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Manuscript title

Association of paternal IQ in early adulthood with offspring mortality and hospital admissions for injuries: a cohort study of 503 492 Swedish children

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ABSTRACT

Background: Higher intelligence (IQ) has been related to a lower risk of mortality and hospital admissions for injuries, but little is known about the effect of parental IQ on offspring outcomes. We explored associations of paternal IQ with mortality and hospitalizations for injuries from all external causes in offspring.

Methods: A cohort of 503 492 Swedish children under 5 years of age with information on paternal IQ was obtained by record linkage of national registers. Hazard ratios (HR) with 95% confidence intervals (CI) were estimated using Cox regression.

Results: There was some evidence that paternal IQ was inversely associated with total and external-cause mortality in offspring, although the effects were modest and disappeared when controlling for parents' socioeconomic position (SEP). The only robust gradient was found between paternal IQ and hospital admissions for injuries ($HR_{\text{per 1-SD increase in IQ}}$; 95% CI= 0.93; 0.92-0.94; P <0.001), which was slightly attenuated but retained statistical significance after adjustment for SEP (0.95; 0.94-0.97; P <0.001).

Conclusion: Children to fathers with lower IQ may have an increased risk of injury by external causes. Messages on family safety and injury prevention might be tailored according to parental cognitive abilities.

INTRODUCTION

Higher intelligence (IQ) both in childhood and early adulthood has been related to lower rates of mortality,[1-3] but only a few studies have analyzed parental IQ. Increased maternal IQ was related to reduced child mortality in a cohort study of 1294 mothers of the Nicaragua's literacy programme[4] and in a sample of 222 Serbian Roma women,[5] but these results cannot be directly generalized to affluent populations. Studies from developed countries have observed that external causes, mostly unintentional injuries, make an important contribution to the inverse IQ-mortality association.[2,3] Similarly, individuals with lower IQ have consistently shown a higher risk of hospital admissions for injuries.[6-9] A recent study based on 1446 mother-offspring and 822 father-offspring pairs from the 1958 British birth cohort showed that children of lower IQ parents, both fathers and mothers, were more likely to have injuries requiring hospitalization.[10] However, there is no study on the association between paternal IQ and offspring mortality. The objective of the present study is to examine associations of paternal IQ with offspring mortality and hospital admissions for injuries from all external causes. Our nationwide population data, based on record linkage of Swedish registers, provides a dataset considerably larger than those for existing studies in this field.

METHODS

Study population

The record linkage methods used to generate this cohort have been reported in detail elsewhere.[2,6] In brief, the study cohort comprised all non-adopted children born in Sweden 1973–1987 for whom fathers were eligible for conscription (born 1950-1969) and could be identified in the Multi-Generation Register. During the years covered by this study, this examination was required by law: only men of foreign citizenship or with severe disability were

excused. Using unique personal identification numbers, the Multi-Generation Register was linked to the Military Service Conscription Register. Further information on mortality based on the Cause of Death Register, hospitalizations based on the National Hospital Discharge Register, and parents' socioeconomic position (years 1980, 1985, 1990) and education based on Censuses records covering the whole Swedish population were linked to these data. The eight and nine revision of the International Classification of Diseases (ICD) was used to identify all external causes of injury, intentional or unintentional (E800–E999).

During the conscription examination, IQ was measured by four written subsets representing verbal, logical, spatial and technical abilities. All test scores, including a total IQ score derived from summing the subset results, were standardized to give a Gaussian-distributed score between 1 and 9 (global IQ).[6,11] Height was measured according to a standardized protocol. The present dataset covers conscription examinations from 1969-1987. Analyses were restricted to children born after father's conscription and multiple births were excluded. Family size ranged from 1 to 10 and almost half of children (49%) belonged to families of two siblings. Father's age range at conscription examination was 17–26 years; however only 3% were older than 20 years of age. Highest occupation based SEP and education were classified to seven categories.[6] The Swedish conscripts were required to enlist in the nearest conscription centre, and thus we used also this covariate in the analyses to take into account possible geographic variation. Together we had information on 503 492 children with complete information on paternal IQ (291 394 fathers) and all covariates described above. Ethical approval was obtained from the Ethical Review Board, Stockholm, Sweden.

