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Why Intelligent People Live Longer

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Numerous studies find a positive relationship between cognitive ability, IQ as measured in childhood or youth, and subsequent survival. Explanations range from the idea that low ability is an indicator of adverse systemic events in early life to the idea that high cognitive functioning is required continuously to maintain health and reduce threats to survival. The Wisconsin Longitudinal Study (WLS) has followed a large cohort of Wisconsin high school seniors from ages 18 to 69. As expected, in the WLS survival varies positively with adolescent IQ. However, rank in high school class accounts completely for the relationship between IQ and survival, and it has a much larger effect on survival. These findings suggest that cognitive functioning improves survival by promoting behaviours that boost health status, minimize exposure to known risks and optimize returns to health producing inputs, and that such behaviours are firmly in place by late adolescence.

In a large American sample of high school graduates the association between early (adolescent) IQ and survival from ages 18 to 69 is entirely explained by a measure of academic performance (rank in high school class) that is only moderately associated (r = 0.6) with IQ. Moreover, the effect of rank in high school class is about three times larger than that of IQ. This finding suggests that higher cognitive functioning improves the chances of survival because it leads to behaviours that are responsible, well organized, timely, and appropriate to the situation, and such patterns of behaviour are well established by late adolescence.

Deary's [1] essay in this journal noted that an association between "early life intelligence and mortality" has been established "across different populations, in different countries, and in different epochs." He offered four potential explanations of this ubiquitous finding: higher education, healthy behaviours, early insults to the brain, and system integrity: "First, … intelligence is associated with more education, and thereafter with more professional occupations that might place the person in healthier environments. …. Second, people with higher intelligence might engage in more healthy behaviours. … Third, mental test scores from early life might act as a record of insults to the brain that have occurred before that date. … Fourth, mental test scores obtained in youth might be an indicator of a well-put-together system. It is hypothesized that a well-wired body is more able to respond effectively to environmental insults" (p. 176). The essay referred only in passing to a finding that "being more dependable or conscientious in childhood is also significantly protective to health"[2,3], yet this may be the key to explaining the association between IQ and survival.

Research on the association between early IQ and survival has led to the development of a nascent subdiscipline, cognitive epidemiology[4-9]. Much of this research has been integrated in a comprehensive account of follow-ups to the Scottish Mental Surveys[9]. In addition to overall mortality[10-16], IQ has been associated with accidental deaths[17-21], with homicide[22], with hypertension, stroke, and cardiovascular disease[15,23-26], with quitting smoking[27], and with time to menopause[28-31]. These studies provide little evidence that differential survival by IQ is explained by the correlation of IQ with social and economic origins. There is mixed evidence that the effects of IQ on mortality are mediated by education and socioeconomic success[32-34].

Some of the risk factors that account for health differentials, e.g., smoking, drinking, overeating, and lack of exercise, are known by almost all adults. The important question is not whether these risks are known and understood, but why people continue to ignore them. Yet interpretations of correlations between IQ and morbidity or mortality have sometimes been speculative and exaggerated. One researcher has suggested that IQ is "the epidemiologists' elusive fundamental cause of social class differences in health"[35], thus implying that it may account for the influence of socioeconomic standing on survival. Deary has written "Whether you live to collect your old-age pension depends in part on your IQ at age 11. You just can't keep a good predictor down"[36]. Batty and Deary interpret the IQ differential as attributable to excessive cognitive demands in healthcare settings[37]: "Given their inherently complex and sometimes conflicting nature, healthcare messages, treatment regimens, and preventative strategies perhaps surpass the cognitive abilities of some people. If this is the case—and bearing in mind that oversimplification of advice might reduce effectiveness substantially— proactive involvement of healthcare providers is warranted to reduce health inequalities attributable to differences in cognitive ability." While cognitive limits may well affect understanding and compliance in healthcare settings, there is not a shred of evidence that this accounts for the life-long association between IQ and survival.

