of the IHA. The subsequent rows show estimates for each parent-child gender combination.

Our baseline estimate for the IHA in overall health using QALY is 0.21. When we focus on mental health and physical health our estimates are 0.22 for the MI and 0.17 for the PI.[20,21] This suggests that there is more persistence in mental health than physical health across generations. We also consistently find that estimates of the IHA are higher when we use mother's health rather than father's health.

[20]Our 0.22 estimate for mental health is similar to that found by Johnston et al. (2013) who estimate an IHA of 0.19 using the British Cohort Study.

[21]We report estimates of the IHA in Table A7 using biomarkers. We do not find evidence of transmission in the overall biomarker index, but we do find some weaker evidence when we use the stress index. However, we caution the reader that these estimates are based on very small sample sizes.

Table 3: Intergenerational Health Associations in QALY, PI, and MI

	QALY	MI	PI
Both parents- all children	0.21***	0.22***	0.17***
N=*5,292*	(0.013)	(0.014)	(0.010)
Mother-daughter	0.21***	0.21***	0.15***
N=*2,373*	(0.018)	(0.019)	(0.014)
Mother-son	0.20***	0.22***	0.16***
N=*2,449*	(0.018)	(0.018)	(0.013)
Father-daughter	0.15***	0.14***	0.10***
N=*1,465*	(0.023)	(0.024)	(0.019)
Father-son	0.16***	0.15***	0.13***
N=*1,597*	(0.022)	(0.024)	(0.016)

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Each cell reports the coefficient, standard error, and number of observations of the parent mental health measure from a separate regression specification. The main explanatory variable is the parent's averaged health measure for all available periods above the age of 25. For regressions that use both parent's health, the parent health measure is the average of the mother's and father's health if both are available. Standard errors are in parentheses. The number of observations are in italics. The sample is the same as the sample in Table 1.

3.2 Rank-Rank Estimates

We report the rank-rank slopes in Table 4. Some of the patterns that we saw in the previous table for the IHA largely carry over to the rank-rank slope. Our baseline estimate of the rank-rank slope in overall health using the QALY is 0.21 when using both parents and pooling all children which is identical to the IHA. However, we now find virtually identical estimates of the rank-rank slope for MI (0.20) and PI (0.21). This implies that although there is faster regression to the mean for PI than MI across generations, the changes in the relative rankings of PI and MI over a generation are quite similar. This can be seen visually in Figure 2, where we compare the main estimates of the IHA and rank-rank slope for our 3 main measures.

Table 4: Intergenerational Rank-Rank Slopes in Health Measures

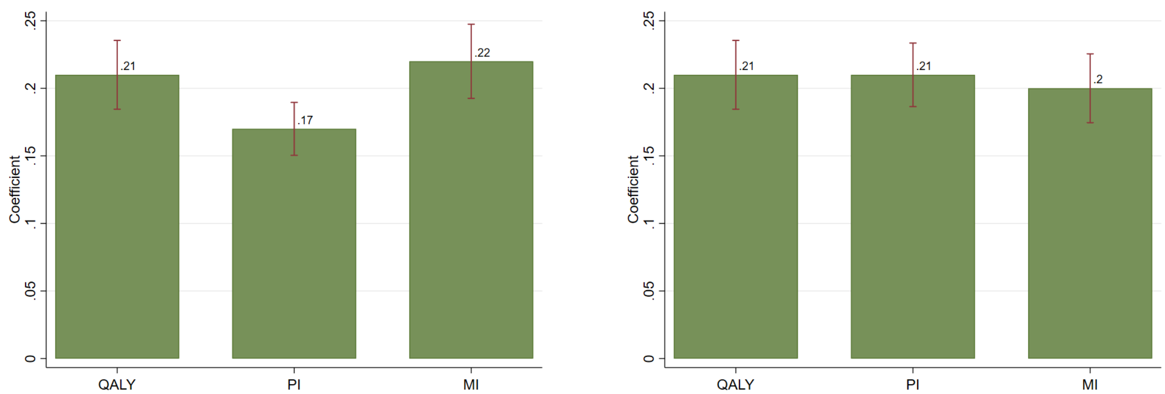
	QALY	MI	PI
Both parents- all children	0.21***	0.20***	0.21***
N=*5,292*	(0.013)	(0.013)	(0.012)
Mother-daughter	0.23***	0.22***	0.20***
N=*2,373*	(0.020)	(0.020)	(0.018)
Mother-son	0.21***	0.22***	0.21***
N=*2,449*	(0.019)	(0.019)	(0.017)
Father-daughter	0.16***	0.14***	0.13***
N=*1,465*	(0.024)	(0.024)	(0.022)
Father-son	0.17***	0.15***	0.17***
N=*1,597*	(0.023)	(0.024)	(0.020)

***$p < 0.01$,**$p < 0.05$,*$p < 0.1$
Each coefficient represents the rank-rank slope from a regression of child rank on parent rank. The ranks were generated from percentiles of an age-adjusted health measure in the respective population. Standard errors are in parentheses. Sample size is in italics. The sample is the same as in Table 1.

In Figure 3, we visually show the rank-rank relationships for QALY, PI, and MI using

Figure 2: Comparison of Intergenerational Health Persistence Estimates by Health Domain

Panel A: Intergenerational Health Associations Panel B: Intergenerational Rank-Rank Slopes



Panel A reports the results from a regression of the average child health outcome on average parent health outcome, controlling for child and parent quadratic age. Panel B reports results from a regression of the child's health rank on the parent's health rank. Health ranks are percentiles within each group (parent or child) of an age-adjusted health outcome. The sample is the same as in Table 1. The green bars represent the coefficient on the parent health outcome, and the red lines represent the standard deviation.