Statistical methods

Cox proportional hazards regression was used to explore paternal IQ-offspring death/hospital admission associations, having first checked that proportional hazards assumptions were not violated. Hazard ratios (HR) with 95% confidence intervals (CI) were estimated before and after adjusting for potential covariates. Follow-up started at birth and ended at the age of hospitalization (only for hospital admissions), death or 5 years; whichever came first. In order to preserve statistical power,[12] IQ was categorized into three groups ('low' = 1–3, 'medium' = 4–6, 'high' = 7–9) in mortality analyses. For the association with hospital admissions, the full IQ scale with nine categories was used. We also calculated HRs per standard deviation (SD) increase in IQ score. CIs were adjusted for clustering of siblings with the same father. All analyses were computed using STATA/IC 12.0 (StataCorp, College Station, Texas, USA).

RESULTS

We observed a stepwise increase in the proportion of parents in a non-manual occupation and university educated and in the mean parental age at birth for children of higher IQ fathers (Table 1). Mean age at testing was marginally greater in the higher IQ-scoring group.

(Table 1 about here)

Associations of paternal IQ with offspring mortality and hospital admissions are presented in Table 2. Adjustment for the covariates of the basic model (father´s birth year and conscription age, testing center, and child's sex and birth year) showed similar results to the unadjusted model (available upon request). Since additional adjustment for parental age and family size had little impact (available upon request), a separate model was not presented. Paternal IQ showed an

indication of a weak, inverse relationship with offspring total mortality ($HR_{\text{per 1-SD increase in IQ}}$ with 95% CI= 0.97; 0.93-1.01), but after controlling for parental SEP, the association practically disappeared (0.99; 0.95-1.04). The evidence of association was stronger with mortality from injuries in the basic model (0.87; 0.75-1.02), but also disappeared after adjusting for SEP (1.01; 0.85-1.19). Accordingly, paternal IQ showed an inverse relationship with hospital admissions for injuries, which remained significant in the multiply adjusted model (0.95; 0.94-0.97).

(Table 2 about here)

DISCUSSION

In this large population-based study, paternal IQ showed only a limited evidence of inverse association with total and external-cause mortality in offspring. In addition, we found that children of higher IQ fathers have less hospital admissions for injuries even after adjustment for parental SEP.

IQ has found to be inversely related to mortality in several studies,[1-3] and there is some evidence from resource-poor populations that lower maternal IQ is also associated with greater offspring mortality.[4,5] Our findings suggest an inverse relationship between paternal IQ and offspring mortality under 5 years, but none of the gradients were statistically significant. In high-income countries, injuries (intentional and unintentional) are the leading cause of child (1-14 years) death.[13,14] Individuals with lower IQ have consistently shown a higher risk of mortality and hospitalizations for injuries.[3,6-9,15] In this study deaths from injuries showed a stronger evidence of association with paternal IQ, but the association disappeared after controlling for parental SEP. When we analyzed hospital admissions, increasing at least two orders of magnitude

the number of cases, we found a significant decrease with father's IQ scores. This association was slightly attenuated but retained statistical significance in the multiply adjusted model, and additional adjustment for parental education had no impact (data not shown). Our findings corroborate those from the 1958 British birth cohort, in which children of lower IQ parents were more likely to have injuries requiring hospitalization.[10]

Maternal intelligence could have had an important influence on child survival in situations of high childhood mortality.[16] The weak effect observed in our study is thus not unexpected; in addition to the particularly low infant mortality rate in Sweden, the reasonably equal distribution of wealth, high standard of living and the countrywide network of maternal and child health clinics [17] allow a small variation in offspring mortality rate due to differential paternal IQ. Similarly, Sweden has one of the lowest childhood injury mortality in the world. [18] A potential explanation for the observed increased risk of injury in children to fathers with lower IQ is that these fathers have a reduced perception of risk, not only for themselves but also for their offspring, and thus might be less likely to discourage risky behaviors. In addition, since IQ is highly heritable it is possible that low IQ children, born to low IQ fathers, might place themselves in additional danger. However in the study of Whitley et al.,[10] adjustment for child's own IQ had no effect, indicating that the associations are not simply a consequence of children with lower inherited IQ taking additional risks.

