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Based on the
1976 Nepal Fertility Survey

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Honolulu, Hawaii

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ABSTRACT

Infant mortality trends based on the 1976 Nepal Fertility Survey are estimated in two ways, directly from maternity histories and indirectly from child survivorship data. The indirect estimates are sensitive to choice of standard life table; hence the direct estimates based on maternity histories are preferred. Direct estimates indicate that infant mortality declined from about 182 deaths per thousand live births in the early 1960s to about 156 in the early 1970s. Highly masculine sex ratios of births prior to 1960 suggest that infant mortality prior to 1960 is substantially underreported. Differential infant mortality is estimated by mother's age at childbirth, birth order, length of previous birth interval, sex of infant, region, urban-rural residence, father's literacy, and father's education.

This paper estimates infant mortality trends and differentials for Nepal between 1950 and 1975, based on the 1976 Nepal Fertility Survey. Trends are estimated both directly from maternity histories and indirectly from child survivorship data. Differentials, derived directly from maternity histories, are estimated by mother's age at childbirth, birth order, length of previous birth interval, sex of infant, region, urban-rural residence, father's literacy, and father's education.

The Nepal Fertility Survey (NFS) was conducted in mid-1976 as part of the World Fertility Survey project. Maternity histories, containing information about infant deaths as well as births, were collected for a self-weighting probability sample of 5,940 ever-married women in the reproductive ages 15-49.¹ These data permit a considerably more detailed analysis of infant mortality trends and differentials in Nepal than has hitherto been possible.

ESTIMATES DERIVED FROM MATERNITY HISTORIES

Direct estimates of infant mortality rates (IMRs) are computed from NFS maternity histories in the usual way, by dividing deaths below one year of age among births for a given calendar year (January through December) by the number of such births. The births in the denominator of an IMR so calculated correspond to a single calendar year, but the infant deaths from those births span two calendar years, since some of the deaths occur in the next calendar year. In conformance with convention, IMRs are identified here by the calendar year in which the births occurred. Since the NFS was taken in mid-1976, the last complete calendar year for which IMRs can be calculated is 1974. Thus results presented in this paper exclude births after 1974, some infant deaths in 1975, and all infant deaths in the first half of 1976.

Survey questions about child deaths asked age at death in completed months. Figure 1 shows the age distribution of deaths over the first 18 months of age. Heaping on 6, 9, 12, and 18 months is evident. Heaping

FIGURE 1. Percent distribution of deaths over the first 18 months of age,
1976 Nepal Fertility Survey

on 12 months presents difficulties, since this is the cut-off age for computation of infant mortality rates. Evidently some children who actually died at 11 months, at less than one year of age, are reported as having died at 12 months, at age one in completed years. Following Goldman et al.,² we have adjusted infant mortality rates for heaping on 12 months of age by assuming that half the deaths at 12 months actually occurred at less than 12 months. The factor of one-half is rough, but it undoubtedly represents an improvement over no adjustment at all. Unadjusted and adjusted infant mortality rates for Nepal are shown in the first two columns of Table 1 and in Figure 2. The adjusted rates are, of course, somewhat higher than the unadjusted rates, by anywhere from 5 to 9 deaths per thousand live births. Only adjusted rates are presented in the remainder of this paper.

TABLE 1. Infant mortality rates, adjusted for heaping and corrected for age truncation, estimated from maternity histories in the 1976 Nepal Fertility Survey (rates per thousand live births)

Period	Unadjusted	Adjusted	
		Uncorrected	Corrected
1950-54	197 (206)	206 (215)	179 (215)
1955-59	181 (378)	188 (393)	176 (393)
1960-64	179 (585)	187 (611)	182 (611)
1965-69	161 (741)	168 (771)	168 (771)
1970-74	151 (860)	156 (890)	156 (890)

Note: Methods for adjusting for heaping and correcting for age truncation are discussed in the text. Figures in parentheses denote numbers of infant deaths, rounded to the nearest integral number (the adjustment for heaping sometimes results in a fractional number of deaths).

FIGURE 2. Infant mortality rates estimated from maternity histories

Source: Table 1.

The second column of Table 1 is duplicated by the uppermost diagonal of Table 2. Table 2 elaborates the second column of Table 1 by additionally tabulating IMRs by cumulated age groups of mothers. Table 2 illustrates that IMRs in columns 1 and 2 of Table 1 are progressively truncated by age of mother for the earlier time periods. Truncation occurs because the age range of women in the sample is restricted to 15-49. This means, for example, that IMRs ten years before the survey can be based only on women aged 15-39 at that time. Were IMRs invariant by age of mother, age truncation would not bias the IMRs presented in the second column of Table 1. But Table 2 demonstrates that IMRs decline as age of mother increases (actually, there is an upturn in the IMR at ages 40-44, as shown in Table 3; this upturn is, however, imperceptibly reflected in IMRs for cumulated age groups in Table 2 because of the small number of births at ages 40-44).

