Effects of Birth Rank, Maternal Age, Birth Interval, and Sibship Size on Infant and Child Mortality: Evidence from 18th and 19th Century Reproductive Histories

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Abstract: There has been long-standing interest in the effects of maternal age, birth rank, and birth spacing on infant and child mortality. Contradictory inferences about the role of these factors have arisen on occasion because of the absence of adequate controls, the use of cross-sectional or incomplete reproductive histories, and inattention to the effect of family size goals and birth limitation practices. This study analyzes completed reproductive histories for German village populations in the 18th and 19th centuries, a period when deliberate fertility control was largely absent. Our results confirm previous studies of the association of infant mortality with maternal age, although in the present data these differentials are largely limited to neonatal mortality. They also confirm the importance of birth interval as a factor in infant mortality. Sibship size is positively related to infant mortality even when birth rank is controlled. However, once sibship size is controlled, there are no systematic differences in infant and child mortality by birth order. The mechanisms relating sibship size and mortality are explored. (*Am J Public Health* 1984; 74:1098–1106.)

Introduction

The association of birth rank, maternal age, and birth spacing with infant and child mortality has been a long-standing interest in population and public health studies. Sibship size (the ultimate number of births) has received less attention because subsequent births have only a limited effect on the outcome of previous ones (through competition for resources and maternal care). The role of these factors is of more than purely academic interest. Concern about possible higher mortality risks associated with late or very early childbearing as well as among high birth rank children, children of all ranks in large families, and children born after short birth intervals serves as part of the rationale for providing family planning services both in developed and developing countries.

Interpretation of results of past studies is complicated for a number of reasons: the factors under study are highly correlated with each other; in populations where deliberate fertility control within marriage is common, the decision to continue childbearing is influenced by the outcome of previous pregnancies; cross-sectional data or truncated longitudinal data are sometimes used to make inferences which are more appropriately based on complete reproductive histories; and both fertility patterns and infant mortality are frequently associated with socioeconomic status, thus leading to possible spurious correlations.

The present study minimizes many of the problems of analysis and inference that have plagued previous studies by using genealogical data for couples residing in 14 German villages during the 18th and 19th centuries. In particular, completed reproductive histories are known, deliberate family limitation within marriage was either absent or at only modest levels during the period under observation, and socioeconomic differentials in infant mortality were not very pronounced. Our results indicate that: 1) differences in maternal age are associated with differences in neonatal but not post-neonatal or child mortality at ages one to four; 2) the association between birth rank and infant mortality disappears once a control for sibship size is introduced; and 3) at most birth ranks, sibship size is directly related to infant mortality. We explore the mechanisms, including birth interval, which might account for the persistent effect of sibship size.

Past Findings

There has been a multitude of individual studies and several major reviews of the basic relationships between infant and child mortality and maternal age, birth rank, and birth interval. The preponderance of evidence points to a curvilinear relation between maternal age and the components of mortality before age one, with higher risks associated both with younger and older ages.[1–3] The age of lowest risk tends to be earlier for fetal mortality and stillbirths and later for perinatal, neonatal, and overall infant mortality. The curvilinear pattern also shifts when a control for birth order is introduced, with the age of lowest risk advancing with birth order, indicating that frequent and/or closely spaced births are additional factors affecting pregnancy outcomes.[1] A variety of patterns between maternal age and childhood mortality for ages one to four have been observed.[4–6]

Studies from both developed and developing countries point quite unambiguously to higher mortality where there are short intervals between births.[6–8] Generally, there is a direct negative relationship between birth interval and all the components of infant and child mortality, although a few studies suggest that the rates for fetal deaths, stillbirths, and neonatal deaths increase at the longest intervals.

Stillbirths and neonatal mortality generally show a J-shaped relationship with birth order, typically decreasing from rank one to two and then increasing.[2,3,6] By contrast, these sources point to a direct positive relationship of birth order with rates of post-neonatal, infant, and child mortality. These patterns are not substantially altered when maternal age is introduced as a control, nor with controls for socioeconomic class.[6,9]

A major difference in the pattern of mortality by birth rank emerges when a control for sibship size is introduced, which becomes possible with longitudinal data. In two major

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studies, within a given sibship size, mortality declines gradually with increasing parity and then falls sharply with the highest birth rank.[10,11] This contrasts sharply with the increase of mortality with birth rank (overall or after rank two) observed in cross-sectional data, or when sibship size is ignored in longitudinal data.

In populations where birth control is practiced extensively, the pattern observed within sibship sizes can be readily explained by a process of self-selection in terms of who continues childbearing. Given that couples desire a certain number of surviving children, those who reach this goal without experiencing any loss often stop childbearing, while others with the same goal and the same number of pregnancies continue if they have experienced an infant death. Since couples are more likely to cease childbearing with a successful outcome than with one ending in a child death, mortality rates are usually lower for the last birth in completed sibships than for previous births. Golding has demonstrated how attempts to achieve particular reproductive goals can affect the observed pattern of fetal mortality.* She concludes that a control for sibship size can be highly misleading whenever fertility control is extensively practiced.

