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Birth order and mortality: a life-long follow-up of 14,200 boys and girls born in early 20th century Sweden

Bitte Modin*

Centre for Health Equity studies, Department of Sociology, Stockholm University, SE-106 91 Stockholm, Sweden

Abstract

The present study examines the sex-specific patterns of mortality by birth order in four stages of the life-course, using Poisson and logistic regression analysis. The main question posed is whether there is any continuing social effect of birth order when (a) biological factors at birth, (b) other social factors at birth and (c) socio-economic circumstances in adulthood are adjusted for. The analyses are based on the Uppsala Birth Cohort Study consisting of all 14,192 boys and girls who were born alive at the Uppsala Academic Hospital in Sweden during the period 1915–29. The results showed that all-cause mortality differed according to birth order in all of the four studied age intervals when birth year, mother's age, birth weight, gestational age, diseases of mother, diseases of the infant, social class and mother's marital status at the time of childbirth were adjusted for. The general tendency was for laterborn siblings, particularly girls/women, to demonstrate a higher mortality risk than firstborn children. However, in the oldest age group (55–80 years) the previously significant association between birth order and male mortality became insignificant when adult socio-economic circumstances were controlled for. This indicates that the long-term influence of childhood birth order position on mortality is partly mediated by adult social class, education and income. The concluding section of the paper notes that laterborn children, and especially girls, were a disadvantaged group in early 20th century Sweden. Thus, for the subjects in the present study, the childhood social conditions linked to birth order position seem to have had consequences for these individuals' health and survival that extend over the whole life-course.

Keywords: Birth order; Mortality; Social class; Birth weight; Sweden

Introduction

The broad concept of childhood social disadvantage covers many aspects of a child's experiences during upbringing. Much research that has considered the implications of childhood social conditions for adult health and mortality has looked at social class (Notkola, Punsar, & Haapakoski, 1985; Kaplan & Salonen, 1990; Östberg & Vågerö, 1991). However, when studying the long-term consequences of childhood social conditions it is important not only to take into consideration the circumstances that tend to vary between families, such as social class, but also to consider those factors that tend to vary within families. An important factor of the latter kind is a child's birth order. The following longitudinal study, based on all 14,192 children who were born alive at the Uppsala Academic Hospital in Sweden during the period 1915–29, will examine the sex-specific patterns of mortality by birth order in four stages of the life-course—from birth to old age. The main question is whether there is any continuing social effect of birth order when (a) biological factors at birth, (b) other social factors at birth and (c) socio-economic circumstances in adulthood are taken into account. The latter information, however, is only available for those who survived until 1970.

Having a large number of siblings may well be considered a resource in many respects. Older brothers and sisters may serve as role models for younger

*Tel.: +46-8-162313; fax: +46-8-162600.
E-mail address: bmodin@sociology.su.se (B. Modin).

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siblings, and they are often important sources of social support. Laterborns are also heavier at birth, on average, and may thus be less prone to heart disease, diabetes and other diseases in adult life (Barker, 1994). However, despite all the possible advantages of laterborns, a large number of studies have indicated that children of high birth order tend to end up in a disadvantaged position during upbringing with regard to both health (Sears, Maccoby, & Levin, 1957; Nixon & Pearn, 1978; Kaplan, Mascie-Taylor, & Boldsen, 1992; Elliot, 1992) and educational achievement (Walldén, 1990, 1992; Belmont & Marolla, 1973; Belmont, Stein, & Wittes, 1976; Breland, 1973, 1974). Taken together, these latter studies suggest that children born late in the sibling order may be more vulnerable to disease and death over the life-course than their earlier-born brothers and sisters.

The historical aspect of the longitudinal approach

Birth order studies have often been criticised for their lack of consistent findings (Schooler, 1972; Freese, Powell, & Steelman, 1999; Ernst & Angst, 1983). Apparently the influence of birth order on various types of outcomes is largely dependent on the social, cultural and historical context in which studies are carried out. Clearly, as society changes, the internal lives of families change as well. For instance, as fertility rates decline and family policy improves, the relative advantage of one birth order position over another may vanish or change. Consequently, the influence of birth order on various outcomes does not always appear as a linear pattern, neither does it stand out as a consistent predictor over time and between countries. The fact that birth order effects tend to vary in strength over time and place, however, can help to clarify how the more specific mechanisms, by which social (dis)advantages within families arise, are connected to certain societal features.

When one follows individuals over the entire life span, as in the present study, one is bound to start out in some historical context. For the subjects of the present study, for example, the social conditions during their infancy and childhood (1915–44) differed dramatically from those of children in present day Sweden. A simple way of forming an idea of a population's life conditions at a particular point in time is to look at the infant mortality rates, since this information often reflects both nutritional status and level of hygiene as well as housing standard and level of education (Högberg, 1983). Swedish infant mortality rates in the periods 1911–20 and 1921–30 were 69 and 59, respectively (Historical Statistics for Sweden, 1955) while by 1999 they had fallen to 3.5. The infant mortality rate of 66 per 1000 live births in the studied cohort, is equal to that of many developing countries of today, such as Senegal and Bolivia (Population Reference Bureau, 1999).

However, the context in which the Uppsala children grew up is, of course, in many respects not comparable with that of today's developing countries. In order to better understand the conditions into which the studied individuals were born, a brief account of the structural and demographic characteristics of early 20th century Uppsala is given below.

By the time the subjects under study here were born, Uppsala had experienced a considerable population growth as part of the urbanisation that took place as Sweden became an industrialised nation (Ullenhag, 1984). Uppsala was among the 12 largest cities in Sweden (Isacson & Magnusson, 1996), dominated by its university, but with an occupational structure that was similar to that of Swedish cities and towns in general. However, the municipality of Uppsala also included several adjacent parishes, predominantly inhabited by farmers, peasants and farm labourers. In 1920, the population of greater Uppsala was 65,000 (Wahlström, 1997).

