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A STUDY OF INFANT MORTALITY AND CAUSES OF DEATH IN A RURAL NORTH-EAST BRAZILIAN COMMUNITY

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Summary. In 1984 a prospective study of 1645 women and 1677 births in a rural community in north-eastern Brazil showed the infant mortality rate to be 65 per 1000 live births. Neonatal, post-neonatal and infant mortality are analysed to determine the most important risk factors for each period. Post-neonatal survival depends largely on factors relating to child care, while neonatal deaths are more likely to be associated with biological factors. The principal cause of death, diarrhoeal disease, was responsible for a third of the deaths.

Introduction

Ninety-seven percent of babies born alive in developed countries survive the first 5 years of life as compared with only 20–25% in many developing countries (Mosley, 1984). Most countries have experienced a reduction in infant and child mortality during recent decades. Brazil has been no exception: infant mortality declined from 163 deaths per 1000 live births in 1940 to 63 in 1987 (Population Reference Bureau, 1987), the last figure being marginally higher than the 1987 average of 58 deaths per 1000 live births for all Latin America.

There are strong regional differences in Brazil. The north-east is the poorest region, with an annual income per head less than half the national average (Merrick & Graham, 1979). In Fortaleza, the state capital of Ceará, and the state where this study was located, almost three-fourths of the population over 10 years of age receive a monthly salary of less than US $80 (Companhia de Desenvolvimento da Região Metropolitana de Salvador, 1986). The north-east also has the highest infant mortality rate (142 per 1000 live births in 1976–86), while the south has the lowest (44 per 1000 live births), according to the 1986 Demographic and Health Survey (Arruda *et al.*, 1987).

Numerous studies have examined infant mortality in Brazil in relation to socioeconomic differentials (Yunes, 1981; Wood, 1982; Barros *et al.*, 1984; Guimarães

& Fischmann, 1985) and all show that the minimum wage index or household income is inversely related to infant mortality levels on both national and subnational levels. Among households with piped water, income-related differences in mortality were narrowed, but maternal and paternal education had the greatest effect on child mortality (Merrick, 1985). Victora *et al.* (1987) and Goldberg *et al.* (1984), in the south and north-east of Brazil respectively, confirmed the increased likelihood of infant death when children are not breast-fed, and Victora *et al.* found the association particularly strong when the cause of death was diarrhoeal disease or respiratory infection.

Chen (1983) based his conceptual framework of the proximate determinants of infant mortality on four sets of factors suggested by Puffer & Serrano (1973). These included parental characteristics (such as maternal age and parity), nutritional factors (both fetal and child), infection factors (fetal and child), and child care factors, including availability and use of health care services. The present study emphasizes the biological factors in Chen's model, among other variables. It describes the principal causes of death and the treatment sought by mothers whose children died.

To avoid the possible inaccuracies attached to child mortality data collected retrospectively, e.g. the omission of deaths and misreporting of the dates of birth and death, the present study is prospective and provides locale-specific information, useful in tailoring survival interventions. The data derive from an enquiry whether traditional birth attendants (TBAs) were making appropriate referrals and what the outcome of referral was on survival. A cohort of live-born infants was followed for 6 weeks to determine the effect of high risk pregnancy and referral on early survival. But this design provided an opportunity to extend the study over a longer period and infants were followed up for 18 months.

For the original study a great deal of attention was paid to collecting information on the health and medical condition of the mother and child around the time of, and subsequent to, delivery as well as to health care received during pregnancy. Thus, these data were thought to be particularly useful in understanding the contribution of conditions of pregnancy and delivery to mortality both in early infancy and in the post-neonatal period.

Data and methods

Data were obtained from all women in Trairi who gave birth between May 1984 and April 1985. Trairi is a rural county 150 km east of Fortaleza, the capital of the state of Ceará (Fig. 1). The primary health facility in Trairi is a small hospital which was run by two auxiliary nurses at the time of the study. Surgery is not possible at Trairi, so serious problems require referral to larger hospitals outside the county. The data collection was described by Janowitz *et al.* (1988).