Moreover, the recent literature on IQ and survival, along with much other epidemiological and demographic literature, ignores the implications of findings that identify variables(s) as statistically significant predictor(s) of an outcome. Halting the analysis at the point where estimates of relative hazard or odds ratios and their standard errors are obtained ignores the possibility that their ultimate implications for outcomes with policy significance can be and sometimes are utterly trivial, despite their statistical reliability.

For example, consider the recent paper in which Batty et al.[11] estimated the relationship between IQ (military induction test) and mortality among 1 million Swedish men for approximately 20 years (from roughly age 18 to age 38). Their main finding is a highly significant hazard ratio of 1.32 for the association between a one standard deviation difference in IQ and the likelihood of death. While this effect appears to be large, it has almost no impact on expected years of life within the age span covered by the survey (roughly 20 years). Of the 968,846 men in the Swedish cohort, just 14,498 men died. At the ages in question, the overall hazard is small and virtually constant, so it is fair to approximate the hazard as 14,498/(20 * 968,846) = .0007482. This implies about19.85 years of expected life, that is, just 0.15 years below the maximum of 20. If average IQ in the cohort were a full standard deviation higher – a most unlikely event – the hazard would fall to .0005668, and the expected number of years of life would rise to 19.89 years, just 0.04 years higher than before. To be sure, under this assumption, the number of deaths would fall by 24 percent, but that merely underscores the extremity of assuming a one standard deviation rise in average IQ.

Is the association between IQ and survival a consequence of purely cognitive processes? Or are there other intervening mechanisms? If IQ were immutable, which is increasingly doubtful[38], what avenues of intervention are available? What good would it do to intervene in the medical care setting if the influence of cognition is pervasive in people's lives? Is cognition about health issues and medical procedures the real issue? And of what importance is the effect of IQ on survival, relative to other known correlates?

Data

The Wisconsin Longitudinal Study (WLS) has followed the lives of 10,317 Wisconsin high school graduates of 1957, a simple random sample of one third of their graduating class[39]. The Wisconsin sample covered 70 to 75% of appropriately aged youth in

Wisconsin[40]. However, participants are all high school graduates and almost all non-Hispanic whites (rather like 2/3 of Americans of their birth cohorts).

Gender was ascertained in a spring 1957 survey of the graduates. Cognitive ability (IQ) was measured in the junior year of high school (1956) using the Henmon-Nelson Test of Mental Ability[41-43], and rank in high school class was ascertained directly from high school records. In U.S. high schools, rank in class is based on the mean grade assigned in courses taken throughout the high school career. Parents' incomes were obtained from federal income tax forms filed with the State of Wisconsin and averaged over the years 1957 to 1960, while parents' occupations were ascertained from the tax forms or from surveys conducted in 1957 and 1975. In this analysis, IQ, high school rank, and parents' income were each categorized in fifths of their distribution, and family head's occupation was classified as either farm or non-farm. Other social background variables were measured, but were not associated with survival. Years of death from 1957 through 2008 were obtained from the Social Security Death Index, from vital records of the State of Wisconsin, or from survivors of the decedent. Of the 10,317 members of the sample, 1603 had died by the end of 2008, and 8701 were known to have survived. Mortality status was unknown in 13 cases.

In fewer than 7 percent of cases, data on high school rank, parents' incomes, or parents' occupations were multiply imputed following the procedure suggested by Van Buuren et al.[44] and implemented by Royston in the ICE routine in Stata 10[45-47]. Conditional on each of five such imputations, missing years of death between 1957 and 1975 were multiply imputed for 50 cases assuming a Weibull distribution. Of these, 20 died before 1964, 22 between 1964 and 1975, and 8 between 1957 and 1975. Analyses of survival were estimated in Stata 10 assuming a Weibull distribution for each of the 25 fully imputed sets of data. In this large sample, adjustment of standard errors for the effect of imputation would be negligible. Imputations and estimates were also carried out assuming a Gompertz distribution, confirming the findings reported here.