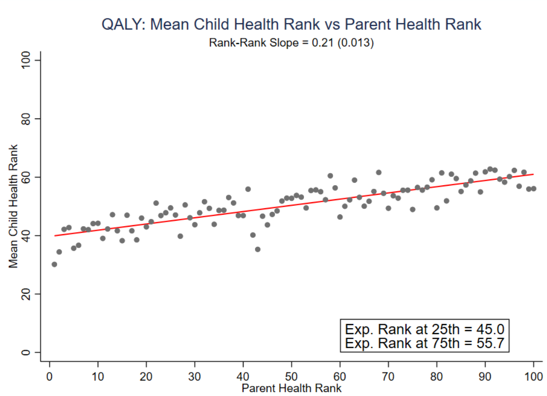
our broadest samples. We also report the conditional expected ranks at p25 and p75. The expected rank of children when their parents are in the 25th percentile of the distribution is the 45th percentile across all three domains. Similarly, their expected rank when their parents are in the 75th percentile is the 55th percentile. This suggests a reasonably large degree of both upward and downward mobility in health.

3.3 The Relative Roles of Parental Mental and Physical Health

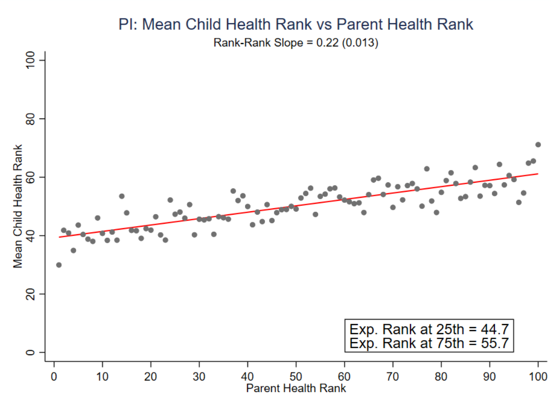
We now consider the relative impacts of parent physical and mental health on children's QALYs. To do this, we regress the child's QALY on their parents' PI and MI in the same estimation. We report the results in Figure 4. In Panel A, we estimate the model in levels and in panel B, we estimate the model using ranks. In both models we find that parents' mental health has a substantially larger association with their children's QALY than their physical health. The coefficient on MI in both models is roughly 0.20 while the

Figure 3: Rank-Rank Relationships in Intergenerational Health

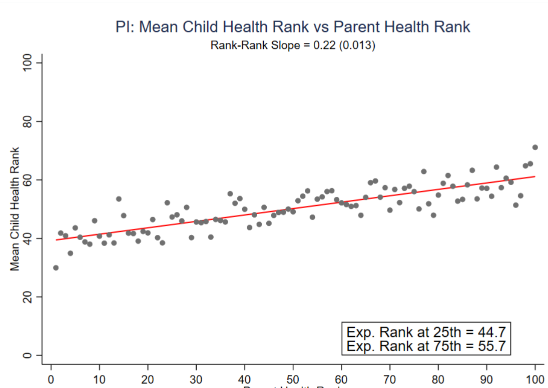
Panel A: QALY



Panel B: Physical Health Index (PI)



Panel C: Mental Health Index (MI)

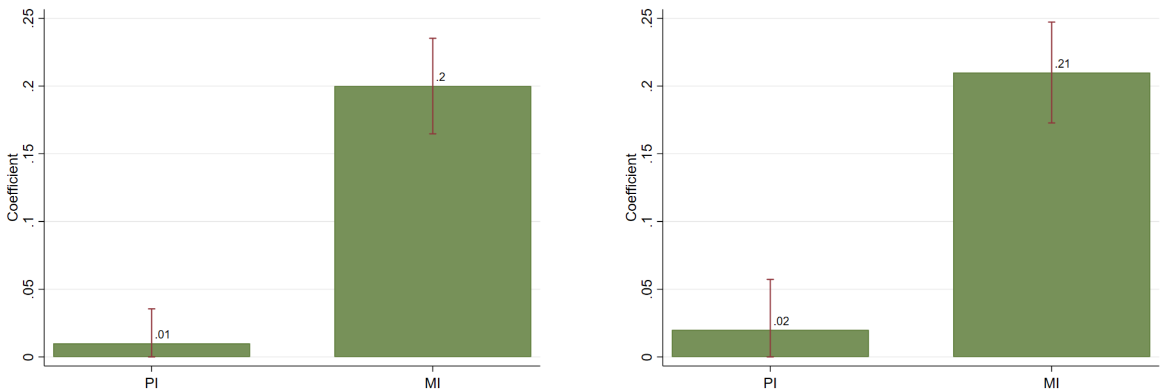


The figures display the average child health rank by parent health rank. The slope and standard deviation in parentheses is from a regression of the child's health rank on the parents' health rank. The expected ranks are the expected health rank of children with parents at the 25th and 75th percentile and are estimated from that same regression specification The sample is the same as in Table 1.

Figure 4: Coefficients of Children's QALY on Parent Health Measures, Levels and Ranks

Panel A: Level of Children's QALY on Level of Parent PI & MI

Panel B: Rank of Children's QALY on Rank of Parent PI & MI



Panel A reports the coefficients of parent MI and PI from a regression of the child QALY time-averaged health measure on the parents' time averaged MI and PI health measures. This regression includes quadratic age controls of the child and parents. Parent age is averaged across observations from MI and PI. Panel B reports the coefficients of parent MI and PI rank from a regression of child QALY rank on parent MI and PI rank. Ranks are percentiles of the age-adjusted health measure. The green bars are the coefficient on the variable of parent health outcome or rank, and the red lines represent the standard deviation.

coefficient on parent PI is barely above 0 and is not statistically significant.[22]

3.4 Interplay between parental income and health

In this section we consider how the joint distribution of income and health evolve over a generation using our rank-based framework. We now add parent income rank in addition to parent health rank to our rank-rank health regressions. Similarly, we also estimate rank-rank income regressions but now also include parent health rank. The results are shown below in Table 5.

First, we consider the results with the child health rank as the dependent variable. In column 1, we estimate a rank-rank slope estimate of 0.18 when we only consider health in

[22]The coefficients in panel A are 0.198 for MI and 0.009 for PI. For panel B, the coefficients are 0.206 and 0.018

both generations. This differs slightly from our main estimates due to the changing sample that now requires information on income. In column 2, we regress child health rank on parent income rank and obtain an estimate of 0.09. These estimates are also plotted in Figure 4. When we include the two parent rank measures in the same estimation, we see a modest reduction in the coefficient on parent health rank to 0.17. We see a much larger reduction in the slope estimate for parent income rank to 0.05. We also find a slight increase in the R^2 from column 1 (0.032) to column 3 (0.034). Thus, it appears that adding parent income does not provide much more additional information than simply using parent health information.

