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BIRTH INTERVALS AND CHILDHOOD MORTALITY IN RURAL BANGLADESH

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ABSTRACT

While there is general concurrence that birth spacing is an important dimension in child health and survival, there have been comparatively few rigorous studies of this issue from developing countries. This paper examines the relationship between birth intervals and child survival, based upon an analysis of longitudinal data from a cohort of 11,687 children in rural Matlab, Bangladesh. The findings demonstrate that short preceding intervals are associated with significantly higher levels of neonatal mortality and short subsequent intervals, to mortality during the second and third years of life. The overall impact of birth intervals upon childhood mortality is limited, however, by the relatively small proportion of women with short intervals. The findings nonetheless suggest that family planning in this setting represents an intervention with the potential for achieving moderate but significant reductions in infant and child mortality.

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Introduction

The possible adverse consequences of high fertility for child health and survival have long been a subject of concern. Indeed, the health benefits to mothers and their children associated with increased use of family planning constitute a primary rationale for the provision of family planning services in contemporary developing countries. The implications of family formation patterns for the health and survival of children has attracted particular attention. Considerable uncertainty persists, however, about the precise nature of this association, particularly in developing societies where the mortality gains associated with changes in reproductive patterns might be expected to be greatest. The effects of the pace of childbearing, and more specifically the interval between successive births or pregnancies, upon child survival has been the subject of particular concern. More detailed inquiry into this relationship in developing countries, however, has until recently been hampered by an absence of reliable empirical data. In this article, further evidence is presented on the relationship between birth intervals and childhood mortality, based upon an analysis of longitudinal data from a cohort of children in rural Bangladesh.

Birth Intervals and Childhood Mortality: A Review of Effects

A survey of the literature on birth intervals and child survival underscores the diversity in definitions used in previous studies of this issue. Definitions range from the interval between two consecutive live births (the interbirth interval), to the interval between the outcome of one pregnancy and the conception of the next (the birth-to-conception

interval), to the interval between two consecutive pregnancies (the inter-pregnancy interval), to the number of births within a given time frame (the average birth interval). It has been customary in analyses of this subject to focus on a specific child of interest (the index child), and to examine his or her risk of death associated with the length of the immediately preceding (the previous birth interval) or following (the subsequent birth interval) interval. In considering the relationship between birth intervals and childhood mortality, it is necessary to distinguish conceptually and analytically between these two intervals, since they imply two quite separate and distinct causal mechanisms.

Explanations for the adverse consequences of a short previous birth interval for child survival have centered largely upon two mechanisms: biological effects related to the `maternal depletion syndrome', and behavioral effects associated with competition between siblings. The maternal depletion syndrome refers to a pattern of repeated, closely-spaced pregnancies which allows insufficient time for the mother to fully recover from the adverse physiological and nutritional demands associated with pregnancy, parturition, and extended breastfeeding.[1] Under such conditions, an inhospitable intrauterine environment exists for the subsequent pregnancy, increasing the likelihood of outcomes such as intrauterine growth retardation of the fetus, low birthweight, and/or reduced length of gestation. All of these outcomes carry intrinsically higher risks of mortality during the early stages of life.[2] The second mechanism-- sibling competition-- rests on the hypothesis that in situations where closely-spaced pregnancies lead to two children of roughly comparable ages, the younger index child is likely to suffer, either because the family is less likely to invest limited resources such as food or care in this child, or simply because such

resources are spread more thinly among more siblings.[3]

While varying extensively in geographical settings, analytical approaches, and data quality, it is noteworthy that most studies of this issue have reported a consistent relationship between a short previous birth interval and mortality.[4] Very short, and to a somewhat lesser extent, very long intervals have been found to result in elevated risks of mortality during childhood. The impact of a short previous interval upon mortality has generally been found to be most pronounced during the first year of life, and during the post- neonatal period in particular, although exceptions to this pattern are numerous. Several studies have reported the adverse effects of a short previous interval to be greater when the previous child survived, suggesting the importance of sibling competition in influencing child survival.[5] Investigations failing to find a significant relationship between short previous birth intervals and higher risks of infant and child mortality have been largely limited to several studies carried out in rural Africa.[6]

Explanations for the adverse effects of a short subsequent birth interval upon the survival of the index child are predicated upon a somewhat different interpretation of the concept of sibling competition. According to this view, it is the first child in the pair--the older index child--who may be placed at a disadvantage by the presence of a closely-spaced younger sibling. Parental attention and investment in resources may be diverted from the older child--who may possibly be perceived as having completed the period of highest risk--to the newborn. Although this may entail direct competition between the two siblings, the role of a more subtle and indirect form of competition--weaning--has received particular attention in the

literature. In societies where breastfeeding is both universal and extended in duration, the onset of a subsequent pregnancy may be sufficient cause for the mother to abruptly terminate breastfeeding of the index child. Such weaning, in the absence of the introduction of adequate nutritional substitutes for breastmilk, may result in sharply elevated risks of mortality to the first child of the pair.[7] While empirical investigations which have considered the effects of the subsequent birth interval upon child survival are much less common, it has generally been found that a short subsequent interval places the index child at increased risk of death during early childhood.[8]

Comparatively little is known about the intervening processes through which birth intervals operate to influence the survival chances of children. Several investigations have reported a positive or curvilinear (lower at the shortest and longest intervals) association between the length of the previous birth interval and birthweight.[9] Other studies have demonstrated a link between a short previous birth interval and prematurity.[10] There is also evidence of an association between birth intervals and nutritional status or growth, although findings on this issue diverge considerably. Short previous, as well as subsequent, birth intervals have been found to be associated with higher rates of malnutrition and lower rates of growth of the index child.[11] Other studies, however, have reported essentially no relationship between the length of the previous or subsequent birth interval and rates of growth.[12] Finally, at least one study has suggested a possible link between short birth intervals and higher childhood measles case fatality rates.[13]

