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# Cognitive ability in adolescence and mortality in middle age - a prospective life course study

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## ABSTRACT

**Background:** An association between childhood cognitive ability measured with IQ-tests and mortality has been reported recently. It is not clear from those studies to what extent the increased relative risk associated with lower IQ-scores may be **attenuated by adjustment for** other risk factors. This study aims to investigate the association between cognitive ability measured at age 18-20 and mortality among middle aged men adjusting for risk factors for mortality over the life course.

**Methods:** Data on cognitive ability, and other risk factors for premature mortality (indicators of mental health and social adjustment and behavioural factors), was collected among 49 321 men, born in 1949-51, at conscription for compulsory military training in 1969/70. Information on socioeconomic factors in childhood and adulthood, as well as information on mortality, was collected through national registers.

**Results:** Cognitive ability showed an inverse and graded association with mortality between 40-53 years of age (1297 cases, crude hazard ratio (HR) 1.15, CI95% 1.12-1.18, for one point decrease on the nine point IQ scale). Adjustment for indicators of social misbehaviour, mental health problems, and behavioural risk factors measured in late adolescence, and adult social circumstances strongly attenuated the increased risks of mortality and it was no longer significantly increased (adjusted HR 1.02, CI95% 0.99-1.06, for one point decrease on the nine point IQ scale).

**Conclusion:** The association between IQ and mortality among men below 54 years of age was almost completely attenuated by adjustment for risk factors captured by our measures of achieved social positions.

## INTRODUCTION

There are marked socioeconomic differences in mortality in industrialised countries. The background to those inequalities are not fully understood. There is a strong association between socioeconomic position and cognitive ability. It has recently been suggested that cognitive ability, or IQ, itself may be a risk factor for mortality and be responsible for health inequalities. The association between cognitive ability in childhood or adolescence and mortality in old age<sup>1</sup> and in mid-life,<sup>2-7</sup> has recently been documented in studies based on populations born 1921-1955. In a recent review of all studies on the association between IQ in early life and later mortality it was concluded that the association seems to be strong and not affected by adjustment for socioeconomic circumstances in childhood.<sup>8</sup> Only few studies have so far investigated the association between cognitive ability in early life and later mortality, and with limited possibilities to adjust in the analyses for risk factors for mortality over the the life course.<sup>8,9</sup> However, in two recently published studies the association between IQ and mortality was to a large extent mediated by adult social circumstances.<sup>10,11</sup>

Here we will investigate the association between IQ test score, measured at ages 18-20, and mortality in middle age in a cohort of 49 321 Swedish males, born in 1949-51, and the possible impact on this association from risk factors for mortality measured in childhood, adolescence, and in adult life. We will consider indicators of a poor childhood environment measured at ages 9-11, mental health, social problems, and behavioural risk factors measured at age 18-20 as well as data on achieved education, adult socio-economic position, and income from the 1990 census, i.e. when the subjects were 40 years of age.

## **Methods**

### *Study population*

The study was based on data from a nation-wide survey of 49 321 Swedish males, born 1949-51, who were conscripted for compulsory military service in 1969/70. The background of the Swedish conscription surveys and the variables included has been presented in detail elsewhere.<sup>12 13</sup> At that time, only 2-3 % of all Swedish men were exempted from conscription, in most cases due to severe handicaps or congenital disorders. Those included in this study accounted for 97.7% of all conscripts in 1969/70, the remaining 2.3% were born before 1949. The data collection is described in Table 1.

### *Information collected at the 1969-70 conscription examination*

The IQ tests performed included tests on logic/general intelligence; verbal test of synonym detection; of visuospatial/geometric perception; and technical/mechanical skills with mathematical/physics problems and has been described in detail elsewhere<sup>14 15</sup>. The outcome of each test was ranked 1-9.<sup>14</sup> These standard-nine values were transformed into a new standard-nine scale as a measure of general ability and corresponding to approximate IQ bands of :<74, 74-81, 82-89, 90-95, 96-104, 105-110, 111-118, 119-126, >126.<sup>15</sup> Of the men 49 262 (99.9%) had a score on cognitive ability.

