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, Scotland.

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 (P < 0.0001) and men (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, and socioeconomic circumstances in childhood are related to mortality from several illnesses. Educational level also contributes to differences in mortality between socioeconomic groups, although the size of this effect varies nationally. Higher mental ability, as assessed by psychometric tests, is associated with more favourable educational and occupational life outcomes. 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, and in old people whose mental functions were declining. 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. This was called the Scottish mental survey 1932 and provided a unique record of intelligence test scores for a complete age group of school children. Test data were obtained for 87 498 children (44 210 boys and 43 288 girls).

In reports of the Scottish mental survey 1932 the cognitive ability test was termed the verbal test. It has 71 items with a maximum score of 76. It contains several general, spatial, and numerical reasoning items. We will refer to it as the Moray house test. The test has criterion validity. Its correlation with the Stanford Binet test was 0.81 for boys (n = 500) and 0.78 for girls (n = 500).

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. We began a forward search in the Register of Deaths from 1932 until 1997. Untraced subjects were then sought in the Scottish Community Health Index, which records everyone registered with a family doctor (more than 99% of the population). For untraced women, we next examined the Register of Marriages in Scotland from 1937 onwards. When we discovered that an untraced woman had married in Scotland, we repeated searches using her married name in the death register and the community health index. Subjects remaining untraced were sought by computerised and hand searching of the NHS Central Register in Southport. We obtained ethical approval for the study from multicentre research ethics committee (Scotland), and Grampian local research ethics committee, and the privacy committee of the NHS Central Register.

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...
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 1992 was significantly related to survival up to age 76 years on 1 January 1997 (P < 0.0001, table 2). While gathering data for a follow on report, we rechecked all deceased people to obtain death certificate details. These checks discovered that 39 people whom we had coded as dead (based on community health index information or notes available in the General Register Office) had no death certificate available. Their mean IQ was 108.0 (SD = 10.3). Inclusion of these people as dead leads to a small underestimate of the true effect of IQ on survival. To illustrate this, we reassigned the 39 from the dead to the untraced category and redid the main univariate Cox proportional hazards regression analyses. The change in survival expectancy showed slightly stronger associations as follows: from 0.9847 to 0.9840 for all subjects, from 0.9887 to 0.9883 for men, and from 0.9775 to 0.9765 for women. We prefer to let the more conservative estimates stand.

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 1 shows that women with a high childhood IQ had a consistently better average survival expectancy than women with low childhood IQ. However, for men with a high IQ, survival suddenly drops during the second world war and does not catch up and improve on that in men with low childhood IQ until later in life.

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%).

Overcrowding in the childhood school’s catchment area was significantly related to survival when all subjects were included (table 2). The effect was significantly in men but not in women when the sexes were subjects were included (table 2). The effect was significantly in men but not in women when the sexes were subjects were included (table 2).

We used the EQS structural equation modelling program competitively to test models of these data that did and did not assume direct effects of IQ, father’s occupation, and overcrowding on age at death. The best fitting model conceptualises IQ at age 11 as a mediating variable between social factors and age at death (fig 2). Models which assumed direct effects of the available social factors on age at death and those which assumed social factors as mediators between IQ and age at death had unacceptable fit statistics.

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 cheerfulness, and permanency of mood (for men only) were associated with living longer. 18 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 significantly correlated with age at death (0.02, P > 0.05). The correlation between IQ at age 11 and age at death after father’s occupation and overcrowding were controlled for was 0.19 (P < 0.001).

