Does ORT reduce diarrhoeal mortality?

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Trends in infant and child mortality from all diarrhoea-related causes and from acute watery diarrhoea
were examined in a rural community in Bangladesh, during the three years preceding and the 10 years
following the introduction of an oral rehydration therapy (ORT) programme. A significant increase in in-
fant mortality due to acute watery diarrhoea was observed throughout the study period. Child mortality
due to acute watery diarrhoea did not decrease during this period. The programme ensured universal
knowledge of the oral rehydration solution and the availability of glucose-electrolyte sachets in every
household. Yet the inadequate formulation of messages concerning the role of oral rehydration may have
caused its incorrect use – oral solutions being administered to too few infants, in too small quantities, and
for too short periods. The decline in infant mortality from other causes may also explain the increased con-
tribution of diarrhoea as a cause of death through a replacement effect.

The findings suggest that efforts should be continued to ensure appropriate formulation of messages pro-
moting ORT for its correct use. ORT should also be viewed as one component among others in diarrhoeal
diseases control programmes if diarrhoea mortality is to be reduced.

Introduction

Diarrhoea, a major cause of mortality of
children aged under five in the developing world,
is estimated to cause the death of five million
children annually.[1,2] As part of a selective
primary health care strategy to reduce diarrhoea-
related mortality, international health organiza-
tions have promoted oral rehydration therapy
(ORT) programmes.[3,4] These programmes are
based on the assumption that as much as half of
these deaths could be averted if dehydration was
prevented or treated.[5-7] Few studies, however,
have examined the impact of ORT on infant and
child mortality in the community. Those that
have been conducted have given inconsistent
results, owing either to differences in design or to
differences in location.[8-12] Adequately controlled
studies to measure this impact are indeed dif-
ficult to justify, as ORT is known to be effective
in the treatment of dehydration due to an acute
watery diarrhoea.[13-15]

The International Centre for Diarrhoeal Disease
Research, Bangladesh (ICDDR, B – formerly the
Cholera Research Laboratory), was one of the
first institutions to implement a community-
based ORT programme in its Matlab field station
in 1979.[16-18] A demographic surveillance system
in this community combined the registration and
assessment of causes of death. Data accumulated
by this surveillance method provide a unique
opportunity to study the changes in diarrhoea
mortality in the community, before and after the
implementation of an ORT programme. In this
study, we examine trends in overall diarrhoea
mortality and in acute watery diarrhoea mor-
tality among infants and children in Matlab from
1976–1988. Trends among infants and children
were examined separately because in rural
Bangladesh the proportion of diarrhoea deaths
associated with watery diarrhoea is higher in in-
fants than in older children.[19] Biological reasons,
namely a rapid body water turnover, a high body

water content and a relatively large body surface increase the risk of a dehydration in infants compared to children.

Subjects and methods

Study area

The Matlab study area, with a total population of about 196000 in 1986, lies in the Ganges-Meghna delta, 45 km southeast of Dhaka, the capital of Bangladesh. It is an area that becomes flooded regularly, and which has a poor communications network, a low literacy rate, a high population density, and high rates of fertility and mortality. Subsistence farming, wage labour and fishing are the main occupations. Every family has easy access to abundant surface water for domestic purposes. Due to sociocultural constraints, women usually remain in their compound and do not go out to seek medical care for themselves or their children.

The demographic surveillance system operating since 1966 includes the registration of births, deaths, migrations and marriages through fortnightly home visits by 110 female community health workers.[20] In 1978, a family planning and health services programme was introduced in half of the area, comprising 79 villages, called the MCH-FP area.[21] The other half, comprising 70 villages, served by the government health programme, is referred to as the comparison area. In addition to community-based health services, the ICDDR,B also maintains a diarrhoea treatment centre in Matlab Bazaar, which serves both the study areas and the neighbouring community. All health services are provided free of charge.

Assessment of the cause of death

For all reported deaths, a health assistant interviewed parents and relatives within one month of death and recorded a detailed history of events and symptoms preceding death. Until 1985, the health assistants themselves determined the cause of death and coded it according to a symptom-based classification. Since 1986, the information has been reviewed by a trained medical assistant. Details of the multiple-stage procedure to assess cause of death are described elsewhere.[22] A death was attributed to diarrhoea when there was a predominant history of frequent stools – either watery, mucoid, or bloody – during the days or weeks preceding death. A death was attributed to acute watery diarrhoea when there was a predominant history of liquid stools, made mostly of water with very little faecal matter and no blood, in the week preceding death. Signs of dehydration were not necessary for inclusion in this latter category.