Model

The workhorse of our analyses is a parametric survival model defined on the age interval (18,68). Individuals whose survival was not ascertained (N = 13) or who survived to 2009 (N = 8701) were censored. The model is as follows:

$$\mu(x) = \mu(x) = \mu_o \exp(\beta\mathbf{X})\exp(\beta\mathbf{X}) \quad (1)$$

where $\mu(x)$ is the force of mortality evaluated at x, μ_o is a baseline force of mortality evaluated at age x, β is a vector of parameters and **X** is a vector of covariates. For pragmatic reasons we choose a Weibull hazard to represent the baseline $\mu_o(x)$ thus imposing the following parametric form:

$$\mu_o(x) = \gamma\rho x^{(\rho-1)} \quad (2)$$

where γ is a level parameter and ρ is the shape parameter. It is well-known that a Weibull hazard can be parameterized as a Gompertz hazard defined on the log of duration (rather than on duration). Both functions capture the pattern of mortality well from adolescence to late adulthood though the Weibull function rises too slowly at ages above 75 to represent mortality well above those ages. However, since the Gompertz and Weibull perform equally well below ages 75, and since a Weibull parametric hazard is also an accelerated failure time model (and hence more robust to some violations of the proportionality assumption), we chose to present results using the Weibull parameterization.

In addition to estimating the vector of parameters, β, along with ρ and γ, we calculated the predicted integrated hazard, $I(y; \beta, \rho, \gamma)$, for selected subgroups (setting all the variables not defining the subgroups to their sample mean) and the probabilities of surviving $S(x; \beta, \rho, \gamma) = \exp(-I(y; \beta, \rho, \gamma))$, and finally, the expected duration in the intervals (x, 68) for all x between 18 and 67. The latter quantities are much better measures of the ultimate effects of selected covariates than the vector, β, or the relative hazards, $\exp(\beta)$.

Empirical Estimation

Our estimation strategy consisted of building successively more complicated models while paying close attention to the role of common causes and mediating mechanisms. The model of relations we have in mind is shown in Figure 1. Our main conjecture is that the effects of IQ are mediated by variables that could be correlated with it but that also represent traits quite different from intellectual skills and are more suitably thought of as indicators of character and personality as well as by behaviours during adulthood.[2] The model in Figure 1 includes constructs whose indicators are not included in our analysis. Among these are variables representing early childhood environments and events that may have shaped or constrained IQ. Thus, the estimated effect of IQ overstates its true effects if early childhood conditions have independent effects on IQ and on mortality [38,48,49].

Findings

Figures 2 and 3 describe observed mortality differentials by IQ and high school rank. Figure 2 shows Nelson-Aalen cumulative hazard estimates of mortality among the top and bottom fifths of Wisconsin graduates in IQ. The two groups have very similar cumulative mortality through the first 20 years after graduation, but life chances diverge modestly thereafter. On the same scale, Figure 3 shows corresponding estimates of the cumulative hazard of mortality for the top and bottom fifths in high school rank. Here, the mortality experience of the two groups diverges within 10 years of graduation, and by

2008, the cumulative risk of death is nearly twice as large among the lowest as among the highest ranking students. Plainly, while there is differential mortality by IQ in the Wisconsin cohort, the differential by high school rank is far larger.

Table 1 shows estimated parameters of Weibull models of survival in the Wisconsin cohort. Model 1 includes only a dummy variable for gender and dummy variables for fifths of the IQ distribution. As one should expect, men experience much higher mortality than women, while mortality decreases as IQ increases. The odds of mortality are almost 20 percent lower in the top fifth of IQ than in the bottom fifth. Model 2 adds social background variables to the model. Graduates with farm background have a mortality advantage that is roughly as large as that of the top fifth in IQ relative to the bottom fifth, while the differential in mortality by parents' income is substantially larger than that by IQ. The odds of mortality among the top fifth of graduates in parents' income are more than 25 percent less than among the bottom fifth. However, the effect of IQ barely changes when the social background variables are added to the model.

