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# LA MORTALITE PAR CAUSE DANS LA PLANIFICATION ET L'EVALUATION DES PROGRAMMES DE SANTE MATERNELLE ET INFANTILE

## THESE

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# RESUME

L'utilisation des taux de mortalité globale et de leurs changements pour évaluer ou planifier les programmes de santé maternelle et infantile est illusoire car trop imprécise. La thèse présentée ici est que la mortalité par cause apporte des résultats nettement plus intéressants, et à plus forte raison si elle est aussi présentée par groupes d'âge et par sexe. Elle est cependant plus difficile à mesurer, et nécessite un système indépendant de surveillance démographique, incluant le relevé des causes de décès par une nouvelle méthode appelée "autopsie verbale".

Un tel système a été mis au point et essayé par l'auteur à Matlab, au Bangladesh, de 1985 à1991. Il a fait l'objet de nombreuses publications dans des revues de santé publique internationales, dont 13 sont présentées dans ce travail, mettant l'accent sur les applications de la méthode pour la planification et l'évaluation des programmes de santé maternelle et infantile.

L'environnement et le cadre général du Projet de Santé Maternelle et Infantile de Matlab sont d'abord résumés, avec la description du système de surveillance démographique et du relevé des causes de décès. Le système de détermination des causes de décès par l'"autopsie verbale" est détaillé dans une publication de méthodologie.

L'extension de la méthode à quelques causes spécifiques de mortalité infantile (complications de la période périnatale, maladies diarrhéiques) est détaillée pour montrer l'importance relative et absolue de chaque groupe de maladies dans la communauté concernée.

Puis les applications de la méthode sont présentées et discutées en quatre catégories:

- celles qui permettent de guider le processus de décision pour des interventions spécifiques,

- celles qui permettent d'évaluer l'effet d'interventions ciblées sur la mortalité spécifique correspondante,
- celles qui permettent de selectionner des stratégies d'actions de santé maternelle et infantile,
- et celles qui permettent des comparaisons internationales.

Enfin, au vu des bons résultats obtenus dans la zone d'essai de Matlab, les conditions d'application de la méthode à d'autres circonstances sont individualisées et analysées, à savoir:
- l'indépendance du système de surveillance démographique,
- la plus grande prudence dans l'extension de la méthode aux zones géographiques étendues ou à l'échelle de pays entiers,
- la considération des ressources, tant financières qu'humaines,
- la nécessité de valider, au moins sur des échantillons,
- l'impossibilité d'appliquer la méthode dans les régions endémiques de maladies àsymptomatologie non spécifique, comme le paludisme,
- la nécessité, malgré les difficultés, de standardiser.

Il est conclu qu'au vu des restrictions énumérées ci-dessus, l'utilisation de la mortalité par cause pour la planification des actions de santé maternelle et infantile est une méthode qui peut et doit être étendue, mais que les applications de la méthode dans un but d'évaluation doivent rester limitées à un petit nombre de centres de recherche en santé publique ou à des zones pilotes.

# I. INTRODUCTION

Un des outils classiques de la santé publique pour évaluer l'effet d'interventions tant préventives que curatives est l'examen des taux de mortalité, soit dans une même population avant et après l'intervention, soit dans deux populations comparables ayant reçu ou non l'intervention.

Dans les pays développés, où la mortalité est relativement facile à mesurer, y compris la mortalité par catégories de causes de décès, on utilise depuis longtemps les taux de mortalité spécifique par cause pour évaluer les interventions spécifiques de telle ou telle maladie.[1,2] En revanche, dans les pays en développement, on en est longtemps resté au taux de mortalité globale, se contentant de la restreindre à des groupes d'âge et/ou de sexe, par exemple la mortalité infantile[3], ou infanto-juvénile[4], ou la mortalité des femmes en âge de procréer.

Les efforts déployés depuis quelques décades par les organisations internationales (OMS, UNICEF, CIE) et les gouvernements des pays en voie de développement pour améliorer la santé des mères et des enfants appellent des évaluations.

Après de nombreux essais des stratégies de survie des mères et des enfants (GOBI, Maternité sans Risque), et avant de les promouvoir monolithiquement pour l'ensemble du monde, il est justifié d'en évaluer les divers composants, en particulier par l'analyse de leur effet sur les mortalités spécifiques.[5,6,7]

L'objet de cette thèse est de montrer qu'à l'aide d'une nouvelle méthode on peut raisonablement détailler l'analyse des causes de décès des mères et des enfants dans les pays à ressources limitées, sans disposer d'un arsenal très sophistiqué, et ainsi utiliser la mortalité spécifique par cause, combinée avec la mortalité spécifique par âge et parfois par sexe, pour planifier et évaluer les programmes de santé maternelle et infantile .

La méthode dite d'"autopsie verbale" utilisée à cet effet a été testée à Matlab, la zone pilote du Projet de Santé Maternelle et Infantile et de Planification Familiale mise en place par le Centre International de Recherche sur les Maladies Diarrhéiques du Bangladesh (connu sous le sigle d'ICDDR,B en anglais).[8,9]

L'auteur de cette thèse a été de 1985 à 1990 le Directeur du Projet de Matlab, et le principal investigateur des activités de recherche entreprises pendant cette période. Son objectif était d'apporter un regard critique sur les stratégies globales de survie des mères et des enfants prônées par les organisations internationales. Pour ce faire il fallait d'abord développer la méthode de relevé des causes de décès par l'"autopsie verbale" et l'appliquer aux principales causes de décès des mères et des enfants dans la région de Matlab.

Les résultats des travaux sur ce thème ont été publiés dans des revues de santé publique internationales entre 1988 et 1993. Le présent ouvrage est le résultat d'une progression de recherche sur les applications de la méthode dans la planification et l'évaluation des programmes de santé maternelle et infantile. Cette progression est scientifiquement documentée par une synthèse de treize publications, parues depuis 1991, qui sont intégralement reproduites.

L'environnement et le cadre général du Projet de Santé Maternelle et Infantile de Matlab sont d'abord résumés, avec la description du système de surveillance démographique et du relevé des causes de décès par l'"autopsie verbale" (une publication de méthodologie, symbole "M1", référence 22).

L'extension de la méthode à quelques causes spécifiques de mortalité maternelle et infantile est ensuite détaillée pour montrer l'importance relative et absolue de chaque cause de décès dans la communauté concernée (trois publications epidémiologiques, appelées "M2", référence 28, "M3", référence 29, et "M4", référence 30).

Puis les applications de la méthode sont présentées et discutées en quatre catégories:

- celles qui permettent de guider le processus de décision pour des interventions spécifiques (deux publications guides, appelées "G1" et "G2", références 32 et 37),
- celles qui permettent d'évaluer l'effet d'interventions spécifiques sur la mortalité spécifique correspondante (quatre publications d'évaluation, appelées "E1" à "E4", références 41,44,47,52),
- celles qui permettent de selectionner des stratégies d'actions de santé maternelle et infantile (deux publications de stratégie, appelées "S1" et "S2", références 60 et 64),
- et celles qui permettent des comparaisons internationales (une publication de comparaison internationale, "C1", référence 86).

Enfin, au vu des résultats obtenus dans la zone d'essai de Matlab, les conditions d'application de la méthode à d'autres circonstances sont individualisées et analysées, les problèmes de validité, de validation, et de standardisation sont soulevés, avant de conclure.

# II. ENVIRONNEMENT: LE PROJET DE SANTE MATERNELLE ET INFANTILE DE MATLAB

Matlab est un district rural du Bangladesh, situé à 45 km au sud-est de Dacca la capitale, dans la plaine inondable du delta du Gange. Caractéristique de la majorité du Bangladesh rural, la région de Matlab est hyper-peuplée, avec une densité proche de 800 habitants par $km^2$, un indice synthétique de fécondité de six enfants par femme, mais aussi une mortalité infantile de plus de 120 pour 1000. La population presque exclusivement rurale vit d'une agriculture de subsistance dominée par le riz, complémentée par les légumineuses et les produits de la pêche. La situation socio-économique est précaire, avec un revenu annuel per capita de moins de 200 dollars US et un taux d'alphabétisation des femmes de moins de 20 pour cent.

Matlab est le siège du système d'étude et de surveillance de population le plus vaste du monde en développement, et sur la période la plus longue. Plus de trois cent chercheurs appartenant aux disciplines biomédicales, démographiques et anthropologiques se sont succédés à Matlab, testant leurs hypothèses dans les domaines des maladies diarrhéiques (choléra surtout), de la santé maternelle et infantile, de la planification familiale, de la dynamique des populations, etc...

## LE SYSTEME DE SURVEILLANCE DEMOGRAPHIQUE DE MATLAB

Depuis 1966, le Centre International de Recherche sur les Maladies Diarrhéiques du Bangladesh (ICDDR,B) a établi et maintenu un système de surveillance démographique dans la zone de Matlab, comprenant des recensements périodiques et l'enregistrement de l'état civil (naissances, décès, mariages, migrations).[10,11]

Ce système de surveillance démographique, pendant la période couverte par la présente étude, s'appliquait à une population totale de 200.000 habitants, divisés en deux zones presque égales: la zone de traitement et la zone de contrôle ou zone de comparaison.
La zone de traitement, elle-même divisée en quatre sous-zones ou "blocs", était le siège de la plupart des interventions appliquées par l'ICDDR,B, tandis que dans la zone de contrôle ne s'appliquaient que les services de santé réguliers du gouvernement.
Dans les deux zones, des agents de santé communautaires visitent chaque foyer deux fois par mois pour mettre à jour le registre familial, dans lequel sont notés les naissances ou interruptions de grossesse, les décès, les mariages et séparations, et les migrations. Les informations sont enregistrées dans les livres au bureau central de Matlab, et vérifiées sur le terrain par des assistants qui vont interroger les familles sur les circonstances des évènements rapportés. Toutes les informations sont codées et saisies sur les ordinateurs du bureau de surveillance démographique, puis encore vérifiées par des superviseurs. Le système permet donc le calcul des âges exacts, au jour près, pour toutes les personnes nées dans la zone de surveillance démographique depuis le début de la surveillance, c'est-à-dire depuis 1966. Pour les personnes nées en dehors de la zone ou avant 1966, les âges sont déterminés à l'année près par référence à des évènements historiques, religieux ou coutumiers.

La bonne marche de ce système repose sur une longue et patiente collaboration entre les villageois et les agents de surveillance démographique, eux-mêmes issus des villages considérés.

Le système de surveillance démographique produit chaque année une compilation des évènements démographiques, en valeur absolue et sous forme de taux, dont le suivi permet une étude des tendances dans le temps.[12]

A l'intérieur de la zone de traitement, un système d'enregistrement continu des divers services de santé maternelle et infantile et de planification familiale (le RKS ou "Record

Keeping System") était assuré par les 80 auxiliaires de santé communautaire (CHWs ou "Community Health Workers") à l'occasion de leurs visites bimensuelles dans chaque foyer de leur circonscription.

# III. LA METHODE DE DETERMINATION DES CAUSES DE DECES DANS LE SYSTEME DE SURVEILLANCE DEMOGRAPHIQUE

A Matlab comme dans beaucoup de pays en développement, la plupart des décès ont lieu àdomicile, sans rapport médical, et les autopsies sont rarissimes. La determination des causes de décès doit se baser sur une autre source d'information, la description des symptômes et évènements ayant précédé la mort par les proches y ayant assisté. Cette idée fut introduite par Biraud[13], et fut suivie par l'OMS qui produisit les premières listes de causes de décès non médicalisées.[14-18] La cause "la plus probable" est déterminée d'après l'analyse, par des médecins, des circonstances du décès recueillies par des non-médecins. Le terme "autopsie verbale" a été proposé par Kielmann et Taylor.[19]

La méthode d'autopsie verbale a été utilisée dès 1979 à Matlab,[20,21] mais elle a été fondamentalement révisée, raffinée, formalisée, et systématisée en 1985-86. Les détails de ces révisions sont dans la publication méthodologique "M1"[22]

Les principales améliorations portent sur les point suivants:

- les formulaires de recueil des circonstances du décès ont un large espace pour l'écriture de la description *verbatim* par l'agent lors de la visite à domicile,
- les agents et leur superviseurs ont reçu une formation supplémentaire, en particulier pour la transcription "naive", en langue locale, sans traduction, des déclarations faites par les proches,
- les mêmes agents ont reçu l'instruction de ne pas "interpréter" les déclarations, en particulier de ne pas affecter un code sur leur formulaire,
- l'interprétation et l'affectation du code sont faits par les médecins (ou assistants médicaux), lors de la lecture ultérieure des notes prises sur le terrain,
- en cas de renseignements insuffisants, un autre agent est envoyé au domicile du défunt pour recueillir plus d'informations,

- la liste des codes utilisables a été allongée et détaillée, permettant plusieurs combinaisons de causes, en particulier les combinaisons de causes primaires et de causes sous-jacentes,
- les résultats sont présentés annuellement sous forme de tables très détaillées par groupes d'âge, par sexe, et par cause,
- quelques essais de validation ont été faits, sur des échantillons, quoique la validation soit en général rendue très difficile par l'absence de standard de référence (autopsie réelle).
- enfin des procédures spéciales, encore plus détaillées, ont été appliquées pour les causes de décès chez les femmes en âge de procréer (en raison de la fréquence des complications obstétricales), et chez les nouveaux-nés (en raison de la fréquence particulière du tétanos néonatal).

# Assessment of Cause of Death In The Matlab Demographic Surveillance System

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# ABSTRACT

Assessment of cause of death is an essential tool for identifying public health priorities and for evaluating health interventions. Few field study areas have been covered by demographic surveillance systems comparable in size, level of completeness, and duration to Matlab, the study area of the International Centre for Diarrhoeal Disease Research, Bangladesh. Procedures to detect and report vital events have not changed in 18 years. Procedures to assess cause of death, however, have been modified in 1986, in an effort to improve quality and reliability, by incorporating medical judgement in the interpretation of available information. The paper presents these modifications in detail, to serve as a reference for researchers using the Matlab cause-specific mortality data. Attempts to validate the modified verbal autopsy method are also reviewed.

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# Tables

# 1. INTRODUCTION

Documentation of causes of death has contributed to the progress of knowledge in epidemiology and public health (Hakulinen et al. 1986, Ewbank 1984, Lopez 1990). It allows assessment of the health status of a population, assignment of health priorities, study of time-trends of mortality from specific causes, and evaluation of health interventions. Such a documentation is a common practice in developed countries, where most deaths occur in a medical environment and post-mortem autopsies are both feasible and culturally acceptable.

In developing countries, however, most deaths occur in the home with limited or no medical attendance, and post-mortem autopsies are rarely possible. The assessment of cause of death must rely on an alternative source of information i.e. the description of symptoms and events preceding death by relatives who have attended the event.

The idea of assessing the cause of death trough an analysis of symptoms and events collected by lay reporters was introduced by Biraud in the 1950s (1956). It was later formalised, with the production of the first list of causes of death to be used through lay reporting of symptoms preceding death (WHO 1978). The term "verbal autopsy", first proposed in Narangwal (Kielmann et al. (1983), refers to a method of retrospective interview of individuals who have attended a death and can describe what happened during the few hours, days or months preceding death. A most likely cause of death is then inferred from the sequence and combination of symptoms and events reported.

Verbal autopsies have been used in a few primary health care projects concerned with research and evaluation of health services in India (Kielmann et al. 1983), in Bangladesh (Chowdhury et al. 1980, Chen et al. 1980, Islam et al. 1982, Zimicki 1986), in South America (Puffer & Serrano 1973, Mata 1978), in Senegal (Garenne & Fontaine 1986), in Kenya (Omandi-Odhiambo et al. 1984), in The Gambia (Alonso et al. 1987).

The purpose of this paper is to present detailed documentation on the modified methods to assess cause of death introduced in 1986 in Matlab, one of the field research areas of the International Centre for Diarrhoeal Disease Research,

Bangladesh (ICDDR,B). The methods to detect vital events and to assess cause of death prior to 1986 in the Matlab Demographic Surveillance System (DSS) have been described elsewhere (Ruzicka & Chowdhury 1978, D'Souza 1985, Zimicki et al. 1985). A study based on improved methods to assess the causes of infant deaths in 1982-83 in Matlab was conducted by Bhatia (1989), but these improved methods were not formally incorporated in the DSS.

# 2. METHODS

## 2.1 Study area and background information

In 1963, the Cholera Research Laboratory, involved in epidemiological studies of diarrhoea and cholera vaccines, established its field station in Matlab, a rural subdistrict 50 km southeast of the capital, Dhaka. Population counts were required for those studies and the first demographic surveillance system was established in 1966, combining periodic censuses and longitudinal registration of births, deaths, migrations (since 1966), and marriages (since 1975). The study area, initially covering a population of 260,000, was reduced in 1978 to 175,000, distributed in 149 villages. It is located in a low-lying deltaic region, regularly flooded, with little infrastructure and poor communications, mostly by waterways. In 1986, the total population under surveillance was 188,000, population density was approximately 750 per sq km, total fertility 6 per woman, and infant mortality 98 per 1000 live births. One-half of the area under surveillance was covered by a Maternal and Child Health - Family Planning (MCH-FP) Project implemented since 1977 by the ICDDR,B, while the other half was covered by the Government of Bangladesh health services only (see map in Figure 1).

Under the DSS, 110 female community health workers (CHWs), literate married women mostly from influential families, visit each household of their village fortnightly to record vital events. Living in the village and having a limited population to survey (1000 to 3000), they are unlikely to miss events. They report these vital events to their male supervisors (health assistants), and within

an average of 6 weeks (2 to 10), accompany them to the houses where the events were detected. During these visits, they interview relatives and the male health assistant completes forms with details of the events. There are specific forms for births, deaths, migrations and marriages. All of them contain village, family and individual identification codes as well as socio-demographic information such as date of birth, date of the event, sex, place, doctor consulted, details of the event. Annexes 1 to 3 show samples of old and new death forms.

## 2.2 Lay reporting of information concerning deaths

Frequency of field visits to detect vital events and supervisory procedures in the demographic surveillance have remained unchanged since 1978. Training of field staff and structure of death forms, however, have been modified in 1986, to give more importance to the description of symptoms and events preceding death. A large portion of the guidelines used to train field staff was borrowed from the study conducted by S. Bhatia (1989).

Of the 16 male health assistants and their 10 supervisors (senior health assistants) in charge of interviewing families and filling death forms, only 2 had actually received a formal health training prior to joining the project. Prior to 1986, they were allowed, and encouraged, to propose their own diagnosis of the cause of death, taking into account their individual background experience, and there was no system to check this diagnosis. Space for writing symptoms was limited to 3 lines on the death form, and only a few significant words were written most of the time. In uncertain cases, the description was longer, but unstructured and biased with personal interpretation, and scattered with sometimes inappropriate medical terms. Writing was mostly in English, with many inaccurate, redundant or meaningless expressions.

These staff were retrained during 2 initial sessions at the beginning of 1986, followed by refresher sessions once a year. The training focused on the need to accumulate relevant information, as precise as possible, on timing, duration and gradation of each of the symptoms preceding death. Although lists of relevant questions were proposed during the training, adapted to the particular age and/or sex group of the deceased person, health assistants were not encouraged

to apply all questions in all cases, but rather to use judgement and concentrate on logical sequences. Only after exhausting a particular logical sequence were they instructed to change subject and ask complementary questions. Interviews were in colloquial Bengali, and interviewers were asked to write descriptive statements in Bengali, preserving local idioms and refraining from approximate translations. The space left for writing was increased from 3 to 12 lines, and additional space was provided on the back of the forms if needed. A sample of a completed revised death form is shown in annex 3, and written instructions to health assistants are shown in annex 4.

### 2.3 Interpretation of cause of death

Another change in the design of death forms was the removal of the list of codes for cause of death. This list, previously present, could have biased the diagnosis by "forcing" it into a fixed set of choices. Instead, health assistants were asked not to indicate their own diagnosis. They were also asked not to write the age at death as calculated in order to reduce the risk of miscalculations. Exact ages were calculated and checked later during computer data entry.

Death forms, once completed in the field, were taken to the central office and read by medically-trained staff. During the first year of the modified procedure, 1986, each death form for children under five years of age was reviewed by a panel of 3 physicians randomly selected from a list of 10 physicians involved in health projects in Matlab. Each of these physicians was experienced in the local health terminology. They were asked to make a diagnosis based on the available information, or to return the forms with requests for additional information if it was felt impossible to make a diagnosis with reasonable confidence. Diagnoses were to be written in full, with primary and underlying causes if necessary, on separate forms. On reviewing these forms, medical diagnoses were compared and majority rules were applied, i.e. if three or at least two physicians agreed, their diagnosis was retained. If the three disagreed, death forms were returned to the field workers for supplementary information as requested, and then reinserted in the system. This initial procedure involving physicians was found time-consuming and difficult to sustain as a routine. It was therefore replaced after

the first year by a simpler and more sustainable one: interpretation of cause of death information was assigned to a medical assistant recruited and trained for this purpose. (The selected candidate had 3 years of formal medical training and 3 years of practical experience in rural areas). Involved in assigning primary and underlying causes of death full-time, this medical assistant also had to go to the field to collect additional information when required, and to code the cause of death. Instructions for coding are shown in annex 5.

## 2.4 Coding and classification

A single 3-digit code was to be selected from a list of 97 possible codes, derived from the "basic tabulation list" of the WHO International Statistical Classification of Diseases, Injuries and Causes of death (WHO 1977). Many of the codes proposed by the WHO basic tabulation list were not retained because they would be irrelevant in the context of lay reporting. On the other hand, new codes were introduced to account for frequent combinations of primary and underlying causes. For example, three distinct 3-digit codes were used for measles: i/death from immediate complication of measles (during the rash period), ii/death from delayed respiratory complication of measles (within 6 weeks of the rash), and iii/death from delayed intestinal complication of measles. These 3 categories could then be used in aggregate form for a study of measles, or separately for studies of respiratory or diarhhoeal diseases.

As for diarrhoeal diseases, there were distinct codes for laboratory-confirmed cholera as opposed to other acute watery diarrhoeas, and distinct codes for laboratory-confirmed shigellosis as opposed to other cases of acute dysentery. Malnutrition, a commonly associated or underlying cause of death, was coded differently when it was felt to be an associated cause or the single cause of death.

Copies of lists of codes are provided in annexes 6 and 7. Certain codes on the new list are marked with an asterisk, indicating that they can only be assigned if the diagnosis was confirmed by a paramedical test such as an X-Ray, a laboratory test, or by a specialist's report. During the first year of the modified procedure, coding of cause of death of children under five was done by the

principal investigator. From the second year onwards, coding was done by the medical assistant in charge of reading death forms.

### 2.5 Supervision

Supervisory checks were set up at every stage of the procedure to assign cause of death. Health assistants supervised the CHWs'detection of deaths in the field through independent household visits, and were in turn supervised by senior health assistants and field research officers for appropriate filling and returning of death forms. Regular meetings of health assistants and their supervisors were held in the central office to review progress, discuss problems, search for missing cases, handle forms returned to the field for additional information, and deal with leave coverage.

The work of the medical assistant in charge of reading death forms was supervised by two physicians and by the principal investigator. At regular intervals, death forms were randomly drawn and checked, and difficult cases were reviewed.

### 2.6 Special procedures for neonatal deaths

Recognizing the particular difficulties in assessing the cause of neonatal deaths, especially in areas where neo-natal tetanus is known to be frequent, an additional procedure was set up from the beginning of 1986 to ensure optimum quality in the assessment of this cause. The issue of misdiagnosing (mostly overdiagnosing) tetanus as a cause of neonatal death has been raised previously in several publications (Chen et al. 1980, Zimicki et al. 1985, Zimicki 1986). It was found that all neonatal deaths perceived to be caused by evil spirits (i.e. unexplained by the current medical knowledge), including those with convulsions, stiffness, coma, were classified in the same category as neonatal tetanus. To sort this problem out, a special questionnaire was designed, translated into Bengali, and administered in all cases of neonatal deaths which had occurred between the 4th and 21st day of life. This restriction was based on the biological implausibility of dying from neonatal tetanus before or after these ages. The questionnaire, of which an English translation is shown in annex 8, was administered in Bengali by

a specially trained female interviewer, well aware of local beliefs and local terminology. It focused on identification of the main criteria for neonatal tetanus: no particular complication at birth, good suckling and crying patterns during the first 48 hours, lockjaw and difficulty in suckling as the first symptoms, spasms of neck and body rigidity (opistotonos), signs of infection of the umbilical stump.

The questionnaire was also designed to identify and differentiate prematurity and intra-uterine growth retardation as underlying causes of neonatal death. Relevant questions were asked about size at birth (rated by mother or attendants as average, above, or below average), duration of pregnancy, and problems during pregnancy. There were also questions on the conditions of delivery, care given to the umbilical stump, maternal coverage with tetanus toxoid immunization.

Since the introduction of this special questionnaire in 1986, all cases have been reviewed and coded by the principal investigator, ensuring consistency of judgement.

## 2.7 Special procedure for adult female deaths

It was also felt that the standard procedure might lead to misdiagnosing cause of death among adult women. As for neonatal deaths, a woman-to-women interview was felt potentially superior to a man-to-women interview to collect accurate and precise information. The most difficult and important cause to detect was complication of abortion, particularly induced abortion. Previous reports of abortion deaths in rural Bangladesh suggested many difficulties in assessing this cause of death, particularly among young unmarried women (Rochat et al. 1981, Khan et al. 1986). Again a special questionnaire was designed, to be administered by a trained female interviewer in all cases of death of women aged 15 to 45 years. This questionnaire focused on menstrual status at the time of death (i.e. regularly menstruating, amenorrhoeic, pregnant), family planning practice, dates of birth and death of previous child, desire for additional children, presence of social, familial, marital problems prior to death, and exact circumstances of death. The female interviewer, known and respected in the area for her integrity, was encouraged to talk to other women in the compound and

neighbouring compounds. The information collected was again read, discussed and assessed by a the principal investigator, thus ensuring consistency.

### 2.8 Analysis and presentation of results

The 3-digits codes are entered in annual death files produced by the DSS, containing exact dates of birth (when known) and death, thus allowing computerized calculation of exact age at death, and classification into age groups: neonates less than 1 month, post-neonates 1 to 11 months, children 12 to 59 months, women of reproductive age from 15 to 44 years. These death files also contain coded information on place of death, doctor(s) consulted prior to death, marital status at death, as well as identification numbers to allow linkages with census and other files. Causes of death can then be grouped easily into categories, using primary or underlying causes.

Results are presented in tables organized by age/sex groups and broad categories of causes. There is often an advantage in grouping years to smooth the effect of annual variations, (except for analysis of time-trends). Tables contain a column for exact numbers (N), a column for proportional mortality rates (PMR) or percentage distribution, and a column for cause-specific mortality rates (CSMR) per 1000 or 100,000 person/years exposed. Mid-year populations were provided by the annual DSS census up-dates. Statistical significance of differences between CSMRs (for example between two areas, or two periods, or between males and females) were assessed by using standard tests for incidence density or rate-ratio (Kleinbaum et al. 1982).

## 3. RESULTS

Tables 1 to 4 present cause of death information for 1986-87 in the Matlab MCH-FP and Comparison areas for neonates, post-neonates, children, and women of reproductive age, respectively. Earlier publications reported detailed findings and discussion on causes of neonatal deaths (Fauveau et al. 1990a), post-neonatal deaths and deaths of children aged 6 to 36 months (Fauveau et al. 1990b), adult female deaths (Fauveau et al. 1989a), maternal deaths (Fauveau et al. 1988),

deaths due to malnutrition (Fauveau et al. 1990c), deaths due to diarrhoea (Fauveau et al. 1989d), deaths due to acute respiratory infection (Fauveau et al. 1990e), deaths due to injuries and induced abortion among women (Fauveau et al. 1989b).

Another example of potential uses of cause of death information is provided in Table 5, showing cause-specific and proportional mortality among children aged 1 to 4 years by sex. Diarrhoeal diseases and severe malnutrition emerge as the specific causes of child death that explain the higher female than male child mortality previously reported in rural Bangladesh by D'Souza & Chen (1980) and Koenig & D'Souza (1986).

# 4. DISCUSSION

The modified procedure to assess cause of death in Matlab since 1986 was introduced with the following objectives:

- to collect a greater amount of information on events and symptoms preceding death,
- to ensure a better accuracy in reporting symptoms and events preceding death in difficult cases, such as neonates and women of reproductive age
- to switch the responsibility of diagnosing the cause of death away from untrained lay reporters to medically-trained people,
- to restrict the number of people assigning cause of death, thus ensuring greater consistency in coding, and easier supervision,
- to offer a greater choice of codes, minimizing forced compliance and allowing greater flexibility in classification, To examine whether these objectives have been met, validation studies should be undertaken. With few exceptions, validation studies all confront the problem of the absence of a "gold standard". Attempts to validate verbal autopsies have been made elsewhere, with inconsistent conclusions (Gray et al. 1990, Kalter et al. 1990, Alonso et al. 1984). Related issues are now discussed.

## 4.1 Validation issues

Several attempts to validate the modified procedure in Matlab are reported below. Some are restricted to a mere discussion of feasibility or relevance, while others are true attempts to compare findings of the modified procedure with those of the previously used procedure. Here again, the challenge lies in the fact that cause of death assessed by verbal autopsy cannot be checked against real autopsy or necropsy, because the latter is almost never performed (except in the very rare cases of legal prescription, or on specific hospital-based studies (Butler et al. 1987)).

Attempts have been made to check verbal autopsies against hospital diagnoses, by reading hospital therapy sheets of patients who died during admission or promptly after discharge. The method did not prove useful because most hospital therapy sheets carried only an admission diagnosis and no discharge diagnosis. The common practice in the region is for the relatives to take back their patient when they judge his/her condition hopeless. Of the very few patients who died while in the hospital, however, all verbal autopsies matched hospital diagnoses.

The issue of inter-observer variation to collect information concerning circumstances of death was not addressed with interviewers of the same gender, because it would have upset families. In the special cases of neonatal deaths and adult female deaths, however, it was observed that female interviewers using a structured questionnaire were always able to collect more information than their male counterparts. It was also observed that male heath assistants tended to interview male relatives, while female interviewers tended to talk to female relatives, who are more aware of detailed information concerning neonates and women. To illustrate this point, and estimate the extent of over-reporting of neonatal tetanus as a cause of neonatal death during the pre-1986 period, 563 neonatal death reports carrying diagnoses made by male health assistants were compared with cause of death assessed by physicians using information provided by female interviewers according to the modified procedure. Results in Table 6 show that in 17% (97/563) of all cases examined, both the old and new systems agreed that the cause of death was neonatal tetanus. In 39% (222/563) of all cases they agreed that the cause of death was not neonatal tetanus, resulting in an

overall degree of agreement of 56%. If it is accepted that the new method is closer to the "gold standard" than the old one, sensitivity of the old method to detect neonatal tetanus death can be estimated at 66%, with a specificity of 53%, and a positive predictive value of 34%. Interpretations of previous reports about neonatal tetanus in rural Bangladesh must be considered with this limitation in mind.

Another way of examining inter-observer variation was to compare diagnoses made by the 3 physicians involved in reading 1008 death forms of children under 5 years during the year 1986. As shown in Table 7, they agreed fully in 49% of all cases, partially in 21%, and they disagreed in the remaining 30%. Rates of full agreement increased with the age of children whose death report was examined, in contrast to rates of partial and complete disagreement, indicating that the assessment of cause of death was more subject to problems among neonates than among older children. The causes of death with the highest rates of disagreement were acute respiratory infection in all age groups, complications of prematurity and dysmaturity in neonates, and conditions associated with severe malnutrition. Disagreement also arose in cases when fever or fits were the only reported symptoms.

The modified procedure introduced questions about recent noticeable wasting of children prior to death, in an effort to determine the role of severe malnutrition. Given the large number of children surveyed in the study area, it was not possible to have an objective measure of the degree of malnutrition of those who died. In half of the study area, however, where the maternal and child health project was implemented, field workers regularly measure mid-upper-arm-circumference (MUAC) of all children aged 6 to 60 months (Briend et al. 1987). In a subsample of 253 deaths of children in this age group for which the MUAC had been measured witin one month of death, the degree of agreement between severe malnutrition assessed by verbal autopsy and by MUAC was 86% (sensitivity 76%, specificity 91% for a MUAC less than 110mm, Fauveau et al. 1990).

Similarly, the modified procedure introduced questions about the size of neonates at birth (bigger or smaller than "average"). This was part of an effort

to determine the role of complications of a small size at birth in settings (such as Matlab) where birth weight is impossible to measure in the community. As part of the maternity care programme introduced in one part of the area in 1987, midwives were trained to measure chest circumference at birth in the community (Fauveau et al. 1990). In a subsample of 18 neonatal deaths for which chest circumference at birth had been measured, the degree of agreement between a small size at birth assessed by verbal autopsy and by a chest circumference was 94% (sensitivity 82%, specificity 100%, positive predictive value 100%).

# 5. CONCLUSION

The efforts to improve quality and reliability of the assessment of cause of death reported in this paper were prompted by the need to prioritise health interventions and to refine the evaluation of their mortality impact. A number of health interventions have been implemented in Matlab since 1986, and their evaluation has been carried out using changes in age-and-cause-specific mortality. Because the level on confidence that can be put in the absolute values of cause-specific mortality rates may vary a lot, a reasonable and often more powerful alternative is to study trends of cause-specific mortality rates. The study of trends, however, may only apply to a limited number of causes of death, and in any case only if these causes have been consistently assessed in the same manner over the period studied.

Caution must be exercised before recommending extension and replication of the method described in this paper, on several grounds: First, more work is needed on validation, and, keeping in mind the quasi-impossibility to use a gold-standard, innovative approaches should be found. Second, a careful revision of the classification of causes of death based on clinical symptoms, not on sophisticated hospital-based findings, should be undertaken for use in areas resorting to verbal autopsy. Third, given that certain causes of death are far more difficult to assess than others, it may be wise to restrict the scope of this method to a limited number of possible causes that meet reasonable criteria of

feasibility. Fourth, the costs of maintaining quality and supervision in a demographic surveillance system should not be underestimated. Finally, a symptom-based assessment of causes of death such as the one described in this paper is highly culture-specific, and requires considerable preliminary work on local perceptions of health and disease..pa

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Table 1: Cause of death among neonates (<30 days), Matlab, MCH-FP and Comparison areas, 1986-87. (rates per 1000 live births)

| CAUSE OF DEATH | MCH-FP area N | MCH-FP area Rate | MCH-FP area Percent | Comparison area N | Comparison area Rate | Comparison area Percent | Difference between Rates |
|---|---|---|---|---|---|---|---|
| Complications of a small size at birth | 132 | 19.8 | 44.1 | 144 | 18.8 | 34.8 | 1.1 |
| Birth trauma | 43 | 6.5 | 14.4 | 44 | 5.7 | 10.6 | 0.7 |
| Neonatal tetanus | 20 | 3.0 | 6.7 | 85 | 11.1 | 20.5 | -8.1*** |
| Acute respiratory infection | 30 | 4.5 | 10.0 | 42 | 5.5 | 10.1 | -1.0 |
| Acute watery diarrhoea | 1 | 0.2 | 0.3 | 3 | 0.4 | 0.7 | -0.2 |
| Acute dysentery | 0 | 0.0 | 0.0 | 3 | 0.4 | 0.7 | -0.4 |
| Chronic diarrhoea | 1 | 0.2 | 0.3 | 0 | 0.0 | 0.0 | 0.2 |
| Other neonatal infections | 32 | 4.8 | 10.7 | 36 | 4.7 | 8.7 | 0.1 |
| Other neonatal complications | 7 | 1.1 | 2.3 | 9 | 1.2 | 2.2 | -0.1 |
| Impossible to specify | 33 | 5.0 | 11.0 | 48 | 6.3 | 11.6 | -1.3 |
| ALL CAUSES | 299 | 44.9 | 100.0 | 414 | 53.9 | 100.0 | -9.1 * |

* p<0.05
*** p<0.001
some totals do not add up because of rounding

Table 2: Cause of death among post-neonates in Matlab, Matlab MCH-FP and Comparison areas, 1986-87 (Rates per 1000 live births)

| Difference | MCH-FP area (n=6,663) | | | Comparison area (n=7,677) | | | between Rates |
|---|---|---|---|---|---|---|---|
| CAUSE OF DEATH | N | Rate | Percent | N | Rate | Percent | |
| Acute watery diarrhoea | 25 | 3.8 | 10.2 | 35 | 4.6 | 11.7 | -0.8 |
| Acute dysentery | 14 | 2.1 | 5.7 | 18 | 2.3 | 6.0 | -0.2 |
| Post-measles dysentery | 1 | 0.2 | 0.4 | 3 | 0.4 | 1.0 | -0.2 |
| Chronic diarrhoea | 16 | 2.4 | 6.6 | 8 | 1.0 | 2.7 | 1.4 |
| Chronic diarrhoea with severe malnutrition | 15 | 2.3 | 6.1 | 19 | 2.5 | 6.3 | -0.2 |
| TOTAL DIARRHOEAL DISEASES | 71 | 10.7 | 29.1 | 83 | 10.8 | 27.7 | -0.2 |
| Acute lower respir infect | 66 | 9.9 | 27.0 | 97 | 12.6 | 32.3 | -2.7 |
| Ac low respir inf with severe malnutrition | 10 | 1.5 | 4.1 | 10 | 1.3 | 3.3 | 0.2 |
| Post-measles pneumonia | 1 | 0.2 | 0.4 | 2 | 0.3 | 0.7 | -0.1 |
| Whooping cough | 2 | 0.3 | 0.8 | 5 | 0.7 | 1.7 | -0.4 |
| TOTAL ACUTE RESPIR INFECT | 79 | 11.9 | 32.4 | 114 | 14.8 | 38.0 | -3.0 |
| Measles | 1 | 0.2 | 0.4 | 2 | 0.3 | 0.7 | -0.1 |
| Tetanus | 0 | 0.0 | 0.0 | 10 | 1.3 | 3.3 | -1.3 |
| Skin and subcutaneous inf | 3 | 0.5 | 1.2 | 3 | 0.4 | 1.0 | 0.1 |
| Fever of unknown origin | 7 | 1.1 | 2.9 | 8 | 1.0 | 2.7 | 0.0 |
| Other infectious diseases | 3 | 0.5 | 1.2 | 3 | 0.4 | 1.0 | 0.1 |
| TOTAL OTHER INFEC DISEASE | 14 | 2.1 | 5.7 | 26 | 3.4 | 8.7 | -1.3 |
| OTHER SEVERE MALNUTRITION | 31 | 4.7 | 12.7 | 26 | 3.4 | 8.7 | 1.3 |
| Drowning | 6 | 0.9 | 2.5 | 2 | 0.3 | 0.7 | 0.6 |
| Extended burns | 0 | 0.0 | 0.0 | 1 | 0.1 | 0.3 | -0.1 |
| Other accidents | 13 | 2.0 | 5.3 | 7 | 0.9 | 2.3 | 1.0 |
| TOTAL INJURIES/ACCIDENTS | 19 | 2.9 | 7.8 | 10 | 1.3 | 3.3 | 1.5 |
| Other causes | 11 | 1.7 | 4.5 | 13 | 1.7 | 4.3 | 0.0 |
| Impossible to specify | 19 | 2.9 | 7.8 | 28 | 3.6 | 9.3 | -0.8 |
| TOTAL UNSPECIFIED | 30 | 4.5 | 12.3 | 41 | 5.3 | 13.7 | -0.8 |
| ALL CAUSES | 244 | 36.6 | 100.0 | 300 | 39.1 | 100.0 | -2.5 |

Table 3: Cause of death among children 1 to 4 years, Matlab, MCH-FP and comparison areas, 1986-87 (Rates perr 1000 children aged 1 to 4 years)

| CAUSE OF DEATH | MCH-FP area (n=22,331) N | Rate | Percent | Comparison area (n=24,560) N | Rate | Percent | Difference between Rates |
|---|---|---|---|---|---|---|---|
| Acute watery diarrhoea | 16 | 0.7 | 6.5 | 18 | 0.7 | 4.2 | 0.0 |
| Acute dysentery | 28 | 1.3 | 11.3 | 30 | 1.2 | 7.0 | 0.0 |
| Post-measles dysentery | 2 | 0.1 | 0.8 | 39 | 1.6 | 9.1 | -1.5*** |
| Chronic diarrhoea | 18 | 0.8 | 7.3 | 24 | 1.0 | 5.6 | -0.2 |
| Chronic diarrhoea with severe malnutrition | 59 | 2.6 | 23.9 | 128 | 5.2 | 29.8 | -2.6*** |
| TOTAL DIARRHOEAL DISEASES | 123 | 5.5 | 49.8 | 239 | 9.7 | 55.6 | -4.2*** |
| Acute lower respir infect | 24 | 1.1 | 9.7 | 37 | 1.5 | 8.6 | -0.4 |
| Ac low respir inf with severe malnutrition | 3 | 0.1 | 1.2 | 8 | 0.3 | 1.9 | -0.2 |
| Post-measles pneumonia | 0 | 0.0 | 0.0 | 14 | 0.6 | 3.3 | -0.6 |
| Whooping cough | 2 | 0.1 | 0.8 | 4 | 0.2 | 0.9 | -0.1 |
| TOTAL ACUTE RESPIR INFECT | 29 | 1.3 | 11.7 | 63 | 2.6 | 14.7 | -1.3** |
| Measles | 1 | 0.0 | 0.4 | 1 | 0.0 | 0.2 | 0.0 |
| Tetanus | 2 | 0.1 | 0.8 | 2 | 0.1 | 0.5 | 0.0 |
| Rabies | 0 | 0.0 | 0.0 | 1 | 0.0 | 0.2 | 0.0 |
| Skin and subcutaneous inf | 2 | 0.1 | 0.8 | 3 | 0.1 | 0.7 | 0.0 |
| Fever of unknown origin | 6 | 0.3 | 2.4 | 8 | 0.3 | 1.9 | -0.1 |
| Other infectious diseases | 3 | 0.1 | 1.2 | 5 | 0.2 | 1.2 | -0.1 |
| TOTAL OTHER INFEC DISEASE | 14 | 0.6 | 5.7 | 20 | 0.8 | 4.7 | -0.2 |
| OTHER SEVERE MALNUTRITION | 13 | 0.6 | 5.3 | 26 | 1.1 | 6.0 | -0.5 |
| Drowning | 51 | 2.3 | 20.6 | 50 | 2.0 | 11.6 | 0.3 |
| Extended burns | 2 | 0.1 | 0.8 | 2 | 0.1 | 0.5 | 0.0 |
| Other accidents | 2 | 0.1 | 0.8 | 2 | 0.1 | 0.5 | 0.0 |
| TOTAL INJURIES/ACCIDENTS | 55 | 2.5 | 22.3 | 54 | 2.2 | 12.6 | 0.3 |
| Other causes | 2 | 0.1 | 0.8 | 10 | 0.4 | 2.3 | -0.3 |
| Impossible to specify | 11 | 0.5 | 4.5 | 18 | 0.7 | 4.2 | -0.2 |
| TOTAL UNSPECIFIED | 13 | 0.6 | 5.3 | 28 | 1.1 | 6.5 | -0.6 |
| ALL CAUSES | 247 | 11.1 | 100.0 | 430 | 17.5 | 100.0 | -6.4*** |

** p<0.01
*** p<0.001
Some totals do not add up because of rounding

Table 4: Cause of death among women 15 to 44 years in Matlab, MCH-FP and Comparison areas, 1986-87 (Rates per 10 000 women 15-44 years)

| CAUSE OF DEATH | MCH-FP area (n=44,317) N | Rate | Percent | Comparison area (n=40,675) N | Rate | Percent | Difference between Rates |
|---|---|---|---|---|---|---|---|
| Acute watery diarrhoea | 3 | 0.7 | 2.9 | 4 | 1.0 | 3.5 | -0.3 |
| Acute non-watery diarrhoea | 3 | 0.7 | 2.9 | 2 | 0.5 | 1.7 | 0.2 |
| Persistent diarrhoea | 6 | 1.4 | 5.9 | 4 | 1.0 | 3.5 | 0.4 |
| Acute respiratory infect. | 1 | 0.2 | 1.0 | 1 | 0.2 | 0.9 | 0.0 |
| Chronic respiratory infect | 6 | 1.4 | 5.9 | 7 | 1.7 | 6.1 | -0.4 |
| Other infectious diseases | 16 | 3.6 | 15.7 | 18 | 4.4 | 15.7 | -0.8 |
| TOTAL INFECTIOUS DISEASES (excluding obst. sepsis) | 35 | 7.9 | 34.3 | 36 | 8.9 | 31.3 | -1.0 |
| Abortion | 6 | 1.4 | 5.9 | 15 | 3.7 | 13.0 | -2.3* |
| Postpartum sepsis | 1 | 0.2 | 1.0 | 2 | 0.5 | 1.7 | -0.3 |
| Postpartum haemorrhage | 7 | 1.6 | 6.9 | 4 | 1.0 | 3.5 | 0.6 |
| Eclampsia | 4 | 0.9 | 3.9 | 5 | 1.2 | 4.3 | -0.3 |
| Obstructed labour | 1 | 0.2 | 1.0 | 2 | 0.5 | 1.7 | -0.3 |
| Other obstetric | 3 | 0.7 | 2.9 | 7 | 1.7 | 6.1 | -1.0 |
| TOTAL DIRECT OBSTETRIC | 22 | 5.0 | 21.6 | 35 | 8.6 | 30.4 | -3.6* |
| Unintentional inj(accident) | 7 | 1.6 | 6.9 | 5 | 1.2 | 4.3 | 0.3 |
| Intentional inj. (suicide) | 10 | 2.3 | 9.8 | 7 | 1.7 | 6.1 | 0.5 |
| Intentional inj. (homicide) | 1 | 0.2 | 1.0 | 1 | 0.2 | 0.9 | 0.0 |
| TOTAL INJURIES | 18 | 4.1 | 17.6 | 13 | 3.2 | 11.3 | 0.9 |
| NON-INFECTIOUS DISEASES (acute and chronic) | 9 | 2.0 | 8.8 | 14 | 3.4 | 12.2 | -1.4 |
| OTHER CAUSES | 13 | 2.9 | 12.7 | 12 | 3.0 | 10.4 | 0.0 |
| IMPOSSIBLE TO SPECIFY | 5 | 1.1 | 4.9 | 5 | 1.2 | 4.3 | -0.1 |
| ALL CAUSES | 102 | 23.0 | 100.0 | 115 | 28.3 | 100.0 | -5.3 |

* : $p<0.05$

Some totals do not add up because of rounding.

