Childhood Intelligence Predicts Premature Mortality: Results From

a 40-Year Population-Based Longitudinal Study

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Abstract

Childhood intelligence has been shown to predict mortality risk in adulthood. This relation has never been investigated in a Central European country with universal health care. The present study investigated whether childhood intelligence predicts mortality risk across 40 years in Luxembourg. 2543 participants completed an intelligence test at age 12 in 1968, and the mortality rate in this sample until 2008 was recorded. Our results showed that higher childhood intelligence predicted a lower risk for mortality, even when childhood socioeconomic status was controlled for. This effect was strongest in men belonging to the group of the lowest 20% in intelligence. These results indicate that even universal access to health care cannot fully offset the cumulative effects of intelligence on mortality.

Keywords: childhood intelligence; premature mortality; socioeconomic status; universal health care

Highlights

- Childhood intelligence predicted the risk for premature mortality in Luxembourg.

- Men at the lower end of the intelligence distribution were at higher risk for premature mortality.

- Controlling for childhood socioeconomic status did not alter these findings.

- Effects of intelligence on mortality remain despite universal access to quality health care.

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1. Introduction

In recent years, various studies have suggested that lower childhood intelligence is predictive of an increased mortality risk across the adult life span (Calvin et al., 2011; Deary, Weiss, & Batty, 2010; Hart et al., 2005; Kuh, Richards, Hardy, Butterworth, & Wadsworth, 2004; Lager, Bremberg, & Vagerö, 2009). The present study addresses three open questions regarding the relations between childhood intelligence and mortality. (1) Does childhood intelligence predict the risk for mortality until middle age in Luxembourg? Many previous studies have investigated later life mortality (Calvin et al., 2011). A replication of intelligence-mortality effects among younger individuals before the regular onset of chronic diseases would highlight the importance of intelligence as a predictor of mortality across the entire life span. Moreover, all previous studies have been conducted in English-speaking or Scandinavian countries (Calvin et al., 2011). It remains to be shown whether these findings can be generalized to Luxembourg, a country with a unique multicultural background). Crucially, whereas Luxembourg offers universal access to quality health care, it has a level of social mobility below many other Western societies (Organisation for Economic Co-operation and Development, 2010).

(2) Previous research has demonstrated that the shape of the intelligence-mortality relation is unclear (Batty, Deary, & Gottfredson, 2007). Does this relation exist across the entire spectrum of the intelligence distribution as some studies suggest (Lager et al., 2009), or is there a high-risk group at the lower end of the intelligence distribution with elevated mortality, thus pointing to a potential threshold effect (Hart et al., 2005; Kuh et al., 2004)? Identification of a specific group with an elevated mortality risk would provide information

about who should be targeted in particular by health care interventions and preventive
measures.

(3) Does the intelligence-mortality relation differ between women and men? Few
studies have investigated gender differences in the relation between intelligence and mortality.
The results seem inconclusive as some studies have found gender differences and others have
not (Calvin et al., 2011; Lager et al., 2009). The examination of gender differences is
important for formulating explanatory models for the intelligence-mortality relation.
Universal effects for women and men may indicate that intelligence predicts mortality
because it may be a marker of a healthy body in general (Batty et al., 2007; Lager et al.,
2009). Differential effects for women and men may be indicative of environmental and
behavioral factors that may be modifiable and thus targeted by interventions.

2. Method

2. 1 Participants

Participants were individuals enrolled in a longitudinal prospective cohort study (the
MAGRIP study) initiated in 1968 in Luxembourg. The MAGRIP study was a school-based
study designed to investigate the determinants of children's school careers. In 1968, detailed
data on intelligence and socioeconomic family background were collected on a randomly
selected nationally representative sample comprised of 2824 children at the end of their
primary education (M_{age} = 11.9 years; SD = 7.2 months; 50.1% male).

2.2 Measures

2.2.1 Childhood intelligence. In 1968, children completed a standardized, objective,
and comprehensive German intelligence test, the Leistungsprüfsystem (L-P-S, [Performance
Test System]; Horn, 1983), in classroom sessions. The L-P-S encompasses 14 subtests that
provide measures of various intellectual abilities. To obtain a measure of childhood
intelligence, we summarized children's performance on the 14 subtests in terms of a total

intelligence score, which was then standardized for the entire 1968 sample ($M = 100$, $SD = 15$). The reliability of the total score was satisfactory with $\alpha = .85$. Previous research has shown that this total score has excellent psychometric properties (e.g., retest reliability across a time span of 32 months = .83; Horn, 1983).