Besides obtaining information at the time of birth, all mothers and their infants were followed up on four occasions by hospital personnel or a TBA when the child reached 6 weeks, and 6, 12 and 18 months of age. The record forms (Fig. 2) were pictorial because not all TBAs are literate. Information was obtained on the survival of the mother and infant, infant's weight, feeding practices, and mother's contraceptive and pregnancy status. When an infant death occurred community

Fig. 1. Map of Brazil.

leaders and the TBAs notified hospital personnel; a physician then visited the mother and completed a questionnaire on the cause of death and treatment sought. Thus the time between the death and the physician's interview was usually much shorter than initially anticipated.

The probability of death, calculated directly from data for the specific cohort, describes the risk of dying for those children born between May 1984 and June 1985. Three dependent variables were used in this analysis—neonatal, post-neonatal, and infant mortality; that is, a child's risk of dying during the 1st month, between 1 and 12 months, and by 12 months of age. Each was separately analysed as a function of selected explanatory variables. All mortality variables had non-normal distributions and were constructed to be dichotomous. Continuous variables were treated as categorical variables because the data were collected as such or because it was required to identify high risk groups in a non-linear relationship. The relative importance of the independent variables was assessed using multivariate logistic regression techniques.

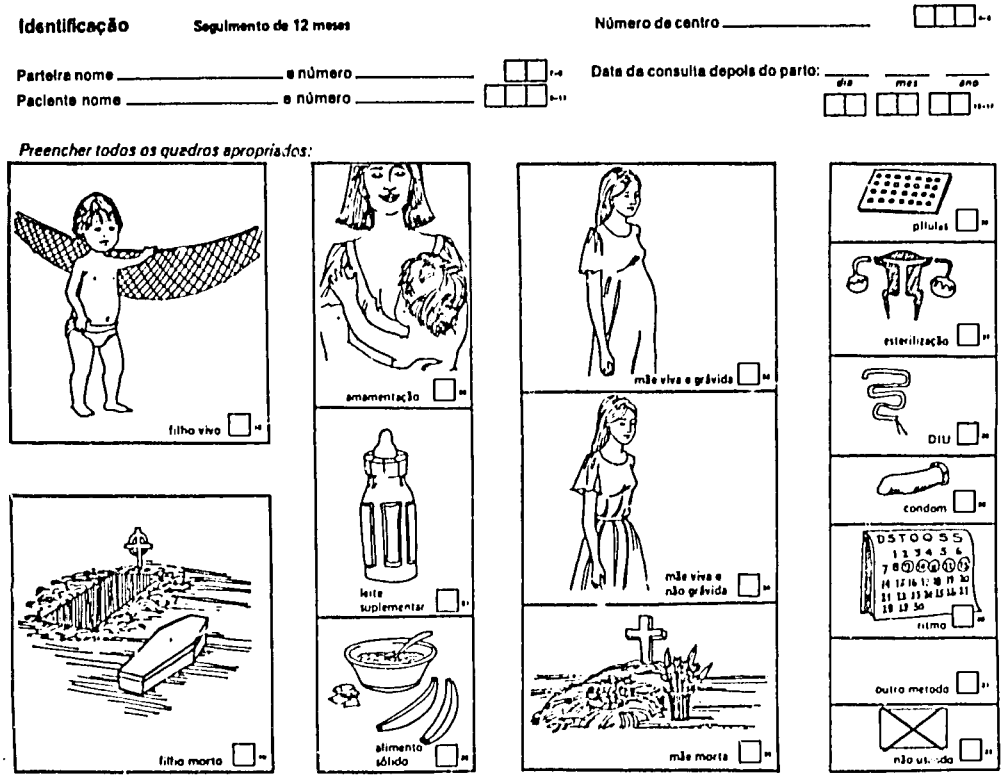

Fig. 2. Pictorial record form used in the study.

Only singleton births were examined, reducing the total number of births from 1677 to 1645, 1592 of which were live births. Thirty live births were excluded because both the 12- and the 18-month forms were missing. Most of these were children in families that had moved out of the county and could not be located. For the logistic regression, cases with missing information on the variables examined were excluded, reducing the sample to 1503 infants. In the post-neonatal mortality analysis, the total was reduced further to 1335 cases because of exclusion of 32 neonatal deaths and 136 infants for whom information on feeding at 6 weeks was incomplete.