Table 5: Cause of death by sex among children, Matlab 1986-87 (rates per 1000 children 1-4 yrs)

| CAUSE OF DEATH | MALE (n=24,219) N | Rate | % | FEMALE (n=22,652) N | Rate | % | Difference between Rates |
|---|---|---|---|---|---|---|---|
| Acute watery diarrhoea | 12 | 0.5 | 4.7 | 22 | 1.0 | 5.2 | 0.5 |
| Acute non-watery dia. | 21 | 0.9 | 8.3 | 35 | 1.5 | 8.3 | 0.7* |
| Post-measles diarrhoea | 14 | 0.6 | 5.5 | 27 | 1.2 | 6.4 | 0.6* |
| Persistent diarrhoea | 12 | 0.5 | 4.7 | 31 | 1.4 | 7.3 | 0.9** |
| TOTAL DIARRHOEAL DISEASES | 59 | 2.4 | 23.2 | 115 | 5.1 | 27.2 | 2.6*** |
| SM with chronic diarrhoea | 52 | 2.1 | 20.5 | 136 | 6.0 | 32.2 | 3.9*** |
| SM with respiratory infec. | 3 | 0.1 | 1.2 | 8 | 0.4 | 1.9 | 0.2 |
| Other severe malnutrition | 16 | 0.7 | 6.3 | 23 | 1.0 | 5.4 | 0.4 |
| TOTAL SEVERE MALNUTRITION | 71 | 2.9 | 28.0 | 167 | 7.4 | 39.5 | 4.4*** |
| Acute lower respir infect | 34 | 1.4 | 13.4 | 27 | 1.2 | 6.4 | -0.2 |
| Immunizable (+) | 12 | 0.5 | 4.7 | 13 | 0.6 | 3.1 | 0.1 |
| Fever, septicaemia | 5 | 0.2 | 2.0 | 10 | 0.4 | 2.4 | 0.2 |
| Other infectious diseases | 4 | 0.2 | 1.6 | 10 | 0.4 | 2.4 | 0.3 |
| TOTAL OTHER INFEC DISEASES | 55 | 2.3 | 21.7 | 60 | 2.6 | 14.2 | 0.4 |
| Drowning | 50 | 2.1 | 19.7 | 51 | 2.3 | 12.1 | 0.2 |
| Other accidents | 4 | 0.2 | 1.6 | 4 | 0.2 | 0.9 | 0.0 |
| TOTAL INJURIES/ACCIDENTS | 54 | 2.2 | 21.3 | 55 | 2.4 | 13.0 | 0.2 |
| OTHER CAUSES | 3 | 0.1 | 1.2 | 9 | 0.4 | 2.1 | 0.3 |
| IMPOSSIBLE TO SPECIFY | 12 | 0.5 | 4.7 | 17 | 0.8 | 4.0 | 0.3 |
| ALL CAUSES | 254 | 10.5 | 100.0 | 423 | 18.7 | 100.0 | 8.2*** |

(+): measles, pertussis, tetanus,
* : p<0.05
** : p<0.01
***: p<0.001

Table 6: Neonatal tetanus diagnosed by male health assistants and by physician on the basis of female-to-female interview, Matlab DSS, 1985-86.

| | | Diagnosis by physician on the basis of female interwiew | | |
|---|---|---|---|---|
| | | NNT | not NNT | ALL |
| Diagnosis by male health assistant | NNT | 97 | 195 | 282 |
| | not NNT | 49 | 222 | 271 |
| | ALL | 146 | 417 | 563 |

Sum of positive and negative agreement : 17% + 39% = 56%

Sensitivity of diagnosis by male health assistant : 66%

Specificity of diagnosis by male health assistant : 53%

Positive predictive value : 34%

Table 7: Agreement between 3 physicians interpreting the same verbal autopsy report, Matlab 1986 (N = 1008 deaths).

| AGREEMENT | Neonates | Post-neonates | Children | ALL |
|---|---|---|---|---|
| % fully agree | 39 | 45 | 60 | 49 |
| % partial agree | 26 | 22 | 17 | 21 |
| % disagree | 35 | 33 | 23 | 30 |
| | 100 | 100 | 100 | 100 |

# IV. APPLICATIONS DE LA METHODE A DES CAUSES SPECIFIQUES

## IV.1. MORTALITE DES FEMMES ADULTES

Dans les quelques années précédant la publication de l'article méthodologique cité plus haut, trois publications avaient été consacrées aux causes de décès chez les femmes en âge de procréer[23,24,25] : les trois étaient basées sur les principes de la méthode générale présentée plus haut, et s'appliquaient aux décès dans les années 1976 à 1986. Elles accompagnaient une grande étude rétrospective de la mortalité maternelle à Matlab de 1976 à 1985.[26] La méthodologie particulière suivie pour la détermination des causes de décès chez les femmes adultes y était présentée, mettant l'accent sur la détermination des "morts maternelles" définies comme étant survenues pendant la grossesse, l'accouchement, ou la période de six semaines après la fin de la grossesse, quelque soit l'issue de la grossesse.[18] La recherche dans le domaine des causes de décès chez les femmes adultes a été dominée par le problème des complications d'avortement (essentiellement avortement provoqué). Le souci de ne jamais exclure *a priori* la possibilité d'une complication d'avortement a impliqué la mise en place de procédures spéciales pour la détermination des causes de décès chez les femmes adultes: utilisation d'une assistante spécialement formée, questionnaire additionnel, recoupements des informations recueillies dans l'entourage.

Les résultats de ces études permettaient déjà de recommander la mise en place d'un programme de soins obstétricaux à domicile ou le plus proche possible du domicile, ainsi que la formation de sage-femmes capables d'intervenir au niveau des villages.

## IV.2. MORTALITE PERINATALE ET NEONATALE

La détermination des causes de décès en période périnatale est une des plus complexes. Il est cependant fondamental d'isoler le tétanos néonatal, en raison de sa fréquence[27] et de la possibilité de son éradication par la vaccination maternelle. Ainsi que décrit dans la publication "M2"[28], la mise en place d'une procédure spéciale pour assurer une meilleure détermination du rôle du tétanos ombilical a abouti à une sous-évaluation de cette cause par rapport aux estimations antérieures, et non pas à une sur-évaluation comme on aurait pu s'y attendre: en effet, en l'absence de critères précis, en particulier concernant la période d'apparition du tétanos, on avait dans le passé attribué au tétanos la plupart des complications neurologiques, respiratoires, ou tout simplement inexpliquées, survenant dans la période néonatale. La part du tétanos dans les décès de la première semaine de vie est ainsi passée de un quart à moins d'un dixième. En revanche, la part des complications dues à un faible poids de naissance (prématurité, dysmaturité) a augmenté dans des proportions inverses. Bien que restant importante, la responsabilité de la vaccination anti-tétanique des mères dans la réduction de la mortalité périnatale doit donc être réajustée à la baisse, tandis que la responsabilité des interventions obstétricales (pendant la grossesse et l'accouchement) doit être inversement révisée à la hausse.

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# Perinatal Mortality in Matlab, Bangladesh: A Community-Based Study

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Fauveau V (International Centre for Diarrhoeal Disease Research (ICDDR-B) GPO Box 128, Dhaka-1000, Bangladesh), Wojtyniak B, Mostafa G, Sarder A M and Chakraborty J. Perinatal mortality in Matlab, Bangladesh: A community-based study. *International Journal of Epidemiology* 1990, **19**: 606–612.

Perinatal deaths, comprising stillbirths and deaths during the first week of life, were monitored over the eight-year period 1979 to 1986 in a rural Bangladeshi population of 196 000. The perinatal mortality rate was 75 per 1000 total births. The rate was 13% higher in males than females. Stillbirth and early neonatal mortality rates were 37 and 38 per 1000 total births, respectively. The major causes of perinatal deaths are presented, as well as some of the maternal determinants.

During the period under study, perinatal mortality declined regularly and significantly over time in an area covered by an intensive Family Planning and Health Services programme, but not in the adjacent control area. This raises the issue of the impact of such a programme upon perinatal mortality, and the need to include a strong maternity care component into primary healthcare strategies if further reductions of perinatal mortality are to be achieved.

Perinatal mortality has been used as an indicator for the evaluation of pregnancy outcome since mid-century.[1] According to the International Classification of Diseases ninth revision it comprises late fetal deaths (stillbirths) and early neonatal deaths (deaths during the first week of life).[2] Whether late fetal deaths should be defined on the basis of birthweight or duration of pregnancy is still debated and varies between countries, but this controversy is only relevant for statistics in developed countries. In the less developed countries, where duration of pregnancy and birthweight are less precisely known in most cases, the classification of perinatal deaths is not clearcut. The great majority of information on perinatal mortality comes from hospitals and does not necessarily reflect the situation in the community. In addition, there are very few studies of perinatal mortality in the rural areas of the developing world. This paper presents such data for a large rural community in Bangladesh under close demographic surveillance and assesses perinatal mortality as a monitoring tool for the evaluation of a community-based Family Planning and Health Services programme.

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## MATERIALS AND METHODS

The data for this analysis come from Matlab, a rural sub-district of southern Bangladesh. Typical of many other districts of the region, this flood-prone area, subsisting on a precarious agricultural economy, was characterized during the study period by a high population density of 700 per square kilometre, a total fertility rate of six per woman, an infant mortality rate of 120 per 1000 live births and a low female literacy rate of 16%. Since 1966 the International Centre for Diarrhoeal Disease Research, Bangladesh has maintained an intensive demographic surveillance, combining periodic censuses and continuous registration of vital events and migrations, in a population of 190 000. In October 1977, a Family Planning and Health Services programme was initiated in half of the study area to test the hypothesis that a carefully implemented family planning programme associated with a few basic maternal and child health services can significantly reduce fertility and improve child survival.[3,4] The maternal health services included gradual implementation of tetanus toxoid immunization during pregnancy (and later for all married women), iron/folic acid supplementation during pregnancy and lactation, distribution of safe delivery kits, and care of simple ailments during pregnancy, mostly through anti-infective therapies.

The remaining half of the surveillance area served as the comparison area, receiving only family planning and health services provided by the government programme, with lower coverage, utilization, and quality.

In each village, one locally recruited female Community Health Worker (CHW) visited each household biweekly to detect vital events (births, deaths, marriages and migrations) which had occurred to permanent residents since her previous visit. Once a month a male Health Assistant accompanied the CHW to each household where a vital event had been noted to conduct a home interview and fill up registration forms with detailed demographic information. In the case of births and deaths, this information included a description of conditions and symptoms accompanying the event.[5]

In this study, stillbirth is defined as the birth of a child after 28 weeks of gestation, for whom no sign of life was observed after delivery. Any death within the first week of life (up to six days) is called an early neonatal death.

Information on the cause of stillbirths and early neonatal deaths was limited in this study to a subsample of births occurring during one year (497 perinatal deaths in 1986). This data was obtained from the birth and death registration forms as follows:

For stillbirths, the birth forms contained information on duration of pregnancy, problems during pregnancy, duration of labour, place and conditions of delivery, type of presentation, multiple birth, complications of delivery and attendance at delivery. It was not possible to assess the degree of maceration, nor to detect whether the underlying cause was maternal or fetal in case of a preterm delivery, the most common cause of stillbirth. Therefore the category called 'disorders due to a very small size at birth' is likely to be inflated.

For very early neonatal deaths, between the first and third days of life, information concerning both birth and death was considered, therefore in addition to the above, information on condition of the child at birth and during the first hours/days of life was considered. In the absence of a birthweight, which was not available in most cases, the size at birth was estimated by interview. The primary causes of death for very small neonates were infectious, neurological or respiratory in origin.

Finally, for neonatal deaths between the fourth and the seventh day of life (a period during which the risk of death from neonatal tetanus is high), an additional questionnaire was administered to the mother in her home by a trained female interviewer, seeking details of symptoms preceding death eg presence or absence of any abnormality during the first three or four days of life, inability to suck, trismus, spasms, or abnormal reaction to stimuli.

This procedure, known as 'verbal autopsy', has limitations due to lay reporting of symptoms and subjectivity of their interpretation. However, carefully supervised, it is a useful alternative to hospital data in areas like Matlab, where less than 5% of all births occur in a medical environment.

The denominators for calculating perinatal mortality rates, ie the sum of live births and stillbirths, were taken from the annual reports provided by the Demographic Surveillance system. Relative risks and their confidence intervals were estimated by Miettinen's test-based interval. Heterogeneity and statistical significance of trends were tested by appropriate chi-square tests.[6]

## RESULTS

During the eight-year study period, from 1979 to 1986, 60 050 total births (TB), 4486 perinatal deaths, 2213 stillbirths, and 2273 early neonatal deaths were reported (Table 1). The perinatal mortality rate was 75 per 1000 TB, while the stillbirth and early neonatal rates were 37 and 38 per 1000 TB, respectively. Males had a perinatal mortality rate 13% higher than females, 79 and 70 per 1000 TB, respectively ($p=0.0001$). This gender differential was higher for stillbirths (17%, $p=0.0003$) than for early neonatal deaths (9%, $p=0.048$).

### *Causes of Perinatal Death*

The major reported causes of stillbirth and early neonatal death are shown in Tables 2 and 3 respectively. A quarter of stillbirths were associated with a very small size at birth (preterm or small-for-dates), one-fifth were the result of a prolonged labour, 13% were directly linked to a maternal medical problem during late pregnancy (infection, diarrhoea, toxaemia/eclampsia), and 12% were the outcome of a malpresentation. In 28% of the stillbirths, it was not possible to determine the cause. Of stillbirths 2% were twin births.

Out of 145 very early neonatal deaths ie occurring during the first three days of life, 63% were due to a very small size at birth, and 31% to a birth trauma resulting from a long or difficult labour. The corresponding proportions fell to 37% and 15% respectively among the 65 neonates who died during the fourth to seventh day of life. Of the latter 25% died from neonatal tetanus, 6% from an acute respiratory infection and another 9% from other neonatal infections. Of all early neonatal deaths, 81% were the result of a very small size at birth or a birth trauma.

TABLE 1 *Perinatal mortality in Matlab, 1979–1986.*

| | Total births | | | Stillbirths | | | Early neonatal deaths | | | Perinatal deaths | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Male | Female | All | Male | Female | All | Male | Female | All | Male | Female | All |
| No. | 30 832 | 29 218 | 60 050 | 1223 | 990 | 2213 | 1215 | 1058 | 2273 | 2438 | 2048 | 4486 |
| Rate (per 1000 total births) | — | — | — | 41.3 | 35.1 | 38.3 | 41.0 | 37.5 | 39.3 | 82.3 | 72.6 | 77.6 |
| Relative risk M/F (95% CI) | | | | 1.16(1.07–1.26) | | | 1.08(1.00–1.18) | | | 1.12(1.06–1.18) | | |

None of the major causes of stillbirth or early neonatal deaths were significantly more common among males than females, with the exception of neonatal tetanus: there were 13 cases among males versus three among females; a relative risk of 4.3 (95% CI=1.4–13.5, p=0.015).

*Demographic Correlates*

As shown in Table 4, perinatal mortality follows an asymmetrical U-shaped relationship when maternal age increases, as well as when gravidity increases. This relationship is slightly more marked for gravidity than for age. Table 4 also shows the effect of one factor when controlling for the other. There seems to be an optimum combination 'age-gravidity' corresponding to the lowest risk, for second-third pregnancy at ages 20–24, fourth-fifth pregnancy at ages 25–29 and sixth-seventh pregnancy at ages 30–34.

*Trends Over Time*

Compared globally over the eight years of the study, the perinatal mortality rates in the area covered since 1978 by a family planning and health services programme (MCH-FP area) and in the adjacent comparison area were not significantly different, 74 and 75 per 1000 TB respectively. Nor were the corresponding stillbirth rates (37 and 36 per 1000 TB) and early neonatal death rates (37 and 39 per 1000 TB). An examination of the trends of the annual perinatal mortality rates over the eight years of the study, however, provides a different picture (Figure 1). In the comparison area, the rates fluctuated considerably but did not show a significant trend ($X^2$ for linear trend: 1.7, 1 df, NS). In the MCH-FP area however the rates declined consistently from 82 per 1000 TB in 1979 to 65 per 1000 TB in 1986 ($X^2$ for linear trend: 15.7, 1 df, $p<0.001$).

As a result, as shown in Table 5, the perinatal mortality rate in the MCH-FP area in the second half of the study period (1983–86), became significantly lower than in the first half of the study period (1979–82), and significantly lower than in the comparison area during the same period ($X^2$ for heterogeneity = 6, df=1, p=0.01).

*Seasonality*

Figure 2 shows the seasonal variations in perinatal mortality rates in the whole study area, aggregated month by month for the three-year period 1982 to 1984. Despite some fluctuations, there seems to be a high season, from August to December, followed by a more favourable season, from January to July.

## DISCUSSION

In contrast to the many hospital-based studies,[7-10] very few community-based studies of perinatal mortality have been done in the developing countries of Asia. In Narangwal (Punjab, India) during the years 1970–73, the perinatal mortality rate was 104 per 1000 TB in the control villages, and 61 per 1000 TB in the villages with healthcare and nutrition interventions.[11]

Our findings raise a number of issues concerning methodology, demographic determinants, impact of a health service programme, and policy implications.

*Methodological Issues*

Given the high density of demographic visits to each household and the many supervisory steps in the Mat-

TABLE 2 *Causes of stillbirth in Matlab in 1986.*

| | No. | % |
|---|---|---|
| Disorders due to a very small size at birth | 70 | 25 |
| Multiple births (twins) | 7 | 2 |
| Malpresentation at term (breech, limb, face) | 34 | 12 |
| Obstructed/prolonged labour | 54 | 19 |
| Maternal medical problem during late pregnancy (infection, diarrhoea, eclampsia) | 37 | 13 |
| Unable to specify | 80 | 28 |
| All causes | 282 | 100 |

TABLE 3 *Causes of early neonatal death Matlab 1986*

| Cause of death | Day | | | | First week of life | |
|---|---|---|---|---|---|---|
| | 1 to 3 | | 4 to 7 | | | |
| | No. | % | No. | % | No. | % |
| Disorders due to very small size at birth) | 91 | 63 | 24 | 36 | 115 | 54 |
| Birth trauma/hypoxia | 45 | 31 | 10 | 15 | 55 | 26 |
| Neonatal tetanus | 0 | 0 | 16* | 25 | 16 | 8 |
| Acute respiratory infection | 0 | 0 | 4 | 6 | 4 | 2 |
| Other neonatal disorders | 0 | 0 | 6 | 9 | 6 | 3 |
| Malformation/accident | 3 | 2 | 2 | 3 | 5 | 2 |
| Unable to specify | 6 | 4 | 3 | 5 | 9 | 4 |
| All causes | 145 | 100 | 65 | 100 | 210 | 100 |

13 among males versus 3 among females: OR=4.3, p=0.015.

lab Demographic Surveillance System, the detection of vital events such as births and deaths is likely to be fairly accurate and complete. The definition of stillbirth remains uncertain, when the duration of pregnancy is not precisely known or when the newborn is nor carefully observed at birth.[12]

Death due to a very small size at birth included preterm delivery and intra-uterine growth retardation. Since the mean birthweight measured on a subsample in Matlab was just over 2500 g (unpublished observations), the assessment of an 'unusually small size at birth' by the birth attendants probably referred to birthweights less than 2500 g. Furthermore all complications associated with a very small size at birth were classified as due to it, and no attempt was made to specify the various clinical presentations.

*Sex Differentials*

All of the 16 deaths from neonatal tetanus occurred during the sixth or seventh day of life, 13 of them in males. This significant sex differential confirms male susceptibility to neonatal tetanus detected in other studies.[13] There were no other significant gender differences among the other causes of perinatal death.

Gender differences, however, were evident in perinatal mortality rates, and particularly in stillbirth rates, to the advantage of females. This confirms the findings of D'Souza and Chen.[14] The perinatal period seems to be, in the particularly unfavourable socioeconomic environment of rural Bangladesh, the only time when females express their superior biological resistance.

*Demographic Determinants*

The relationship between perinatal mortality and maternal age and gravidity has been well established since the middle of the century and is consistent in various parts of the world.[12,15,16] Perinatal mortality usually increases with maternal age for a given gravidity. In the present study however, for a given gravidity, there seems to be a U-shaped pattern of risk of perinatal mortality. Similarly, when controlling for age, there seems to be a U-shaped pattern of perinatal mortality. It also appears from Table 4 that there were very few 'elderly primigravidae' over the age of 29 years. This was noted by Swenson and Harper in Matlab in 1966–69.[17]

Among the other biological determinants of still-

TABLE 4 *Perinatal mortality in relation to maternal age and gravidity, Matlab 1982–1984*

| Maternal age | Gravidity | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2–3 | | 4–5 | | 6–7 | | 8–9 | | 10+ | | All | |
| < 20 years | (283) | 115.9 | (80) | 84.7 | (3) | * | (1) | * | (0) | * | (0) | * | (367) | 107.1 |
| 20–24 years | (148) | 92.0 | (240) | 52.7 | (66) | 59.8 | (10) | 120.7 | (0) | * | (0) | * | (464) | 63.1 |
| 25–29 years | (12) | 97.6 | (91) | 69.5 | (145) | 59.1 | (57) | 73.5 | (11) | 125.0 | (0) | * | (316) | 66.4 |
| 30–34 years | (3) | * | (13) | 71.4 | (68) | 70.7 | (80) | 60.0 | (45) | 91.1 | (17) | 193.2 | (226) | 73.6 |
| 35–39 years | (0) | * | (2) | * | (10) | 54.1 | (41) | 72.7 | (55) | 78.5 | (31) | 79.3 | (139) | 70.7 |
| 40+ years | (3) | * | (1) | * | (3) | * | (10) | 64.5 | (26) | 104.4 | (47) | 138.6 | (90) | 113.6 |
| All ages | (449) | 107.2 | (427) | 60.6 | (295) | 61.9 | (199) | 66.2 | (137) | 89.0 | (95) | 114.8 | (1602) | 75.0 |

Figures in parenthesis are number of perinatal deaths
Perinatal mortality ratios per 1000 live births
*: Cells with less than 50 live births or no perinatal deaths.

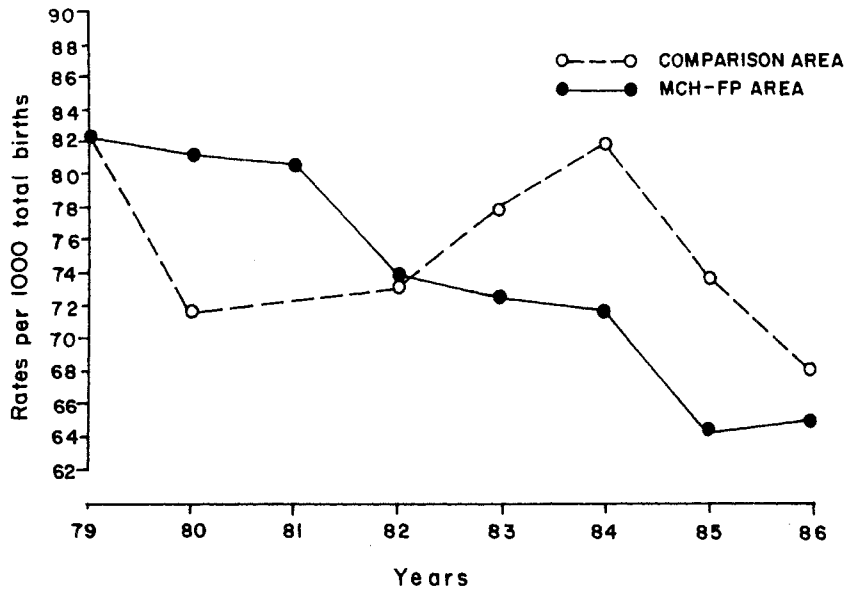


FIGURE 1 *Trends in perinatal mortality by area, Matlab, 1979–86.*

birth and perinatal mortality, studied by Mostafa *et al.* in Matlab during the period 1982–1984, a past history of previous fetal wastage and a short pregnancy interval of less than 18 months were the most significant. None of the social determinants such as maternal and paternal education, and paternal occupation were found to be significantly associated (G Mostafa personal communication).

*Impact of a Family Planning and Health Services Programme*

The somewhat erratic pattern shown by the annual perinatal mortality rates in the comparison area over the eight years covered by this study is not fully understood. It appears that the stillbirth rate has increased since 1983 in the comparison area, while the early neonatal death rate decreased. In the MCH-FP area, however, there was a sustained decrease in perinatal mortality rates. This was mostly due to a decrease in stillbirths during the first years of the study period, and a decrease of early neonatal deaths during the last years of the study period. The actual numbers of live births remained roughly the same in both areas, with a 16% lower figure in the MCH-FP area than comparison area. It was therefore a decreasing number of perinatal deaths and particularly of early neonatal deaths that explained the trends in the MCH-FP area. This is consistent with the decrease in neonatal deaths also observed in that area, and with increasing coverage of tetanus toxoid immunization during the study period (unpublished observations), although no direct causal link can be demonstrated.

The impact of the MCH-FP programme on perinatal mortality, is mostly attributable, in our opinion, to tetanus toxoid immunization of mothers. Iron supplementation of pregnant mothers, treatment of infectious diseases during pregnancy, and use of safe delivery kits during delivery might also have contributed, probably to a lesser extent. Individual measurement of these effects, however, must control for socioeconomic status and education, because some people are likely to use several services, while others may not use any. On the other hand, the theoretically beneficial effect of the recently increased use of contraception in the project area is likely to have been offset

TABLE 5 *Perinatal mortality rates by area during the two periods 1979–1982 and 1983–1986. Matlab 1979–1986*

| | Comparison area | Family planning and health services area (MCH-FP) | p value of the difference between areas |
|---|---|---|---|
| 1979–1982 | 75.0 (1258:16 781) | 79.5 (1098:13 818) | NS |
| 1983–1986 | 75.4 (1208:16 018) | 68.6 (922:13 433) | 0.04 |
| p value of the difference between periods | NS | 0.002 | |

$X^2$ for heterogeneity = 6, df = 1, $p<0.05$

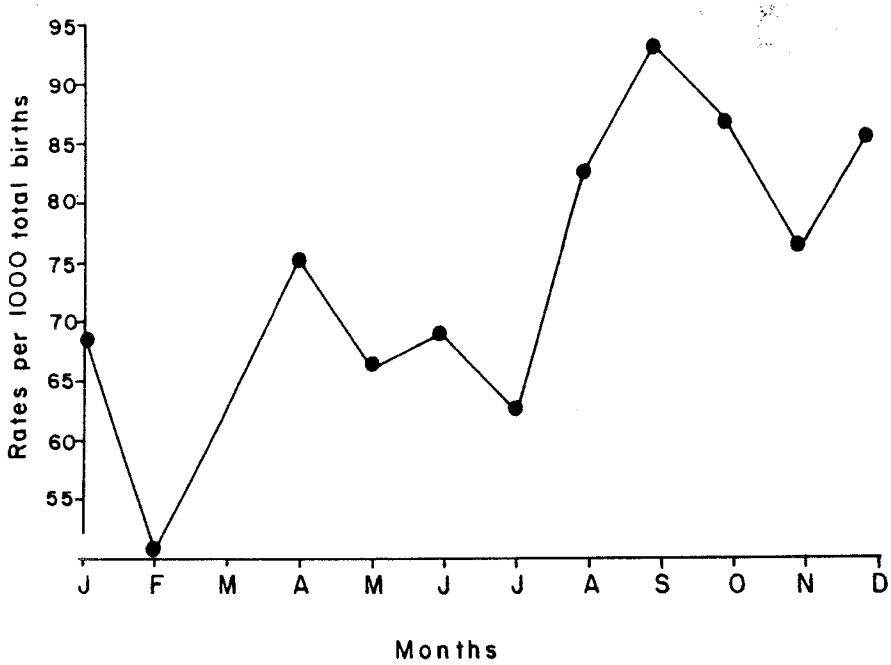


FIGURE 2 *Monthly variations in perinatal mortality rates, Matlab, 1979–86.*

by the resulting shift in the distribution of births from the high-risk group of high parities to the even higher risk group of primigravidae.[18,19] In fact, the risk of perinatal mortality may be higher among women who refused family planning, among those who failed in the use of contraception, or who had their first pregnancy. This group of women represent more and more of the total births when family planning use increases.

In conclusion, the decline in perinatal mortality, expressed as a rate per 1000 total births, was modest and was more likely to be the result of healthcare than family planning interventions. A lot remains to be done if further decline is to be achieved.

*Policy Implications*

Several authors have suggested that the underlying causes of late fetal deaths resulting in stillbirths are similar to those of early neonatal deaths.[20] It is often a matter of chance whether the foetus dies *in utero* shortly before delivery or whether it is born alive and succumbs shortly after delivery. The great majority of these causes are environmental, ie they are directly related to the mother's health[21] and therefore they must be managed during pregnancy and delivery.

What are the options for reducing the high rates of perinatal mortality in settings like rural Bangladesh, where 99% of births take place in homes with no assistance or only the attendance of a traditional midwife? Socio-cultural changes such as more widespread education, higher income and freer movement of women outside of their homes are essential, and underway, but their effects will take time to produce results. Maternity clinics or obstetric wards in hospitals are being built but are unlikely to attract rural women. In rural situations, only community-based and outreach-oriented maternity care programmes have the potential to reach village women. Currently two approaches are being tried; training traditional birth attendants (TBAs),[22,23] and posting trained midwives to outlying areas.

The impact of training TBAs on perinatal mortality has been debated.[24] The other strategy, which should not be viewed as an alternative but as a complement, needs to be tested in Bangladesh.[25] Another potentially useful component of a community-based programme would be adequate nutritional education eg insisting on early colostrum feeding and dispelling feeding taboos during pregnancy and the post-partum period.

The effect of such interventions in reducing perinatal mortality in settings such as rural Bangladesh, however, will be limited by several factors. Maternal nutritional status has been shown to be generally poor, and to follow seasonal variations according to food availability, economic activity and infectious diseases.[26,27] These seasonal nutritional variations, including a deficit from October to January, may partially explain the higher perinatal mortality rates observed during the same months.

Availability and efficacy of referral systems for delivery complications will have an impact. The requirements for these systems to be effective include rapid transportation, well-maintained infrastructures, trained and dedicated staff, and confidence on the part of the community. All conditions which are yet to be met in rural Bangladesh. Intervention studies are required to determine what reduction of perinatal mortality can be achieved and at what cost.

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## IV.3. MORTALITE DUE AUX MALADIES DIARRHEIQUES

Etant données les relations très particulières de l'ICDDR,B et de Matlab avec les maladies diarrhéiques en général et le choléra en particulier, il était nécessaire d'accorder une attention spéciale à ces maladies en tant que causes de décès. Les publications référencées "M3"[29] et "M4"[30] font état d'études sur les rôles respectifs des trois catégories de maladies diarrhéiques en tant que causes de décès: diarrhées hydriques responsables de déshydratation aigue, diarrhées de type dysentérique aigu[31] responsables de septicémies, d'hyperthermies ou d'hypoglycémies, et diarrhées chroniques ou persistantes responsables de malnutrition grave. De plus ces études différencient les trois types de diarrhées selon deux catégories d'âge: chez les nourrissons de moins d'un an et chez les enfants de un à quatre ans. Les résultats montrent des différences notables, avec une prédominance des morts par diarrhée aigue déshydratante chez les nourrissons, et une large prédominance des morts par complications de diarrhées persistantes et, dans une moindre mesure, des diarrhées dysentériques, chez les enfants de un à quatre ans. Ces résultats ont des implications bien précises, et bien individualisées dans les articles mentionnés, sur les potentiels des interventions en matière de maladies diarrhéiques. Nous y reviendrons dans les chapitres suivants.

Nous abordons maintenant une autre catégorie d'applications de la méthode d'"autopsie verbale", celles qui permettent de guider, de préciser, d'affiner le processus de décision dans le choix de telle ou telle intervention dans un domaine spécifique.

# Diarrhoea Mortality in Rural Bangladeshi Children

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**Summary**

**Diarrhoeal mortality and hospital admissions for diarrhoea are described among children under the age of 5 years in a large rural Bangladeshi community during 1986–87. Acute watery (dehydrating) diarrhoea was associated with 11 per cent of all deaths among infants aged 1–11 months and 5 per cent among children aged 1–4 years. Acute non-watery diarrhoea, including bloody dysentery and diarrhoea with mucoid stools, was associated with 16 per cent of all deaths among children aged 1–4 years. In this age group, persistent diarrhoea, particularly when accompanied by recent and/or severe wasting, was associated with 63 per cent of all diarrhoeal deaths and 34 per cent of all deaths.**

**These data suggest that exclusive emphasis on ORT will have little impact on diarrhoea mortality among children in rural Bangladesh. A broader strategy, both preventive and curative, including measles immunization, nutrition education, dietary management of diarrhoea, and the treatment of dysentery in the community, carries a greater potential.**

## Introduction

Diarrhoeal diseases are estimated to be responsible for five million infant and child deaths annually in the world, the great majority of them occurring in the poor areas of the developing countries.[1] Oral rehydration therapy (ORT), a cornerstone of the universal strategy for child survival launched in the late 70s, was expected to prevent more than half of these deaths worldwide.[2] Ten years later, the results of the few studies which critically evaluated the impact of ORT on mortality remain confusing.[3–6]

Few studies have separated the relative effects on mortality of different clinical types of diarrhoeas, namely watery or dehydrating, invasive or dysenteric, and persistent (defined by duration more than 2 weeks rather than by stool characteristics). Since ORT is likely to have an impact mostly on watery and potentially dehydrating diarrhoeas, differences in case mix of diarrhoeas from place to place may help to explain variations of the impact of ORT programmes in different places.

In this study, efforts have been made to distinguish the contribution of different types of diarrhoea to infant and child mortality in rural Bangladesh. Based on data collected from a large rural community under intensive surveillance and served by a diarrhoea hospital, the paper describes diarrhoeal mortality and hospital admission among children in 1986–87. Policy implications are discussed, emphasizing the need to include interventions against non-watery diarrhoeas in control strategies.

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## Material and Methods

*Study area*

Since 1963, the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B, known as Cholera Research Laboratory up to 1978), has maintained a Diarrhoea Treatment Centre (DTC) at its field station in Matlab, 45 km south-east of Dhaka. Initial studies were concerned with the epidemiology of diarrhoeal diseases and field testing of cholera vaccines. For that purpose, a Demographic Surveillance System (DSS) was started in 1966, continuously recording births, deaths, marriages and migrations.[7] Typical of many districts of southern Bangladesh, Matlab is located in a riverine low-lying area, with a subsistence agricultural economy, and poor communications. It had, in 1986, a high population density (700 per km$^3$), a high infant mortality (100 per 1000 live births), and a low literacy rate (30 per cent among adults).

  

In 1978, an intensive Family Planning and Health Services Project was initiated in half of the study villages, representing the MCH-FP area.[8] The remaining half served as a comparison area, where free treatment for diarrhoea at the DTC and distribution of ORS packets were added to the services provided by the government health programme. In 1986, the population was approximately 95 400 in the treatment area and 94 300 in the comparison area.

ORT was first introduced in Matlab for home treatment of diarrhoea in 1978.[9] The distribution and promotion of glucose ORS packets for use in any case of diarrhoea started in half of the treatment area and half of the comparison area in 1979 and was extended to the whole area in July 1981.[10] All ORS packets in use in the Matlab project were produced locally and, since 1986, they have been standardized to contain sugar and salts needed to make 1/2 litre of solution. In the MCH-FP area, Community Health Workers (CHWs) have identified a woman called 'Bari-Mother' in each cluster of households surrounding a courtyard (bari), and trained her in the promotion and distribution of ORS packets.[11] In the comparison area, ORS packets are distributed by the field demographic workers during their routine visits. Therefore, everyone in the two areas has access to ORS packets and to the DTC located in Matlab Bazar.