In model 3, high school rank is added; its effects are large and statistically reliable. The odds of mortality are more than 40 percent lower in the top fifth of the class than in the bottom fifth; the obverse is that the odds of mortality are 2/3 greater in the bottom than in the top fifth. The inclusion of high school rank in model 3 scarcely alters the effects of the social background variables, but it has marked effects on the estimated coefficients of gender and of IQ. In model 2, the odds of mortality among men are 62 percent greater than among women, but in model 3, the gender differential is reduced to 51 percent. The reason is that high school girls earn higher grades than high school boys of equal IQ – by nearly half a standard deviation – and that accounts in part for the gender differential in mortality.

More important, once high school rank enters the model, there are no longer any statistically significant differentials in mortality by IQ. That is, the association between IQ and mortality is entirely explained by its correlation – presumably a causal relationship – with high school rank. However, that correlation is far from perfect. Among the Wisconsin graduates, the correlation is r = 0.6, which is to say that nearly two thirds of the variance in high school rank is independent of IQ. While the independent features of high school rank may be partly cognitive, they must also include aspects of character, habit, and personality. Personal characteristics that lead students to do the right thing in the right way at the right time and place when they are in secondary school evidently persist in ways that lead to greater longevity.

Table 2 shows selected estimates of expected years of life, based on the Weibull models, during the 52 year period of observation. In models 1 and 2, women outlive men by 1.3 years, but in model 3 women's advantage is reduced to 1 year. In models 1 and 2, the highest fifth in IQ outlive the lowest fifth by about half a year, but that differential is actually reversed in model 3. Both in model 2 and in model 3, farm youth outlive nonfarm youth by about half a year, while high income youth outlive low income youth by almost a year. However, the largest differential in expected years of life is 1.4 years, between youth in the top and bottom fifths of their high school classes.

Discussion

Taken at face value, these findings suggest substantial modification in the previously offered explanations for the association between IQ and survival. There is no need to invoke "early insults to the brain" or "system integrity" to explain the association, nor is it necessarily mediated by post-secondary schooling – though some studies have found that the IQ-survival relationship is partly mediated by educational attainment[33]. In fact, the latter finding may be attributable to the fact that high school grades, more than test scores, account for the completion of college[50]. Neither is it necessary to invoke health literacy, except to the extent that it may reflect highly motivated or compliant behaviour. The leading candidate to explain the IQ-survival relationship would appear to be lifelong attitudinal and behavioural patterns that contribute both to academic success in secondary school and to systematic accumulation of health benefits.

The present analysis cannot claim to parse the content of high school rank in terms of personality or motivation. That should be a goal of future research. What does seem clear is that it is a cumulative indicator of responsible, compliant behaviour, of consistently doing the right thing in the right way at the right time and place. That possibility has been noted by Deary[1]: "For example, it seems that, independently of any association with intelligence, being more dependable or conscientious in childhood is also significantly protective to health." Class rank in itself probably has little or no causal importance, and, to be sure, not everyone can be at the head of the class. The important things more likely are the personal characteristics, the habits and tendencies that lead to academic success.

Where educational attainment or other economic characteristics have been shown to mediate the association between IQ and survival, cognitive epidemiologists have often attempted to diminish such findings with the claim that the mediating variables are merely proxies for IQ. Such arguments are fallacious. To the extent that IQ is associated with survival, independent of social background and other prior events and circumstances, its effects are real, and they are not diminished by the introduction of mediating variables. However, the mediating variables must have sources of variability other than IQ, whose effects are necessarily distinct from those of IQ. In the present analysis, for example, the correlation between IQ and high school rank is just 0.60, so 64 percent of the variance in rank is independent of IQ and cannot properly be labelled a proxy effect.

The present analysis locates the explanation of the IQ-survival association firmly in personal characteristics, attitudes, and behaviours that are well established by late adolescence. However, it also raises many more questions than it answers. Are the present findings peculiar to the social circumstances of those who grew up in mid-20^{th} century America? Among the many studies establishing the correlation between IQ and survival, are there others in which these findings can be tested? What are the specific, behaviourally relevant characteristics of individuals that are reflected both in high school rank and in later survival? Throughout life, what salutary behaviours are affected by them? And perhaps most important, how can those behaviours be altered, even in the absence of responsible habits in adolescence?