Because IMRs decline with age of mother (except for the older reproductive ages where few births occur), age truncation tends to exaggerate the extent of IMR decline in the second column of Table 1. We have used a simple ratio method to correct for this truncation bias. The method assumes that the IMR for the last cumulated age group--say 15-29 for 1955-59--is related to the unknown IMR for ages 15-44 for those same years in the same proportion that the IMR for 15-29 is related to the IMR for 15-44 in 1970-74. It follows from this assumption that the corrected IMR for 1955-59 in Table 2 is obtained as $\frac{188(156/167) \approx 179}{206(156/180) = 179}$, where 206 is the second entry in the row for 1955-59 and 156 and 180 are the second and sixth entries in the row for 1970-74. By the same reasoning, the corrected IMR for 1960-64 is $187(156/160) = 182$, and the corrected IMR for 1965-69 is $168(156/156) = 168$. This method is rather crude, but it is considerably better than no correction at all. When the correction is made, the estimated decline in the IMR between 1950-54 and 1970-74 is reduced in Table 1 by 27 per thousand, which is the difference between a corrected starting level of 179 and an uncorrected starting level of 206. The corrected decline of 23 per thousand is less than half the uncorrected decline of 50 per thousand.

The corrected IMRs in the last column of Table 1 (see also Figure 2) increase slightly between 1950-54 and 1960-64 before falling off sharply after 1960-64. It is likely that at least part of the apparent rise between

TABLE 2. Infant mortality rates for births classified by cumulated age groups of mothers, estimated from maternity histories in the 1976 Nepal Fertility Survey

Period	Mother's age at childbirth					
	15-19	15-24	15-29	15-34	15-39	15-44
1950-54	233 (107)	206 (215)				
1955-59	234 (121)	191 (272)	188 (393)			
1960-64	221 (149)	207 (338)	192 (512)	187 (611)		
1965-69	210 (183)	188 (408)	177 (573)	169 (702)	168 (771)	
1970-74	213 (193)	180 (469)	167 (667)	160 (778)	156 (855)	156 (890)

Note: Rates are adjusted for heaping. Births to mothers below age 15 are included in births to mothers aged 15-19, and births to mothers aged 45-49 are included in births to mothers aged 40-44. Some births and infant deaths are omitted from the table because of age truncation within 5-year age groups; for example, although an entry could be made for 1950-54 under the heading 15-29, it is not, because the true span of ages would be 15-28.5 (1.5 years truncated), which is not comparable with subsequent entries lower down in the same column, which are not truncated.

TABLE 3. Infant mortality rates for 1970-74 for births classified by age of mother, estimated from maternity histories in the 1976 Nepal Fertility Survey

15-19	20-24	Mothers' ages		35-39	40-44	Total
		25-29	30-34			
213 (193)	163 (276)	142 (198)	129 (112)	125 (77)	145 (35)	156 (890)

Note: Births to mothers below age 15 are included in births to mothers aged 15-19, and births to mothers aged 45-49 are included in births to mothers aged 40-44. Rates are adjusted for heaping.

1950-54 and 1960-64 is spurious, stemming from failure to report births and deaths of children who died in infancy during the earlier period. Because of a cultural preference in Nepal for sons over daughters, we would expect such omissions, if present, to be concentrated among female births, hence to be reflected in excessively masculine sex ratios of births. Since the ratio of male births to female births is normally about 1.05, ratios substantially above 1.05 are evidence of omissions.

We see in Table 4 that for Nepal as a whole (the remainder of the table will be considered later), sex ratios of births are quite reasonable after 1960. But the sex ratio of 1.08 for 1955-59 is somewhat too high, and the sex ratio of 1.17 for 1970-54 is much too high. Since some male births are no doubt omitted in addition to female births, the true omission rate for both sexes might plausibly be about 15 percent. If these births are omitted because the children died many years ago in infancy, hence are forgotten, at least temporarily, or regarded as not worth mentioning, then the infant mortality rate for 1950-54 might also be underestimated by about 15 percent. The true infant mortality rate for 1950-54 would then be in the neighborhood of 206 instead of 179 as indicated in Table 1. Interestingly, if the adjusted-corrected curve in Figure 2 is extrapolated backward from 1960, it is visually evident that the extrapolated IMR for 1950-54 is about 210. These rough calculations and extrapolations, though involving an element of speculation, suggest strongly that the true IMR for 1950-54 was very likely above 200. Although the extent of underestimation cannot be ascertained with precision, the NFS infant mortality estimates previous to 1960 are clearly too low.

ESTIMATES DERIVED FROM CHILD SURVIVORSHIP DATA

The second approach to estimating infant mortality is by Feeney's method of estimating infant mortality from child survivorship data,³ which is an extension of Brass's method of estimating child mortality from child survivorship data.⁴ (By child survivorship data is meant number of children ever born per woman and number of children still living per woman, classified by woman's age at interview.) The essence of Brass's method is to posit an

TABLE 4. Sex ratios of births, estimated from maternity histories in the 1976 Nepal Fertility Survey

Period	Mother's age at childbirth	Nepal	Region			Residence		Literacy	
			Mountain	Hill	Terai	Urban	Rural	Illiterate	Literate
1950-54	15-24	1.17 (1045)	1.23 (87)	1.06 (506)	1.31 (451)	- -	1.17 (1026)	1.26 (648)	1.05 (397)
1955-59	15-29	1.08 (2087)	1.04 (163)	1.05 (1093)	1.13 (829)	- -	1.07 (2022)	1.06 (1282)	1.12 (802)
1960-64	15-34	1.02 (3269)	1.09 (230)	0.97 (1740)	1.08 (1293)	1.09 (92)	1.02 (3157)	1.01 (1976)	1.03 (1281)
1965-69	15-39	1.01 (4592)	1.10 (352)	1.02 (2304)	0.98 (1908)	1.07 (126)	1.01 (4423)	1.03 (2654)	0.99 (1929)
1970-74	15-44	1.05 (5710)	1.08 (383)	1.02 (2834)	1.08 (2448)	1.08 (125)	1.05 (5495)	1.04 (3125)	1.06 (2576)

Note: Figures in parentheses denote numbers of births of both sexes. Births within region, residence, or literacy categories do not quite add to births for the whole country, because region, residence, and literacy status are not stated for some cases. Dashes indicate insufficient numbers of cases.

underlying model life table family appropriate to the population under consideration, then to solve for the specific life table in that family that is consistent with the proportion of dead children of women in a specified age group. The life table so obtained specifies an infant mortality rate. (Actually, Brass provides a shortcut via multipliers, but this need not concern us here.) In this way one obtains an infant mortality estimate corresponding to each age group of women.