In examining neonatal, post-neonatal, and infant mortality, the independent variables were: maternal age, number of previous live births, previous death of a child, educational level, number of prenatal visits, problems during pregnancy or delivery, place of birth/referral status, sex of infant, birthweight, and breast-feeding at 6 weeks.

First the main effects of the independent variables taken together were examined. Next was added a group of interaction terms involving low birthweight, maternal age, prenatal visits and place of birth/referral status. However, the additional variance explained by the interaction terms was significant only for post-neonatal mortality. For this the non-significant interaction terms were eliminated by backward stepwise regression while retaining the main effect terms. The final post-neonatal model contained the one interaction term that significantly increased the variance explained.

Results

Of the total of 1677 births, which included sixteen sets of twins (Table 1), there were 58 stillbirths and 39 neonatal deaths. About two-thirds of the neonatal deaths occurred during the first week of life. Neonatal deaths accounted for about a third of all deaths, contrasting with developed countries where neonatal deaths usually account for two-thirds of all infant deaths (United Nations, 1987). The Trairi rate of 24 per 1000 live births, however, is in keeping with neonatal mortality rates for other areas of the country, 28·2 in Riberão Preto 1968–70 (Puffer & Serrano, 1973) and 20·4 for Porto Alegre in 1980 (Guimarães & Fischmann, 1985). Excluding the 30 children for whom follow up was incomplete, the infant mortality rate was 65 per 1000 live births.

Table 2 shows the distribution of deliveries according to the characteristics of the mothers and infants, and the proportions deceased in each category during each period. About 7% of women were less than 18 years old and 15% were 35 years or over. Infants of the youngest mothers (< 18) were the most likely to die, especially in the post-neonatal period, suggesting poor child care skills.

For about 20% of women the delivery was their first, while for almost one-third it was their fifth or higher order birth. The proportion of infant deaths by parity is described by a J-shaped curve, lowest at parity two. Twenty per cent of mothers reported that a previous child had died; the proportion of infants that died among mothers with prior mortality experience was almost twice that among mothers who had never lost a child.

Women in Trairi have minimal formal education: the 13% who had more than a primary education (the equivalent of 4 years in Brazil) is lower than the national figure (about half of the women 15–44 years). The lack of variation in educational

Table 1. Outcome through year one by single and multiple birth status, Trairi, Brazil, 1984–85

Outcome	Singletons	All births
Deliveries	1 645	1 661
Births	1645	1677
Stillbirths	53	58
Deaths		
Days: 0–6	24	27
7–27	12	12
Months: 2–3	18	18
4–6	14	14
7–12	33	33
Cohort mortality rates*		
Neonatal	22·8	24·2
Post-neonatal	41·6	40·9
Infant	64·7	65·4

* Excluding 30 children lost to follow-up.

Table 2. Infant, neonatal and post-neonatal mortality for women with singleton deliveries by selected characteristics, Trairi, Brazil, 1984–85

Characteristics	No. of singleton deliveries	% deceased		
		Infant	Neonatal	Post-neonatal*
Total	1503	6·3	2·1	4·6
Maternal characteristics				
Age (years)				
<18	99	9·1	2·0	8·2
18–24	604	4·1	1·7	2·8
25–34	585	8·2	2·6	6·4
≥35	215	5·6	2·3	3·2
Previous live births				
0	287	4·5	1·7	3·3
1	255	3·9	2·0	2·1
2–4	497	6·8	1·6	5·8
≥5	464	8·0	3·0	5·4
Previous child died				
Yes	305	9·8	3·6	6·9
No	1198	5·3	1·8	4·0
Education (years)				
None	359	6·7	2·5	4·4
1–2	534	6·4	1·5	5·4
3–4	421	5·5	2·1	3·7
≥5	189	6·9	3·2	4·3
Prenatal care (visits)				
None	266	7·9	3·4	4·7
1–3	740	7·6	2·2	6·0
4–5	396	3·0	1·0	2·3
≥6	101	5·0	3·0	2·3
Problem during pregnancy				
Yes	78	10·3	7·9	3·1
No	1425	6·0	1·8	4·6
Problem during delivery				
Yes	168	8·9	4·8	4·5
No	1335	5·9	1·8	4·6
Place of birth and referral status				
Home	973	6·9	2·1	5·1
Hospital non-referral	412	4·6	2·2	3·2
Hospital referral	118	6·8	2·5	3·8
Infant characteristics				
Sex				
Male	766	6·5	2·2	4·7
Female	737	6·0	2·0	4·5
Birthweight (g)				
<2500	83	24·1	14·5	12·3
2500–4000	1312	4·9	1·4	3·8
>4000	108	9·3	1·9	8·3
Breast-feeding at 6 weeks				
Breast only	271			2·2
Breast and supplement or no breast	1064			5·2

