ST/ESA/SER.A/84

Department of International Economic and Social Affairs
POPULATION STUDIES, No. 84

Data Bases for Mortality Measurement

Papers of the Meeting of the United Nations/
World Health Organization Working Group
on Data Bases for Measurement of Levels,
Trends and Differentials in Mortality

Bangkok, 20-23 October 1981

United Nations
New York, 1984

NOTE

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The designations "developed" and "developing" economies are intended for statistical convenience and do not necessarily express a judgement about the stage reached by a particular country or area in the development process.

The views expressed in signed papers are those of the individual authors and do not imply the expression of any opinion on the part of the United Nations Secretariat.

Papers have been edited and consolidated in accordance with United Nations practice and requirements.

Symbols of United Nations documents are composed of capital letters combined with figures. Mention of such a symbol indicates a reference to a United Nations document.

The printing of this volume was made possible by a grant from the United Nations Fund for Population Activities.

ST/ESA/SER.A/84

UNITED NATIONS PUBLICATION

Sales No. E.83.XIII.3

01800

PREFACE

The continuing co-operative programme of mortality studies undertaken by the United Nations and the World Health Organization (WHO) strives not only to improve knowledge of recent levels and trends in mortality but, by carrying out small-area case studies and by analysing social and economic correlates of mortality patterns, to improve understanding of the factors that affect the mortality spectrum throughout the developing countries. The aim of the programme is to improve the ability of countries to incorporate health considerations into their development planning and to improve the health and mortality situation of their populations.

Although an enormous number of questions about levels, trends and determinants of mortality remain unanswered, the subject has failed, in the past several decades, to arouse the interest of donor agencies or of developed countries. Developing countries themselves have given low priority to health in their national planning. Currently, overall health expenditures in most developing countries amount to less than 2 per cent of the national product. Furthermore, the greatest portion of these public expenditures is for curative medicine, which reaches only a narrow segment of the population.

The lack of a sound statistical basis on which to judge current mortality conditions and to evaluate the effect of current health programmes is prominent among the reasons for the insufficient progress in improving health and survival. The most elementary data on mortality are missing; those data available are not of a quantity, breadth or quality sufficient to provide government planners with needed information on the levels, trends, structure and differentials in mortality, or to provide the necessary background for initiating or evaluating programmes relating to health and mortality.

As part of the joint programme, the Population Division of the Department of International Economic and Social Affairs of the United Nations Secretariat, in co-operation with the Statistical Office of the Department and the World Health Organization, with the financial support of the United Nations Fund for Population Activities (UNFPA), organized a Working Group on Data Bases for Measurement of Levels, Trends and Differentials in Mortality. The purpose of the interregional meeting of the Working Group, which was held at Bangkok, Thailand, from 20 to 23 October 1981, was to discuss experiences by various government and national institutions in collecting, analysing and using mortality data relevant to the setting of policies in the health and development sectors of their countries. The members of the Working Group were representatives of national statistical offices, national health services and non-governmental institutions involved in the collection, analysis and use of mortality data.

The report of the meeting, including the recommendations of the Working Group for future action at national and international levels, constitutes part one of the present publication. The subsequent parts are devoted to papers that were selected from the commissioned papers and country statements discussed by the Working Group and that were revised after the meeting.

Grateful acknowledgement is due to Kenneth Hill of the United States National Academy of Sciences, who graciously consented to serve as scientific editor for the publication on behalf of the United Nations Secretariat and WHO, and to UNFPA, which made possible the present publication through its grant for mortality studies (INT/80/PO9).

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Explanatory notes

The following symbols have been used in the tables throughout this publication:

Two dots (..) indicate that data are not available or are not separately reported.

An em dash (—) indicates that the amount is nil or negligible.

A hyphen (-) indicates that the item is not applicable.

Parentheses ( ) indicate a deficit or decrease, except as otherwise indicated.

A point (.) is used in English to indicate decimals.

A slash (/) indicates a crop year or financial year, e.g., 1980/81.

Use of a hyphen (-) between dates representing years, e.g., 1981-1983, signifies the full period involved, including the beginning and end years.

Details and percentages in tables do not necessarily add to totals, because of rounding.

Reference to "dollars" ($) indicates United States dollars, unless otherwise stated.

Reference to "billion" indicates a thousand million.