A large community-based oral cholera vaccine trial took place in 1985 in the whole area under demographic surveillance. The results, so far, indicate a reduction of admissions to the DTC for acute watery diarrhoea, but no reduction of diarrhoea mortality among vaccinated children.[12,13]

*Mortality data*

Over the whole DSS area, each household was visited twice a month by female resident village health workers to detect and record all deaths which occurred since the last visit. This information was passed to health assistants who interviewed the relatives in their home, asking details about the events and symptoms preceding death. These death histories were distributed to three physicians who reviewed the information independently and assigned a most likely cause of death. Their findings were matched and the majority rule was applied in case of two-to-one disagreement. In case of complete disagreement the forms were sent back to the field for additional information and then re-examined. All death forms were then coded according to a classification derived from the WHO-recommended classification.[14]

In the absence of aetiological information for diarrhoea-related deaths, a classification by stool characteristics and timing, as reported by the mother, was used: the term 'acute watery diarrhoea' referred to liquid stools containing mostly water and very little solid material passed more frequently than usual. The other types of diarrhoea lasting less than 2 weeks, either with mucoid or bloody stool, were called 'acute non-watery diarrhoea'. The term 'persistent diarrhoea' was used when the diarrhoeal episode had lasted more than 2 weeks before death, regardless of the clinical characteristics of the stools. Persistent diarrhoea associated with severe and/or recent wasting was categorized separately. Given that the total population under 5 years was around 30 000, it was impossible to get an objective measure of the degree of malnutrition prior to death. Hence, the diagnosis of 'severe malnutrition' was applied when parents or relatives of the deceased child had noted a rapid and/or recent wastage of the child's tissues prior to death, and/or the recent apearance of tibial oedema. In a subsample of 253 cases for which measurement of the mid-upper-arm circumference was taken within a month of death, the degree of agreement between the assessment of severe malnutrition by verbal autopsy and by arm-circumference of less than 110 mm prior to death was 86 per cent.

Deaths with diarrhoea observed within 6 weeks of measles were pooled in a category called 'post-measles diarrhoea'.

*Hospital admission data*

The Matlab DTC admits patients from the entire DSS area (MCH-FP and comparison) and also from the neighbouring districts. The data used for this study refer only to under-5 children living in the DSS area. A stool culture on rectal swab was done routinely for all admitted cases, looking for *Vibrios*, *Shigella*, and *Salmonella* species.

## Results

*Diarrhoeal mortality*

Table 1 gives the numbers and percentages of diarrhoeal deaths by type of diarrhoea and age for the entire DSS area. Out of a total of 60 669 under-5 child/years of exposure, there were 520 diarrhoeal deaths (8.6 per 1000 children per year). The proportion of diarrhoeal deaths increased from 1 per cent of all deaths during the first month of life to 65 per cent during the third year of life. This proportion declined to 46 and 48 per cent of all deaths during the fourth and fifth years of life, respectively.

Acute watery diarrhoea (AWD) was the most important cause of diarrhoeal deaths at ages 1–11 months, responsible for 11 per cent of all deaths and 40 per cent of all diarrhoeal deaths (60/149). At ages 1–4 years, however, AWD was a relatively more modest cause of death, responsible for only 5 per cent of all deaths and 9 per cent of all diarrhoeal deaths (34/363).

Among children who died at ages 1–4 years, the other types of acute diarrhoea (mucoid, bloody) taken together were a more important cause of death than AWD. They were associated with 9 per cent of all deaths and 16 per cent of all diarrhoeal deaths (58/363). Among children who died from these causes, 68 per cent had a history of blood in stool.

TABLE 1

*Diarrhoeal mortality by age and type, Matlab, 1986–87 and percentage of all causes of death in the age group considered*

| | Less 1 month | | 1–11 months | | 12–23 months | | 24–35 months | | 36–47 months | | 48–59 months | | 1–4 years | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cause of death | *n* | % | *n* | % | *n* | % | *n* | % | *n* | % | *n* | % | *n* | % |
| Acute watery diarrhoea | 4 | 0.6 | 60 | 11.0 | 18 | 5.8 | 5 | 2.7 | 5 | 4.3 | 6 | 9.4 | 34 | 5.0 |
| Ac. bloody or mucoid diar. | 3 | 0.4 | 33 | 6.1 | 28 | 8.9 | 16 | 8.6 | 7 | 6.1 | 7 | 10.9 | 58 | 8.6 |
| Post-measles diarrhoea | 0 | 0.0 | 2 | 0.4 | 16 | 5.1 | 17 | 9.2 | 5 | 4.3 | 3 | 4.7 | 41 | 6.1 |
| Persistent diarrhoea | 1 | 0.1 | 19 | 3.5 | 22 | 7.0 | 12 | 6.5 | 6 | 5.2 | 2 | 3.1 | 42 | 6.2 |
| Persistent diarrhoea with severe/recent wasting | 0 | 0.0 | 35 | 6.4 | 75 | 24.0 | 70 | 37.8 | 30 | 26.1 | 13 | 20.3 | 188 | 27.8 |
| All diarrhoeal diseases | 8 | 1.1 | 149 | 27.4 | 159 | 50.8 | 120 | 64.9 | 53 | 46.1 | 31 | 48.4 | 363 | 53.6 |
| Other causes of death | 705 | 98.9 | 395 | 72.6 | 154 | 49.2 | 65 | 35.1 | 62 | 53.9 | 33 | 51.6 | 314 | 46.4 |
| All deaths | 713 | 100.0 | 544 | 100.0 | 313 | 100.0 | 185 | 100.0 | 115 | 100.0 | 64 | 100.0 | 677 | 100.0 |

TABLE 2
*Characteristics of children who died from four different types of diarrhoea in Matlab, 1986–87* (n = 520)

| Characteristics | Ac. Watery (98) | Ac. Non-Wat. (94) | Persistent (265) | Post-measles (43) |
|---|---|---|---|---|
| Percentage of all deaths under 5 years of age | 5 | 5 | 14 | 2 |
| Percentage of all deaths at ages 1 to 59 months | 8 | 8 | 22 | 4 |
| Mean age (months) | 13 | 20 | 23 | 27 |
| % Females | 53 | 56 | 73 | 65 |
| % Died during dry season | 68 | 49 | 43 | 60 |
| % Died in hospital | 10 | 3 | 4 | 2 |
| % Consulted no doctor | 7 | 7 | 4 | 9 |
| % Consulted M.D. | 42 | 27 | 37 | 9 |
| % Consulted village doctor | 69 | 81 | 89 | 88 |
| % From comparison area | 57 | 55 | 67 | 93 |
| Associated symptoms | | | | |
| % with blood in stool | 3 | 68 | 71 | 77 |
| % w/sev/recent malnutr | 5 | 16 | 45 | 23 |
| % with tibial oedema | 2 | 9 | 46 | 16 |
| % with pneumonia | 2 | 4 | 3 | 7 |
| % w/mouth ulcers | 7 | 7 | 17 | 47 |

TABLE 3
*Hospital admissions by age and aetiological agent isolated, Matlab, 1986–87*

| | 1–11 months | | 12–23 months | | 24–35 months | | 36–47 months | | 48–59 months | | 1–4 years | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aetiological agent | *n* | % adm* | *n* | % adm* | *n* | % adm* | *n* | % adm* | *n* | % adm* | *n* | % adm* |
| Cholera El Tor | 22 | 2.9 | 52 | 5.2 | 55 | 11.3 | 47 | 14.5 | 40 | 21.1 | 194 | 9.7 |
| Cholera classical | 15 | 2.0 | 51 | 5.1 | 56 | 11.5 | 54 | 16.7 | 36 | 18.9 | 197 | 9.8 |
| Non-cholera *Vibrio* | 52 | 6.9 | 100 | 10.0 | 54 | 11.1 | 43 | 13.3 | 16 | 8.4 | 213 | 10.6 |
| *Shigella shiga* | 7 | 0.9 | 19 | 1.9 | 19 | 3.9 | 12 | 3.7 | 14 | 7.4 | 64 | 3.2 |
| *Shigella flexneri* | 30 | 4.0 | 62 | 6.2 | 57 | 11.7 | 30 | 9.3 | 13 | 6.8 | 162 | 8.1 |
| Other *Shigella* | 9 | 1.2 | 15 | 1.5 | 8 | 1.6 | 6 | 1.9 | 0 | 0.0 | 29 | 1.4 |
| Total positive | 135 | 18.0 | 299 | 29.8 | 249 | 51.0 | 192 | 59.3 | 119 | 62.6 | 859 | 42.9 |
| Culture negative | 604 | 80.5 | 686 | 68.5 | 229 | 46.9 | 125 | 38.6 | 67 | 35.3 | 1107 | 55.2 |
| No culture done | 11 | 1.5 | 17 | 1.7 | 10 | 2.0 | 7 | 2.2 | 4 | 2.1 | 38 | 1.9 |
| Total admissions | 750 | 100.0 | 1002 | 100.0 | 488 | 100.0 | 324 | 100.0 | 190 | 100.0 | 2004 | 100.0 |

*Percentage of all hospital admissions in the age group.

Deaths related to post-measles diarrhoea accounted for 5 per cent of all child deaths and 11 per cent of all diarrhoeal deaths (41/363). However, they occurred almost exclusively in the comparison area, where the measles-immunization programme had not been implemented.

In the age group 1–4 years, persistent diarrhoea with or without severe wasting accounted for the highest proportion of all deaths and of diarrhoeal deaths, 63 (230/363) and 34 per cent (230/677), respectively.

Table 2 shows that the mean age of children who died from acute watery diarrhoea was 13 months, as opposed to 20 and 23 months for acute watery diarrhoea and persistent diarrhoea, respectively. The proportion of female children dying from persistent and post-measles diarrhoea was higher than for acute diarrhoea. Blood in stools was found in more than two-thirds of children who died from acute non-watery and persistent diarrhoea, and 77 per cent of those who died of post-measles diarrhoea. The proportion of children with signs of severe malnutrition, including tibial oedema, was highest among those who died with persistent diarrhoea.

*Hospital admissions*

Table 3 shows the admissions and pathogens isolated at the Matlab DTC during 1986–87, broken down by age. Out of a total of 2754 admissions of children aged 1–59 months from the DSS area, the age groups with the most admissions were children 12–23 months (36 per cent of the total) and infants aged 1–11 months (27 per cent). These age groups were also those with

the highest proportions of negative cultures, perhaps a result of high rates of enterotoxigenic *Eschericia coli* and rotavirus diarrhoeas, which, for technical reasons, were not looked for in the laboratory surveillance. There was a progression with age of the rate of cholera vibrios isolated, from a low 5 per cent of all admissions among infants aged 1–11 months to 40 per cent of all admissions among children aged 1–4 years. The isolation rate of Classical cholera was similar to that of El Tor. The rate of *Shigella* isolated was low in the first 2 years of age, reached a peak of 18 per cent among children aged 24–35 months, and declined slightly in older children. The isolation rate of *Shigella shiga* increased with age, but *Shigella flexneri* was the most common shigella in most age groups.

During the same period the distribution of clinical presentation for patients admitted varied with age, from 79 per cent watery diarrhoea and 12 per cent bloody dysentery among infants aged 1–11 months, to 64 per cent watery diarrhoea and 27 per cent bloody dysentery among children aged 1–4 years (J. Clemens and F. van Loon, personal communication).

## Discussion

This study attributes a relatively modest role to AWD in overall diarrhoeal mortality among the children of Matlab in 1986–87.

The data on mortality were based on a well supervised longitudinal demographic surveillance, unlikely to miss deaths. The assessment of cause of death, because it involved several physicians, was presumably more reliable than previously used systems. Yet there remains some uncertainty on the cause of death when multiple factors were involved. The contribution of malnutrition in diarrhoea-related deaths relied not on anthropometry, but on the perception of wasting by the mother, which is likely to lead to an underestimate. Studies from the same community using a prospective approach and anthropometry, however, attributed a similar proportion of diarrhoeal deaths to severe malnutrition (49 *v.* 47 per cent in our study).[16]

Hospital data provide a partial picture and should be interpreted with caution because there was no systematic attempt to isolate viruses, protozoa, ETEC, *Campylobacter jejuni*, and other pathogens known to cause diarrhoea.

The findings of this study, at odds with the common concept that dehydrating diarrhoeas are the leading cause of mortality and morbidity among young Bangladeshi children,[17–19] may be the result of either a successful ORT programme in Matlab, or a change in the nature of diarrhoeal diseases among children.

In favour of the former interpretation, the success of the Matlab ORT programme lies in the almost universal availability of ORS packets in the entire area, and the almost universal knowledge of home-made solutions. However, the analysis of ORS consumption during the study period indicates that children with acute watery diarrhoea consume less than 1 litre of rehydration solution during the entire first week. A recent study evaluating the knowledge and practice of ORT among the mothers of Matlab showed that although 99 per cent of them knew ORT, only 67 per cent of those whose child had a watery diarrhoea episode claimed to have used it (Sh. Islam, personal communication). Attempts to evaluate the impact of ORT on diarrhoeal mortality in Matlab have been inconclusive.

The low contribution of AWD to mortality is unlikely to be due to the oral cholera vaccine trial of 1985 since this trial involved a small number of the children considered in this study, and also had no measurable impact on infant and child mortaility.

In favour of a change in the aetiology of diarrhoeal diseases among Bangladeshi children, a few community-based mortality and morbidity observations tend to confirm the recent increase of non-watery diarrhoea across the country, since 1984.[15,20–22] The contribution of *Shigella* pathogens, however, is not clear from all these reports. A study from rural Bangladesh showed that the presence of blood in stool had a positive predictive value of 50 per cent for *Shigella* infection.[15] Since 68 per cent of the children who died from acute non-watery diarrhoea had a history of blood in stools in the 2 weeks preceding death, one may estimate that at least 34 per cent of these deaths may be due to *Shigella*. An outbreak of *Shigella dysenteriae* type I was identified at the Matlab DTC in 1984–85.[22]

In this study, the second and third years of life were shown to be the most important with regard to non-watery diarrhoea mortality. This may be due to an increased exposure to enteric pathogens due to the introduction of contaminated weaning foods, or to an increased susceptibility to invasive pathogens as a result of malnutrition which is common at this age.[23,24]

*Policy implications*

The findings of this study suggest that, to decrease diarrhoeal mortality in this community, the strategy of diarrhoeal control programmes should be broadened.[25] First, the use of ORT should be reinforced, particularly among infants which is the age group most sensitive to dehydration.[26] Education campaigns should emphasize the life-saving capacity of ORT in infants with a watery diarrhoea. Promoting the unselective use of ORS, for example, for non-watery diarrhoea, may have a negative effect because mothers do not perceive any efficacy of this labour-intensive and time-consuming process.[27]

Secondly, of the preventive measures potentially capable of reducing diarrhoea mortality, measles immunization might be one of the most effective in areas like Matlab, where post-measles diarrhoea mortality is high. Improvement of nutritional status of

children under-5 years old is also likely to prevent diarrhoea deaths. Case-fatality is considerably higher in malnourished children,[28,29] who are also more often predisposed to persistent diarrhoea.[24,30] Nutritional status is, to a large extent, influenced by food availability at the household level.

Thirdly, curative approaches to control dysentery should be promoted, including early detection and home treatment in the community.[15] Yet, the potential impact of a curative intervention may be limited by operational constraints and increased bacterial resistance to antibiotics. A recent study in Matlab showed that most children with dysentery received some antibiotics from village practitioners, but only 10 per cent of them received a correct one at a correct dose.[31]

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# Persistent diarrhea as a cause of childhood mortality in rural Bangladesh

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To determine the importance of persistent diarrhea in childhood mortality a multiple-step verbal autopsy method was used to study 1934 deaths in Matlab, Bangladesh. We found that most of the deaths from acute watery diarrhea occurred in infancy, whereas the peak of non-watery diarrhea deaths was in children over 12 months of age. Children suffering from persistent diarrhea and malnutrition were at highest risk of dying during their third year of life. Children with infectious diseases have a two to four times higher risk of dying if they are malnourished, and for diarrhea the risk is 17 times as high. Forty-nine percent of the diarrheal deaths were in children with malnutrition associated with persistent diarrhea. These results imply that fluid and dietary management are key aspects in the treatment of diarrhea, particularly for those episodes which persist. We conclude that attempts to reduce diarrhoeal deaths with vertical ORT programmes will not have a major impact unless other interventions are directed to the persistent diarrhoea–malnutrition complex. □ *Control, malnutrition, mortality, persistent diarrhea*

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In developing countries diarrhea remains a major cause of death in children one to five years of age even where there is widespread use of oral rehydration therapy (1). Apart from dehydration the other causes of diarrheal deaths are poorly understood (2).

In Bangladesh ORT has been the main component of the strategy to reduce diarrheal deaths. However, to plan diarrheal control programs a clear assessment of the specific types of diarrheal deaths and their age distribution should be made, particularly because ORT is unlikely to have an impact on dysentery and persistent diarrhea. This paper describes diarrheal deaths in Matlab, Bangladesh with a focus on persistent diarrhea to assist the planning of future diarrhea control strategies.

## Methods

The Matlab study area, located in the deltaic flood plain at the junction of the Ganges and the Meghna rivers, is representative of rural southern Bangladesh. It has a subsistence agricultural economy, poor intrastructure and communications, uneven land distribution, and socioeconomic indicators among the lowest in the world (3). Since 1966 the International Centre for Diarrheal Disease Research, Bangladesh (ICDDR,B) has maintained a demographic surveillance system (DSS) in a population which amounted to 200,000 in 1986–87. Periodic censuses are updated by longitudinal recording of births, deaths, marriages and migrations (4). This study area comprises a Maternal and Child Health and Family Planning (MCH-FP) project area, where intensive FP program and various MCH interventions are operated by the ICDDR,B since 1978 (5), and a comparison area of the same size, serviced by the national health program, with the addition of free access to diarrhea treatment centres operated by the ICDDR,B. This study reports data from the comparison area only.

In 1986–87 the assessment of the cause of death of children was made through a multiple-step procedure called 'verbal autopsy' (6, 7). Whenever deaths were reported by community health workers during their routine biweekly health visits, health assistants interviewed the nearest relatives to record socio-demographic information and write a semi-structured description of events and symptoms preceding death. This information was recorded on a special form in the local language, without attempting to make a diagnosis at this stage. These forms were then distributed to three medical officers of the project, who assigned their diagnosis independently, giving priority to the final cause of death. A cause of death was accepted when two or three of the reviewers agreed on the diagnosis. In case of complete disagreement, which was about 15% of cases, the forms were returned to the field for additional

information and then re-entered into the process. For about 8% of deaths, however, it was not possible to assign a cause.

A classification of stool characteristics and timing, as reported by the mother, was used: the term acute watery diarrhea referred to liquid stools containing mostly water and very little material passed more frequently than usual. The other types of diarrhea lasting less than two weeks were described as either mucoid or bloody depending on the visual appearance of the stool. The term persistent diarrhea was used when the diarrheal episode had lasted more than two weeks before death, regardless of the characteristics of the stools. Separate categories were made for persistent diarrhea with severe malnutrition.

In most cases it was impossible to get an objective measure of the degree of malnutrition prior to death. Hence the term 'severe malnutrition' was applied when parents or relatives of the diseased child had reported a rapid and/or recent wastage of the child's tissues prior to death, and/or the recent appearance of tibial oedema. In a subsample of 253 cases for which measurement of the mid-upper arm circumference (MUAC) had been made within a month of death, the degree of agreement between the assessment of severe malnutrition by verbal autopsy and by a MUAC less than 110 mm prior to death was 86% (sensitivity: 76% and specificity: 91% for a MUAC less than 110 mm). The denominators for calculation of global and cause-specific death rates were provided by the DSS, and expressed in child-years of exposure to the risk of death. Differences between groups were tested by comparison of incidence density ratios, and 95% confidence intervals (CI) of risk ratios by the Miettinen test-based method (8).

## Results

Table 1 shows that during the neonatal period diarrhea accounts for only 1% of the total number of deaths; however, after infancy about half of the deaths are associated with diarrhea. Most of the deaths from acute watery diarrhea occur among post-neonatal infants when the majority of childhood deaths occurred. The peak of deaths from non-watery diarrhea occurs after infancy. The number of deaths associated with persistent diarrhea is similar to the other non-watery diarrheas except when it is associated with severe malnutrition. The proportion of deaths from the malnutrition–persistent diarrhea syndrome increases rapidly with age with a peak during the third year of life. Children dying from this syndrome account for less than 1% of deaths in the neonatal period, 6% in post-neonatal, and 28% in the 1–4-year-old period. Between 24 and 35 months of age more children die from the malnutrition/persistent diarrhea complex than from all the non-diarrhea causes of death combined.

In this study we used the age range 6–35 months to estimate the contribution of severe malnutrition to childhood mortality since it captures the period of weaning and also when children are at a high risk of dying from infectious diseases. To support the verbal autopsy data we applied the previously reported finding that in the comparison area 6% of children 6–36 months had a MUAC equal to or less than 110 mm in 1986 (9). We estimated that there were 977 severely malnourished children in the study area and that 115 out of 222 diarrheal deaths occurred among them (Table 2). By difference, it was estimated that the 107 deaths not associated with malnutrition occurred among a total of 15,299 non-severely malnourished children. Hence the relative risk of dying from diarrhea among severely malnourished as opposed to non-severely malnourished children was 17 ($p < 0.001$). Among the 133 persistent diarrhea cases, 108 (81%) were associated with malnu-

*Table 1.* Diarrheal deaths (%) by age and type. Matlab 1986–87.

| | Age in months | | | | | |
|---|---|---|---|---|---|---|
| | <1 | 1–11 | 12–23 | 24–35 | 36–47 | 48–59 |
| All deaths N= | 713 | 544 | 313 | 185 | 115 | 64 |
| Acute watery | 0.6 | 11.2 | 7.3 | 4.3 | 5.2 | 10.9 |
| Acute M/bloody | 0.4 | 6.2 | 12.5 | 13.5 | 8.7 | 14.0 |
| Persistent | 0.1 | 3.5 | 7.0 | 6.5 | 5.2 | 3.1 |
| Persistent with severe malnutrition | 0 | 6.4 | 24.0 | 37.8 | 26.1 | 20.3 |
| All diarrhea | 1.1 | 27.4 | 50.8 | 64.9 | 46.1 | 48.4 |
| All other | 98.9 | 72.6 | 49.2 | 35.1 | 53.9 | 51.6 |

*Table 2.* Estimated relative risk of death with severe malnutrition by cause. Matlab 1986–87.

| | All children | | +S.M. | | −S.M. | | |
|---|---|---|---|---|---|---|---|
| Cause of death | N | R[a] | N | R | N | R | RR (95% CI) |
| Persistent diarrhea | 133 | 8.2 | 108 | 110.5 | 25 | 1.6 | 67.6 (54.0–84.7) |
| Acute diarrhea | 89 | 5.4 | 7 | 7.2 | 82 | 5.3 | 1.4 (0.6–2.9) |
| All diarrhea | 222 | 13.6 | 115 | 117.8 | 107 | 7.0 | 16.8 (13.9–20.4) |
| Measles | 47 | 2.9 | 10 | 10.2 | 37 | 2.4 | 4.2 (2.2–8.0) |
| Other inf. | 85 | 5.2 | 10 | 10.2 | 75 | 4.9 | 2.1 (1.1–4.0) |
| All others | 58 | 3.6 | 4 | 4.1 | 54 | 3.5 | 1.2 (0.4–3.2) |
| Total | 412 | 25 | 139 | 142 | 273 | 18 | 8.0 (6.7–9.4) |
| No. of children | 16276 | | 977 | | 15299 | | |

[a] = Rate per 1000 children aged 6–35 months.

trition compared to 25 (19%) without malnutrition, having a relative risk of 68. Similarly, the relative risk was 4.2 for measles ($p < 0.001$), 2.1 for other infectious diseases ($p = 0.02$), and 1.2 for other causes, which include accidents and non-infectious diseases.

## Discussion

Verbal autopsy is a practical method to evaluate the cause of death and can be very helpful in formulating health policies (6, 7, 10). This method is most useful in settings like rural Bangladesh, where over 90% of deaths occur in villages which are away from medical care, and there are no hospital records or post mortem autopsies. The Matlab surveillance system, using resident village health workers to locate and record all deaths during their twice monthly visits, was vastly improved by the involvement of several physicians in the diagnosis of cause of death. Nevertheless, the validity of these results was limited by the multiple illnesses associated with these deaths and also the reliance on mothers' perception of wasting rather than anthropometry in diagnosing severe malnutrition. However, longitudinal studies using anthropometry in the same area attributed 49% of diarrheal deaths to severe malnutrition (11) and this was similar to the 47% in this study.

This study shows that malnutrition significantly increases the risk of dying in children suffering from infectious diseases, particularly those with persistent diarrhea. These assessments of increased risk might still be underestimates, since the diagnosis of severe malnutrition was made through lay reporting of events and symptoms preceding death. Malnutrition is quite common in this community and a parent's perception of severe malnutrition is likely to occur only in cases of extreme wasting. A previous study in this area showed that the proportion of deaths attributable to severe malnutrition ranged from 37 to 51% in accordance with the type of other associated factors (9).

Oral rehydration therapy was introduced in Matlab in 1979 and has been the main component of the diarrhea control program. This study shows that because of, or in spite of, the ORT program persistent diarrhea and its associated conditions demand a high priority when planning the future control strategy. Because most child deaths associated with watery diarrhoea occur in children of less than one year of age, special emphasis should be placed on giving ORT to infants. While support for ORT should continue there is a clear need for specific measures to reduce the number of deaths from non-watery diarrhoea, particularly in children 1–4 years old. The effectiveness of rehydration therapy in preventing deaths due to dysentery and persistent diarrhea is uncertain. Diarrhea control programs which focus on rehydration therapy must also emphasize the importance of feeding during and after diarrhea to achieve a major impact on diarrheal mortality. Furthermore, the persistent diarrhea–malnutrition complex should be tackled at the same time. Although the pathogenesis of persistent diarrhea is unclear, its association with malnutrition prompts action towards optimal nutritional management. Some trials of dietary therapy using elemental formulations have been used successfully to treat this syndrome (13) but the goal must be to identify locally available ingredients which are shown to be efficacious (14) and also inexpensive and culturally acceptable. We conclude that a strategy broader than fluid replacement is necessary for diarrheal control in Bangladesh, since a large proportion of deaths occur in malnourished children with persistent diarrhoea.

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# V. APPLICATIONS DE LA METHODE POUR GUIDER, AFFINER, LES INTERVENTIONS SPECIFIQUES

L'utilisation de la méthode d'autopsie verbale avait permis de démontrer la contribution de la malnutrition grave dans la mortalité des enfants de six à trente-six mois[32], et d'affiner la définition des groupes à risque de décès par malnutrition grave. Elle avait aussi permis de guider les interventions pour améliorer la santé en matière de reproduction chez les femmmes de Matlab[33] par la mise en place d'un programme de soins obstétricaux décentralisés[34], programme dont l'évaluation par la méthode d'autopsie verbale est rapportée au chapitre suivant.

Nous voyons maintenant plus en détail ce type d'application dans les domaines des maladies diarrhéiques et de la rougeole.

## V.1. MALADIES DIARRHEIQUES

Dans une partie de la publication "G1"[35] il est fait appel à l'examen des taux spécifiques de mortalité par maladies diarrhéiques selon leur type (diarrhée aigue déshydratante ou diarrhée de type dysentérique) et selon l'âge au moment du décès (nourissons de moins d'un an ou enfants de un à quatre ans). Les résultats sont confrontés à ceux de l'examen des taux de prévalence des divers types de diarrhée et des taux d'admission à l'hôpital par type de diarrhée et par âge. Ils permettent de conclure que si les programmmes de lutte contre les maladies diarrhéiques devraient insister sur la promotion de la réhydratation orale dans le groupe d'âge des moins d'un an, ils devraient en revanche donner une place plus grande, dans les régions rurales du Bangladesh au moins, aux interventions curatives et préventives dirigées contre les diarrhées de type dysentérique, telles que le dépistage et le traitement précoces des épisodes aigus de dysenterie, la gestion et la récupération nutritionelles de ces épisodes, et les opérations d'hygiène et d'assainissement.

Nous verrons plus loin l'application de la méthode de détermination des causes de décès àl'évaluation de ces interventions en matière de maladies diarrhéiques.

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# Is acute watery diarrhoea an important cause of morbidity and mortality among rural Bangladeshi children?

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**Abstract**

To assess the relative importance of acute watery diarrhoea (AWD) and other types of acute diarrhoea as causes of morbidity and mortality among infants and 1–4 years old children, we examined 3 different data sources from the Matlab field project of the International Centre for Diarrhoeal Disease Research, Bangladesh. In infants, prevalence rates for AWD and non-watery diarrhoea were similar. In children, prevalence of AWD was 1·8 times lower than prevalence of other acute diarrhoeas. In infants, admission rate to a diarrhoea hospital was 4·1 times higher for AWD than for other acute diarrhoeas ($P<0·001$). In children, admission rate was only 1·7 times higher for AWD than for acute diarrhoeas ($P<0·001$). Infant mortality was 1·7 times higher for AWD than for other acute diarrhoeas, but child mortality was 3 times lower for AWD. These data suggest that, while diarrhoeal disease control programmes should give more importance to oral rehydration therapy in infants, field management of the other types of acute diarrhoea should receive more emphasis in children.

## Introduction

Diarrhoeal diseases have long been recognized as a leading cause of morbidity and mortality, particularly in infants and children of the developing world (WALSH & WARREN, 1979; SNYDER & MERSON, 1982). Nearly 500 million children suffer from acute diarrhoea annually world-wide. Of the 15 million deaths occurring each year in children under 5 years old in the developing world, about 4 million are associated with diarrhoea (SNYDER & MERSON, 1982). It has often been taken for granted that many of these diarrhoea deaths could be averted by oral rehydration therapy (ORT) (WHO/UNICEF, 1983; UNICEF, 1983; PARKER *et al.*, 1985). Very few studies, however, have examined the contribution of watery diarrhoea (AWD), the type most likely to respond to ORT, to overall diarrhoea morbidity and mortality. The relative contribution in different age groups is also little known. This information is essential to devise control strategies and assess the potential impact of ORT programmes.

The aim of this study was to assess the relative importance of AWD and other types of acute diarrhoea in 2 different age groups of children under 5 years old in rural Bangladesh.

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## Subjects and Methods

This study was made on data collected in the Matlab field station of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B). The Matlab study area lies in the Ganges delta, 45 km south-east of Dhaka, the capital of Bangladesh. It is a regularly flooded area, with poor communications, low literacy, high population density, high fertility and high mortality. Subsistence farming and fishing are the main occupations.

Since 1966, the ICDDR,B has maintained a demographic surveillance system (DSS) in 149 villages comprising about 200 000 people of whom 16% were children under 5 years old. This included regular cross-sectional censuses and longitudinal registration of births, deaths, marriages and migrations (RUZICKA *et al.*, 1978).

Data used in this study came from the following 3 sources.

(i) *Prevalence*

In 1978, the ICDDR,B introduced a comprehensive Maternal and Child Health and Family Planning (MCH-FP) programme in half of the DSS area, comprising 70 villages (BHATIA *et al.*, 1980). The MCH-FP programme maintained records which included service-related information and morbidity information on about 15 000 children under 5 years old. Eighty female community health workers (CHWs) visited every family in their village biweekly and, since 1986, have recorded monthly point prevalence of diarrhoea by clinical type.

Throughout the study, AWD was defined, based on the mother's report, as passage of 3 or more watery stools with little faecal matter in 24 h, of less than 8 d duration. All other types of acute diarrhoea, including dysenteric (i.e. with blood in stools) and mucoid, were considered as a single separate category.

(ii) *Hospital admissions*

Since 1963, the ICDDR,B has provided free treatment for diarrhoea at its Matlab hospital. Information on diarrhoea at admission by age and clinical type was collected from hospital therapy sheets for the years 1986 and 1987. Hospital admission rates were calculated using population-based denominators provided by the DSS (HOSSAIN *et al.*, 1983).

(iii) *Cause-specific mortality*

Whenever a death was reported by a CHW, a male health assistant visited the household within a month and completed a registration form with socio-demographic information and a description of the symp-

toms and events leading to death. In 1986–1987 the death forms were circulated among 3 physicians for independent diagnosis and the cause of death was assigned on a majority basis (FAUVEAU *et al.*, 1990). Denominators for calculating rates were provided by the DSS.

The differences between rates within age-groups were evaluated by standard $\chi^2$ tests. The differences of rates between age-groups were evaluated by the $\chi^2$ test for heterogeneity, based on the comparison of the risks after a logit transformation (ARMITAGE, 1971).

## Results

(i) *Point prevalence of diarrhoea*

Prevalences of AWD and other types of diarrhoea were not significantly different among infants. In children aged 1–4 years the prevalence of AWD was lower than that of other types of diarrhoea (Table 1). The rate differential in the 2 age groups was significantly different ($P<0{\cdot}001$).

(ii) *Hospital admissions*

AWD represented 84% of admissions among infants but only 64% among children aged 1–4 years (Table 2). Population-based admission rates were 4·1 times higher for AWD than for other types of diarrhoea among infants, but only 1·8 times higher among children. This difference of admission rates between age groups was significant.

(iii) *Cause-specific mortality*

The AWD-specific death rate was 1·7 times higher than for other types of acute diarrhoea in infants, but 3 times lower in 1–4 years old children. This difference in the risk of dying from AWD as opposed to other acute diarrhoeas was significantly different between these 2 age groups ($P<0{\cdot}001$, Table 3).

In infants, AWD was the cause of 63% of all acute diarrhoea deaths, but it caused only 26% in 1–4 years old children ($P<0{\cdot}001$). Since Matlab infant and child mortality rates in 1986–1987 were 81 and 11·2 per 1000 respectively, AWD was responsible for 5·5% of infant deaths and 6% of child deaths.

**Table 1. Point prevalence of diarrhoea by age and by clinical type, ICDDR,B Matlab Maternal and Child Health and Family Planning Programme, Bangladesh, 1986–1987**

| Age in years | N[a] | Acute watery diarrhoea No. | Acute watery diarrhoea Rate/1000[b] | Other types of acute diarrhoea No. | Other types of acute diarrhoea Rate/1000[b] |
|---|---|---|---|---|---|
| <1 | 64 691 | 356 | 5·5 | 382 | 5·9 |
| 1–4 | 253 803 | 1447 | 5·7[c] | 2538 | 10·0[c] |

[a]N=number of child-days observed.
[b]$\chi^2$ for heterogeneity for rates=35·5, one degree of freedom, $P<0{\cdot}001$.
[c]Significant difference between rates, $P<0{\cdot}0001$.

**Table 2. Hospital admission by age and by clinical type at ICDDR,B Matlab Hospital, Bangladesh, 1986–1987**

| Age in years | N[a] | Acute watery diarrhoea No. | Acute watery diarrhoea Rate/1000[b] | Other types of acute diarrhoea No. | Other types of acute diarrhoea Rate/1000[b] |
|---|---|---|---|---|---|
| <1 | 14 340 | 884 (81%) | 61·6[c] | 213 (19%) | 14·9[c] |
| 1–4 | 46 891 | 1593 (64%) | 34·0[c] | 890 (36%) | 19·0[c] |

[a]N=number of child-years of exposure.
[b]$\chi^2$ for heterogeneity for rates=94·2, 1 degree of freedom $P<0{\cdot}001$.
[c]Significant difference between rates in each age group, $P<0{\cdot}0001$.

**Table 3. Diarrhoea deaths by age and clinical type, ICDDR,B Matlab Demographic Surveillance System, Bangladesh, 1986–1987**

| Age in years | N[a] | Acute watery Diarrhoea No. | Acute watery Diarrhoea Rate/1000[b] | Other types of Acute Diarrhoea No. | Other types of Acute Diarrhoea Rate/1000[b] |
|---|---|---|---|---|---|
| <1 | 14 350 | 64 | 4·5[c] | 38 | 2·6[c] |
| 1–4 | 46 891 | 34 | 0·7[d] | 99 | 2·1[d] |

[a]N=number of child-years of exposure.
[b]$\chi^2$ for heterogeneity for rates=31·2, 1 degree of freedom, $P<0{\cdot}001$.
[c]Significant difference between rates, $P=0{\cdot}01$.
[d]Significant difference between rates, $P<0{\cdot}001$.

## Discussion

This study suggested that, in infants, AWD was more important in terms of prevalence, hospital admission and mortality than other types of diarrhoeas. In 1–4 years old children, however, the contribution of AWD to morbidity and mortality seemed to be relatively less important. This suggested that the potential reduction of mortality which could be obtained by further promoting ORT in rural Bangladesh may be limited and disappointing.

Several limitations of the study should be considered. First, point-prevalence of acute diarrhoea may seem low, since acute diarrhoea was defined as diarrhoea of less than 8 d duration on the day of interview, compared to the more commonly used duration of less than 14 d (BLACK *et al.*, 1982). Second, the clinical symptoms as described by the mother at home or the attending nurse in the hospital may have been influenced by individual perception. Third, the assessment of the cause of death was based on home interviews and may have been subject to misreporting.

Our findings regarding 1–4 years old children may be the result of extensive promotion of ORT by the ICDDR,B in Matlab for more than a decade (CHEN *et al.*, 1980; SNYDER *et al.*, 1982; CHAKRABORTY *et al.*, 1981). AWD mortality among infants, however, remains high, suggesting that better promotion of ORT could have an impact on infant mortality. The potential impact of ORT in children may be overestimated, on the other hand, since this intervention does not seem to be very effective in shigellosis, which often starts as AWD (STOLL *et al.*, 1982; RABBANI *et al.*, 1983). In this respect, shigellosis seems to have increased over the last few years in the Matlab area (STOLL *et al.*, 1982; BAQUI *et al.*, 1988).

To reduce diarrhoeal morbidity and mortality among 1 to 4 years old children, diarrhoeal disease control programmes should give more emphasis to the field management of the non-watery, non-dehydrating types of diarrhoea. These programmes should include education on dietary management of diarrhoea, treatment of severely malnourished children, and community-based treatment of acute episodes of dysentery. Feasibility and effectiveness of these interventions still need to be assessed.

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## V.3. ROUGEOLE

Le rôle majeur des complications de la rougeole dans la mortalité infantile a été montré àMatlab.[36] La question dès lors a été de savoir si la décision de changer la stratégie vaccinale en adoptant les vaccins donnés entre 4 et 6 mois d'âge serait appropriée.[37,38] Dans la publication "G2"[39], on a examiné la distribution par âge des cas de rougeole ainsi que des décès par complication de rougeole, pour conclure à la pertinence du changement de vaccin et d'une vaccination plus précoce. Un des raffinements apportés à la méthode était précisément la détermination par l'autopsie verbale du rôle des complications retardées de la rougeole comme causes de décès, à savoir les complications respiratoires et surtout la dysenterie persistente.

# Measles among under-9-month-olds in rural Bangladesh: its significance for age at immunization*

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*Any decision to modify measles immunization strategies away from the use of the conventional vaccine given to children at 9 months of age to the adoption of recently proposed vaccine strains that can be given to 4–6-month-olds will depend on the age distribution of severe cases of measles in the community. Reported are the results of an analysis of two community-based measles surveillance systems in rural Bangladesh, which found that 17% of all measles cases reported for under-5-year-olds in a nonvaccinated population involved infants aged less than 9 months. In a vaccinated population from the same area, 31% of all measles cases reported for under-5-year-olds occurred among under-9-month-olds. Using a rather restrictive definition for measles-related deaths (those occurring within 6 weeks of the onset of the rash), the proportion of measles-related deaths that occurred before 9 months of age was 13% of all such deaths that were reported.*

Although in Africa measles is recognized to be a major public health problem (*1, 2*), less concern has been expressed about its contribution to child mortality in parts of Asia, particularly in the Indian subcontinent. Two recent findings, however, have triggered a renewed interest in measles control. The first of these was the discovery and successful pretesting of the new generation of measles vaccines, which permit children to be immunized at an earlier age (*3–6*).[a] The second was the impressive reduction in mortality resulting from measles immunization in Bangladesh (*7–9*).

The decision to modify current measles immunization strategies from the use of conventional vaccine strains given to infants at 9 months of age to the recently tested strains administered at 4–6 months of age depends ultimately on the age distribution of severe cases and case fatality rates in the community (*10–12*).[b] Such a decision is about to be made in many African countries because they have age-related data on measles, a situation that does not apply in Bangladesh.

In this paper, we present data on the epidemiology of measles in rural Bangladesh, based on an analysis of two community-based measles surveillance studies conducted in Matlab over the past 10 years. The Matlab study area has the advantage of a well-established demographic surveillance system, which permits a precise assessment of dates and ages.

## Methods

Matlab is a rural deltaic area quite typical of southern Bangladesh, where the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B), has maintained a demographic surveillance system (DSS) since 1966. Under this system, 110 community health workers (CHWs) visit each household in their village every 15 days and note any births, deaths, migrations, or marriages that have occurred since their last visit (*13*). Since 1980 they have also reported all cases of measles that have occurred during or between their visits (*14, 15*). In one half of the DSS area (the MCH–FP or treatment area) 80 CHWs cover a population of approximately 1200 each, and provide maternal and child health—family planning (MCH–FP) services. For practical reasons, this area is divided into four operational blocks (A, B, C, and D) of 25 000 inhabitants each (*16*). In the other half of the DSS area (the comparison area), 30 CHWs cover a population of approximately 3200 each, and health

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[a] *High-dose E–Z measles vaccine. Research and Development Group Meeting, Tokyo, Japan, 12–13 October 1989.* Unpublished WHO document EPI/RD/89/WP.13.OCT.