Whereas Brass's original method generally assumes that mortality has been constant in the past, Feeney's extension assumes that the IMR has been changing at a constant rate in the past. Feeney's estimation equations are too complicated to be presented here, but the upshot is that a date is assigned to each of the seven IMR estimates (corresponding to age groups 15-19, 20-24, ..., 45-49) derived by the original Brass method. The date of the IMR estimate based on child survivorship data for women in a given age group is earlier in time the older the age group.

Of interest in the present context is the choice of underlying model life table family presumed to fit the mortality experience of the population in question. This family is computed as the logit transformation of some standard life table, typically the so-called Brass general standard life table.⁵ The model life table family generated from the Brass general standard is close, but not identical, to the Coale-Demeny West model life table family.⁶ In the case of Nepal, it is not at all clear that the Brass general standard life table is appropriate. Accordingly, we have experimented with other standard life tables, logit transformations of which provide alternative underlying model life table families on which to base the estimation procedure.

Figure 3 shows results of this experimentation. It is evident that both the estimated level and the estimated rate of decline of infant mortality, as derived by Feeney's method, are sensitive to choice of standard life table. The rate of IMR decline is uniformly less than that derived from maternity histories, except when Coale-Demeny East Level 11 is used as the standard. Indirect estimates based on the West and Brass general standard life tables agree better with direct estimates based on maternity histories than do estimates based on other standards. The divergence of IMR estimates based on different standard life tables is particularly great

FIGURE 3. Infant mortality trends derived indirectly by Feeney's method with alternative standard life tables, and directly from maternity histories

Note: Solid lines denote estimates derived by Feeney's method; the broken line denotes adjusted-corrected rates estimated directly from maternity histories (column 3 of Table 1). In applying Feeney's method, the survey date was taken as 1976.5 and six alternative standard life tables were used: Brass general standard, Brass African standard, and Coale-Demeny Model West Level 11, Model East Level 11, Model North Level 11, and Model South Level 11.

for the earlier periods, with the range of estimates in Figure 3 slightly above 60 per thousand around 1960 and slightly below 20 per thousand around 1975.

IMR trends derived by Feeney's method show a characteristic pattern of bias that is visually evident in Figure 3. Consider, for example, the trend based on the Brass general standard life table. The IMR first rises between the leftmost two points based on child survivorship data for women aged 45-49 and 40-44, then falls until the fifth point based on child survivorship data for women aged 25-29, then rises again between the last two points based on child survivorship data for women aged 20-24 and 15-19. This typical pattern of distortion resembles an elongated Z rotated 90 degrees.

Tables 1-4 suggest that the principal sources of this typical pattern of distortion are omission by older women of births of children dying in infancy many years ago, which helps explain the spuriously low IMR for the earliest period, and the pattern of declining infant mortality with increasing age of mother, which helps explain the spurious rise in indirect estimates of the IMR during the years immediately preceding the survey. (Indirect estimates close to the survey date are based on child survivorship data for mothers aged 15-19 and 20-24--i.e., young mothers who have especially high IMRs and for whom infant deaths are a high proportion of total child deaths.) The pattern of declining infant mortality with increasing age also helps explain why the overall IMR decline is usually less steep in the indirect estimates (even when distortions at the tails are disregarded) than in the direct estimates in Figure 3.

Table 5, which shows published IMR estimates from other sources, provides further perspective on IMR levels and rates of decline (it also shows sex differentials in IMRs, which we shall discuss later). Many of these estimates are inconsistent with each other, but overall the sequence of estimates suggests an IMR trend that starts higher and ends lower than the trend estimated from NFS maternity histories (last column of Table 1).

We have somewhat greater confidence in the NFS estimates than in the earlier estimates shown in Table 5, because the NFS data are of higher quality and allow direct estimates from maternity histories. Many of the

TABLE 5. Previously published estimates of infant mortality by sex for Nepal

Source	Reference period	Male	Female	Both Sexes
Vaidyanathan and Gaige	1954	260	250	255
CBS	1953-61	195	217	206
Krotki and Thakur	1961	266	230	248
Gubhaju	1961-70	200	186	193
Worth and Shah	1965-66	-	-	152
CBS	1961-71	209	177	193
CBS	1971	-	-	172
DSS	1974-75	141	123	133
DSS	1976	128	138	134
DSS	1977-78	110	98	104

Note: Infant mortality estimates for both sexes by Vaidyanathan and Gaige, Krotki and Thakur, Gubhaju, and CBS for 1953-61 and 1961-71 are averaged, based on an assumed sex ratio at birth of 1.05, from estimates for males and females separately. Estimates by Worth and Shah, and CBS 1971 are not available for males and females separately. CBS denotes Central Bureau of Statistics. DSS denotes Demographic Sample Survey.