* Excludes neonatal deaths and 136 infants with missing information for food at 6 weeks.

background may partially explain the absence of any observable relationship between it and infant mortality.

The small hospital in Trairi is the principal source of prenatal care, though one TBA and several health attendants who work from mini-posts (small primary health care centres) are also trained to provide prenatal services. There is no information on the content of care received or on the date of the first prenatal visit, so that the only measure of care is the number of visits. The proportion of infant deaths was highest among women with few or no prenatal visits. The higher proportion of infant deaths to women with six or more prenatal visits than to those with four to five visits is explained by the greater proportion of women in the former with problems during pregnancy, requiring more frequent prenatal visits.

Only 5% of women were reported to have had problems during pregnancy while 11% had problems during delivery. The most frequent problems during pregnancy were hypertension, haemorrhage, fatigue, nausea or dizziness. Problems at the time of delivery included malpresentation, prolonged or obstructed labour, premature rupture of the membranes or other delivery-related complications. Problems during pregnancy and delivery were often cited as the reason for referral to the hospital for delivery. Mothers who experienced problems during pregnancy were more likely to lose a child in the neonatal period but not in the post-neonatal period. Similarly, an increased neonatal but not an increased post-neonatal risk was also evident for women with problems during delivery.

Almost two-thirds of the women gave birth at home. While most of these were attended by a TBA, some were attended only by a family member or neighbour, or were unattended. Most of the 8% who were referred to a hospital were referred by TBAs, and a small proportion of these women were referred further by the Trairi hospital staff to the Teaching Maternity Assis Chateaubriand in Fortaleza where surgery is available. One of the original objectives of the study was to enquire whether TBAs correctly identified women at high obstetric risk and made the appropriate referrals to a hospital for delivery (reported by Janowitz *et al.*, 1988). A greater proportion of infants born at home or whose mothers were referred died than did those born in hospitals. Differences were greater in the post-neonatal period than in the neonatal period.

There was no significant difference in the proportion of deaths according to sex of the infant, the slightly larger proportion of male deaths conforming with the findings of most studies.

Low birthweight, less than 2500 g, may be the single most powerful predictor of infant mortality, especially neonatal mortality, because of increased risk of cerebral palsy, its relation to physiological immaturity, and permanent growth deficiencies (Kramer, 1987). Maternal and fetal factors directly influence birthweight, which in turn influences survival through growth and development. In the present sample only 83 infants (5·5%) weighed less than 2500 g. This proportion is low compared with hospital births in Guatemala City (11–17%) (Kestler *et al.*, 1987) or New York City (7–19%) (Gortmaker, 1979). A study carried out in the same region as Trairi showed that only 5% of the infants attended at birth by TBAs in semi-urban obstetric units were of low birthweight (Araujo *et al.*, 1983). Barros *et al.* (1984) found that the proportion of low birthweight infants in Pelotas, Rio Grande do Sul, was 8%. Since

the scales used by TBAs were not calibrated during the study nor were weighing procedures standardized, the relatively small percentage of infants weighing less than 2500 g at birth may be attributable to poor measurement techniques. In the present study, almost a quarter of the low birthweight infants died: 14% in the neonatal period (most of whom were premature) and 12% in the post-neonatal period.