A related complication in interpreting the effect of sibship size is created by the existence of a considerable degree of intra-woman homogeneity in the chances of a successful pregnancy.[11,12] Since women with unsuccessful previous outcomes are more likely to continue childbearing at any given parity, those who go on to higher numbers of pregnancies are increasingly selected for being prone to infant loss.

In brief, there are a number of artifacts that can arise in the analysis of biologic factors affecting infant mortality. The data set on which the present study is based is particularly valuable because it permits distinguishing some of these artifacts from the true underlying patterns.

Material and Methods

The present analysis utilizes a set of data that serves as the basis for a larger research project examining a whole range of demographic behavior in the past. A number of results dealing with fertility, marriage, and mortality have been reported in a series of articles.[12–18] The data come from a sample of village genealogies (*Ortssippenbuecher*) which in turn are based on parish and civil registers. Unlike usual genealogies that trace descendants of only one family line, these genealogies cover all families that have ever resided in the village.

The nature and quality of the genealogies and the records on which they are based have been discussed at length elsewhere.[13,19] In general, the data appear to be remarkably accurate with the exception of certain fairly readily identifiable periods of incomplete or imprecise death registration which are excluded from the present study. The data are limited to births occurring in the sample villages to couples for whom complete reproductive histories are known. Details about the rules of selection and the nature of the sample are discussed elsewhere.[13]

Within these limits, the present study covers births to couples married during the 18th and 19th centuries in 14 villages located in five different states or regions of Germany: Baden, Wuerttemburg, Bavaria, Waldeck, and East Friesland. While the villages cannot be considered a random sample of the rural population of the period, they do cover a moderate range of demographic conditions and represent diversity in occupational distribution, inheritance system, and religious affiliation.[16] An interesting feature of Germany during the period of study was the sharp regional differences in the prevalence and duration of breast-feeding and this is reflected in the sample. One of the villages in Bavaria is located in an area where, at the turn of the century, over 80 per cent of mothers did not breast-feed their infants at all, while in the area of the East Friesland villages, the large majority of mothers nursed their infants and the average duration of breast-feeding was close to a year. These differences have been well documented and their implications for levels of infant mortality thoroughly explored.[20–23] Overall, the data represent more than 9,000 reproductive histories, covering some 48,000 births and nearly 11,000 infant deaths. The large number of observations minimizes the problem of sampling fluctuation for most of the results presented.

Use of the German historical data offers several important methodological advantages to the present study. The data refer to couples whose reproductive histories are complete rather than to couples at differing stages of childbearing. Moreover, they cover a period when, for the most part, deliberate control of fertility was either absent or at very modest levels.[16] There have been suggestions, however, that during this period family size was limited by mortality due to child neglect, underinvestment in child care, and abusive practices.[24–26]

In the present study, we examine several components of mortality which we refer to as neonatal (in the first month of life); post-neonatal (one to 11 months); infant (the entire first year); and early childhood (one to four years). Our measurement of these components differs somewhat from those conventionally used. Most significantly, we include stillbirths in the numerator and denominator of the neonatal and infant mortality rates. The reason for this is that in the original records on which the genealogies were based, stillbirths were not consistently differentiated from deaths to infants during the first few days of life. Since some stillbirths may also not have been registered, what we label as neonatal mortality is between what conventionally is considered perinatal and neonatal mortality. A second difference concerns the post-neonatal mortality rate which we define as the number of post-neonatal deaths divided by the number of infants surviving the first month of life rather than by the number of births. This represents a more precise measure of the mortality risk. Similarly, early childhood mortality is measured as the life table probability ($_4q_1$) with deaths occurring at ages one through four divided by births surviving to age one. The differences between these usages and more conventional ones should be kept in mind when interpreting results.

Results

The levels and trends in infant and child mortality in the sample villages have been described elsewhere.[16] Over the whole period and across all the villages, the infant mortality rate was 228 per 1,000. This is very close to the rate for Germany as a whole during the end of the 19th century when national level statistics on infant mortality first became available. Almost 50 per cent of the deaths occurred in the

*Golding J: The analysis of completed reproductive histories: a cautionary tale. Paper presented at the meeting on Developments in the Analysis of Infant and Foetal Mortality sponsored by the British Society for Population Studies, London, January 1980.

first month, resulting in a neonatal rate of 107 and a post-neonatal mortality rate of 131 per 1,000. If stillbirths were excluded from the neonatal rate, a lower proportion of deaths would be attributable to the first month. There was little consistent upward or downward trend in infant mortality over time. The rate of 228 for our sample may be contrasted with a Swedish rate for 1841–50 of 180 (also including stillbirths) and with contemporary rates ranging from under 10 in a number of European countries (excluding stillbirths) to estimates of 200 or more for several developing countries.[27,28] The probability of dying during early childhood in the German village sample was 122 per 1,000 over the period. Unlike infant mortality, child mortality shows a strong downward trend, declining from 155 per 1,000 in 1750–74 to 93 per 1,000 in 1875–99.