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Author information: A public-use version of WLS data is available from the Inter-University Consortium for Political and Social Research (ICPSR) at the University of Michigan or the WLS Web site (http://www.ssc.wisc.edu/wlsresearch/). Reprints and permissions information is available at www.nature.com/reprints. Correspondence and requests for materials should be addressed to R.M.H. (hauser@ssc.wisc.edu).

Table 1. Estimated Parameters of Weibull Models: Survival of Wisconsin High School Graduates from 1957 to 2009

Variable	Model 1	Model 2	Model 3
Constant	-11.437	-11.244	-11.105
	(0.240)	(0.245)	(0.247)
Shape	0.879	0.879	0.880
	(0.025)	(0.025)	(0.025)
Male	0.479	0.482	0.410
	(0.051)	(0.051)	(0.053)
Medium Low IQ	-0.141	-0.136	-0.058
	(0.075)	(0.075)	(0.077)
Medium IQ	-0.061	-0.049	0.070
	(0.074)	(0.074)	(0.079)
Medium High IQ	-0.213	-0.195	-0.026
	(0.079)	(0.079)	(0.087)
High IQ	-0.216	-0.188	0.069
	(0.080)	(0.081)	(0.097)
Farm background		-0.204	-0.183
		(0.070)	(0.071)
Medium Low Parents' Income		-0.211	-0.205

	(0.078)	(0.078)
Medium Parents' Income	-0.140	-0.133
	(0.079)	(0.079)
Medium High Parents' Income	-0.220	-0.221
	(0.081)	(0.081)
High Parents' Income	-0.319	-0.312
	(0.084)	(0.084)
Medium Low Rank in High School Class		-0.201
		(0.075)
Medium Rank in High School Class		-0.301
		(0.079)
Medium High Rank in High School Class		-0.249
		(0.084)
High Rank in High School Class		-0.513
		(0.100)

Note: Parenthetic entries are approximate standard errors.

Table 2. Expected Years of Life from 1957 to 2008 by Gender, IQ, Farm Origin, Parents' Income, and Rank in High School Class: Wisconsin Longitudinal Study