All conscripts were seen by a physician who diagnosed any disorders according to the Swedish version of the ICD, 8th revision (ICD-8). All the men were seen by a psychologist for structured interviews. Conscripts reporting or presenting psychiatric symptoms were seen by a psychiatrist and any diagnoses were recorded according to ICD-8.

At conscription all men went through a health examination where height and weight were measured. The following variables were used as possible confounders of the cognitive ability – mortality association. Body mass index (BMI) was calculated using body weight (kg) divided by height (m) squared. In the analyses BMI as well as body height was used as continuous variables.

During the conscription the men completed questionnaires concerning information on social background, behaviour and adjustment, psychological factors, health, and substance use, e.g. alcohol consumption and tobacco smoking. In the analyses smoking was divided into the following four categories: 1>20 cigarettes/day, 2=11-20 cigarettes/day, 3=1-10 cigarettes/day, and 4=none smokers. Alcohol consumption in grams 100%/alcohol/week was calculated on the basis of the answers to the questions on frequency and average consumed volume of beer, wine, and strong spirits. A composite variable, risky use of alcohol, included at least one of the following indicators of problem drinking: consumption of at least 250 gr 100% alcohol/week, to have taken an eye-opener during hangover, to have been apprehended for drunkenness, or to have often been drunk (alternatives given in the questionnaire were "often", "rather often", "sometimes", and "never"). The variable 'contact with police and child welfare authorities' (at least once) indicated problem behaviour and has been shown to be strongly related to later psychiatric diagnosis.<sup>16</sup> The variable 'emotional control' was assessed in the structured interview by the psychologist. Low emotional control, defined as a score of 1 or 2 on a scale from 1 (lowest) to 5 (highest) was reported for 20% of the cohort, and served as a summary assessment of mental stability, emotional maturity, and tolerance for stress and frustration.

### *Census data on childhood social circumstances*

The conscripts and their parents, and other head of household when different from the parents, were linked to each other between censuses through their personal identification numbers by Statistics Sweden. Information on ‘childhood socioeconomic position’ and of “crowded housing” was obtained from the National Population and Housing Census of 1960 (response rate 99%), i.e. when the subjects were 9–11 years old. The classification, into the following six socioeconomic groups, was based on information on the occupation of the head of the household: (1) unskilled workers, (2) skilled workers, (3) assistant non-manual employees, (4) non-manual employees at intermediate or higher level, (5) farmers, (6) those not classified in a socioeconomic group. We here used a measure of ‘crowded housing’ (in the 1960 census > 2 people/room - kitchen not included - was classified as crowded).

### *Data on adulthood socioeconomic position, attained education, and income*

Information on adulthood socioeconomic group for each conscript was obtained by record linkage with the National Population and Housing Census of 1990 held by Statistics Sweden. This census had a response rate of over 98%. The classification into the following eight socioeconomic groups in 1990 was conducted at Statistics Sweden and is based on information on occupation and the educational level required for the occupations: (1) unskilled workers, (2) skilled workers, (3) assistant non-manual employees, (4) non-manual employees at intermediate level, (5) non-manual employees at higher level, (6) farmers, (7) self-employed (mostly skilled workers or drivers), (8) those for whom no occupation was reported (e.g. unemployed, early retired, or disabled). The data was also linked to the Longitudinal Database of Education, Income and Occupation (LOUISE) of 1990-2002 held by Statistics Sweden in order to receive information on achieved education for each study member and income for the year 1990. In the analyses achieved education was divided into

five categories (<= 9 years, 10-11 years, 12-13 years, 14 years, 15 or more years) and income was divided into quartiles.

#### *Information on outcomes*

Information on mortality and age at death in the subjects between 1970 and 2003 was obtained from the National Cause of Death Register administered by the Centre for Epidemiology at the National Board of Health and Welfare in Sweden.