Data and Setting

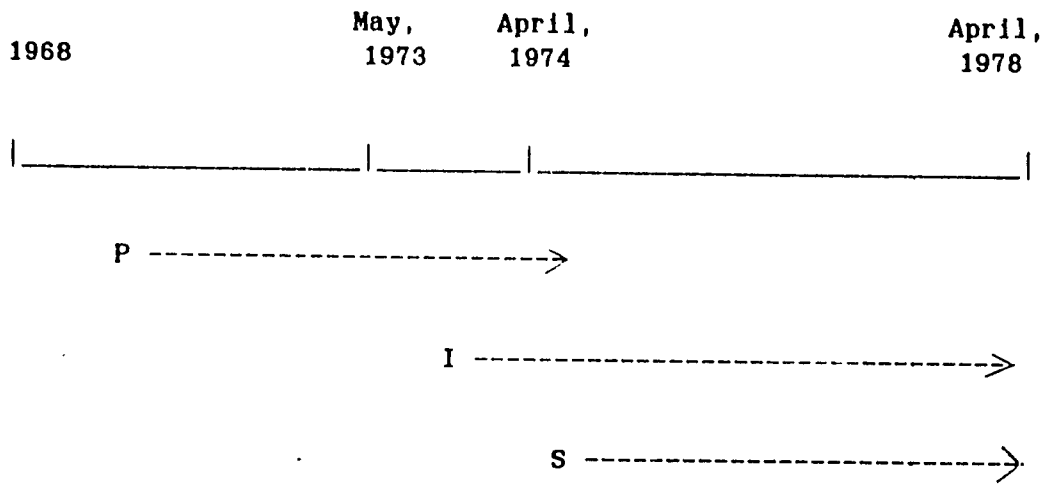
The data for this study come from the ongoing Demographic Surveillance System conducted by the International Centre for Diarrhoeal Disease Research, Bangladesh in rural Matlab thana, Bangladesh. Since 1963, the Centre has maintained a system of continual registration of vital events--births, deaths, in- and out-migrations--and has conducted periodic censuses in the study area. At the time of the 1974 census, the Matlab study area consisted of 277,000 residents residing in 233 villages. An elaborate and carefully designed system of data collection has produced an extremely accurate registration of vital events in the study area. During the period of the present study, continuous surveillance of events was maintained by 290 female village workers, who visited each household on a daily basis, and noted any changes in events which may have occurred.[14] These female village workers were supervised by 16 male field assistants, who visited each household once a month to check their work and to obtain more detailed information about vital events which may have taken place. These male field assistants were in turn supervised by four senior field assistants who visit each household at least three times per year to check the accuracy of registration.[15]

An important feature of this surveillance system is the assignment of a unique identification number to each individual in the study area. Thus, while not originally designed for this purpose, it was possible to link records for individuals in the study area and to follow them over time. These longitudinally linked records form the basis of the present analysis. Our focus is on the cohort of 11,454 singleton births which occurred in the surveillance area between May 1, 1973 and April 30, 1974.[16] At the time of

the present study, longitudinal data on vital events was available for those children through April 30, 1978. It is thus possible to follow the mortality experience of all children who remained in the study area for an extended period--48 to 60 months, depending upon their date of birth (see Figure 1). The starting date of our study is also proximate to a census which was carried out in April, 1974, making it possible to obtain additional information on selected socioeconomic and demographic characteristics of the family at a time point close to the start of the period of observation. It also represents an approximate midpoint in the currently linked and edited Matlab data files, and is therefore appropriate for an analysis which requires information on the length of the previous as well as the subsequent birth interval. For index children who were not first births, it was thus possible to obtain information on the date of birth and survival status (to April, 1974) of the preceding sibling for most children in our study.[17] For subsequent closed birth intervals, information on the date of birth and survival status of subsequent siblings of these index children was available through April, 1978. Subsequent open birth intervals were by definition a minimum of 48 months in duration (April, 1974 to April, 1978).

Our data set offers several distinct advantages over most previous investigations of this issue. In contrast to other studies using retrospective survey data, where the issues of data quality and completeness remain fundamental concerns, our data appear to be of uniformly high quality with respect to events such as fertility and mortality. The system of data collection in the Matlab Demographic Surveillance System has resulted in a

Figure 1: Outline of Matlab Data Used for the Analysis of Birth Intervals and Childhood Mortality



P = 1968-73 Cohort of Preceding Siblings

I = 1973-74 Cohort of Index Births

S = 1974-78 Cohort of Subsequent Siblings

level of completeness and accuracy in the recording of vital events such as births and deaths perhaps unprecedented in a society characterized by such low levels of socioeconomic development. Precise intervals between births and exact ages at death can therefore be calculated. Second, the fact that our data come from a cohort of children born during a specific 12-month period means that our analysis largely avoids many of the analytical problems common to previous studies of this issue using retrospective data--period effects associated with aggregating birth cohorts which may have experienced markedly dissimilar mortality regimen given secular declines in mortality, and statistical complications arising from pooling multiple observations from individual mothers. Lastly, the data permit an assessment of the effects of birth intervals upon mortality for an extended time period, since all children who remained in the study area could be followed for a minimum of 48 months. It is therefore possible to examine the effects of birth intervals upon survival over both specific segments as well as the entire course of infancy and early childhood.

These data are also not without limitations. Most significantly, our period of observation coincides with a severe famine which affected much of Bangladesh, including Matlab. Widespread flooding resulted in extensive damage to rice crops during 1974, and a subsequent sharp increase in the price of rice. As a result, mortality for all age groups, but for young children in particular, rose precipitously in late 1974 and remained high for much of 1975.[18] Mortality among index children in our study thus in part reflects the effects of this famine. At the very least, mortality levels were sharply elevated during this crisis; the possibility that the famine may have altered basic relationships between covariates of interest and childhood mortality can also not be ruled out.[19] If not taken into con-

sideration, the timing of the famine can lead to spurious associations between birth intervals and childhood mortality. Whenever possible, additional results are cited which are free from this potentially confounding event.