The Matlab ORT programme

Oral rehydration was studied clinically as early as 1968 in the Matlab diarrhoea treatment centre.[23,24] In 1978 and 1979, two ORT programmes were implemented in the community, comparing distribution of glucose and oral rehydration salts sachets (G-ORS) and promotion of home-prepared solution made of locally available salt and molasses in the other half. The objectives were to compare feasibility and safety of these two approaches, but not mortality impact.[16,17] From January 1981, G-ORS sachet distribution was extended to the whole Matlab study area: in the comparison area, 30 community health workers motivated the community, educated the mothers, provided G-ORS sachets to the homes during their visits, and referred severe cases to the hospital. In the MCH-FP area, 80 community health workers performed the same tasks, assisted by a group of 1500 female village volunteers who acted as depot-holders of G-ORS in each cluster of households and motivated mothers to feed rehydration solution in case of diarrhoea.[18] All G-ORS sachets distributed in this programme were manufactured locally. During 1985 and 1986, a nationwide campaign promoting the use of homemade ORT solutions was conducted in the Matlab area. This campaign, led by a non-governmental health organization called Bangladesh Rural Advancement Committee (BRAC), combined the efforts of teams of ORT motivators visiting each village with radio broadcasts.[25,26]

Programme monitoring

The numbers of G-ORS sachets distributed were continuously monitored from the entries in field workers' record books. Since 1986, in the MCH-FP area, the number of sachets actually consumed by a child during a diarrhoea episode has also been recorded. Random samples of reconstituted rehydration solution were regularly taken from the field for laboratory analysis of electrolyte concentration.

The numbers of deaths and their causes and mid-year populations by age were provided by the annual reports of the demographic surveillance system.[27] During the 13-year period under study, there were on average 3900 and 3300 live births per year in the comparison and MCH–FP areas respectively. Mid-year populations of children aged one to four years were on average 11 900 and 11 100 in the comparison and MCH–FP areas respectively.

The numbers of patients admitted to the Matlab diarrhoea treatment centre since 1977, together with the type of diarrhoea and enteric pathogens isolated, were continuously recorded. In 1988, 187 mothers in the MCH–FP area and 169 mothers in the comparison area were interviewed about the source of their knowledge of ORT, their understanding of its effects, and the type of treatment received by their children during the last episode of diarrhoea.

Results

Between 1978 and 1988, infant mortality declined in both the MCH–FP and comparison areas, although the decline started earlier in the MCH–FP area (Figure 1). There was, however, a consistent and significant increase in overall diarrhoea mortality among infants in both areas, from three to 13 per 1000 live births (Figure 2, Chi-square for trend: 57; p<0.001). Mortality from acute watery diarrhoea also increased significantly in both areas, from one to seven per 1000 live births (Figure 2, Chi-square for trend: 36; (p<0.001) in MCH–FP area and 24; (p<0.001) in comparison area).

Trends in child mortality from all causes and from diarrhoea-related causes, shown in Figures 1 and 3, are not as straightforward as trends among infants. In both the MCH–FP and comparison areas, they remained at similar levels until 1982, experienced a sharp increase in 1983 and 1984, and declined from 1985 to 1988. Mortality attributed to all types of diarrhoea averaged seven per 1000 children aged one to four years from 1977 to 1982 (Figure 3), reached twice this rate in 1984, and declined to four per 1000 in 1988. The 1983-84 peak, observed in both areas, was caused by an epidemic wave of *Shigella dysenteriae* type I. Mortality attributed to acute watery diarrhoea remained low and relatively
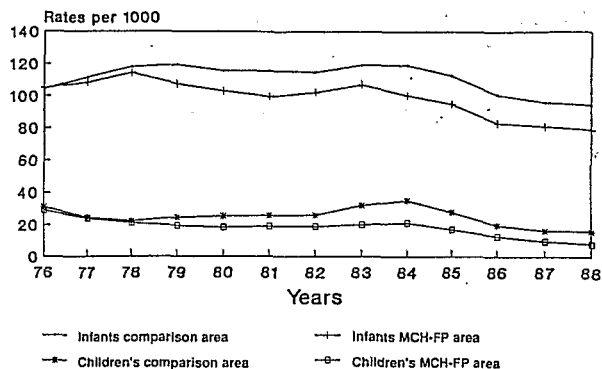