#### *Data analysis*

Associations between cognitive ability and mortality 1991-2003 were estimated using Cox's proportional-hazards models, yielding hazard ratios (HR:s) with 95 % confidence intervals, in both univariate and multivariate (including the potential confounders) models using the PHREG-procedure in the SAS computer package. Cognitive ability was modelled as a continuous variable, with HR:s given for an increase of 1 in the 9 point scale, as well as with dummy variables for each of nine categories using the highest test score as the reference category. In the adjusted models the relative hazard associated with a particular level of IQ score was estimated adjusting for the effect of the risk factors added to the model in order of their appearance in the life course. **In order to calculate the proportions of the increased relative risk of mortality associated with IQ that was attenuated after adjustment for other risk factors** we used the formulae  $((RR_{\text{crude}} - RR_{\text{adjusted}}) / (RR_{\text{crude}} - 1)) * 100$ . Possible interaction effects between IQ (dichotomised IQ 1-4 versus IQ 5-9) and other early life factors was investigated according to the method proposed by Rothman.<sup>17 18</sup>



## Results

Of the 49 321 men conscripted for military service in 1969/70 there were 48 283 men still alive in 1990. Of them 47 678 (98.7%) participated in the census that year. Our presentations are based on those 43 834 men (94.0%) for whom there was information on all the variables included in the final analyses. In Table 2 the childhood and adolescent characteristics of the full cohort of those included in the analytical sample are shown. The differences in the prevalence of each risk factor between the full cohort and the sample are small.

In Table 3 the associations between cognitive ability, measured at conscription, and mortality between 40 and 54 years of age are shown. IQ was inversely associated with mortality (RR=1.15, CI95% 1.12-1.18, for each decrease of one on the nine-grade scale). In the multivariate analyses risk factors were added to the model in the order of their appearance in the life course, i.e. 1) childhood social circumstances, 2) adolescence behaviour and mental health, 3) adult social circumstances. Adjustments for indicators of poor social circumstances in childhood (low childhood SEP, crowded housing, and low body height) did not contribute to lower the increased risk found in the crude analyses. Adjustment for indicators of adolescent mental health and social adjustment, as well as for smoking and risky use of alcohol, contributed each to some attenuation of the association between IQ and mortality, while adjustment for overweight did not. After adjustment for all early life factors the relative risk was attenuated by 40%. Adjustment for all indicators of social circumstances in adulthood by themselves lowered the increased relative risk substantially (HR=1.04, CI95% 1.01-1.07, for each decrease of one on the nine-grade scale, i.e – 73%). The single factor that contributed most to attenuate the increased relative risk found in the crude analyses was adult socioeconomic position. In the final model, taking all risk factors into account, the risks were

strongly attenuated and the relative risks associated with an increase of 1 on the 9-point scale was on the limit to significantly increased (HR=1.02, CI95% 0.99-1.06, i.e. – 87%). We investigated possible interaction effects between IQ and each confounding or mediating factor adjusting for the other factors. There were no indications of interaction effects. A strong and graded increase of HR for mortality was seen on the nine-grade scale from high to low test scores (Table 4). After adjustment for risk factors over the life course no significantly increased risk remained. The HR in the lowest of nine IQ groups, in comparison with the highest, decreased from 3.3 (CI95% 2.3-4.6) to 1.2 (CI95% 0.9-1.8) after adjustment for all risk factors. Excluding information on achieved education from the fully adjusted model did not change the results.

## **Discussion**

This is one of the very few studies on the association between IQ and mortality with possibilities to adjust in the analyses for a large number of risk factors for mortality over the life-course. It shows, in a cohort of Swedish males, that IQ test scores at ages 18-20 were associated with mortality between 40 and 54 years of age. A graded risk increase was seen across all IQ score groups. The increased risk was markedly attenuated by simultaneous adjustment for indicators of poor mental health and behavioural factors measured in late adolescence. Further adjustment for measures of adult social position almost entirely attenuated the increased risk found in the crude analyses indicating a strong mediating effect from adult circumstances.

Only a very small proportion of Swedish men are exempted from conscription, i.e. the cohort is highly representative of males born around 1950 in Sweden.