Effect of the Previous Birth Interval

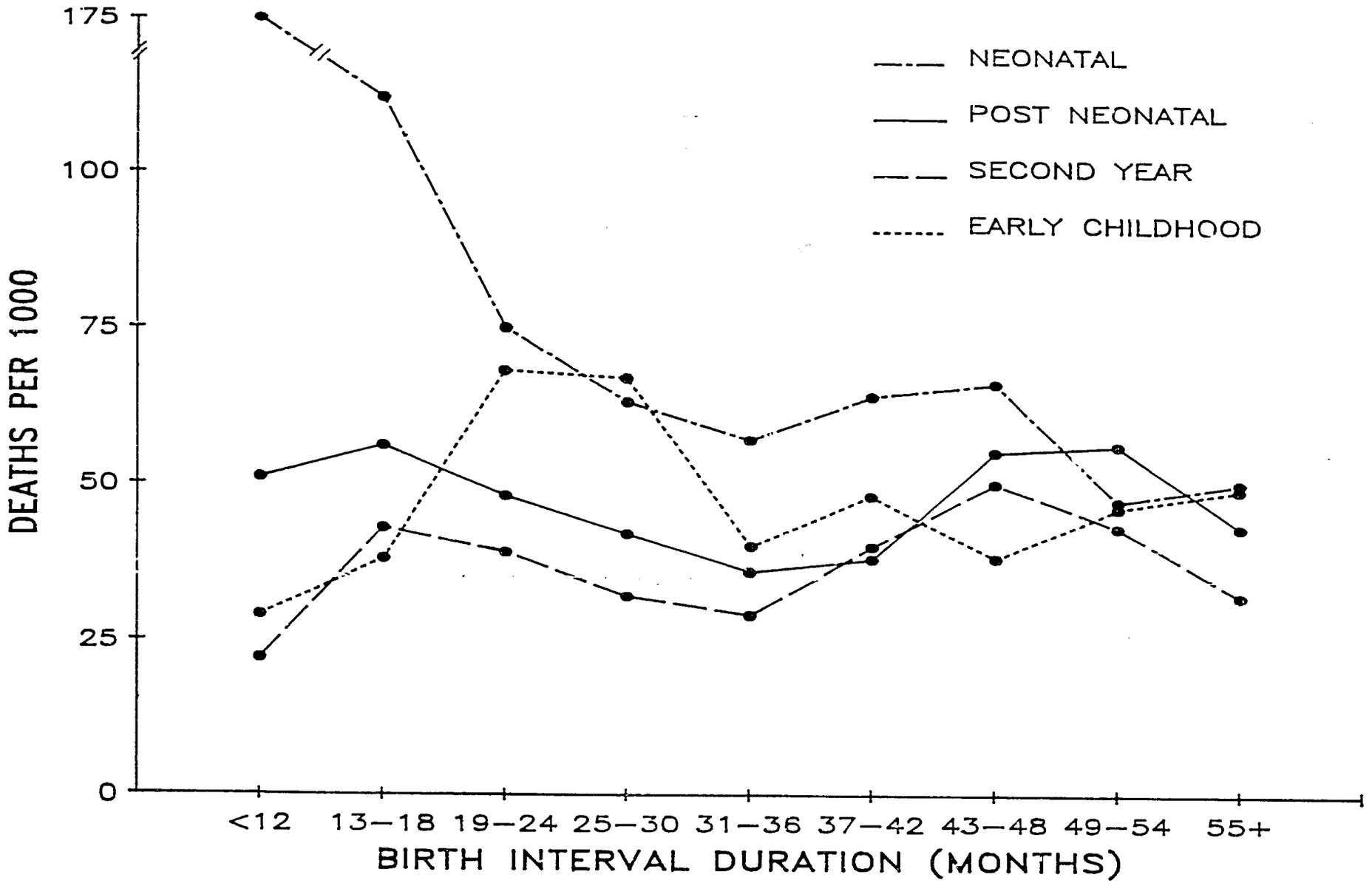
Life table analysis of the effects of the previous birth interval upon infant and child mortality is shown in Table 1 and illustrated in Figure 2. The systematic relationship between the length of the previous birth interval and neonatal mortality emerges as the most important finding of the table. The relationship between birth intervals and neonatal mortality is particularly pronounced for intervals of under 24 months. Neonatal mortality rates plateau for intervals of 25 to 48 months in length; thereafter, smaller but further modest declines in neonatal mortality with longer birth intervals are evident. While neonatal mortality rates are extremely high for birth intervals of less than 12 months, as several investigators have noted, given the brevity of this interval, this group is likely to be self-selected toward premature births.[20] Even ignoring this briefest interval, however, the risk of neonatal mortality to infants born 13-18 months after their previous sibling face neonatal mortality risks over twice as high as infants born after intervals of 55 months or longer (112 vs. 50). There is no apparent relationship between the length of the previous birth interval and either postneonatal or child mortality.

Table 1: Effect of Previous Birth Interval on Infant and Child Mortality: Mortality of the Index Child

Length of Birth Interval (mos.)	Deaths per Thousand				
	Neonatal	Postneonatal	Second Year	Early Childhood	(N)
< 13	176	51	22	29	(136)
13-18	112	56	43	38	(507)
19-24	75	48	39	68	(1119)
25-30	63	42	32	67	(2104)
31-36	57	36	29	40	(2089)
37-42	64	38	40	48	(1381)
43-48	66	55	50	38	(530)
49-54	47	56	43	46	(339)
55+	50	43	32	49	(398)

Note: Neonatal = 0-1 months
Postneonatal = 2-11 months
Second Year = 12-23 months
Early Childhood = 24-59 months

FIGURE 2. EFFECT OF PREVIOUS BIRTH INTERVAL ON INFANT AND CHILD MORTALITY: MORTALITY OF INDEX CHILD



The results of Table 1 are further complicated by the potentially confounding association between previous child death and short birth intervals. In societies such as rural Bangladesh, long birth intervals are primarily attributable to lactational amenorrhea associated with relatively universal and prolonged patterns of breastfeeding.[21] The death of the previous infant or young child, however, interrupts breastfeeding leading to an early return to ovulation, and in the absence of contraception, an increased likelihood of an early subsequent conception.[22] As an illustration, among mothers of index children in our study, only 14 percent had a subsequent birth within 24 months when the preceding sibling survived. When the preceding sibling died, however, 61 percent of these mothers experienced a subsequent birth within 24 months (Table 2 and Figure 3).[23] The death of the previous child may therefore be a primary determinant of short birth intervals. This finding assumes added significance when it is considered that previous child loss has been shown to be a significant predictor of subsequent childhood mortality--i.e., that there is a strong intrafamilial correlation in mortality risk.[24] Thus, the death of the previous sibling may lead both to a short birth interval as well as signal elevated mortality risks to the subsequent child. Failure to control for the fate of the previous child may therefore result in a spurious association between short previous birth intervals and childhood mortality.