Both infant and childhood mortality rates varied across regions. The three villages in Bavaria, where breast-feeding was relatively rare, showed the highest levels of infant mortality, as high as 381 in one village. In contrast, the lowest infant mortality was only 122 in one of the two villages in East Friesland where breast-feeding was relatively long. Mortality among children ages one to four also varied across villages but did not follow the same pattern as infant mortality; indeed, the lowest rates of child mortality were found in the Bavarian villages where the infant mortality rates were highest.[16] In the present study, we combine all villages in the analysis since an initial examination of results on a region-by-region basis did not lead to different conclusions but did lead to more unstable estimates due to fewer cases for some of the analyses. In addition, we control for region when multivariate results are presented.

Figure 1 presents measures of four mortality components by maternal age, birth rank, and sibship size, each taken separately, to permit comparison with previously reported patterns. With maternal age, neonatal and overall infant mortality show the clearest curvilinear pattern with rising levels associated with age groups following ages 25–29. Post-neonatal mortality and early childhood mortality, in contrast, display essentially a pattern of a modest direct increase with mother's age.

Overall, infant mortality and, to a lesser extent, neonatal mortality show a curvilinear pattern in relation to birth rank, with levels falling between the first and second birth orders but increasing fairly steadily with birth rank from the third birth order on and with an acceleration after birth order six. Post-neonatal mortality varies little over the first eight births but increases rapidly thereafter. There is little association of early childhood mortality with birth rank.

Post-neonatal and early childhood mortality at ages one to four both display a fairly strong direct increase with sibship size. By contrast, neonatal mortality is relatively stable except for rates in families with only one child and in families with 10 or more children. Given the unusually small number of completed families with only one birth, their high mortality could be due to statistical fluctuation.

Table 1 presents the relationship between birth interval and infant mortality according to whether the previous birth survived. Regardless of the status of the prior birth, mortality is generally highest at the shortest interval and lowest at intermediate durations with a slight upturn at the longest durations. Table 1 also indicates the strong effect of previous outcome on subsequent risks. In each interval category beyond the two shortest, infant mortality is higher when the previous child died in infancy than when it survived, the difference becoming increasingly marked at longer intervals. Infant mortality is undoubtedly inflated at the shortest intervals due to the greater likelihood of a short interval involving a premature birth.[29]