Figure 1. Infant and child mortality from all causes, Matlab MCH-FP and comparison areas, 1976-88
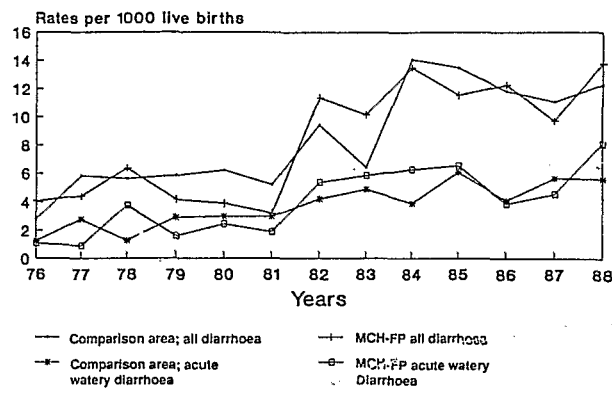

Figure 2. Infant mortality from diarrhoeal causes, Matlab MCH-FP and comparison areas, 1976-88
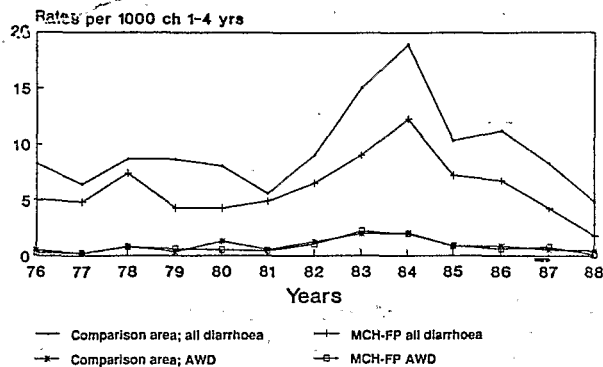

Figure 3. Child mortality from diarrhoeal causes, Matlab MCH-FP and comparison areas, 1976-88

constant at one per 1000 children. A transient rise at two per 1000 was also observed during 1983-84.

Trends in hospital admissions for acute watery diarrhoea (Figure 4) show significant declines for both infants and children. Trends in the

proportions of infant mortality attributed to acute watery diarrhoea (Figure 5) show significantly increasing proportions in the MCH–FP area (Chi-square for linear trend = 17.3; p<0.001) and, to a lesser extent, in the comparison area (Chi-square for linear trend = 7.2; p<0.01).

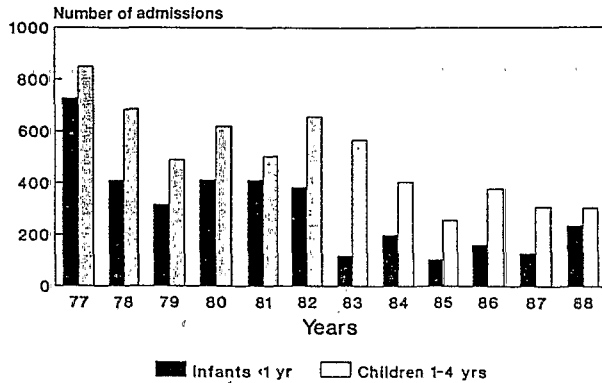**Figure 4.** Admissions for acute watery diarrhoea, Matlab Diarrhoea Treatment Centre, 1977–88
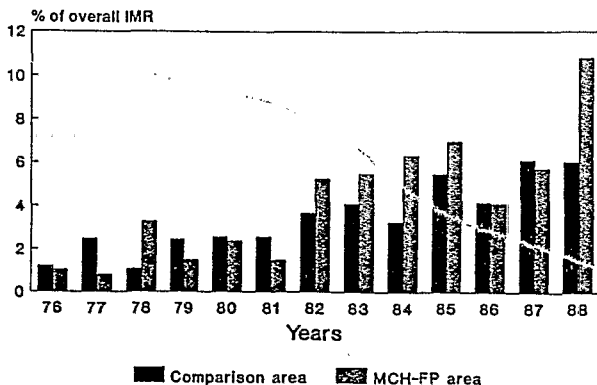

Figure 5. Percent of infant mortality due to acute watery diarrhoea, Matlab MCH–FP and comparison areas, 1976–88

In 1988, 92% of interviewed mothers in both the MCH–FP and comparison areas were aware of the benefits of using G-ORS sachets or homemade ORT solutions. Of these mothers, however, 78% in the MCH–FP area and 85% in the comparison area thought that oral rehydration should stop diarrhoea. Seventy-eight percent of mothers in the MCH–FP area and 57% in the comparison area had used G-ORS sachets the last time their child had diarrhoea. Of the village mothers responsible for G-ORS sachet distribution in the MCH–FP area, 58% had a provision of sachets in their homes on the day of visit.