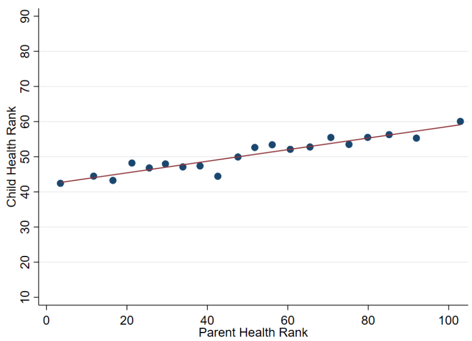
We note that this is different from what HMW found using US data. HMW estimate the unconditional coefficient on parent income rank to be much larger at 0.22 and that this coefficient falls to 0.13 when they include parent health rank. They also find an increase in R-squared from 0.075 to 0.087. Therefore, it appears that parent income plays more of a distinct role in determining children's health in the US than it does in the UK.

Table 5: Interplay of Health and Income Mobility

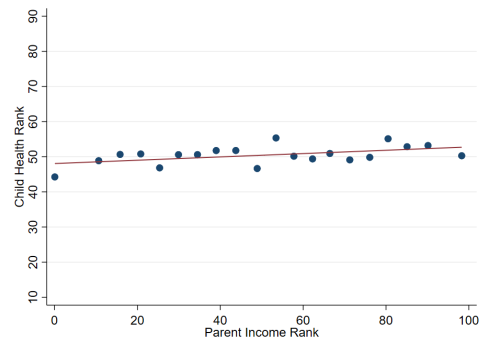
	Child Health Rank			Child Income Rank		
	(1)	(2)	(3)	(4)	(5)	(6)
Parent Health Rank	0.18		0.17	0.13		0.04
	(0.015)		(0.015)	(0.015)		(0.015)
Parent Income Rank		0.09	0.05		0.34	0.33
		(0.015)	(0.015)		(0.014)	(0.015)
Constant	41.42	45.66	39.73	43.74	33.20	31.82
	(0.855)	(0.865)	(1.017)	(0.862)	(0.817)	(0.972)
Observations	4470	4470	4470	4470	4470	4470
R^2	0.03	0.01	0.03	0.02	0.12	0.12

This table reports the coefficients from regressing child health or income rank on parent health rank and/or parent income rank. The sample is taken from the same sample as in Table 1, while further including only children with a non-missing income rank and had at least one parent with a non-missing income rank.

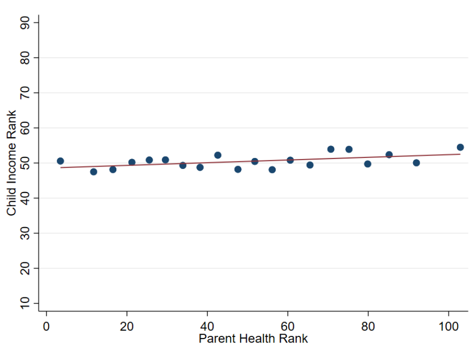
Figure 5: Interplay of Health and Income Mobility



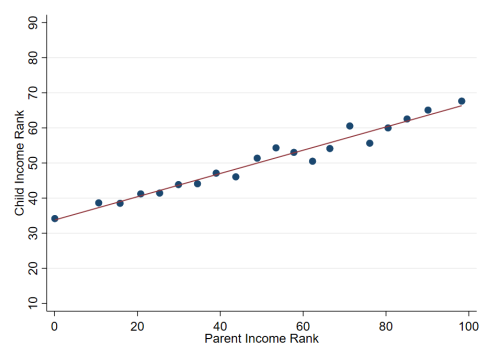
a) Child's Health versus Parent's Health Rank, controlling for parent income



b) Child's Health versus Parent's Income Rank, controlling for parent health



c) Child's Income versus Parent's Health Rank, controlling for parent income



d) Child's Income versus Parent's Income Rank, controlling for parent health

These graphs plot the average child health or income rank at each parent health or income rank, controlling for parent health or income. The sample is the same sample as in Table 5.

In the next 3 columns (4,5 and 6), child income rank is the dependent variable. In column 5, the rank-rank slope in income is estimated at 0.34. This is similar to, or somewhat below, estimates for the US (Chetty et al. (2014); Mazumder (2016); HMW). The coefficient on parent health rank alone is 0.13 as shown in column 4. When we include parent health and income rank simultaneously, we see that the coefficient on parent health rank falls to just 0.04 while the rank-rank slope in income falls very slightly to 0.33. The R^2 does not change from column 5 to column 6.

Overall, we find that the persistence in either health or income status in the UK is largely unaffected by including the other measure. This contrasts with the US, where the "cross-effects" are important. In the Appendix (see Table A8), we present similar results when we substitute parent physical health and mental health for the parental QALY.

3.5 Intergenerational Persistence in Overall Welfare

Given the importance of considering both health and income as important measures of overall welfare, in this section we explicitly combine these two dimensions of SES into a single welfare measure. We follow HMW and first convert our QALY to a monetary metric.[23] We convert a QALY to British pounds by multiplying the QALY by 60,000 pounds (HM Treasury, 2020). We combine this monetized measure of health with annual income to construct an overall welfare measure and then estimate intergenerational persistence in two ways. First, we take logs of this measure and estimate the intergenerational elasticity. Second, we convert this measure to ranks and estimate the rank-rank slope.

The results are shown in Table 6. The intergenerational elasticity is 0.31 and the rank-rank slope is 0.32. The corresponding estimates in HMW for the US were 0.37 and 0.43. This suggests that while persistence in health and income is broadly similar in both the UK and the US, persistence in overall welfare is much lower in the UK. *Prima facie*, this

[23] HMW only used a single question on general health status to create a QALY whereas we use a broader set of questions from the SF-12 to create our QALY based on Brazier et al. (2002).