[b] *Measles control. Expanded Programme on Immunization, Global Advisory Group Meeting, 16–20 October 1989, Tokyo, Japan.* Unpublished document WHO/EPI/GEN/90.1.

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services are limited to those provided by the government health programme.

Measles vaccination was not provided in the study area until April 1982, when it was systematically offered at home to all children in blocks A and C in the MCH–FP area. Children in the other half of the MCH–FP area (blocks B and D) were first vaccinated against measles in November 1985 in the same way. Those in the comparison area were dealt with by the national expanded programme on immunization (EPI), which only covered about 5% of the children until its intensification in 1989 (*17*).[c]

This experimental design permitted evaluation of the impact of measles vaccination on mortality (*7–9*) and also of the age distribution of the disease in communities with different vaccination coverage rates.

We used the following data sets for measles surveillance: the comparison area (largely unvaccinated) for 1980–81; blocks A and C of the MCH–FP area (coverage rates that ranged from 50% in May 1982 to 78% in December 1985); and blocks B and D of the MCH–FP area over the same period (coverage rates of less than 1%). Data on the age distribution of measles-related deaths from three other studies conducted in the area were also reviewed (*15, 18, 19*).

## Results

### *Measles morbidity*

During 1980–81 in the largely unvaccinated comparison area, 4–6-month-olds exhibited the highest reported incidence of measles (Table 1). Besides the usual definition of measles (taking into account the type of rash and accompanying symptoms), the cases reported here were restricted to children whose rash lasted 4–12 days. The age distribution of reported cases declined uniformly until the age of 10 years. Cases of measles that occurred among 3–9-month-olds represented 17% of the total number of cases among under-5-year-olds (11% of the total cases among under-10-year-olds).

From January 1982 to October 1985 in the largely unvaccinated blocks B and D, children aged 5–42 months exhibited the highest incidence of reported measles cases, with peaks among 5–7-, 14–16-, and 26–29-month-olds (Table 1). Cases of measles among 3–9-month-olds represented 10% of the total among under-5-year-olds (9% of the total cases reported among under-10-year-olds).

In blocks A and C, where 50–78% of children were vaccinated between May 1982 and October 1985, the highest reported incidence of measles occurred among 5–9-month-olds (Table 1). Cases that occurred among 3–9-month-olds represented 31% of all measles cases reported for under-5-year-olds (29% of all cases reported for under-10-year-olds).

Table 1: **Proportion of measles cases in infants aged 3–9 months, Matlab maternal and child health–family planning (MCH–FP) and comparison areas, 1980–85**

| Area (period) | No. | Peak age groups (months) | Percentage of cases[a] |
|---|---|---|---|
| Comparison area, not vaccinated (January 1980–December 1981) | 3711 | 4–7 | 17 |
| MCH–FP area blocks B+D, not vaccinated (January 1982–October 1985) | 1921 | 5–7<br>14–16<br>26–29 | 10 |
| MCH–FP area, blocks A+C, 50–78% vaccinated (May 1982–October 1985) | 370 | 5–9 | 31 |

[a] Expressed as a percentage of all cases of measles among children aged under 5 years.

***Seasonality.*** Analysis of the data for 1980–81 as well as from 1982–85 confirms that measles had a strong seasonality, with a consistent peak in March (Fig. 1 and 2). Annual and spatial variations occurred, with a particularly high number of cases in block A during the dry months of 1982, and in block B during the dry months of 1985 (blockwise, data not shown).

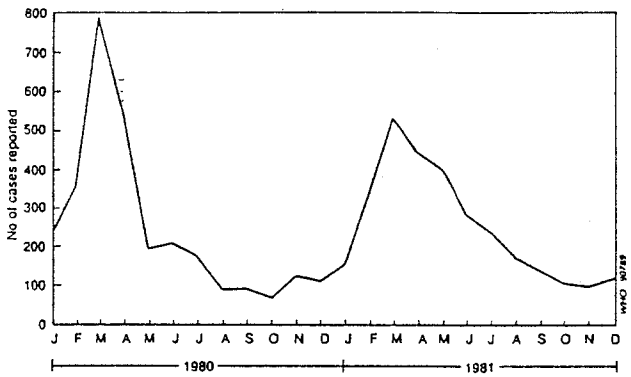
Table 2: **Measles case fatality rates by age for two follow-up periods, Matlab comparison area (unvaccinated), 1980–81**

| | | Follow-up period[a] | | | |
|---|---|---|---|---|---|
| | | 6 weeks | | 12 weeks | |
| Age group (months) | No. with measles | No. of deaths | CFR | No. of deaths | CFR |
| 6–12 | 425 | 11 | 2.59 | 13 | 3.06 |
| 13–24 | 564 | 13 | 2.30 | 15 | 2.66 |
| 25–36 | 526 | 9 | 1.71 | 10 | 1.90 |
| 37–48 | 529 | 7 | 1.32 | 8 | 1.51 |
| 49–60 | 386 | 1 | 0.26 | 2 | 0.52 |
| >60 | 1084 | 3 | 0.28 | 4 | 0.37 |

[a] CFR = case fatality rate.

[c] **Government of Bangladesh/World Bank/SIDA/USAID/UNICEF/WHO.** *Joint review of the Expanded Programme on Immunization in Bangladesh: summary report of findings, key issues and recommendations*, 1989. Unpublished document, Ministry of Health and Family Planning, Dhaka, Bangladesh.

Fig. 1. **Seasonality of measles among the unvaccinated population in Matlab comparison area, January 1980 to December 1981.**




### *Measles mortality*

From 1986 to 1988 in the largely unvaccinated comparison area, 98 measles-related deaths were reported among 3–60-month-olds, i.e., 11.5% of all deaths in this age range. Measles-related deaths were defined as either those that occurred during the acute phase of the disease (13/98 when the rash was present) or within 6 weeks of onset of the rash; most post-measles deaths were due to dysentery (68/98), followed by pneumonia (17/98).

The highest reported measles-related deaths occurred among 16–33-month-olds (Fig. 3). Measles-related deaths among 4–9-month-olds represented 13% (13/98) of all such deaths that were reported. The great majority of these deaths took place at home (91%). Only 12% of the children had been examined by a qualified doctor prior to death, and for most the examination was only carried out after a series of consultations with unqualified and traditional doctors had failed to produce results. In the whole of the DSS area, a significantly higher proportion of all measles-related deaths involved females rather than males (58% versus 42%, $P<0.05$, Fig. 3).

Of the measles-related deaths reported during 1986–88, 47% occurred during the dry months of March–May (Fig. 4).

As shown in Table 2, the measles case fatality rates (CFRs) among those who were not vaccinated were highest for infants who had measles before reaching their first birthday, and declined regularly with increasing age. This pattern was similar for deaths observed within 6–12 weeks after onset of the disease.

## Discussion

Our data indicate that among rural Bangladeshi children who were not vaccinated against measles, between 17% and 10% of all measles cases among under-5-year-olds occurred before the EPI-recommended immunization age of 9 months, and that at least 13% of all measles-related deaths occurred before this age. In the vaccinated study population, however, 30% of all measles cases occurred in infants

Fig. 2. **Seasonality of measles among the unvaccinated (blocks B+D) and vaccinated (blocks A+C) populations, Matlab maternal and child health–family planning (MCH–FP) area, January 1982 to October 1985. The percentages are the measles vaccine coverage rates in blocks A+C for all children aged 9–60 months.**

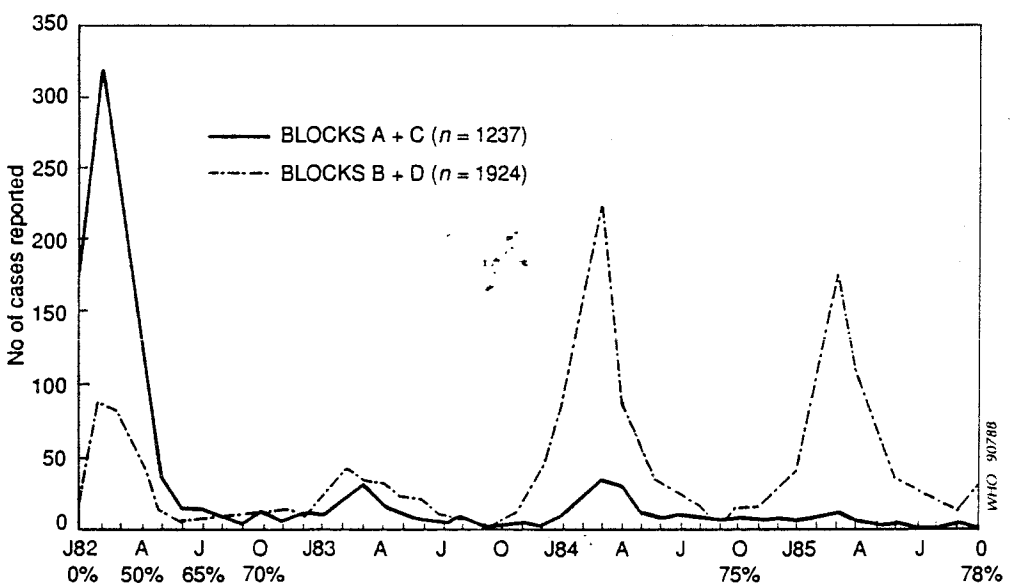


Fig. 3. **Measles mortality (immediate and 6-weeks' delayed mortality) by age and sex, Matlab comparison area (unvaccinated), 1986–88 ($n=98$).**

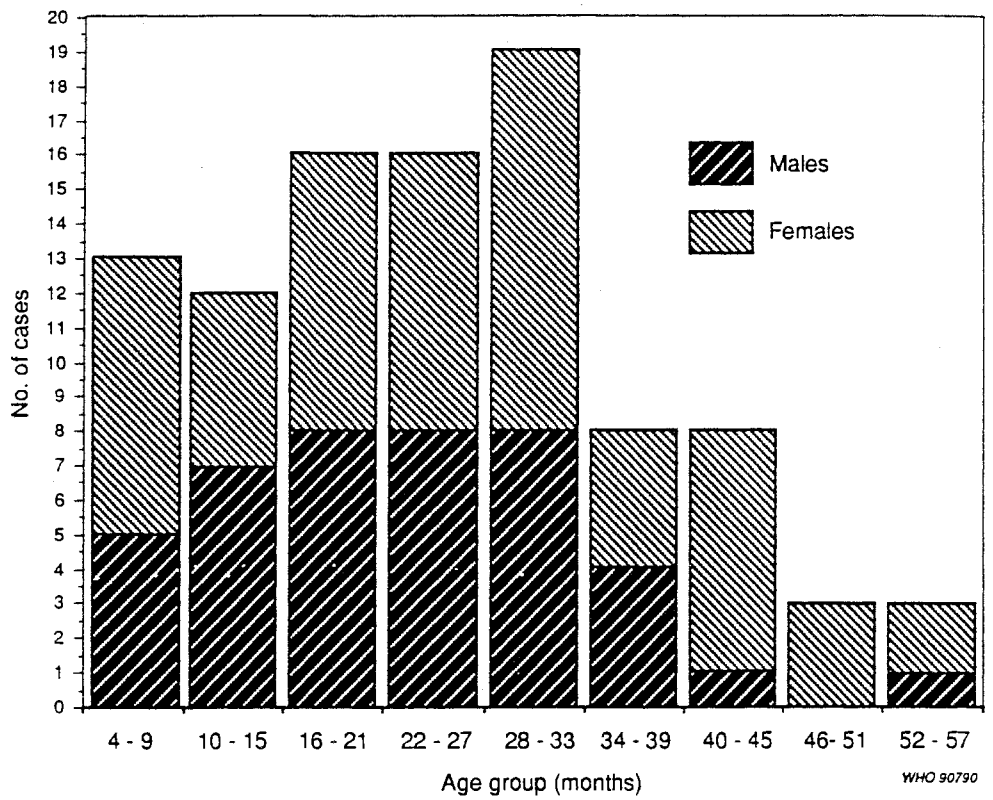
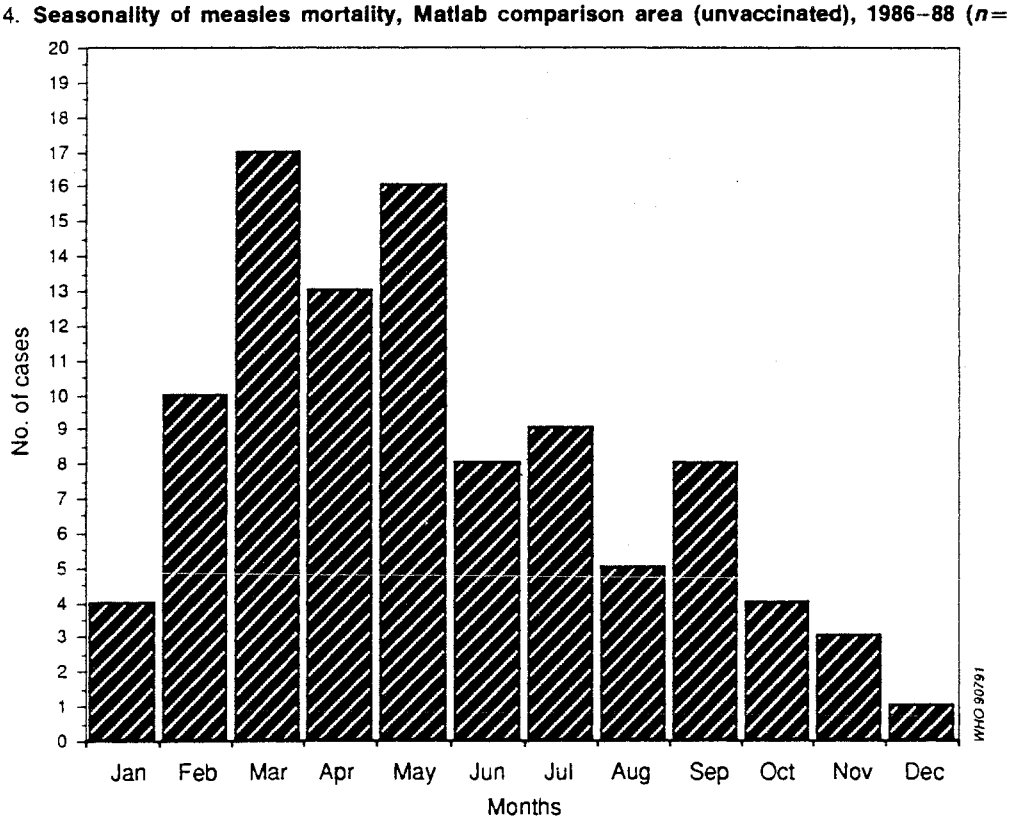



Fig. 4. **Seasonality of measles mortality, Matlab comparison area (unvaccinated), 1986–88 ($n=98$).**



under 9 months of age. Because the numbers involved are small, the proportion of measles-related deaths in the vaccinated population (11 deaths in the MCH–FP area in 1986–88) could not be estimated.

The validity of our data should be examined critically. Although the surveillance systems in Matlab were carefully supervised and occasionally validated in home visits by medical officers, there was a tendency to overreport as measles some rashes that occurred among under-3-month-olds. Both Koster et al. (based on serology) and Bhuiya et al. (based on home visits by a doctor) found that the rate of such overreporting was 2% (*15*, *18*); the latter authors also reported that the rate of double reporting was 4%.

Cases of measles were reported every month throughout the study period. The marked and consistent seasonality observed is, however, in keeping with a reasonably valid reporting system, since no known childhood diseases other than measles follow such a seasonal pattern.

The assessment of measles CFRs is approximate, because all deaths following the disease over a given period have to be accounted for. The trends observed in the study were consistent, and did not change with the duration of the follow-up period. The CFRs at 12 weeks were also consistent with the findings of a national measles survey performed in 1984 in urban areas of Bangladesh, which reported ~~lower~~ higher CFRs among the younger age groups (*20*).

In the Matlab area, Koster et al. previously reported measles CFRs at 6 weeks that ranged from 4.4% (among children <24 months of age) to 1.6% (among children >72 months of age) (*18*), while Bhuiya et al. reported CFRs of 1.3% among under-12-month-olds and 1.7% among over-36-month-olds (*15*). Shahid et al. reported a CFR of 1.3% for children under 24 months of age, but 40% of all the measles-related deaths found by these authors were among under-6-month-olds (*19*). Comparison of CFRs between age groups requires large numbers of measles cases. Recent evidence from studies in Matlab suggests that the long-term effect of measles vaccination on delayed mortality might be far more important than has generally been assumed (*9*).

The data presented here make a case for considering the new generation of measles vaccines to be a valid alternative for the national EPI in Bangladesh. The magnitude of the additional reduction in infant mortality provided by shifting the age for measles vaccination from 9 months to between 4 and 6 months needs, however, to be further evaluated.

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## Résumé

### La rougeole chez les enfants de moins de 9 mois dans le Bangladesh rural: son importance pour l'âge de vaccination

Toute décision de modifier les stratégies de vaccination contre la rougeole, qui consistent à utiliser le vaccin classique chez des enfants de 9 mois, pour adopter les souches vaccinales récemment proposées pouvant être administrées aux enfants de 4–6 mois, dépendra de la distribution par âge des cas sévères de rougeole dans la communauté. Dans cet article, sont rapportés les résultats d'une analyse de deux systèmes de surveillance de la rougeole à base communautaire, dans le Bangladesh rural (Matlab), qui montrent que 17% de tous les cas de rougeole notifiés chez des enfants de moins de 5 ans dans une population non vaccinée intéressent des nouveau-nés âgés de moins de 9 mois. Dans une population vaccinée de la même région, 31% de tous les cas de rougeole notifiés chez des enfants de moins de 5 ans s'étaient produits chez ceux de moins de 9 mois. En utilisant une définition assez restrictive des décès dus à la rougeole (ayant lieu dans les 6 semaines qui suivent le début de l'éruption), la proportion des décès dus à la rougeole qui ont eu lieu avant l'âge de 9 mois était de 13% de tous les décès notifiés.

Les taux de létalité à six semaines de suivi allaient de 2,59% chez les enfants de 6–12 mois à 0,28% chez les enfants de plus de 60 mois; à 12 semaines de suivi, les taux correspondants étaient de 3,06% et 0,37%. Seuls 12% des enfants avaient été examinés par un médecin qualifié avant leur décès, et pour la plupart d'entre eux le médecin n'avait été consulté qu'après des tentatives infruc-

tueuses de traitement par des tradipraticiens et des guérisseurs non qualifiés. La comparaison des taux de létalité dans différents groupes d'âge nécessite de grands nombres de cas de rougeole. Des données récentes provenant d'études effectuées au Matlab laissent à penser que les effets à long terme de la vaccination contre la rougeole sur la mortalité retardée peuvent être beaucoup plus importants qu'on ne le suppose en général.

Les données présentées dans cette étude incitent à penser que l'emploi de la nouvelle génération de vaccins contre la rougeole est une alternative valable pour le Programme élargi de vaccination (PEV) du Bangladesh. L'ampleur de la réduction de la mortalité infantile obtenue en abaissant l'âge de la vaccination contre la rougeole, de 9 mois à un âge situé entre 4 et 6 mois, demande cependant à être davantage évaluée.

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# VI. APPLICATIONS DE LA METHODE POUR L'EVALUATION D'INTERVENTIONS SPECIFIQUES

Après le processus de guide vers le choix d'interventions spécifiques, il est logique d'aborder une autre des applications de la méthode de détermination des causes de décès par l'autopsie verbale: l'évaluation de l'effet de ces interventions spécifiques sur la mortalité correspondante: nous l'avons essayé pour quatre groupes de causes de décès: les maladies évitables par la vaccination, les complications obstétricales, les infections respiratoires aigues, et les maladies diarrhéiques.

## VI.1. LES MALADIES EVITABLES PAR LA VACCINATION

En réponse aux déclarations de l'UNICEF annonçant des réductions considérables de mortalité infantile et infanto-juvénile par le Programme Elargi de Vaccination (PEV) dans le cadre de l'approche "GOBI",[40] nous avons utilisé la méthode de détermination des causes de décès pour estimer la réduction réelle de mortalité due à la vaccination à Matlab (publication "E1"[41]). De fait, l'analyse ne s'applique qu'à trois des maladies-cibles du PEV: le tétanos néonatal, la rougeole, et la coqueluche. La tuberculose, la diphtérie et la poliomyélite sont exclues de l'analyse car elles sont généralement considérées comme participant moins à la mortalité, et elles sont beaucoup plus difficiles à diagnostiquer par l'autopsie verbale. L'utilisation combinée de l'étude des causes de décès, de la structure par âge de la mortalité de la naissance jusqu'à l'âge de cinq ans, et d'études rétrospectives sur l'impact de la vaccination anti-rougoleuse,[42] permet d'estimer des réductions de mortalité bien inférieures à celles annoncées par l'UNICEF (et cependant dominées, en valeur absolue, par les effets de la vaccination anti-rougeoleuse).

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# Mortality Reductions from Health Interventions: The Case of Immunization in Bangladesh

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RECENT HEALTH CARE INITIATIVES in many developing countries are based on the assumption that significant reductions in infant and child mortality levels can be achieved through the introduction of a limited number of simple, cost-effective health technologies.[1] Prominent among the various child survival strategies advocated is UNICEF's GOBI strategy, which emphasizes the interventions of growth monitoring, oral rehydration, breastfeeding, and immunization.[2] A cornerstone of the GOBI strategy is the World Health Organization's Expanded Programme on Immunization (EPI), which aims at achieving significant reductions in levels of childhood mortality through immunization against six of the major infectious diseases prevalent in developing countries—tetanus, diphtheria, pertussis, poliomyelitis, tuberculosis, and measles.

While EPI has rapidly become an integral aspect of most primary health care programs in developing countries, considerable uncertainty persists regarding the magnitude of improvements in child survival that could be expected as a result of its successful implementation. In part, this is because reductions in disease-specific mortality do not necessarily translate into improvements in overall child survival if children remain at high risk of death from other causes. A more basic explanation is the limited information available on the importance of diseases such as those targeted by EPI as causes of death in settings where mortality remains high. Proponents of the GOBI strategy and its EPI subcomponent have frequently offered ambitious estimates of potential impact, yet the absence of reliable empirical data on this issue is conspicuous.

In this article, we examine potential mortality reductions resulting from

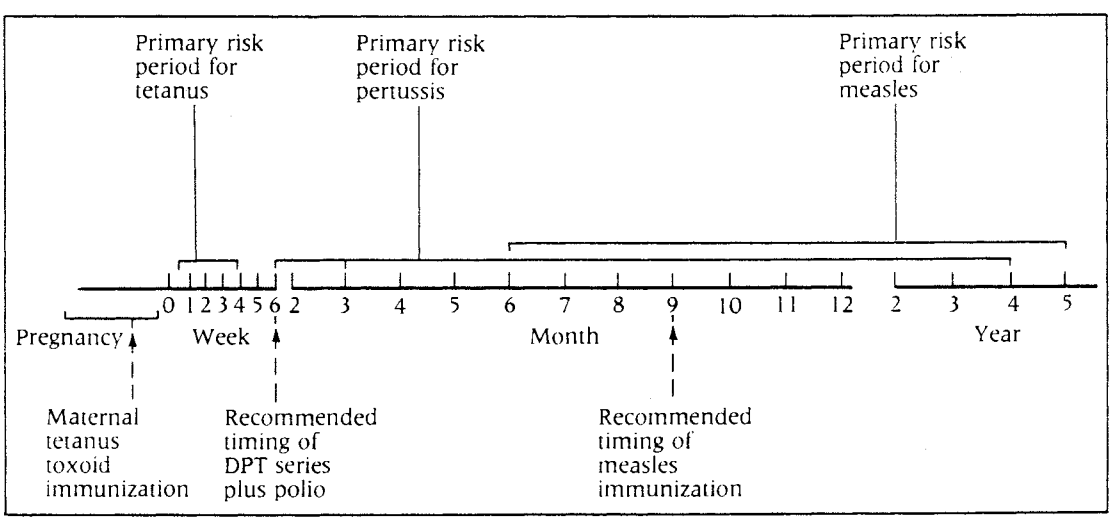
immunization in rural Bangladesh. We draw on detailed information from the Matlab study area on both specific causes of death and the age distribution of mortality during infancy and early childhood, in addition to recently available data on the mortality impact of a measles immunization intervention. These data provide a basis for estimating reductions in mortality that could result from EPI in rural Bangladesh.

## Background

The present study focuses on three important infectious diseases that are preventable by immunization—tetanus, measles, and pertussis. Tuberculosis, diphtheria, and poliomyelitis are excluded here because of their generally secondary importance as causes of childhood death, and the difficulty in reaching conclusive diagnoses concerning these diseases based on lay reporting. Moreover, in the case of polio, which remains a major public health problem in Bangladesh, the end result is usually serious physical handicap rather than death. Figure 1 illustrates the primary periods of risk, as well as the recommended immunization schedules in Bangladesh, for the three diseases considered.

Death due to neonatal tetanus results primarily from infection of the umbilical stump by *Clostridium tetani*. Tetanus deaths are extremely rare during the initial days of life, rise rapidly to a peak during the seventh to eighth days, then decline slowly through the end of the first month of life.[3] Deaths due to tetanus later in infancy and early childhood are much less common. Neonatal tetanus can be prevented through immunization of the mother with at least two doses of tetanus toxoid, either prior to or during pregnancy, with protection lasting for a minimum of several years.[4]

**FIGURE 1 Tetanus, pertussis, and measles: Epidemiology and recommended timing of vaccination**



The timing of the onset of measles varies: the risk period begins when protection conferred by maternal antibodies wanes and continues throughout early childhood. Although onset occurs as early as four to six months of age in some settings, measles cases at such early ages appear to be less common in rural Bangladesh.[5] A high level of protection against measles is conferred by a single dose of live measles vaccine. Current WHO guidelines recommend nine months as the optimal age for measles vaccination.[6]

The risk period for pertussis, or "whooping cough," varies considerably by geographical region, with infection concentrated during the first year of life in some settings and during early childhood in others. Pertussis results from infection of the tracheobronchial tree by the bacterium *Bordetella pertussis*. Although we consider pertussis in the present study, conclusive diagnosis of this disease as a cause of death remains problematic. High levels of protection against pertussis are achieved through three shots with combined diphtheria-pertussis-tetanus (DPT) vaccine, given from the age of six weeks onward at least four weeks apart.[7]

## Data and setting

Data for the present study come from the Demographic Surveillance System in Matlab, a rural, riverine area approximately 45 kilometers southeast of Dhaka, the capital of Bangladesh. Since 1966 the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) has maintained a system of continuous demographic surveillance (births, deaths, migration, changes in marital status) for a population of approximately 200,000.[8] Data from this surveillance system are widely recognized as unique within the developing world in terms of both their completeness and their accuracy in the timing of events to the exact day.

In 1977 an innovative family planning and health services program was introduced into half of the Matlab study area; the remaining area was retained for purposes of comparison. The initial focus of the Matlab service program was on family planning, with only limited curative maternal and child health (MCH) services.[9] Over time, the range of MCH services offered has been gradually and carefully expanded to include oral rehydration therapy, tetanus vaccination, measles vaccination, and subsequently the full range of EPI vaccines.[10] The impact of the measles vaccination intervention is of particular interest here.

In the comparison area, by contrast, the ICDDR,B maintains demographic surveillance but offers only limited curative treatment for diarrheal diseases. Although a government service program functions in this area, it is much less effective in terms of coverage, quality, and the range of services offered than the ICDDR,B program in the neighboring treatment area.[11] During the period of interest here (1982–87), the delivery of immunization

services in the comparison area was largely confined to nonmobile clinics. As a result, overall immunization coverage rates remained very low during the period of interest, and were unlikely to have exceeded estimated national averages of less than 5 percent.[12] The mortality profile of children in the comparison area during this period thus reflects that of a largely unvaccinated population.

We use data from the Matlab study area to examine potential reductions in mortality from three contrasting perspectives. First, we examine data from the comparison area on diagnosed cause of death for all deaths that occurred to children under age 5 years during 1986–87. Diagnosis of specific cause of death was obtained through a multiple-step procedure. Detailed information, which included a description of the events and symptoms preceding death, was obtained by health workers who visited each household within six weeks of the death. These forms were then independently reviewed by three public health physicians to assign probable cause of death, giving priority to the primary cause. Because of difficulty in assessing neonatal tetanus as a cause of death, a special questionnaire was also administered by a female health worker to each family in which a death occurred during four to 21 days after birth, to obtain additional information on symptoms and the chronology of events preceding the death. Cause-of-death codes were derived from the WHO international classification.[13]

A second perspective, also from the comparison area, is obtained from longitudinal data on the age distribution of infant and early childhood deaths. We examine the mortality experience of a cohort of 8,161 births, representing all live births that occurred within the Matlab comparison area during the years 1982–83. By linking subsequent vital events records, it is possible to follow the survival status of this cohort through December 1987. We employ life-table analysis to estimate conditional mortality risks during the cohort's first five years of life.

A third perspective on potential mortality reductions is obtained from data on the mortality impact of a measles immunization program in the Matlab intervention area. Measles vaccination was introduced into half of the intervention area in 1982 and subsequently expanded to the other half in late 1985. This phased introduction of the program allows us to evaluate its independent mortality impact. The results of two recent studies from Matlab on this subject are also considered.

## Findings

### Cause of death

Table 1 shows the breakdown by cause and by age at death for the 1,144 deaths under age 5 years that occurred during 1986–87 in the Matlab com-

**TABLE 1 Distribution of deaths by primary cause and by age at death during infancy and early childhood: Matlab comparison area, 1986–87**

| | Neonatal (< 1 month) | | Postneonatal (1–11 months) | | 1–4 years | | 0–4 years | |
|---|---|---|---|---|---|---|---|---|
| Cause of death | Percent | (N) | Percent | (N) | Percent | (N) | Percent | (N) |
| **Low birthweight/prematurity** | **34.8** | **(144)** | **0.0[a]** | **(0)** | **0.0[a]** | **(0)** | **12.6** | **(144)** |
| **Birth trauma** | **10.6** | **(44)** | **0.0** | **(0)** | **0.0** | **(0)** | **3.8** | **(44)** |
| **Infections** | **39.4** | **(163)** | **47.7** | **(143)** | **28.4** | **(122)** | **37.4** | **(428)** |
| Tetanus | 20.5 | (85) | 3.3 | (10) | 0.5 | (2) | 8.5 | (97) |
| Acute respiratory infection | 10.1 | (42) | 33.7 | (101) | 10.0 | (43) | 16.3 | (186) |
| Measles and associated complications | 0.0 | (0) | 2.7 | (8) | 12.6 | (54) | 5.4 | (62) |
| Pertussis | 0.0 | (0) | 3.3 | (10) | 1.4 | (6) | 1.4 | (16) |
| Other infections | 8.7 | (36) | 4.7 | (14) | 4.0 | (17) | 5.9 | (67) |
| **Diarrheal disease/ malnutrition** | **2.4** | **(10)** | **35.3** | **(106)** | **52.6** | **(226)** | **29.9** | **(342)** |
| Watery diarrhea | 0.7 | (3) | 11.7 | (35) | 4.2 | (18) | 4.9 | (56) |
| Dysentery | 0.7 | (3) | 6.0 | (18) | 7.0 | (30) | 4.5 | (51) |
| Chronic diarrhea only | 0.0 | (0) | 2.7 | (8) | 5.6 | (24) | 2.8 | (32) |
| Chronic diarrhea/severe malnutrition | 0.0 | (0) | 6.3 | (19) | 29.8 | (128) | 12.8 | (147) |
| Severe malnutrition only | 1.0 | (4) | 8.7 | (26) | 6.0 | (26) | 4.9 | (56) |
| **Malformations, injuries, and accidents** | **1.2** | **(5)** | **3.3** | **(10)** | **12.6** | **(54)** | **6.0** | **(69)** |
| **Unable to specify** | **11.6** | **(48)** | **13.7** | **(41)** | **6.5** | **(28)** | **10.2** | **(117)** |
| **Total** | **100.0** | **(414)** | **100.0** | **(300)** | **100.0** | **(430)** | **100.0** | **(1,144)** |

[a] Deaths after the first month of life are attributed to other primary causes.

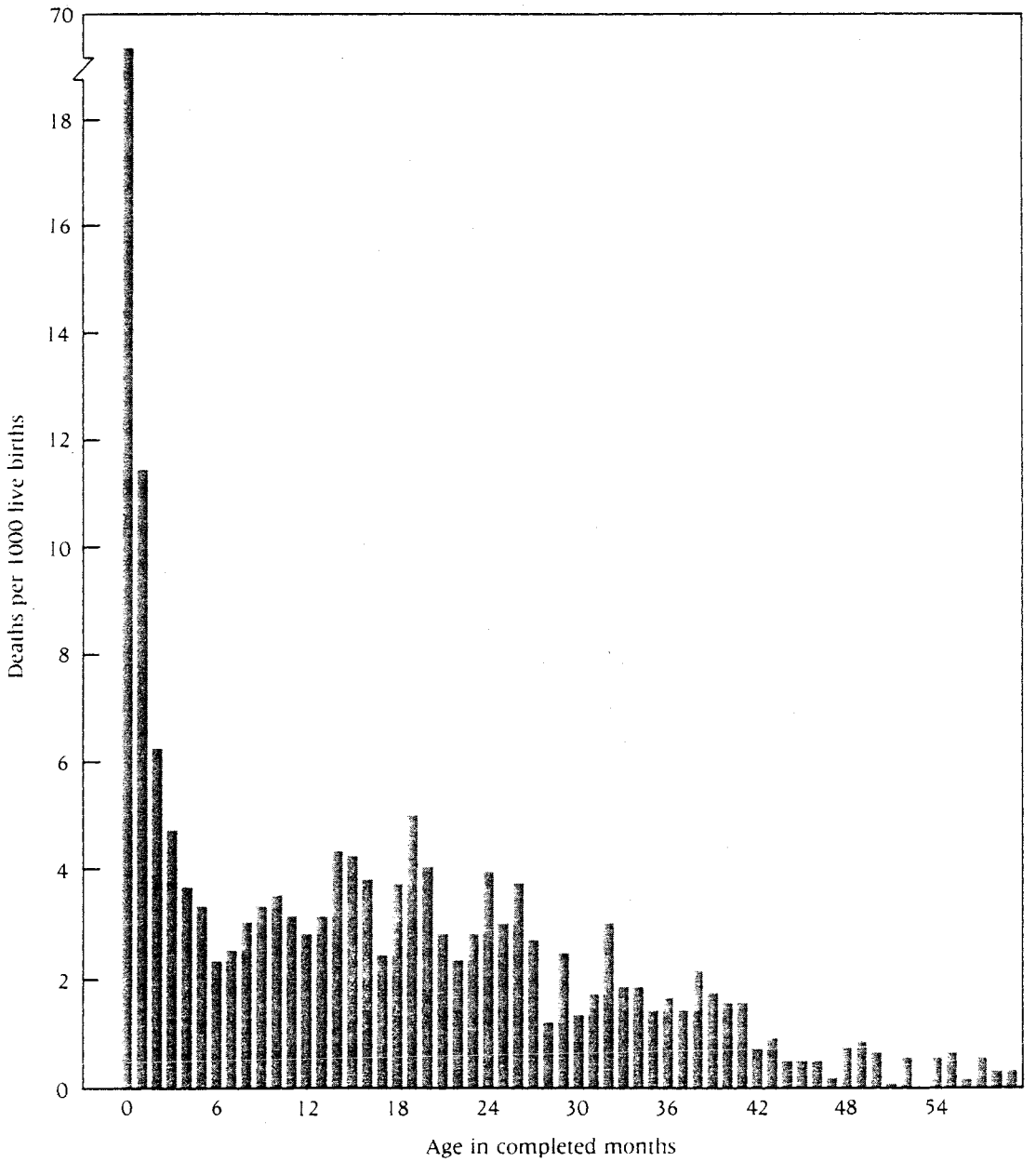
parison area. The most important causes of neonatal death (i.e., deaths during the first four weeks of life) are complications associated with low birthweight/prematurity and birth trauma. Almost half of all neonatal deaths are attributable to these causes. Tetanus is responsible for more than one-fifth of all deaths during the neonatal period. Infections other than tetanus, notably acute respiratory infection, also account for nearly 20 percent of neonatal deaths.

During the postneonatal period (i.e., 1–11 months of life), acute respiratory infection emerges as the leading cause of death (34 percent). It is possible that at least some of the deaths attributed to respiratory infection were actually due to pertussis; the problem of accurate case definition, however, does not permit a more precise estimate of the importance of this cause. Other prominent causes include diarrheal disease and malnutrition, jointly accounting for over one-third of all postneonatal deaths. Deaths due to

tetanus, measles, and diagnosed pertussis are all of secondary importance, with each responsible for fewer than 5 percent of postneonatal deaths.[14]

During ages 1–4 years, the complex of diarrheal disease/malnutrition assumes increasing importance, jointly accounting for over half of all deaths at these ages. The role of chronic diarrhea and severe malnutrition during

**FIGURE 2 Mortality by month during the first 5 years of life: Matlab comparison area, 1982–87**



this age period is especially prominent. Deaths due to measles as a primary cause also increase in significance during early childhood (13 percent), while tetanus and pertussis deaths remain largely inconsequential.

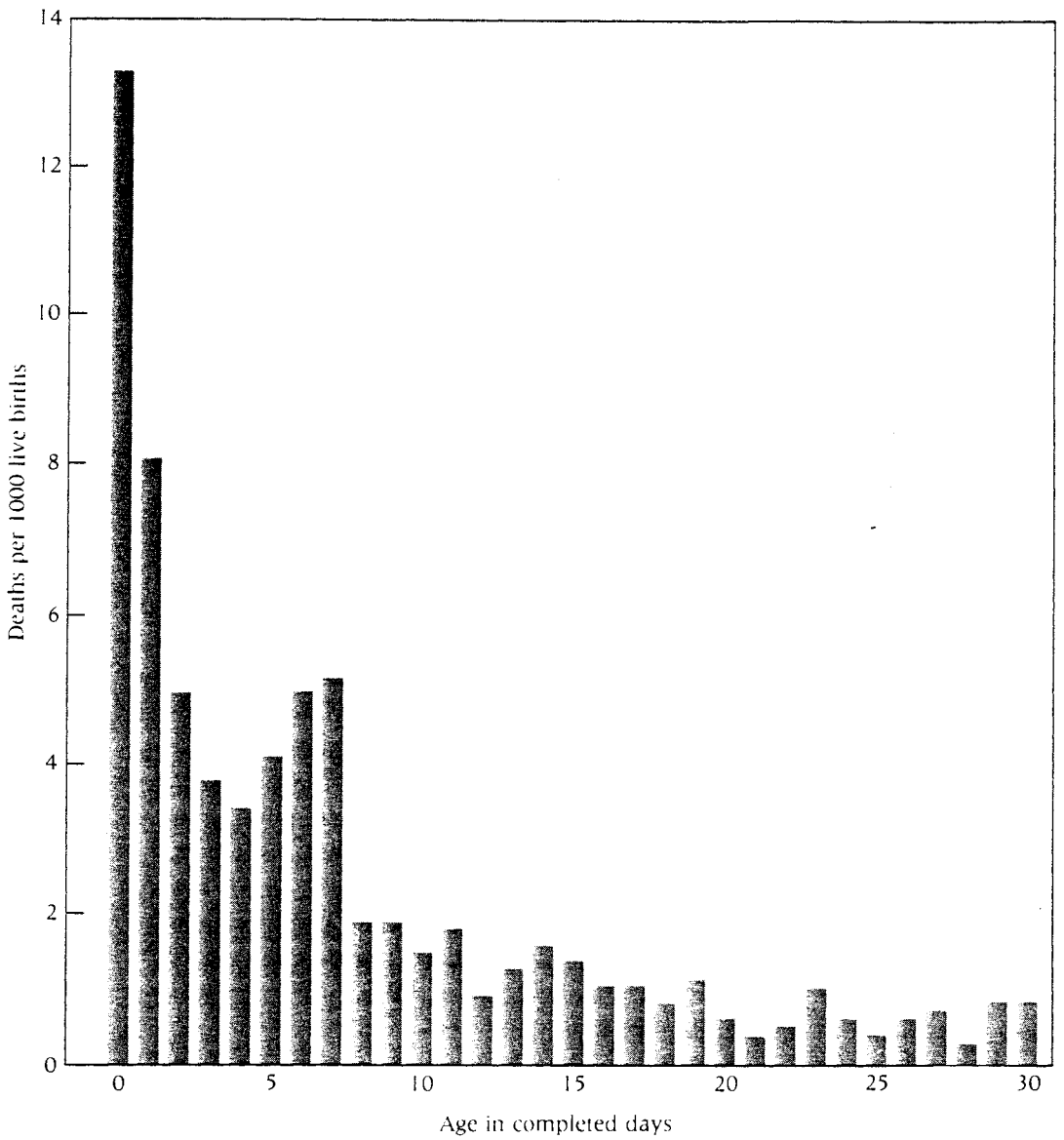
### Age structure of childhood mortality

Figure 2 shows the monthly distribution of the proportions dying from the original cohort of 8,161 births during the first 60 months of life. Cumulative proportions dead are 116 and 206 per thousand live births through the first 12 months and 60 months of life, respectively. The striking finding from this figure is the paramount importance of early mortality as a component of overall infant mortality. Mortality during the first month of life is 69 per thousand live births, accounting for more than 60 percent of all infant deaths and one-third of all deaths to children under age 5 years. Although not as pronounced as in the first month of life, mortality remains high during the second and third months as well. The cumulative proportion dead after three months of life is 87 per thousand live births, which represents over three-fourths of all infant mortality and more than 40 percent of all mortality under age 5. Monthly mortality risks after the first year of life remain relatively low, with mortality during ages 1 to 4 years accounting for 44 percent of all under-5 mortality in this population.