      2.2.2 Childhood socioeconomic status. In 1968, children reported their parents' current occupation. These occupations were mapped onto the International Socio-Economic Index of occupational status (ISEI; Ganzeboom & Treiman, 1996). The ISEI scale takes the income and educational levels of occupations into account. It has interval scale properties and a theoretical range from 16 (e.g., cleaners) to 90 (e.g., judges). The ISEI scale is internationally comparable and has been demonstrated to be a reliable and valid indicator of socioeconomic status in many international large-scale assessments (e.g., PISA; Organisation for Economic Co-operation and Development, 2004). In the present study, we used the highest ISEI value in a family as an indicator of childhood socioeconomic status. Interrater reliability of the ISEI coding was tested for two independent groups of raters and was satisfactory at .72.

      2.2.3 Mortality. In 2008, a second wave of the MAGRIP study was initiated. The mortality rate among the MAGRIP participants in the period between 1968 and 2008 was obtained from the social security agency of Luxembourg. Of the 2824 former participants, 2377 (84%) were alive, and 166 (6%) had died by 2008. The remaining 281 (10%) former participants could not be traced by their social security ID. The analyses for the present study were based on those 2543 individuals for whom data on mortality were available.

   2.3 Statistical analyses

      To quantify how childhood intelligence predicted mortality, we ran two series of logistic regression models. In the first series, we applied logistic regression models using the full range of the continuous intelligence score as a predictor. In Model 1, we used a bivariate

logistic regression model to study how this intelligence score would predict mortality. In Model 2, we included gender as an additional predictor and controlled for childhood socioeconomic status. To investigate gender differences in the relations between childhood intelligence or socioeconomic status and mortality, we added the interaction between gender and intelligence and between gender and socioeconomic status in a third model (Model 3). All models were computed with mean-centered intelligence and socioeconomic status variables.

To explore the shape of the intelligence-mortality relation, we divided all participants into equal-sized groups according to their intelligence scores. This resulted in five groups with increasing mean intelligence scores (i.e., quintiles), with each group comprising 20% of the participants of our total sample.[1] In the second series of logistic regression models, we then explored whether individuals with low levels of intelligence would exhibit a particularly increased mortality risk. To this end, we repeated the logistic regression Models 1-3 using an intelligence grouping variable as a predictor (Models 4-6). This dichotomous grouping variable was based on the five intelligence groups and coded whether a participant belonged to the lowest 20% or to the remaining 80% of the intelligence distribution.

We included all 2543 participants for whom data on mortality were available. To account for missing data in childhood intelligence (3% missing data, $n_{miss} = 87$) and childhood socioeconomic status (1% missing data, $n_{miss} = 14$), we applied multiple imputation. We conducted 10 cycles of imputations using the Amelia II package for the R software (Honaker, King, & Blackwell, 2011). In each cycle, the missing values were estimated based on the available data in the predictors. This process resulted in 10 imputed data sets, each one containing slightly different versions of the imputed values. We then used the software Mplus 7 (Muthén & Muthén, 1998–2007) to conduct the logistic regression analyses. Mplus allows

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[1] Using quintiles is a standard technique applied when a major goal of the grouping process is to retain as many of the properties of the original variable's distribution as possible (Austin, 2011).

for the combination of the results from imputed data sets to obtain overall parameter

estimates and standard errors that reflect uncertainty in the imputation as well as uncertainty

due to random variation (Schafer & Graham, 2002).

3. Results

In a first step, we investigated the descriptive statistics for the entire MAGRIP study

sample in 1968 ($N = 2824$), for all participants included in the present study ($n = 2543$), and

separately for those participants in the present study who were still alive in ($n = 2377$) or who

had died ($n = 166$) by 2008. Mean childhood intelligence ($M_{IQ} = 100$), mean childhood

socioeconomic status ($M_{ISEI} = 39$), the ratio of men to women (50:50), and the percentage of

native Luxembourgers (84%) were similar across the entire 1968 study population, the

sample in the present study, and the survivors in 2008. These results indicate that the sample

in the present study was representative of the original sample. However, those 166

participants who had died by 2008 had a lower mean childhood intelligence ($M_{IQ} = 96$,

