

## Longitudinal cohort study of childhood IQ and survival up to age 76

Lawrence J Whalley, Ian J Deary

### Abstract

**Objectives** To test the association between childhood IQ and mortality over the normal human lifespan.

**Design** Longitudinal cohort study.

**Setting** Aberdeen.

**Subjects** All 2792 children in Aberdeen born in 1921 and attending school on 1 June 1932 who sat a mental ability test as part of the Scottish mental survey 1932.

**Main outcome measure** Survival at 1 January 1997.

**Results** 79.9% (2230) of the sample was traced. Childhood mental ability was positively related to survival to age 76 years in women (0.978 (0.971 to 0.984),  $P < 0.0001$ ) and men (0.989 (0.984 to 0.994),  $P < 0.0001$ ). A 15 point disadvantage in mental ability at age 11 conferred a relative risk of 0.79 of being alive 65 years later (95% confidence interval 0.75 to 0.84); a 30 point disadvantage reduced this to 0.63 (0.56 to 0.71). However, men who died during active service in the second world war had a relatively high IQ. Overcrowding in the school catchment area was weakly related to death. Controlling for this factor did not alter the association between mental ability and mortality.

**Conclusion** Childhood mental ability is a significant factor among the variables that predict age at death.

### Introduction

Inequalities in health and mortality exist among different socioeconomic groups. People living in deprived conditions generally suffer more illness and die younger,<sup>1,5</sup> and socioeconomic circumstances in childhood are related to mortality from several illnesses.<sup>6,7</sup> Educational level also contributes to differences in mortality between socioeconomic groups,<sup>8,10</sup> although the size of this effect varies nationally.<sup>11</sup> Higher mental ability, as assessed by psychometric tests, is associated with more favourable educational and occupational life outcomes.<sup>12</sup>

Socioeconomic status, educational level, and mental ability are closely related. However, there is little information about the link between mental ability and morbidity and mortality. Mental ability was significantly associated with longevity in a longitudinal study of Australian Vietnam veterans after discharge,<sup>13</sup> and in old people whose mental functions were declining.<sup>14,15</sup>

We examined the effects of childhood mental ability on survival up to 76 years in a year of birth cohort.

### Subjects and methods

#### Scottish mental survey 1932

Under the auspices of the Scottish Council for Research in Education, an intelligence test (the Moray house test No 12) was given to all Scottish children who were born in 1921 and were attending school on 1 June 1932.<sup>16,17</sup> Test data were obtained for 87 498 children (44 210 boys and 43 288 girls).

#### Follow up

We obtained survey data from the Scottish Council for Research in Education. For each subject, these data comprised family name, given name, date of birth, name of school, and raw Moray house test score. We identified Aberdeen city as our target area and searched for all subjects ( $n = 2792$ ) who had attended schools within its boundaries using public and health records in the United Kingdom (more details of the search method are available on the *BMJ's* website).

#### Measures of childhood IQ and social factors

We converted Moray house test scores to IQ-type scale scores (with mean = 100, SD = 15) and corrected them for the subject's age in days at the time of testing. We used an estimate of overcrowding in the childhood family home as an ecological measure of social disadvantage (see *BMJ's* website for more details). Paternal occupation was stated on 722 of 1084 death certificates, and we classified these into Office of Population Censuses and Surveys' categories.<sup>9</sup>

#### Statistical analyses

We used one way analyses of variance with conservative post hoc (Scheffe) tests to compare the age adjusted Moray house test scores for dead, living, and untraced subjects and those known to have moved away from Scotland. We tested the influence of childhood IQ on subsequent survival using Cox's proportional hazards regression. Men who died in combat during the second world war were compared with other men in terms of childhood mental ability using Student's independent *t* tests.