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

<table>
<thead>
<tr>
<th>Predictor variable</th>
<th>No alive*</th>
<th>No dead†</th>
<th>Regression coefficient (SE)</th>
<th>P value</th>
<th>Change in survival expectancy (95% CI)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moray house test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All subjects</td>
<td>1146</td>
<td>1071</td>
<td>-0.0155 (0.0020)</td>
<td>&lt;0.0001</td>
<td>0.9847 (0.9807 to 0.9886)</td>
</tr>
<tr>
<td>Women</td>
<td>612</td>
<td>438</td>
<td>-0.0228 (0.0032)</td>
<td>&lt;0.0001</td>
<td>0.9775 (0.9713 to 0.9837)</td>
</tr>
<tr>
<td>Men</td>
<td>534</td>
<td>633</td>
<td>-0.0114 (0.0026)</td>
<td>&lt;0.0001</td>
<td>0.9867 (0.9837 to 0.9897)</td>
</tr>
<tr>
<td>Excluding deaths in second world war</td>
<td>532</td>
<td>586</td>
<td>-0.0139 (0.0027)</td>
<td>&lt;0.0001</td>
<td>0.9862 (0.9816 to 0.9913)</td>
</tr>
<tr>
<td>Including only those alive on 1 January 1950</td>
<td>534</td>
<td>560</td>
<td>-0.0128 (0.0027)</td>
<td>&lt;0.0001</td>
<td>0.9873 (0.9820 to 0.9925)</td>
</tr>
<tr>
<td>Overcrowding index</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All subjects</td>
<td>1103</td>
<td>1024</td>
<td>0.0119 (0.0053)</td>
<td>0.026</td>
<td>1.0119 (1.0014 to 1.0226)</td>
</tr>
<tr>
<td>Women</td>
<td>589</td>
<td>417</td>
<td>0.0112 (0.0080)</td>
<td>0.158</td>
<td>1.0113 (0.9956 to 1.0272)</td>
</tr>
<tr>
<td>Men</td>
<td>514</td>
<td>607</td>
<td>0.0142 (0.0073)</td>
<td>0.053</td>
<td>1.0143 (0.9998 to 1.0290)</td>
</tr>
<tr>
<td>Excluding deaths in second world war</td>
<td>512</td>
<td>561</td>
<td>0.0167 (0.0076)</td>
<td>0.028</td>
<td>1.0169 (1.0018 to 1.0322)</td>
</tr>
<tr>
<td>Including only those alive on 1 January 1950</td>
<td>514</td>
<td>537</td>
<td>0.0190 (0.0078)</td>
<td>0.014</td>
<td>1.0192 (1.0038 to 1.0348)</td>
</tr>
</tbody>
</table>

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

*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.

Fig 2 Best fitting structural equation model of associations among paternal occupation, overcrowding, IQ at age 11, and age at death up to 76 years. All parameter estimates are significantly greater than zero. Squaring the parameter weights gives the variance shared by adjacent variables; they are comparable to partial $\beta$ weights in linear regression. Average off diagonal standardised residuals=0.015; $\chi^2$ (df=2)=0.29, P=0.89; Bentler Bonett normed fit index=0.965, Bentler Bonett non-normed fit index=0.956; comparative fit index=0.965. All of these indices are indicative of a well fitting model.
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*—The mental ability test was taken in 1932, at a time when poverty was far greater and health standards were lower than at present. IQ at age 11 years could therefore 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. In this scenario, childhood IQ in part represents a record of the subject’s neurological tribulations before age 11. 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. IQ, as tested by the Moray house test, has a high stability coefficient ($r=0.63; 0.73$ when corrected for attenuation of the sample’s range of scores) between age 11 years and 77 years. Any mechanism relating IQ to survival might be stronger at lower levels of mental ability, when learning problems are accompanied by physical disorders. People with higher IQs are said to have more cerebrospinal 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. Children 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.

*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 benefitted 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. The effect of IQ is difficult to separate 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 IQ as predictor of entry to safer environments—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 benefitted 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. The effect of IQ is difficult to separate 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.

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
on the causes of inequalities in health and mortality should investigate childhood mental ability as one of the factors.

We thank the Scottish Council for Research in Education, especially Graham Thorpe, for providing data from the Scottish Mental Survey 1932. Elizabeth and Patricia Whalley traced subjects in public records. David Hunter assisted in compiling and checking data. Steven Leaper assisted with census data. Professor Gordon Murray provided statistical advice and suggestions.

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.

Funding: The chief scientist’s office of the Scottish Executive and Henry Smith’s Charities supported this research.

Competing interests: None declared.