Table 6: Welfare Regressions

	Log(Child Welfare) (1)	Child Welfare Rank (2)
Log(Parent Welfare)	0.31	
	(0.014)	
Parent Welfare Rank		0.32
		(0.014)
Constant	7.73	34.53
	(0.154)	(0.825)
Observations	4470	4470
R^2	0.10	0.10

The table reports the results from a regression of the child log or rank welfare index on the parent log or rank welfare index. The welfare index was constructed by first converting the time-averaged QALY health measure into monetary units by multiplying it by 60,000. We then average the monetized health measure and real annual labor income to construct an welfare measure. The sample is the same as in Table 5.

suggests that intergenerational mobility in the UK is higher than in the US. Interestingly, the difference in mobility between the US and UK is higher than what one would infer from looking at income (or health) alone. Recall, that we found the rank-rank slope in income to be 0.34 in the UK which is only modestly lower than the US estimate of 0.39 in HMW.

3.6 Heterogeneity by parental income, education, and race

In this section, we consider heterogeneity by parent education and race. When considering education, we split the sample into two distinct parent education groups as described earlier. We find that there is greater upward health mobility and greater downward mobility for families with less educated parents (see results in Figure A3 in the Appendix). We further find that these educational differences are entirely driven by mental health. However, these differences are not statistically significant so we do not wish to place too much emphasis on these results. Nevertheless, future studies, perhaps with larger samples may be able to reexamine these findings.

Looking at race, we also find some interesting patterns. White and White British children appear to have lower expected ranks in mental health throughout the parent health distribution than the BAME group. When looking at physical health, we see the reverse; the expected health rank is higher for Whites throughout the parent health distribution. However, we again caution that these group differences are not statistically significant. Nevertheless, the differences are provocative and may benefit from exploration in future research.

4 Robustness checks

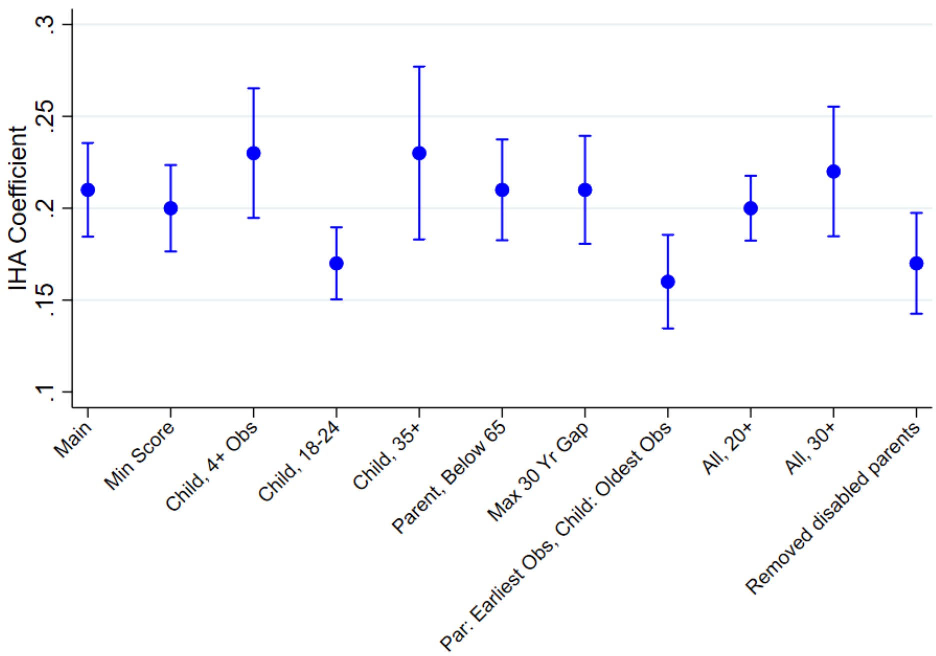
We now consider a number of robustness tests. First, we replace our QALY measure with the SRHS, which is comparable to the QALY used by HMW based only on the general health status question. We also show results with the SRHS100 described earlier (See results in Table A4.) The results are similar.

We also re-define the health measures in a number of ways and show the results in Figure 6. We replace the individual's average health measure score with their minimum score, to test whether parent-child worst health years correlate similarly. We also replace the average with the earliest observation for parents and the latest observation for children to bridge the generational age gap as much as possible. Lastly, we limit the sample to children with at least four observations to reduce noise.

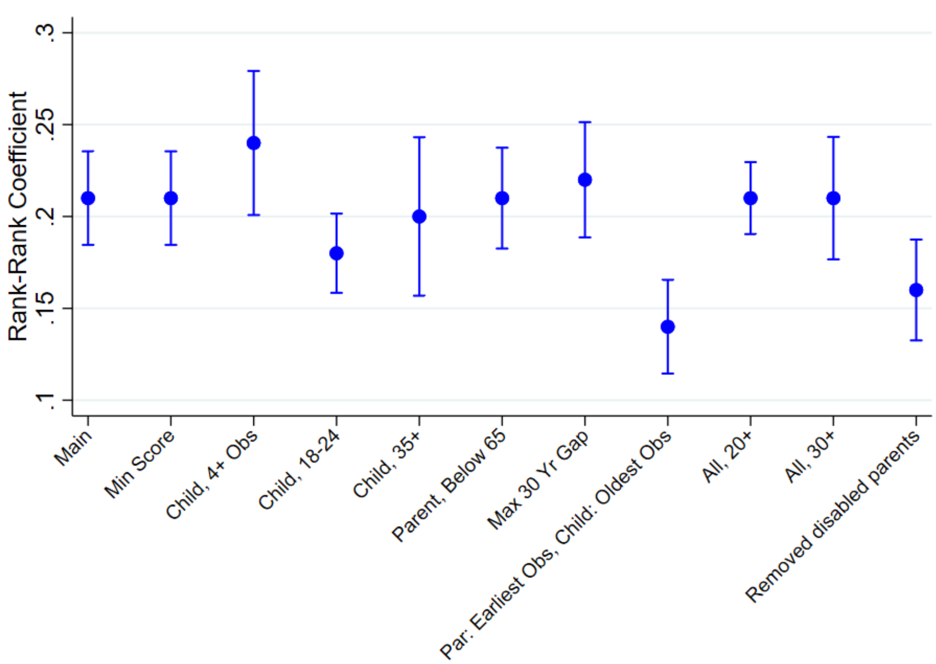
Next we check robustness to our age restriction of using only those at least 25 years old in each generation. First, we expand the sample to include children 18-24 years old. Next, we go in the opposite direction and limit the sample to children 35 and above. Similarly, we check robustness to limiting parents to those below the age of 65. We also impose a limit of a maximum of a 30 year age gap (on average) between parents and children. Finally, we exclude disabled parents from the analysis, as children who are potentially