OVERVIEW

*Kenneth Hill**

More of life is generally regarded as better than less of life. And the overriding justification for studying mortality is to find ways in which it can be reduced and survival can be extended. Mortality risks vary among populations over both time and place. Crude death rates vary between and within countries by as much as a factor of five; and some mortality measures, such as the infant mortality rate, vary even more widely. Mortality measures have, for many countries, declined by at least comparable amounts since the beginning of the twentieth century, although the declines have been far from uniform. These and other trends and differentials in mortality are of importance because of their relevance to devising and implementing mortality-reducing strategies. Mortality levels are also important because mortality, with fertility and migration, is one of the three components of population change, a key variable in much economic and social planning.

Reliable mortality analysis depends upon reliable mortality data. The Meeting of the United Nations/World Health Organization Working Group on Data Bases for Measurement of Levels, Trends and Differentials in Mortality was a significant step towards finding means to deal with this question. Part one of the present publication reports briefly on the background of the Meeting and includes the recommendations of the Working Group.

The papers in the present volume are concerned with the measurement of mortality levels, trends and differentials; they cover approaches to data collection, evaluation and analysis. The papers in part two discuss the various uses to which mortality data are put and the implications of their uses for the available methods of data collection and analysis. Part three consists of an overview of current data-collection methods and of their strengths and weaknesses. The papers in part four are concerned with the use of vital registration systems for the collection of mortality data and with the evaluation of such data. Part five contains discussions of sample survey approaches to mortality measurement at the macrolevel and covers both data collection and analytical procedures. The papers in part six consider survey approaches for more intensive and specialized mortality studies.

The overall focus of this publication is undoubtedly on issues in mortality measurement for statistically less developed countries. In these countries, which lack a long history of civil registration and censuses, the provision of even the most basic mortality information is hedged with uncertainty and therefore the issue of alternative approaches is most pressing. Most developed countries obtain basic mortality measures of a high degree of reliability from their civil registration systems and censuses, and will continue to do so; the issues that remain concern the ways in which fully to exploit the data available and to conduct specialized surveys in the areas of epidemiological and clinical medical research. In developing countries, on the other hand, the basic collection systems are weaker, if not in absolute coverage then in the quality of the information recorded, or non-existent, and the range of possible approaches is thus wider.

The papers in the present publication are briefly discussed below, in order to guide the reader to this area of interest.

A. Uses of mortality data

The primary consideration in the collection of mortality data is the need for such data; only what is needed should be collected, and all that is collected should be used. Chapter III, by the present author and the United Nations Secretariat, provides an overview of the uses to which mortality information is put. The first category of uses, termed ''descriptive'' and ''demographic'', views mortality as one of the three components of population dynamics and centres on population forecasting, an essential element of socio-economic planning, and social description. The second category covers uses in the health sector; examples include the identification of high mortality-risk groups so that health services can be efficiently targeted and the evaluation of health services and projects. The third category covers uses in medical research and investigation. For each type of use the characteristics of the information required, such as accuracy, detail and timing, are discussed.

Chapter IV, by Ewbank, specifically concentrates on the use of mortality information for assessing the health impact of health and general development programmes in developing countries and on the shortcomings of the existing collection and analysis procedures for meeting such needs. Although the general tone of the paper is one of caution—that is, in some cases there may be no affordable way for assessing health impacts—the issues and approaches are clearly laid

*Committee on Population and Demography, United States National Academy of Sciences, Washington, D.C., United States of America.

out and should assist in the selection of an appropriate assessment strategy.

B. Overview of approaches for collection of mortality data

The chapter prepared by the United Nations Secretariat, which constitutes part three of the present volume, provides a summary description of the characteristics, advantages and disadvantages of the various approaches used in the collection of mortality information. The approaches are divided into three categories: those whereby deaths are continuously recorded, such as civil registration systems; those where deaths are retrospectively reported for a past period, which may or may not be specifically bounded, such as survey questions on deaths in the preceding 12 months or on children dead among those ever born; and those which infer numbers of deaths or rates of death from numbers of living, again either specifically time-bounded, such as intercensal survival methods, or unbounded, such as stable or quasi-stable population methods. The basic conclusions are that measurement approaches must be selected with reference to the needs and conditions of the country and that the three collection vehicles—civil registration, census and survey—must be viewed as complementary rather than competitive, each having its place in a fully developed system.

C. Collection of mortality data through vital registration systems

The most important source of information about mortality levels, trends and differentials has been historically and remains currently the continuous recording of deaths and their characteristics by civil registration. The primary purpose of such systems has generally been administrative, although the statistical by-product has become increasingly valuable with the recognition that provision of health services is a legitimate concern of national Governments. Moriyama, in chapter VI, provides a useful summary of experience with civil registration, beginning with a brief description of the historical development of the use of such information for mortality estimation; and then describing common features of existing systems, illustrating the uses to which the information is put, discussing the advantages (mainly richness of data) and disadvantages (mainly coverage limitations in developing countries) of such systems, and suggesting approaches to the upgrading of defective registration systems.