### Results

We traced 2230 (79.9%) of the 2792 subjects tested in schools within Aberdeen city in 1932. Subjects who

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**Table 1** Mean (SD) IQ at age 11 years for subjects who were dead, alive, untraced, and migrant on 1 January 1997

	Total	Dead	Alive	Untraced	Moved away	P value*
<b>All subjects</b>						
No	2792	1084	1101	562	45	
IQ score	100.0 (15.0)	97.7 (15.4)	102.0† (14.2)	100.8† (15.1)	98.9 (17.1)	<0.0001
<b>Men</b>						
No	1427	646	507	247	27	
IQ score	100.5 (15.5)	98.9 (15.6)	102.5† (14.8)	101.1 (15.6)	99.0 (19.5)	0.001
<b>Women</b>						
No	1365	438	594	315	18	
IQ score	99.4 (14.5)	95.9 (14.8)	101.5† (13.6)	100.5† (14.7)	98.7 (13.3)	<0.0001

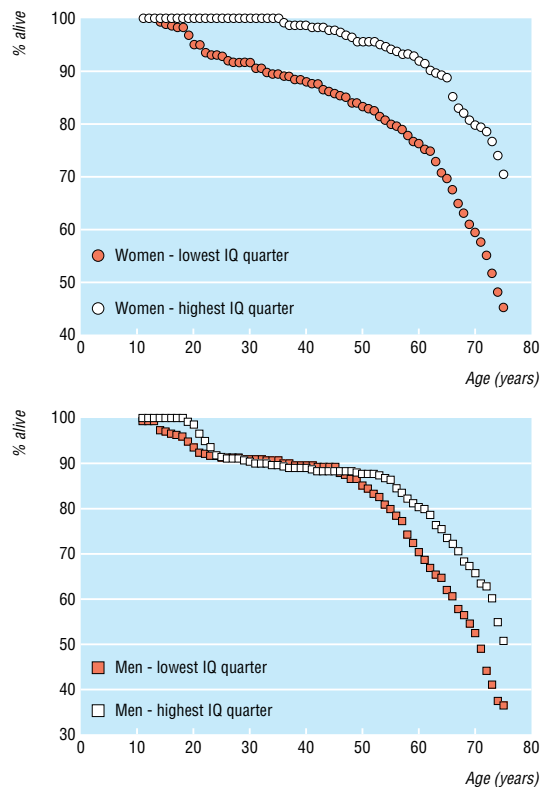
\*Analysis of variance.  
 †Significant post hoc differences existed between groups (Scheffe tests): All subjects: dead<alive (P=0.0001; 95% CI for difference -5.6 to -1.7), dead<untraced (P<0.0001; -5.7 to -1.9); Men: dead<untraced (P=0.018; -5.8 to -0.4); Women: dead<alive (P<0.0001; -8.3 to -2.8), dead<untraced (P<0.0001; -7.6 to -2.3).

died before 1 January 1997 had a significantly lower mean IQ at age 11 years than subjects who were alive or untraced (table 1). This effect was also seen when men and women were analysed separately. Overall, untraced subjects had childhood IQs similar to those of subjects who were still alive.

A Cox regression analysis including all traced subjects (alive, dead, and moved out of Scotland) showed that IQ at age 11 years on 1 June 1932 was significantly related to survival up to age 76 years on 1 January 1997 (table 2). The influence of childhood IQ on survival was weaker in men than in women. This could be due to the effect of the second world war on death rates in men (figure).

The implications of the Cox regression analyses can be shown by comparing the mean probabilities of people of different childhood IQ levels being alive on 1 January 1997. When subjects with 1 SD difference in childhood IQ are compared, the chances of those with the lower IQ being alive on 1 January 1997 are 79% for all subjects (95% confidence interval 75% to 84%), 71% for women (64% to 78%), and 83% for men (76% to 89% including only those alive on 1 January 1950). If the IQ difference is 2 SD—for example, 85 *v* 115—the relative mean chances of survival for those with the lower IQ compared with those with the higher IQ are 63% for all subjects (56% to 71%), 51% for women (42% to 61%), and 68% for men (58% to 80%).

Controlling for overcrowding hardly altered the association between childhood mental ability and survival. The correlation between IQ at age 11 and age



Probability of survival at ages 12-76 years for women and men in highest and lowest quarters for IQ score at age 11

at death after father's occupation and overcrowding were controlled for was 0.19 (P < 0.001).