Figure 6: Robustness Samples for QALY

Intergenerational Health Association (IHA)



Rank-Rank Estimates



also caregivers (often informally) might have a different parent-child health relationship than those who are not.

Overall, we find that the additional results are broadly in line with our main estimates. The two changes that most affect our results are using the earliest parent and oldest child observation and excluding disabled parents. In both of these cases, the results are somewhat weaker. These changes impact the estimates for MI the most and the estimates for QALY the least. (MI and PI robustness results are available in Figure A4.)

5 Conclusion

We use the British Household Panel Survey and the UK Household Longitudinal Survey to study intergenerational mobility in health in the UK. We find that both the rank-rank slope and the intergenerational health association (IHA) to be 0.21. These estimates suggest that about a fifth of parents' health status persists to the next generation in the UK. This suggests a relatively rapid rate of regression to the mean.

A unique contribution of our analysis is that we are able to separate physical and mental health. We find that there is at least as much persistence in mental health as there is in physical health. The IHA in mental health is 0.22, whereas the IHA in physical health is 0.17. However, the rank-rank slopes for physical and mental health are virtually identical. In regressions where we use both measures as independent variables, parents' mental health is a substantially stronger predictor of children's health status than parent's physical health. This is true in both levels and ranks.

We also incorporate income into our rank-rank models and show that adding parent income rank adds little more predictive power over and above parent health rank in predicting children's adult health rank. Similarly, adding parent health rank in addition to parent income rank provides little additional power in predicting child income rank. This is a departure from the US, where HMW show that the two parent measures offer more meaningful independent predictive power.

We combine income and health into an overall measure of social welfare and estimate the rank-rank slope in this measure to be 0.31. The comparable estimate for the US is 0.43 suggesting that there is greater intergenerational mobility in a broad measure of welfare in the UK than in the US. This gap is larger than would be inferred by simply looking at income mobility alone.

There are several important avenues for future research. First, researchers should utilize administrative health records to verify that estimates based on self-reported survey data are similar. Second, while we see some provocative differences in patterns by parent education and race, it would be useful for future research with larger samples to further explore these differences. Finally, a comparative study of mobility in the UK and US should be conducted where special attention is given to similar construction of samples in the two countries.

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Table A1: Construction of Health Measurements

Self-Reported Health Status (SRHS)

Question	In general, would you say your health is... Excellent (1), Very good (2), Good (3), Fair (4), or Poor (5)?
Procedure	The measure is created by following the procedure used in the PSID paper. The answer provided to the above question is rescaled to the midpoint of the appropriate HALex interval (Excellent → 97.5, Very Good → 90, Good → 77.5, Fair → 50, Poor → 15).

Physical Index (PI)

Question	This measure is derived from five of the SF-12 questions. These five questions are listed below: **1.** (Health limits moderate activities) The following questions are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much? Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling or playing golf... Yes, limited a lot (1), Yes, limited a little (2), No, not limited at all (3) **2.** (Health limits several flights of stair) Climbing several flights of stairs... Yes, limited a lot (1), Yes, limited a little (2), No, not limited at all (3) **3.** (Last 4 weeks: Physical health limits amount of work) During the past 4 weeks, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of your physical health? Accomplished less than you would like... All of the time (1), Most of the time (2), Some of the time (3), A little of the time (4), None of the time (5) **4.** (Last 4 weeks: Physical health limits kind of work) Were limited in the kind of work or other activities... All of the time (1), Most of the time (2), Some of the time (3), A little of the time (4), None of the time (5) **5.** (Last 4 weeks: Pain interfered with work) During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)? ... Not at all (1), A little bit (2), Moderately (3), Quite a bit (4), Extremely (5)
Procedure	The measure is created by following the procedure used in the PSID paper. The answer provided to the above question is rescaled to the midpoint of the appropriate HALex interval (Excellent → 97.5, Very Good → 90, Good → 77.5, Fair → 50, Poor → 15).

Mental Index (MI)

Question	This measure is derived from five of the SF-12 questions. These five questions are listed below: **1.** (Last 4 weeks: Mental health meant accomplished less) During the past 4 weeks, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)? Accomplished less than you would like… All of the time (1), Most of the time (2), Some of the time (3), A little of the time (4), None of the time (5) **2.** (Last 4 weeks: Mental health meant worked less carefully) Did work or other activities less carefully than usual… All of the time (1), Most of the time (2), Some of the time (3), A little of the time (4), None of the time (5) **3.** (Last 4 weeks: Felt calm and peaceful) These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past 4 weeks... Have you felt calm and peaceful? … All of the time (1), Most of the time (2), Some of the time (3), A little of the time (4), None of the time (5) **4.** (Last 4 weeks: Had a lot of energy) Did you have a lot of energy? … All of the time (1), Most of the time (2), Some of the time (3), A little of the time (4), None of the time (5) **5.** (Last 4 weeks: Felt downhearted and depressed) Have you felt downhearted and depressed? … All of the time (1), Most of the time (2), Some of the time (3), A little of the time (4), None of the time (5)
Procedure	Each question response is recoded (such that a higher score indicates better mental health) and converted to a 1 to 100 scale. Then the measure is aggregated each period by averaging across these five scores. The measure is missing if at least one of the responses to the five questions is missing.