Chapter VII, by Padmanabha, discusses the experience of India with a sample civil registration system introduced in the mid-1960s. He first describes the context, in terms of alternative sources of information, then turns to a detailed description of the organization of the system, basically a dual-based survey combining continuous death registration with survey interviewing every six months, and then presents an evaluation of the results obtained using internal and external consistency checks. The strengths and shortcomings of the system are objectively examined.

In chapter VIII, Preston provides a very useful and compact description of the methods available for evaluating the coverage of death registration, and, if necessary, adjusting for omission. The first part of the paper covers indirect methods, which evaluate coverage by appeal to independent information on population age distributions, beginning with those which assume that the population is stable, that is, characterized by constant fertility, mortality and age distribution; and proceeding to the more recent methods, which avoid this assumption by substituting information on population change over time. The second part of the paper discusses direct procedures for evaluation, basically dual-record approaches, and the relative advantages of the indirect and direct procedures.

D. Collection of mortality data through sample survey approaches

In countries where the study of mortality on the basis of civil registration data is complicated by data deficiencies, such as omission, erroneous or inadequate reporting of associated characteristics, or lack of adequate population denominators, sample surveys have been extensively used to provide macrolevel information on mortality levels, trends and, to some extent, differentials. Blacker (chapter IX) describes, illustrates and evaluates the use of retrospective information about mortality collected by single-round sample surveys, covering the evaluation and adjustment of data on household deaths in a recent, defined reference period, the use of information from mothers on the survival of their children, the use of information on survival of parents and the use of information on survival of first spouses. While not attempting to be a handbook, the paper presents real examples and concludes that although the use of such approaches is not invariably satisfactory, it represents a cost-efficient way of filling a number of basic needs for mortality information where alternative sources are lacking.

In chapter X, Hobcraft describes the use of maternity history data in the estimation of levels, trends and differentials of child mortality, using as his context the World Fertility Survey programme, which has greatly expanded the amount of such information available, particularly for developing countries. Estimates of levels, trends and differentials of child mortality for some 20 countries are presented; and the basic plausibility of the estimates is demonstrated. The use of such data for the study of differentials and trends using proportional hazard models is particularly interesting.

Adlakha and Nizamuddin, in chapter XI, describe the use of multi-purpose household surveys and multi-round demographic surveys in the estimation of mortality. Actual examples, three of multi-purpose surveys and three of multi-round surveys, are used to bring out the main features in terms of survey organizaton and methodology. The chapter concludes with a discussion of the relative merits of the two approaches, the decision between the two being seen to depend both upon what is wanted and upon what is feasible.

E. Data collection for intensive mortality studies

Mortality information has uses other than the study of national mortality levels, trends and differentials, perhaps the most important of which is epidemiological and medical research and programme evaluation. For such purposes, small-scale, intensive surveys are frequently the only suitable data-collection vehicle. The work by Lynge (chapter XII), which is the only chapter in the volume with a direct focus on data-collection issues for mortality studies in developed countries, describes a number of ways in which the information is used in the study of disease aetiology; it then outlines, with examples, the ways in which the information can be extracted from existing sources, such as record-linkage exercises between census and death registration data, or specially collected through such approaches as small-scale longitudinal surveys. The examples are exclusively drawn from studies of occupational risks, although the methodologies are applicable also to studies of other differentials. In an evaluation of the various approaches, Lynge draws a conclusion that runs like a continuing thread throughout this entire publication: the appropriate methodology depends upon the context and objectives of the study. She appeals for the use of collection and storage procedures that maximize the possibilities for combining information from different sources.

Puffer's contribution (chapter XIII) describes experience in the Americas with a somewhat different approach to intensive mortality studies, that of using an existing source of data—in this case, death certificates for young children—as the basis and supplementing the information available by special collection procedures covering improvement of recording procedures; visits by medically trained interviewers to households that have experienced child deaths in order to obtain further background information; and relevant medical or pathological information available from hospitals, health centres and physicians. The chapter continues by presenting the results of the exercise in terms of child mortality differentials according to a variety of characteristics for different localities. The differentials look, in general, much as one would expect, although the lack of rigorous testing for omission raises questions about the reliability of their magnitude.

The final chapter, by D'Souza, describes the background and history of, and some findings from, the pioneer Cholera Research Laboratory (now the International Centre for Diarrhoeal Disease Research) in Matlab Thana, Bangladesh, as well as from the more recent, and somewhat less intensive, Companiganj Health Project. The Matlab Project, combining intensive registration efforts with periodic censuses for a population of around 200,000, has provided both an abundance of mortality information useful for the study of disease aetiology and a ready-made setting for treatment trials. This chapter brings out the uses to which the mortality information has been put and also describes some of the bottle-necks experienced.