This factor is controlled for in Table 3 and illustrated in Figures 4 and 5.[25] Among index children whose previous sibling had died, there is a systematic and almost linear decline in neonatal mortality with increasing intervals between births. Among index children whose previous sibling had survived, an association between interval length and neonatal mortality is

Table 2: Cumulative Proportion of Women With a Subsequent Birth by the Fate of the Preceding Child: Previous to Index Birth Interval

Length of Birth Interval (mos.)	Total	Fate of Previous Child	
		Died	Survived
6	0.0	0.0	0.0
12	1.6	10.4	0.3
18	7.4	39.0	2.9
24	20.3	60.6	14.5
30	44.6	76.8	39.8
36	69.0	87.2	66.2
42	85.1	94.1	83.7
48	91.3	96.0	90.6
54	95.3	97.5	94.9
60	97.3	98.7	97.1
(N)	(8779)	(1080)	(7612)

Note: Total includes 87 cases where the survival status of the previous sibling could not be ascertained.

FIGURE 3. CUMULATIVE PROPORTION OF WOMEN HAVING A SUBSEQUENT CHILD BY FATE OF THE PRECEDING CHILD: PREVIOUS TO INDEX BIRTH INTERVAL

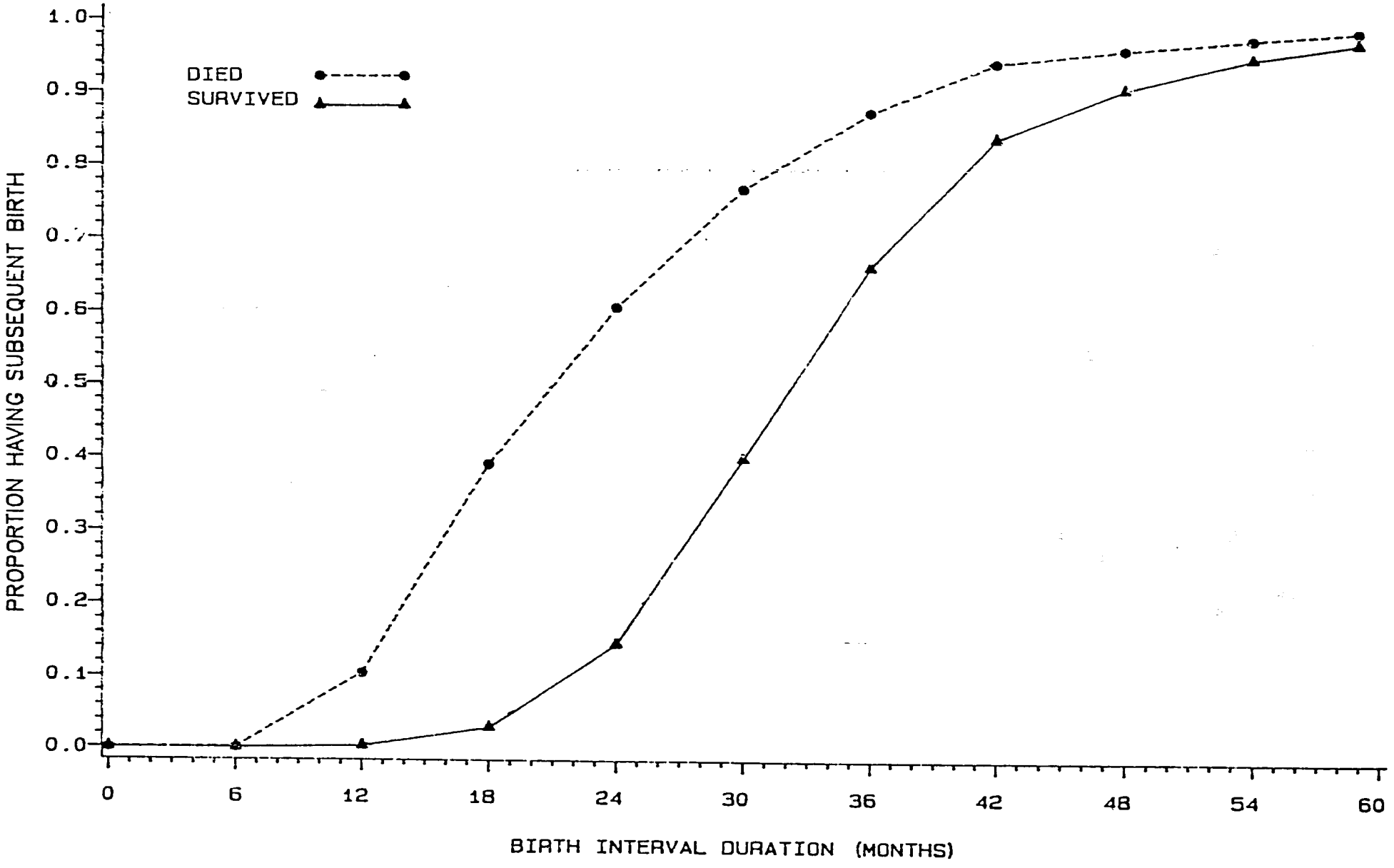


Table 3: Effect of Previous Birth Interval on Infant and Child Mortality of Index Child: By Fate of Previous Child

Length of Birth interval (mos.)	Deaths per Thousand									
	Neonatal		Post-Neonatal		Early Childhood		Late Childhood		Starting N	
	Died	Survived	Died	Survived	Died	Survived	Died	Survived	Died	Survived
< 13	170	-[a]	[38][b]	-[a]	[19][b]	-	[9][b]	-	(106)	(26)
13-18	120	99	49	63	57	16	35	44	(309)	(191)
19-24	104	64	52	48	31	41	31	78	(231)	(865)
25-30	63	63	46	41	18	33	43	68	(175)	(1896)
31-36	[59][a]	57	[49][b]	33	[40][b]	29	[10][b]	41	(102)	(1596)
37-42	[43][b]	66	[43][b]	37	[15][b]	41	[31][b]	49	(70)	(1298)
43-48	-	65	-	44	-	52	-	34	(21)	(506)
49-54	-	46	-	53	-	42	-	48	(14)	(322)
55+	-	43	-	41	-	28	-	50	(24)	(368)