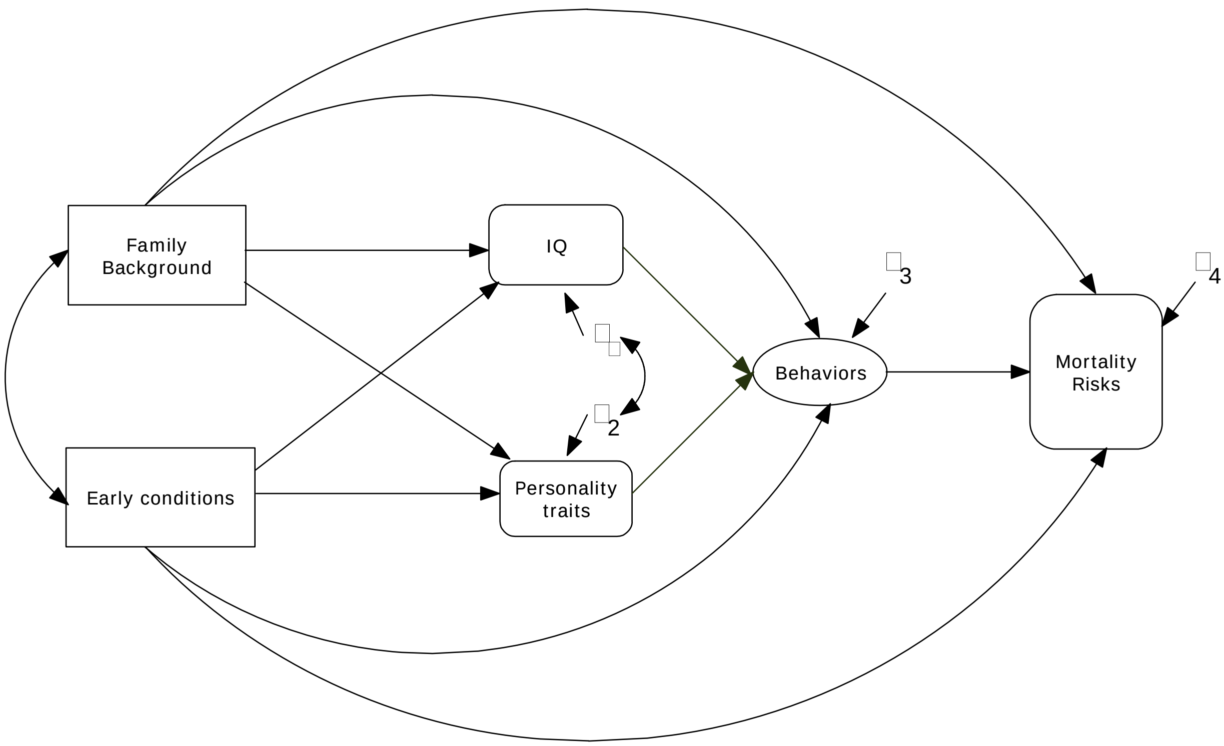
Variables in Weibull Model	Men	Women	Low IQ	High IQ	Farm	Nonfarm	Low income	High Income	Low rank	High rank
Model 1: Gender and IQ	50.5	51.8	50.9	51.5						
Model 2: Gender, IQ, Farm Origin, Parents' Income	50.5	51.8	50.9	51.4	51.6	51.1	50.7	51.6		
Model 3: Gender, IQ, Farm Origin, Parents' Income, Rank in High School Class	50.7	51.7	51.3	51.1	51.6	51.2	50.8	51.6	50.5	51.9