The strength of this population-based study lies in its size and nationwide coverage, with information on paternal IQ, offspring outcomes and a wide range of covariates. This large dataset allows us to find small effects that would not be detectable in smaller samples, thus avoiding bias towards reporting significant and "large effect" results. However, our results are limited to men

and cannot be generalized to similar outcomes of young women. Other potential limitations are that 30% of children were excluded from analyses because of missing IQ of the father, and also that injuries seen in primary medical care or other outpatient medical services were not included.

In conclusion, even if childhood total and injury mortality rates in Sweden are among the lowest in the world, children to fathers with lower IQ have an increased risk of injury by external causes independently of parental SEP. These findings may be interpreted to mean that messages on family safety and injury prevention should be presented and perhaps tailored according to parental cognitive abilities.

What is already known on this subject?

Higher IQ has been related to lower risk of mortality and hospitalizations for injuries, but little is known about the effect of parental IQ on offspring outcomes. Two studies have suggested that maternal IQ is associated with greater offspring mortality and a third one that children to parents with lower IQ are more likely to have injuries requiring hospitalization.

What this study adds?

In this study, based on more than 500 000 Swedish children (around 100 times more than previously studied in this context), some evidence of inverse association was found between paternal IQ and offspring mortality. In addition, we showed that children to fathers with lower IQ had a higher risk of hospitalization for injuries. Messages on family safety and injury prevention should be tailored according to parental cognitive abilities.

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Competing interests None declared

REFERENCES

1 Batty GD, Deary IJ, Gottfredson LS. Premorbid (early life) IQ and later mortality risk: systematic review. *Ann Epidemiol* 2007;**17**:278-288.

2 Batty GD, Wennerstad KM, Smith GD, et al. IQ in early adulthood and mortality by middle age: cohort study of 1 million Swedish men. *Epidemiology* 2009;**20**:100-109.

3 Leon DA, Lawlor DA, Clark H, et al. The association of childhood intelligence with mortality risk from adolescence to middle age: Findings from the Aberdeen Children of the 1950s cohort study. *Intelligence* 2009;**37**:520-528.

4 Sandiford P, Cassel J, Sanchez G, et al. Does intelligence account for the link between maternal literacy and child survival? *Soc Sci Med* 1997;**45**:1231-1239.

5 Cvorovic J, Rushton JP, Tenjevic L. Maternal IQ and child mortality in 222 Serbian Roma (Gypsy) women. *Personality and Individual Differences* 2008;**44**:1604-1609.

6 Whitley E, Batty GD, Gale CR, et al. Intelligence in early adulthood and subsequent risk of unintentional injury over two decades: cohort study of 1 109 475 Swedish men. *J Epidemiol Community Health* 2010;**64**:419-425.

7 Batty GD, Deary IJ, Schoon I, et al. Childhood mental ability in relation to cause-specific accidents in adulthood: the 1970 British Cohort Study. *QJM* 2007;**100**:405-414.

8 Osler M, Andersen AM, Laursen B, et al. Cognitive function in childhood and early adulthood and injuries later in life: the Metropolit 1953 male birth cohort. *Int J Epidemiol* 2007;**36**:212-219.

9 Lawlor DA, Clark H, Leon DA. Associations between childhood intelligence and hospital admissions for unintentional injuries in adulthood: the Aberdeen Children of the 1950s cohort study. *Am J Public Health* 2007;**97**:291-297.

10 Whitley E, Gale CR, Deary IJ, et al. Influence of maternal and paternal IQ on offspring health and health behaviours: evidence for some trans-generational associations using the 1958 British birth cohort study. *Eur Psychiatry* 2013;**28**:219-224.

11 David AS, Malmberg A, Brandt L, et al. IQ and risk for schizophrenia: a population-based cohort study. *Psychol Med* 1997;**27**:1311-1323.

12 Gunnell D, Magnusson PK, Rasmussen F. Low intelligence test scores in 18 year old men and risk of suicide: cohort study. *BMJ* 2005;**330**:167.

13 Segui-Gomez M, MacKenzie EJ. Measuring the public health impact of injuries. *Epidemiol Rev* 2003;**25**:3-19.

14 A league table of child deaths by injury in rich nations **[**Innocenti Report Card **no. 2].** Florence: UNICEF Innocenti Research Centre; 2001. Available at: http://www.unicef-irc.org/publications/pdf/repcard2e.pdf. Accessed 11/12, 2013.