F. Conclusion

The recommendations of the Working Group, given in the report of the Meeting (see part one), strongly endorse the upgrading of civil registration systems where they are inadequate. The papers themselves, on the other hand, take a more balanced view of the complementarity of the different approaches and of the importance of civil registration as only one element of a thorough system for collecting information on mortality and of the need to improve all the elements in the development of such a system.

The present publication presents accounts of a wide range of approaches to mortality measurement and the results obtained from them, covering the provision of information for all the uses envisioned. It does not, however, present accounts of how to carry out a field exercise or how in detail to analyse a body of data. For such purposes, the reader is referred to the relevant technical manuals published by the United Nations. It is hoped, however, that the papers included here will be helpful in clarifying the issues and options involved in mortality measurement.

Part One

REPORT ON THE MEETING OF THE WORKING GROUP ON DATA BASES FOR MEASUREMENT OF LEVELS, TRENDS AND DIFFERENTIALS IN MORTALITY

INTRODUCTION

A. Background and purpose

As part of the joint programme of the United Nations Secretariat and the World Health Organization (WHO), the Meeting of the Working Group on Data Bases for Measurement of Levels, Trends and Differentials in Mortality was convened at Bangkok, Thailand, from 20 to 23 October 1981, with the financial support of the United Nations Fund for Population Activities (UNFPA). The objective of the interregional meeting was to discuss experiences by various government bodies and national institutions in the collection, analysis and use of mortality data relevant to the setting of policies in the health and development sectors of their countries. The meeting was endorsed by the Population Commission at its twenty-first session, held from 26 January to 4 February 1981.[1]

The participants included 22 scholars with expertise in mortality measurement and the setting of health policy, representatives of the Secretary-General of the United Nations and of the Director-General of WHO; representatives of Secretariat units, regional commissions, United Nations bodies and specialized agencies; and staff of the Population Division of the Department of International Economic and Social Affairs of the United Nations and of the WHO Secretariat.

The following persons, who were invited in a personal capacity, served as members of the Working Group: John G. C. Blacker (United Kingdom); Stan D'Souza (India); Douglas C. Ewbank (United States of America); John Hobcraft (United Kingdom); Antoine Houehougbe (Institut de formation et de recherche démographiques); Kwok Kwan Kit (Malaysia); Elsebeth Lynge (Denmark); Khin Maung Lwin (WHO); Bothina Mahmoud el Deeb (Egypt); Anthony S. K. Mak (Hong Kong); Luis Massé (France); Teodora Morales de Díaz (Peru); Iwao M. Moriyama (United States of America); M. Nizamuddin (India); Leopoldo Núñez Fernández (Mexico); P. Padmanabha (India); Samuel H. Preston (United States of America); Ruth R. Puffer (United States of America); Santhat Sermsri (Thailand); Siva Subramaniam (Sri Lanka); Ken Williams (United Kingdom); Fatu Yumkella (Sierra Leone). Mr. Preston served as Rapporteur for the Working Group.

Léon Tabah, Director of the Population Division, represented the Secretary-General of the United Nations at the Meeting. Kazeo Uemura, Director, Division of Health Statistics, represented the Director-General of WHO. Messrs. Tabah and Uemura served as Co-Chairmen.

Zulma Recchini de Lattes, Chief, Population Trends and Structure Section, Population Division; and Larry Heligman, Population Affairs Officer of that section, served as Technical Secretaries from the United Nations Secretariat. Harald Hansluwka, Chief, Global Epidemiological Surveillance and Health Situation Assessment; and Kyo Handa, Statistician, served as Technical Secretaries from the WHO Secretariat. Rose Kian, Population Trends and Structure Section, Population Division, served as Working Group Coordinator.

The Statistical Office of the United Nations was represented by William Seltzer, Chief, Demographic and Social Statistics Branch.

The United Nations Fund for Population Activities was represented by K. V. R. Moorthy.

Michael N. Azefor represented the Economic Commission for Africa (ECA); Boonlert Leoprapai and Abdus Samad represented the Economic and Social Commission for Asia and the Pacific (ESCAP).

The International Labour Organisation (ILO) was represented by M. T. R. Sarma; and the United Nations Educational, Scientific and Cultural Organization (UNESCO) was represented by G. Carceles.