Figure Legends

Figure 1. Relations between factors producing mortality risks at adult ages

Figure 2. Nelson-Aalen Cumulative Hazard Estimates by IQ

Figure 3. Nelson-Aalen Cumulative Hazard Estimates by Class Rank


Family
Background
IQ
Early conditions
Personality
traits
Behaviors
Mortality
Risks
2
3
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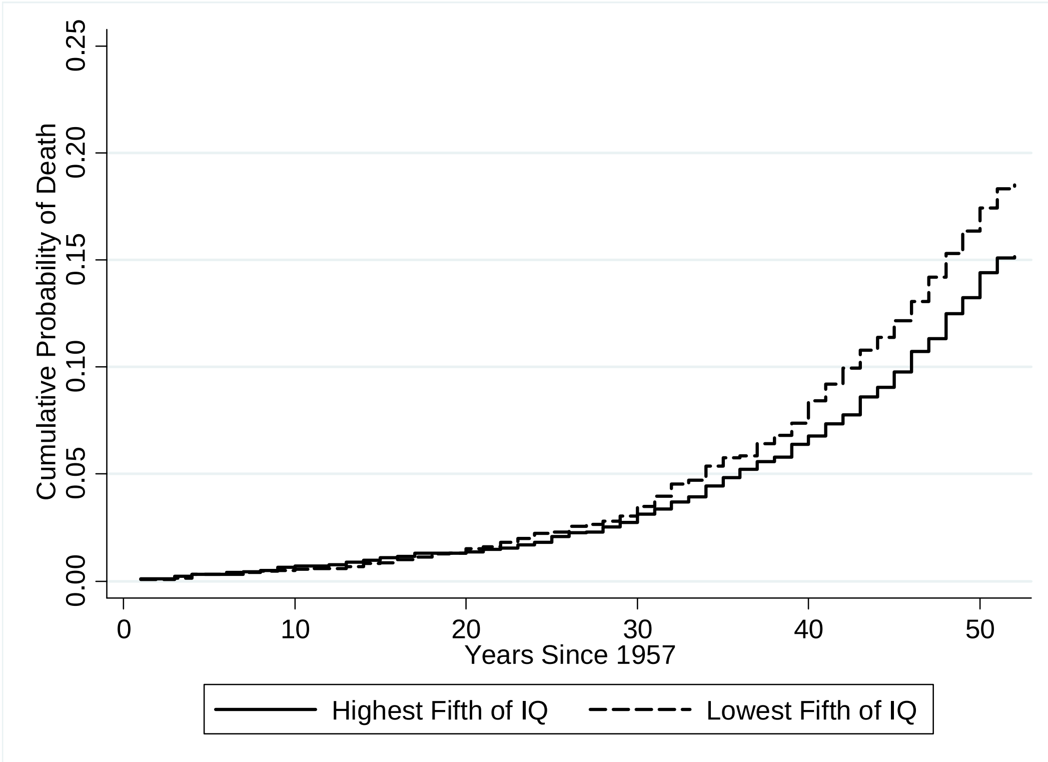
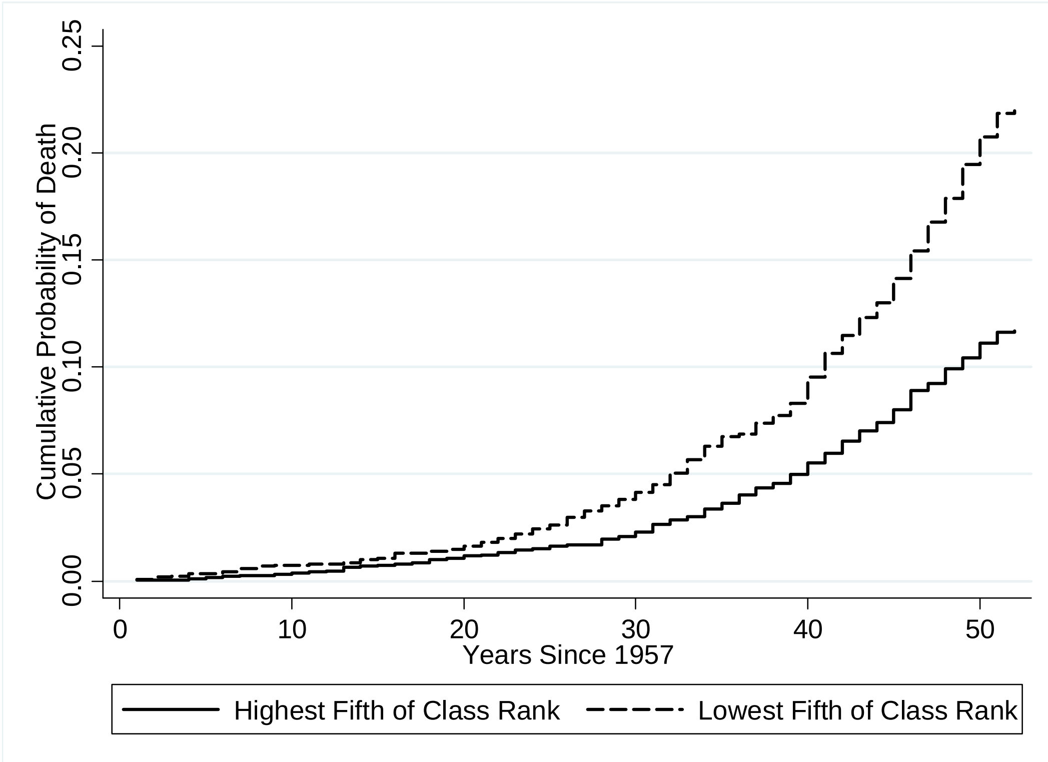

Cumulative Probability of Death
0.00
0.05
0.10
0.15
0.20
0.25
0
10
20
30
40
50
Years Since 1957
Highest Fifth of IQ
Lowest Fifth of IQ



Cumulative Probability of Death
0.00
0.05
0.10
0.15
0.20
0.25
0
10
20
30
40
50
Years Since 1957
Highest Fifth of Class Rank
Lowest Fifth of Class Rank

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