Mean duration of breast-feeding in much of north-east Brazil is short, considering the poor socioeconomic conditions; however, it may help to explain the relatively high levels of fertility and mortality. North-east Brazilian state surveys carried out in 1980 show that in states neighbouring Ceará, the mean duration of breast-feeding was only 5 months (Anderson, Rodriques & Thomé, 1983). According to the 1986 Demographic and Health survey, the North-eastern region as a whole has the lowest average duration (7·5 months) of all regions in Brazil (Arruda *et al.*, 1987).

The introduction of other milks and foods takes place early in Trairi. By 6 weeks, 80% of infants have received foods other than breast-milk, placing the infants at increased risk of infection as well as curtailing the mother's period of post-partum amenorrhoea. Only 2% of infants exclusively breast-fed at 6 weeks died, compared with 5% of those who received supplementary foods.

Logistic regression results

Table 3 shows the odds ratios and their confidence intervals based on the logistic coefficients and their standard errors in the three logistic regressions. The adjusted odds ratios show the independent effect of each variable net of the effects of the other variables.

Infant mortality is significantly associated only with few prenatal visits (infants of mothers with little antenatal attention are more than twice as likely to die as are infants whose mothers made four or five visits) and especially with low birthweight (< 2500 g). Babies of low birthweight are six times as likely to die as infants in the middle birthweight range.

Two variables are significantly associated with neonatal mortality. Problems during pregnancy increase the probability of dying during the first month by a factor of five, and a low birthweight (< 2500 g) baby is thirteen times as likely to die as babies of normal weight.

The factors associated with post-neonatal mortality differ from those associated with neonatal mortality. They are less related to conditions during pregnancy or at delivery. Infants of the oldest mothers (> 35) and of mothers of low parity are much less likely to die before the age of 1 year, while babies heavy at birth (> 4000 g) are more than twice as likely to do so.

In view of these results, a further investigation was made of the number of prenatal visits and birthweight and their potential interactive effect on post-neonatal mortality. For low birthweight babies the risk of post-neonatal mortality associated with one to three prenatal visits was significantly increased over that where the mothers had four or more visits. Low birthweight infants whose mothers had one to three prenatal visits were fourteen times more likely to die during the post-neonatal period than those whose mothers had four to five visits and weighed 2500–4999 g. Odds of post-neonatal death were also significantly increased for normal birthweight babies whose mothers had one to three prenatal visits and for almost all babies

Table 3. Odds ratios from logistic regression of infant, neonatal and post-neonatal mortality for women with singleton deliveries by selected characteristics, Trairi, Brazil, 1984–85

Characteristic	Infant		Neonatal		Post-neonatal	
	OR	90% CI	OR	90% CI	OR	90% CI
Maternal characteristics						
Age (years)						
<18	2·1	0·9–5·0	0·8	0·2–3·7	3·6	1·2–10·5
18–24	0·7	0·4–1·1	0·8	0·3–1·9	0·6	0·3–1·2
25–34	1·0		1·0		1·0	
≥35	0·5	0·3–0·9	0·6	0·2–1·5	0·3*	0·2–0·8
Previous live births						
0	0·6	0·3–1·2	1·5	0·5–4·8	0·4	0·1–1·0
1	0·5	0·3–1·0	1·1	0·4–3·2	0·3*	0·1–0·8
2–4	1·0		1·0		1·0	
≥5	1·1	0·6–1·8	1·8	0·7–4·4	1·0	0·5–1·7
Previous child died						
Yes	1·6	1·1–2·6	2·0	0·9–4·1	1·4	0·8–2·5
No	1·0		1·0		1·0	
Education (years)						
None	0·8	0·4–1·3	0·6	0·2–1·5	0·9	0·5–1·8
1–2	0·9	0·5–1·4	0·4	0·2–1·1	1·2	0·6–2·1
3–4	1·0		1·0		1·0	
≥5	1·6	0·9–3·0	1·6	0·6–4·3	1·7	0·7–3·8
Prenatal care (visits)						
None	2·3	1·2–4·4	3·0	1·0–9·0	1·9	0·8–4·3
1–3	2·5*	1·4–4·4	2·3	0·9–6·0	2·1	0·1–4·2
4–5	1·0		1·0		1·0	
≥6	1·5	0·6–3·8	2·2	0·6–8·5	1·0	0·2–3·7
Problem during pregnancy						
Yes	1·8	0·9–3·6	5·1*	2·0–13·0	0·8	0·2–2·7
No	1·0		1·0		1·0	
Problem during delivery						
Yes	1·6	0·9–2·9	1·8	0·7–4·7	1·1	0·4–2·6
No	1·0		1·0		1·0	
Place of birth and referral status						
Home	1·7	1·0–2·8	1·2	0·5–2·8	1·2	0·6–2·5
Hospital non-referral	1·0		1·0		1·0	
Hospital referral	1·1	0·5–2·4	0·3	0·1–1·4	1·0	0·3–3·1
Infant characteristics						
Sex						
Male	1·2	0·8–1·7	1·1	0·6–2·1	1·1	0·7–1·8
Female	1·0		1·0		1·0	
Birthweight (g)						
<2500	6·1*	3·6–10·2	13·4*	6·4–28·0	0·8	0·1–4·5
2500–4000	1·0		1·0		1·0	
>4000	2·0	1·1–3·6	1·2	0·3–4·3	2·4*	1·2–5·0
Birthweight* prenatal care					8·5	1·2–58·5
Breast-feeding at 6 weeks						
Breast only					1·0	
Breast and supplement or no breast					2·2	1·0–4·7