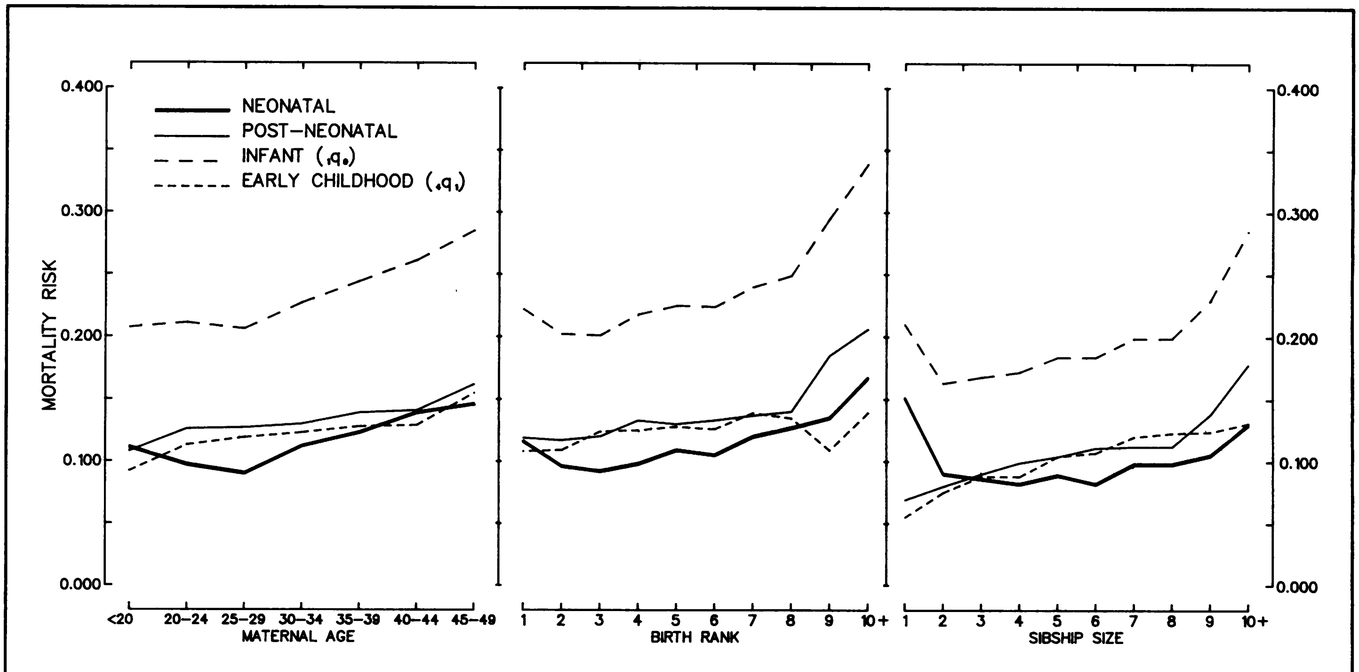

FIGURE 1—Neonatal, Post-neonatal, Infant and Early Childhood Mortality, by Maternal Age, Birth Rank, and Sibship Size, Combined Sample of 14 German Villages
NOTES: All results exclude prenuptial births. Results for birth rank are based only on first marriage for the mother; results for sibship size are based only on first marriages of mothers who reach at least age 45 before the marriage ends.

TABLE 1—Infant Mortality ($_1q_0$) by Length of Interval to Current Birth and Fate of Previous Birth, Combined Sample of 14 German Villages

Interval in Months to Current Birth	Fate of Previous Birth: Survived Infancy $_1q_0$	N	Died in Infancy $_1q_0$	N	All Fates $_1q_0$	N
Less than 12	.403	406	.379	714	.388	1174
12–17	.294	4298	.293	3488	.293	7786
18–23	.216	5970	.251	1991	.225	7961
24–29	.183	6836	.267	792	.192	7628
30–35	.170	5115	.286	396	.178	5511
36–47	.166	4382	.320	377	.178	4759
48+	.175	2968	.316	297	.188	3265

NOTES: Results are limited to births of second and higher birth rank; exclude prenuptial births. In the case of a multiple birth, only the first born is considered. In this and subsequent tables, mortality risk is expressed per person. For definitions of mortality measures, see text.

Given the close association between maternal age and birth rank, it can be instructive to examine the relationship between infant mortality and maternal age when controlling for birth order. Such a comparison is complicated, however, and would be strongly biased at higher birth orders, since women who bear higher order children at young ages necessarily experienced short birth spacing which itself is strongly associated with increased infant mortality. Thus high rates of child loss among younger women are almost inevitable when high births orders are included and are more a reflection of a selection process than of a true age effect.

Figure 2 examines the effect of maternal age controlling for birth order. To avoid the implicit introduction of birth interval effects referred to above, we have limited the analysis to only the first three birth orders. Since a bias may be present to a degree even at birth orders two and three, the curves for women under age 30 are shown as dotted for these orders. The results show an increase in neonatal mortality with age of mother, especially marked during the latter part of the reproductive span. For first births, the only deviation from this pattern is the slightly higher mortality for babies born to women under age 20 than for those 20–24; for birth rank three, the pattern is distinctly curvilinear. By contrast, there is no relation of post-neonatal mortality with maternal age, so that the relationship of age to overall infant mortality is virtually identical to that with neonatal. Except for a slight upturn at the highest ages, there is also almost no relationship between maternal age and early childhood mortality. These results suggest that maternal age is of some importance for mortality soon after birth, when endogenous causes predominate, but it is of little consequence for children who survive the first month.

The patterns observed in Figures 1 and 2 are in general agreement with the findings of previous studies. The historical German data reveal less of a U-shaped pattern with maternal age than indicated in other studies. The major differences in our findings on birth order difference arise in the patterns for post-neonatal, infant and child mortality. The studies reviewed above point to a direct positive trend for all three measures, while these German data indicate: 1) a stable pattern for post-neonatal mortality except at the highest birth orders; 2) a curvilinear pattern with infant mortality; and 3) no relationship between birth order and child mortality.

Both the past findings and these German data indicate that mortality tends to rise with birth rank in analyses that combine data for women at all different parities. This result would be obtained if children from larger families were at greater risk at all ranks than those from smaller families, even if there were no birth rank effects within given sibship sizes. The reason is that women at all parities contribute to births of rank one and those with two or more contribute to rank two, while only those with a large number of final births can contribute to high birth ranks. Thus, if women who bear larger numbers of children generally experienced greater rates of child loss, mortality will automatically rise with birth rank when results are based on a combined population of all sibship sizes. Cross-sectional studies of the relationship between infant mortality and birth rank typically suffer from this problem.

Relevant results in this study are shown in Figure 3 which present infant mortality rates by birth rank within sibship size. Even in view of the reduced number of cases for each size and rank combination, the results are quite clear: within each sibship size, infant mortality shows no systematic relationship with birth rank. The reverse, however, is not true; for each birth rank, there is generally an upward trend with sibship size consistent with the pattern evident in panel 3 of Figure 1.