Many studies on early-life factors and health outcomes in adult life rely on retrospective information collected at some point of the subject's adult life which may introduce bias.<sup>19</sup> In

this study all information was collected at the time point when the conditions reported were actually present. This concerns socioeconomic positions and crowded housing in childhood as well as the behavioural factors measured at conscription (over-weight, smoking, risky use of alcohol) and the information obtained when the subjects were 39-41 years of age. Hence, the non-differential misclassification in this study is most likely smaller than in previous studies, leading to less dilution of relative risk estimates associated with the risk factors measured in early life and result in a higher explanatory power of each potential risk factor.

The psychiatric diagnoses given at conscription were categorised according to the International Classification of Diseases (ICD), version 8. At present, version 10 of ICD is in use. We believe that the measure of psychiatric illness used in this study quite well captures what would have been found using the updated version of ICD, although the specific diagnoses would differ somewhat.

All conscripts met with a psychologist for a face-to-face interview in order to assess their level of emotional control. We are not fully aware of any similar measure used in personality research today, but we have previously reported strong associations between the measure of low emotional control and smoking<sup>20</sup>, alcoholism<sup>21</sup>, early retirement<sup>22</sup>, and mortality<sup>13</sup>.

This study only includes men and the reported associations may not be similar among women. In the study based on the British 1946 birth cohort<sup>4</sup> men but not women showed an increased risk of mortality with low IQ. The men were followed for mortality between 40-53 years of age when mortality rates are still low. In a study by Hart et al there was an association between IQ and mortality among persons younger than 65 but not among persons older than 65.<sup>23</sup> In a previous study based on the 1969 conscription cohort we found that the strengths of association between IQ and mortality was the same over 35 years of follow up after the conscription examination.<sup>6</sup>

### *Comparison with previous studies*

Only a limited number of previous studies have reported on the association between childhood IQ and mortality.<sup>8</sup> A Scottish study based on 922 subjects born in 1921 found an association, including males and females in the same analyses, between IQ measured at age 11 and mortality during a follow from middle age. An increased relative risk of mortality was found only in the lowest, compared with the highest, IQ-quartile (RR=1.47) and for those who died before the age of 65, but not among those who died later in life.<sup>3 23</sup> This study did not include information on other early life circumstances. In the British 1946 birth cohort IQ was measured at age eight and the study population was divided into IQ quartiles and followed for mortality between 9-54 years of age.<sup>4</sup> In the crude analyses a doubled risk of mortality was found among men in the lowest IQ quartile. After adjustment for indicators of social circumstances in childhood and adulthood the increased risk was reduced by 63 % and was no longer significantly increased. No association between IQ and mortality was found among women. In a Scottish cohort based on just over 2000 men and women born in Aberdeen in 1921 a stronger association among women than among men was found between IQ at age 11 and mortality up to the age of 76.<sup>1</sup> In a Danish cohort based on men born in Copenhagen in 1953 a graded association was found between IQ measured at age 12 and mortality followed up to the age of 47.<sup>5</sup> The study did not include information on the participants adult life circumstances and adjustment for childhood social class only slightly attenuated the association. Batty et al (2008) investigated the association between IQ and mortality in a cohort consisting 4316 male former Vietnam-era US army personnel.<sup>11</sup> The men were tested for IQ at entry into the service in late adolescence and were interviewed in middle age concerning potential risk factors for mortality, e.g. smoking and social circumstances over the life course. The association between IQ and mortality found in the crude analysis was not affected by adjustment for childhood social circumstances but almost completely attenuated

by adjustment for adult social circumstances. Very similar results have been reported from three other US cohorts with data on IQ collected in adolescence and mortality up to middle age.<sup>10</sup> Our finding of a strong mediating effect from socioeconomic factors in middle age on the association between childhood IQ and mortality is in strong agreement with those recently published findings.

### *Is IQ a risk factor for mortality?*

We found a gradually increased risk of mortality by decreasing test score on all nine levels among men 40-54 years of age. Adjustment for all risk factors almost entirely **attenuated** the increased risk of mortality found in the crude analysis.