* Significant at $P < 0·05$.

heavier than 4000 g with fewer than six visits. It is not clear why these large infants are at greater risk during the post-neonatal period than the neonatal period, but possible factors include birth injuries, or the effects of diabetes.

Because of the importance of exclusive breast-feeding in reducing mortality risk, a separate analysis was made to determine the factors associated with early supplementation (Table 4). Mothers who made no prenatal visits are more than three times as likely, and mothers with one to three visits are 1·7 times as likely, to introduce other foods by 6 weeks as women who make four to five visits. Surprisingly, mothers who give birth at home are more than four times as likely to give supplements by 6 weeks as non-referred women who give birth in hospitals. But women referred to the hospital for delivery, are only twice as likely to introduce food other than breast-milk by 6 weeks. These results suggest that efforts of the staff at the Trairi hospital to encourage exclusive breast-feeding both during prenatal visits and during delivery have had a positive effect.

Table 4. Odds ratios of supplementation at 6 weeks for neonatal survivors among women with singleton deliveries by selected characteristics, Trairi, Brazil, 1984–85

Characteristic	Odds ratio	90% CI
Age		
<18	1·0	0·6–1·7
18–24	1·4	1·0–1·9
25–34	1·0	
≤35	1·0	0·6–1·5
Previous live births		
0	0·9	0·6–1·3
1	1·0	0·7–1·6
2–4	1·0	
≥5	1·0	0·7–1·4
Prenatal care (visits)		
None	3·4*	2·1–5·4
1–3	1·7*	1·3–2·2
4–5	1·0	
≥6	0·9	0·6–1·4
Place of birth and referral status		
Home	4·3*	3·3–5·6
Hospital non-referral	1·0	
Hospital referral	2·2*	1·4–3·3
Education (years)		
None	1·5	1·0–2·2
1–2	1·2	0·9–1·6
3–4	0·6*	0·4–0·8
≥5	1·0	

* Significant at $P < 0·05$.

Causes of death, treatment and risk factors

About a third of infant deaths were neonatal (Table 1), and about a third of these deaths were attributable to birth-related causes, most of which occurred in the first month. This group included causes such as prematurity, congenital defects, fetal distress, complications from surgery, a case of pulmonary haemorrhage and umbilical infection (not identified as tetanus). The high proportion of infant deaths that occurred in the post-neonatal period suggests that environmental factors play a major role in determining the principal causes of death. The principal causes of death in this period were diarrhoeal diseases, malnutrition, and respiratory infections (the last two included in 'other causes' in Table 5), all strongly influenced by exogenous factors.

Unfortunately, data on morbidity for the surviving infants were not collected and the true association between maternal behaviour regarding medical treatment or known risk factors and their effect on survival cannot be examined.