[a] < 50 cases

[b] [ ] indicates 50<N <100 cases

FIGURE 4. EFFECT OF PREVIOUS BIRTH INTERVAL ON INFANT AND CHILD MORTALITY OF INDEX CHILD: PREVIOUS CHILD DIED

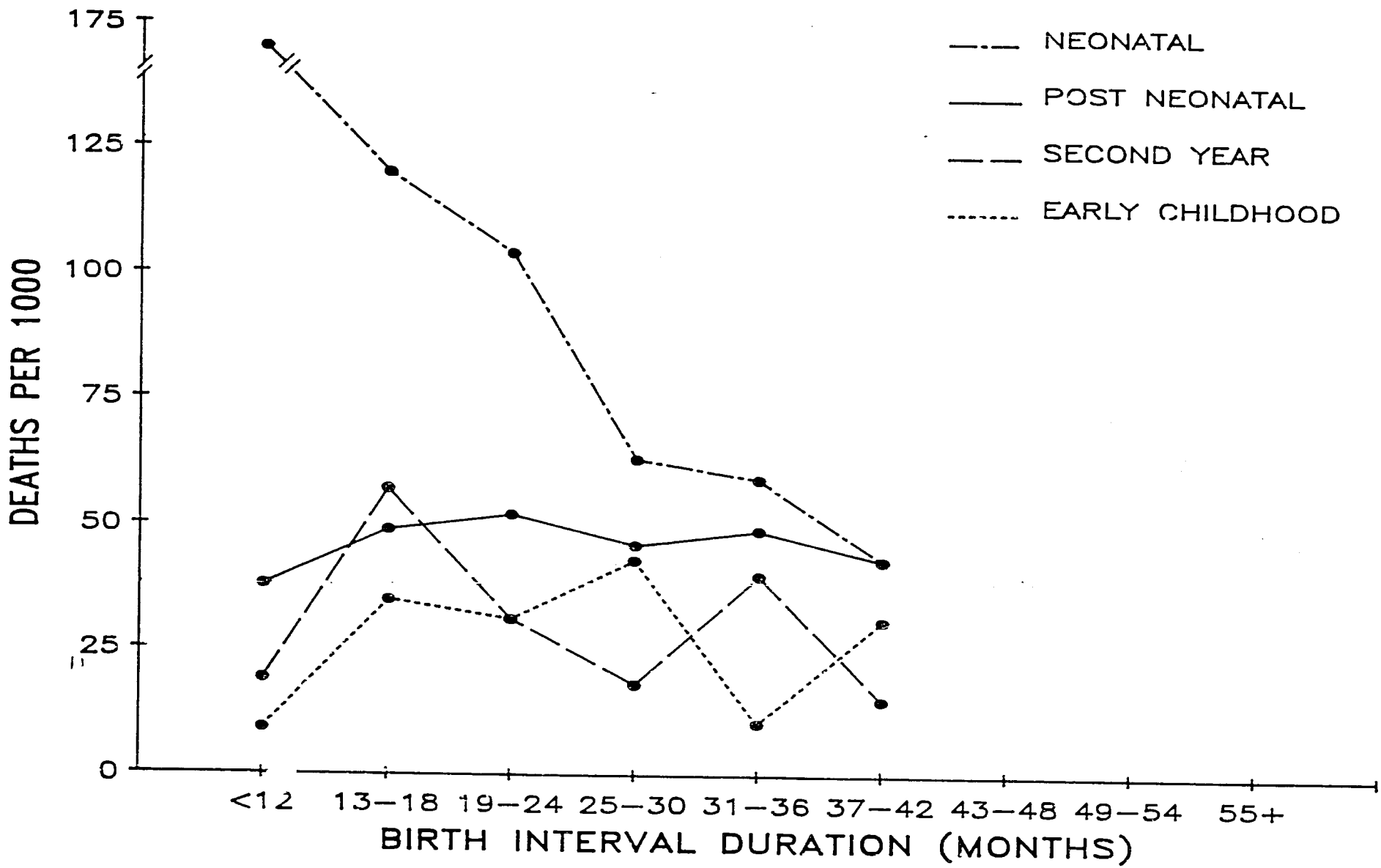
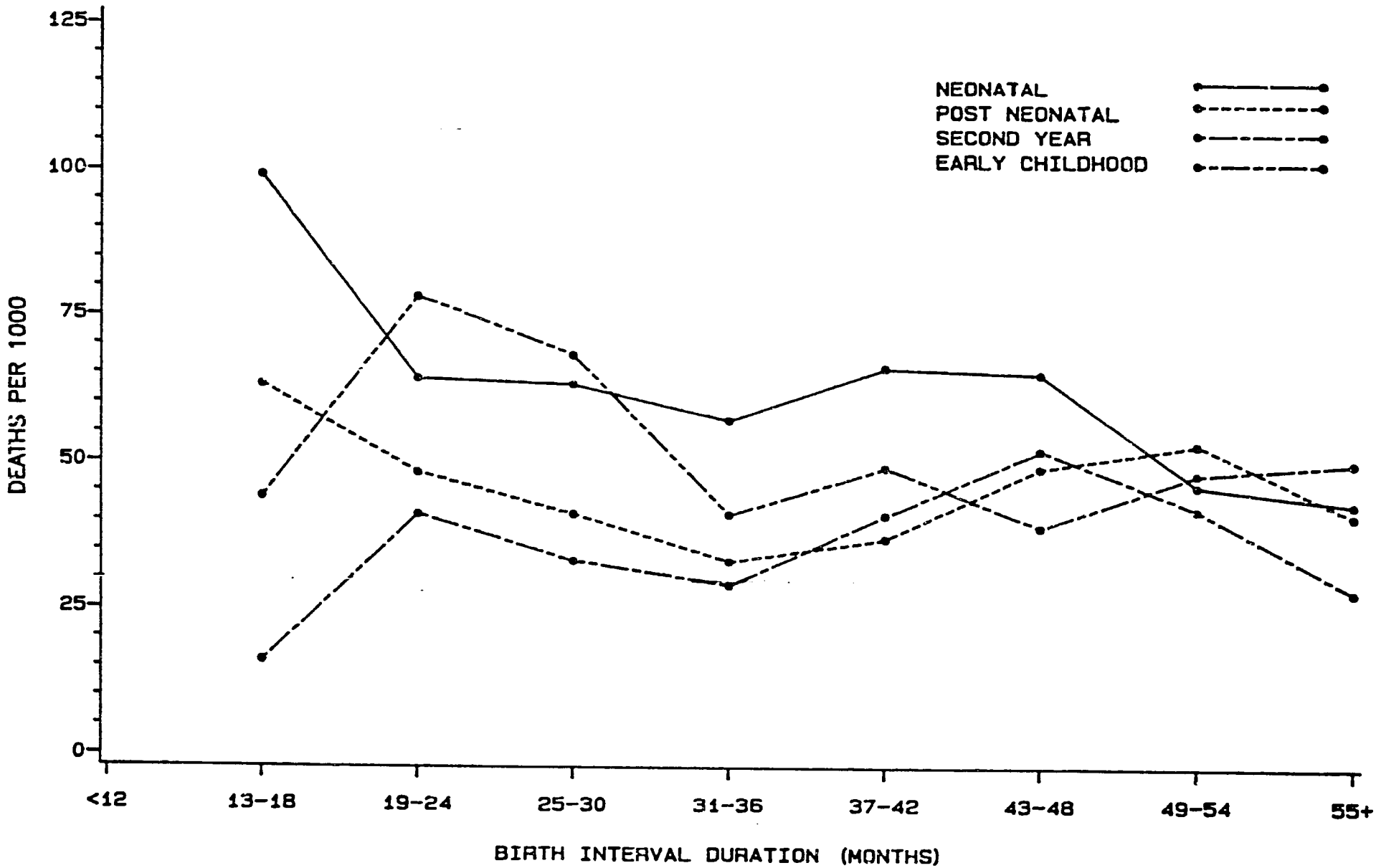