One disease targeted by EPI that could influence mortality during the first months of life is neonatal tetanus. Evidence on the possible importance of this disease is provided in Figure 3, which breaks down mortality during the first month of life by exact day of life. This figure indicates that a significant proportion of deaths during the neonatal period occurs outside of the primary risk period for neonatal tetanus (4–14 days postpartum), with deaths concentrated during the initial days of life. Mortality during days 1 and 2 is very high (13 and 8 per thousand live births, respectively), then declines steadily through the fifth day of life, followed by an upsurge during days 6 to 8.[15] Mortality from the eighth day of life onward is comparatively low, remaining below 2 deaths per thousand live births.

Further evidence on the role of tetanus in neonatal mortality is presented in Figure 4, which shows the cause-of-death data for neonatal deaths from Table 1 by exact day of death broken down into two groups: deaths from tetanus and from other causes. Tetanus deaths are absent during days 1 to 4 and rare during days 5 and 6; they are heavily concentrated in days 7 and 8. For days 4 to 14 as a whole, tetanus deaths account for slightly less than half of all deaths (45 percent). Figure 4 also illustrates the low incidence of neonatal tetanus deaths after the second week of life: tetanus is responsible for fewer than 10 percent of all deaths occurring between days 15 and 30. Thus, almost half of all neonatal deaths occur before tetanus becomes a factor in mortality. Moreover, the vast majority of deaths during the second half

**FIGURE 3 Neonatal mortality by day during the first month of life: Matlab comparison area, 1982–87**

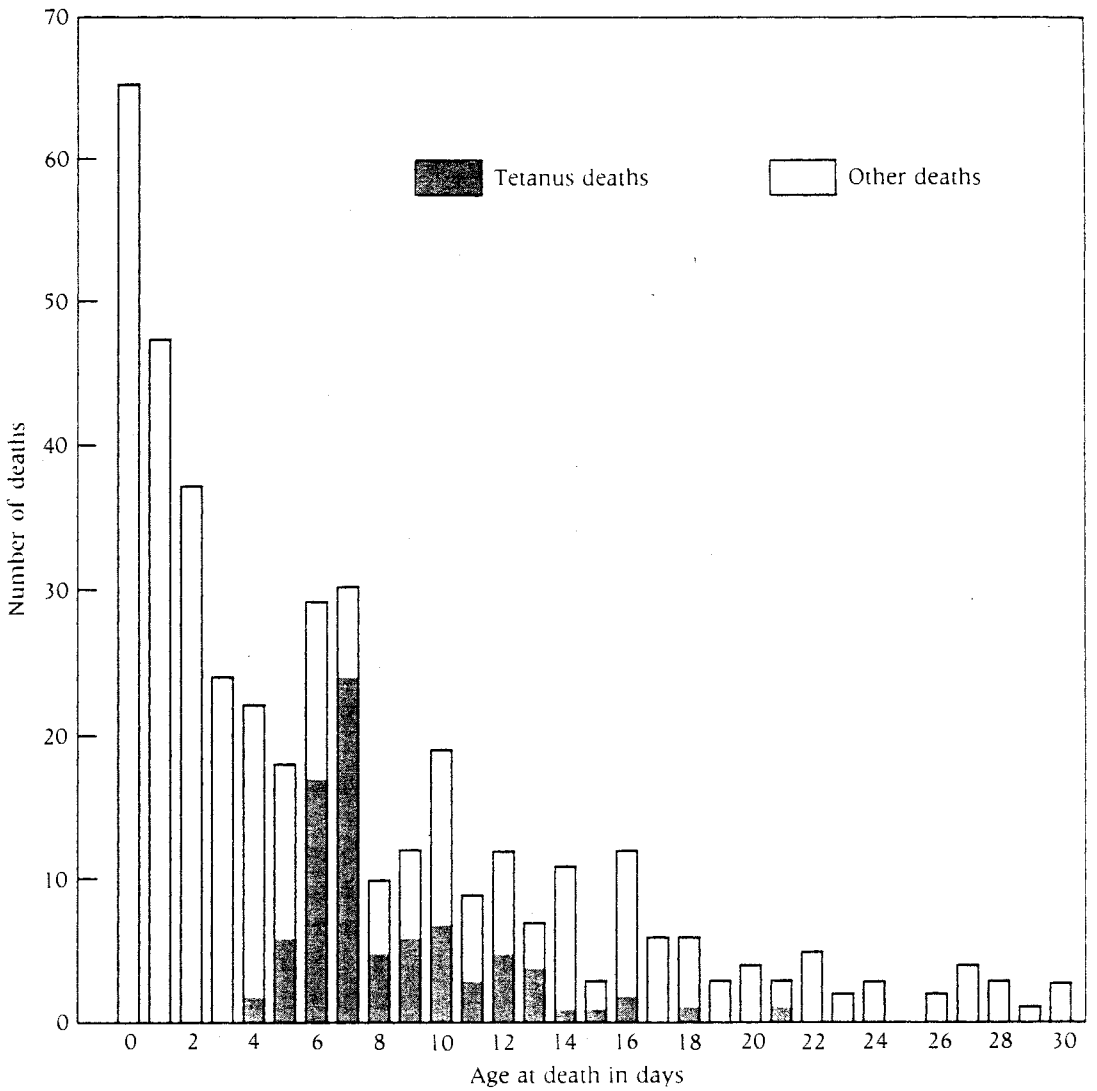



of the first month of life, and a significant proportion even during the period 4–14 days postpartum, are attributable to causes other than tetanus.

### Mortality impact of measles vaccination

Two recent studies from the Matlab treatment area on the impact of a measles vaccination program suggest that measles vaccination may lead to signifi-

**FIGURE 4 Number of neonatal deaths attributable to tetanus and to other causes, by age at death: Matlab comparison area, 1986–87**




cantly greater reductions in early child mortality than the 13 percent that the cause-of-death data for 1–4-year-olds would seem to indicate. A case–control study of 536 deaths at ages 10–60 months and 1,072 age-sex-matched controls in the Matlab intervention area during 1982–84 found measles vaccination to be associated with 36 percent lower child mortality.[16] A subsequent longitudinal cohort study of 8,135 vaccinated and 8,135 randomly matched unvaccinated children aged 9–60 months reported mortality levels during 1982–85 that were as much as 46 percent lower among the vaccinated than among the unvaccinated.[17]

There are several reasons to believe that the cause-of-death data presented earlier may significantly underestimate the importance of measles in early childhood mortality. First, the conservative definition employed in classifying measles-related deaths in the present study (within 45 days of the onset of measles) may have excluded a number of deaths due to delayed mortality from measles.[18] Second and relatedly, the cause-of-death data may have largely overlooked the potentially substantial indirect effect of measles on mortality through its relationship to such other causes of death as diarrhea and acute respiratory infection.[19] The likelihood of underreporting of measles illness that occurred prior to a child's death is also high. Finally, in light of the frequently observed multi-year cycle of the incidence of measles, the years for which cause-of-death data are considered here (1986–87) may have been a period of unusually low measles-related mortality. To account for the possibility that the mortality impact of measles vaccination may be underestimated by the cause-of-death data, we also consider the results of the two Matlab vaccination studies in estimating potential reductions in mortality.

## Estimates of potential mortality reductions

These three sources of data—relating to cause of death, age structure of childhood mortality, and the impact of vaccination against measles—permit us to derive estimates of potential reductions in mortality resulting from immunization against tetanus, pertussis, and measles (see Table 2). We have made one adjustment to the previously reported tetanus-related mortality rates. We deem the reported rates artificially low because significant numbers of women in the comparison area had earlier received tetanus toxoid as a placebo in a large-scale cholera vaccine trial in the Matlab study area in 1974.[20] Information from a recent study on reductions in neonatal mortality resulting from this placebo allows us to estimate the overall magnitude of bias introduced into our data by this vaccine trial, which, on the whole, appears to be quite modest.[21] Our estimates of reductions in tetanus-related mortality shown in Table 2 incorporate a small upward adjustment to reflect the effects of this bias.

It is evident from the table that any reductions in neonatal mortality resulting from immunization will be dependent upon reductions in the number of tetanus deaths. The estimates based on the cause-of-death and age distribution data are quite similar, indicating anticipated reductions in neonatal mortality between 16 and 19 deaths per thousand births, from a baseline neonatal mortality of 69 per thousand. Neonatal mortality rates are unaffected by either measles or pertussis. During the postneonatal period, the elimination of tetanus deaths would yield reductions of fewer than 2 deaths per thousand births, from a baseline mortality of 47 per thousand. Estimated mortality

**TABLE 2 Mortality reductions from elimination of tetanus, measles, and pertussis through immunization estimated by means of alternative methods: 1982–83 birth cohort, Matlab comparison area**

| | Deaths per 1000 live births | | |
|---|---|---|---|
| | Neonatal (1 mo. or less) | Postneonatal (1–11 months) | 1–4 years |
| Baseline mortality rate | 68.6 | 47.0 | 90.1 |
| **Estimated mortality reduction by disease and by alternative methods** | | | |
| Tetanus[a] | | | |
| Cause of death | 18.6 | 1.6 | 0.4 |
| Age distribution | 15.5[b] | NA[c] | NA[c] |
| Measles | | | |
| Cause of death | 0.0 | 1.3 | 11.0 |
| Age distribution | 0.0 | 2.9[d] | NA[c] |
| Measles vaccination | | | |
| Clemens et al.[e] | 0.0 | 3.6 | 31.5 |
| Koenig et al.[f] | 0.0 | 4.6 | 40.2 |
| Pertussis | | | |
| Cause of death | 0.0 | 1.6 | 1.2 |
| Age distribution | 0.0 | NA[c] | NA[c] |

NOTE: For discussion of the methods of estimation, see text.
[a] Adjusted to take into account the effects of the 1974 cholera vaccine trial (see text).
[b] Assumes the following distribution of tetanus deaths: 0 percent of all deaths during days 0–3, 50 percent during days 4–14, and 15 percent during days 15–30.
[c] Could not be ascertained from age distribution data since disease could occur throughout the risk period.
[d] Assumes the following distribution of measles deaths: 5 percent of all deaths during months 1–8, and 10 percent during months 9–11.
[e] See note 16.
[f] See note 17.

reductions from the elimination of measles would be only slightly greater, ranging between 1 and 5 deaths per thousand births according to the three sources of data. The reduction in postneonatal mortality resulting from the elimination of pertussis deaths is also quite modest (fewer than 2 deaths per thousand births).

Measles immunization clearly offers the greatest potential for mortality reductions during ages 1–4 years. Our minimum estimate, based on the cause-of-death data, is a mortality reduction of 11 deaths per thousand from an estimated baseline mortality of 90 deaths per thousand live births. Our estimates based on the results of the two measles vaccination programs suggest much greater effects on child mortality levels—potential reductions as high as 40 deaths per thousand births. As is the case with postneonatal mortality, reductions from the elimination of tetanus and pertussis deaths during ages 1–4 years are of limited significance.

In terms of overall reductions in infant and early child mortality, we have selected the highest estimate of mortality reduction for each disease and have assumed that individual mortality effects are additive and non-overlapping. The results indicate that immunization against these three diseases has the potential for reducing infant mortality from a baseline rate of 116 to 89 per thousand live births, or 23 percent. For ages 1–4 years, possible mortality reductions are substantially higher—from a baseline level of 90 per thousand births to as low as 48 per thousand births, or 47 percent.

## Discussion

Any exercise assessing potential reductions in mortality due to public health interventions requires numerous assumptions. One could argue that our estimates of potential mortality reduction in infant and early childhood mortality due to immunization either underestimate or overestimate true levels. With regard to possible *underestimation,* we noted at the outset that only three of the six major diseases targeted by EPI were considered in our analysis; the other infectious diseases targeted by EPI, however, are generally believed to play a minor role in childhood mortality.

Further, we may have significantly underestimated the importance of pertussis as a cause of childhood mortality in this population. The limitations of the method of establishing cause of death through verbal autopsy by lay reporters are well known.[22] While this caveat could apply to almost all causes of death during childhood, there is reason to believe that diagnosing pertussis-related deaths may be particularly problematic. The figures we have presented are therefore most appropriately viewed as minimum estimates of pertussis-related mortality in this population.

Our estimates of tetanus-related mortality are also substantially lower than those presented in other retrospective national surveys carried out in Bangladesh. A 1978 national survey reported that tetanus accounted for 56 percent of all neonatal deaths, and a similar survey in 1986 found tetanus to be responsible for 41 deaths per thousand live births.[23] These estimates contrast with the adjusted findings from our study, according to which tetanus accounted for 27 percent of all neonatal deaths, or roughly 21 deaths per thousand live births.

Several possible explanations exist for these divergent findings. First, the importance of tetanus as a cause of neonatal death in the Matlab comparison area may still be underestimated, as a result of other earlier cholera vaccine trials in Matlab during the 1960s in which tetanus toxoid was also provided as a placebo.[24] A review of this evidence, however, suggests that the effect of these earlier vaccine trials upon tetanus-related mortality in our study is in all probability modest and does not satisfactorily account for the discrepancies between the findings from our study and these other sources

of data.[25] A second possibility is that tetanus-related mortality in Matlab may, in fact, be somewhat lower than in other parts of rural Bangladesh. Data from reliable demographic surveillance systems in other areas of rural Bangladesh have reported somewhat higher levels of both neonatal and tetanus-related mortality.[26] It is thus possible that estimates based on Matlab data might understate the absolute mortality gains that may result from tetanus immunization for Bangladesh as a whole.

A third and more plausible explanation, in our view, is that tetanus may have been substantially overreported as a cause of death during infancy and early childhood in the two national surveys cited. Providing support for this thesis, a study on cause-of-death reporting in Matlab found that a significant proportion of lay-reported neonatal deaths had been incorrectly attributed to tetanus.[27] The tendency to overreport tetanus as a cause of death might be even more common in a retrospective survey, where data on mortality and causes of death may be inaccurate or incomplete and where the recall period may be long, thus increasing imprecision.

One can also argue convincingly that the present analysis may have *overestimated* the potential impact of EPI on mortality. Our estimates assume that each child "saved" through immunization will survive. In reality, reductions in cause-specific mortality may not be directly translated into improvements in overall survival. Preventing a child from dying from one cause may not prevent subsequent death from competing causes.[28] At the same time, the findings from recent research on the impact of measles vaccination programs, showing substantial and sustained effects on mortality, raise important questions about the relevance of the competing risks argument for immunization programs.[29]

Perhaps more to the point, our focus on the potential impact of immunization programs on mortality assumes that all young children are effectively protected against these EPI target diseases. In many developing countries, however, where health infrastructures are inadequate or largely absent, coverage rates for EPI remain far from universal. Significant proportions of all young children remain unprotected, and often it is these children who are most at risk of death from the diseases in question. Recommended ages for immunization are difficult to adhere to, either because of weaknesses in the service delivery program or the reluctance of parents to have their children immunized at very young ages.[30] Even when recommended schedules are followed, children will not be even partially protected from pertussis until they are 10 weeks old, and will not be fully protected until they are 14 weeks old; in the case of measles vaccination, protection is not currently achieved until the ninth month. The risk periods for both of these diseases, as well as for other diseases targeted by EPI, often precede these young ages. As a consequence, significant numbers of children continue to die from preventable diseases without having been vaccinated.

These problems are most acute in the least developed countries such as Bangladesh, where infectious diseases continue to be a major health problem and service programs remain weak.

Among the population reached by vaccination programs, reduced vaccine efficacy will occur in some cases, due to deficiencies in the delivery system.[31] Even when an effective delivery system is in place, vaccination will not provide complete protection: theoretical protective efficacy levels have been reported to reach almost 100 percent for two doses of tetanus toxoid, but only 70–90 percent for pertussis vaccine and 80–90 percent for measles vaccine.[32]

While the net effects of these qualifications on the estimates given in Table 2 are by no means clear, they are unlikely to appreciably alter the central finding of our study: Aside from maternal tetanus toxoid vaccination, current immunization programs have only limited potential to reduce mortality during the initial months of life, since this interval antedates both the primary risk periods and the current recommended ages at immunization for the other diseases targeted by EPI.

## Conclusions

Increasing attention has been focused on the considerable gap between anticipated and observed mortality impacts from primary health care programs in developing countries. Such factors as competing risks of other causes of morbidity and mortality, social and cultural constraints on the use of health technologies, and the limitations of disease-specific approaches are commonly advanced as explanations for this gap.[33] While these factors are undoubtedly important, the present study underscores the need to consider an additional explanation, one so simple as to be frequently overlooked: the failure of such technologies to adequately address the causes of death during the early months of life. Our analysis has also identified a number of important causes of childhood death—low birthweight/prematurity, acute respiratory infection, dysentery, and chronic diarrhea/severe malnutrition—that remain largely outside the purview of primary health care strategies such as GOBI. Recognizing the complexity of the factors affecting childhood mortality in developing countries, UNICEF in collaboration with WHO has recently broadened its health strategy for the 1990s to address many of these causes.[34] Progress in carrying out such a strategy, however, will undoubtedly be slow since few such causes are likely to be controlled by means of simple health technologies, and many are intricately tied to broader social and economic conditions that determine overall health status—as well as access to, and use of, health services.

Our focus on immunization in this study was not intended to question its role as a central component of programs aimed at improving child health

and survival in developing countries. On the contrary, strong justification exists for including immunization as a key component of any program designed to reduce childhood mortality, whatever the criteria employed—feasibility of implementation, cost-effectiveness, or overall mortality reduction.[35] Our results nevertheless indicate that while EPI has the potential to significantly reduce mortality during ages 1–4 years—largely as a consequence of measles vaccination—its effect on infant mortality is likely to be much more modest. Levels of infant mortality in settings such as rural Bangladesh are thus likely to remain high even after the successful implementation of this intervention. This conclusion is borne out by the experience of the Matlab maternal and child health/family planning program, in which the introduction of a full-scale EPI program (and implementation of much of the GOBI strategy) has led to significant declines in mortality at ages 1–4, but only to much more limited reductions in infant mortality levels.[36]

Rather than demonstrating a failure of immunization programs, our results are consistent with the growing recognition that individual health interventions, even those as efficacious as EPI, are alone unlikely to produce radical improvements in child survival, given the complex and multi-causal nature of childhood mortality in impoverished settings like Bangladesh. Seen from the proper perspective, primary health care initiatives such as GOBI are most appropriately viewed as starting points, rather than solutions, to the challenging problem of improving child health and survival in the developing world.

## Notes

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10 See J. F. Phillips et al., "Integrating health services into an MCH–FP program: Lessons from Matlab, Bangladesh," *Studies in Family Planning* 15, no. 4 (1984): 153–161. The DPT series was introduced in 1986 throughout the treatment area, making it difficult to assess the unique mortality impact resulting from this intervention.

11 See M. Koblinsky et al., "Barriers to implementing an effective national MCH–FP program," in D. Kluge (ed.), *Selected Papers of the 1984 Annual Conference of the National Council for International Health* (Arlington, Virginia, 1984), pp. 195–207; and M. Koenig et al., "Contraceptive use in Matlab, Bangladesh: Levels, trends, and explanations," unpublished paper, 1991.

12 National vaccination coverage rates for Bangladesh during this period were estimated to be 2 percent or less for the three DPT doses, measles, and maternal tetanus immunization. See World Health Organization, "Expanded Programme on Immunization: Global status report," *Weekly Epidemiological Record* 60, no. 34 (1985): 261–263.

13 World Health Organization, *Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death*, 9th Revision (Geneva: WHO, 1977).

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15 Tetanus is commonly referred to in many settings as the 7th or 8th day disease.

16 J. D. Clemens et al., "Measles vaccination and childhood mortality in rural Bangladesh," *American Journal of Epidemiology* 128, no. 6 (1988): 1330–1339.

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20 See R. E. Black et al., "Reduction of neonatal tetanus by mass immunization of non-pregnant women: Duration of protection provided by one or two doses of aluminum-adsorbed tetanus toxoid," *Bulletin of the World Health Organization* 58, no. 6 (1980): 927–930.

21 In the absence of the tetanus toxoid placebo, the neonatal mortality rate in the en-

tire comparison area during 1982–83 would have been 73.3 per thousand, compared with the actual level of 69.2 per thousand, a difference of 4.1 deaths per thousand live births (5.9 percent). Similarly, for 1986–87 comparison-area deaths, in the absence of the 1974 vaccine trial, tetanus would have accounted for 27.2 percent of all comparison-area neonatal deaths in 1986–87, compared with the reported 20.5 shown in Table 1. The calculations are based on data from M. A. Koenig et al., "Duration of protective immunity conferred by maternal tetanus toxoid immunization: Further evidence from Matlab, Bangladesh," unpublished paper, 1991.

22 R. Gray et al., *The Use of Verbal Autopsy Methods to Determine Selected Causes of Death in Children* (Liège: IUSSP Papers No. 3, February 1990).

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24 See A. S. Benenson et al., "Cholera vaccine field trials in East Pakistan: 2. Effectiveness in the field," *Bulletin of the World Health Organization* 38, no. 3 (1968): 359–372; and W. H. Mosley et al., "Report of the 1966–67 cholera vaccine field trial in rural East Pakistan: 4. Five years of observation with a practical assessment of the role of a cholera vaccine in cholera control programmes," *Bulletin of the World Health Organization* 47, no. 2 (1972): 229–238.

25 We base this conclusion on several facts. First, the cholera vaccine trials carried out during the 1960s involved relatively small numbers of women who received tetanus toxoid as a placebo. Second, significant numbers of women who received the tetanus toxoid placebo were excluded from the Matlab study area when the original surveillance area was reduced in size in 1978. Lastly, of those women who remained, many were likely to have passed their prime reproductive years and therefore not to have borne children during the period of interest here, 1982–87.

26 See A.B.M.K.A. Mozumder et al., "The Sample Registration System: An innovative system for monitoring demographic dynamics," *Asia-Pacific Population Journal* 5, no. 3 (1990): 63–72; M. Whittaker et al., ICDDR,B Extension Project, unpublished results; and International Centre for Diarrhoeal Disease Research, Bangladesh, *Annual Report 1989* (Dhaka, 1990).

27 S. Zimicki et al., "Cause of death reporting in Matlab," *Scientific Report No. 63*, International Centre for Diarrhoeal Disease Research, Bangladesh (October 1985).

28 For a discussion of this issue, see Kasango Project Team, "Influence of measles vaccination on survival pattern of 7–35 month-old children in Kasango, Zaire," *Lancet*, Vol. 1 (1981): 764–767; and W. H. Mosley, "Epidemiological strategies in infectious disease control," *Indian Journal of Community Services* 10 (1985): 53–76.

29 See Koenig et al., cited in note 17; and P. Aaby et al., "Measles vaccination and child mortality," *Lancet* (letter), Vol. 2 (1981): 93.

30 See N. Halsey and A. Galazka, "The efficacy of DPT and oral poliomyelitis immunization schedules initiated from birth to 12 weeks of age," *Bulletin of the World Health Organization* 63, no. 6 (1985): 1151–1169.

31 Most vaccines deteriorate when exposed to heat, and many require refrigeration. Deficiencies in the storage, transport, and cold chain systems can result in loss of vaccine potency. See A. Galazka, *Stability of Vaccines*. World Health Organization, WHO/EPI/GEN/89.8 (1989).

32 See W. A. Orenstein et al., "Diphtheria and tetanus toxoids and pertussis vaccine, combined," and N. A. Halsey, "The optimal age for administering measles vaccine in developing countries," both in Halsey and deQuadros, cited in note 4, pp. 30–51 and 4–17 respectively. It should be noted, however, that in the case of the Matlab measles vaccination results, reported mortality reductions reflect actual field vaccine efficacy levels.

33 See, for example, L. C. Chen, "Primary health care in developing countries: Overcoming operational, technical, and social barriers," *Lancet*, Vol. 2 (1986): 1260–1265.

34 See UNICEF, *Development Goals and Strategies for Children in the 1990s: A UNICEF Policy Review* (New York: UNICEF, 1990).

35 See, for example, A. Creese, "The economic evaluation of immunization programmes," in K. Lee and A. Mills (eds.), *The Economics of Health in Developing Countries* (Oxford: Oxford University Press, 1983), pp. 146–166; and L. Benzel, *The Costs of EPI: A Review of Cost and Cost-Effectiveness Studies (1977–1987)* (John Snow, Inc., Resources for Child Health Project, 1989.)

36 M. A. Strong, "Mortality in Matlab, 1966–90," paper presented at the Annual Meeting of the Population Association of America, 20–23 March, Washington, D.C.

## VI.2. INTERVENTIONS EN MATIERE DE PATHOLOGIE OBSTETRICALE

La mortalité maternelle, en particulier due aux causes obstétricales, est très élevée au Bangladesh[26]. Les interventions proposées pour la réduire ont été peu nombreuses et en tous cas pas ou mal évaluées.[43] A Matlab, les résultats des études sur les causes de la mortalité maternelle[24] ont non seulement permis de guider les interventions, mais aussi d'en évaluer les effets sur la mortalité obstétricale, comme le rapporte l'étude numérotée "E2"[44].

Dans cette étude prospective, des sages-femmmes ont été installées dans des villages et chargées d'assister autant d'accouchements à domicile que possible, afin de détecter et gérer les complications dès leur apparition, et accompagner les patientes au centre de santé du projet si nécessaire. L'effet de ce projet a été évalué par la comparaison des taux de mortalité obstétricale entre les villages du projet et des villages voisins et comparables mais sans sage-femmes. Bien que les taux soient similaires dans les trois années ayant précédé le début du projet, le taux de mortalité obstétricale dans les trois années suivantes a été trouvé significativement inférieur dans les villages du projet que dans les villages de comparaison.

Il est conclu que, dans le contexte étudié où toutes les femmes sont à haut risque obstétrical, cette intervention essentiellement curative mais faisable a un potentiel d'effet positif sur la mortalité obstétricale. Il est aussi conclu que la replication de ce type d'action à l'échelle nationale ne sera pas possible à court terme.

PUBLIC HEALTH

# Effect on mortality of community-based maternity-care programme in rural Bangladesh

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Various community-based interventions have been proposed to improve maternity care, but hardly any studies have reported the effect of these measures on maternal mortality. In this study, the efficacy of a maternity-care programme to reduce maternal mortality has been evaluated in the context of a primary health-care project in rural Bangladesh.

Trained midwives were posted in villages, and asked to attend as many home-deliveries as possible, detect and manage obstetric complications at onset, and accompany patients requiring referral for higher-level care to the project central maternity clinic. The effect of the programme was evaluated by comparison of direct obstetric maternal mortality ratios between the programme area and a neighbouring control area without midwives. Random assignment of the intervention was not possible but potentially confounding characteristics, including coverage and use of other health and family planning services, were similar in both areas. Maternal mortality ratios due to obstetric complications were similar in both areas during the 3 years preceding the start of the programme. By contrast, during the following 3 years, the ratio was significantly lower in the programme than in the control area (1·4 *vs* 3·8 per 1000 live births, $p=0·02$).

The findings suggest that maternal survival can be improved by the posting of midwives at village level, if they are given proper training, means, supervision, and back-up. The inputs for such a programme to succeed and the constraints of its replication on a large scale should not be underestimated.

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## Introduction

Complications of pregnancy and delivery, mainly due to obstetric difficulties, cause the death of half a million women a year world wide. 99% of these deaths occur in developing countries, where they account for more than one-third of all deaths of women.[1,2] Although maternity care has long been proposed to reduce neonatal mortality, only recently has it been promoted as an essential component of maternal survival in primary health-care programmes. Various community-based interventions have been put forward to improve maternity care, including the training of traditional birth attendants, development of maternity hospitals, family planning programmes, and obstetric case-management. Very few studies, however, have reported the effect of these measures on maternal mortality[3,4] because of a lack of longitudinal data about large populations.

We here report the effect on maternal mortality of a maternity-care programme implemented within a community-based maternal and child health and family planning (MCH-FP) project in Matlab, the field station of the International Centre for Diarrhoeal Disease Research, Bangladesh.

## Subjects and methods

Matlab is a rural subdistrict of the Ganges-Meghna delta, about 30 km south-east of Dhaka, Bangladesh. As in most areas of flood-prone southern Bangladesh, rural people subsist poorly on rice-growing and fishing, use mostly water communication, and follow male-dominated cultural patterns such as the seclusion of women in their compound. Literacy rates are as low as 30% for men and 17% for women. Despite efforts to promote family planning since 1977 in the project area, total fertility rates have remained high, ranging from 5·5 to 4·3 per woman during the study period. Infant mortality rates have fluctuated from 110 per 1000 live births in 1983 to 75 in 1989.

### *Demographic surveillance and assessment of cause of death*

A demographic surveillance system was started in 1966, combining periodic censuses and longitudinal reporting of births, deaths, marriages, and migrations in a population of about 196 000 at the time of the study.[5] In late 1977, the area under surveillance was divided into a treatment area, where the MCH-FP project was implemented, and a comparison area of equal size, only covered by the Government health services.[6] The present study is restricted to the treatment area only.

In this area, 80 female community health workers (CHWs) visit each household of their village every two weeks, and report deaths and other vital events to their male supervisors. These supervisors, accompanied by the CHW, visit the family and complete death forms with demographic information about the individual, and an open description of symptoms and events preceding death. These forms are then sent to a physician who assigns primary and underlying causes of death. Causes are coded according to the ICD classification.[7] Methods to assign cause of maternal deaths in this area have been previously described.[8] Briefly, all households in

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TABLE I—DEMOGRAPHIC AND SOCIOECONOMIC CHARACTERISTICS OF CONTROL AND INTERVENTION AREAS IN 1986

| | Control area | Intervention area |
|---|---|---|
| Population (no) | 51 468 | 47 808 |
| No of women 15–44 yr | 11 564 | 10 260 |
| No of live births | 1781 | 1534 |
| Infant mortality rate (/1000 live births) | 79·6 | 86·2 |
| Female death rate (/10 000 women 15–44 yrs) | 25·9 | 29·2 |
| Contraceptive use rate (% of eligible couples) | 42·4 | 44·4 |
| Tetanus immunisation rate (% of married women) | 86·2 | 87·8 |
| Mean no of years of school attended by married women | 2·3 | 2·0 |
| Proportion of married women who attended school | 42% | 37% |

which a death of a woman of reproductive age was reported were visited by a specially trained female assistant; she interviewed the female relatives who had attended the death. Her written statement was then interpreted by an experienced physician. In the rare event of death in a health facility, medical reports were taken into account to establish cause of death. Our analysis focuses on direct obstetric deaths—ie, those that occurred during pregnancy, delivery, or six weeks after termination of pregnancy and were attributed to obstetric complications. The analysis does not account for deaths due to conditions not directly related to obstetric complications but that were aggravated by the pregnancy or postpartum status (eg, diarrhoea, respiratory tract infection, hepatitis, violence).

### *Health and family planning services*

The Matlab maternity care programme was implemented within the MCH-FP project.[9] The principal providers of MCH-FP services are the village CHWs; they offer a choice of contraceptives, motivate and counsel mothers for family planning, monitor and manage adverse effects, administer EPI (Expanded Programme on Immunisation) vaccines, promote oral rehydration, distribute vitamin A capsules, provide nutritional education, detect and refer malnourished children, and distribute safe-delivery kits and iron tablets to pregnant women. They refer severely sick mothers or children to one of four decentralised MCH-FP outposts staffed by paramedics, or to the central Matlab clinic where at least one female physician is always available. The CHWs record all services provided by them, and also demographic and morbidity information.

Contraceptive use prevalence rates in the MCH-FP project area increased from 8% in 1977 to 40% in 1984, and to 56% in 1989. The demographic effect of the MCH-FP project has been described elsewhere.[9,10] The effect of the project on maternal mortality, however, was limited, with maternal mortality ratios remaining around 5·5 per 1000 live births.[3,11] These findings, in addition to the study on cause of death,[8] led to an effort to develop maternity-care interventions in a subsequent phase of the MCH-FP project, from 1987.[12]

### *Maternity-care programme*

The main features of the intervention were derived from the findings of a retrospective study of causes and conditions of maternal deaths in the area.[8] These findings led to the hypothesis that the posting of professional midwives in villages would have the best potential for saving lives, provided that these midwives were equipped to treat immediately obstetric complications at their onset, and were backed up by an effective chain of referral.

So that effect could be evaluated by comparison with a control area, the programme was implemented in only half the MCH-FP area, consisting of about 48 000 people living in 39 villages. There were two health outposts in each programme and control area. Two nurse-midwives (government trained) were recruited and posted in each outpost of the programme area. Their duties were: to work with CHWs and traditional birth attendants and ensure that these CHWs called them during labour; to carry out antenatal visits to the pregnant women identified by CHWs; to assess risks of complications antenatally; to attend as many home deliveries as possible; to treat arising complications at onset before they became too severe; to organise referral and accompany the patient to the central clinic at Matlab if judged necessary; and to visit as many new mothers as possible within 48 h of delivery. Details of their duties, treatment guidelines, essential drugs and equipment, and record keeping system are described elsewhere.[12] There were about 1600 pregnancies a year in the programme area (an average of 33 a month per midwife) with much seasonal variation.

The aim of the project was for midwives to live as near as possible to pregnant or delivering women, to enable rapid intervention at the onset of a complication. Early intervention, such as early administration of anti-preeclamptic drugs and management of malpresentation, was needed to prevent progression to a severe condition, which would be almost impossible to treat in this setting. Interventions for the health of the baby were also recommended.

Midwives were supported by two other components of the programme—namely, development of a referral chain, including a boatman and a helper to accompany patients day or night to the central clinic, and installation of a maternity clinic at Matlab, where trained paramedics and female physicians were always available for intensive surveillance, treatment, or further referral to a district hospital. Patients requiring caesarean section and blood transfusion were further referred by ambulance to the district hospital. The Matlab maternity clinic was not equipped with surgical, radiological, or modern laboratory facilities. The only items of obstetric equipment available were vacuum extractor, suction machine, and obstetric forceps. The emphasis was on immediate care of admitted patients, and stabilisation for rapid transfer of patients requiring surgery.

### *Programme monitoring and analysis*

The midwives maintained a record of all prenatal and postpartum visits and all deliveries attended. The outcome of intervention, however, was measured independently by comparison of the direct obstetric mortality ratios per thousand live births between the intervention and control areas during the three years before and the 3 years after the start of the programme. Midwives did not assess cause of death. The main reason for the 3-year grouping was to average the annual variations with rare (relative to other) events such as obstetric deaths.

The ratio of deaths per thousand live births rather than rate of deaths per thousand women of reproductive age, was chosen for comparison because the ratio specifically measures the risk of dying during pregnancy, whereas the rate measures both the risk of becoming pregnant and the risk of dying during pregnancy.[11] Numbers of live births came from the demographic surveillance data.

Standard tests were used to calculate odds ratios (ORs) and their 95% confidence intervals (CI) when mortality differences between areas and between pre-intervention and post-intervention periods

TABLE II—OBSTETRIC MORTALITY, 1984–89

| | Control area | | Intervention area | | Odds ratio between areas (95% CI) |
|---|---|---|---|---|---|
| | No of deaths (live births) | Ratio* | No of deaths (live births) | Ratio* | |
| Pre-programme period (1984–86) | 20 (5177) | 3·9 | 20 (4548) | 4·4 | 1·14 (0·59–2·21) |
| Programme period (1987–89) | 20 (5206) | 3·8 | 6 (4424) | 1·4 | 0·35 (0·13–0·93)† |
| *Odds ratio between periods (95% CI)* | 0·99 (0·51–1·93) | | 0·31 (0·11–0·81)‡ | | |

*per 1000 live births; †$p < 0·05$; ‡$p < 0·01$. Chi-square for heterogeneity 4·8, $p = 0·03$.

were assessed. A heterogeneity test with a logit transformation was used to test differences in risk of obstetric death between periods while stratifying by area.[13]

## Results

Demographic, socioeconomic, and health-service use indicators were similar in both study areas in 1986, before the start of the maternity-care programme (table I). Infant and adult female mortality rates were higher in the intervention than in the control area, despite higher service use rates. However, levels of maternal education were lower in the intervention area.

During the 6 years covered by this study, a total of 66 deaths of women were due to obstetric complicatons (40 control area, 26 intervention area). During the baseline period (1984 to 1986), the obstetric mortality ratio in the intervention area was not significantly different from that in the control area (table II). During the 3-year period after the start of the maternity care programme (1987–1989), however, the ratio in the intervention area was significantly lower than that in the control area (table II). Within the intervention area, the odds ratio of obstetric death between the programme period and the pre-programme period was 0·31 (95% CI 0·11–0·81, p = 0·007), whereas there was no significant change in the control area (odds ratio 0·99, 95% CI 0·51–1·93). These differences in change between the two areas were significant—ie, the risk of obstetric death in the intervention area relative to the control area was significantly lower during the years after the start of the programme than during the preceding years (chi-square for heterogeneity 4·8, p = 0·03).

Female death rates (per 10 000 woman-years of exposure) from causes other than obstetric complications were not statistically significantly different in the intervention and control areas during the two study periods (table III).

At the start of the maternity-care programme there were 10 521 women aged 15–44 years. Of the 4884 registered pregnancies, 2160 (44%) were visited at home at least once by midwives, and 4395 (90%) ended in live births. Although 15% of all registered pregnant women had requested the programme midwives to attend them during labour, only 9% (449) were attended in the true sense—ie, the midwife herself delivered the baby. In 4% (191), the midwife was present but allowed either a traditional midwife or a female paramedic to deliver the baby, and in 1% (49) the midwife was on her way. A total of 134 women from the programme area (ie, 19% of all those attended by midwives at home during labour) were referred to the Matlab maternity clinic. Of the 1712 women visited at home after delivery, (481, within 48 h of outcome; 1231, 2–4 days after outcome), 44 (3%) were referred to the same clinic for post-partum complications.

The principal causes of obstetric deaths that were reduced by the programme were, in order of decreasing importance, complications of abortion, post-partum haemorrhage, post-partum sepsis, obstructed labour, and eclampsia.

## Discussion

The findings of this study show a significant association between the implementation of the maternity-care programme in the intervention area and a substantial reduction in obstetric mortality in the community. Since the study was not designed by random allocation of pregnant mothers to intervention or control groups (a procedure that would have been impracticable), this conclusion does not necessarily imply that the mortality reduction in the intervention area was due to the intervention itself. Geographic, demographic, socioeconomic, and health-service use data collected before the start of this programme suggest, however, that the two areas were similar and that observed differences can be attributed to the intervention. Moreover, mortality indicators were worse in the intervention than in the control area before the implementation of the programme.

The enumeration of deaths and live births was probably exhaustive in this study owing to the intensive supervision of the demographic surveillance in Matlab. The "verbal autopsy" method used to assign cause of death, however, has its limits—eg, possible misclassification of cause of death, difficulties when there are multiple causes of death, and lack of necropsy validation. Because the assignment of cause of death was not specifically designed for this study, health assistants and physicians involved in the reporting and interpretation of symptoms preceding death were unlikely to be biased with respect to our findings. That deaths from causes other than obstetric were constant over time in both study areas rules out a spurious replacement of obstetric deaths by deaths from other causes.

Although statistically significant, the outcome of this intervention is modest in absolute terms, but it is in scale with the magnitude of the process indicators that show the proportion of deliveries done by the midwives. It is possible that the midwives had reached the small fraction of obstetric complications that needed little input to ensure survival. Because the collection and recording of obstetric data, done by the midwives themselves, was obviously not done for women who did not request assistance, comparative data are not available.

Several reasons may explain the apparently low coverage of home deliveries. Research done in 1988 in the programme area identified factors that differentiated women who called midwives from those who delivered alone or with a traditional birth attendant (G. Hlady, V. Fauveau, unpublished). Two of the factors were proximity to the midwife's residence and previous antenatal contact. The discrepancy between the proportion of women visited by midwives during pregnancy and the low proportion of labour calls and deliveries by midwives may arise from the distance factor, and also from the rarity of obstetric complications. In traditional societies, the decision to call an external birth attendant is often made by male family members or by elderly women; their potential unwillingness to seek assistance may have been underestimated.