Cohen's $d = 0.22$) and childhood socioeconomic status ($M_{ISEI} = 37$, $d = 0.19$). Further, a

substantial majority of the deceased were men (70%, $\varphi = .10$). These results indicate that

lower childhood intelligence, lower socioeconomic status, and being a man could be risk

factors for premature mortality in adulthood

3.1 Childhood intelligence and mortality: General and gender-specific relations

Table 1 (upper panel) shows the results of the first series of logistic regression models

that investigated the impact of the full-range childhood intelligence predictor on mortality

risk. Model 1 showed that higher childhood intelligence significantly predicted a lower

mortality risk in adulthood. Specifically, participants with a higher childhood intelligence had

a lower risk of having died by 2008 (OR 0.80, 95% CI 0.69 to 0.92). Model 2 showed that the

effect of childhood intelligence on mortality remained robust when controlling for childhood

socioeconomic status. Further, gender was significantly related to mortality: Men had a

higher risk of having died by 2008 (OR 2.43, 95% CI 1.72 to 3.42), even when controlling for socioeconomic status and intelligence. Model 3 showed a tendency for stronger effects of intelligence on mortality in men than in women, as reflected in the odds ratio for the interaction (OR 0.80, 95% CI 0.56 to 1.14). However, this interaction failed to reach significance.

3.2 Is the lowest intelligence group at particularly high risk of mortality?

Figure 1 shows premature mortality rates in five equal-sized intelligence groups for the total sample (Figure 1a) and for women and men separately (Figure 1b), as well as the frequency distribution of intelligence scores in the five groups for the total sample. Each group comprised approximately 508 participants. The lowest intelligence group (M_{IQ} = 78, M_{ISEI} = 34) comprised 252 men (37 deceased by 2008) and 256 women (10 deceased). The second group (M_{IQ} = 92, M_{ISEI} = 37) comprised 236 men (20 deceased) and 273 women (11 deceased). The third group (M_{IQ} = 100, M_{ISEI} = 39) comprised 258 men (23 deceased) and 251 women (8 deceased). The fourth group (M_{IQ} = 108, M_{ISEI} = 41) comprised 268 men (17 deceased) and 241 women (16 deceased). The fifth group (M_{IQ} = 120, M_{ISEI} = 44) comprised 277 men (19 deceased) and 231 women (5 deceased).

A visual analysis of these plots indicated that participants at the lower end of the intelligence distribution, and particularly men, seemed to constitute a risk group with an increased mortality risk. Specifically, the overall mortality rate seemed to be particularly high in the lowest intelligence group compared to the remaining four intelligence groups, which in turn showed similar mortality rates (see Figure 1a). Moreover, the mortality rate in men belonging to the lowest intelligence group was substantially higher than the mortality rate in women belonging to the lowest intelligence group (see Figure 1b). The mortality rates for men in the remaining four groups were also mostly higher than those for women, yet these gender differences were smaller. These analyses pointed to an increased mortality risk for

men in the lowest intelligence group.

Table 1 (lower panel) shows the results of the second series of regression models that back up these conclusions. Our analyses suggested that the intelligence grouping variable significantly predicted mortality risk. Specifically, being in the lowest intelligence group increased the risk of dying by 2008 compared to being in the remaining intelligence groups (Model 4; OR 1.63, 95% CI 1.14 to 2.32). This relation remained robust when controlling for childhood socioeconomic status and including gender in the model (Model 5). Importantly, there was a significant interaction between the intelligence grouping variable and gender (Model 6). Being a man in the lowest intelligence group increased the risk of dying by 2008 compared to being a man in the remaining intelligence groups or to being a woman in any group (OR 2.37, 95% CI 1.03 to 5.48).

4. Discussion

The principal findings of this prospective cohort study were: (1) Childhood intelligence predicted the risk for premature mortality in Luxembourg. (2) The results indicated that men at the lower end of the intelligence distribution were at higher risk for premature mortality.

The first finding of intelligence-mortality effects among comparatively young individuals before the regular onset of chronic diseases substantiates the generalizability of the results of the research on intelligence and mortality and highlights the importance of intelligence as a predictor of mortality. Notably, our results were obtained when controlling for childhood socioeconomic status. This finding is important as Luxembourg has a level of social mobility below the OECD average (OECD, 2010). Luxembourg's low social mobility indicates that—contrary to many modern societies (Mackenbach, 2010)—an individual's social achievement depends largely on the socioeconomic position of the individual's family of origin. Social achievement in turn is linked to mortality (Gottfredson, 2002). Thus,

childhood socioeconomic status could have been expected to yield the strongest effects on mortality. By contrast, the impact of intelligence on mortality could have been smaller in Luxembourg, compared to more meritocratic societies in which life outcomes depend more on personal factors. Importantly, our results showed that childhood intelligence predicted mortality over and above the socioeconomic family background.