This result has a number of important implications:

- It calls into question the validity of inference about birth rank observed in cross-sectional studies or in longitudinal studies which ignore sibship size or do not obtain complete reproductive histories;
- In these data, where birth control was minimal, there is no downturn in mortality risks for the last birth order in each sibship size as observed in previous studies.[10,11] Unlike the present study, these studies were based on modern populations where birth control was common, and their findings are influenced by the self-selection process described above by which women whose last desired birth survives deliberately cease childbearing; in contrast, many of those whose infants die go on to have births of higher orders in a deliberate attempt to achieve their desired number of surviving children;
- It casts doubt that abuse and neglect were used to control family size among German families in the past. If such practices were at all frequent, they should manifest themselves more strongly at higher parities after a family has reached its desired number of children. No such pattern is

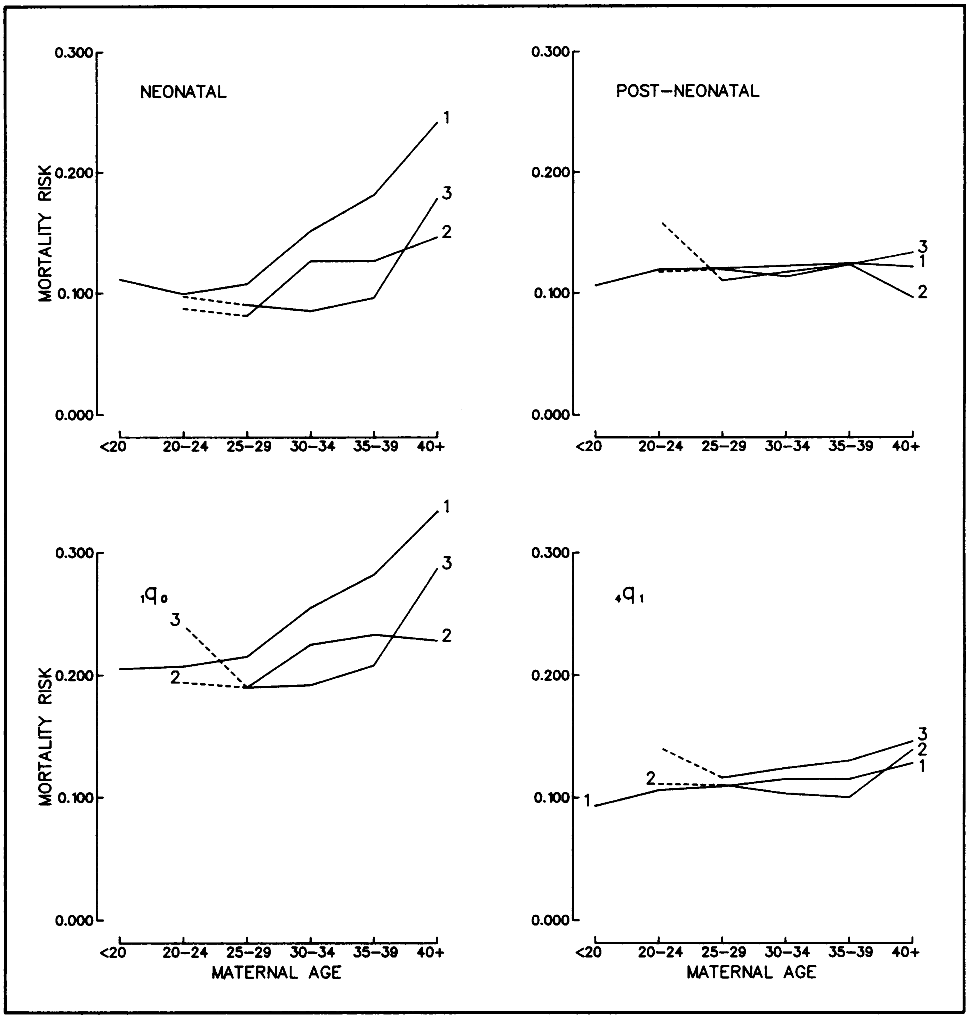

FIGURE 2—Neonatal, Post-neonatal, Infant and Early Childhood Mortality by Maternal Age for Birth Ranks 1, 2, and 3, Combined Sample of 14 German Villages

NOTES: Results are based on births to first marriages of mothers; prenuptial births are excluded.

revealed. When control for sibship size is lacking, it is risky to interpret the association of a rise in infant mortality with birth rank as an underinvestment in child care.

Additional evidence that poor child care, to whatever extent it existed, was not more common at higher birth orders is provided by data on early childhood mortality rates by birth rank and final number of births (results not shown). Although early childhood mortality is higher for ranks 3 and 4 than for ranks 1 or 2 for most sibship sizes, there is no direct increase with birth rank when higher ranks are considered. Among the larger sibships, mortality of the higher birth orders differs little from the lower birth orders.

While birth order seems to have little consistent effect once sibship size is controlled, the converse is not true. There is a steady increase in both infant and child mortality rates with ultimate number of children at most birth orders, gradual over much of the range but accelerating at the highest sibship sizes.