TABLE III—ADULT FEMALE MORTALITY 1984–89

| | Control area | | Intervention area | | Odds ratio between areas (95% CI) |
|---|---|---|---|---|---|
| — | No of deaths (woman-years) | Rate | No of deaths (woman-years) | Rate | |
| Pre-programme period (1984–86) | 61 (33 771) | 18·1 | 60 (30 808) | 19·5 | 1·08 (0·74–1·56) |
| Programme period (1987–89) | 62 (36 604) | 16·9 | 58 (32 508) | 17·8 | 1·05 (0·73–1·53) |
| *Odds ratio between periods (95% CI)* | 0·94 (0·65–1·36) | | 0·92 (0·63–1·33) | | |

Death rates are per 10 000 woman-years (for women aged 15–44 yr). Chi-square for heterogeneity = 0·008.

Additionally, many families would not call external assistance until obvious complications develop, and many would be reluctant to call for fear of further referral to the district hospital. That this fear is based on negative previous experiences and also on rumours about neglected care points to the need to reinforce the range and quality of services offered at the district hospital, especially blood transfusion and surgical procedures such as caesarean section.

A community-based maternity-care programme in rural Bangladesh, provided that it involves professional midwives and an effective referral system, has the potential to reduce maternal mortality. A preliminary analysis shows that neonatal mortality had also significantly dropped in the programme area and not in the control area. Whether such a project can be sustained and replicated on a large scale remains to be seen. The posting of a nurse-midwife in every health outpost countrywide is not practicable owing to insufficient staff and lack of committment at a national level. A more suitable alternative would be to post family welfare visitors—ie, female paramedical field workers with 18 months' training in maternal and child health. A simple screening method for community-health workers to detect high-risk pregnancies could make the best use of paramedical staff. This modified approach has now been implemented in Matlab and is now being evaluated. Two other related issues are also being investigated—namely, the effect of the programme on perinatal mortality and the costs of this programme.

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CLINICAL PRACTICE

# Percutaneous catheter fragmentation and distal dispersion of proximal pulmonary embolus

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Rapid restoration of pulmonary blood flow is important in preventing death due to a massive pulmonary embolus. Devices developed specifically for percutaneous transvenous removal of pulmonary emboli are bulky and their insertion through a cut down or by the use of a large venous sheath can lead to bleeding at the entry site. In 3 patients with acute massive pulmonary embolism, conventional cardiac catheters were used to break up the embolus and disperse the fragments distally. Cardiac output was rapidly restored in all patients. There were no serious complications. This technique requires no more specialist equipment or skill than those needed for temporary cardiac pacing and could be important for the emergency management of patients with acute severe pulmonary embolism.

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## Introduction

Acute severe pulmonary embolism can be treated by anticoagulation, thrombolysis, or occasionally by surgical removal of the obstruction. Specifically designed percutaneous transvenous catheters to remove emboli from the major pulmonary arteries are not widely used.[1] We describe the use of standard cardiac catheters in 3 patients to fragment such emboli and disperse them into the distal pulmonary vessels.

## Patients and methods

*Patient 1*—7 days after a bone graft operation on her nose an 18-year-old girl consulted her general practitioner because of

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## VI.3. INTERVENTIONS EN MATIERE D'INFECTIONS RESPIRATOIRES AIGUES

Les infections respiratoires aigues, communément appelées "pneumonies" dans la nomenclature de l'OMS, font partie des causes de mortalité infantile et infanto-juvénile les plus fréquentes àMatlab, comme dans le reste du monde en développement.[45,46] Il était donc naturel de mettre en place un programme d'intervention, basé sur la détection et le traitement rapide des pneumonies par les auxiliaires de santé villageoises, et d'évaluer l'effet de ce programme à l'aide des taux de mortalité spécifique. Ainsi que rapporté dans la publication "E3"[47], les taux de mortalité spécifiques ont été examinés séparément pour les groupes d'âge d'un à onze mois et d'un àquatre ans, excluant les nouveaux-nés de moins d'un mois en raison des difficultés diagnostiques. Le taux de mortalité due aux infections respiratoires aigues a été trouvé significativement plus bas dans la période suivant la mise en place du programme que dans la période précédente dans la zone affectée par le projet, mais non dans la zone de contrôle. De plus, cet effet a été trouvé plus important dans le groupe d'âge des nourrissons (un à onze mois) que chez les enfants plus agés.

# Impact on mortality of a community-based programme to control acute lower respiratory tract infections*

V. Fauveau,[1] M. K. Stewart,[2] J. Chakraborty,[3] & S. A. Khan[4]

*Acute lower respiratory tract infections (ALRIs) are a major cause of death among young children in developing countries. A targeted programme designed to treat children with ALRI was implemented in 1988 in a primary health care project in rural Bangladesh. In the 2 years preceding the introduction of the programme (1986–87), non-ALRI-specific health services were provided, including promotion of oral rehydration therapy, family planning, immunization of children and mothers, distribution of vitamin A, referral of severely sick children to field clinics, and nutritional rehabilitation of malnourished children. The targeted ALRI programme, which was in place in 1988–89, was based on systematic ALRI case detection and management by community health workers, who were linked to a referral system for medical support. These two levels of intervention have been evaluated by comparing the ALRI-specific mortality in the programme area and a neighbouring control area during the two periods.*

*During the first phase (1986–87), the ALRI mortality among under-5-year-olds was 28% lower in the intervention than in the comparison area ($P<0.01$). During the second phase (1988–89), the ALRI mortality was 32% lower in the intervention area than during the preceding phase, while there was no significant difference for the comparison area. These findings suggest that in the study region the combination of specific and nonspecific interventions can reduce ALRI mortality by as much as 50% and the overall mortality among under-5-year-olds by as much as 30%.*

Acute lower respiratory infections (ALRIs) cause the death of 4 million under-5-year-olds annually in the world, and in developing countries they are associated with a third of all deaths in childhood (*1–4*). However, ALRI control has only recently been promoted as a component of child survival programmes. WHO has developed guidelines to treat acute respiratory infections (ARIs) at the primary health care level, using community and first-level health workers to detect cases, assess the severity, and provide antibiotic treatment at home or refer severely affected children to a field health centre (*5, 6*).[a] The WHO approach is based on the assumption that a substantial proportion of life-threatening ALRIs are bacterial and respond to antimicrobials (*7, 8*).

A number of field trials have evaluated the effect of community-based ALRI treatment on mortality (*9–11*).[b] However, the relative impacts on ALRI mortality of a general primary health care programme and of a specific case-management programme have never been clearly evaluated.[b]

We have implemented sequentially these two types of programmes in Matlab, the field station of the International Centre for Diarrhoeal Disease Research, Bangladesh. The results obtained permit comparison of their respective and cumulative effects on ALRI mortality.

## Subjects and methods

### Study area

Matlab is a rural subdistrict of the large Ganges–Meghna delta, approximately 50 km southeast of Dhaka, the capital of Bangladesh. This flood-prone area is typical of rural Bangladesh, with its lack of infrastructure and limited communication facilities. The population subsists mainly by rice cul-

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[a] *Case management of acute respiratory infections in children in developing countries: report of a Working Group meeting, Geneva, 3–6 April 1984.* Unpublished document WHO / RSD / 85.15.Rev.2.

[b] *Programme for the Control of Acute Respiratory Infections: report of the fourth meeting of the Technical Advisory Group, Geneva, 6–10 March 1989.* Unpublished document WHO / ARI / 89.4, pp. 10-11.

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tivation, fishing, and through wage-labour. The literacy rates are 30% for men and 17% for women; in 1986 the total fertility was 5.5 per woman and the infant mortality, 93 per 1000 live births.

### Demographic surveillance and assessment of cause of death

A demographic surveillance system (DSS) was instituted in Matlab in 1966, combining periodic censuses and longitudinal reporting of births, deaths, marriages, and migrations in a population that was approximately 200 000 at the time of the present study (*12*).

A total of 110 female community health workers (CHWs) visit each household in their village once every two weeks, and report deaths to their supervisors. Whenever a death is reported, a health assistant visits the family within a month and fills in a form with details of the symptoms and events preceding the death. The forms are then read by a medical assistant, who assigns the primary and underlying causes of death, under the supervision of a physician (*13*). This assignment is not based on the use of algorithms, as is the case with lay health workers, but on diagnoses made by medically trained persons. The causes of death are coded according to a system derived from the International Classification of Diseases (*14*). Although this system had no separate codes for deaths primarily attributed to pneumonia or bronchiolitis, such deaths were classified as ALRI in the study. There were, however, distinct codes for deaths caused by pertussis and post-measles pneumonia, and they were included in the study.

### Health services in the study area

In 1978, a community-based family planning and health services project was launched in one half of the DSS study area (the intervention area), whose original goal was to increase contraceptive use and reduce fertility and mortality (*15*); however, since 1986 the development of maternal and child health (MCH) interventions has been emphasized (*13*).

The other half of the DSS study area (the comparison area) receives only government health services. Its primary health care services are somewhat limited, with poor coverage and utilization.

The key providers of health services in the intervention area are the village CHWs. These individuals deliver a range of family planning methods, monitor and manage adverse effects of contraceptives, administer vaccines for the six common childhood diseases, promote the use of oral rehydration therapy for diarrhoea, distribute vitamin A capsules, provide nutritional education, and detect and refer seriously ill or malnourished children for care at a higher level. Seriously ill children are referred to one of four decentralized MCH clinics staffed by paramedics or to the central Matlab clinic, where at least one MCH physician is always available.

### The specific ALRI intervention

***Training of health workers.*** In January 1988, the CHWs were trained to detect children with ALRIs, assess the severity, and treat or refer them. At the initial training session the workers received a copy of a local version of the WHO guidelines for management of ALRIs. Slides produced by WHO were translated into Bangla, the local language, and shown to help workers identify signs of ALRI. Lastly, the CHWs were given case demonstrations of ALRIs in the field by their paramedic supervisors. The paramedics had previously received similar training, but were given practical experience by carrying out rotational duties in Matlab and by working with physicians in the clinic and hospital.

***Diagnosis of ALRIs.*** The CHWs carried out active case detection during scheduled house visits, while passive detection occurred when they were informed of cases in their village during the intervals between their visits. A diagnosis of severe ALRI was based on the presence of chest retractions with a respiratory rate greater than 50 per minute. Children with associated signs of severe disease, including high fever, convulsions, extreme lethargy, or inability to suck or drink, were also diagnosed as having severe ALRI. Moderate cases were defined as those with a respiratory rate greater than 50 per minute without chest retractions or other signs of severe disease. Children presenting with only a cough and/or low-grade fever were diagnosed to have mild ARI.

***Case management.*** All cases diagnosed as severe were referred to Matlab for evaluation and management by medical officers. All neonates, children with a cough that had lasted for more than 30 days, and children with a wheeze or stridor were also referred to Matlab. After assessment by the physician, the ALRI cases that were considered to be severe were admitted to hospital for treatment with oxygen and, if necessary, intravenous antibiotics.

When the project was initiated, one intention was to examine, for similar cases, the impact of home treatment on children with moderate ALRI compared with that following referral to the subcentre clinic. Therefore, in one half of the intervention area, moderate ALRIs were managed by CHWs at home using five daily injections of procaine penicillin in doses of 400 000–800 000 IU, depending on age. In the other half of the intervention area, mod-

erate cases were treated in the subcentre clinics with ampicillin syrup. Since ALRI mortality was not different in the two subareas in the 2 years following initiation of the project in 1986, the data from them were pooled for the analysis. All the facilities were provided with drugs and equipment to manage potential adverse reactions caused by the antibiotics, but no such reactions were reported.

Mild cases were not managed with antibiotics, but were given supportive care. The mothers of these children were advised about worsening signs and symptoms and asked to seek help if any of these developed.

***Supervising and monitoring the CHWs.*** The CHWs were supervised in the field by paramedics, who provided technical support. The workers attended fortnightly meetings with their supervisors, to report the numbers of cases detected and case-management methods, and to discuss problems and referrals.

***Concurrent activities in the intervention area.*** The only other new service introduced in one half of the intervention area during the study period was a maternity care project that was initiated in April 1987. This project targeted pregnant women and would not be expected to have had an impact on ALRI-specific deaths among under-5-year-olds. The addition of the ALRI case-management component was therefore the only difference in child health services between the two phases (1986–87 and 1988–89) in the intervention area.

### *Programme monitoring and analysis*

The methods used to detect vital events and assess the cause of death were identical in both study areas. In the intervention area, the CHWs also recorded morbidity information along with details of the services provided. The outcome of these interventions was analysed by comparing ALRI-specific mortality rates within the following age groups: all children aged under 5 years; children aged 1–4 years; and post-neonates aged 1–11 months (excluding neonates because of difficulties in diagnosing under-1-month-olds). The rates were calculated by dividing the number of ALRI deaths in each period and area by the number of child-years of exposure to the risk of ALRI death. The total number of child-years was obtained by adding the mid-year populations of children in each year.

Standard Mantel–Haenszel tests for person–time comparisons were used to assess the statistical significance of the differences in mortality rates between areas and between periods. A $\chi^2$ test for heterogeneity, based on stratification of rate-ratios, was used to evaluate the differences in rates between periods, while stratifying by area (*16*).

## Results

Table 1 shows the coverage rates for various maternal and child health and family planning services (MCH–FP), other than specific ALRI control, during the pre- and post-intervention periods in the intervention and comparison areas. Immunization and family planning were the services that exhibited the greatest differences in use between the two areas.

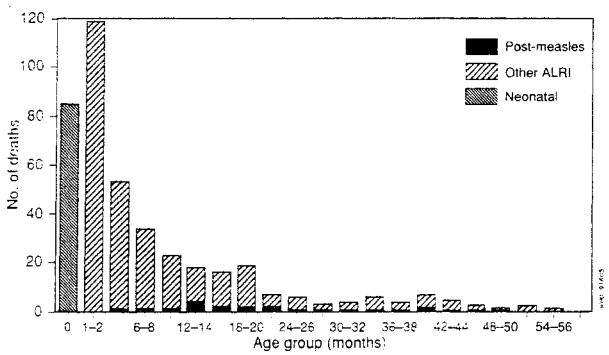
Table 1: **Coverage rates for maternal and child health services during the pre- and post-intervention periods in the two study areas, Matlab ALRI control project, 1986–89**[a]

| | Comparison area | Intervention area |
|---|---|---|
| Measles immunization coverage (% of children aged 9–59 months) in: | | |
| 1986–87 | 2–5 [b] | 69 |
| 1988–89 | 13 [b] | 81 |
| DPT–polio coverage (3 injections) (% of children aged 6 weeks–2 years) in:[c] | | |
| 1986–87 | 1–2 [b] | 57 |
| 1988–89 | 5–9 [b] | 64 |
| Vitamin A distribution coverage (% of children aged 6–59 months) in: | | |
| 1986–87 | 90 | 96 |
| 1988–89 | 88 | 95 |
| Contraceptive use (% of eligible couples) in: | | |
| 1986–87 | 18 [b] | 47 |
| 1988–89 | 22 [b] | 52 |
| Admission rate to Matlab diarrhoea hospital (% of under 5-year-olds) in: | | |
| 1986–87 | 4.4 | 4.7 |
| 1988–89 | 5.7 | 6.3 |
| Mean weight for age (% of NCIH standards for children aged 6–47 months) in: | | |
| 1986–87 | NA [d] | NA [d] |
| 1988–89 | 74 [b] | 73 |

[a] Whenever possible, the rates shown are those for the mid-period point.
[b] Estimated from nationwide surveys.
[c] DPT = diphtheria–pertussis–tetanus.
[d] NA = not available.

During the 4 years covered by the study, the deaths of 649 under-5-year-olds were reported as ALRI deaths in the whole study area. The age distribution of 417 such deaths that occurred in the comparison area in 1986–89 (Fig. 1) is strongly skewed towards younger age groups, with 61% involving under-6-month-olds. With the exception of deaths from post-measles pneumonia, the age-distribution

Fig. 1. **Age distribution of deaths from acute lower respiratory infections in the Matlab comparison area, 1986–89.**




of ALRI deaths in the intervention area prior to the start of the programme was very similar for all causes, with 69% of deaths occurring among under-6-month-olds.

During the first 2-year phase of the programme, the ALRI-specific mortality rate for all children under 5 years of age was 28% lower in the intervention than in the comparison area ($P$ <0.01, Table 2). In the second 2-year phase, over 3000 ALRI episodes were reported by CHWs and other health workers in the intervention area, 57% of which were seen and managed by the CHWs (73% at their own home and 27% at the patient's home), 35% were treated by village practitioners, 6% were not treated, while 2% were lost to follow-up. The ALRI-specific mortality rate among under-5-year-olds was 48% lower in the intervention than in the comparison area ($P$ <0.001). This difference was responsible for one third of the 30% lower overall mortality among under-5-year-olds in the intervention than in the comparison area (211 versus 30.7 per 1000; see Table 3).

Within the intervention area, the ALRI-specific death rate was 32% lower during the second phase of the programme than during the first ($P$ = 0.003, Table 2). In contrast, the rate decreased by 6% in the comparison area (not significant). The difference in the reduction of ALRI-mortality was, however, found to be significant when the risk of dying from ALRI in the two areas was compared for the two phases ($\chi^2$ test for heterogeneity: 4.1, $P < 0.05$).

The mortality patterns varied according to age group. During the first phase, for children aged 1–4 years, the ALRI-specific death rate in the intervention area was half that in the comparison area. Although it was halved again during the second phase, the reductions in the ALRI-specific death rates in the two areas were not significantly different between the two phases ($\chi^2$ test for heterogeneity = 0.6, Table 2).

Among infants aged 1–11 months (post-neonates), the ALRI-specific death rate during the first phase was not significantly lower in the intervention than in the comparison area, but in the intervention area was 30% lower during the second phase than during the first ($P < 0.05$, Table 2). The difference in the reduction between the two areas was of border-

Table 2: **ARI-specific mortality during the two phases of the Matlab ALRI control programme, 1986–89**

| | Comparison area | | Intervention area | | % difference in rates between the areas |
|---|---|---|---|---|---|
| | No. of ALRI deaths | Rate[a] | No. of ALRI deaths | Rate[a] | |
| *All under-5-year-olds* | | | | | |
| 1986–87 | 210/32 237 | 6.5 | 136/29 011 | 4.7 | – 28; $P < 0.01$ |
| 1988–89 | 207/33 679 | 6.1 (– 6; NS)[b] | 96/30 350 | 3.2 (– 32; $P < 0.01$) | – 48; $P < 0.001$ |
| $\chi^2$ test for heterogeneity 4.1, $P$ = 0.04 | | | | | |
| *Children aged 1–4 years* | | | | | |
| 1986–87 | 61/24 560 | 2.5 | 27/22 331 | 1.2 | – 52; $P < 0.01$ |
| 1988–89 | 42/25 701 | 1.6 (– 36; $P < 0.05$) | 14/23 700 | 0.6 (– 50; $P < 0.05$) | – 63; $P < 0.001$ |
| $\chi^2$ test for heterogeneity 0.6, NS | | | | | |
| *Infants aged 1–11 months (post-neonates)* | | | | | |
| 1986–87 | 108/6979 | 15.5 | 79/6057 | 13.0 | – 16; NS |
| 1988–89 | 116/7238 | 16.0 (+ 3; NS) | 56/6136 | 9.1 (– 30; $P < 0.05$) | – 43; $P < 0.001$ |
| $\chi^2$ test for heterogeneity 3.4, $P$ = 0.06 | | | | | |

[a] Per 1000 child-years of exposure.
[b] Figures in parentheses are the percentage change in mortality rates between the two periods; NS = not significant.

line statistical significance ($\chi^2$ test for heterogeneity = 3.4, $P = 0.06$).

The death rates for causes other than ALRI and for all causes are shown in Table 3. The former rates were lower in the intervention than in the comparison area, both for all under-5-year-olds and those aged 1–4 years, but not for post-neonates who died aged 1–11 months. In both areas and for all age groups, death rates from causes other than ALRI decreased during the second phase of the programme, ruling out any "replacement" phenomenon in the assignment of cause of death during the second phase. None of the differences in the reduction of non-ALRI mortality or overall mortality was significant between the two periods after stratifying by area, making it unlikely that the decline in ALRI-specific mortality was merely part of a secular trend.

## Discussion

Our findings suggest that the nonspecific MCH–FP interventions reduced ALRI mortality among under-5-year-olds by one fourth and that the additional specific community-based ALRI treatment programme reduced it further by one third. It is not surprising that the impact of the targeted intervention was particularly marked in post-neonates, in view of the importance of ALRI as a cause of death among this age group.

The study was not designed by randomly allocating children to treatment and control groups. Rather, it was based on comparisons of mortality between areas and its results therefore do not necessarily imply that the reduction in mortality in the intervention area was caused by the intervention itself. However, geographical, socioeconomic, demographic and mortality data collected before the beginning of the MCH programme suggest that the two study areas were comparable (*17*) and that observed differences can reasonably be attributed to the intervention. This is reinforced by the observation that the decline in ALRI-specific mortality was statistically significant, while the decline in mortality due to other causes was not.

The enumeration of deaths and exposed populations was probably exhaustive in the study, because of the intensive supervision of demographic surveillance in Matlab. The "verbal autopsy" method used to determine the cause of death does, however, result in possible misclassification of some causes of death. In this respect malaria is often difficult to distinguish from ALRI, but is very rare in the study area. The lack of clear criteria to diagnose death from neonatal pneumonia through verbal autopsy prevented the inclusion of neonatal deaths in the analysis. Since 95% of all child deaths take place at home without medical attendance, and necropsies are impossible to perform, there was no systematic validation of the diagnoses made.

Because the assignment of the cause of death was not specifically designed for the study, and was independent of the intervention itself, in making their diagnoses the medical assistants and physicians were unlikely to be biased. Moreover, the decrease of deaths from other causes in both study areas rules out any spurious replacement of ALRI by such causes.

The selective impact of the two phases of the programme on different age groups supports the hypothesis that the programme itself was the cause

Table 3: **Mortality rates (per 1000 child-years of exposure) from non-ALRI causes and from all causes during the two phases of the Matlab ALRI control programme, 1986–1989**[a]

| | Comparison area | | Intervention area | |
|---|---|---|---|---|
| | Non-ALRI causes | All causes | Non-ALRI causes | All causes |
| *All under-5-year-olds* | | | | |
| 1986–87 | 29.0 | 35.5 | 22.5 | 27.2 |
| 1988–89 | 24.5 (– 15)[b] | 30.7 (– 14) | 17.9 (– 21) | 21.1 (– 23) |
| *Children aged 1–4 years* | | | | |
| 1986–87 | 15.1 | 17.6 | 9.9 | 11.1 |
| 1988–89 | 11.0 (– 27) | 12.6 (– 28) | 6.2 (– 37) | 6.8 (– 38) |
| *Infants aged 1–11 months (post-neonates)* | | | | |
| 1986–87 | 27.5 | 43.0 | 27.2 | 40.3 |
| 1988–89 | 25.2 (– 9) | 41.2 (– 4) | 24.9 (– 9) | 34.1 (– 15) |

[a] $\chi^2$ tests for heterogeneity for the comparison between non-ALRI mortality rates in the intervention and comparison areas were not significant.

[b] Figures in parentheses are the percentage change in mortality rates between the two periods.

of the observed differences in ALRI mortality. At least the three following nonspecific components of the MCH–FP programme during the first phase might have contributed to the lower mortality from ALRI and other causes among 1–4-year-olds: immunization, through its effect on measles and pertussis; referral and treatment of severely sick children at the field clinics; and family planning, which resulted in fewer children, less crowding, and prolonged breastfeeding. Of these, measles vaccination was likely to have had the greatest impact on mortality from ALRI (*18–20*). In the comparison area the reductions of 36% in ALRI-mortality and 27% in non-ALRI mortality between the two periods are probably also explained in these terms: an increase in immunization coverage and family planning services occurred in the comparison as well as in the intervention area (Table 1), while the availability and use of village practitioners also increased over time (*21*).

Infants aged 1–11 months seem to be the age group with the highest potential for reduction in ALRI mortality through a specific control programme. Such deaths amounted to 36–40% of all deaths in this age group, and, compared with children aged 1–4 years, the scope for mortality reduction through the use of conventional vaccines at 1–11 months of age is somewhat limited (*20*). As shown in Table 3, the other components of the MCH–FP programme appeared not to have had much influence on the post-neonatal death rate from causes other than ALRI. Moreover, anthropological data reveal that mothers in Bangladesh are less likely to seek allopathic treatment outside the home for young infants than for older children. Therefore, infants with ALRI may have benefited more from home treatment (M.K. Stewart et al., unpublished observations, 1990).

In view of the staffing and financial constraints on the health programme in Bangladesh, we recommend that a modified version of this experimental project be implemented as follows:

- physicians and nurses at the referral hospitals should receive training on the clinical management of severe cases and be provided with reliable supplies of antibiotics and oxygen-delivery equipment;
- medical assistants and family welfare visitors posted at union level should be trained and properly supplied with ampicillin or sulfamethoxazole + trimethoprim for the management of ALRI cases as outpatients;
- village-level workers should be trained to recognize ALRI cases and to inform families about the risks, symptoms, and treatment possibilities; and
- home treatment with injectable penicillin should be replaced by sulfamethoxazole + trimethoprim paediatric tablets, which are easier to handle and less expensive.

An ongoing modification of the Matlab project along these lines should provide more insight into its feasibility.

In conclusion, ALRI control programmes, through their specific and nonspecific components, emerge as most promising elements of child survival strategies. The impact of such programmes is particularly important among under-1-year-olds, although their effect on neonatal mortality has still to be assessed. While the implementation of a such a targeted programme on a large scale may not produce the same level of impact in the short term, it can still be expected to result in significantly fewer deaths from ALRI.

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## Résumé

### Impact sur la mortalité d'un programme à base communautaire de lutte contre les infections aiguës des voies respiratoires inférieures

Dans les pays en développement, les infections aiguës des voies respiratoires inférieures (ALRI) sont responsables d'un tiers de l'ensemble des décès chez les jeunes enfants. L'OMS a récemment élaboré des directives sur le traitement des infections respiratoires aiguës au niveau des soins de santé primaires. Un programme ciblé conçu pour le traitement des enfants atteints d'ALRI a été mis en place en 1988 dans le cadre

d'un projet de soins de santé primaires dans une zone rurale du Bangladesh. Au cours des 2 ans précédant la mise en place du programme (1986–1987), des services de santé non spécifiques des ALRI ont été fournis, avec notamment la promotion de la thérapie par réhydratation orale, la planification familiale, la vaccination des enfants et des mères, la distribution de vitamine A, l'envoi des cas graves dans un dispensaire, et la réadaptation nutritionnelle des enfants souffrant de malnutrition. Le programme ciblé sur les ALRI, mis en place en 1988–1989, était fondé sur la détection systématique des cas d'ALRI et leur prise en charge par les agents de santé communautaires, eux-mêmes reliés à un système de recours en cas de besoin. Ces deux niveaux d'intervention ont été évalués par comparaison de la mortalité spécifique des ALRI au cours des deux périodes—1986–1987 et 1988–1989—dans la zone couverte par le programme et dans une zone voisine prise comme témoin. Les causes de décès ont été évaluées indépendamment de l'étude selon les mêmes critères dans les deux régions, au moyen d'une procédure d'"autopsie verbale", qui consiste à interroger rétrospectivement les soignants et à analyser les symptômes rassemblés. En raison d'incertitudes quant au diagnostic de la pneumonie néonatale par une telle méthode, les ALRI du nouveau-né n'ont pas été incluses dans l'étude.

Les décès dus aux ALRI frappaient les très jeunes enfants, 61% survenant chez les nourrissons de 1 à 6 mois. Lors de la première phase de l'étude (1986–1987), la mortalité spécifique des ALRI chez les moins de 5 ans était inférieure de 28% dans la zone d'intervention à sa valeur dans la zone témoin (4,7 pour 1000 enfants contre 6,5, $P<0,01$). Au cours de la deuxième phase (1988–1989), ce taux était dans la zone d'intervention inférieur de 32% au taux de la phase précédente (3,2 pour 1000 contre 4,7, $P<0,01$), alors qu'il n'y avait aucune différence significative entre les deux périodes dans la zone témoin. Les différences d'une phase à l'autre étaient particulièrement sensibles chez les enfants de 1 à 11 mois, ce qui laisse à penser que l'impact de ce type de programme est plus grand chez les nourrissons (nouveau-nés exceptés) que chez les enfants plus âgés. Il semble que chez les enfants âgés de 1 à 4 ans, les interventions de soins de santé primaires non spécifiques (par exemple vaccination, planification familiale, envoi des cas graves dans un dispensaire) aient un impact significatif sur la mortalité par ALRI, mais qui n'est que très peu amélioré par les interventions spécifiques. D'après nos observations, il semble que dans cette région, l'association d'interventions spécifiques et non spécifiques des ALRI puisse réduire d'au moins 50% la mortalité par ALRI, et d'au moins 30% la mortalité globale chez les moins de 5 ans. Ces interventions devront donc recevoir la priorité dans les programmes de soins de santé primaires.

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## VI.4. INTERVENTIONS EN MATIERE DE MALADIES DIARRHEIQUES

Un des programmes phares de l'ICDDR,B à Matlab est celui concernant la rehydratation orale par la solution sucrée-salée, un temps saluée comme la découverte la plus importante du siècle en matière de santé publique(!)[48], et testée à Matlab[49]. Il était donc de la plus grande importance d'évaluer scientifiquement l'effet de la réhydratation orale sur la mortalité par diarrhée à l'échelle d'une communauté, et non pas seulement à l'échelle hospitalière[50] ou en cas d'épidémie de choléra.[51]

Malgré les difficultés inhérentes à ce genre d'étude, et en particulier l'impossibilité de monter une étude prospective contrôlée, Matlab représentait une occasion unique d'examiner les tendances de la mortalité par type de diarrhée et par groupe d'âge pendant les années précédant et les années suivant l'introduction de la réydratation orale en communauté. Bien que ce type d'étude rétrospective ne fasse état que de relations d'association et non pas de causalité, les résultats en sont intéressants. Présentés dans la publication "E4"[52], ils montrent non seulement une absence de réduction de la mortalité par diarrhée en général, et de la mortalité par diarrhée aigue désydratante en particulier, après l'introduction du programme de réhydratation orale en communauté, mais encore un augmentation de la mortalité par diarrhée aigue chez les enfants de moins de un an. Diverses hypothèses sont avancées et discutées pour expliquer ces résultats inattendus et décevants, les plus plausibles ayant trait à l'utilisation inappropriée de la solution. Il est conclu que si des efforts doivent être poursuivis pour une meilleure utilisation des solutions de réhydratation orale, d'autres interventions préventives et curatives doivent être associées si l'on veut diminuer significativement le rôle des maladies diarrhéiques dans la mortalité infanto-juvénile.

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# 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 infant 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 contribution 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 promoting 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 organizations 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 difficult 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 mortality 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 infants 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 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

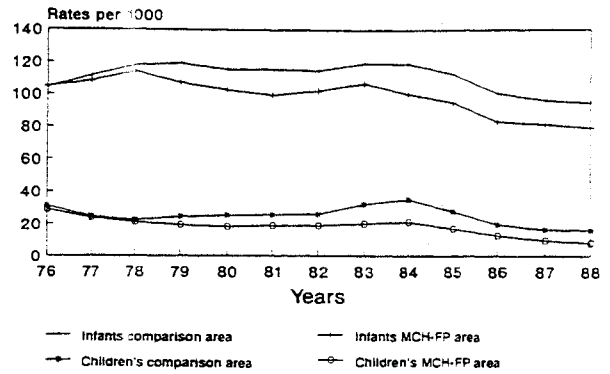


**Figure 1.** Infant and child mortality from all causes, Matlab MCH-FP and comparison areas, 1976–88

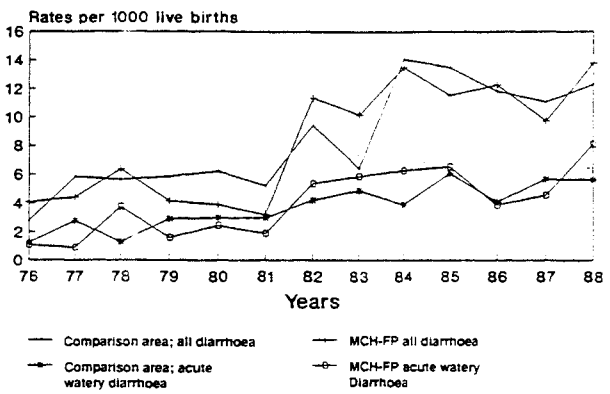


**Figure 2.** Infant mortality from diarrhoeal causes, Matlab MCH-FP and comparison areas, 1976–88

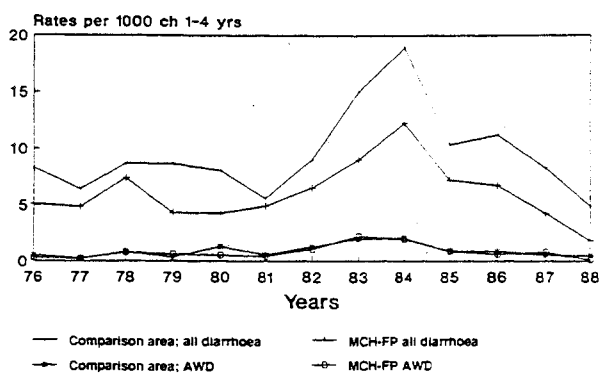


**Figure 3.** Child mortality from diarrhoeal causes, Matlab MCH-FP and comparison areas, 1976–88

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; $p<0.01$).

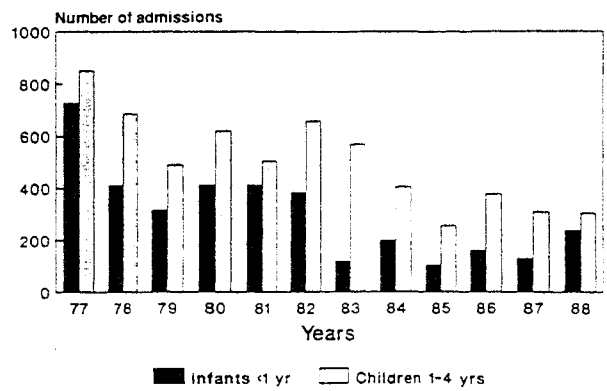


Figure 4. Admissions for acute watery diarrhoea, Matlab Diarrhoea Treatment Centre, 1977–88

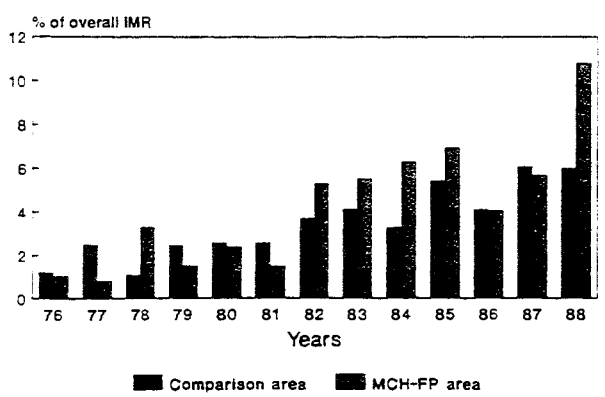


Figure 5. Percent of infant mortality due to acute watery diarrhoea, Matlab MCH-FP and comparison areas, 1976–88

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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Au total, sans discuter ici la nature et la couverture des interventions proposées, nous avons affirmé la pertinence de l'utilisation des taux de mortalité spécifiques recueillis par la méthode de l'autopsie verbale pour évaluer des programmes de santé maternelle et infantile en communauté.

Nous verrons maintenant les applications de la méthode de détermination des causes de décès pour selectionner les stratégies d'intervention dans les programmes de santé maternelle et infantile.

# VII. APPLICATIONS DE LA METHODE POUR SELECTIONNER LES STRATEGIES D'INTERVENTION EN SANTE MATERNELLE ET INFANTILE

Ce type d'application diffère de celui étudié au chapitre V en ce sens qu'il ne s'agit plus de choix d'interventions pour une catégorie donnée d'affections (diarrhées, infections respiratoires, complications obstétricales), mais du choix de la meilleure combinaison d'interventions dans un programme global d'amélioration de la santé des mères et des enfants. Cette amélioration étant mesurée à l'aune de la mortalité, il convient de rappeler que la diminution du taux de mortalité globale dans un groupe donné n'est pas nécessairement la somme des diminutions des taux de mortalités spécifiques, en raison des phénomènes de compétition et de potentialisation.[53,54]

## VII.1. ANALYSE CRITIQUE DES STRATEGIES GLOBALES

Dans l'année précédant la période couverte par les travaux de cette thèse, une série d'articles avaient proposé une analyse critique des stratégies globales de santé maternelle et infantile ("child survival strategies") appliquées au Bangladesh.[55-57]

Dans ces publications on a appliqué la méthode de détermination des causes de décès chez les mères et les enfants dans la zone de contrôle de Matlab pour vérifier si les priorités proposées par les stratégies essentiellement préventives de type "GOBI" (monitorage de la croissance, réhydratation orale, allaitement au sein, vaccination)[58,59] correspondaient aux réalités de la situation au Bangladesh.

Le bilan n'indiquait une efficacité réelle que pour le programme de vaccination mais uniquement en ce qui concerne la rougeole et le tétanos néonatal, et uniquement pour la mortalité de 1 à 4 ans (pour la rougeole) et la mortalité néonatale (pour le tétanos).

En revanche, les causes de décès les plus importantes, variant selon les groupes d'âge, n'ont que peu de chances d'être réduites par l'application de la statégie proposée: il s'agit des complications obstétricales, responsables d'une majorité des décès maternels et néonataux, des infections respiratoires aigues du nourrisson, des diarrhées de type dysentérique, et des diarrhées persistentes, responsables de malnutrition grave.

Les conclusions de ces études sont cohérentes: les stratégies qui ne font pas une place suffisante (qu'on pourrait même qualifier d'essentielle) aux services de dépistage précoce et de traitement "le plus près possible du domicile" des principales affections ou infections touchant les mères et les enfants auront un impact décevant sur la mortalité.

Nous abordons maintenant deux applications originales de la méthode de détermination des causes de décès par l'autopsie verbale pour selectionner les stratégies d'intervention en santé maternelle et infantile.

## VII.2. SURMORTALITE DES FILLES AU BANGLADESH

Un domaine d'analyse complètement nouveau est abordé dans l'étude publiée en "S1"[60], celui de l'examen de la mortalité par cause et selon le genre chez les enfants du Bangladesh. Il était déja connu que la mortalité des filles est supérieure à celle des garçons au Bangladesh comme dans toute la région au sud de l'Himalaya[61,62], mais les causes de décès particulièrement responsables de cette différence n'avaient pas été mises en évidence: il s'agit de la malnutrition grave et des diarrhées, particulièrement diarrhées persistentes. Ces résultats sont confirmés par l'âge auquel la différence de mortalité est la plus marquée, la troisième année de vie, juste après le sevrage. Comme prévu, les taux de décès liés aux accidents ne montrent pas de différence selon le genre.

Pour information, il a été ultérieurement montré par l'auteur (bien que non publié) que l'amplitude de la différence de mortalité entre garçons et filles a commencé à diminuer dans la zone du programme de Matlab vers 1985, alors qu'elle restait identique dans la zone de contrôle, et que cette diminution d'amplitude était surtout dûe à une diminution plus rapide de la mortalité des filles[63]. Une étude des causes de décès s'impose pour vérifier lesquelles sont particulièrement impliquées dans ce changement.

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# Excess Female Deaths among Rural Bangladeshi Children: An Examination of Cause-Specific Mortality and Morbidity

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Fauveau V (International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B)), Koenig MA and Wojtyniak B. Excess female deaths among Bangladeshi children: An examination of cause-specific mortality and morbidity *International Journal of Epidemiology* 1991: **20**: 729–735.

Excess female over male mortality during childhood, well known in the northern Indian subcontinent, is particularly marked in rural Bangladesh. While the determinants of this phenomenon and the respective roles of cultural and economic factors are still debated, little data exist on cause-specific mortality, to identify the specific causes of death producing this differential. In 1986–1987 in Matlab, a study area under intensive demographic surveillance in rural Bangladesh, female children aged 1 to 4 years had a risk of dying 1.8 times higher than male children (95% confidence interval: 1.5–2.1). The causes of death which contributed the most to this excess female mortality were severe malnutrition and diarrhoeal diseases. The risks of dying were 2.5 and 2.1 higher for female than for male children for these two causes, respectively. Possible mechanisms are examined using data on incidence of selected diseases and admission rates to curative facilities. There was no gender difference in incidence of severe diarrhoeal diseases, but female children with diarrhoea were taken to the hospital significantly less often than male children. In contrast, there was a higher incidence of severe malnutrition in female than male children, and a lower rate of hospital admission. The data suggest that gender differentials in mortality may not be as much affected by preventive measures against diarrhoea as by efforts to provide equivalent curative services to female and male children.

The issue of excess female over male mortality among children has been observed all over the northern Indian subcontinent[1–3] and particularly in rural Bangladesh.[4–6] While the determinants of this phenomenon and the roles of cultural and economic factors are still debated, little data exist on cause-specific mortality, which could identify the major causes producing this differential.

Cause-specific mortality, combined with data on illness incidence and utilization of health services, may shed some light on the mechanisms explaining this differential, and on the debate over the primary role of infectious, nutritional or behavioural factors. This approach may also suggest some programmatic solutions to the problem.