Working class families (including the rural labourers) most often lived in accommodation consisting of one single room and a kitchen. This was particularly the case for large families, since their higher food and clothing expenses had to be compensated for by a lower expenditure on accommodation (Isacson & Magnusson, 1996; Prenzlau-Enander, 1991). Sibsize was much bigger than it is in Sweden today. In the Uppsala cohort, 11 percent were six or higher in the birth order, while the corresponding figure for Sweden in 1985 was 1 percent (Vågerö, Koupilová, Leon, & Lithell, 1999). Nevertheless, by the early decades of the 20th century, Swedish fertility rates had already declined quite dramatically since the 19th century when Swedish women had on average 4–5 children. During the period 1916–20 to 1926–30, total fertility rates continued to decline from 2.8 to 2.1, and the corresponding figure of 1.5 in 1999 does not imply any dramatic decline since then (Statistics, Sweden, 1999:2; Population Reference Bureau, 1999). However, in the early 20th century, the proportion of childless women was larger than it is today, which is consistent with the fact that high parity was so much more common during this period, despite the relatively low fertility rate (Statistics, Sweden, 1992:1).

It was not only in the working class that children of high birth order could be found, as demonstrated in Table 1. In fact, it was in the fairly well-off group of entrepreneurs and farmers that the largest share of children with high birth order were to be found. The lowest percentage of children of high birth rank, on the other hand, was found among those for whom no occupation was classifiable. This is mainly due to the fact that a large share of unmarried mothers, still living

Table 1
Distribution of birth order (in percent) by social class at birth for children born alive at the Uppsala Academic Hospital during 1915–29

Birth order	Higher non-manuals	Lower non-manuals	Skilled workers	Unskilled manual workers[a]	Entrepreneurs and farmers	Not classified	Total
1	44.1	33.9	31.1	40.9	24.2	71.8	39.1
2	26.2	27.4	24.7	24.3	21.5	14.2	23.4
3–4	20.8	22.9	25.1	20.9	28.2	8.6	21.8
5–6	5.0	9.2	10.0	7.6	13.2	2.8	8.4
7–18	3.9	6.6	9.1	6.3	12.9	2.6	7.3
Total	100	100	100	100	100	100	100
n	1158	952	1944	6493	2416	1209	14,189

[a] Including farm labourers.

at home with their parents, ended up in this category. Unmarried mothers rarely gave birth to more than two children, as shown in Table 2.

Table 2
Distribution of birth order (in percent) by mother's marital status at the time of childbirth for children born alive at the Uppsala Academic Hospital during 1915–29

Birth order	Married	Unmarried	Total
1	30.0	75.7	39.3
2	24.8	18.1	23.4
3–4	25.9	5.2	21.7
5–6	10.3	0.6	8.4
7–18	9.0	0.4	7.2
Total	100	100	100
n	11,202	2844	14,046

Theoretical considerations

When studying birth order differences in mortality it may, at first, seem relevant to look only at those stages of the life-course in which the individual actually lives in a birth order structure. Any social disadvantage tied to a specific birth order position, it could be argued, should only be manifested while still living in the family of origin. However, the social conditions under which children grow up also tend to structure many aspects of their future life chances, including their mortality risk at adult and old age (Preston, Hill, & Drevenstedt, 1998; Notkola et al., 1985; Kaplan & Salonen, 1990). Thus, even after they have left their family of origin, high birth order adults may be expected to have an elevated mortality risk as a result of factors such as their lower level of education (Walldén, 1992; Modin, 2000).

While birth order *in itself* cannot be assumed to have a direct influence on mortality, there are some childhood social conditions, important to health, that seem to be closely connected to certain birth order positions. The resource theory maintains that family resources—material as well as human—become diluted as the family of brothers and sisters grows larger (Blake, 1981, 1989). Thus, in contrast to most first- and earlier-borns, children of high birth order are born into conditions characterised by restricted access to parental attention and supervision (Hanushek, 1992). Such a limited access to parental time, it would appear, may also result in less attention being paid to the health and safety of these children during their first years of life. For instance, laterborns of large families have been found to run a higher risk of experiencing accidents during early childhood (Nixon & Pearn, 1978; Bijur, Golding, & Kurzon, 1988). Furthermore, in early 20th century Sweden, even if the poverty that sometimes accompanied growing families affected all siblings equally, earlier-borns in large families may still be expected to have been less exposed by the shortage of economic resources and crowded housing during early childhood than their laterborn siblings. Moreover, deaths from infectious diseases still played a role in Sweden at the time when the studied subjects were born (Statistics, Sweden, 1997:2), and children who were born into an already crowded house clearly ran a higher risk of catching a life-threatening infection during their first vulnerable years of life than were small children with few or no older siblings (Burnett, 1991).

Several factors need to be taken into consideration when one is trying to separate the social consequences of birth order position on mortality from biological explanations and social confounders. Thus, while sociological and psychological research almost exclusively finds firstborns to be the most privileged children during upbringing, the biological advantage of laterborns in terms of their physical size at birth is just as well documented (Magnus, Berg, & Bjerkedal, 1985; Modin, 2000). Since the physical size and constitution of a newborn baby is important for survival in early life, this ought to speak in favour of the survival of infants of higher birth orders. However, there are also biological factors connected to *short birth interval* and *maternal ageing* that speak against the survival of laterborns over first- and earlier-borns. Thus, the "biological depletion" of the mother has been put forward as an explanation behind the often-observed higher mortality of children born towards the end of large sibships (Chidambaram, McDonald, & Bracher, 1987; Majumder, 1988).