FIGURE 5. EFFECT OF PREVIOUS BIRTH INTERVAL ON INFANT AND CHILD MORTALITY OF INDEX CHILD: PREVIOUS CHILD SURVIVED



also apparent, although considerably less pronounced perhaps owing to the relatively few cases at short intervals. Among both groups, neonatal mortality risks at the longest intervals are less than one-half those at the shortest intervals. In both subgroups of children, the length of the previous birth interval continues to be unrelated to postneonatal or child mortality.

The Effect of the Subsequent Birth Interval

As noted in the earlier discussion, the subsequent birth interval may influence childhood mortality through mechanisms quite distinctive from the previous birth interval. Analyses of the effects of the subsequent birth interval also confront potentially serious methodological problems. Most notable among these is the need to distinguish cases where the death of the index child led to a short subsequent birth interval from cases of interest; where a short subsequent birth interval led to increased mortality risks to the index child. Failure to distinguish between these two situations will lead to a spurious association between short subsequent birth intervals and childhood mortality. Index children who died prior to the estimated date of conception of the subsequent child are therefore excluded from this analysis.[26]

Table 4 presents the analysis of the effects of the subsequent birth interval upon mortality risks to the index child. Mortality rates are presented separately for each of the first five years of life. Mortality rates among index children who had no subsequent siblings by the end of the

study period (April, 1978) have been included for comparison. Only associations in which the subsequent birth could have plausibly influenced index child survival during the specific segment of life are shown.[27]

The results provide evidence for an association between the subsequent birth interval and child mortality. For both second and third year mortality, risks decline systematically with longer subsequent birth intervals. The fact that this relationship is only apparent during the early years of life suggests that breastfeeding may be an important intervening mechanism between the subsequent birth interval and mortality, since it is this period when the adverse consequences of weaning for the index child will be most pronounced. Since some of the elevated mortality risks reported are, however, attributable to their coincidence with the 1974-75 famine, caution should be exercised in interpreting some of these findings. At the same time, results from the analysis of the effects of the index birth upon the survival of the previous birth-- also an indication of the effects of the subsequent birth interval and one largely free of the effects of the famine-- are generally consistent with the results of Table 4 (results not shown).

An unresolved question is whether it is the subsequent conception, rather than (or in addition to) the subsequent birth, which initiates the process leading to elevated mortality risks to the index child. Several findings lend indirect support to the conclusion that the subsequent conception may play a central role. First, a more systematic relationship between

Table 4: Effect of Subsequent Birth Interval on Infant and Childhood Mortality: Mortality of Index Child

Length of Birth Interval (mos.)	Deaths per Thousand					Starting N
	Infant (<12 mos.)	2nd Year (12-23 mos.)	3rd Year (24-35 mos.)	4th Year (36-47 mos.)	5th Year (48+ mos.)	
	a	a	a	a	a	
<13	-	-	-	-	-	(23)
13-18	91.6	[259.5]	[38.6]	[10.3]	[11.7]	(111)
19-24	-	71.7	54.8	3.4	7.1	(294)
25-30	-	19.9	39.9	17.7	9.7	(855)
31-36	-	-	35.9	19.3	10.39	(1766)
37-42	-	-	16.5	18.8	13.1	(1821)
43-48	-	-	-	18.9	14.4	(1065)
49-54	-	-	-	15.6	5.6	(579)
55+	-	-	-	-	[0.0]	(95)
No subsequent Child	70.5	40.3	22.4	[10.6]	[8.2]	(2976)
TOTAL	24.4	19.7	22.4	15.6	10.1	(9585)

[a] N< 50 cases

[b] [ ] indicates 50 < N < 100 cases

the subsequent interval and early child mortality is evident when the birth-to-conception interval, rather than the birth-to birth interval in Table 4, is employed as the independent variable (results not shown). Second, the results of Table 4 also suggest the possible significance of the subsequent conception. There is an apparent relationship between subsequent birth intervals of 25-30 months and second year mortality. If the effect of the subsequent interval upon mortality was solely the result of the subsequent birth, and not the subsequent conception, no consistent relationship between this interval and mortality should be expected. Similar associations are apparent with respect to 13-18 month intervals and infant mortality, and 37-42 month intervals with third year mortality.