Sources: K.E. Vaidyanathan and F. Gaige, "Estimates of Abridged Life Tables, Corrected Sex-Age Distribution and Birth and Death Rates for Nepal, 1954," Demography India 2(1973):278-290. K.J. Krotki and H.N. Thakur, "Estimates of Population Size and Growth from the 1952-54 and 1961 Censuses of the Kingdom of Nepal," Population Studies 25 (1971):89-103. B.B. Gubhaju, An Abridged Life Table Construction for Nepal for the Period 1961-70 (Kathmandu: Ministry of Health and Nepal Family Planning and Maternal Child Health Project, 1974), . Mimeo. R.M. Worth and N.K. Shah, Nepal Health Survey 1965-66 (Honolulu: University of Hawaii Press, 1969). Nepal Central Bureau of Statistics, Population Projection for Nepal 1971-86 (Kathmandu: Central Bureau of Statistics, 1974). Nepal Central Bureau of Statistics, The Demographic Sample Survey of Nepal (three reports, for 1974-75, 1976, and 1977-78) (Kathmandu: Central Bureau of Statistics, 1976, 1977, 1978). Nepal Central Bureau of Statistics, The Analysis of the Population Statistics of Nepal (Kathmandu: Central Bureau of Statistics, 1977).

earlier estimates are indirect. For example, the estimates by Vaidyanathan and Gaige, Krotki and Thakur, Gubhaju, and the Central Bureau of Statistics (CBS) are all based on application of stable or quasi-stable population analysis to census data. Among these estimates, the Vaidyanathan and Gaige estimates for 1954 and the Krotki and Thakur estimates for 1961 are extremely high, implying, when matched to Coale-Demeny West model life tables, a life expectancy of only about 31 years, which seems too low. Roughly comparable IMR estimates from the NFS are about 180 for the early 1960s, implying a life expectancy of about 40 years.

Worth and Shah's estimate for 1965-66 in Table 5 is based on maternity histories from the 1965-66 Nepal Health Survey (NHS). Partly because the NHS excludes most of the mountain region, which, as we shall see, has particularly high infant mortality, Worth and Shah's IMR estimate of 152 is probably too low; the comparable NFS estimate, obtained by averaging corrected rates for 1960-64 and 1965-69 in Table 1, is 175. The Demographic Sample Surveys (DDS) likewise underrepresent the mountain region and generally overrepresent the more accessible and developed districts of the country, so that the DDS estimates of 133 for 1974-75 and 134 for 1976 are probably also too low. The DDS estimate of 104 for 1977-78 is especially low, for reasons that are not clear. By way of comparison, the NFS estimate for 1970-74 is 156, implying a life expectancy of about 44 years.

The preceding discussion suggests that IMR estimates after 1960 derived from NFS maternity histories are fairly accurate. Since indirect estimates based on application of Feeney's method to NFS child survivorship data show a systematic pattern of bias and are sensitive to choice of underlying model life table family, results presented in the remainder of this paper are based solely on NFS maternity histories.

DIFFERENTIAL INFANT MORTALITY BY BIRTH ORDER AND BIRTH INTERVAL

Turning now to infant mortality differentials, we first examine differentials by birth order and birth interval. Table 6 shows infant mortality rates by birth order and time period. For the earliest time period, 1950-54, IMRs increase as birth order increases. (Although our earlier discussion

TABLE 6. Infant mortality rates by birth order and time period

Period	Mother's age at childbirth	Birth order			
		1	2	3-4	5+
1950-54	15-28.5	186 (101)	216 (73)	222 (62)	- -
1955-59	15-33.5	184 (125)	151 (84)	183 (129)	267 (79)
1960-64	15-38.5	200 (168)	165 (120)	172 (176)	199 (161)
1965-69	15-43.5	183 (188)	161 (150)	152 (215)	178 (235)
1970-74	15-48.5	176 (208)	150 (161)	155 (263)	146 (259)

Note: Rates based on fewer than 20 infant deaths are not shown. Rates are adjusted for heaping but are not corrected for age truncation. In this and all subsequent tables, rates are estimated directly from maternity histories. In this and subsequent tables, numbers in parentheses denote numbers of infant deaths (not births).

indicated that IMRs for 1950-54 and 1955-59 are underestimates, their pattern of variation by birth order is still of interest.) For later time periods the variation by birth order is less consistent: The IMR consistently drops off sharply from birth order 1 to birth order 2. After birth order 2 IMRs increase as birth order increases, except for 1965-69, where the minimum IMR occurs at birth orders 3-4, and 1970-74, where the IMR after birth order 1 is fairly constant.

To test how the IMRs in Table 6 are affected by age truncation, we decided to introduce a control for age. Because of limited numbers of observations, this was feasible only for the period 1970-74. Results are shown in Table 7. Reading across rows, we see that IMRs consistently increase by birth order when age is controlled. Down columns, IMRs consistently fall with age when birth order is controlled. Unfortunately, even for 1970-74 many cells lack entries because of insufficient numbers of observations.

Table 8 helps explain the findings in Tables 6 and 7 by considering the relationship between infant mortality and birth interval. Table 8 shows infant mortality rates for second and higher-order births by length of previous birth interval. Only those births are considered for which the previous birth survived to the current birth. To control for age truncation, only women aged 15-34 are considered for each of the three time periods examined. Only time periods after 1960 are considered, owing to further age truncation and small numbers of observations for the earlier two periods.