As for the confounding effect of certain social factors, there are some that speak against the advantage of firstborns over laterborns, while others run in the opposite direction. Firstborns are heavily over-represented among the so-called *illegitimately born* children, a highly disadvantaged group during the period under study. Furthermore, while having a young ("undepleted") mother may constitute a biological advantage, which favours the survival of firstborns over laterborns, the corresponding social consequences of maternal youth may have the opposite effect. On the other hand, children of high birth ranks are more likely to be brought up under conditions characterised by economic shortage because of their higher probability of belonging to *large families* (Hanushek, 1992; Berglin, 1980) and lower *social classes* (Schooler, 1972; Kennet & Cropley, 1970). However, among the Uppsala children, there was no obvious tendency for children of high birth order to come from the lower social classes, as demonstrated in Table 1.

Previous empirical findings

Research on health and mortality with regard to birth order has primarily focused on infancy and early childhood; only a handful of studies have considered such differences at adult and old age. Most studies have been of a cross-sectional character or with little information on biological and social characteristics in early life. Nevertheless, a positive association between birth order and mortality *during infancy* has been demonstrated for Swedish and Norwegian infants born during 1985–88. Thus, when firstborns were the reference category, Swedish infants born as number 2, 3 and 4+ in the ordinal position of siblings had a mortality ratio of 1.2, 1.1 and 1.7, respectively, when maternal age and region were adjusted for. The corresponding figures for Norwegian infants were 1.4, 1.6 and 2.3 (Espehaug et al., 1994). However, considering the demographic characteristics of the Uppsala cohort, references to contemporary industrialised nations may not give the best guideline to what patterns of mortality by birth order should be expected in the present study. Indeed, a comparative study of 41 developing countries discovered that infant mortality by birth order differed with regard to the country's level of child mortality. Thus, for five groupings of countries, the association was u-shaped, j-shaped or linear, respectively, depending on whether the corresponding level of under-five mortality was "extremely high" to "high" (12–20%), "moderate to high" (8–12%) or "moderate" (4–8%) (Rutstein, 1984).

In the Uppsala cohort, 8.5 percent died before their fifth birthday, which corresponds to a "moderate to high" child mortality in the above classification. In these countries, firstborns had a slightly elevated risk of mortality when 2nd–3rd borns were the reference category, while those born as the 4–6th and 7th or higher in the ordinal position of siblings had a 16 and 44 percent higher mortality risk, respectively (Rutstein, 1984). Thus, the level of child mortality in early 20th century Uppsala has a closer resemblance to that of countries where a j-shaped association has been demonstrated than to that of countries with very high child mortality, for which a u-shaped pattern is usually found (Omran, 1981; Chidambaram et al., 1987; Majumder, 1988; Rutstein, 1984), or to those of countries with "moderate and low" infant mortality rates, for which there often seems to be a positive association (Rutstein, 1984; Espehaug et al., 1994). However, it should be pointed out that this is not an all-encompassing phenomenon. Thus, for example, a j-shaped association has been demonstrated for US infants born in the 1980s (Houge, Buehler, Strauss, & Smith, 1987).

A positive association between birth order and mortality *during childhood* has most often been demonstrated for developing countries (Chidambaram et al., 1987; Newcombe, 1965; Ballweg & Pagtolun-an, 1992; Rutstein, 1984), and studies based on samples from industrialised nations seem to point in the same direction. For instance, in a large British study, the number of older siblings was shown to have a significant positive association with the percentage of children between 1 and 5 years who had ever been hospitalised due to accidents (Bijur et al., 1988). Furthermore, among Australian children who had experienced a non-fatal drowning accident, more than half were found to be last-born children of large sibships. The causes of these findings, the authors state, may be lack of time for parental supervision leading to an increased risk of accidents for laterborn children of large sibships (Nixon & Pearn, 1978). This may also result in parents paying less attention to the health of the child as well as a tendency to less disease prevention. For instance, children of early birth order have been shown to receive more acute medical care (Horwitz, Morgenstern, & Berkman, 1985), and to attend maternal and pre-school health care services more often than those of later birth order (Celik & Hotchkiss, 2000; Fergusson, Dimond, Horwood, & Shannon, 1984). Furthermore, a British study of more than 14,000 children born in 1958 discovered that first and second children were more often immunised against diphtheria and smallpox than their laterborn siblings. Firstborns were also more likely to have been immunised against polio than any of the subsequently born children (Kaplan et al., 1992).

At adult and old age, there is little evidence of an association between birth order and mortality. As far I know, only one study has previously examined all-cause mortality by birth order in adulthood (O'Leary et al., 1995). This study of subjects born during 1904–15 failed to verify their hypothesised positive association. However, as pointed out by the authors, the studied subjects were not generalisable to the whole population. They consisted, namely, of a group of students who scored 135 or higher on the Stanford IQ test who were selected around 1920 from schools throughout California, and more than half of whom were firstborns. Therefore, the privileged positions of these subjects, regardless of their birth order, may explain the fact that such an association was not present in this sample (O'Leary et al., 1996).

Of the research that has been carried out into the effects of birth order on adult illnesses, two studies have compared adult patients who had suffered a myocardial infarction with control groups of patients with other illnesses. In one of these studies, 100 men and women were compared with controls (Oscherwitz, Krasnov, & Moretti, 1968), while in the other 100 females constituted the cases (Szlako, Tonascia, & Gordis 1976). In both studies, laterborns from large sibships were overrepresented among myocardial infarction patients. A number of studies have also examined the influence of birth order on adults with various types of psychopathological diagnoses. In a study of 90 alcoholic adult sons of alcoholic parents, laterborns ran a significantly higher risk than firstborn sons of developing psychopathological symptoms as a result of their alcoholism (Keltner, McIntyre, & Gee, 1986). Some researchers have also claimed that laterborns run a higher risk of developing anorexia nervosa (Crisp, 1970), although later research has failed to confirm these results (Gowers, Kadambari, & Crisp, 1985).