About 71% of mothers whose children died of diarrhoeal disease or of other causes sought medical attention (Table 5). It was not surprising that so few infants who died of birth-related reasons were taken for treatment, since many of them died shortly after birth or of maladies which were difficult to treat. More than half of the mothers whose children died of diarrhoea sought attention at the Trairi hospital. Traditional faith healers were a second important source. Mothers whose children died from other causes were equally likely to seek care from faith healers or at the Trairi hospital.

An apparently larger proportion of infants dying of diarrhoea were treated (85%) than of children dying from other causes (70%), but this difference is not statistically significant (Table 5). The three most frequent treatments for diarrhoea were antidiarrhoeics (41%), home remedies (generally teas) (18%), and antibiotics (15%). Treatments given to infants dying of other causes included home remedies (36%), antispasmodics/antiemetics (23%) and antibiotics (14%).

Antibiotics are often used indiscriminately to treat diarrhoea (DeClerque *et al.*, 1988, unpublished). Although they are readily available in Trairi pharmacies, the

Table 5. Causes of infant mortality and percentages of infants whose mothers sought medical attention and received treatment, Trairi, Brazil 1984–85

Cause of death	Total	% sought attention	% received treatment
Diarrhoeal diseases	34 (34)	71 (34)	85 (34)
Birth-related	30 (30)	34 (29)	45 (29)
Other causes*	37 (37)	70 (37)	70 (37)
Total	100 (101)	60 (100)	68 (100)

Absolute numbers are in parentheses.

* Includes: malnutrition (11), respiratory infections (8), vaccine preventable deaths (6), other infectious diseases (6), accidents (1), and unknown causes (4).

mothers of infants who died appeared not to use them. Nor did it appear that the Trairi hospital staff liberally dispensed them. Fully two-thirds of the children who died of diarrhoea were rehydrated: 44% with oral rehydration therapy and 24% with both oral rehydration therapy and intravenous fluids. Many mothers of deceased infants sought what appea.s to be appropriate care.

Mothers whose children died were asked about the home's water and sanitary facilities, food preparation and feeding practices. Sources of water and toilet facilities were classified as more or less risky in relation to faecal contamination, but cause of death did not vary according to these categories. Cause of death did vary, however, with the conditions under which food was prepared: children whose mothers boiled water less consistently, or gave milks classified as risky (dried milks rather than breast-milk or cow's milk), or either never breast-fed or introduced supplementary milks during the first week of life, were more likely to die of diarrhoeal diseases than of other causes.

Discussion

As regards data quality, since the data used in this study were collected prospectively, there is little likelihood of misreported dates, since a shorter memory span and independent recording were involved. But some births may have been missed, especially those attended by neighbours, relatives, or TBAs who did few deliveries. Community reporting was good: 89% of the mothers were interviewed 18 months after delivery, and virtually all of those not interviewed had moved out of the county. Finally, assuming an annual growth rate of 3% since 1980, when the county's population was 31,098, and a crude birth rate of 40 50 per 1000 (Goldberg, 1983, unpublished), 1400 1750 deliveries were expected during the year of the study. Information was obtained on 1577 births to 1661 mothers, giving a crude birth rate of 48. Since the birth rate is within and at the upper end of the anticipated range, it is concluded that the number of deliveries missed is probably small.

Because infant mortality is a relatively rare event, the number of cases (numerator) is often small. Childhood epidemics are not uncommon in less developed areas and can cause sharp fluctuations in an estimate based on births and deaths of only one year. At the time of this study, however, there was no evidence of recent epidemics occurring in Trairi.

Levels of infant mortality in Trairi are lower than most other estimates for the north-east that cover larger geographic areas. These differences may be attributed to study design, or to different techniques used to calculate mortality, or they may be explained by lower mortality in Trairi than in the north-east in general. Its location on the coast provides ready access to fish protein and dependable rainfall for subsistence farming, which may result in a relatively high nutritional status of its population. This relatively good nutrition may be reflected in the low proportion of low birthweight babies.