The Matlab study area of the International Centre for Diarrhoeal Disease Research, Bangladesh provides an appropriate venue to address these issues. Its demographic surveillance system covers a large population, and includes a recently improved method to assess the cause of death based on 'verbal autopsy'.

## SUBJECTS AND METHODS

The study area, Matlab, with a population of 196 000, lies in the Ganges delta, 45 km southeast of Dhaka, the capital of Bangladesh. Like most of the country, it is a low-lying and flood-prone area, with poor infrastructure and communications. The population depends mainly upon subsistence farming. Population density was 750 per square km in 1986, literacy rates were 30% for men and 17% for women, total fertility around 5.5 per woman, and infant mortality around 95 per 1000 live births. The rural Bangladeshi society is patrilineal and conservative, with less value attached to female than male children. Due to social restrictions on movements outside of their homes, women do not usually seek health care for their children from the public sector, but rather utilize the services of their local village practitioners.

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The area has been under intensive demographic surveillance since 1966: every household is visited twice a month by one of the 110 female community health workers (CHWs) to record births, deaths, migrations and changes in marital status.[7] A diarrhoea hospital has been operating in the centre of the study area since 1963, providing free treatment and transport to patients with diarrhoea. Oral rehydration salts and vitamin A capsules were distributed to all households. A nutrition rehabilitation unit has been attached to the hospital since 1986.

In 1978, a Family Planning-Health Services programme was introduced in half of the area (the MCH-FP area).[8] Among the morbidity data regularly collected in this area during the period covered by this study were point prevalence of diarrhoea by clinical type and by duration, and measurement of the mid-upper-arm-circumference (MUAC). The latter has been shown to be a strong predictor of the risk of death associated with malnutrition.[9] The other half of the study area, the comparison area, continued to depend mainly on government health services, in addition to free access to the diarrhoea hospital.

The cause of death was determined in the same way in the entire study area by a multiple-step procedure called 'verbal autopsy'.[10] Deaths were detected by CHWs during their routine fortnightly home visits. Health assistants interviewed the families within six weeks of the death to collect sociodemographic information and the history of symptoms and events preceding death. The information collected from the field was passed on to three physicians who independently assigned the most likely underlying and primary causes of death. The final cause was determined on a majority rule, and coded according to a classification derived from the WHO-recommended classification.[11] In cases of insufficient information to formulate a diagnosis, the forms were returned to the field to collect more information, and then re-entered in the pool.

For some cases, the cause of death categories recommended by WHO were not applicable. In the absence of aetiological information concerning diarrhoeal diseases, the classification was made according to the clinical type of diarrhoea, i.e. acute watery, acute non-watery (combining bloody dysentery and mucoid diarrhoea), and persistent. As a result of a large number of children in the study area, it was not possible to obtain an objective measure of the degree of malnutrition prior to death. Hence the term 'severe malnutrition' was applied when parents or relatives of the deceased child had reported a rapid or recent wastage of the child's tissues prior to death, or the recent appearance of tibial oedema. In a subsample of 253 cases for which measurement of the MUAC had been made within a month of death, the degree of agreement between the assessment of severe malnutrition by verbal autopsy and by a MUAC prior to death less than 110 mm was 86%.

The denominators for calculation of sex-cause-specific mortality rates were provided by the demographic surveillance system, and expressed in child-years of exposure to the risk of death. The results of two years of surveillance were combined to reduce the possible effect of yearly variations. Differences between sex groups were tested by comparison of incidence density ratios, and expressed as relative risks (RR) with 95% confidence intervals (CI).[12]

Morbidity data were obtained from the CHWs' service record books which are regularly updated during household visits, and included point prevalence of diarrhoeal diseases by type, and measurement of MUAC. Because morbidity data were collected in the MCH-FP project area only, the information on incidence of selected illnesses by sex was analysed for this area only.

## RESULTS

Of 677 children who died aged 1 to 4 years in the whole Matlab study area in 1986–1987, 423 were female (62.5%, $p < 0.001$). The overall risk of dying was 1.8 times higher for female children relative to male children aged 1 to 4 years (95% CI: 1.5—2.1, $p < 0.0001$, Table 1). In other words, the excess of female over male child death rate was 80%. This excess death rate varies with age (Figure 1), with a negative value in the first month of life, and a peak of 130% for deaths occurring during the third year of life, 24 to 35 months.

### *Sex-Cause-Specific Mortality*

Severe malnutrition was the broad cause of death with the greatest sex differential (RR = 2.5, 95% CI: 1.9–3.3, Table 1). Within this category, severe malnutrition associated with recurrent diarrhoea, the most common of all causes of death in this age group, contributed the most to the differential (RR = 2.8, 95% CI: 2.1–3.8). Looking at proportional mortality rates, or per cent distribution of causes of death, severe malnutrition was also significantly higher in female than male children (39.5% versus 28.0%, $Z = 3.0$, $p < 0.01$).

Diarrhoea not associated with severe malnutrition was also a more important cause of death among girls than boys (RR = 2.1, 95% CI: 1.5–2.8). Within this category, persistent diarrhoea contributed the most to the observed differential (RR = 2.8, 95% CI:1.5–5.2). Post-measles diarrhoea, acute non-watery diarrhoea,

TABLE 1 *Cause of death by sex, Matlab (MCH-FP and comparison areas combined), 1986–1987*

| Cause of death | Male (n = 24 219) N | Rate† | % | Female (n = 22 65[illegible]) N | Rate† | % | Relative risk female/male |
|---|---|---|---|---|---|---|---|
| Total diarrhoeal diseases: | 59 | 2.4 | 23.2 | 115 | 5.1 | 27.2 | 2.1*** |
| Acute watery diarrhoea | 12 | 0.5 | 4.7 | 22 | 1.0 | 5.2 | 2.0 |
| Acute non-watery diarrhoea | 21 | 0.9 | 8.3 | 35 | 1.5 | 8.3 | 1.8* |
| Post-measles diarrhoea | 14 | 0.6 | 5.5 | 27 | 1.2 | 6.4 | 2.1* |
| Persistent diarrhoea | 12 | 0.5 | 4.7 | 31 | 1.4 | 7.3 | 2.8* |
| Total severe malnutrition: | 71 | 2.9 | 28.0 | 167 | 7.4 | 39.5 | 2.5*** |
| Severe malnutrition with recurrent diarrhoea | 52 | 2.1 | 20.5 | 136 | 6.0 | 32.2 | 2.8*** |
| Severe malnutrition with respiratory infection | 3 | 0.1 | 1.2 | 8 | 0.4 | 1.9 | 2.8 |
| Other severe malnutrition | 16 | 0.7 | 6.3 | 23 | 1.0 | 5.4 | 1.5 |
| Total other infectious diseases: | 55 | 2.3 | 21.7 | 60 | 2.6 | 14.2 | 1.2 |
| Acute lower respiratory infection | 34 | 1.4 | 13.4 | 27 | 1.2 | 6.4 | 0.8 |
| Immunizable disease‡ | 12 | 0.5 | 4.7 | 13 | 0.6 | 3.1 | 1.2 |
| Fever, septicaemia | 5 | 0.2 | 2.0 | 10 | 0.4 | 2.4 | 2.1 |
| Other infectious diseases | 4 | 0.2 | 1.6 | 10 | 0.4 | 2.4 | 2.7 |
| Total injuries/accidents: | 54 | 2.2 | 21.3 | 55 | 2.4 | 13.0 | 1.1 |
| Drowning | 50 | 2.1 | 19.7 | 51 | 2.3 | 12.1 | 1.1 |
| Other accidents | 4 | 0.2 | 1.6 | 4 | 0.2 | 0.9 | 1.1 |
| Other causes | 3 | 0.1 | 1.2 | 9 | 0.4 | 2.1 | 3.2 |
| Impossible to specify | 12 | 0.5 | 4.7 | 17 | 0.8 | 4.0 | 1.5 |
| All causes | 254 | 10.5 | 100.0 | 423 | 18.7 | 100.0 | 1.8*** |

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
† Rate =/1000 children aged 1–4 years.
‡ Measles, pertussis, tetanus.

and acute watery diarrhoea were all approximately twice as frequently the causes of death among female than male children. Proportional mortality rates for diarrhoea were not significantly higher among female than male children (27.2% versus 23.2%, Z = 1.1).

The risk of death due to the broad category of other infectious diseases was not statistically significantly different among girls and boys. It must be noted, however, that complete immunization was provided to all children in the MCH-FP area, and therefore few immunizable disease-related deaths occurred in that area. As expected, there was no sex differential in injury-related mortality rates.

The following sections focus on the two causes of death which contributed the most to female excess mortality in the area: severe malnutrition and diarrhoeal diseases.

*Severe malnutrition*

As shown in Table 2, the incidence of severe malnutrition, defined as the change of MUAC in one month from over to under the cutoff point of 110 mm, was significantly higher among girls than boys (RR = 1.6, 95% CI: 1.4–2.0). But the proportion of all newly malnourished children who were taken to the nutrition rehabilitation unit at Matlab was significantly lower in girls than boys, (RR: 0.7, 95% to CI: 06.–0.9), indicating that malnourished girls were less likely to be taken to the hospital than malnourished boys. Admitted girls had a significantly lower MUAC at admission than boys (94.1 versus 98.3, p = 0.002). However, they were not significantly younger than boys, did not stay for significantly less time in the hospital, and their case-fatality rate during or after hospitalization was not higher.

*Diarrhoeal Diseases*

Morbidity data, collected one day a month for each child in the MCH-FP area, indicate a similar point-prevalence for boys and girls for all types of severe

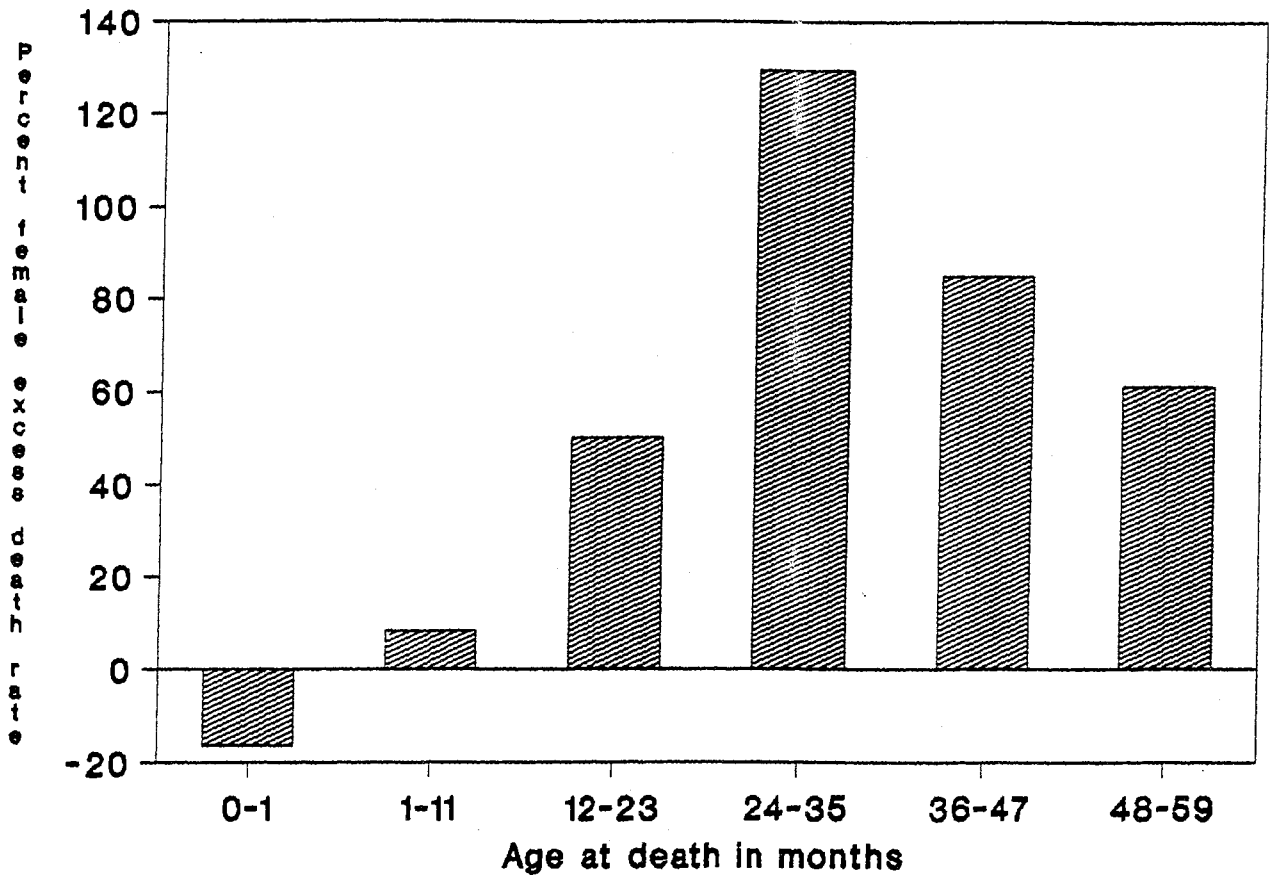


FIGURE 1. *Excess female mortality by age at death. Matlab, 1986–1987.*

diarrhoeal diseases (Table 2). As for admissions to the nutrition rehabilitation unit, admissions to the Matlab diarrhoea hospital show a significantly lower rate for girls than boys, (RR = 0.7, 95% to CI: 0.6–0.8), indicating a difference in the decision-making process for referral. Specific admission rates for various aetiological diarrhoea agents isolated in the laboratory are shown in Table 2. Differences were highly significant for shigellosis and non-identified pathogens, and of borderline significance for cholera, suggesting that the referral decision for each sex was not completely independent from the type of diarrhoea. Case-fatality rates during or after hospitalization were significantly higher among girls than boys (7.5% versus 3.2%, Z = 4.4).

*Utilization of Health Care*

Table 3 shows that a greater (but not significantly) proportion of male than female children were taken to a hospital prior to death (9.4% versus 6.6%, Z = 1.3). The difference in the proportions of male and female children seen by a qualified physician was of borderline significance (30.2% versus 24.6%, Z = 1.6), while a greater proportion of male than female children were seen by a traditional practitioner prior to death (19.7% versus 13.2%, Z = 2.2). A significantly greater proportion of male children were seen by more than one health provider, indicating a stronger commitment to cure boys than girls (38.6% versus 25.8%, Z = 3.5).

Examination of seasonal variations over the two-year study period (data not shown) revealed a seasonal peak of diarrhoea mortality, diarrhoea incidence, and admissions for diarrhoea in April to June. This peak corresponded with the hot and dry season. It was more marked among male than female children, with 47% of all male diarrhoea deaths versus 30% of all female diarrhoea deaths concentrated in these three months, and therefore a broader spread of female diarrhoea deaths over the year. A seasonal peak of malnutrition-related mortality, incidence of malnutrition, and admissions at the nutrition rehabilitation unit was observed from September to December which corresponded with the post-monsoon and pre-harvest period of low food availability. It was more marked among boys than girls, indicating a broader spread of malnutrition-related mortality during the year among girls.

## DISCUSSION

Our data confirm the findings of previous studies

TABLE 2 *Community incidence and hospital admission of male and female children 1 to 4 years for severe malnutrition (MUAC<110mm) and severe diarrhoeal diseases. Matlab MCH-FP area, 1986–1987 (Rates per thousand except when indicated)*

| | Male | | Female | | Relative Risk for Female (95% Confidence Interval) |
|---|---|---|---|---|---|
| | N | Rate | N | Rate | |
| Severe malnutrition: | | | | | |
| Child/months of observation | 10 344 | | 9899 | | |
| Incidence in the community | 182 | 17.6 | 288 | 29.1 | 1.6 (1.4–2.0)*** |
| Admissions at nutr. rehab. unit | 110 | 60.4† | 123 | 42.7† | 0.7 (0.6–0.9)*** |
| Deaths during or after hospitalization | 8 | 7.3‡ | 8 | 6.5‡ | 0.9 (0.4–2.3) |
| Severe diarrhoea: | | | | | |
| Child/days of observation | 129 789 | | 124 014 | | |
| Point-prevalence in the community | 3760 | 29.0 | 3620 | 29.2 | 1.0 (1.0–1.1) |
| Acute watery diarrhoea | 740 | 5.7 | 721 | 5.8 | 1.0 (0.9–1.1) |
| Acute non-watery diarrhoea | 1333 | 10.3 | 1289 | 10.4 | 1.0 (0.9–1.1) |
| Diarrhoea 8 days+ | 1697 | 13.1 | 1610 | 13.0 | 1.0 (0.9–1.1) |
| Admissions at diarrhoea hospital: | 1199 | 31.9† | 814 | 22.5† | 0.7 (0.6–0.8)*** |
| Cholera | 334 | 8.9 | 284 | 7.8 | 0.9 (0.8–1.0)* |
| Shigella | 151 | 4.1 | 103 | 2.8 | 0.7 (0.6–0.9)** |
| Others | 714 | 19.0 | 427 | 11.8 | 0.6 (0.5–0.7)*** |
| Deaths during or after hospitalization | 38 | 3.2‡ | 61 | 7.5‡ | 2.4 (1.6–3.5) |

* $p = 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
† Per cent of incident children.
‡ Per cent of admitted children.

regarding the magnitude of sex differentials in child mortality in rural Bangladesh.[4–6] They add to the understanding of this phenomenon by identifying severe malnutrition and diarrhoeal diseases as the causes of death mostly responsible for the differential, and by examining detailed morbidity and behavioural patterns.

Given the frequency of field visits and the quality of the supervision in the Matlab demographic surveillance, it is unlikely that vital events were missed. Causes of death, however, are more difficult to assess precisely and must be considered indicative. Some causes might have been misclassified, for example, when multiple causes were involved. In particular, malnutrition and diarrhoea are often associated, and interactive. The causes of approximately 5% of all deaths remained unspecified. In any case the same procedures, and potential biases, were applied irrespective of sex and comparisons should remain valid.

Two distinct mechanisms seem to be involved in determining excess female over male child mortality in this setting:

To the extent that data on point-prevalence can be extrapolated to incidence (and they can at least for acute diarrhoea), the higher diarrhoea-specific female mortality is not a reflection of higher incidence of acute diarrhoeal diseases in the community, but rather of higher case fatality. In turn, higher female case fatality may result from lower utilization of health services, including hospital admission and possible delays in

TABLE 3 *Gender differences in utilization of health practitioner prior to death among children: 1 to 4 years. Matlab 1986–1987*

| | Male | | Female | | P value of the difference between proportions |
|---|---|---|---|---|---|
| Sought care from*: | N | %† | N | %‡ | |
| Any hospital | 24 | 9.4 | 28 | 6.6 | 0.09 |
| Any health practitioner | 211 | 82.7 | 354 | 83.7 | 0.09 |
| Qualified physician | 77 | 30.2 | 104 | 24.6 | 0.055 |
| Village quack | 159 | 62.4 | 268 | 63.4 | NS |
| Religious/traditional healer | 50 | 19.6 | 56 | 13.2 | 0.017 |
| More than one health provider | 98 | 38.6 | 109 | 25.8 | 0.0005 |

* A child may have been seen by more than one health provider prior to death.
† Per cent of all deaths in male children (n = 254).
‡ Per cent of all deaths in female children (n = 423).

referral of girls to hospital. Data on prolonged or persistent diarrhoea also suggest a higher case fatality for girls than boys. This was observed during longitudinal studies conducted on smaller samples of children.[13,14]

In contrast, the higher female than male mortality associated with severe malnutrition appears to be the product of both a higher incidence of severe malnutrition among girls than boys, and a lower proportion of malnourished girls than boys being admitted to the hospital. Evidence for female discrimination in intra-household allocation of food and health care has been shown in two previous longitudinal studies of food consumption by weanlings in Matlab.[5,15] Boys received more cereals i.e. energy, more protein, vitamin A and iron than girls. The fact that female members of the household, including mothers themselves, distribute food within the family indicates a strong cultural bias towards male offspring. This cultural bias may stem from male dominance and exogamy, both characteristic of the study area. However, no gender differences have been reported on the duration of breastfeeding in Matlab.[16]

Differential use of health care must also be considered as a leading mechanism to explain excess female over male mortality.[17] Barriers to seeking health care from hospital or clinic include cost of travelling, breach of *purdah* or women's seclusion, pressure of housework, shyness in expressing complaints, and lack of confidence due to the frequently low quality of care.

The choice of MUAC is justified in this study because it is a sensitive predictor of death associated with recent worsening of malnutrition, regardless of pre-existent chronic malnutrition.[9,18] Longitudinal studies of Matlab children[19,20] showed little differences between boys and girls in weight for length, and greater differences in weight for age and arm circumference, indicating more sensitivity to short-term variations, including seasonal variations.

The seasonal variations reported over this two-year study period have also been observed in previous studies.[13,20] Seasonal peaks, in this study, were more marked among male than female children, indicating a broader spread of severe diseases across the year among girls than boys. One implication of these findings is that there is little prospect of seasonally targetted interventions benefitting female more than male mortality in terms mortality reduction.

The differences observed in case-fatality rates during or after hospitalization for severe malnutrition and severe diarrhoea are consistent: girls were more severely malnourished on admission to the nutrition rehabilitation unit than boys, but the programme insisted on providing equal or higher quality care to girls than boys during hospitalization, as well as during post-discharge follow-up. In the diarrhoea treatment centre, there was no particular focus of quality of care on females, and there was no follow-up after discharge. As previously observed,[21] the excess mortality after discharge from diarrhoea hospital was concentrated on children with associated severe malnutrition. This indicates the need to develop nutrition rehabilitation during hospitalization for diarrhoea and immediately after diarrhoea has been treated.

Our findings on gender differential in use of health providers prior to death (i.e. which illnesses are perceived as severe) corroborate anthropological observations.[22] Mothers tend to seek care from religious healers and also from qualified physicians more for their sons than for their daughters. They also tend to seek care from more health providers for their sons than daughters, to give them more chance of being cured.

The findings of this study suggest that gender differential in diarrhoea mortality among Bangladeshi children may not be as influenced by preventive interventions against diarrhoea as by curative interventions, because diarrhoea incidence is similar in both groups. Measures to prevent malnutrition, however, may influence the differential in malnutrition-related mortality because they may decrease the incidence of severe malnutrition proportionally more in girls than boys. On the other hand, equal access to equally effective curative services for boys and girls with either illness may have a higher potential for reducing mortality differentials because it may level off case-fatality rates. Measures to ensure equal access are complex and require behavioural and socioeconomic changes. Interim strategies such as diffusion of community-based health services to the household level and facilitation of access to quality curative facilities may prove effective.

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*(Revised version received March 1991)*

## VII.3. ETUDES DE COÛT-EFFICACITE

Une application marginale, et sujette à discussion, de la méthode de détermination des causes de décès, a été utilisée dans l'étude publiée sous le numéro "S2"[64], en vue de l'analyse coût-efficacité des services de santé dans le programme de Matlab. A supposer qu'on arrive à individualiser le coût de chacune des interventions/activités prodiguées dans le cadre du programme, il est tentant d'en estimer l'efficacité par le nombre de morts évitées (ou de naissances évitées dans le cas des services de contraception). Par comparaison des taux de couverture des interventions/activités et des données de mortalité par cause dans les deux zones du projet, il a été possible de conclure que le programme de vaccination (rougeole-tétanos) a eu le meilleur rapport coût-efficacité, suivi par le dépistage/traitement des infections respiratoires aigues du nourrisson, le dépistage/traitement des dysenteries aigues chez l'enfant, tandis que la réhydratation orale et les soins obstétricaux avaient un rapport nettement plus élevé.

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# Cost-effectiveness of the Matlab MCH-FP Project in Bangladesh

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The cost-effectiveness of a set of MCH and FP activities in Matlab, a rural area in Bangladesh, was examined using simplified methods. They looked only at the recurrent cost incurred by the provider on service delivery. Cost-effectiveness was measured separately for each intervention. Cost per death averted and cost per birth averted were measured with respect to a comparison area using cause-specific death and birth rates, respectively. Incremental cost and average cost were also measured for some activities.

It was found that among the nine service activities, EPI has moved closer to satiety level and, therefore, the cost involved in this intervention has tended to move upwards. Among other interventions, family planning, control of ARI and control of dysentery appear to have generated relatively high cost-effectiveness, either by way of decreasing incremental cost or with the achievement of low average costs. One implication of the findings is the necessity to reorganize the activities which have already come close to satiety level, by way of restructuring the present resource allocation pattern.

## Introduction

This paper focuses on the cost-effectiveness of the Matlab MCH-FP project in Bangladesh for the period of 1986–89 with a view to assessing its economic viability. The project was undertaken by the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B). It is well documented that the Matlab project, which was initiated in 1978 in a rural area in Matlab sub-district called the "treatment area", has been able to upgrade the health status of mothers and children in that area by introducing and maintaining a comprehensive package of family planning and MCH services (Phillips 1984 and Bhatia et al. 1980). The treatment area is divided into four operational blocks: A, B, C and D. In 1986, the project was subjected to a cost-effectiveness analysis (CEA) covering the period of 1978–1985 and an attempt was made to compare the cost of services with some effectiveness indicators related to both intermediate and final outcomes of the project (Simmons et al. 1991; Balk et al. 1988). Basically three indicators, namely contraceptive users generated and births/deaths prevented, were used in the CEA. It was concluded that the allegedly high cost of the project had been significantly offset by extra births and deaths prevented, and improvements in reproductive health.

With the introduction of several new MCH interventions between 1986 and 1989, however, the cost structure of the Matlab project underwent significant changes. During this period, five new interventions were introduced: nutrition education and rehabilitation (1986), maternity care (1987), vitamin A capsule distribution (1987), control of acute respiratory infections (1988) and control of dysentery (1989). Also, certain interventions which were initially confined to two blocks were extended to other blocks during this period. As a result of these changes several new input items were added to the cost structure making it more complicated. These new interventions changed the time allocation pattern of the personnel involved in the project as well. Although the 1986 CEA had attempted to assess economic worthiness of the overall project, no emphasis was put on measuring cost-effectiveness at activity level (with only a few activities at that time). In the present context, only a CEA at activity level would help the decision-makers

reach decisions concerning reallocation of resources within the project itself and/or to justify the decisions which have already been made. This paper attempts to provide an in-depth analysis of the cost structure of the Matlab project at activity level. It will, however, be confined to provider's cost and, specifically, to recurrent cost. Only cost items included in the annual budget of the Matlab project will be taken into the cost analysis.

## Sources of data and methods

### Cost

Data pertaining to cost elements are readily available in the cost reports of the project. During the four year period of 1986–89, the project was administered by four concomitant budgets and a cost report was prepared monthly for each budget. The four budgets are MCH-FP (main budget), Vitamin A Capsule Distribution, Control of ARI, and Maternity Care. There were nine activities/interventions, namely, 1) Family planning programme (FPP), 2) Expanded programme of immunization (EPI), 3) Maternity care (MAT), 4) Control of acute respiratory infection (ARI), 5) Control of dysentery (DYS), 6) Vitamin A capsule distribution (VAC), 7) Oral rehydration therapy (ORT) (through home distribution of ORS packets), 8) Nutrition education and rehabilitation (NRU) and 9) Curative services (CUR).[1] As none of these were supported by a single budget, each cost report was screened very carefully and cost items in each report were classified into ten subgroups. Expenditure on research was included in the tenth subgroup.

Through this exercise it was found that many cost items had been related with several activities. For instance, for each drug item the proportion of it used for each activity had to be identified. Observations, discussions with administrative, clinical, field and other staff members of the project, and screening of log sheets (e.g. for transportation) were undertaken to apportion multi-functional non-human cost items among activities in each year. To apportion the expenditure on salaries and wages among activities, a time allocation study was undertaken by administering a questionnaire among all employees of the project, from field workers to the principal investigator; and a 100% response was reported for it.

The findings of the time allocation study, however, had to be adjusted because it was undertaken in late 1990 and, hence, provided information on the time allocation pattern at that time. The structure of activities in that year was somewhat different from that of previous years. Table 1 shows the time at which each intervention/activity was introduced. Having considered all these changes, distributional proportions of human inputs among activities were adjusted to obtain a more realistic distribution pattern for each year.

All expenditure figures in each annual cost report were condensed into a two-way table illustrating the distribution of total expenditure among ten activities by five expenditure categories: wages and salaries, travelling, drugs, supplies and materials, and supportive services. In this context supportive services basically consist of inter-departmental services such as repair and maintenance, financial charges, printing charges, washing charges, staff development, and laboratory tests.

### Effectiveness

Data such as cause-specific deaths, births and contraceptive prevalence, which were used to measure effectiveness indicators, were obtained from the Record Keeping System including Contraceptive Monthly Progress Reports, the Demographic Surveillance System of the ICDDR,B, Clinical Performance Reports of the Matlab Station, and various other records and reports of the Matlab project. These sources provided data on the comparison area as well: the neighbouring area receiving services from the government health system with which the comparisons were made.

### Cost-effectiveness indicators (CEIs)

Basically three types of CEI were measured: cost per birth/death averted, average cost (AC) to attend/perform/treat one case, and incremental cost (IC) to reduce/increase an effectiveness indicator by one point (see Table 1).

1. For NRU, ORT, EPI and FPP, measurement of the number of *deaths/births averted* in relation to the comparison area was straightforward because these interventions had been made in all blocks of the treatment area. For control of ARI and DYS, the same method was adopted

Table 1. Interventions and their cost-effectiveness indicators

| | Intervention | Initiated Year | Initiated in blocks | Cost-effectiveness indicators |
|---|---|---|---|---|
| 1 | Family planning (FPP) | 1978 | All | a) CPBA b) ICCPR c) ICIOC |
| 2 | Curative services (CUR) | 1978 | All | ** |
| 3 | Oral rehydration therapy (ORT) | 1978 | All | a) CPDA b) ICRMR c) Cost per ORS packet distributed |
| 4 | Expanded programme of immunization (EPI) | | | |
| | 4.1 Measles vaccine | 1982<br>1986 | A & C<br>B & D | a) CPDA b) ICRMR<br>c) IMCICR d) CPV |
| | 4.2 Tetanus vaccine | | | |
| | a) To pregnant women only | 1978 | All | a) CPDA b) ICRMR |
| | b) To all married women | 1982<br>1986 | A & C<br>B & D | c) ICICR d) CPV |
| | 4.3 DPT, Polio, and BCG | 1986 | All | a) ICICR b) CPI |
| 5 | Nutrition education & rehabilitation (NRU) | 1986 | All | a) CPDA b) ICRMR c) ICRMLR c) CPCT |
| 6 | Vitamin A capsule distribution (VAC) | 1987 | All | ** |
| 7 | Maternity care (MAT) | 1987 | C & D | a) CPDA b) ICRMR |
| 8 | Control of acute respiratory infections (ARI) | 1988 | A & B* | a) CPDA b) ICRMR c) CPCT |
| 9 | Control of dysentery (DYS) | 1989 | B & D* | a) CPDA b) ICRMR c) CPCT |

CPBA = cost per birth averted
CPDA = cost per death averted
ICCPR = incremental cost to increase contraceptive prevalence rate by one unit
ICIOC = incremental cost to increase one more contraceptive user
ICRMR = incremental cost to reduce mortality rate by one unit
ICICR = incremental cost to increase coverage rate by one unit
CPV = cost per vaccine
CPI = cost per immunization
ICRMLR = incremental cost to reduce malnutrition rate by one unit
CPCT = cost per case treated/attended/performed

*Since referrals were made from other blocks this intervention covered, in fact, the whole treatment area
**Cost-effectiveness indicators were not measured for these interventions

because, although they were primarily in the hands of Community Health Workers (CHWs) in the two blocks where these activities were undertaken, referrals of patients from the other two blocks to the Sub Centres of the project and to the Matlab clinic were also made as part of the intervention. For MAT, however, the number of deaths averted was measured in relation to blocks A and B because this intervention had been done only in blocks C and D.[2] No CEIs were measured for CUR and VAC because of the complexity in quantifying their consequences.

2. *Average cost per case attended/performed/treated* was simply the arithmetic mean of the total cost of any intervention. Cost per case treated was measured for ARI, dysentery and malnutrition. Cost per case performed was measured for EPI and the cost per case attended for ORS packets distribution.

3. *Incremental cost* to reduce/increase an effectiveness indicator of an activity by one point in a particular year was measured by dividing the marginal increase in its cumulated cost figure by the absolute change in the corresponding indicator in that year. However, the very economic meaning of marginal cost cannot be strictly applied to variations in IC in the present case because the process of generating outcomes in these health interventions is significantly different from that of a normal physical production unit. For activities like EPI and family planning, for example, there always exists an upper limit for intermediate outcomes such as full coverage. Further, for many health interventions there always exists a lower limit for their final outcome (except the improvements in health status) as zero cause-specific mortality rate. Continuation of any such intervention with the generation of a higher coverage rate and/or aversion of deaths should necessarily lead to a reduction in the IC to a certain point. But, for any intervention, a cost has to be incurred even at the satiety level (i.e. the level at which the expected health outcome has been achieved) to maintain it. Nevertheless, with no significant technological changes in almost all interventions of the Matlab project, decreasing ICs should be apparent for all of them.

## Results

### Costs

*Composition and growth by component:* Table 2 shows that during the period concerned, Matlab project allocated about 40% of its total expenditure on research and the rest on delivery of services. Among the cost components of service delivery, wages and salaries show the highest percentage, with 40.6% in 1989 which is about 4% less than the same in 1986. The component of supportive services has almost doubled from 4.8% in 1986 to 9% in 1989. All other components demonstrate substantially constant shares throughout the period. While travelling stood at around 0.3%, drugs, and supplies and materials reported to be around 3% and 5% respectively in 1989. Travelling has a very low share because a large portion of total travelling expenditure (called 'transport') was related to research including international travel and, hence, it was added to the share of research expenditure.

**Table 2.** Costs of the Matlab MCH-FP Project by component, 1986–1989 (US$)

| Component | 1986 | 1987 | 1988 | 1989 | Growth rate* |
|---|---|---|---|---|---|
| a) At constant prices** | | | | | |
| 1 Wages and salaries | 150 761 | 187 725 | 199 533 | 249 890 | 18.4 |
| 2 Travelling | 1 057 | 1 211 | 1 494 | 1 856 | 20.6 |
| 3 Drugs | 9 462 | 11 709 | 10 691 | 18 204 | 24.4 |
| 4 Supplies and materials | 18 970 | 18 258 | 23 337 | 27 380 | 13.0 |
| 5 Supportive services | 16 186 | 24 468 | 35 413 | 55 636 | 50.9 |
| 6 Research | 138 970 | 156 614 | 178 270 | 262 945 | 23.7 |
| Total | 335 406 | 399 985 | 448 738 | 615 911 | 22.5# |
| b) Percentages | | | | | |
| 1 Wages and salaries | 44.9 | 46.9 | 44.5 | 40.6 | |
| 2 Travelling | 0.3 | 0.3 | 0.3 | 0.3 | |
| 3 Drugs | 2.8 | 2.9 | 2.4 | 3.0 | |
| 4 Supplies and materials | 5.7 | 4.6 | 5.2 | 4.4 | |
| 5 Supportive services | 4.8 | 6.1 | 7.9 | 9.0 | |
| 6 Research | 41.4 | 39.2 | 39.7 | 42.7 | |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | |

*Exponential growth rate
**Exchange rate of Taka was used for the conversion (1989 = 100)
# Growth rate of the total cost except research is 21.6

During the period concerned, the total cost of the Matlab project has increased at an annual rate of 22.5% in real terms. While expenditure on research has reported a growth rate of 23.7%, service related expenditure has grown at a rate of 21.6%. Among service related expenditure items, the highest growth rate is reported for supportive services with 50.9%. Expenditure on drugs has recorded the next highest growth rate of 24.4%, its value almost doubling from 1986 to 1989.

*Composition and growth by activity*

When total expenditure is apportioned into ten activities (Table 3), the highest share among service activities is reported for family planning. This share has, however, declined significantly from 17.8% in 1986 to 14.5% in 1989. While CUR, NRU and EPI appear to have the next highest shares, respectively, these three activities, too, demonstrate a gradual decline in their shares. The decline in the shares of EPI and ARI are, however, relatively lower than other activities. In general there has been no recorded increase in the cost share of any service activity from 1986 to 1989. This pattern is, of course, not an unhealthy sign because the introduction of new activities after 1986 naturally brought down the relative significance of existing activities within the total budget.

Real growth rates of the total cost of activities provide a better picture of the changes in the cost structure. As Table 3 indicates, all service activities, except for NRU, have reported positive growth rates. Among them, maternity care has recorded the highest growth rate of 19.6% followed by family planning and ORT with 14.3% each. As the detailed cost reports indicate, the prime reason underlying this tendency was the relatively high increase in the cost of supportive services, and supplies and materials, in each activity.

**Table 3.** Cost of the Matlab MCH-FP Project by activity, 1988–1989 (US$)

| Activity | 1986 | 1987 | 1988 | 1989 | Growth rate* |
|---|---|---|---|---|---|
| a) At constant prices** | | | | | |
| 1 FPP | 59 827 | 65 329 | 74 860 | 89 351 | 14.3 |
| 2 EPI | 31 803 | 33 879 | 38 476 | 45 147 | 12.4 |
| 3 ORT | 14 956 | 15 425 | 17 968 | 22 308 | 14.3 |
| 4 ARI | 0 | 0 | 31 513 | 33 346 | 5.8 |
| 5 MAT | 0 | 25 542 | 28 111 | 36 550 | 19.6 |
| 6 NRU | 44 410 | 47 909 | 37 350 | 44 303 | -0.1 |
| 7 VAC | 0 | 12 907 | 11 764 | 13 849 | 3.6 |
| 8 CUR | 45 440 | 42 380 | 30 426 | 48 297 | 2.1 |
| 9 DYS | 0 | 0 | 0 | 19 815 | — |
| 10 Research | 138 970 | 156 614 | 178 270 | 262 945 | 23.7 |
| Total | 335 406 | 399 985 | 448 738 | 615 911 | 22.5 |
| b) Percentages | | | | | |
| 1 FPP | 17.8 | 16.3 | 16.7 | 14.5 | |
| 2 EPI | 9.5 | 8.5 | 8.6 | 7.3 | |
| 3 ORT | 4.5 | 3.9 | 4.0 | 3.6 | |
| 4 ARI | 0.0 | 0.0 | 7.0 | 5.4 | |
| 5 MAT | 0.0 | 6.4 | 6.3 | 5.9 | |
| 6 NRU | 13.2 | 12.0 | 8.3 | 7.2 | |
| 7 VAC | 0.0 | 3.2 | 2.6 | 2.2 | |
| 8 CUR | 13.5 | 10.6 | 6.8 | 7.8 | |
| 9 DYS | 0.0 | 0.0 | 0.0 | 3.2 | |
| 10 Research | 41.4 | 39.2 | 39.7 | 42.7 | |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | |

*Exponential growth rate
**Exchange rate of Taka was used (1989 = 100)

**Cost-effectiveness indicators**

*Cost per death averted (CPDA)*

Among the six activities for which CPDA was computed, EPI, which was restricted to measles and tetanus components, is the most efficient one (Table 4). In terms of the number of deaths averted, it has recorded a total of 101 for measles and 100 for neonatal tetanus. In terms of cost, for the age group under 5 years, CPDA for measles is reported as $201. For neonatal tetanus, it is $294. Moreover, except for a few cases, annual increases in the CPDA of EPI do appear to be relatively lower than that of almost all other interventions. The only exception is the sharp increase in CPDA for neonatal tetanus from 1988 to 1989. One reason for this increase is the intensification of many activities including EPI in the comparison area in 1989 by the Government which, among other things, resulted in a sharp drop in its neonatal tetanus mortality rate.

Among the other five activities, control of ARI has the second lowest CPDA. On average, the Matlab project has spent $717 to avert a single death from ARI. CPDA was computed for sub-age groups of 1–4 years and post-neonates. Neonates were not considered in this analysis in view of diagnostic uncertainties concerning neonatal pneumonia. The highest number of deaths averted (42) was reported for post-neonates which is about 50% of the total number of deaths averted from ARI. Its CPDA is reported as $310. Although the age group of 1–4 years appears to be the one with the highest CPDA for the whole period, it has sharply moved down from $4341 in 1988 to $1375 in 1989 making the magnitude of overall average less important.

Control of dysentery is the next efficient activity with 20 deaths averted for a CPDA of $997. In contrast to ARI, CPDA for post-neonates has a very high value of $2246 with only 2 deaths averted. Nonetheless, the dysentery mortality rate among post-neonates was extremely low in both areas. Children between 1 and 5 years are the most affected age group from this intervention with 18 deaths averted for a CPDA of $855.

Maternity care appears to be a least efficient activity in terms of CPDA. Compared to blocks A and B it has averted a total of 42 direct obstetric and neonatal deaths with a CPDA of $2158.

NRU was associated with a total of 99 deaths averted from severe malnutrition. This high number takes into account deaths caused by persistent diarrhoea when associated with malnutrition – one of the most common causes of child mortality in Matlab. But its cost component seems to be relatively higher than that of most other interventions as indicated by its CPDA of $1757. Moreover, the effectiveness rate of this intervention shows a continuous annual decline from 36 deaths averted in 1986 to 10 in 1989. This has resulted in a sharp increase in its CPDA to $4665 in 1989.