Findings from the ORT programme monitoring in the MCH–FP area in 1986–87 indicate that, out of a representative sample of 355 severe acute watery diarrhoea episodes in infants, the mean number of G-ORS sachets consumed during the first two days of illness corresponded to 400 ml of rehydration solution.

Discussion

Our findings suggest that in Matlab, the promotion of ORT and home distribution of G-ORS sachets in the community did not reduce infant and child deaths from acute watery diarrhoea. Indeed, an increase in infant deaths was observed. Since this study examines trends over a long period, it is conceivable that the observed absence of impact might be the result of changes in the assessment of deaths and causes of death in the Matlab demographic surveillance system. With few exceptions, the same community health workers and the same health assistants have reported deaths in the same areas, according to the same procedures, from 1976 until 1988. Supervision and management of the demographic surveillance system have not changed, and biases in reporting diarrhoea-related deaths, if any, would rather be expected in the direction of underreporting, given the focus on control of diarrhoeal diseases in Matlab. The only change was the addition of a medical input into the assessment of cause of death from 1986. This change, however, did not seem to have affected the trends in mortality from diarrhoea, which started to increase long before. Interpretations other than reporting biases should be examined to explain these findings. They have been grouped in four categories:

Biological factors

Clinical efficacy of ORT has been demonstrated in many controlled studies conducted in diarrhoea treatment centres[13,14,28] and during cholera outbreaks.[15,23] Properly balanced oral rehydration solutions prevent and treat dehydration caused by diarrhoea. Adverse effects of ORT due to inappropriate concentrations of electrolytes are unlikely to explain our findings: none of the random checks applied in the programme monitoring has ever evidenced dangerous concentrations of sodium chloride or potassium in the reconstituted solutions. On the contrary, it was reported in Matlab that ORT had a protective

effect against hyponatraemia, and did not increase the risk of hypernatraemia.[16]

Rehydrated infants could have been secondarily infected due to the use of unsafe water to prepare rehydration solutions. This hypothesis may particularly concern fully breastfed infants who would then be suddenly and massively exposed to contaminated water. In the Matlab area, however, 70% of all households have access to safe drinking water and this proportion has increased during the study period.

Deaths attributed to acute watery diarrhoea may actually have been caused by complications other than dehydration, not preventable by ORT. Determining the presence of dehydration and its contribution as a cause of death is difficult, given the fact that most deaths take place in homes. Hypoglycaemia,[29,30] hypokaliemia,[31] and septicaemia[32] may frequently also be involved.

Programmatic factors

After the intensive initial ORT education campaign launched by the ICDDR,B sustained by the repeated visits from community health workers and resident village volunteers, the community was reached by a national mass education campaign, focusing on the benefits of both G–ORS sachets and homemade solutions.[25,26] The 1988 survey confirmed that nearly all mothers were aware of ORT. Lack of information about ORT is therefore unlikely to explain our findings. Information regarding the role of ORT in diarrhoea, however, was wrongly perceived by a majority of mothers, who believed that ORT should stop diarrhoea. Educational messages may have been inappropriately designed, or rather, their effect may have been insufficiently checked, particularly with regard to cultural perceptions.[26,33]

Availability of ingredients for preparation of the homemade rehydration solution does not seem to be a problem in the Matlab area, although the increasing price of sugar and molasses is a concern. All the community health workers always carry G–ORS sachets with them during their home visits, and permanent residents of their assigned village can be contacted easily in case of need. Yet, at the time of the survey, eight years after the initial training, over 40% of the village volunteers surveyed in their homes in the MCH-

FP area did not have stocks of G–ORS sachets, suggesting an erosion of the demand for this type of service, or from the programme itself.