The survey relates to a homogeneous population. It is not surprising, therefore, that some expected associations are weak. Education, for example, was not a significant factor, probably because overall levels of schooling in Trairi are uniformly low.

Other studies show that the distributions of mortality by age and parity generally

manifest a J- or U-shaped curve, but this was not always the case for Trairi infants, the categories used being perhaps too numerous. Age showed a reverse J-shaped relationship with infant and post-neonatal mortality but not for neonatal mortality. The effect of young maternal age during the post-neonatal period may be explained by the mothers' lack of experience or knowledge in caring for and treating their infants. The odds ratios for parity suggest the expected J-shaped pattern, but it was not significant.

As expected, the determinants of neonatal, post-neonatal and infant death differ. One might expect that events during pregnancy and at delivery would be more important in the neonatal than in the post-neonatal period and, in general, this is found, the factors significantly associated with neonatal death being pregnancy complications or problems, little or no prenatal care, and low birthweight. Place of delivery did not have an independent effect on neonatal survival, although earlier analyses, which included stillbirths, had shown that hospital referrals had much higher perinatal death rates than did home births, while hospital births which were not referrals exhibited rates similar to those of home births (Janowitz *et al.*, 1987, unpublished). In fact, in the earlier study, the effect of hospital referral appeared to be protective although not significant. The results of the current study indicate a similar finding: by controlling for problems during pregnancy and delivery, referral to a hospital increased the neonate's chances of survival. However, this protective effect disappears in the post-neonatal period. Over and above the effect that problems during pregnancy may have had on low birthweight, and consequently on neonatal survival, the mother's problems during pregnancy still had a direct effect on neonatal but not on post-neonatal survival.

Pregnancy complications and low birthweight may be operating in two ways: first, as indicators of maternal risk factors (e.g. poor maternal nutrition, infection), and secondly, as independent determinants of neonatal mortality, since a low birthweight baby, or one born to a mother whose own health has been compromised, has fewer reserves with which to confront extrauterine hazards. Providing adequate prenatal services may reduce the number of low birthweight infants and pregnancy complications. Early identification of pregnant women who fail to gain sufficient weight during pregnancy or have other problems could result in the referral of these high risk patients to Trairi for closer supervision and treatment. Prenatal services are known to improve pregnancy outcomes by lowering the incidence of low birthweight babies and reducing premature births.

This study provides empirical evidence for the important role of prenatal care during the post-neonatal period as well. The introduction of supplementary feeding by 6 weeks increased the risk of mortality which in turn was significantly associated with contact with hospital personnel both during prenatal care and during hospitalization for delivery.

There are several child survival activities that Trairi health care personnel can actively promote, or train TBAs to promote. First, TBAs could be instrumental in encouraging breast-feeding, with exclusive breast-feeding for the first 4–6 months. More TBAs need to be trained to provide prenatal care, and for those few who provide it, skills could be upgraded.

Besides promoting exclusive breast-feeding, simple interventions can prevent

death from dehydration due to diarrhoea episodes, a principal cause of post-neonatal deaths. Trairi health care providers should encourage the use of oral rehydration therapy. Most mothers whose children died sought treatment. However, the large proportion of infants who died despite rehydration suggests that treatment came too late. Attention may need to be focused on encouraging mothers to seek treatment earlier. Local faith healers, mentioned in this study as an important source of attention for mothers whose infants suffered from diarrhoea, have been instrumental in areas neighbouring Trairi in the promotion and use of oral rehydration therapy (Nations *et al.*, 1988). Their assistance in Trairi is a viable option.

Health care personnel could promote the use of a simple risk index to evaluate whether a pregnant woman requires services in an institutional setting or educational counselling in infant care. This study suggests that items for inclusion which would not require medical personnel to recognize, would be maternal age, loss of a previous child, poor weight gain, or problems during pregnancy.

The TBA network may have had an indirect effect on mortality. Although the TBAs do not routinely provide health care to infants beyond the perinatal period, their interactions with mothers may have helped to reduce infant mortality. They give advice to mothers concerning the seeking of treatment, an effect that may have been magnified during this study which called for more frequent contact with mothers because of the need to collect follow-up data.

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