It is necessary that Table 8 exclude women whose child of a previous birth died before the current birth, in order to control for the simultaneous effect of infant mortality on birth interval. That is, we must eliminate the possibility that the previous birth interval is short because the previous child died in the first year of life, thereby cutting short lactation and causing early resumption of ovulation. Without this control, women with shorter birth intervals could be selected for a history of high infant mortality among their children, in which case it would not be clear whether we were measuring the effect of birth interval on infant mortality or vice versa. Excluding women whose previous birth died before the current birth largely eliminates this ambiguity about the direction of causality. Henceforth

TABLE 7. Infant mortality rates by birth order of child and age of mother, 1970-74

Age	Birth order		
	1	2-3	4-6
15-19	203(121)	231(70)	-
20-24	147(67)	148(139)	234(70)
25-29	-	126(66)	144(103)
30-34	-	-	126(59)
35-39	-	-	117(31)
40-44	-	-	-

Note: Rates are adjusted for heaping. Births to mothers below age 15 are included in births to mothers aged 15-19, and births to mothers aged 45-49 are included in births to mothers aged 40-44. Rates based on fewer than 20 deaths are not shown.

TABLE 8. Infant mortality rates for second and higher-order births by length of previous birth interval for which the previous birth survived to the current birth

Period	Mother's age at childbirth	Previous surviving birth interval in completed months		
		8-23	24-33	34-60
1960-64	15-34	205 (99)	147 (93)	93 (54)
1965-69	15-34	183 (123)	151 (119)	104 (75)
1970-74	15-34	213 (172)	143 (134)	86 (84)

Note: Rates are adjusted for heaping. Intervals greater than 60 months are not considered because the survey recorded ages at death only up to 65 months of age. Since mother's age at childbirth is specified, rates in this table are not corrected for age truncation. In cases where the child of a previous birth did not survive to the current birth, the current birth is excluded from the above table.

we shall refer to birth intervals for which the child of a previous birth survived to the current birth as "surviving birth intervals."

Table 8 shows that even when the effect of infant mortality on birth interval is controlled in this way, the effect of previous birth interval on IMRs is large. For the three time periods after 1960, the IMR for interval group 34-60 is less than half the IMR for interval group 8-23. Thus the effect of birth interval on IMRs is far larger than the effect of either age or birth order.⁷

It is interesting to note in Table 8, if one reads down columns instead of across rows, that IMRs by previous surviving birth interval length show no apparent decline after 1960, despite the substantial decline in overall infant mortality after 1960 noted earlier. This unexpected finding suggests, rather implausibly, either that the IMR decline is due mainly to IMR decline for first births (which are excluded from Table 8), or that surviving birth intervals are increasing over time. IMRs for first births did indeed fall, as shown in Table 6; but the minor changes over time in the proportionate distribution of cases among the three interval length categories in Table 8 offer no evidence that surviving birth intervals increased over time. (The proportionate distributions, which are not shown, can be computed roughly from the numbers of infant deaths given in parentheses in the table.) Unfortunately, numbers of cases are too small to explore this anomaly much further, as for example, by introducing a finer control for mother's age at childbirth.

We return now to Table 7, to see how Table 8 can be used to interpret it. The fact that IMRs are substantially higher the shorter the previous birth interval helps to explain why IMRs increase with birth order at ages 15-19 in Table 7: Previous birth intervals must be relatively short for women who manage to have second or third births before age 20; hence the birth order-specific IMRs for birth orders 2-3 are relatively high. At ages 20-24, on the other hand, it does not take any substantial compression of previous birth intervals for a woman to have three births before age 25, given the early marriage pattern that prevails in Nepal, so one would not expect a big increase in the IMR between birth orders 1 and 2-3; and in fact none is observed in Table 7. Some compression is again necessary to have 4-6 births before reaching age 25. Hence if IMRs are higher the shorter

the previous birth interval, one would expect IMRs for women 20-24 to increase between birth orders 2-3 and 4-6; this is observed in Table 7, not only at ages 20-24 but also at ages 25-29.

The interpretation of Table 6 is somewhat more complicated because of variable ages at childbirth from one period to the next. In the earliest period, 1950-54, where mothers' ages at childbirth are below age 28.5, it is possible that compression of birth intervals within a limited age range might explain why the IMR rises between birth order 1 and 2. But for later periods the possible ages at childbirth are 33.5 and over. Since most women have their first and second births before age 33.5, one should not expect to see any compression effect for birth orders 1 and 2 for periods after 1955. And in fact none is observed; for all periods after 1955, the IMR falls off sharply between birth orders 1 and 2. There remains some compression at higher birth orders, but in Table 6 this attenuates for later periods, where age truncation is less severe, and is virtually absent for 1970-74, where age truncation is negligible. For 1970-74, the IMR falls between birth orders 1 and 2 and, consistent with the above reasoning, is approximately constant thereafter.

Since the impact of birth interval on IMRs is so large, and since, because of declining fecundity, birth intervals increase with age, it is appropriate to ask how much of the decline of IMRs with age of mother at childbirth is explained by birth interval length. The possibilities for testing this hypothesis are extremely limited by small numbers of cases, but we have made one test that is shown in Table 9. Here, for the period 1970-74, where the number of births is large and the span of ages almost complete, we have tabulated IMRs by mother's age at childbirth and length of previous birth interval, excluding, as before, any birth intervals where the child of a previous birth died before the current birth. This tabulation suggests that controlling for birth interval length does not explain away age effects on IMRs. Reading across rows, we find that, for interval lengths 8-23 and 24-33, IMRs fall off with age. For interval lengths 34-60, however, IMRs increase with age. Because of small numbers of observations, there are, unfortunately, many empty cells in this table. The data do suggest, however, that when birth interval is statistically controlled, the variation of infant mortality with age of mother at childbirth is still somewhat U-shaped.⁸

TABLE 9. Infant mortality rates for second and higher-order births in 1970-74, classified by cumulated age groups of mothers and by length of previous birth interval for which the previous birth survived to the current birth

Previous surviving interval in completed months	Mother's age at childbirth					
	15-19	20-24	25-29	30-34	35-39	40-44
8-23	258 (24)	232 (70)	189 (51)	190 (28)	- -	- -
24-33	- -	176 (61)	136 (45)	- -	- -	- -
34-60	- -	- -	77 (28)	106 (31)	109 (22)	- -

Note: Births to mothers below age 15 are included in births to mothers aged 15-19, and births to mothers aged 45-49 are included in births to mothers aged 40-44. See also the note to Table 8.