Finally, the effect of the subsequent interval upon mortality does not appear to be related to or conditional upon the sex of the siblings of interest. Given that female child mortality rates have been found to exceed male rates by more than 50 percent in rural Bangladesh,[28] it would be anticipated that the effect of the subsequent birth interval is contingent upon the sex of the two siblings involved. For example, the older sibling (especially a female sibling) might be expected to face higher mortality risks if the subsequent birth is a male. Separate analyses, however, found that the effect of the subsequent birth interval upon index child mortality did not appear to be contingent upon the sex of the children involved. This finding is consistent with the supposition that the subsequent conception, a time when the sex of the subsequent sibling is of course unknown, may play a central role in the associations reported.

Discussion

The results of our analysis provide further evidence for the importance of birth intervals in influencing childhood mortality in rural Bangladesh. The findings also indicate that while both significant, the previous and subsequent birth interval may influence mortality through quite separate and distinct mechanisms. The effect of the previous birth interval appears to arise primarily from the adverse physiological effects upon the mother of closely spaced pregnancies. Support for this conclusion comes from the finding that this association is limited to the neonatal period, when the impact of physiological factors is most evident, and that it is more pronounced among children whose previous sibling died than when the previous sibling lived, suggesting that sibling competition may play a relatively small role. The effect of the subsequent interval, on the other hand, appears concentrated during early childhood period, most plausibly through the mechanism of sibling competition. Although further research is needed, our results are consistent with the hypothesis that such competition may be largely indirect, possibly operating through an early subsequent conception terminating breastfeeding to the index child.

While systematic effects of birth intervals upon childhood mortality are thus evident from our analysis, care must be taken not to overstate the extent to which increasing the interval between births can contribute to reductions in mortality in settings such as rural Bangladesh. This is due to the distribution of births, since birth intervals in such societies tend to already be very long, given the practice of prolonged breastfeeding and lactational amenorrhea. As our analysis has shown, if the index child survives,

relatively few women experience a subsequent birth within 24 months. Thus, while the risks of short intervals may be high, comparatively few births fall into these high risk intervals, and thus the overall demographic impact of birth intervals, as well as programs which modify them, may be more modest. The magnitude of this effect, however, is by no means inconsequential-- elimination of all birth intervals of 24 months or less would lead to significant reductions in both neonatal as well as second and third year mortality. Moreover, it is possible that these potential reductions may compare favorably with several other health interventions which are currently being implemented or presently feasible in countries such as Bangladesh. While it has been shown that birth intervals in such conditions of natural fertility tend to on average be very long, with changes in breastfeeding or abstinence practices-- changes which may already be underway with increased modernization or urbanization-- the importance of birth intervals for child survival, in the absence of other compensating changes, will undoubtedly increase.

Several caveats are in order in interpreting the results of our study. One limitation of our study is that the analysis has been confined to consideration of the interval between live births. The absence of data on length of gestation prevents us from ascertaining with precision the date of conception among children in our study-- a date which is of central importance in sorting out the issue of cause and effect between child death and short birth intervals. We have attempted to overcome this limitation by considering findings based upon using a range of assumptions about the length of gestation. A second and related drawback is that our focus on the interval between live births rather than pregnancies means that the role of foetal wastage has been ignored. To the extent that foetal wastage lengthens

the interval between live births, and carries independent risks of mortality of subsequent offspring, we may have overlooked a potential confounding factor.[29]

Third and most significantly, interpretation of our results are complicated by the effects of the 1974-75 famine. Some of the findings reported here-- for example, those for neonatal mortality-- were uninfluenced by the effects of the famine. Many of the findings for the postneonatal and early childhood periods may have been affected by this event. To the fullest extent possible, we have attempted to supplement the reported results with additional analyses free from this potentially confounding event. While consistent relationships have emerged, it would nevertheless be desirable to validate the findings of this study with data from a more recent crisis-free period.

While a relationship between birth intervals and childhood mortality has been clearly demonstrated, our knowledge of the specific mechanisms which give rise to these associations remains very limited. Much insight could be gained by investigation into the relationships between birth intervals and the more proximate factors which influence mortality-- birthweight, length of gestation, breastfeeding patterns and nutritional status, and variation in the allocation of familial resources.

Investigation of these issues would represent an important step toward gaining more insight into the determinants of child health and survival in developing societies.

Footnotes

1) For a discussion of the `maternal depletion syndrome' see D.B. Jellife, The Assessment of the Nutritional Status of the Community, Monograph Series No.53 (Geneva: World Health Organization, 1966).

2) P. R. Puffer and C.V. Serrano, Birthweight, Maternal Age and Birth Order: Three Important Determinants in Infant Mortality, Scientific Publication No.294 (Washington: Pan American Health Organization, 1975).

3) This latter explanation would suggest that both children of the pair would be disadvantaged by a short preceding birth interval.

4) J. Yerulshalmy, `On the interval between successive births and its effect on survival of infant: I. an indirect method of study', Human Biology 17, 2 (1945), pp. 65-106; J. Yerulshalmy, J.M. Bierman, D.H. Kemp, A. Connor, F.E. French, `Longitudinal studies of pregnancy on the island of Kauai, territory of Hawaii' American Journal of Obstetrics and Gynecology 71, 1 (1956), pp. 80-96; J.B. Wyon and J.E. Gordon, `A long term prospective type field study of population dynamics in the Punjab, India', in Research in Family Planning, C.V. Kiser (ed.), (Princeton: Princeton University Press, 1962), pp. 17-32; J. Knodel, `Infant mortality and fertility in three Bavarian villages: an analysis of family histories from the 19th century', Population Studies, 22, 5 (1968), pp. 297-318; J. Fedrick and P. Adelstein, `Influence of pregnancy spacing on outcome of pregnancy', British Medical Journal 4 (December 29, 1973), pp. 753-756; D. Wolfers and S. Scrimshaw, `Child survival and intervals between pregnancies in Guayaquil, Ecuador', Population Studies 29, 3 (1975), pp. 479-496; A.R. Omran and C.C. Standley, Family Formation Patterns and Health (Geneva: World Health Organization, 1976); A.K.M.A. Chowdhury, Infant Deaths, Determinants and Dilemmas, Scientific Report No. 46 (Dacca: International Centre for Diarrhoeal Disease Research, Bangladesh, 1981); I. Swenson, 'Relationship between pregnancy spacing, sex of infants, maternal age, and birth order, and neonatal and post-neonatal mortality in Bangladesh', Social Biology 28, 3/4 (1981), pp. 299-307; B. Edmonston, `Demographic and maternal correlates of infant and child mortality in Bangladesh', Journal of Biosocial Science 15,2 (1983), pp. 183-192; J. Hobcraft, J.W. McDonald, and S. Rutstein, `Child-spacing effects on infant and early childhood mortality', Population Index 49, 4 (1983), pp. 585-618; C. DeSweemer, `The influence of child spacing on child survival', Population Studies 38, 1 (1984), pp.47-72; J.G. Cleland and Z.A. Sathar, `The effect of birth spacing on childhood mortality in Pakistan', Population Studies 38, 3 (1984), pp. 401-418.