The Meeting was opened by Mr. Tabah, on behalf of the Secretary-General of the United Nations; by Mr. Uemura, on behalf of the Director-General of WHO; and by Mr. Princy H. Siriwardene, Deputy Executive Secretary of ESCAP. They welcomed the experts and thanked them for their assistance to the United Nations/WHO joint work programme in the field of mortality studies.

B. Organization of the work

The provisional agenda was adopted, and the items considered by the Working Group were:

Use of mortality data for health and development programmes;

Approaches for collection of mortality data;

Use of continuous registration systems;

Collection of mortality data through multi-purpose surveys;

Birth or death records as a sampling frame for studies of mortality;

Special data-collection systems for studying health processes.

Papers covering the various topics had been prepared by the members of the Working Group and were presented at the Meeting.[2]

NOTES

[1] *Official Records of the Economic and Social Council, 1981, Supplement No. 3*(E/1981/13), para. 162.

[2] For list of documents, see annex to this report.

I. DISCUSSION OF AGENDA TOPICS

The participants at the Meeting discussed the usefulness of mortality data and took note of its value as a measure of the quality of life and its necessity for evaluation of the impact of governmental and non-governmental interventions in the health and development sectors of the society. The type of data, the extent of data and the quality of data needed depended upon the way in which the data were to be used: when a data-collection activity was being considered, attention must be paid to its ultimate purpose. Use, however, should not be considered in its narrow sense in relation to a given specific project. It might very well be that, through discussion with other agencies and offices, the data could have a broader use, costs could be shared and benefits could be more than proportionally increased. In the same way, prior to initiation of a data-collection activity, researchers should investigate what data might have been collected in the preceding periods or should ascertain the existence of currently ongoing data-collection systems. Through innovative methods of data exploration, evaluation and adjustment, existing data sets, even if deficient, might find new uses.

The participants considered that methods of data collection could be subdivided into several categories: vital registration systems; *ad hoc* or continuous surveys; special questions in quinquennial or decennial censuses; or special and intensive mortality/health studies. They then discussed those various procedures and took note of the advantages and disadvantages of each in terms of cost, ease of collection, quality of results, type of data acquired, analysis possibilities and methods of evaluation.

A general conclusion of the participants was that for the determination of long-term mortality trends for subnational areas, special population groups or special age/sex combinations, a vital registration was of paramount importance and that all countries should be encouraged to initiate such a system or to enhance their current systems. In the meantime, however, a system of regular surveys was necessary. Even with the existence of a strong registration system, regular surveys might still be necessary for the study of the correlates of mortality and health trends and the efficient setting of health policies. For evaluation of the effect of health policies or specific intervention programmes, some types of intensive surveys in small areas were recommended.

In general, the Working Group believed that the appropriate data-collection system depended upon the needs and resources of the country and that each country should carefully evaluate its needs and resources before it embarked on a data-collection procedure.

II. RECOMMENDATIONS OF THE WORKING GROUP

Reliable and timely mortality data serve many purposes in national planning: identification of a population's demographic circumstances; delineation of major health problems; identification of associations between diseases and underlying factors; and provision of the opportunity for demonstrating impacts of health and development programmes on mortality. Many types of data-collection systems exist for generating mortality information. These systems include civil registration, sample vital registration, censuses, multi-round surveys and single-round surveys. There are many possibilities for building on or combining these systems for more intensive investigations of mortality differentials and determinants. Which set of approaches is adopted in a particular country will depend upon its needs and pre-existing capabilities. Nevertheless, accumulated evidence on the performance of different systems makes it possible to draw certain lessons. The following recommendations, based on these lessons, were made by the Working Group.

A. CIVIL REGISTRATION

With respect to civil registration, the Working Group recommended that:

1. Countries lacking adequate civil registration systems should:

(*a*) Strengthen such systems with the aim of achieving complete and timely registration of deaths by age, sex, cause and region. Such data are indispensable for an accurate understanding of national health problems and achievements. The Working Group recommended the goal of achieving "birth and death registration for all by the year 2000". Progress towards this goal may, for example, be advanced by constituting a "civil registration area" within which the registration reaches a prescribed minimum level of completeness. If initiated, a registration area should tabulate deaths by place of normal residence of the decedent;

(*b*) Consider formulation of an intermediate system that would provide nationally representative and continuous mortality data. An example of such a system is the Sample Registration System of India. Another possibility is a geographically stratified sample of areas in which more or less complete civil registration is attained. These systems are not substitutes for complete national-level civil registration but they do constitute an interim strategy until complete registration is achieved;

(*c*) Consider adoption of an active system of registration in which influential village heads or persons associated with health services, local governments or religious institutions would act to supplement registration by relatives of the decedent;