Table 10 helps explain why IMRs decline as mother's age at childbirth increases. Both mean birth interval and mean duration of breastfeeding increase with age. The consistent increase in mean duration of breastfeeding with age is somewhat surprising, given that the mother's reproductive machinery generally deteriorates in efficiency with advancing age. It should be borne in mind, however, that the duration of breastfeeding at the younger ages would probably be much longer were it not terminated prematurely by the arrival of the next birth. Birth intervals affect duration of breastfeeding as well as vice versa; and birth intervals increase with age because of declining fecundity. Therefore, increase in mean duration of breastfeeding with age is not incompatible with decrease in the ability to breastfeed.

TABLE 10. Breastfeeding during the last closed birth interval (surviving birth intervals only)

Woman's age at birth of last child	Mean length of interval (months)	Mean length of breastfeeding within interval	Percent breastfeeding for more than 30 months	N
15-19	25.5	17.8	5.3	114
20-24	32.9	21.6	16.0	644
25-29	38.3	23.8	22.9	904
30-34	40.2	25.2	28.2	678
35-39	47.2	27.1	30.8	558
40-44	44.6	26.6	34.5	197
45-49	54.6	31.1	47.8	23

Note: Table excludes women who did not breastfeed at all during the last closed interval and women whose last closed interval exceeded 60 months.

Table 10 raises an ambiguity as to why the effect of birth interval on IMRs is so large. Is it because women breastfeed longer when birth intervals are longer (under high mortality conditions, breast-fed infants have much lower mortality than children fed on breast-milk substitutes), or is it because the next sibling is older and less likely to be sick (morbidity declines with age for young children) with a contagious disease that can be communicated to the newborn infant? No doubt both of these factors help explain observed differentials, but the NFS data are not detailed enough to allow disentanglement of their separate effects. Other effects may be involved as well.

The above findings strongly support the often-made assertion that under high mortality conditions, use of contraception to increase birth spacing leads to substantial infant mortality reduction.

DIFFERENTIAL INFANT MORTALITY BY SEX, REGION, RESIDENCE, AND EDUCATION

We turn now to infant mortality differentials by sex, shown in Table 11 and Figure 4. For periods after 1960, male infant mortality, conforming to the usual pattern, is consistently higher than female infant mortality; prior to 1960, the pattern is erratic. Earlier it was shown that omissions of infant deaths, presumably concentrated among female infants, were especially noticeable for the period 1950-54; such omissions probably explain most of the apparent increase in female infant mortality between 1950-54 and 1955-59. The trend in male infant mortality is puzzling; we are unable to explain the anomalous dip in male infant mortality between 1950-54 and 1960-64, although we strongly suspect that it is not real.

Table 12 and Figure 5 show infant mortality rates for the three principal regions of Nepal, namely mountain, hill, and terai (terai refers to the plain region bordering India). The hill area is the only one of the three that shows a fairly smooth downward trend. Both the mountain and the terai regions show infant mortality increases between 1950-54 and 1960-64, which are implausible. The likely explanation of the pattern in Figure 5 is that the mountain and terai regions are characterized by serious underreporting of births prior to 1960 but the hill region is not. This hypothesis is supported

TABLE 11. Infant mortality rates by sex

Period	Male	Female	Male/Female
1950-54	192 (124)	161 (91)	1.19
1955-59	172 (199)	179 (193)	.96
1960-64	190 (322)	171 (288)	1.11
1965-69	171 (398)	163 (372)	1.05
1970-74	159 (466)	152 (423)	1.05

Note: In this and all subsequent tables, IMR estimates are both adjusted for heaping and corrected for age truncation as in the last column of Table 3. Raw tables, similar in format to Table 2, are given in the Appendix.

FIGURE 4. Infant mortality rates by sex

Source: Table 11.

FIGURE 5. Infant mortality rates by region

Source: Table 12.

by the data on sex ratios of births presented earlier in Table 4, which shows highly masculine sex ratios during the early periods for the mountain and terai regions, but normal sex ratios for the hill region. Thus it appears that reporting was considerably more complete in the hill region than in the other two regions. This is perhaps not surprising when it is considered that the hill region contains Kathmandu and is the most developed region of the country. Goldman et al.⁹ also found that the quality of age reporting (as evidenced by heaping) was better in the hill region than in the other two regions.

TABLE 12. Infant mortality rates by region

Period	Mountain	Hill	Terai
1950-54	221 (20)	169 (101)	181 (95)
1955-59	235 (42)	150 (177)	196 (173)
1960-64	238 (60)	150 (272)	212 (279)
1965-69	189 (68)	149 (349)	183 (349)
1970-74	188 (72)	143 (407)	165 (405)

Note: Because of a few individuals for whom region could not be ascertained, numbers of deaths for the three regions combined are slightly smaller than the number of deaths for the whole country in earlier tables.