Analytical considerations

A common problem when studying rare events such as mortality, is that certain statistical prerequisites tend to force a constraint upon the theoretical prospects of the analyses. In the present study, for example, the number of deaths within each combination of sex, birth order group and age interval cannot be too small, if statistically reliable results are to be obtained. The four age intervals examined in this study are infancy (first year of life), childhood (1–10 years), adulthood (20–54 years) and mature and old age (55–80 years), while birth order has been grouped into five categories consisting of children born as number 1, 2, 3–4, 5–6 and 7–18 in the ordinal position of siblings. Thus, although it would have been preferable from a theoretical point of view to divide age interval and birth order into even narrower categories, the data material does not lend itself to a more detailed analysis than the present one. Moreover, children and teenagers in the age span 11–19 have been excluded from analyses because of the small number of deaths at these ages. Nevertheless, the Uppsala cohort still offers the unique possibility of examining the patterns of mortality by birth order over an entire generation of Swedish men and women born in the early 20th century.

There are, however, some limitations of the data which need to be elucidated. First of all, the records from the Uppsala Academic Hospital lack information on birth interval. Birth spacing has proved to be of great significance for both infant and child mortality, with short intervals leading to a higher risk of death, partly because of the "biological depletion" of the mother (Chidambaram et al., 1987; Majumder, 1988). Instead, the present study will use mother's and infant's health as registered at the maternity ward as controls for any biological differences by birth order. Yet another drawback in this study is the lack of information on final family size. However, family size is a dynamic variable, and therefore quite difficult to handle when studying people over extensive periods of time. Nevertheless, in this study, birth order and family size are practically equal at the beginning of the studied period, i.e. during the first year of life.

Finally, some inaccuracies regarding the measurement of birth order have to be borne in mind when interpreting the results of the following study. The mother's registered parity, i.e. number of previous births, was used as a measure of birth order. This means that approximately 3 percent of the birth order information is biased toward higher birth orders due to the fact that a stillbirth was counted as one birth in the studied registers. However, it was highly unusual for mothers in the present study to experience more than one stillbirth. Information on stillbirths is available for 50 percent of the subjects. Of 7897 mothers, 19 had had two stillbirths, while only 7 had had three stillbirths. Furthermore, deaths among siblings occurring later in life may further have altered the ordinal relations between children in the family. Nevertheless, these errors are small and the results should not be greatly affected.

Data material and variables

The Uppsala Birth Cohort Study (UBCoS) database consists of all 14,609 births at Uppsala Academic Hospital during the period 1915–29. In the present study only those 14,192 children who were born alive are included in the analyses. Nearly all births (97.3 percent) have been successfully traced through parish archives and were, thereafter, linked to computerised census and death registers. More details about the tracing can be found in Leon et al. (1998). The UBCoS database includes information on biological characteristics and social information at birth, educational and occupational achievement as well as income at specific points in time, and mortality over the whole life-course up to 1995. Birth order information (mothers' parity) is available for 14,189 of the boys and girls who were born alive. Births at the Academic Hospital accounted for 75 percent of all births during 1915–29 among residents in Uppsala city and 50 percent of all births among residents of neighbouring parishes. Home births became increasingly uncommon during this period.

Table 3 presents the independent variables used in the analyses. Social class at the time of birth was classified according to the occupation of the head of the household. The mother's occupation was used when there was no father in the household. The socio-economic classification scheme (SEI) was applied. Five groupings of social class were used in addition to a category of individuals for whom occupation could not be classified or was missing (Statistics, Sweden, 1989:5). Adult social class is based on the individuals' own occupation in 1960. Here it was only possible to discern three categories of social class, plus a category of not gainfully employed. This categorisation has been used previously

Table 3
Range and mean/percentage of the independent variables used in the analyses

Independent variables	Range/categories	Mean or percentage	
		Boys	Girls
UBCoS: Live-born boys ($n = 7411$) *and girls* ($n = 6781$)			
Birth year	1915–29		
Mother's age	15–49	$m = 28.4$	$m = 28.4$
Birth order (mother's parity)	1: $n = 5547$	39.2	39.0
	2: $n = 3314$	23.3	23.4
	3–4: $n = 3097$	21.8	21.9
	5–6: $n = 1192$	8.5	8.3
	7–18: $n = 1039$	7.2	7.4
Gestational age (days)	127–329 (boys), 103–330 (girls)	$m = 277.4$	$m = 278.1$
Birth weight (g)	370–5500 (boys), 310–5500 (girls)	$m = 3459.8$	$m = 3335.5$
Maternal diseases before delivery	Yes: $n = 7304$	51.7	51.2
	No: $n = 6887$	48.3	48.8
Infant diseases before being discharged from the hospital	Yes: $n = 2035$	14.6	14.1
	No: $n = 12,157$	85.4	85.9
Social class at birth	Higher non-manual: $n = 1158$	8.4	7.9
	Lower non-manuals: $n = 952$	6.7	6.7
	Skilled workers: $n = 1944$	13.3	14.2
	Semi or unskilled manual workers: $n = 6493$	45.7	45.8
	Entrepreneurs and farmers: $n = 2436$	17.5	16.7
	Not classified: $n = 1209$	8.4	8.6
Mother's marital status	Married: $n = 11,205$	79.3	78.9
	Single: $n = 2956$	20.7	21.1
Variables used in the analyses of men ($n = 5833$) *and women aged 55–80* ($n = 5556$)			
Social class in 1960	Non-manuals: $n = 4945$	38.0	50.0
	Manuals: $n = 4505$	45.3	34.3
	Entrepreneurs and farmers: $n = 1488$	13.9	12.4
	Non-wage earning: $n = 342$	2.8	3.3
Achieved education in 1970	Not upper secondary school: 1014	87.5	94.4
	Upper secondary school: 10,052	12.5	5.6
Own income in 1970	No income: $n = 1662$	4.1	25.8
	1st quartile: $n = 2469$	24.9	18.5
	2nd quartile: $n = 2414$	23.8	18.6
	3rd quartile: $n = 2412$	23.8	18.8
	4th quartile: $n = 2373$	23.4	18.3

(Vågerö & Norell, 1989; Vågerö & Leon, 1994). Mother's health consists of two categories based on whether she was registered in the hospital journals as having any diseases at the time of delivery. Infant's health is also a dichotomous variable, based on whether the child was registered as having a disease before being discharged from the hospital.