Table A2: Summary Statistics for Omnibus Health Measurements

	All Children	Fathers	Mothers
SRHS (Scale: 0 to 100)			
Age	32.89	60.74	59.57
	(9.29)	(10.08)	(11.67)
Overall Score	80.80	70.50	68.14
	(17.81)	(21.96)	(23.13)
Years of Health Measurement	3.03	4.10	4.11
	(1.75)	(1.78)	(1.69)
Number of Observations	5,737	2,607	4,093
SRHS100 (Scale: 0 to 100)			
Age	32.89	60.74	59.57
	(9.29)	(10.08)	(11.67)
Overall Score	72.48	61.13	59.13
	(19.62)	(20.26)	(20.92)
Years of Health Measurement	3.03	4.10	4.11
	(1.75)	(1.78)	(1.69)
Number of Observations	5,737	2,607	4,093

Note: Averages are reported. Standard deviations are in parentheses. This sample includes individuals who have at least one health measurement observation above the age of 25 and are matched to at least one parent with at least one health measurement observation above the age of 25. Age is the averaged for all available health measures.

Table A3: Correlation Matrix of Health Measures in the full UKHLS

Complete UKHLS	SRHS100	PI	MI	Biomarker	Stress
SRHS100	1.00				
	29,160				
PI	0.68	1.00			
	22,547	*25,654*			
MI	0.58	0.64	1.00		
	22,605	*25,605*	*25,714*		
Biomarker	0.31	0.31	0.14	1.00	
	4,570	*4,547*	*4,544*	*4,570*	
Stress	0.22	0.24	0.14	0.59	1.00
	5,004	*4,975*	*4,972*	*4,570*	*5,004*

Table A4: Comparing Intergenerational Health Associations in Various Measures of SRHS

	SRHS	SRHS100
Both parents- all children	0.22***	0.23***
N=*5,737*	(0.012)	(0.012)
Mother-daughter	0.21***	0.23***
N=*2,328*	(0.018)	(0.020)
Mother-son	0.22***	0.24***
N=*2,910*	(0.016)	(0.017)
Father-daughter	0.15***	0.17***
N=*1,479*	(0.022)	(0.025)
Father-son	0.16***	0.18***
N=*1,947*	(0.019)	(0.021)

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Each cell reports the coefficient, standard error, and number of observations of the parent mental health measure from a separate regression specification. The main explanatory variable is the parent's averaged health measure for all available periods above the age of 25. For regressions that use both parent's health, the parent health measure is the average of the mother's and father's health if both are available. Standard errors are in parentheses. The number of observations are in italics. The sample is the same as the sample in Table A2.

Table A5: Comparing Rank-rank slopes in Various Measures of SRHS

	SRHS	SRHS100
Both parents- all children	0.22***	0.23***
N=*5,737*	(0.012)	(0.012)
Mother-daughter	0.21***	0.23***
N=*2,328*	(0.018)	(0.020)
Mother-son	0.22***	0.24***
N=*2,910*	(0.016)	(0.017)
Father-daughter	0.15***	0.17***
N=*1,479*	(0.022)	(0.025)
Father-son	0.16***	0.18***
N=*1,947*	(0.019)	(0.021)

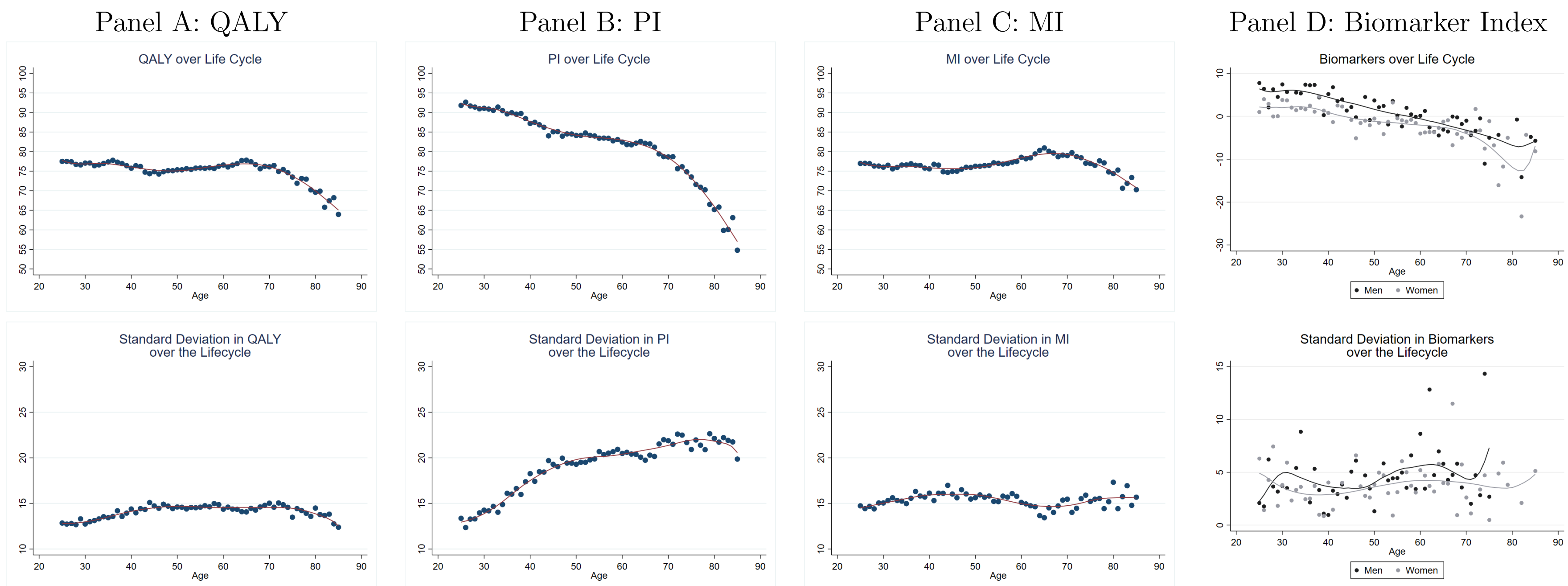
Each coefficient represents the rank-rank slope from a regression of child rank on parent rank. The ranks were generated from percentiles of an age-adjusted health measure in the respective population. Standard errors are in parentheses. Sample size is in italics. The sample is the same as the sample in Table A2.