Table 13 shows IMRs by urban-rural residence. Urban infant mortality rates are invariably substantially below rural infant mortality rates. This is not surprising, since health facilities are disproportionately found in urban areas. (Unfortunately, the urban population was not oversampled, so there are very few urban women in the sample. In earlier tables, rates were not shown when infant deaths in the numerator fell below 20. Were this restriction followed in Table 13, no rates for urban women would appear at all. We have shown the urban rates despite the small number of deaths involved because the pattern is so consistent.)

TABLE 13. Infant mortality rates by urban-rural residence

Period	Urban	Rural
1950-54	- -	179 (207)
1955-59	- -	177 (383)
1960-64	139 (13)	184 (598)
1965-69	115 (15)	168 (744)
1970-74	112 (14)	157 (861)

Note: Because of a few individuals for whom urban-rural residence could not be ascertained, numbers of deaths for urban and rural combined are slightly smaller than the number of deaths for the whole country in earlier tables. Rates are shown for urban despite numbers of deaths below 20.

Table 14 shows infant mortality rates by husband's literacy and husband's education. In most cases, the literate and some schooling categories have lower IMRs than do the illiterate and no schooling categories. But the differentials are usually not very large, and in some cases they are reversed. Sex ratios of births in Table 4 for illiterate and literate suggest that omissions for illiterate are larger than for literate for the period 1950-54, and that these omissions help account for the reversal of the infant mortality differential by literacy for that period.

TABLE 14. Infant mortality rates by husband's literacy and education

Period	Literacy		Schooling	
	Illiterate	Literate	None	Some
1950-54	175 (134)	179 (82)	177 (185)	- -
1955-59	177 (248)	168 (143)	175 (328)	176 (34)
1960-64	194 (395)	159 (210)	187 (505)	134 (48)
1965-69	186 (491)	142 (279)	174 (608)	136 (95)
1970-74	160 (499)	151 (390)	156 (644)	152 (166)

Note: Because of a few individuals for whom literacy and schooling could not be ascertained, numbers of deaths for illiterate and literate and for none and some schooling are slightly smaller than the number of deaths for the whole country in earlier tables.

CONCLUSION

Infant mortality trends based on the 1976 Nepal Fertility Survey have been estimated in two ways, directly from maternity histories and indirectly from child survivorship data. The indirect estimates are sensitive to choice of standard life table, hence the direct estimates based on maternity histories are preferred. Direct estimates indicate that infant mortality declined from about 182 deaths per thousand live births in the early 1960s to about 156 in the early 1970s. Highly masculine sex ratios of births prior to 1960 suggest that infant mortality prior to 1960 is substantially under-reported. Infant mortality differentials by mother's age at childbirth, birth order of child, and length of previous surviving birth interval are interrelated; the finding of an especially strong inverse relation between infant mortality and length of previous surviving birth interval supports, by implication, the often-made assertion that under high mortality conditions, use of contraception to increase birth spacing leads to substantial infant mortality reduction. Infant mortality is highest in the mountain region of Nepal and lowest in the hill region, with the terai region in between. Infant mortality is higher for males than for females, higher for rural than for urban, and higher for the illiterate and uneducated than for the literate and educated.

APPENDIX TABLE 1. Infant mortality rates for males

Period	Mother's age at childbirth					
	15-19	15-24	15-29	15-34	15-39	15-44
1950-54	243 (62)	220 (124)				
1955-59	221 (58)	194 (143)	184 (199)			
1960-64	233 (78)	215 (177)	205 (274)	195 (322)		
1965-69	217 (95)	195 (215)	181 (300)	174 (364)	172 (398)	
1970-74	221 (105)	182 (249)	170 (353)	163 (410)	160 (451)	159 (466)

Note: In this and subsequent tables, rates are per thousand live births and figures in parentheses denote numbers of infant deaths in the numerator. Rates are adjusted for heaping, as described in the text, and are estimated directly from maternity histories in the 1976 Nepal Fertility Survey.

APPENDIX TABLE 2. Infant mortality rates for females

Period	Mother's age at childbirth					
	15-19	15-24	15-29	15-34	15-39	15-44
1950-54	219 (45)	189 (91)				
1955-59	244 (62)	186 (129)	192 (193)			
1960-64	206 (70)	196 (159)	178 (236)	177 (288)		
1965-69	204 (88)	181 (192)	172 (272)	164 (337)	163 (372)	
1970-74	203 (88)	178 (220)	163 (314)	157 (368)	152 (403)	152 (423)

APPENDIX TABLE 3. Infant mortality rates for the Mountain region

Period	Mother's age at childbirth					
	15-19	15-24	15-29	15-34	15-39	15-44
1950-54	265 (9)	230 (20)				
1955-59	351 (13)	266 (26)	258 (42)			
1960-64	229 (8)	299 (34)	247 (46)	261 (60)		
1965-69	140 (6)	182 (27)	183 (45)	189 (59)	192 (68)	
1970-74	243 (9)	196 (28)	206 (49)	194 (61)	191 (68)	188 (72)

APPENDIX TABLE 4. Infant mortality rates for the Hill region

Period	Mother's age at childbirth					
	15-19	15-24	15-29	15-34	15-39	15-44
1950-54	198 (43)	199 (101)				
1955-59	208 (49)	170 (127)	162 (177)			
1960-64	190 (60)	171 (138)	162 (227)	156 (272)		
1965-69	190 (73)	172 (176)	162 (251)	154 (318)	151 (349)	
1970-74	199 (81)	168 (209)	154 (296)	149 (352)	145 (394)	143 (407)