### Discussion

Our data show that high mental ability in late childhood reduces the chances of death up to age 76 years. The effect is not caused by a single factor and may even be reversed, as was found for men during the second world war. This result adds to our knowledge of the personal traits in youth that contribute to survival in subsequent decades. Studies of an unrepresentative sample of children with high ability in the United States found that conscientiousness, lack of cheerful-

**Table 2** Results of Cox proportional hazards regression used to predict age at death from IQ scores at age 11 and overcrowding

Predictor variable	No alive*	No dead†	Regression coefficient (SE)	P value	Change in survival expectancy (95% CI)‡
<b>Moray house test</b>					
All subjects	1146	1071	-0.0155 (0.0020)	<0.0001	0.9847 (0.9807 to 0.9886)
Women	612	438	-0.0228 (0.0032)	<0.0001	0.9775 (0.9713 to 0.9837)
Men:	534	633	-0.0114 (0.0026)	<0.0001	0.9887 (0.9837 to 0.9937)
Excluding deaths in second world war	532	586	-0.0139 (0.0027)	<0.0001	0.9862 (0.9810 to 0.9913)
Including only those alive on 1 January 1950	534	560	-0.0128 (0.0027)	<0.0001	0.9873 (0.9820 to 0.9925)
<b>Overcrowding index</b>					
All subjects	1103	1024	0.0119 (0.0053)	0.026	1.0119 (1.0014 to 1.0226)
Women	589	417	0.0112 (0.0080)	0.158	1.0113 (0.9956 to 1.0272)
Men:	514	607	0.0142 (0.0073)	0.053	1.0143 (0.9998 to 1.0290)
Excluding deaths in second world war	512	561	0.0167 (0.0076)	0.028	1.0169 (1.0018 to 1.0322)
Including only those alive on 1 January 1950	514	537	0.0190 (0.0078)	0.014	1.0192 (1.0038 to 1.0348)

\*Subjects alive on 1 January 1997 and those who moved out of the area but were alive at a known date before 1 January 1997.

†All people with a known date of death.

‡Change in survival expectancy for a unit change in the predictor variable.

ness, and permanency of mood (for men only) were associated with living longer.<sup>18</sup> In our study, women with a deficit in IQ of 15 points at age 11 had less than 75% survival and those with a deficit of 30 points were about half as likely to survive.

The association between higher childhood IQ and an increased risk of dying in the second world war requires further investigation. Part of the effect might be explained by some men being rejected for active service because of low mental ability. More evidence is needed on the roles fulfilled by people of higher mental ability in the war and, indeed, whether the relation is true beyond Aberdeen.

We found a weak association between estimated overcrowding in the area of the childhood family home and survival. However, the association between childhood IQ and survival was not affected by controlling for overcrowding.

### Mechanisms for association

Various, non-exclusive, explanations exist for the association between childhood IQ and survival. These include genetic factors, environment before and after birth, childhood illness, and nutrition and other privation.

*Childhood IQ as record of bodily insults*—IQ at age 11 years could reflect the effect of multiple factors on the developing brain. These might include the quality of antenatal care, prenatal and postnatal nutrition, and the disabling effects of chronic childhood physical illnesses. As such, childhood IQ might be seen partly as a mediator between physical and social disadvantage and survival. These effects could be cohort specific.

*Childhood IQ as an indicator of system integrity*—Childhood IQ might also act as a general, moderately stable, indicator of system integrity within the body by indexing the efficiency of information processing in the nervous system. People with higher IQs are said to have more cerebral reserve capacity—for example, lower IQ and linguistic ability in children and young adults is associated with cognitive decline and Alzheimer's disease in late life.<sup>19 20</sup>

*Childhood IQ as predictor of healthy behaviours*—Childhood IQ might be related to the subsequent acquisition of behaviours conducive to good health. These include adopting healthy diets, sensible alcohol consumption, avoidance of injury, and not smoking. A similar set of factors was hypothesised to account for the association between conscientiousness and survival.<sup>18</sup>

*Childhood IQ as predictor of entry to safer environments*—Higher childhood IQ in men, especially in the early and middle decades of the 20th century, may have allowed entry into relatively safe employment (with wartime an important exception). In women the effect of a higher childhood IQ was possibly more indirect. Women with higher childhood mental ability might have married higher ability men and benefited indirectly from reduced exposure to occupational hazards, material privation, and, critically, the impact on family life of the husband's premature death because of dangerous work.