ORT demonstrates mixed results with positive as well as negative effectiveness rates in different years indicating that the intervention was, indeed, not very effective in certain years for certain age groups. This is partly due to some measurement errors: with less intensity, the intervention was implemented in the comparison area as well through the distribution of ORS packets by CHWs and promotion of the use of homemade solutions. Further, unlike many other activities, ORT does not show an upward trend in its effectiveness rates: it is a relatively old and stabilized intervention.

*Cost per birth averted (CPBA)*

Relative to the comparison area, from 1986 to 1989 a total of 4343 births were averted by the Matlab project with an average CPBA of $67 (Table 4). There is an upward movement in the number of births averted: an increase from 841 in 1986 to 1343 in 1989. CPBA, too, shows a decline from $71 in 1986 to $60 in 1988. These numbers are relatively lower than the figures of Balk et al. (1988) for the period up to 1985. This is largely due to the broadness of the definition of cost adopted by them. However, the low figure of CPBA cannot be directly compared with CPDAs of other interventions due to their different dimensions and implications.

*Incremental cost*

Although wide variations in IC can be observed among all interventions (Table 5), family planning and NRU demonstrate somewhat similar patterns: with the increase in prevalence rate of

Table 4. Cost-effectiveness indicator I – cost per death/birth averted by intervention,* Matlab MCH-FP Project (US$)

| Intervention/ Activity | 1986 | | 1987 | | 1988 | | 1989 | | 1986–89 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. of deaths averted | Cost per death averted | No. of deaths averted | Cost per death averted | No. of deaths averted | Cost per death averted | No. of deaths averted | Cost per death averted | No. of deaths averted | Cost per death averted |
| ARI | | | | | | | | | | |
| 1 Under 5 years | | | | | 49 | 648 | 42 | 796 | 91 | 717 |
| 2 1–4 years | | | | | 6 | 4 341 | 19 | 1 375 | 24 | 2 057 |
| 3 Post-neonates | | | | | 23 | 284 | 20 | 339 | 42 | 310 |
| DYS | | | | | | | | | | |
| 1 Under 5 years | | | | | | | 20 | 997 | 20 | 997 |
| 2 1–4 years | | | | | | | 18 | 855 | 18 | 855 |
| 3 Post-neonates | | | | | | | 2 | 2 246 | 2 | 2 246 |
| NRU | | | | | | | | | | |
| Under 5 years | 36 | 1 246 | 31 | 1 530 | 22 | 1 674 | 10 | 4 645 | 99 | 1 757 |
| ORT | | | | | | | | | | |
| 1 Infants | 3 | 1 226 | 4 | 826 | (9) | —— | 10 | 479 | 8 | 1 903 |
| 2 1–4 years | 3 | 3 858 | (3) | —— | 3 | 3 993 | (2) | —— | 1 | 38 596 |
| Total | 6 | 2 408 | 2 | 7 050 | (5) | —— | 9 | 2 462 | 13 | 5 578 |
| EPI | | | | | | | | | | |
| 1 Measles | | | | | | | | | | |
| Under 5 years | 34 | 140 | 20 | 138 | 24 | 255 | 24 | 284 | 101 | 201 |
| 2 Neonatal tetanus | 27 | 144 | 30 | 249 | 28 | 281 | 14 | 724 | 100 | 294 |
| MAT | | | | | | | | | | |
| Compared to Blocks A&B | | | 16 | 1 631 | 10 | 2 782 | 17 | 2 205 | 42 | 2 158 |
| FPP | No. of births averted | Cost per birth averted | No. of births averted | Cost per birth averted | No. of births averted | Cost per birth averted | No. of births averted | Cost per birth averted | No. of births averted | Cost per birth averted |
| Compared to comparison area | 841 | 71 | 903 | 72 | 1 256 | 60 | 1 343 | 67 | 4 343 | 67 |

* at constant prices (1989 = 100)
NA = not available
Note: brackets indicate negative numbers

**Table 5.** Cost-effectiveness indicator II - incremental cost to reduce/increase an effectiveness indicator by one unit,* Matlab MCH-FP Project (US$)

| | 1986 | | 1987 | | 1988 | | 1989 | |
|---|---|---|---|---|---|---|---|---|
| Intervention/Activity | Rate | Incremental cost | Rate | Incremental cost | Rate | Incremental cost | Rate | Incremental cost |
| 1 To reduce the mortality rate related to: | | | | | | | | |
| ARI | | | | | 3.6 | | 2.7 | 38 602 |
| Dysentery | | | | | | | 0.6 | 26 525 |
| Malnutrition | 4.4 | NA | 4.0 | 114 553 | 3.7 | 140 207 | 3.3 | 93 072 |
| ORT | 1.3 | NA | 1.6 | —— | 2.0 | —— | 1.2 | 22 945 |
| Maternity care** (Only in Blocks C&D) | 59.3 | NA | 40.5 | 1 359 | 42.2 | —— | 40.7 | 24 110 |
| EPI | | | | | | | | |
| a. Measles | 0.5 | NA | 0.1 | 5 706 | 0.4 | —— | 0.1 | 15 387 |
| b. Neonatal tetanus | 3.9 | NA | 2.1 | 4 100 | 1.6 | 16 186 | 0.6 | 10 427 |
| 2 To reduce malnutrition rate +: Among children between 6-60 months | 19.9 | NA | 15.3 | 10 516 | 11.1 | 8 860 | 7.1 | 11 236 |
| 3 To increase the coverage rate of EPI: | | | | | | | | |
| a. Measles | 78.6 | NA | 80.7 | 1 299 | 87.1 | 950 | 91.9 | 1 435 |
| b. Tetanus toxoid | 87.6 | NA | 89.1 | 5 042 | 91.7 | 3 081 | 93.6 | 5 143 |
| c. DPTP | 55.7 | NA | 57.7 | 7 740 | 64.8 | 2 578 | 72.2 | 2 923 |
| d. BCG | 28.8 | NA | 78.0 | 165 | 84.7 | 909 | 89.1 | 1 558 |
| e. Criterion I (a,b,c&d)# | 57.6 | NA | 75.4 | 1 988 | 81.4 | 6 580 | 86.2 | 9 253 |
| f. Criterion II (a&b)# | 83.0 | NA | 84.8 | 5 660 | 89.4 | 3 080 | 92.7 | 4 935 |
| 4 To increase the prevalence rate of contraceptive use ##: | 46.4 | NA | 49.8 | 19 027 | 51.9 | 35 747 | 56.5 | 19 247 |
| (To increase one more contraceptive user) | | NA | | (74) | | (133) | | (97) |

* at constant prices (1989 = 100)
** direct obstetric and neonatal deaths
+ percentage of children between 6-60 months with MUAC < 110
#Criterion I = Geometric mean of the coverage rates of Measles, TT, DPTP and BCG
#Criterion II = Geometric mean of the coverage of Measles and TT
## per 100 eligible women
—— indicates incapability of measuring incremental cost as the rate has gone up during the year concerned
NA = not available

the former and the decrease in the mortality rate of the latter, IC appears to be decreasing. For family planning, with the increase in contraceptive prevalence rate from 46.4% in 1986 to 56.5% in 1989, IC decreased sharply from $35 747 in 1988 to $19 247 in 1989. IC to increase one more contraceptive user, too, declined from $133 to $97 in the same period. For NRU, while mortality rate declined from 4.4 in 1986 to 3.3 in 1989, IC to reduce it by one unit declined from $114 553 in 1987 to $93 072 in 1989.

With respect to the four components of EPI, although the coverage rate of each of them marginally increased in each year (except the sharp increase in BCG in 1987), IC continuously increased only for BCG. For the other components of EPI (measles, tetanus toxoid and DPTP), IC declined in 1988. This could be largely due to the relatively high increase in coverage rates of all the three activities in 1988. But with the advancement towards satiety level, all of them showed an upward trend in IC in

1989. It seems that the incremental achievements in the coverage rates of the four components of EPI intervention were naturally constrained as they were moving closer to their satiety levels and this led to an increase in their ICs. While the coverage rate of the combination of all four components of EPI (Criterion I) has increased at a very sharp rate, the same of measles and tetanus toxoid (Criterion II) has increased at a lower rate. Both indicators have, however, come closer to the satiety level with respect to their intermediate outcomes. Thus, substantial increases in IC appear in both indicators for 1988 and 1989. ICs to reduce the mortality of measles and neonatal tetanus, however, demonstrate irregular patterns. Except for ARI, almost all other interventions, too, show irregular IC patterns.

IC to reduce malnutrition rate, however, seems to be fairly constant in that while the malnutrition rate significantly declined from 15.3% in 1987 to 11.1% in 1989, its IC increased from $8860 in 1988 to $11 236 in 1989. But this increase in IC cannot be treated as similar to that of EPI or family planning because the decline in malnutrition rate has not come closer to its satiety level. As mentioned earlier, this indicates that although the NRU intervention has been associated with a decline in cause-specific mortality rate, the overall cost-effectiveness of this intervention still needs to be improved further.

*Average cost per case*

Average cost (AC) per case treated/performed/attended was computed for five activities. But all the AC figures are moving upwards, as shown in Table 6. Among them, NRU can be considered as the most expensive one with more than $400 per case treated on average. ARI shows a cost of around $40 per case treated. The AC figures of other activities appear to be reasonably low: around $2 and $0.1 have been spent per immunization and per ORS packet distributed, respectively. Among other reasons, delivering of more than one unit of EPI or ORT (i.e. packets), often to the same user/patient at the same time, seems to have brought down the cost of delivery. As indicated in the above section, for interven-

**Table 6.** Cost-effectiveness indicator III - average cost to attend/perform/treat per case by intervention,* Matlab MCH-FP Project (US$)

| | 1986 | 1987 | 1988 | 1989 |
|---|---|---|---|---|
| Intervention/Activity | Average cost | Average cost | Average cost | Average cost |
| 1 Cost per case treated | | | | |
| ARI | | | | |
| a. For cases treated at home | | | 35 | 46 |
| b. For all cases including OPD and hospitalized cases | | | 32 | 41 |
| Dysentery | | | | |
| a. For all cases treated at home/sub centres or admitted to Matlab clinic | | | | 46 |
| Malnutrition | | | | |
| a. For cases treated at Matlab Centre | 673 | 386 | 424 | 554 |
| 2 Per ORS pkt. distributed | 0.10 | 0.08 | 0.09 | 0.11 |
| 3 Per immunization | | | | |
| Measles | 1.7 | 1.8 | 2.1 | 2.5 |
| Tetanus toxoid | 1.4 | 1.8 | 2.1 | 2.5 |
| DPTP | 1.4 | 1.8 | 2.1 | 2.5 |
| BCG | 1.7 | 1.8 | 2.1 | 2.3 |

* at constant prices (1989 = 100)

tions like EPI, however, the upward movement in cost per immunization can be easily understandable as it has already come close to its satiety level.

## Discussion

The cost-effectiveness of a set of MCH and FP activities in a rural area in a developing country was examined using simplified methods. Only the recurrent cost incurred by the provider on service delivery was looked at. This inevitably excluded the cost of certain inputs such as contraceptives granted by external agencies to the project. Since these inputs were provided free throughout the study period, their exclusion from the cost analysis was assumed to have made no significant effect on comparisons made over the period concerned. Exclusion of rental values and depreciation was also made with an assumption that no significant differences exist among the activities with respect to capital intensity. The only exception is curative services, but no CEIs were computed for them.

The confinement of cost analysis to the service delivery system naturally excluded the social cost as well. However, most services of the Matlab project are being provided at the door step by CHWs and the cost borne by the users to receive these services is extremely low. One exception to this is the time cost of users for nutrition rehabilitation for which the mother accompanies the child at the centre until the end of the rehabilitation period. Although the opportunity cost of mothers in Matlab still remains an area for research, a resistance was observed among some mothers in following up referrals, particularly for NRU. This indicates that the CEIs could have been somewhat different if social cost was measured and added to the analysis.

In this simple analysis, cost-effectiveness was measured separately for each intervention. CPDA and CPBA were measured with respect to the comparison area using cause-specific death rates and birth rates, respectively. It was assumed that the cause-specific death rates provided by the project were significantly accurate. As mentioned earlier, one exception was the diagnostic uncertainties in neonatal pneumonia. Incremental cost and average cost were measured particularly to indicate the productivity of interventions in the generation of intermediate health outcomes. One of the limitations in this methodology is its neglect of interactions among interventions in relation to the generation of health outcomes. Concepts of competing risks and frailty are, indeed, important in measuring more realistic CEIs (Mosley and Becker 1991). In this context, NRU interventions could certainly have had indirect positive impact on the morbidity and mortality rates of other childhood afflictions such as diarrhoeal diseases and ARI. Similarly EPI (measles) might have had an impact on ARI and DYS. This necessitates further improvements in the methodology of CEA to distinguish the influence of each MCH intervention on health and survival of the target population. If these considerations were incorporated, the results of the present analysis could have been changed. But the presentation of results in that format would have been extremely complex.

On the same theme, it is important to measure the impact of multiple interventions on selective CEIs as was attempted in the Narangwal study (Kielmann et al. 1983). Since all the interventions in the present case are PHC components, there is enough scope in a CEA to identify the impact of various combinations of them on health status. Such an attempt is particularly important for policy making. Spill-over effects including quality of life gained by the users from the interventions, especially from maternity care, could be considered as another important area to be examined in an economic evaluation. With the availability of a properly collected set of data for the Matlab project these issues can be addressed in future research.

The methodology used in this study to measure incremental cost should be treated with caution. Measurement of IC became complicated because a portion of the increment in total cost of any activity in any given time period was always related to the maintenance of coverage rate/mortality rate which had been already achieved at the beginning of the time period concerned. This study, however, did not attempt to apportion the IC into those two components and therefore the interpretation of IC should be done with caution. The methodology of measuring IC can be further developed to incorporate the impact of multiple interventions. In such an exercise, cost of maintaining the already acquired

level of each intervention should also be adjusted in expressing incremental results.

With the CEIs used in this study, it appeared that the Matlab MCH-FP Project was able to generate a significant impact on the maternal and child health of the intervention area during the period concerned. Among the nine service activities, EPI has moved closer to satiety level and therefore the cost involved in this intervention has tended to move upwards. However, a significant portion of this upward movement should be attributed to the cost of maintaining already achieved coverage rates, which was not measured in this study. This adjustment is necessary not just for EPI but also for other interventions, and it would be an area for further research. Among other interventions, family planning, control of ARI and control of dysentery appear to have generated relatively high cost-effectiveness compared to other interventions either by way of decreasing incremental cost or with the achievement of low average costs. When all indicators examined in this study are taken into consideration, maternity care, ORT and, particularly, NRU appear to be relatively disadvantaged in reaching an economically worthwhile status.

However, all these interventions do have indirect and spill-over effects on the health status of the target population. Maternity care, especially, appears to have a considerable indirect impact on child health. Therefore, the conclusions made on the findings of the present study should be treated with caution, but one implication of the findings is the necessity to reorganize the activities which have already approached satiety level, by way of restructuring the present resource allocation pattern. By doing so, a portion of both human and non-human resources allocated for those activities can be diverted to new interventions or to existing activities which are now at an economically less efficient status. Such a reallocation of resources should be based on a feasibility study. A guiding principle for resource reallocation would be to retain the minimum volume of resources within an activity to maintain the health outcomes which have already been achieved. This is extremely important for EPI. In general, the measured values of CPDA, CPBA and AC seem to be comparable with the findings of similar studies undertaken in developing countries such as Creese (1983), Shepard et al. (1986), Phillips (forthcoming) and Robertson et al. (1985). But the cost figures of all these studies should be subject to adjustments to make a meaningful comparison which is out of the scope of this study. Yet the Matlab figures do not show any significant difference from other studies in a simple comparison.

## Conclusion

It is quite clear that the Matlab project has been able to upgrade the health status of mothers and children in a rural area of Bangladesh to an appreciable level, although the methods adopted in this study still need developing to capture many other important issues related to a CEA, such as maintenance cost in calculating IC, and interaction among interventions in generating desired health effects and indirect effects. In undertaking CEAs on a set of interactive PHC activities, the simple CE framework appears to be insufficient to obtain a more realistic understanding of the cost-effectiveness of such interventions. Yet with these limitations, it was possible to come to some valid conclusions; particularly, the activities which have progressed closer to the satiety level should be subject to a reallocation of resources and a reorganization of process to avoid wastage and to obtain maximum use of available resources. Further, the need to place more emphasis on certain activities which were still of an economically inferior status was identified by the study. However, adaptation of a more developed cost-effectiveness methodology, which addresses the issues mentioned above, would necessarily produce more useful findings leading to more concrete policy conclusions. With this background, although some drawbacks can be observed in some interventions at the implementation stage, the Matlab project clearly demonstrates an excellent example to the developing world of how PHC objectives can be achieved in an economically efficient manner.

## Endnotes

[1] The cost component related to hospital services for each activity is included for the respective activity.

[2] This method should, however, be treated with caution as there was a spontaneous drain of high risk women from blocks A and B to receive services in blocks C and D.

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## Biographies

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Après les utilisations de la méthode d'"autopsie verbale" pour guider la composition de stratégies de santé maternelle et infantile, nous abordons une dernière catégorie d'applications, les comparaisons internationales.

# VIII. APPLICATIONS DE LA METHODE POUR LES COMPARAISONS INTERNATIONALES

La méthode d'autopsie verbale, sous des formes et des noms différents, a été essayée dans plusieurs pays dès le début des années 1980.[65-68] Un séminaire tenu à l'Université Johns Hopkins en 1990 fut la première tentative de réunir et discuter ces expériences initiales.[69] A la suite d'une seconde réunion d'experts en 1992 et de recommendations de l'OMS[65], d'autres équipes ont utilisé des méthodes de détermination des causes de décès par l'autopsie verbale à travers le monde. Sans pouvoir citer toutes ces équipes, on peut rappeler des travaux publiés en Inde[71], au Zaire[72], au Mexique[73,74], au Liberia[75], au Ghana[76], en Ethiopie[77], au Pakistan[78,79], au Kenya[80-82], en Tanzanie[83], en Gambie[84], en Haiti[85]. On pourrait imaginer, à condition que l'utilisation de la méthode soit standardisée et homogène dans les différents endroits, des comparaisons inter-régionales, inter-nationales, ou inter-temporelles. A ce jour, l'auteur n'a participé qu'à une étude internationale, rapportée ici dans la publication "D1"[86].

Il s'agissait pour le Programme de Contrôle des Maladies Diarrhéiques de l'OMS de mettre en évidence les différences ou les ressemblances entre divers pays au sujet de la mortalité par diarrhée, selon les catégories de diarrhée et les groupes d'âge.

Bien qu'initialement il était prévu d'impliquer plus de vingt pays, seuls quatre ont pu se conformer aux conditions de l'étude et comparer leurs données de mortalité collectées selon la même méthode d'autopsie verbale. Cet échec relatif est dû au fait que les coordonateurs de l'étude ont voulu exploiter des données existantes (donc non nécessairement cohérentes), au lieu de lancer une étude nouvelle, qui aurait nécessité plus de temps et plus d'argent, pour s'assurer d'une méthodologie similaire.

Bien que n'ayant pas été réalisée à notre connaissance, une étude comparative internationale des causes de décès des enfants et des femmes serait tout à fait faisable et extrêmement intéressante à analyser. Une telle étude a été planifiée par la firme américaine Macro International pour la troisième série de ses Enquêtes Démographie et Santé.

Après avoir détaillé les diverses applications testées à Matlab de la méthode de détermination des causes de décès par l'autopsie verbale, et afin de discuter l'extension de la méthode àd'autres régions ou d'autres pays, il est temps d'analyser les conditions sous lesquelles on pourrait recommander l'extension de la méthode.

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# International Differences in Clinical Patterns of Diarrhoeal Deaths: A Comparison of Children from Brazil, Senegal, Bangladesh, and India

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## ABSTRACT

**Population-based data on deaths due to diarrhoea among children less than 5 years of age were obtained from areas of Brazil (227 deaths), Senegal (531), Bangladesh (236) and India (146). Fatal episodes of diarrhoea were classified as either acute diarrhoea, dysentery, or persistent diarrhoea based on their duration and on the presence or absence of blood in the stools. Persistent diarrhoea accounted for over 60% of infant diarrhoeal deaths in Brazil, 47% in India, 36% in Senegal, and 26% in Bangladesh. In the latter two studies, over one-half of infant diarrhoeal deaths were due to acute watery episodes. Among children 1-4 years old dying from diarrhoea, persistent episodes were the most common in Senegal and India, whereas dysentery was the leading pattern in Bangladesh. These differences may be related to the use of oral rehydration therapy and the utilisation of health care, as well as to environmental characteristics, and are relevant for planning control strategies. Further data are required from other parts of the less developed world.**

*Key words*: Diarrhoea; Mortality; Dysentery; Fluid therapy.

## INTRODUCTION

Limited information is available on the clinical characteristics of fatal childhood diarrhoea in less developed countries. The few available studies (1-3) suggest that one-third to one-half of all diarrhoea-associated deaths among children occurred following episodes of persistent diarrhoea, that is, those with a duration of 14 days or more. Information on the frequency of clinical patterns of fatal episodes (acute diarrhoea, persistent diarrhoea and dysentery) in various settings from less developed parts of the world will be useful for planning the prevention (4) and management of diarrhoeal episodes. For example, the promotion of oral rehydration therapy (ORT) will help prevent deaths due to dehydration in children with acute watery diarrhoea (5-8), but is unlikely to reduce mortality due to persistent and dysenteric diarrhoeas. Therefore, lower proportionate mortality due to acute watery diarrhoea might be expected in areas with higher ORT-use rates.

The lack of reliable data on clinical patterns of diarrhoeal deaths has prompted the Programme for the Control of Diarrhoeal Diseases of the World Health Organization to support the setup of the present collaborative study.

## MATERIALS AND METHODS

Over twenty research centres in less developed countries were contacted. For inclusion in the

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present collaborative study, these centres were requested to provide data on at least 100 diarrhoeal deaths in children less than 5 years old, either from a population-based or a health services-based study (only if 70% or more of all these deaths occurred in health facilities). Four centres (Brazil, Senegal, Bangladesh and India) were able to provide the necessary data, which are presented below.

The main characteristics of the areas served by each of the four collaborating centres are given in Table I. Most health indicators were better in Rio Grande do Sul, a relatively wealthy area of Brazil; poorest in Niakhar (Senegal); and Matlab (Bangladesh) and Ballabgarh (India) presented intermediate levels. The high reported usage of ORT in the Matlab area is to be noted.

Table I. Characteristics of the four study areas (some of these figures are the best available estimates)

| | Brazil | Senegal | Bangladesh | India |
|---|---|---|---|---|
| Population (thousands) | 2,500 | 24 | 100 | 64 |
| Adult literacy rate | 90% | 7% | 30% | 39% |
| Infant mortality rate per thousand births | 40 | 120 | 97 | 61 |
| % deaths due to diarrhoea | 12%[a] | 35%[b] | 15%[b] | 18%[b] |
| Median duration of breast feeding (months) | 3.3 | 24 | 30 | 11.5 |
| Prevalence of malnutrition among under-fives[c] | | | | |
| stunting | 12% | 20% | 30%[d] | 17% |
| wasting | 3% | 5% | 27%[d] | 4% |
| underweight[e] | | | | 74% |
| ORT use in diarrhoea | 40% | 4% | 57% | 45% |
| Number of diarrhoea deaths studied | 227[a] | 531[b] | 236[b] | 146[b] |

a = Infants only;
b = All under-fives;
c = Below NCHS median minus two standard deviations;
d = Children 6-48 months;
e = Low weight-for-age.

Details of the study design in the four areas are shown in Table II. In Brazil, the two largest cities in the southern state of Rio Grande do Sul, Porto Alegre and Pelotas (joint population 2,500,000), were studied in 1985. Infant deaths were identified through regular visits to hospitals, coroner services, death registries and cemeteries, ascertainment being virtually complete. The case-notes of all children who died were reviewed and their parents were interviewed by a physician. Two reviewers went through the available information independently to determine the underlying and associated causes of death. Disagreements were resolved by the study coordinator (CGV). This study was restricted to infant deaths.

In Senegal, the study covered a population of approximately 4,800 children less than 5 years old living in 30 villages in the district of Niakhar. From 1984 to 1988, data on child deaths were collected during the yearly census (1984-86) and through weekly visits to households (1987-88). Extensive verbal autopsy forms were filled out for each death and then analysed by at least two independent physicians. The data on ORT use refer to the beginning of the study period (1984).

Table II. Details of the study methods according to area

| | Brazil | Senegal | Bangladesh | India |
|---|---|---|---|---|
| Study period | 1985 | 1984-8 | 1988-9 | 1988-9 |
| Age range of children (months) | 0-11 | 0-59 | 0-59 | 0-59 |
| Number of diarrhoea deaths studied | 227[a] | 531[b] | 236[b] | 146[b] |
| Type of surveillance | hospitals cemeteries registries | home visits | home visits | home visits |
| Frequency of surveillance | weekly | yearly (1984-86) weekly (1987-88) | bi-weekly | bi-weekly |

a = Infants only; b = All less than 5 years.

In Bangladesh, the study was carried out in the rural Matlab area where a demographic surveillance system covered a population of approximately 100,000 during the years 1988-89. Each household was visited fortnightly by health workers; when a recent death was recorded, a health assistant obtained a history of the fatal illness. These histories were reviewed by a medical assistant supervised by two experienced physicians.

The data from India were obtained from a community health project in a rural area at Ballabgarh, Haryana state, near New Delhi, during 1988-89. All households in a community of 64,000 were visited every two weeks to detect births and deaths. The study supervisor applied a detailed questionnaire on every death, and the cause of death was established after a review by two physicians.

The studies included all child deaths *with* diarrhoea (the death of a child who presented diarrhoea during the fatal illness episode, either as the underlying or associated cause). All tabulations refer to these children. An attempt was also made to

identify those children for whom diarrhoea was considered to be the *underlying* cause of death, that is, that which started the chain of events which led directly to death.

Table III. Percental distribution of children dying with diarrhoea according to age and clinical pattern of the illness

| Age group and clinical pattern of diarrhoea | Brazil | Senegal | Bangladesh | India |
|---|---|---|---|---|
| **Infants** | | | | |
| Acute | 28% | 58% | 52% | 39% |
| Persistent | 62% | 36% | 26% | 47% |
| Dysentery | 10% | 6% | 22% | 14% |
| | (227)* | (160)* | (108)* | (92)* |
| **1–4 years** | | | | |
| Acute | – | 40% | 20% | 28% |
| Persistent | – | 51% | 21% | 59% |
| Dysentery | – | 9% | 59% | 13% |
| | | (371)* | (128)* | (54)* |
| **Less than 5 years** | | | | |
| Acute | – | 46% | 34% | 35% |
| Persistent | – | 47% | 23% | 51% |
| Dysentery | – | 8% | 42% | 14% |
| | | (531)* | (236)* | (146)* |

* Number of deaths.

For each child, information was obtained on age, sex, presence of blood in the stools, diarrhoea duration and place of death. The following definitions were used for describing the clinical patterns of diarrhoeal deaths:

*Dysentery*: diarrhoea with the presence of blood in stools (more than just one or two streaks), regardless of duration

*Acute diarrhoea*: nonbloody diarrhoea lasting less than 14 days

*Persistent diarrhoea*: non-bloody diarrhoea lasting 14 days or more

To characterise a new diarrhoeal episode, a period of at least 48 hours without diarrhoea was required.

## RESULTS

The clinical patterns of diarrhoeal deaths varied considerably between the four areas (Table III). In Brazil, 62% of the infants dying with diarrhoea had persistent episodes, compared to 47% in India, 36% in Senegal and 26% in Bangladesh (Figure 1). Dysentery deaths were relatively common in Bangladeshi infants (22% of deaths), and acute diarrhoeal deaths were more frequent in Senegal (58%).

Table III also shows mortality patterns for children 1–4 years old in Senegal, Bangladesh and India (no such information was available from Brazil). In India and Senegal, 1–4 year old children who died were more likely to have persistent diarrhoea (and less likely to have acute episodes) than infants; in Bangladesh, dysentery was the most common type of diarrhoeal death among older children, and acute episodes became less important.

Table IV. Estimated infant mortality rate (per 1,000 live births) according to clinical pattern of diarrhoea

| Clinical pattern of diarrhoea | Study | | | |
|---|---|---|---|---|
| | Brazil | Senegal | Bangladesh | India |
| Acute | 1.3 | 23.2 | 7.8 | 5.0 |
| Persistent | 3.0 | 14.5 | 3.9 | 6.1 |
| Dysentery | 0.5 | 2.2 | 3.3 | 1.6 |
| Total | 4.8 | 39.9 | 15.0 | 12.7 |

In none of the four areas did these clinical patterns vary according to gender. The median durations of all fatal diarrhoeal episodes (including dysentery) were 24 days in Brazil, 15 in Senegal, 13 in Bangladesh and 29 in India. In Brazil, 82% of the deaths occurred in a hospital or health facility, compared to 5% in Senegal and in India, and 3% in Bangladesh.

Diarrhoea was considered to be the underlying, rather than an associated, cause of death in 75% of the deaths with diarrhoea in Brazil. In Senegal, Bangladesh and India, the respective percentages were 70%, 76% and 86%. There were no marked differences in terms of clinical patterns when the analysis was restricted to deaths in which diarrhoea was judged to be the underlying cause.

The above clinical pattern data (Table III), in conjunction with estimates of infant mortality rates and the proportion of infant deaths due to diarrhoea shown in Table I may be used to calculate the infant mortality rates for each diarrhoeal pattern (Table IV). Due to the high mortality levels in Senegal, and particularly to the high proportion of diarrhoeal deaths, infant mortality rates in that study tended to be the highest, whereas those from the Brazilian study were the lowest. It is noteworthy that dysentery mortality rates showed considerably less variations than the other clinical patterns.

## DISCUSSION

Information on clinical patterns of diarrhoea mortality were obtained from four countries using simplified criteria, based only upon the duration of the fatal episode and on the presence of blood in the stools. Nevertheless, even such simple information proved difficult to obtain; only four centres were able to provide a sufficient number of deaths, out of over twenty which had been contacted.

Collating data from existing studies in different countries is bound to lead to comparability problems.

For example, no uniform definition of diarrhoea was used in the four studies, although this would probably not markedly affect mortality studies. Also, existing information on ORT-use rate was based on different surveys and may too have been affected by lack of consistency. Case ascertainment varied from place to place: in Brazil, it was based on surveillance of hospitals, cemeteries and registries, whereas in the other three areas surveillance took place at the home level. Nevertheless, it is unlikely that the present results would have been affected by these differences, and interesting findings have emerged.

Firstly, clinical patterns varied markedly from one setting to another. The most frequent pattern of diarrhoeal death among Brazilian infants was persistent diarrhoea; among children less than 5 years old in Senegal, acute and persistent diarrhoea were associated with equal proportions of deaths, dysentery being uncommon as a cause of mortality, whereas in Bangladesh the latter was the dominating type. In India, persistent diarrhoea was responsible for about one-half of all diarrhoeal deaths among those less than 5 years old and acute diarrhoea for one-third.

noted, however, that high ORT-use rates do not necessarily imply correct use (9). Nevertheless, the above findings are generally supportive of lower proportionate mortality from acute diarrhoea in areas where ORT-use rates are higher.

Other explanations for the differing clinical patterns may include variations in aetiologic agents; environmental factors; nutritional status; maternal behaviour including breastfeeding, and personal and domestic hygiene; and health care availability and utilisation. The scope and quantity of the data currently available to the investigators does not allow a more refined analysis of the determinants of different clinical patterns.

These findings may be used for tailoring control programmes to each specific situation (10). In Senegal, for example, ORT promotion is certainly the number one priority for reducing diarrhoea mortality. In southern Brazil, however, additional efforts to increase ORT coverage would probably have little impact. While ensuring that high levels of ORT use are maintained, mortality would be more strongly affected by preventive measures aimed at reducing persistent diarrhoea, such as extending the extremely

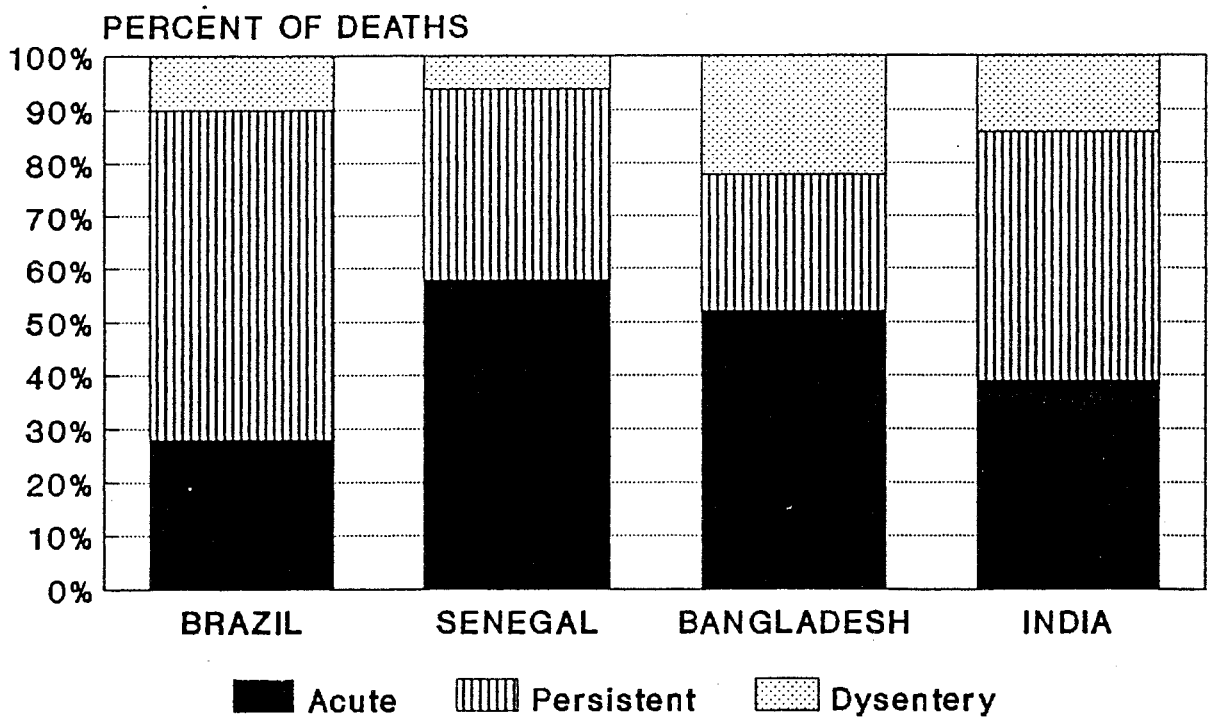


**Figure.** Distribution of diarrhoeal deaths among infants, according to clinical pattern

Secondly, although drawing conclusions on this issue from only four settings may be unwarranted, it is interesting that the highest proportion of deaths due to acute diarrhoea was observed in Senegal where the ORT-use rate was lowest. It should be

short duration of exclusive and total breastfeeding (11), and by the appropriate management of these prolonged episodes. In India, measures are needed to control persistent diarrhoea, but improved promotion of ORT for acute watery cases is also

required. In Bangladesh, on the other hand, special attention is required to acute diarrhoea among infants and particularly to dysentery among children of 1 – 4 years of age; hygiene behaviour interventions are likely to play an important role in reducing mortality due to the latter (12).

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# IX. CONDITIONS D'EXTENSION DE LA METHODE

Ces conditions peuvent être présentées en six groupes:

1. D'abord l'**indépendance** du système de surveillance démographique. Pour s'assurer de la neutralité et de l'objectivité des résultats issus des applications de la méthode, il est essentiel que le système de surveillance démographique qui comprend le relevé des décès et la détermination des causes de décès par l'autopsie verbale soit indépendant du système de prestation de services de santé. Ceci implique un budget important pour maintenir deux systèmes parallèles.

2. Problèmes de **qualité**. La plus grande prudence doit être observée avant de décider l'extension de la méthode à une zone géographique étendue ou à l'échelle d'un pays entier. En effet la crédibilité de la méthode proposée est fondée sur la qualité du procédé, elle-même fonction de la qualité et de la quantité de la supervision, et donc du coût. Il faut aussi considérer qu'une fois le système mis en place il est conçu pour durer, et il est clair que l'érosion de qualité est une fonction du temps. La justification d'une extension d'un tel système à un pays tout entier est peu convaincante dans les pays à ressources limitées.

3. Liée aux conditions précédentes, la considération des **ressources**, tant financières qu'humaines, doit précéder tout projet d'extension de la méthode, ou de mise en place de la méthode en un nouvel endroit. Les besoins de formation, de supervision, de logistique, ainsi que la pérennité de ces besoins, doivent être soigneusement évalués.

4. La méthode doit pouvoir être **validée**. C'est là un de ses points faibles. Plusieurs tentatives de validation ont été rapportées[87-92], mais toutes se heurtent au problème du standard de réference ("gold standard"). L'idéal serait l'autopsie réelle, mais elle se pratique rarement ou pas du tout dans la plupart des cultures. Sa pratique se heurte à de nombreux problèmes techniques. La plupart des registres d'hôpitaux dans les pays moins

avancés contiennent les symptômes ou syndromes à l'entrée, mais pas les diagnostics de sortie. Il n'en reste pas moins que, au moins sur des petits échantillons, une certaine validation est indispensable avant d'investir dans la mise en place d'un système.

5. L'impossibilité d'appliquer la méthode dans les régions endémiques de **maladies à symptomatologie non spécifique, comme le paludisme**[80,81,84]. Les symptômes rapportés en phase terminale de paludisme grave (accès pernicieux), peuvent être confondus avec ceux de pneumonies, de septicémies, de méningites, ou de n'importe quelle affection neurologique. La pratique de la goutte épaisse n'étant pas généralisée, loin s'en faut, les risques d'erreurs sont trop grands. Bien que peu de travaux en fassent encore état[85], il est probable que la méthode soit aussi difficilement applicable dans les régions à forte endémie de SIDA.

6. Dans l'optique de comparaisons spatiales ou temporelles se pose le problème de la **standardisation** des méthodes. Plusieurs essais d'"arbres décisionnels" ou algorithmes ont été proposés et évalués[91-93]. Il en ressort que les causes de décès réunissant les meilleures combinaisons de sensibilité, de spécificité et de répétitivité sont le tétanos néo-natal, la rougeole, la méningite. Les causes de décès intermédiaires quoique moins "performantes" que les précédentes sont les diarrhées, la malnutrition, les infections respiratoires aigues, tandis que les moins performantes sont le paludisme, la tuberculose infantile.

La standardisation des méthodes se heurte aussi à divers autres problèmes tels que la qualification des enquêteurs, leur genre, la langue de travail, la période de délai entre le décès et l'interview, le nombre des personnes interrogées et leur lien de parenté avec la personne décédée, la classification en causes primaires ou secondaires, et le traitement des cas de décès à causes multiples.

7. Enfin il est clair que la méthode ne peut s'appliquer valablement dans tous les cas, à tous les décès. Une certaine **modestie** doit s'exercer dans l' attribution d' une cause de décès dans les cas difficiles, atypiques, non spécifiques, ou lorsque les renseignements obtenus par l'autopsie verbale sont insuffisants. Dans la présentation des résultats, la catégorie "cause impossible àspécifier" doit toujours exister, et peut parfois représenter un pourcentage non négligeable.

# X. CONCLUSION



En conclusion , on a vu que l' utilisation de la mortalité par cause est intéressante en santé publique pour:

-établir l'importance de diverses pathologies et causes de décès,

-selectionner et guider des interventions spécifiques ou globales,

-évaluer l'effet de programmes ou d'interventions spécifiques,

-comparer des sous-groupes, ou des régions, ou des périodes de temps,

-et, pourrait-on ajouter, identifier certains problèmes étiologiques, ou comportementaux, àl'échelle de communautés, qui pourraient appeler des investigations explicatives (anthropologiques, épidémiologiques, biologiques).

Au terme de cette revue, on peut risquer une définition de l'autopsie verbale:

**"c'est une technique d'utilisation de l'information acquise auprès des proches d'une personne décédée pour reconstruire les évènements et symptômes ayant précédé le décès et en déduire une cause de décès médicalement acceptable."**

En tenant compte des restrictions énumérées au chapitre IX, l'utilisation de la mortalité par cause pour la **planification** des actions de santé maternelle et infantile, pour guider les stratégies et les interventions, est une méthode qui peut et doit être étendue.

La question de l'utilisation de la méthode pour l'**évaluation** des programmes de santé maternelle et infantile ou de leurs composants spécifiques est beaucoup plus difficile. Non seulement il faut distinguer entre "efficacité potentielle" (mesurée dans des conditions "expérimentales") et "efficacité réelle" (mesurée dans des conditions "de terrain" ou de communauté), mais il faut aussi tenir compte du type de l'étude d'évaluation et de son organisation. Pour les applications de la méthode dans un but d'évaluation, nous recommandons qu'elles restent limitées à un petit nombre de centres de recherche en santé publique ou à des zones pilotes, dans lesquelles les conditions d'application peuvent être correctement contrôlées.

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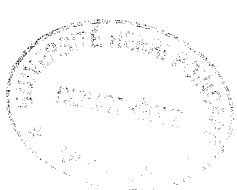

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