Method and analytical design

Logistic regression was applied in the analyses of infant mortality (0–1 year), while Poisson regression was used in the mortality analyses of childhood (1–10 years), adulthood (20–54 years) and middle and old age (55–80 years). Age was divided into one-year age-bands and included as a time-varying covariate in the regression models (Clayton & Hills, 1996), except for the analyses of infant mortality as they extend over no more than one year. Thus, by expansion of the files, each year of follow-up was treated as an observation that was censored in cases of emigration. This way of expanding the dataset makes *N* (number of years at risk) very large in relation to the probability of an event (number of years at which a death occurred), thereby taking on a Poisson distribution. By using logistic regression in the analyses of infant mortality, however, the Bernoulli distribution is assumed since the probability of an event (number of deaths) cannot be described as being very low in relation to *N* (number of infants at risk) in the studied cohort.

On the basis of previous empirical findings, a j-shaped association during infancy is expected in the present study, while a positive association is hypothesised for childhood, adulthood, and middle and old age. Any observed higher mortality risk for laterborns than for firstborns should remain after social and biological factors at birth have been controlled for, before we can conclude that a social effect of birth order on mortality may indeed exist. Moreover, for subjects who have left their family of origin, adult socio-economic status should also be taken into consideration in order to ascertain whether any continuing effect of birth order on adult mortality risk is mediated through factors such as adult social class, education and income. In the present study, however, this latter information is only available for subjects who survived until 1970, i.e. when they were between 55 and 80 years of age.

Biological and social factors at the time of birth will successively be taken into consideration in the analyses. The classification of the analysis variables into "biological" and "social" factors could well be called into question. Clearly, biological effects cannot be distinguished from social effects as easily as the simple classification suggests. Instead, biological and social factors tend to influence and sometimes even reinforce one another in more or less favourable directions. These two crude categories of variables are therefore first and foremost a way of simplifying analyses and discussions. For each of the studied age groups, the first model will adjust only for age, birth year and mother's age. In the next step, the influence of birth weight, gestational age and mother's and infant's health will also be taken into consideration. Thereafter, the additional impact of social class and mother's marital status at the time of birth will be adjusted for. Finally, in the oldest age group (55–80 years), further adjustments for social class in 1960, achieved education and own income in 1970 will be carried out.

Results

In Table 4, the odds ratios for infant mortality by birth order are presented separately for boys and girls, adjusted only for birth year and mother's age (Model 1). For boys and girls, infant mortality is clearly elevated in the highest birth order categories. The tendency for boys, if anything, is linear and positive, while the pattern for girls is most consistent with the hypothesised j-shaped association. When biological factors at birth are taken into consideration, however, mortality risk shows a clearly increasing trend with rising birth orders, for boys as well as for girls. This is mainly a consequence of birth weight adjusted for gestational age.

In Model 3, additional adjustments are made for social class and mother's marital status at the time of birth. These social factors do not seem to change the results found in Model 2 much. Nevertheless, birth order clearly continues to have an effect on the mortality of both sexes even after the influence of biological and social factors at birth has been taken into consideration. Moreover, it seems as though the social disadvantage linked to the highest birth order group is more pronounced among girls. Thus, while girls born as the 7–18th in the sibling order have a more than tripled odds ratio of death compared to firstborns, the corresponding figure for boys is 2.07. Among firstborns, 6 percent of the girls and 7.4 percent of the boys died during the first year of life, while the corresponding figures for those born as the 7–18th in the sibling order were 9 and 8.5 percent, respectively. However, there was practically no difference between boys and girls with regard to the increase in mean birth weight between these two extreme categories of birth order (322.5 g for boys and 324.3 g for girls).

The numbers of deaths during childhood are quite small in all birth order categories, which makes analyses weak in statistical power. However, in Table 5 (Model 1) a clear tendency towards a rising mortality risk for boys of increasing birth orders can be noted, although none of the estimates are significantly different from that of

Table 4
Infancy (0–12 months): odds ratios for all-cause mortality by birth order group and sex[a]

	Girls				Boys			
	Model 1	Model 2	Model 3	Σ deaths	Model 1	Model 2	Model 3	Σ deaths
Birth order	$p = 0.0027$	$p = 0.0002$	$p = 0.0002$		$p = 0.183$	$p = 0.0101$	$p = 0.0069$	
1 (ref. gr.)	1	1	1	148	1	1	1	195
2	0.84	1.08	1.10	72	1.01	1.25	1.33[b]	113
3–4	0.92	1.36	1.39	70	1.03	1.39[b]	1.51[c]	103
5–6	1.10	1.79[b]	1.82[b]	30	1.36	1.83[c]	1.95[c]	48
7–18	2.00[c]	3.13[c]	3.20[c]	42	1.56[b]	2.09[c]	2.07[c]	45
n	6352	6352	6352	362	7001	7001	7001	504
Log likelihood	−1381.0	−1136.9	−1135.7		−1808.3	−1526.5	−1513.4	

[a] Model 1: adjusted for birth year and mother's age; Model 2: adjusted for birth year, mother's age, birth weight, gestational age, diseases of mother and diseases of infant; Model 3: adjusted for birth year, mother's age, birth weight, gestational age, diseases of mother, diseases of infant, social class and mother's marital status at the time of childbirth.
[b] Estimate statistically significant on a 5% level.
[c] Estimate statistically significant on a 1% level.