Behavioural factors

Although 68% of interviewed mothers (a combined average) claimed they had used rehydration solution made from G–ORS sachets the last time their child had had watery diarrhoea, the quantity used (400 ml on average) would in most cases have been insufficient to effectively treat infants with severe dehydration or high purging rates. A dehydrated infant would typically need at least 1000 ml in the first two days. This low consumption may be partially due to a low demand from the infants themselves, unable to express thirst. Alternatively, or additionally, the intensive labour and time necessary to coax a sick infant into drinking a bad-tasting solution, together with the absence of an immediate reduction in stool volume, may discourage many mothers soon after their first rehydration attempts.[34,35] The discrepancy between the perceived role of ORT (believed by many mothers to stop diarrhoea), and mothers' experiences may have contributed to their being discouraged.[26,36]

Despite recommendations that ORT should be used in any type of diarrhoea, it is likely that many people restrict its use to certain types of diarrhoea only. People, and communities, categorize diarrhoea according to their own perceptions, and these perceptions may be very different from those of health professionals', and this categorization influences the choice of therapy. An in-depth study of village perceptions of infantile diarrhoea in the vicinity of Matlab revealed that, out of four types of diarrhoeal diseases recognized by rural people, only one was believed to be eligible for oral therapy, the others being seen as the domain of traditional practices.[26]

It is also possible that promotion of home-based therapy had an unexpected and untoward effect on diarrhoea-related mortality, through less reliance on hospitals and increased delays before taking severely-ill children to the hospital. The decreasing trends in admission to the Matlab diarrhoea hospital for acute watery diarrhoea (Figure 4) seem to support this hypothesis; and this possibility had already been highlighted before the start of the programme.[37]

Epidemiological factors

The emergence, or recent increase, of new aetiologic agents that kill by mechanisms other than dehydration could also explain our findings. Shigellosis has been shown to be of growing importance in Matlab,[38,39] and frequently to produce a watery diarrhoea at onset.[40,41] During the epidemic of *Shigella dysenteriae* type I in 1983-4, both dysentery and watery diarrhoea-related mortality increased, as shown by the transient peak in acute watery diarrhoea deaths observed among children in 1983-4 (Figure 3). If patients die from complications of shigellosis before the onset of dysentery, the death may be classified as watery diarrhoea-related. Such deaths are unlikely to be prevented by ORT alone.

Population increased in Matlab over the study period and it may be that some diarrhoea pathogens, particularly viruses, produced more severe infections with increasing overcrowding, as shown elsewhere for measles.[42]

Malnourished children are known to be at increased risk of death during diarrhoea, and a deterioration of the nutritional status of children could account for the increase in diarrhoea mortality during the period of this study.[43,44] Preliminary analysis of longitudinal nutrition studies in Matlab, however, does not seem to reveal such a deterioration (Briend, personal observations).

A recent review of mortality patterns in 100 developing countries showed that the proportion of infant deaths attributable to diarrhoea is highest in countries with the lowest infant mortality rates.[45] Our findings may be explained in these terms: diarrhoea may have become one of the predominant 'replacing' diseases as infant mortality from other causes declined in Matlab.[46] That this may be the case is suggested by the trends in infant mortality and the proportions attributed to acute watery diarrhoea in the MCH-FP and comparison areas (Figures 1 and 5). Indeed, the trend is sharper in the MCH-FP area, with an infant mortality rate of 80 per 1000 live births in 1988, whereas in the comparison area, the infant mortality rate is 100 per 1000 live births. The causes of infant mortality that have declined over the period covered by this study include neonatal tetanus, pneumonia, pertussis, measles, and some neonatal infections.

Conclusions

There is not enough evidence to help decide which of these different factors best explains the apparent lack of effect of ORT on water diarrhoea mortality in Matlab. Undoubtedly, the small amounts of oral rehydration solution used, the early discontinuation of oral rehydration, delays in referring severely ill children and death from complications other than dehydration are all factors at play. The relative increase in diarrhoea deaths among infants fits with the hypothesis of diarrhoea being a major 'replacing' cause of death. It remains to be seen if these diarrhoea deaths are evenly distributed in the community, and if not, in what types of families they are concentrated.

The findings in Matlab raise questions about the potential impact of other ORT programmes in Bangladesh, based on a similar model but perhaps implemented with less supervision. Knowing the factors limiting the impact of the Matlab ORT programme are important for these other programmes. It is also important to continue efforts to formulate more appropriate educational messages, and to test the impact of these messages on the utilization of ORT.

Our findings also suggest that the impact on mortality of single (or 'selective') technology-based interventions may be less effective than anticipated. ORT should be viewed as one component of diarrhoeal disease control programmes, together with other preventive and curative components.[47] A balanced combination of ORT and other interventions may explain the reduction of diarrhoea mortality reported from other programmes.[12,48]

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