The finding that sibship size is more strongly related to infant mortality than birth rank requires explanation; the ultimate number of children cannot be a direct determining factor since a subsequent birth can affect the infant mortality risk of a previous one to only a limited degree, as discussed below. At least four major factors underly the strong relation between infant mortality and ultimate number of children: the length of the birth interval, breast-feeding patterns, genetic causes, and a combination of family resources and parental care practices. This mix of environmental, behavioral, and biological factors underlies the interrelationships between infant mortality and fertility. As shown in Table 1 and in other studies,[7] shorter intervals are associated with a greater risk of infant as well as childhood mortality. Women with a larger number of children, other factors constant, will experience more rapid childbearing and thus shorter birth intervals. There are two immediate determinants of birth interval: the survival status of the previously born infant, and the length of its breast-feeding. Termination of lactation because of an infant's death hastens the return of ovulation, contributing to a shorter birth interval. Even where the previous child survives, the duration of breast-feeding will affect the next birth interval through its role in the duration of postpartum amenorrhea. As previously noted, the German villages under study varied considerably in the customary length of breast-feeding. Conversely, a short birth inter-

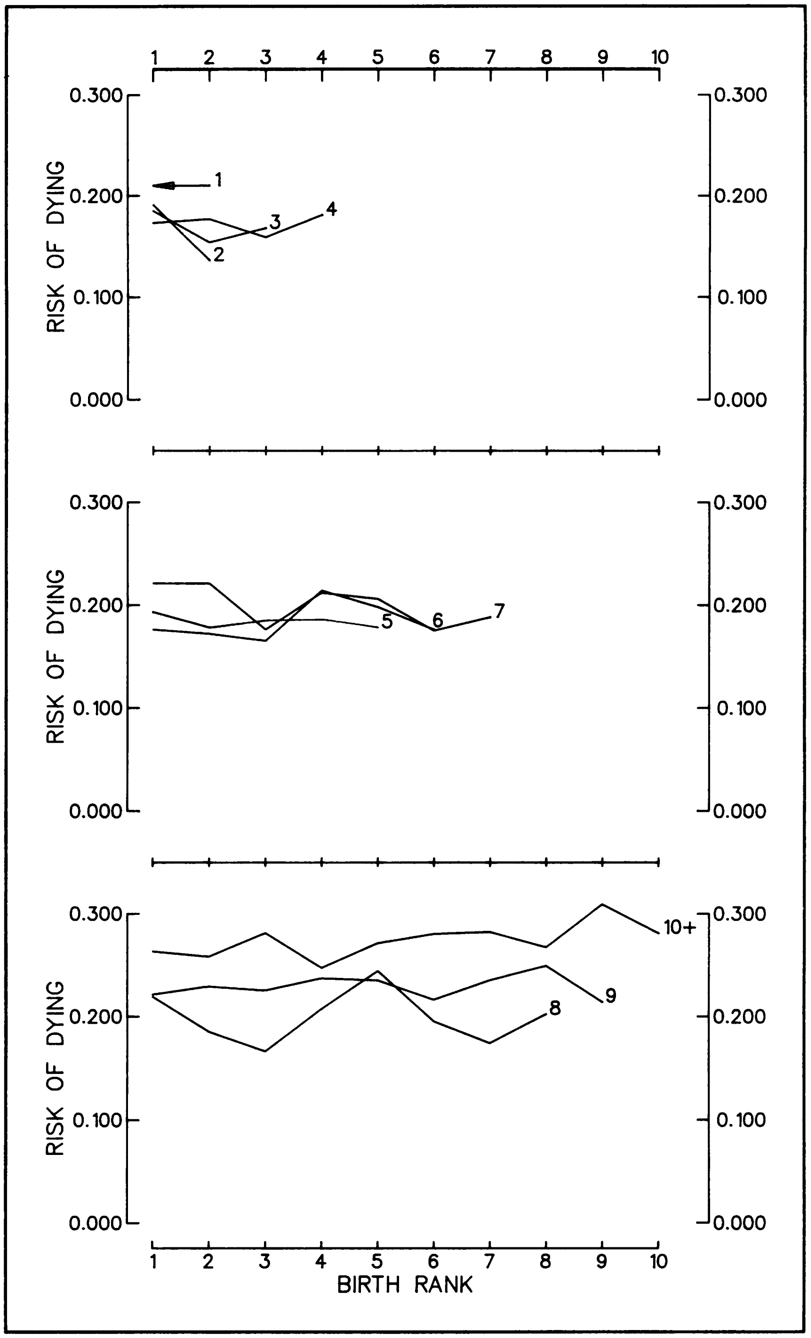

FIGURE 3—Infant Mortality ($_1q_0$) by Birth Rank and Sibship Size, Combined Sample of 14 German Villages

NOTES: Results are based on births to first marriages for mothers who reached at least age 45 before the marriage ended; prenuptial births are excluded.

val may adversely affect the prior birth by curtailing the length of breast-feeding. Both behavioral and biological components are involved: a mother may cease breast-feeding a child once she is pregnant again, and the pregnancy may reduce milk flow and make breast-feeding more difficult.[7]