2. Countries should periodically evaluate the products of their civil registration system for completeness and accuracy;

3. Countries should make full use of internationally recommended definitions of a live birth and of death, as well as of internationally recommended classifications of causes of death, age groups and other relevant variables. These standards help to ensure comparability of results both within countries and among countries. The United Nations and the World Health Organization should disseminate appropriate guidelines as widely as possible and should attempt, in particular, to encourage their use in medical and public health curricula;

4. There should be recognition of the need to establish adminstrative systems that would provide a regular and continuous flow of basic data on births, deaths and causes of death as part of the routine reporting structures within the department concerned. The scope and content of such reporting systems would be dependent upon available levels of financing, personnel and current needs of data; but every effort should be made towards establishing such regular systems of reporting;

5. Beginning with the sixth revision of the International Classification of Diseases, Injuries, and Causes of Death, there has been an increasing emphasis on the morbidity aspects of the classification. In the ninth revision, the International Classification was additionally oriented towards uses for medical delivery systems. However, because a majority of deaths are not medically certified in many developing countries, it is necessary to develop and test alternative systems of collection and classification. Therefore, the Working Group recommended that additional studies should be undertaken on ways and means of obtaining cause-of-death information from lay informants and on providing a suitable classification of cause of death for the developing countries, using, as far as possible, the International Classification of Diseases as a base. A system in which lay informants report cause of death should be considered for adoption where a large proportion of deaths are not medically attended;

6. Complete civil registration necessarily entails complete registration of births. In turn, complete birth registration facilitates the measurement and analysis of infant and child mortality. When registration is incomplete, countries should consider recording information on the registration form on the order of the

births together with information on the mother's age and the number of the mother's previous children who are still living and the number who have died. This information may permit the indirect estimation of infant and child mortality.

B. Censuses and surveys

The Working Group made the following recommendations concerning censuses and surveys:

1. Population censuses provide important information for mortality measures and analysis. They provide the essential denominators for most mortality measures and permit distinctions in those measures by region and by major socio-economic and demographic groups. Where registration is incomplete, regular censuses should be undertaken to provide important information on adult mortality levels through intercensal comparisons of population change. Such censuses should also be used to provide opportunities for the evaluation of registration completeness;

2. Countries should take note of the successes in mortality estimation achieved through questions on the survivorship of relatives, particularly in the area of child mortality. These questions have vastly improved knowledge of mortality levels and differentials in many countries; and they should be considered for inclusion in all censuses and surveys with a mortality component, whether the survey is single-round or multi-round;

3. Many types of mortality-oriented surveys or survey topics could be usefully included within the context of national survey programmes, for example, those which are part of the National Household Survey Capability Programme. Such an integrated approach was seen not only as being cost-effective but as contributing to the analysis of mortality in relation to its socio-economic and health context.

C. Other data needs

With respect to other data needs, the Working Group recommended that:

1. In certain intensive mortality investigations and surveys, recent deaths should be followed up by suitably trained interviewers who would visit the family and obtain information concerning the fatal illness (or injury) and the medical attention received. If a record was available in a hospital or health centre, the information should be utilized to assist in the assignment of the underlying cause of death. This method of medical interviewing has been found to be successful in improving cause-of-death assignments and thus in identifying disease patterns. At the same time, this follow-back approach could also be used to provide better information on determinants of mortality, provided it was accompanied by a survey of the living population at risk;

2. In view of the complexity of mortality and morbidity processes, small-area intensive studies of those processes in developing countries should be expanded in size and scope. A great deal of the existing knowledge about the biological processes and their social correlates leading to disease, death or recovery is derived from such projects, for example, those of the International Centre for Diarrhoeal Disease Research (Bangladesh) and the Institute for Nutrition in Central America and Panama. These projects deserve continued support and additional projects of this nature should be initiated because of the variety of disease patterns and social circumstances in developing countries;

3. In view of the critical importance of low birth weight and prematurity in neonatal mortality, countries should attempt to record information on birth weight, to tabulate birth-weight distributions; and, where possible, to calculate mortality rates by birth weight. Such activities might well begin in hospitals. However, because of the importance of low birth weights in rural areas, midwives and village workers should also be encouraged to weigh babies soon after birth, and scales should be made available for this purpose;

4. Greater emphasis should be given to the need for community participation in data-collection systems both in mobilizing public interest and in the use of community workers, institutions, elders etc., as participants in the collection of mortality data. At the international level, a review should be undertaken to synthesize experience both in this area of community participation and in lay reporting.