The indicators of poor childhood social circumstances (socioeconomic position and crowded housing measured at ages 9-11, and body height measured at ages 18-20) did not contribute to decrease of the association between IQ and mortality. This is in accordance with findings in previous studies.<sup>14-7</sup> In this study we were able to adjust for psychiatric diagnoses, social misbehaviour (self-reported contact with police and childcare authorities), and low emotional control at conscription. All three factors contributed each somewhat to attenuate the increased risk found in the crude analyses. It may be that those factors indeed are indicators of negative childhood experiences not captured by our measures of childhood social circumstances. There is evidence that a poor psychosocial home environment may be associated with negative health outcomes,<sup>24</sup> negative health related behaviours,<sup>25</sup> as well as hamper IQ development.<sup>26 27 28</sup> It may also be that persons with lower IQ have difficulties in interpreting signs of upcoming psychiatric symptoms and therefore have a lower ability to take preventive actions.

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It has been suggested that persons with lower IQ may have more difficulties in understanding and interpreting health prevention messages, e.g. related to smoking, risky use of alcohol and

physical activity.<sup>29</sup> Previous investigations on the association between IQ and life style habits often point at the importance of socioeconomic factors. In this study smoking and risk use of alcohol, but not overweight, contributed somewhat to attenuate the increased risk found in the crude analyses. Taylor et al<sup>30</sup> found that childhood IQ was not associated with starting smoking, but with smoking cessation in adulthood among persons born 1921. However, after adjustment for adult social class and deprivation category the association was no longer significant. We have recently shown in this conscription cohort an association between IQ and smoking at age 18, which almost disappeared after adjustment for other predictors of smoking. No association was found between IQ and smoking cessation later in life.<sup>31</sup> It is therefore not likely that the misclassification of smoking status during follow-up is related to IQ. It has been reported that persons with lower IQ more often report high alcohol consumption.<sup>32</sup> In other studies a high alcohol consumption seems to be more common among persons with higher IQ.<sup>33</sup> In our study a measure of risky use of alcohol somewhat contributed to attenuate the association between IQ and mortality.

Cognitive ability is strongly associated with indicators of achieved social position. In the study by Kuh et al<sup>4</sup> on the association between IQ and all-cause mortality, 63% of the increased risk among men disappeared after adjustment for education and achieved socioeconomic circumstances indicating a strong importance of a path-way mechanism.<sup>4</sup> In this study we adjusted in the analyses for risk factors for mortality measured at different points in time during the life course. It turned out that adjustment in the analyses for indicators of adult social position strongly contributed to reduce the associations between IQ and mortality (-73% and fully adjusted -87%). Very similar results were shown in three US cohorts with data on IQ collected in early life.<sup>10 11</sup> This result is in line with a pathway effect where IQ determines adult social circumstances and those circumstances in turn determine risk of mortality.<sup>34 35</sup>

Since IQ and education are strongly correlated, one might question the logic of adjusting the association between IQ and mortality for education. However, in this study the introduction of achieved education in the analytical model after accounting for all other factors did not change the results at all.

### *Conclusions*

In our analyses of the association between childhood IQ score and later mortality we adjusted for indicators covering information on childhood circumstances, health behaviours, and adult social circumstances. We found that the association between IQ and mortality disappeared entirely after adjustment in the analyses for adult social circumstances and social and behavioural factors measured in late adolescence. The association between IQ and mortality was strongly mediated by adult social circumstances.

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Ethical approval: The ethics committee at the Karolinska Institute, Stockholm, approved the study.

### **What this paper adds:**

*What is already known on this subject?*

The association between IQ and mortality has been found in many studies. The mechanisms and causal pathways are not fully understood.

*What does this study add?*

This is the largest study to date to investigate the potential confounding and mediating factors in the association between IQ and mortality.

The association between IQ and mortality was strongly mediated by adult social circumstances and social and behavioural factors measured in late adolescence.