Breast-feeding also has a direct effect on the survival chances of an infant. In the absence of sterile and nutritionally adequate substitutes, breast-fed infants tend to have a lower incidence of infectious diseases and are less likely to be malnourished.[7,30] Thus mothers who did not breast-feed or did so only for a short time would experience shorter birth intervals, and hence more births, as well as a greater risk of infant loss. Relatively little is known about the variation of breast-feeding durations across children of the same mother. These are likely to be related since both community norms and familial customs about the appropriate length of breast-feeding should contribute to a positive relationship. It is also possible, however, that in cases where a child died, the mother may extend more care to a subsequent child through extended breast-feeding and other steps, thus weakening the relationship.[31]

A number of studies have implicated an endogenous biological factor specific to each woman that affects chances of infant survival of all births to that woman.[5,11,12,32,33] The German data shown in Table 1 confirm this pattern at all but the shortest intervals: holding interval constant, infants whose prior sib died in infancy had a higher risk of dying than those where the prior birth survived. Lastly, there is a mix of familial inputs likely to affect survival probabilities and to contribute to the relation between sibship size and level of infant mortality. Among these are parental care practices (other than breast-feeding), the level of resources, and competition for these resources across children. These will influence not only the survival of the indexed child but prior and succeeding births. Several studies point to a higher incidence of malnutrition, infectious gastroenteritis, and unsatisfactory maternal care with increasing family size.[6] Gray cites data from the United Kingdom which "show a markedly higher risk of mortality from domestic accidents among infants born after a short birth interval, and it is known that the risk of such accidents is related to the level of maternal attention."[7] The factors that are associated with pressure on resources, crowded living arrangements, and demands on the mother may play a larger role in accounting for the association between family size and childhood mortality than the continuing effect of shorter birth intervals. One would expect that biological factors would be most manifest within the early months of life, although even here environmental factors would not be absent.[5]

The interrelationships traced above suggest that the pattern observed in the present study of rising infant mortality by sibship size—particularly noticeable among families with nine or more births—arises from the interplay of fertility and mortality. Mothers with a large number of births will tend to have shorter intervals and a number of other characteristics, such as shorter breast-feeding and more pressure on limited resources, that contribute to higher infant and child mortality. At the same time, those women with biological and behavioral characteristics that lead to unsuccessful outcomes will experience more rapid childbearing and a larger number of births. Thus, women with the largest number of births are highly selected for characteristics that contribute to high levels of mortality among their offspring.

The genealogical data permit a direct assessment of only some of the factors implicated. Table 2 examines the degree to which differentials in birth interval and the survival of the previous birth account for differentials in the infant mortality rates of the indexed birth among different sibship sizes. For every category of birth interval, the highest infant mortality is still found among births from the largest sibship sizes. Also noticeable is the much higher infant mortality at very short intervals (less than 12 months) of births in large sibships, possibly due to the higher proportion of premature births among mothers who have many births. In addition, there is an upturn in mortality at the longest intervals (48 months or more) which might be attributable to a maternal age effect.

To further probe the factors underlying the relation of infant mortality to sibship size, the rates for different sibship size categories were adjusted by Multiple Classification Analysis for the effect of several factors implicated in the discussion above. In order to eliminate any possible confounding influence of birth rank and to permit a measure of birth interval and each woman's endogenous proclivity for infant loss, the analysis is limited to births of ranks 2 through 5 among sibships of five or more. The factors for which the infant mortality rates are adjusted, in various combinations, are maternal age (at the time of the birth), previous birth interval, region (as a proxy for breast-feeding), and the number of infant deaths among the first five births excluding the indexed birth. The results are shown in Table 3. Sibship sizes have been grouped into three categories and the difference between the largest (10+) and the smallest (5–7) categories is shown to facilitate comparison of the impact of sibship size on infant mortality for each particular combination of adjustments.

Prior to adjustment for any contributing factor, the probability of dying before age one for the subset of births analyzed was .181 among sibships of 5–7 births and .254 for births of sibships of at least 10—yielding a difference of 73 more infant deaths per 1,000 births for the larger compared to the smaller sibship category. Adjustment for maternal age alone serves to increase the impact of sibship size. The reason for this is that, on the average, mothers of large sibships are younger at any given birth rank (in this case, the second through fifth ranks) than mothers of smaller sibships. Since infant mortality risks generally rise with mothers' age

TABLE 2—Infant Mortality ($_1q_0$) by Sibship Size and Birth Interval, and by Whether the Previous Birth Survived

Birth Interval (Months)	Survival Outcome of Previous Birth*	Sibship Size 2–6	7–9	10 or More
All intervals	Died	.24	.27	.31
	Survived	.16	.18	.27
	Total	.17	.20	.28
Less than 12	Died	.26	.35	.42
	Survived	.37	.32	.42
	Total	.31	.34	.42
12–17	Died	.24	.27	.32
	Survived	.22	.27	.33
	Total	.23	.27	.33
18–23	Died	.22	.24	.26
	Survived	.18	.20	.26
	Total	.19	.21	.26
24–29	Died	.19	.25	.29
	Survived	.14	.17	.22
	Total	.15	.18	.23
30–35	Died	.25	.27	.33
	Survived	.14	.16	.23
	Total	.15	.16	.24
36–47	Died	.28	.29	.31
	Survived	.13	.15	.24
	Total	.14	.16	.24
48 or more	Died	.33	.28	.56
	Survived	.15	.19	.24
	Total	.17	.20	.27

NOTES: Results are based on first marriages for mothers who reached at least age 45 before the marriage ended; prenuptial births are excluded. In case of a multiple birth, only the first-born is considered.