D. Research strategies

The Working Group made the following recommendations concerning research strategies:

1. Special investigations of infant and child mortality should be undertaken in every country where the levels of such mortality are considered excessive or problematical. These investigations should include the determination of the underlying causes of death; and, where possible, the associated causes, such as short gestation period, low birth weight and nutritional deficiencies. They should also include an analysis of the major socio-economic differentials in mortality and an examination of the impacts of environmental factors and health care availability. The importance of personal health practices, such as breast-feeding, care of sick children, immunization and personal sanitation, should also be investigated. Such investigations provide the data base necessary for effective policy formulation and implementation;

2. The shortage of reliable information on mortality levels, trends and differentials for adults was particularly acute in developing countries. Because the death of an adult usually has very serious economic and social consequences, major efforts should be undertaken for collection and analysis of data on adult mortality, using a wide range of approaches and

procedures and expanding this range where possible by extension of analytical techniques;

3. Many disciplines contribute to the study of mortality, and the Working Group stressed the advantages of combining several approaches. In particular, ways should be sought to combine the typical concerns, data and procedures of epidemiology with those of demography. Institutional arrangements for encouraging collaboration of epidemiologists and demographers should be encouraged. Furthermore, training programmes that combine major elements of the two approaches should be fortified or initiated.

E. DATA MANAGEMENT

With respect to data management, the Working Group recommended that:

1. In conducting mortality data initiatives, research organizations should from the outset have a clear and feasible plan for data processing, tabulation and analysis. Although there is a great need for additional mortality data and research, no increment in knowledge will result from activities that never get beyond the data-collection stage. It is quite common to find unprocessed or unanalysed data. National Governments, international organizations and funding agencies should support the mobilization of these resources in view of the cost-effectiveness of incremental expenditures. It is also important that ample support should be given to developing data-processing and analytical capabilities within developing countries;

2. Statistics resulting from mortality investigations should be placed in archives and ultimately should be made available to any interested user, since it is not possible to anticipate all potentially valuable uses of the statistics at the time they are produced. The archival and public nature of civil registration statistics is one of their intrinsic advantages. Investigators, organizations and countries should also consider the scientific advantages of making accessible the basic microlevel records within the constraints of national laws pertaining to the confidentiality of certain information.

F. ROLE OF INTERNATIONAL ORGANIZATIONS AND FUNDING AGENCIES

As concerns the role of international organizations and funding agencies, the Working Group recommended that:

1. The study of fertility and related topics, including infant child mortality, has been greatly advanced through the World Fertility Survey. However, no comparable internationally organized activity has been tailored specifically to the requirements of mortality studies. International organizations and non-governmental organizations should consider ways of serving as visible and effective focal points for assistance to countries that wish to improve their mortality data. Efforts should be made to develop and document a variety of approaches to meet the needs of individual countries. The activities that need expansion relate both to the collection and cumulation of national experience with mortality studies and to the development, testing and evaluation of new data instruments and their accompanying technical documentation;

2. Studies of determinants of mortality are of extreme importance for policy formulation on health. International organizations should assist and co-operate with national Governments to undertake such studies. Because of the diversity of data, environments and cultural and social situations, the studies themselves are best organized on a national level. However, the international organizations could play a pivotal role by responding to national requests for assistance, by fostering studies based on common protocols and by ensuring that experiences in mortality studies shall be widely shared. In their role as international organizations, the United Nations and the World Health Organization are in a unique position to integrate these studies into a comparative framework;

3. A review of the current state of knowledge of mortality in the developing countries caused great concern about the almost total absence of even the most basic mortality data in most countries of Africa and in many parts of Asia and Latin America. Even where data are more abundant, they are usually inadequate or improperly analysed for health and development planning. There is concern also about the lack of national and international resources to stimulate mortality data and research in developing countries. An expanded national and international effort should be made to promote studies on health and mortality in order to provide appropriate and reliable data for socio-economic and health planning and for reducing the current high levels of mortality in these countries. Donor agencies have a critical role to play in advancing the state of mortality knowledge and in putting that knowledge to work in improving health conditions. The Working Group stated in the strongest possible terms its belief that donor agencies concerned with advancing human welfare should expand sharply their support for programmes of mortality data collection and analysis and for implementation of the results of these programmes.