Table 5
Childhood (1–10 years): Poisson regression; relative risk of all-cause mortality by birth order and sex[a]

	Girls				Boys			
	Model 1	Model 2	Model 3	Σ deaths	Model 1	Model 2	Model 3	Σ deaths
Birth order	$p = 0.0005$	$p = 0.0001$	$p = 0.0000$		$p = 0.4104$	$p = 0.2151$	$p = 0.1144$	
1 (ref. gr.)	1	1	1	56	1	1	1	72
2	1.06	1.17	1.29	34	1.09	1.15	1.20	46
3–4	2.07[b]	2.36[b]	2.65[b]	55	1.32	1.44	1.54[c]	51
5–6	1.83	2.14[c]	2.33[b]	16	1.59	1.75[c]	1.94[c]	22
7–18	3.31[b]	3.96[b]	4.19[b]	21	1.61	1.83	2.03[c]	19
n	5986	5986	5986	182	6497	6497	6497	210
Person years	58,589	58,589	58,589		63,649	63,649	63,649	
Log likelihood	−1161.6	−1154.9	−1146.4		−1374.9	−1368.0	−1364.8	

[a] Model 1: adjusted for one-year agebands birth year and mother's age; Model 2: adjusted for one-year agebands birth year, mother's age, birth weight, gestational age, diseases of mother and diseases of infant; Model 3: adjusted for one-year agebands birth year, mother's age, birth weight, gestational age, diseases of mother, diseases of infant, social class and mother's marital status at the time of childbirth.
[b] Estimate statistically significant on a 1% level.
[c] Estimate statistically significant on a 5% level.

firstborns. Girls, on the other hand, demonstrate an overall significantly higher mortality risk among laterborns than among firstborns. These differences become even more pronounced when the "biological advantage" of laterborns is adjusted for in Model 2. Girls in the highest birth order group now have almost 4 times the risk of dying than firstborns. When social circumstances at birth are taken into consideration in Model 3, the estimates for laterborn girls are further strengthened. This reinforced influence of birth order is mainly the effect of controlling for the so-called illegitimate children who were usually of early birth order. The same tendency for birth order to have a stronger influence on mortality risk when biological and social factors at birth are adjusted for can also be noted for boys. Thus, in spite of the absolute mortality level of boys generally being much higher than that of girls during infancy and childhood, the absolute mortality risk does not differ much between the sexes among children of late birth orders.

The implications of birth order for mortality in adulthood are presented in Table 6. A hump-shaped association appears to exist for both men and women, with first and very late borns having approximately the same mortality risk. Considering the fact that both men and women show the same mortality pattern, these findings are not likely to be attributable to random variation because of the small number of deaths in the highest birth order categories, although this possibility cannot be excluded. It is possible that, at adult and old age, having a large number of siblings acts as a buffer against ill health and mortality by means of greater access to social support from the family of origin. It seems nevertheless unlikely that such an effect would hold true only for those of the highest birth order category, as an interpretation of the results presented in Table 6 would suggest. Adjusting for biological factors at birth (Model 2) increases the estimates for men and women somewhat, as does additional adjustment for social factors at birth (Model 3), giving an overall statistically significant association for men also.

Table 7 reveals only small relative differences in mortality between birth order categories at middle and old age. There is practically no difference between the first three categories of birth order for either men or women. For male mortality however, the two highest categories of birth order differ significantly from firstborns, with 5–6th borns and 7–18th borns having a 35 and 26 percent higher mortality risk, respectively. Hence, for the first time, laterborn men appear to be a more disadvantaged group than laterborn women, although in comparison to firstborns the differences are quite small. The adjustment for biological and social factors at birth in Models 2 and 3 leaves the estimates practically unaltered. Thus, 55–80 years after birth, the effect of these birth factors on the association between birth order and mortality has disappeared. However, information on occupational class (1960), achieved education (1970) and own income (1970) is available for this age group. When these adult socio-economic circumstances are controlled for, the previously significant association between mortality and birth order for men becomes insignificant, suggesting that the long-term influence of childhood birth order position on mortality is partly mediated by achieved social class, education and income.

Discussion

For boys and girls who were born in the Swedish city of Uppsala during the early part of the 20th century, total mortality at four stages of the life-course differed substantially by birth order. There was a general tendency of individuals who were born late in the sibship to have a higher mortality risk than firstborns. An initial vague j-shaped association between birth order and female infant mortality turned into a positive linear one when biological factors at birth were adjusted for. Girls born as the 7–18th in the ordinal position of siblings were left with an odds ratio for death that was three times that of firstborn girls, while the corresponding figure for boys was double.

These findings suggest that the elevated infant mortality of firstborns, found in many developing

Table 6
Adulthood (20–54 years): Poisson regression; relative risk of all-cause mortality by birth order and sex[a]

	Women				Men			
	Model 1	Model 2	Model 3	Σ deaths	Model 1	Model 2	Model 3	Σ deaths
Birth order	$p = 0.0071$	$p = 0.0045$	$p = 0.0022$		$p = 0.1059$	$p = 0.0538$	$p = 0.0198$	
1 (ref. gr.)	1	1	1	110	1	1	1	196
2	1.00	1.03	1.09	66	1.11	1.16	1.21	124
3–4	1.60[b]	1.67[b]	1.78[b]	93	1.27	1.33[c]	1.42[b]	127
5–6	1.47	1.54	1.63[c]	31	1.48[c]	1.55[c]	1.68[b]	52
7–18	0.95	1.00	1.04	16	0.99	1.04	1.11	29
n	5714	5714	5714	316	6199	6199	6199	528
Person years	194,762	194,762	194,762		210,081	210,081	210,081	
Log likelihood	−2306.8	−2305.9	2304.0		−3609.2	−3606.8	−3601.4	

[a] Model 1: adjusted for one-year agebands birth year and mother's age; Model 2: adjusted for one-year agebands birth year, mother's age, birth weight, gestational age, diseases of mother and diseases of infant; Model 3: adjusted for one-year agebands birth year, mother's age, birth weight, gestational age, diseases of mother, diseases of infant, social class and mother's marital status at the time of childbirth.