*Survival status refers to whether or not the previous birth died in infancy.

TABLE 3—Infant Mortality ($_1q_0$) among Birth Ranks 2 through 5 for Sibships of 5 or More by Sibship Size, Unadjusted and Adjusted in Various Combinations for Maternal Age, Region, Previous Birth Interval, and the Number of Infant Deaths among the First 5 Births Excluding the Indexed Birth

Adjustment Variables	Sibship Size			Difference between 5–7 and 10+
	5–7	8–9	10+	
No adjustments	.181	.201	.254	.073
Maternal age	.172	.207	.269	.097
Region	.187	.200	.242	.055
Previous interval	.189	.200	.237	.048
Other infant deaths	.186	.201	.243	.057
Region, previous interval, other infant deaths	.192	.200	.229	.037
Maternal age, region, previous interval, other infant deaths	.185	.205	.241	.056

NOTES: Results are based on births to first marriages for mothers who reached at least age 45 before the marriage ended; prenuptial births and families with multiple births among the first 5 births are excluded. Adjustment is made by Multiple Classification Analysis (MCA).

during much of the reproductive span, the younger maternal age at ranks 2 through 5 for mothers of large sibships helps lower their associated infant mortality rate. When adjustment is made for this, the relation of sibship size and infant mortality becomes even stronger. The other three factors each help contribute to the positive association of sibship size and infant mortality and thus adjustment for them reduces the degree of association. Each of the factors—region, previous interval, and other infant deaths—has about the same strength of association when considered individually.

Since adjustment for maternal age operates in the opposite direction, an assessment needs to consider the extent to which the three other factors account for the positive association between sibship size and infant mortality. In the absence of an adjustment for maternal age, the three other factors taken together reduce the difference between the larger and smaller sibship size categories by about half (from .073 to .037). When adjustment is made for maternal age and the three other factors simultaneously, the difference is reduced by only about a quarter (from .073 to .056), but a more relevant comparison is with the results adjusted for maternal age alone, in which case the other three factors again reduce the difference by almost half (from .097 to .056). Thus a sizable proportion of the relationship between sibship size and infant mortality is accounted for by variables available on our data set. The fact that a relationship persists even after adjustment suggests that some of the difference resides with other factors not included as well as possibly imprecise measurement of the included factors, particularly the proxy variable for breast-feeding. Finally, it is worth noting that when all four factors were included in the multivariate analysis, a substantial association between each one and infant mortality persisted after adjustment was made for all the others (results not shown).

Discussion

The present study of factors influencing infant and child mortality, based on 18th and 19th century German experience, confirm some findings but contradict others observed in previous studies. Some of the differences reflect methodological inadequacies of previous studies. Others probably arise from differences in settings. In the case of the present study, we are dealing with a period of high mortality when the level of effective medical care and fertility control were modest.

We have discussed above the reasons why the presence of deliberate fertility control can alter the observed associations. In addition, the fact that populations today in both developed and developing countries have access to effective health interventions in the event a child becomes ill could also alter the association between infant or child mortality and the variables we have examined. In particular, a stronger association between birth order and mortality within given sibship sizes might appear if the extent to which mothers took advantage of health facilities was related to birth rank. In some countries, there is evidence that mothers are less likely to take a female child for medical help than a male child.[34] Conceivably, parents might also make more effort to seek medical help for ill children of lower birth ranks than higher birth ranks, in which case a positive association between birth rank and mortality risk could emerge if it is not offset by deliberate fertility control. Given the paucity of effective medical interventions in 18th and 19th century rural Germany, such a behavioral mechanism is unlikely to have operated.

The finding that sibship size is a more important correlate of infant mortality than birth order finds partial support in an analysis by Cohen of three historical samples of completed fertility histories using a different methodology.[35] Cohen's study finds in some cases a differential by birth order, with a higher mortality among first born in the first month of life, and in other cases, a strong effect with sibship size. Both our results and his have several important methodological implications: complete reproductive histories are necessary to adequately sort out the major biological and behavioral factors affecting infant mortality; analyses based on populations where deliberate fertility control is widespread must take its presence into account or risk misleading inferences about biological effects; methods of analysis must be employed which simultaneously take into account several relations. The most important relationships to be considered include the effect of mortality on sibship size (and hence birth orders), the effect of fertility on mortality, and the intra-woman endogenous factors which produce correlation in outcomes across birth orders. Stated otherwise, the complexity of the underlying processes affecting infant mortality must be specified and the absence of simple one-way cause-effect relationships recognized.

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