5) Knodel, loc. cit. in footnote 4; Swenson, loc. cit. in footnote 4, DeSweemer, loc. cit. in footnote 4.

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13) P. Aaby, J. Bukh, I.M. Lisse, and A. Smits, `Measles mortality, state of nutrition, and family structure: a community study from Guinea-Bissau',The Journal of Infectious Diseases 147, 4 (1983), pp. 693-701.

14) The surveillance area was subsequently reduced in 1978 to 149 villages and the staffing patterns and field procedures for data collection were substantially revised. See M.K. Chowdhury, et al. Demographic Surveillance System-Matlab: Vital Events and Migration - 1978, Scientific Report No.47, International Centre for Diarrhoeal Disease Research, Bangladesh, 1981.

15) For a more detailed description of the Matlab study area and data collection system during the period of the present study, see Demographic Surveillance System-Matlab: Methods and Procedures, Scientific Report No. 9, Cholera Research Laboratory, Bangladesh, 1978.

16) This figure does not include 233 multiple births.

17) Excluded from this analysis are 1699 children where the index child was the first birth, and 1402 children where date of birth or the survival status of the previous child could not be accurately ascertained. These latter children were predominantly born to mothers who had recently in-migrated into the DSS study area and thus the survival status of the previous sibling could not be obtained with certainty. In one-half of the DSS area, reliable vital events data on the previous sibling extended back only to 1970; in the other half, such data extended back to 1968. Thus, particularly in the former area, there were a number of cases where it was necessary to exclude births for whom the date of birth or survival status of the previous sibling could not be ascertained; these cases consisted of largely of births in which the previous interval was quite long.

18) L.T. Ruzicka and A.K.M.A. Chowdhury, Demographic Surveillance Systems in Matlab: Vital Events and Migration - 1974, Scientific Report No. 11, Cholera Research Laboratory, Bangladesh, 1978; L.T. Ruzicka and A.K.M.A. Chowdhury, Demographic Surveillance System - Matlab, Vital Events and Migration - 1975, Scientific Report No.12, Cholera Research Laboratory, Bangladesh, 1978.

19) See, for example, R. Langsten, 'The effects of crisis on differential mortality by sex in Bangladesh', Bangladesh Development Studies 9, 2 (1981), pp. 75-96.

20) At the same time, prematurity itself may be attributable in part to short birth intervals. See note 10.

21) S.L. Huffman and B.B. Lamphere, 'Breastfeeding performance and child survival', Pp. 93-116 in Child Survival: Strategies for Research, W.H. Mosley and L.C. Chen (eds.), Population and Development Review, Supplement to Volume 10, 1984.

22) See, for example, G. Santow and M.D. Bracher, 'Child Death and Time to the Next Birth in Central Java, 'Population Studies 38, 2 (1984), pp. 241-253.

23) For the birth interval between the index and subsequent child, the percentage of women having a subsequent birth within 24 months is 43.6 percent when the previous sibling died and 4.4 percent when the previous sibling survived. These somewhat lower figures may be attributable to the disruptive effects of the 1974-75 famine, as well as

to declines in fecundity with increasing age, and increased reliance upon contraception among this cohort of mothers.

24) J. Stoeckel and A.K.M.A. Chowdhury, 'Neo-natal and post-neo-natal mortality in a rural area of Bangladesh,' Population Studies 26, 1 (1982), pp. 113-120; and B.B. Gubhaju, 'The effect of previous child death on infant and child mortality in rural Nepal,' Studies in Family Planning 16, 4 (1985), pp. 231-236.

25) This was determined by ascertaining the survival status of the previous sibling at the time of the conception of the index child. Since date of conception was not available, this was estimated based upon an assumption of a normal length of gestation of 40 weeks (280 days). Alternative assumptions about length of gestation, a minimum of 28 weeks (196 days) and a maximum of 44 weeks(308 days), had only a minimal effect on the results of Table 3. This is attributable to the fact that so few previous siblings died during the period 28 to 44 weeks prior to the index birth,a period which generally corresponds to early childhood for the previous sibling, when mortality levels are low. These gestation lengths were derived from E. Alberman, 'Sociobiological Factors and Birth Weight in Great Britain, Pp. 145-156 in D.M. Reed and F. J. Stanley (eds.), The Epidemiology of Prematurity (Baltimore: Urban and Scharzenberg, Inc., 1977).

26) Conception dates based upon a gestation length of 40 weeks were again employed. Substitution of alternative gestation lengths (28 and 44 weeks) affects the reported levels of mortality, but does not eliminate the basic associations between birth intervals and mortality reported in Table 4.

27) For example, subsequent births occurring 24 months after the birth of the index child should not be expected to influence mortality during the first year of life.

28) S. D'Souza and L.C. Chen, 'Sex differentials in mortality in rural Bangladesh,' Population and Development Review 6, 2 (1980), pp.257-270; and M.A. Koenig and S. D'Souza, 'Sex differences in childhood mortality in rural Bangladesh,' Social Science and Medicine 22, 1 (1986), pp. 15-22.

29) Recent estimates based upon data from the Matlab Demographic Surveillance System indicate that foetal wastage constitutes 10-12 percent of all pregnancy outcomes.