Table A6: Biomarkers in UKHLS

Biomarker Group	Health Outcome/Applications	Specific variable
Cholesterol	Cardiovascular disease (CVD)	Cholesterol HDL cholesterol
Triglycerides	CVD	Triglycerides
Glycated hemoglobin (HbA1c)	Diabetes, used to identify those who have undiagnosed diabetes or do not manage their diabetes well	Glycated haemoglobin
Ferritin	Lower measures indicate poor nutrition, anemia. Higher measures indicate haemochromatosis (associated w/ heart disease + diabetes)	Ferritin
Hemoglobin	Poor nutrition, anemia	Hemoglobin
Liver function tests	How well liver functions, Linked to alcohol, drugs, obesity + other diseases	Albumin Alkaline phosphatase Alanine transaminase Aspartate transaminase Gamma glutamyl transferase
Creatinine	Kidney diseases (chronic kidney disease)	Creatinine
Urea	Kidney diseases (acute or chronic kidney disease)	Urea
Insulin-like growth factor 1 (IGF-1)	Growth + development, diet, diabetes, cancer, heart disease	Insulin-like growth factor 1
Dihydroepiandrosterone sulphate (DHEAs)	Cardiovascular disease (CVD), muscle strength, cognition	Dihydroepiandrosterone sulphate
C-reactive protein (CRP)	Measure of inflammation (due to injury/infection, response to stress), CVD, mortality	**C-reactive protein**
Fibrinogen	Measures of inflammation (due to injury/infection, response to stress)	**Clauss fibrinogen**
Cytomegalovirus (CMV) seropositivity	“wear + tear” on immune system, chronic stress, diabetes	**Cytomegalovirus IgG** **Cytomegalovirus IgM**

Biomarkers are from waves 2 and 3 of the UKHLS. Those denoted in **bold** are also part of the Stress Index

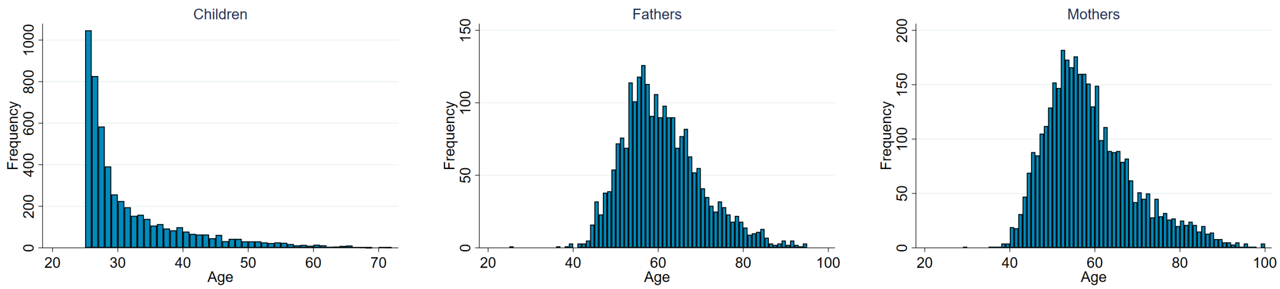
Figure A1: Health Measures Over the Lifecycle



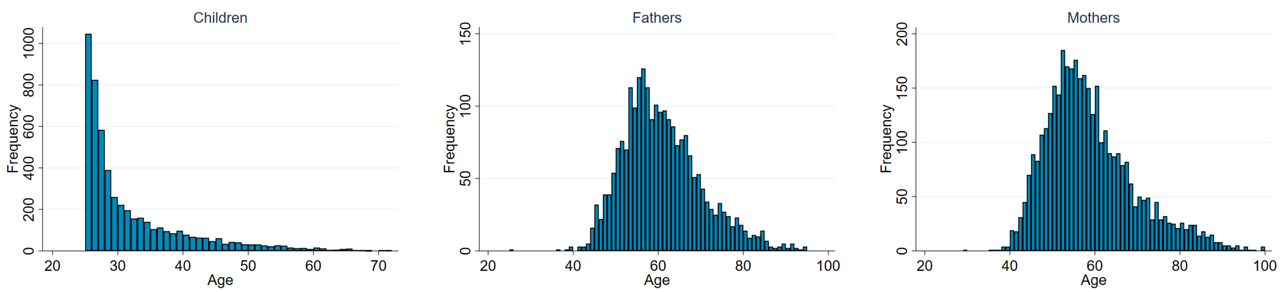
Panels A to C display the average health outcome by age group. Panel D displays the average Biomarker value by age and gender. Ages are each individual are averaged for all available health measures. Ages 85 and above are binned together. The sample includes observations from both children and parents found in the same sample as in Table 1.

Figure A2: Age Distribution of Children, Mothers, and Fathers

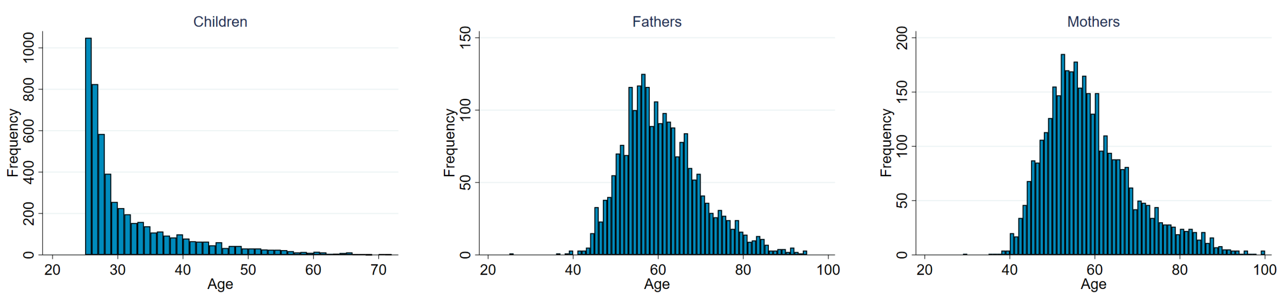
QALY



Physical Health Index (PI)