[b] Estimate statistically significant on a 1% level.

[c] Estimate statistically significant on a 5% level.

Table 7
Middle and old age (55–80 years): Poisson regression; relative risk of all-cause mortality by birth order and sex[a]

	Women				Men			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Birth order	$p = 0.7734$	$p = 0.6989$	$p = 0.7209$	$p = 0.8462$	$p = 0.0425$	$p = 0.0262$	$p = 0.0235$	$p = 0.2361$
1 (ref. gr.)	1	1	1	1	1	1	1	1
2	1.00	1.02	1.05	1.03	1.07	1.09	1.11	1.06
3–4	1.02	1.05	1.08	1.07	1.08	1.11	1.14	1.05
5–6	1.16	1.19	1.21	1.19	1.35[b]	1.38[c]	1.41[c]	1.28
7–18	1.17	1.20	1.20	1.10	1.26[b]	1.29[b]	1.28[b]	1.12
n	5366	5366	5366	5203	5666	5666	5666	5454
Person years	96,255	96,255	96,255	93,531	95,791	95,791	95,791	92,573
Σ deaths	928	928	928	885	1715	1715	1715	1616
Log likelihood	−5084.4	−5083.0	−5076.4	−4847.1	−8349.4	−8347.3	−8335.2	−7817.6

[a] Model 1: adjusted for one-year agebands birth year and mother's age; Model 2: adjusted for one-year agebands birth year, mother's age, birth weight, gestational age, diseases of mother and diseases of infant; Model 3: adjusted for one-year agebands birth year, mother's age, birth weight, gestational age, diseases of mother, diseases of infant, social class and mother's marital status at the time of childbirth; Model 4: adjusted for one-year agebands birth year, mother's age, birth weight, gestational age, diseases of mother, diseases of infant, social class, mother's marital status at the time of childbirth, social class in 1960 and income and education in 1970.
[b] Estimate statistically significant on a 5% level.
[c] Estimate statistically significant on a 1% level.

countries, is partly caused by these children being at a biological disadvantage compared to the laterborn ones. Thus, the fact that a positive association between birth order and infant mortality is often found in countries with relatively low child mortality rates may be the result of societal features, such as the higher standard of maternal welfare and obstetrical care in these countries than in the less developed nations. Hence, the excess mortality of firstborns in the former countries may have been largely wiped out by the prevention of fatal outcomes among "biologically disadvantaged" children, thereby making the social disadvantage of laterborns more apparent.

The results found for childhood were in accordance with previous research, where a positive association between birth order and mortality has usually been demonstrated. Again, laterborn girls were found to have a considerably higher mortality risk in relation to firstborns than did the corresponding group of boys. This positive association became successively stronger when biological and social factors at birth were adjusted for. Thus, in the final model, girls born as the 7−18th in the sibling order ran 4 times the risk of mortality compared to firstborns, while the corresponding estimate for boys was 2. The much higher infant and child mortality risk of laterborn girls than firstborns as compared to the corresponding groups of boys makes it inevitable that we should ask whether some kind of discrimination linked to the sex of the child may have been involved. Although the above findings further support the notion of insufficient parental resources directed towards the health and safety of laterborn children, this seems to be especially the case among laterborn girls.

Based on her studies of child mortality in developing countries, Scrimshaw (1978) formulated the so-called "underinvestment hypothesis". According to this hypothesis parents do not always make every effort to protect the life of a child. Moreover, parents may invest more time, attention and resources in some children than in others. The purpose of this parental behaviour, Scrimshaw maintains, is to stabilise family size and to promote the survival of those children who it is believed will make the largest future contribution to the family. This form of discrimination within the family is most commonly observed with regard to the sex of the child, but it is noticeable also in connection with birth order (Scrimshaw, 1978).

The "underinvestment hypothesis" may seem a distasteful way of looking at parents' relations with their children. However, in early 20th century Sweden, economic shortage may actually have forced parents of large families to prioritise one child over another when it came to costly investments that could prevent disease. For example, new clothes and footwear to protect from freezing during the cold Swedish winter months may, for practical reasons, first of all have been purchased for the oldest son, since larger sizes of clothes could eventually be taken over by the younger siblings. In the school records kept by the teachers of the Uppsala children, there were several pre-printed alternatives for the teacher to mark if the child was absent from school.

One of these read: "Absence due to lack of proper footwear".

Among adults aged 20–54 years, in contrast to the hypothesised positive association, a hump-shaped pattern was found, with firstborns having approximately the same mortality risk as 7−18th borns. Why relative mortality risk should be lower for men and women of the highest birth order category than for those born as number 2−6 is not clear: two possible explanations are chance, and the "protective effect" of having many sources of social support at these ages.

When the studied subjects had reached middle and old age, a slightly elevated mortality risk was present for men and women in the two highest birth order categories, although the association was only significant for men. At these ages, adjusting for biological and social factors at birth did not alter the results much. However, when three indicators of adult socio-economic conditions were controlled for, the effect of birth order decreased and the previously significant association for men became insignificant. This suggests that adult socio-economic conditions do have a mediating effect on the association between childhood birth order position and adult mortality. Thus, after they had long since left their family of origin, men of high birth order had a lower income, education and occupational class than first-borns, which resulted in an elevated mortality risk during middle and old age.