The second finding, which indicated that individuals with low childhood intelligence exhibited an increased mortality risk, is in line with the results of other studies that have pointed towards a threshold effect (Hart et al., 2005; Kuh et al., 2004). The finding that men but not women in the lowest group of the intelligence distribution showed an increased mortality risk could be the result of individual differences in factors beyond intelligence (e.g., personality factors) that could not be detected in the present study. However, this finding is in line with prior studies that found gender differences in the intelligence-mortality relation (Kuh et al., 2004; Lager et al., 2009), and with gender differences in the causes of premature mortality. The most important causes of premature mortality in Europe are external causes (e.g., transport accidents), intentional self-harm (e.g., suicides), and alcohol-related mortality (Eurostat, 2009). For men of working age, factors related to working environments also play an important role (Statec, 2009*)*. Many of these causes are strongly related to behavioral risks (e.g., risky driving), psychological risks (e.g., depression), or both (e.g., suicides), and all of them are more pronounced in men than in women (Eurostat, 2009; Statec, 2009). Importantly, intelligence may be directly and indirectly related to these factors. For instance, intelligence is inversely related to psychiatric disorders, suicide, alcohol intake (Deary et al., 2010), and transport accidents (O'Toole, 1990). Thus, the gender differences in the intelligence-mortality relation found in our study may be the result of stronger associations between intelligence and the causes of premature mortality in men. Furthermore, as men were the principal earners in our study cohort, the detrimental consequences of lower childhood

intelligence, such as a lower socioeconomic status in adulthood or low problem solving and thinking skills in working environments (Gottfredson, 2002), may have been even worse for them.

4.1 Strengths and limitations

The current study features several strengths. First, we used a prospective longitudinal cohort design, thus adding to the small number of studies that have investigated the longitudinal relations between childhood intelligence and later mortality risk. Second, the present study investigated a nationally representative sample and was thus the first to investigate the intelligence-mortality relation in a Central European country with universal access to quality health care. Importantly, the present study controlled for childhood socioeconomic status, given the high impact socioeconomic family background has on an individual's later life achievement in Luxembourg. Third, whereas many previous studies have been based on data from men only, our study included data on men and women, thus enabling the systematic investigation of gender differences in the intelligence-mortality relation.

One important limitation of our study is the low number of deaths in our study sample. In particular, the lack of an effect in women may be the result of lower statistical power due to a smaller number of deaths in women (Calvin et al., 2011). This could be due to the comparatively young age of our study sample in combination with women's higher average life expectancy. Investigating late life instead of premature mortality may yield a higher number of deaths in women and may thus indicate no substantial gender differences in the intelligence-mortality relation. Another limitation is that we did not include potential mediators of the intelligence-mortality relation, such as educational attainment and adult socioeconomic status. Whereas it has been shown that educational attainment and socioeconomic status mediate this relation to some extent (Calvin et al., 2011), other studies

have suggested an influence of intelligence on mortality independent of these mediators

(Lager et al., 2009). Thus, future research should examine the mediating processes that link

childhood intelligence to later mortality.

4.2 Conclusion

Taken together, our findings, in line with the findings of other studies, highlight the

importance of intelligence as a predictor of mortality. The finding of gender differences may

suggest that, rather than intelligence being a marker of a healthy body in general and

therefore predicting mortality, environmental and behavioral factors may explain the

intelligence-mortality relation, (Lager et al., 2009). These factors are potentially modifiable

and could be targeted by interventions.

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Appendix A. Supplementary material
Supplementary data associated with this article can be found, in the online version, at
http://dx.doi.org/10.1016/j.jrp.2015.06.003.