15 Batty GD, Gale CR, Tynelius P, et al. IQ in early adulthood, socioeconomic position, and unintentional injury mortality by middle age: a cohort study of more than 1 million Swedish men. *Am J Epidemiol* 2009;**169**:606-615.

16 Charlton BG. Why are women so intelligent? The effect of maternal IQ on childhood mortality may be a relevant evolutionary factor. *Med Hypotheses* 2010;**74**:401-402.

17 Kohler L. Infant mortality: the Swedish experience. *Annu Rev Public Health* 1991;**12**:177-193.

18 Jansson B, De Leon AP, Ahmed N, et al. Why does Sweden have the lowest childhood injury mortality in the world? The roles of architecture and public pre-school services. *J Public Health Policy* 2006;**27**:146-165.

1- Descriptive statistics for study variables by paternal IQ score (n=503 492)

	Global IQ		
	Low	Medium	High
No. of children	105 827	275 235	122 430
No. of fathers	62 047	159 903	69 444
Proportion (%)			
Sex of children (%), male	51.4	51.5	51.4
Father/mother in non-manual occupation (%)	20.3/31.0	43.3/44.9	73.7/63.5
Father/mother university educated (%)	4.6/15.8	20.0/28.1	55.4/49.2
Mean (SD)			
Family size (number of siblings)	1.9(0.8)	2.0(0.8)	2.0(0.8)
Paternal age at testing (years)	18.5(0.8)	18.5(0.7)	18.7(0.7)
Paternal age at birth (years)	26.5(3.7)	27.1(3.7)	28.2(3.5)
Maternal age at birth (years)	24.5(4.1)	25.4(4.1)	26.9(4.1)

Table 2- Hazards ratios (95% CI) for the relation of paternal IQ with offspring mortality and hospital admissions before 5 years of age

IQ score	No. of cases/total	Basic model[a]	Adjusted for SEP[b]	Multiply adjusted[c]
Total mortality				
Low	702/105 827	1.0	1.0	1.0
Medium	1620/275 235	0.89(0.81,0.98)	0.92(0.84,1.01)	0.91(0.83,1.00)
High	730/122 430	0.91(0.81,1.01)	0.97(0.87,1.10)	0.93(0.83,1.04)
Per 1 SD IQ increase	3052/503 492	0.97(0.93,1.01)	0.99(0.95,1.04)	0.98(0.94,1.02)
P value		0.10	0.80	0.24
Mortality from injuries				
Low	40/105 827	1.0	1.0	1.0
Medium	90/275 235	0.91(0.62,1.34)	1.07(0.72,1.58)	1.08(0.73,1.59)
High	27/122 430	0.69(0.41,1.15)	1.02(0.59,1.75)	1.02(0.59,1.75)
Per 1 SD IQ increase	157/503 492	0.87(0.75,1.02)	1.01(0.85,1.19)	1.01(0.85,1.19)
P value		0.09	0.95	0.95
Hospital admissions for injuries				
1	764/14 260	1.0	1.0	1.0
2	1743/35 285	0.90(0.83,0.99)	0.93(0.85,1.01)	0.93(0.85,1.01)
3	2656/56 282	0.87(0.80,0.94)	0.90(0.83,0.98)	0.90(0.83,0.98)
4	3859/83 395	0.85(0.79,0.92)	0.89(0.83,0.97)	0.90(0.83,0.97)
5	4518/101 989	0.81(0.75,0.88)	0.86(0.80,0.93)	0.87(0.80,0.94)
6	3768/89 851	0.78(0.72,0.84)	0.84(0.77,0.91)	0.84(0.78,0.91)
7	2631/64 800	0.76(0.70,0.82)	0.82(0.76,0.90)	0.83(0.76,0.90)
8	1476/38 357	0.71(0.65,0.78)	0.79(0.72,0.87)	0.79(0.72,0.87)
9	753/19 273	0.73(0.66,0.81)	0.81(0.73,0.91)	0.82(0.74,0.91)
Per 1 SD IQ increase	22168/503 492	0.93(0.92,0.94)	0.95(0.94,0.97)	0.95(0.94,0.97)
P value		<0.001	<0.001	<0.001

[a]Adjusted for father´s birth year, age at testing and conscription testing center, and child's sex and birth year.

[b]Basic model additionally adjusted for parental SEP.

[c]Basic model additionally adjusted for parental SEP, parental age at birth and family size.