APPENDIX TABLE 5. Infant mortality rates for the Terai region

Period	Mother's age at childbirth					
	15-19	15-24	15-29	15-34	15-39	15-44
1950-54	264 (55)	210 (95)				
1955-59	239 (58)	204 (119)	209 (173)			
1960-64	252 (81)	235 (166)	223 (239)	216 (279)		
1965-69	233 (100)	206 (201)	192 (272)	185 (321)	183 (349)	
1970-74	225 (102)	191 (227)	176 (317)	168 (360)	165 (388)	165 (405)

APPENDIX TABLE 6. Infant mortality rates for urban areas

Period	Mother's age at childbirth					
	15-19	15-24	15-29	15-34	15-39	15-44
1950-54	-	-				
1955-59	-	-	-			
1960-64	-	-	-	136 (13)		
1965-69	-	-	-	132 (15)	119 (15)	
1970-74	-	-	-	109 (12)	116 (14)	112 (14)

Note: Empty cells have fewer than 12 infant deaths.

APPENDIX TABLE 7. Infant mortality rates for rural areas

Period	Mother's age at childbirth					
	15-19	15-24	15-29	15-34	15-39	15-44
1950-54	233 (105)	207 (212)				
1955-59	236 (117)	193 (267)	189 (383)			
1960-64	227 (148)	213 (335)	196 (504)	189 (598)		
1965-69	207 (170)	188 (390)	177 (550)	170 (676)	168 (744)	
1970-74	216 (184)	182 (451)	168 (643)	161 (753)	157 (828)	157 (861)

APPENDIX TABLE 8. Infant mortality rates for births of children whose fathers are illiterate.

Period	Mother's age at childbirth					
	15-19	15-24	15-29	15-34	15-39	15-44
1950-54	235 (68)	206 (134)				
1955-59	218 (72)	188 (167)	193 (248)			
1960-64	241 (89)	219 (205)	207 (331)	200 (395)		
1965-69	229 (102)	211 (242)	198 (359)	190 (450)	185 (491)	
1970-74	221 (91)	188 (233)	174 (354)	165 (426)	159 (473)	160 (499)

APPENDIX TABLE 9. Infant mortality rates for births of children whose fathers are literate

Period	Mother's age at childbirth					
	15-19	15-24	15-29	15-34	15-39	15-44
1950-54	228 (39)	205 (82)				
1955-59	254 (47)	193 (104)	178 (143)			
1960-64	192 (58)	183 (126)	166 (174)	163 (210)		
1965-69	191 (81)	163 (165)	150 (213)	142 (251)	144 (279)	
1970-74	206 (102)	173 (236)	160 (313)	155 (351)	153 (381)	151 (390)

APPENDIX TABLE 10. Infant mortality rates for births of children whose fathers have no schooling.

Period	Mother's age at childbirth					
	15-19	15-24	15-29	15-34	15-39	15-44
1950-54	237 (91)	210 (185)				
1955-59	228 (94)	186 (218)	190 (328)			
1960-64	238 (115)	214 (261)	198 (417)	192 (505)		
1965-69	215 (121)	196 (293)	184 (434)	176 (549)	174 (608)	
1970-74	217 (114)	185 (303)	169 (454)	160 (546)	156 (613)	156 (644)

APPENDIX TABLE 11. Infant mortality rates for births of children whose fathers have some schooling

Period	Mother's Age at childbirth					
	15-19	15-24	15-29	15-34	15-39	15-44
1950-54	153 (6)	171 (13)				
1955-59	284 (17)	205 (29)	185 (34)			
1960-64	147 (17)	145 (36)	144 (45)	137 (48)		
1965-69	181 (42)	158 (76)	142 (85)	135 (91)	137 (95)	
1970-74	219 (66)	170 (124)	160 (153)	155 (160)	153 (165)	152 (166)

NOTES

1. A more detailed description of the sample is contained in the first NFS Report; see Nepal Ministry of Health and Nepal Family Planning and Maternal Child Health Project, Nepal Fertility Survey 1976; First Report (Kathmandu: Nepal Ministry of Health, 1977).
2. N. Goldman, A.J. Coale, and M. Weinstein, The Quality of Data in the Nepal Fertility Survey, Scientific Reports No. 6 (London: World Fertility Survey, 1979).
3. G. Feeney, "Estimating Infant Mortality Trends from Child Survivorship Data," Population Studies 34(1980):109-128.
4. W. Brass, Methods for Estimating Fertility and Mortality from Limited and Defective Data (Chapel Hill: University of North Carolina at Chapel Hill, 1975), pp. 50 ff.
5. G. Feeney (1980) loc. cit. in footnote 3.
6. A. Coale and P. Demeny, Regional Model Life Tables and Stable Populations (Princeton: Princeton University Press, 1966).
7. Other studies have also found that birth interval exerts a strong influence on infant mortality; see, for example, D. Wolfers and S. Scrimshaw, "Child Survival and Intervals Between Pregnancies in Guayaquil, Ecuador," Population Studies 29(1975):479-496.
8. This is not surprising, since it is well established that, for example, infant mortality from congenital defects, which is probably influenced very little by birth interval, is also U-shaped by age of mother at childbirth; see J. Stoeckel and A.K.M. Alauddin Chowdhury, "Neo-natal and Post-neo-natal Mortality in a Rural Area of Bangladesh," Population Studies 26(1972):113-120.
9. N. Goldman et al. (1979) op. cit. in footnote 2.

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