Acknowledgements

Table 1

Odds ratios (95% confidence intervals) for the relation of a 1 standard deviation increase in full range childhood intelligence or of belonging to the lowest childhood intelligence group vs. all higher childhood intelligence groups, a 1 standard deviation increase in childhood socioeconomic status, and gender with premature all-cause mortality

| | Predictor of premature all-cause mortality | | | | |
	IQ	SES	Gender	IQ*Gender	IQ*SES
Full range IQ					
Model 1	0.80 (0.69, 0.92)				
Model 2	0.82 (0.71, 0.95)	0.84 (0.70, 1.01)	2.43 (1.72, 3.42)		
Model 3	0.96 (0.71, 1.29)	0.70 (0.50, 0.99)	2.45 (1.71, 3.51)	0.80 (0.56, 1.14)	1.29 (0.87, 1.92)
Lowest vs. higher IQ groups					
Model 4	1.63 (1.14, 2.32)				
Model 5	1.52 (1.06, 2.20)	0.83 (0.69, 1.00)	2.40 (1.70, 3.38)		
Model 6	0.83 (0.40, 1.70)	0.69 (0.49, 0.97)	2.04 (1.37, 3.04)		1.31 (0.88, 1.94)

Note: Gender was coded 0 = women, 1 = men. Lowest IQ group vs. higher IQ groups was coded 0 = higher IQ groups, 1 = lowest IQ group. Models 2-3 and 5-6 adjusted for childhood SES and Gender. Key: IQ = intelligence; SES = socioeconomic status.
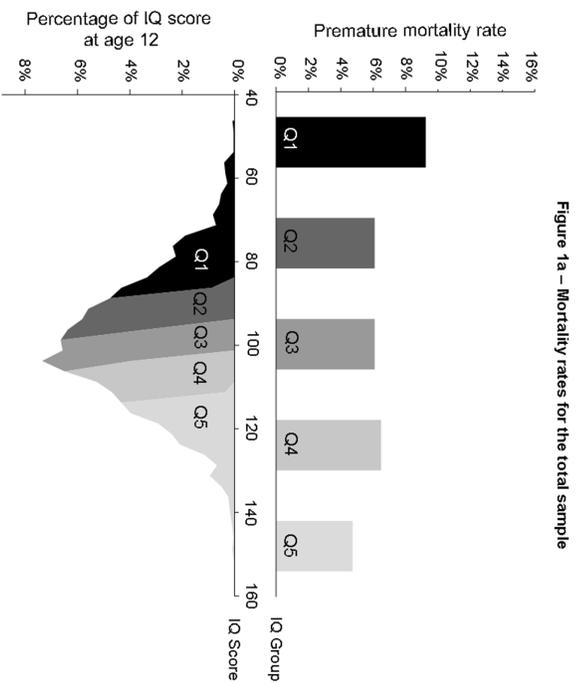
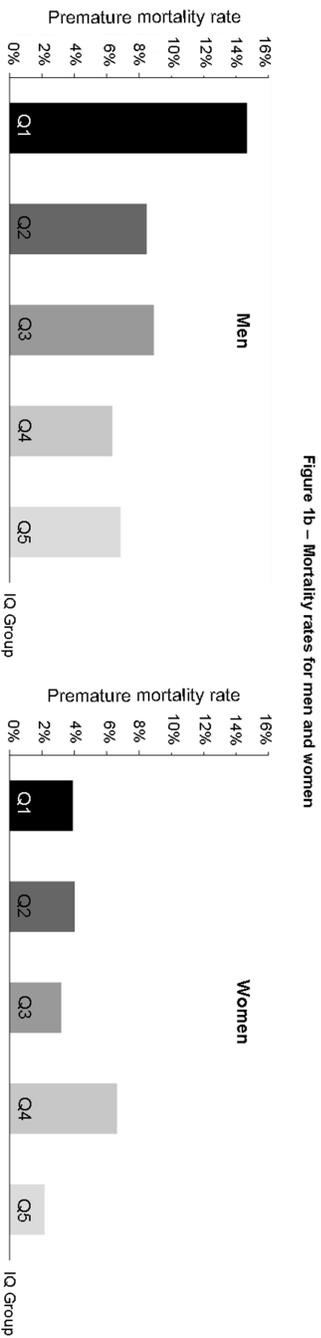**Figure 1a – Mortality rates for the total sample**

Figure 1b – Mortality rates for men and women

Men

Women

Fig. 1. *Premature mortality rates and frequency distribution of intelligence (IQ) scores in five equal-sized intelligence groups for the total sample (Figure 1a) and for women and men (Figure 1b). IQ score scale applies to the lower part of Figure 1a.*