Thus childhood mental ability is, arguably, a conveniently measured, relatively reliable, and valid indicator for several disparate antecedents and outcomes.<sup>12 21-24</sup> The effect of IQ is difficult to separate

### What is already known on this topic

People in deprived conditions tend to have more illness and die younger

The reasons for this inequality in health are not fully established

### What this study adds

IQ at age 11 years was significantly associated with survival up to 76 years in an Aberdeen cohort

The association was unaffected by adjustment for overcrowding

Men with high IQ were more likely to die in active service in the second world war

from the effects of social class and education. These variables are moderately highly correlated, and one can act as a surrogate for one or more of the others in causing associations. For example, personality traits have been found partly to explain associations between childhood social class and poor health in adulthood.<sup>25</sup> The US national longitudinal study of youth showed that, within the white American population, both parental social class and cognitive ability in the late teens were associated with multiple indices of social, educational, and occupational outcomes many years later, although the effects were often small.<sup>21 26</sup> Social class and mental ability would often retain their influence on outcomes after the covariation was statistically controlled for. This indicates that mental ability is not entirely a surrogate for social class and vice versa.

### Possible sources of bias

We traced nearly four fifths of our target sample after a gap of about 65 years. This is higher than the percentage traced in landmark studies examining the influences of early life on health in old age. For example, Barker and colleagues' study of infant weight and death from ischaemic heart disease was based on a tracing of 71% of men.<sup>27</sup> Tracing in other influential studies is lower.<sup>6</sup> Nevertheless, it is possible that the association we found could be nullified or reversed by data from the 20% of people we could not trace. One reason for not being able to track subjects was migration. Migrants are a relatively healthy group<sup>28</sup> and had an average mental ability in our study. Although such evidence is not definitive, it suggests that severe bias in the opposite direction to our association is unlikely.

### Conclusions

In our cohort childhood IQ was a significant predictor of human survival. We do not know, however, whether this effect is cohort specific. Other possible mechanisms for the effect include previous childhood privation, the adoption of healthy behaviours in adulthood, and access to safer environments. Future studies on the causes of inequalities in health and mortality should investigate childhood mental ability as one of the factors.

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Contributors: LJW and IJD had the original idea for the study and contributed to its design. LJW coordinated the collection, compilation and checking of data, discussed the analyses, and made critical revisions to the paper. IJD contributed to the coordination of data compilation, designed and conducted the analyses, and wrote the first draft of the paper. The authors are joint guarantors of the paper.

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## The UK accelerated immunisation programme and sudden unexpected death in infancy: case-control study

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### Abstract

**Objectives** To investigate whether the accelerated immunisation programme in the United Kingdom is associated, after adjustment for potential confounding, with the sudden infant death syndrome.

**Design** Population based case-control study, February 1993 to March 1996. Parental interviews were conducted for each death and for four controls matched for age, locality, and time of sleep.

Immunisation status was taken from records held by the parents.

**Setting** Five regions in England with a combined population of over 17 million.

**Subjects** Immunisation details were available for 93% (303/325) of infants whose deaths were attributed to the sudden infant death syndrome (SIDS); 90% (65/72) of infants with explained sudden deaths; and 95% (1515/1588) of controls.

**Results** After all potential confounding factors were controlled for, immunisation uptake was strongly associated with a lower risk of SIDS (odds ratio 0.45

(95% confidence interval 0.24 to 0.85)). This difference became non-significant (0.67 (0.31 to 1.43)) after further adjustment for other factors specific to the infant's sleeping environment. Similar proportions of SIDS deaths and reference sleeps (corresponding to the time of day during which the index baby had died) among the controls occurred within 48 hours of the last vaccination (5% (7/149) v 5% (41/822)) and within two weeks (21% (31/149) v 27% (224/822)). No longer term temporal association with immunisation was found ( $P = 0.78$ ). Of the SIDS infants who died within two weeks of vaccination, 16% (5/31) had signs and symptoms of illness that suggested that medical contact was required, compared with 26% (16/61) of the non-immunised SIDS infants of similar age. The findings for the infants who died suddenly and unexpectedly but of explained causes mirrored those for SIDS infants. **Conclusions** Immunisation does not lead to sudden unexpected death in infancy, and the direction of the relation is towards protection rather than risk.

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