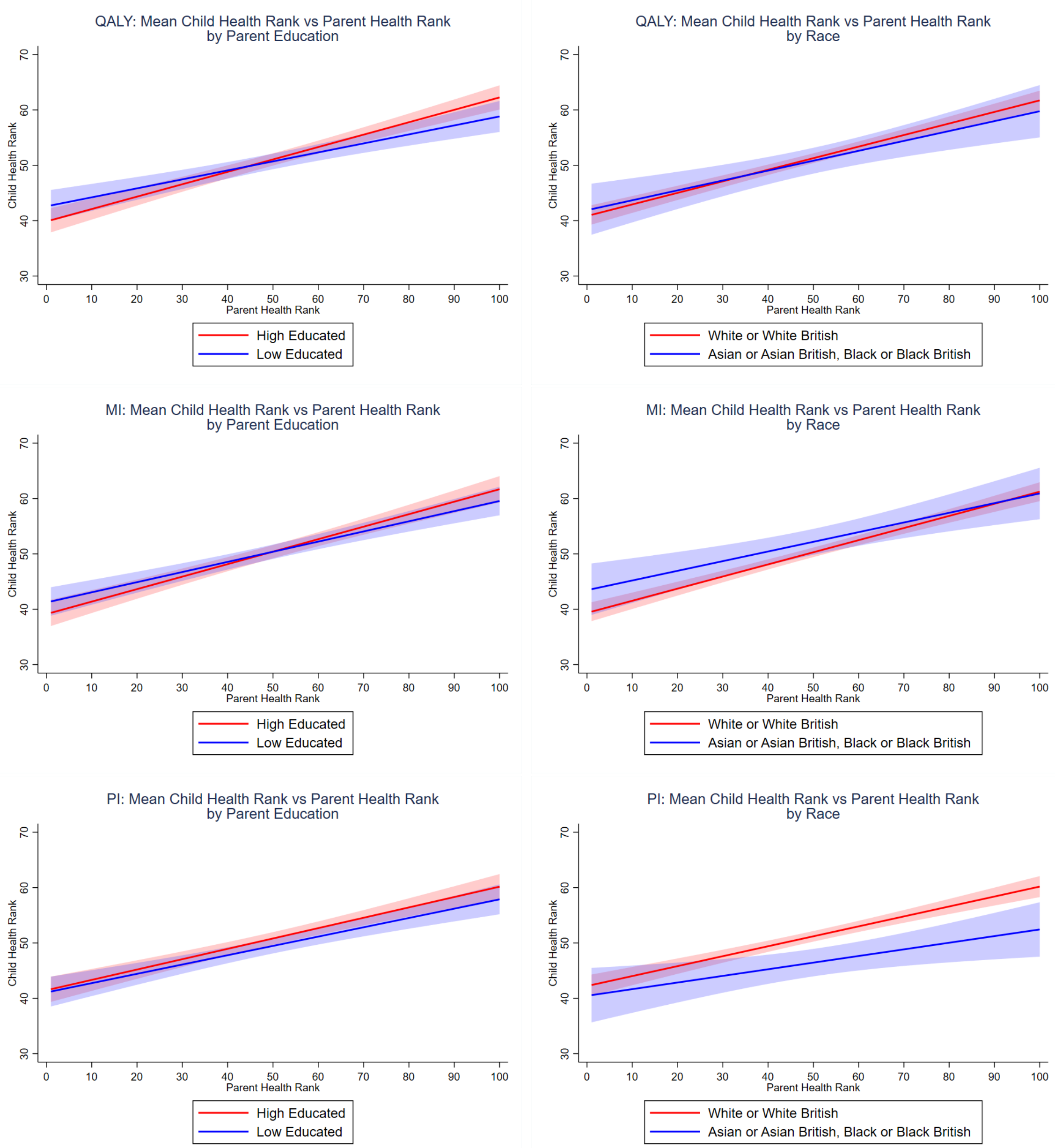


Mental Health Index (MI)



Ages for each individual are averaged for all available health measures. Ages are binned by year. The sample is the same as in Table 1.

Figure A3: Rank-Rank Relationships by education and race



These graphs show the slope from a regression of the child health rank on parent health rank by the parent's education and the child's race. 95% Confidence bands are represented by the dashed lines. Education is defined as the highest level across both parents for the most recent survey period. The child's race is taken from the most recent survey period.

Table A7: Intergenerational Health Associations in Biomarkers

	Biomarker Index	Stress Index
Both parents- all children	0.06	0.12**
	(0.059)	(0.056)
	235	*275*
Mother-daughter	-0.06	0.18*
	(0.096)	(0.099)
	94	*113*
Mother-son	0.12	0.19*
	(0.085)	(0.100)
	86	*98*
Father-daughter	0.06	0.03
	(0.155)	(0.099)
	58	*70*
Father-son	0.15	-0.06
	(0.136)	(0.107)
	54	*67*

***$p < 0.01$,**$p < 0.05$,*$p < 0.1$
Notes: Per Table3.

Table A8: Interplay of Health and Income Mobility Controlling for MI and PI

	Child Health Rank			Child Income Rank		
	(1)	(2)	(3)	(4)	(5)	(6)
Parent PI Rank	0.01		0.00	0.08		0.03
	(0.020)		(0.020)	(0.020)		(0.019)
Parent MI Rank	0.18		0.17	0.08		0.03
	(0.020)		(0.021)	(0.021)		(0.020)
Parent Income Rank		0.09	0.05		0.34	0.33
		(0.015)	(0.015)		(0.014)	(0.015)
Constant	40.84	45.66	39.24	42.17	33.20	31.06
	(0.904)	(0.865)	(1.045)	(0.910)	(0.817)	(0.999)
Observations	4470	4470	4470	4470	4470	4470
R^2	0.03	0.01	0.04	0.02	0.12	0.12

This table reports the results from regressing child health or income rank on parent PI/MI and/or income rank. The sample is the same as in Table 5.

Figure A4: MI & PI: Robustness Samples