Having established an association between birth order and all-cause mortality over the life-course, a relevant question would be whether there were any specific cause(s) of death that gave rise to this association. Analyses of cause-specific mortality were feasible in the two age intervals of 1–12 months[1] and 20–80 years,[2] although the number of deaths for each specific death-cause was generally too small to reach statistical significance. Nevertheless, the results demonstrated a surprisingly consistent pattern of elevated post-neonatal mortality risk among laterborns for all of the five death-causes examined. In contrast, the analysis of all-cause mortality during the first month of life demonstrated that firstborns were at a disadvantage in relation to all categories of laterborn children (data not shown). Similarly, a general tendency of a higher mortality risk among laterborns was found for all of the four causes of death examined at adult and old age, the only exception being female mortality from accidents and violence. Nevertheless, some causes of death were more strongly associated with birth order than others, and deserve to be mentioned here.

As expected, in the age interval 1–12 months, a steep increase in mortality from infectious diseases with rising birth orders was found ($p = 0.0001$), with those born as number 7−18th having more than 7 times the mortality risk of firstborns when biological and social factors at birth were controlled for. Among adult and old men, the higher mortality risk with rising birth orders was most obvious for mortality from accidents and violence ($p = 0.09$), and for death from other causes ($p = 0.08$), while for women, mortality from circulatory diseases ($p = 0.09$) indicated the strongest association with birth order. Furthermore, a significant interaction between birth order and mother's marital status revealed a very strong and significant association between birth order and mortality from circulatory diseases among women who were born outside marriage. Here, women born as the 3rd–4th, 5–6th and 7–16th in the ordinal position of siblings had 2.3, 7.4 and 9.6 times the mortality risk of firstborns. Thus, the combination of having a high birth rank and being born outside marriage seems to have been an extraordinarily unfortunate combination of childhood social conditions for the girls of the present study, leading to an increased susceptibility to adult circulatory disease and mortality (data not shown). The latter result is consistent with previous findings on the association between birth order and myocardial infarction among women (Szlako et al., 1976).

The fact that there was an overall tendency for laterborns of an elevated mortality risk for practically all of the studied causes of death (except during the first month of life) suggests that we should interpret this in terms of susceptibility towards disease in general. According to Cassel (1976), exposure to psychosocial stressors may or may not lead to a deterioration of an individual's resistance towards disease processes, depending on his or her degree of buffer against these. Throughout life, and especially during childhood, individuals accumulate social and psychological resources that may act as buffers against disease. Thus, one possible explanation behind the findings of the present study is that laterborn children were less likely to become well equipped with such resources over the life-course compared to earlier-borns, and therefore, more susceptible towards many kinds of disease. However, the positive association between birth order and male mortality from accidents and violence is not likely to be caused by reduced susceptibility towards disease. Instead, these findings may be connected to life-style factors, such as alcohol consumption and drug abuse. For a small subsample of UBCoS men

[1] *Infectious and parasitic diseases* (ICD: 000−136), *Diseases of the Circulatory system* (ICD: 390−458), *Diseases of the respiratory organs* (ICD: 460−519), *Congenital malformations* (ICD: 740−759), *Other causes*.

[2] *Cancer* (ICD: 6th and 7th rev: 1400–2059, 2940–2949, 2923; 8th rev: 1400–2099; 9th rev: 1400–2089, 2384, 2898), *Diseases of the Circulatory system* (ICD: 6th and 7th rev: 3300–3349, 4000–4689; 8th rev: 3900–4589; 9th rev: 3900–4599), *Accidents and Violence* (ICD: 6th–9th rev: 8000–9999) *and Other causes*.

who were interviewed at the ages of 50 ($n = 616$) and 60 years ($n = 508$) some information on tobacco and alcohol consumption are available. In brief, ex- and current smokers were less prevalent among firstborns than among any of the laterborn men. All categories of laterborn men also reported a lower age at which they started to smoke. Regarding alcohol consumption, firstborn men more frequently reported that they were abstainers (data not shown). Hence, for men at least, a less healthy life-style in terms of cigarette and alcohol consumption may be a contributory explanation to the elevated mortality risk among laterborns.

In the present study, there was no information on either final family size or birth interval. Since short birth-spacing as well as large family sizes are more common among children of high birth orders than for earlier-borns (Berglin, 1980; Hanushek, 1992), some of the birth order effects found in this study may be due to these factors. However, since both mother's and infant's health were adjusted for, any detectable medical consequences of birth interval for the mother's or the new-born baby's health as registered at the maternity ward have been taken into consideration in the present study.

In conclusion, the above study supports the suggestion that laterborn children are a disadvantaged group within the family during upbringing. This brings into focus the social relations within the family and their material correlates—a social environment often ignored in epidemiological research. The relative social disadvantage of laterborns seems, moreover, to have had long-term consequences for many aspects of these individuals' quality of life. In a previous study of the Uppsala cohort, it was shown that laterborns had lower third grade school marks and that they less often completed secondary school (Modin, 2000). The above study adds to these findings, by showing that they also tend to have a higher risk of mortality at practically all stages of life. Biological factors in early life, such as poor fetal growth, have been shown to represent an elevated risk of adult mortality from ischaemic heart disease (Barker, 1994; Leon et al., 1998). Likewise, childhood social class seems to give rise to long-term consequences for heart disease mortality (Notkola et al., 1985; Kaplan & Salonen, 1990; Vågerö & Leon, 1994). On the basis of the results found in this study, it can now also be said that early social factors that tend to vary within families may have equally far-reaching consequences for health and mortality.

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