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**Table 1.** Data collection 1949-2003

	Calendar year	Age of subject	
Birth years	1949-51	0	
National Population and Housing Censuses of 1960	1960	9-11	Information on socioeconomic position and on crowded housing was collected from information given by the father or other head of household
<b>Conscription examination</b>	<b>1969/70</b>	<b>18-20</b>	Information on BMI, body height, risky use of alcohol, smoking, systolic and diastolic blood pressure
National Population and Housing Censuses of 1990	1990	39-41	Information on socioeconomic position
Longitudinal database of Education, Income, and Occupation	1990	39-41	Information on achieved education and income
Swedish Causes of Death register 1991-2003	1991-2003	40-54	Information on mortality

**Table 2.** Prevalence of childhood and adolescent risk factors in the full cohort and among those included in the analytic sample.

	<b>Full cohort (n=49321)</b>	<b>Analytical sample (n=43834)</b>
	<b>%</b>	<b>%</b>
Father manual worker	54.5	54.8
Crowded housing in childhood	20.7	20.6
Body height <171 cm	11.0	10.9
Psychiatric diagnosis	12.5	11.8
Contact with police and child care	28.8	28.4
Low emotional control	30.5	29.6
Daily smoking	58.6	58.4
Risky use of alcohol	13.6	13.1
BMI>25	6.6	6.6

**Table 3.** IQ-score and all cause mortality (1297 cases). Crude and adjusted relative risks (hazard ratios), with 95% confidence intervals, associated with 1 point decrease in IQ score on the nine level scale.

		<b>RR</b>	<b>CI 95%</b>
	<b>Crude</b>	<b>1.15</b>	<b>1.12-1.18</b>
	<b>Adjusted for:</b>		
<i>A. Early life circumstances</i>	Low childhood SEP	1.16	1.13-1.19
	Crowded housing in childhood	1.15	1.12-1.18
	Body height	1.15	1.12-1.18
	<b>All (A)</b>	<b>1.15</b>	<b>1.11-1.18</b>
<i>B. Mental health and social adjustment measured at age 18</i>	Psychiatric diagnosis	1.13	1.10-1.16
	Contact with police and child care	1.13	1.10-1.16
	Low emotional control	1.13	1.10-1.16
	<b>All (B)</b>	<b>1.11</b>	<b>1.08-1.14</b>
<i>C. Behavioural factors measured at age 18</i>	Daily smoking	1.13	1.10-1.16
	Risky use of alcohol	1.13	1.10-1.16
	BMI	1.15	1.12-1.18
	<b>All (C)</b>	<b>1.11</b>	<b>1.08-1.14</b>
	<b>All (B+C)</b>	<b>1.09</b>	<b>1.06-1.13</b>
<i>D. Adult social position</i>	Attained education	1.09	1.06-1.13
	SEP at age 40	1.08	1.05-1.11
	Income at age 40	1.09	1.06-1.12
	<b>All adult factors (D)</b>	<b>1.04</b>	<b>1.01-1.07</b>
	<b>All (B+C+D)</b>	<b>1.02</b>	<b>0.99-1.06</b>

**Table 4.** IQ-score and all cause mortality. Crude and adjusted relative risks (hazard ratios), with 95% confidence intervals, with the highest IQ score as reference category (9 = highest).

IQ-level	Crude		Adjusted*		Adjusted**	
	RR	CI 95%	RR	CI 95%	RR	CI 95%
9	1	---	1	---	1	---
8	1.1	0.8-1.5	1.0	0.7-1.3	1.0	0.7-1.3
7	1.3	0.9-1.7	1.0	0.7-1.4	1.0	0.7-1.4
6	1.5	1.1-2.0	1.0	0.8-1.4	1.1	0.8-1.4
5	1.7	1.2-2.2	1.0	0.8-1.4	1.1	0.8-1.5
4	1.9	1.4-2.5	1.0	0.7-1.4	1.1	0.8-1.4
3	2.0	1.5-2.7	1.0	0.7-1.4	1.0	0.8-1.5
2	2.6	1.9-3.6	1.2	0.8-1.7	1.2	0.9-1.7
1	3.3	2.3-4.6	1.2	0.9-1.8	1.3	0.9-1.9

\* all mental health indicators, behavioural factors and socioeconomic position, income, and achieved education

\*\* all mental health indicators, behavioural factors and adult socioeconomic position, and income, but not including achieved education