ANNEX

List of documents

Document No.	*Title and author*
IESA/P/AC.17/1	Provisional agenda
IESA/P/AC.17/2	Use of mortality data for identifying general health conditions and major health problems Luis Massé
IESA/P/AC.17/3	Use of mortality data for evaluating the success of specific health and development programmes Douglas C. Ewbank
IESA/P/AC.17/4	Options for collection of mortality data for various uses United Nations Secretariat
IESA/P/AC.17/5	Experiences in estimating differentials in mortality in developed countries—achievements and shortcomings of the various approaches Elsebeth Lynge
IESA/P/AC.17/6	Advantages and disadvantages of continuous registration systems for national, subnational, and differential mortality analysis Iwao M. Moriyama
IESA/P/AC.17/7	Use of sample registration system for studying levels, trends and differentials in mortality P. Padmanabha
IESA/P/AC.17/8	The use of direct and indirect techniques for estimating the completeness of death registration systems Samuel H. Preston
IESA/P/AC.17/9	Experiences in the use of special mortality questions in multipurpose surveys: the single round approach John G. C. Blacker
IESA/P/AC.17/10	Use of special mortality questions in fertility surveys—the WFS experience John Hobcraft
IESA/P/AC.17/11	Mortality data collection: A review of integrated multi-purpose household surveys and multi-round demographic surveys A. Adlakha and M. Nizamuddin
IESA/P/AC.17/12	Experience of Pan American Health Organization using death certificates for intensive studies of mortality Ruth R. Puffer
IESA/P/AC.17/13	Birth records as a sample frame for intensive studies of infant and childhood mortality—the IFORD experience Antoine Houehougbe
IESA/P/AC.17/14	Small-area intensive studies for understanding mortality and morbidity processes. Two models from Bangladesh: The Matlab Project and the Companiganj Health Project Stan D'Souza
IESA/P/AC.17/15	The role of surveys in providing health and related data, for policy analysis and social planning Ken Williams
IESA/P/AC.17/CRP.1	Country statement for the Arab Republic of Egypt Bothina Mahmoud El Deeb
IESA/P/AC.17/CRP.2	Country statement for the Republic of Sierra Leone Fatu Yumkella
IESA/P/AC.17/CRP.3	Country statement for Malaysia Kwok Kwan Kit
IESA/P/AC.17/CRP.4	Country statement for the Republic of Cuba O. Ramos Piñol
IESA/P/AC.17/CRP.5	Country statement for Mexico Leopoldo Nuñez Fernández
IESA/P/AC.17/CRP.6	Country statement for Peru Teodora Morales de Diaz
IESA/P/AC.17/CRP.7	Country statement for Sri Lanka Siva Subramaniam
IESA/P/AC.17/CRP.8	Country statement for Hong Kong Anthony S. K. Mak

Part Two

USES OF MORTALITY DATA

III. USES OF MORTALITY DATA FOR PLANNING AND RESEARCH*

*Kenneth Hill*** and the United Nations Secretariat*****

The discussion of different approaches to the collection of mortality data needs to be conducted within the context of the uses to which such data can or will be put. The various available approaches to collection produce data with distinctive characteristics in terms of accuracy, detail (geographical, socio-economic, cause-of-death), the delay before results become available and the period to which the measures of mortality obtained refer. Similarly, the uses of mortality information attach different levels of importance to these characteristics. For some purposes, high accuracy is not the first essential, but speedy availability may be; whereas for other purposes, a combination of high accuracy and extensive detail may outweigh speed of availability. The clear conclusion to be drawn is that no one method of data collection is to be preferred to all others. The approach to select for a particular study will depend upon the objectives of the study; and the objectives should therefore be carefully defined in advance. The objectives must also be feasible, given the available statistical infrastructure. This chapter, and to some extent that by Ewbank[1] which follows it, set the context for the remaining papers on different collection procedures by discussing the various uses to which mortality information is put and the characteristics of the categories: those of a general descriptive or demographic nature, usually the responsibility of national statistical offices; those related to health sector development, usually the responsibility of ministries of health; and those of an epidemiological or medical perspective, usually the responsibility of research organizations.

A. GENERAL DESCRIPTIVE AND DEMOGRAPHIC USES

Population forecasting

Mortality is one of the three factors, the others being fertility and migration, that determine changes in population size, distribution and structure. For most countries, mortality is the second most important factor after fertility in determining such changes at the national level, although migration becomes increasingly important as disaggregation proceeds below the national level. Population forecasting is essential for all long-term planning, and for much short-term and medium-term planning as well. In the education sector, the size, distribution and structure of the school-age population is an essential prerequisite of orderly planning for the provision of services, and the school-age population will be determined by the future stream of births attenuated by child deaths. Development of the transport sector will also depend in part upon population growth, distribution and structure, although economic factors will also be important. Agricultural development, in particular the mix between products for domestic consumption and those for exportation, requires that likely population changes be taken into account. Development of the modern sector requires a consideration of population factors, both from the point of view of demand for its products and from that of supply of labour, dependent upon changes in the economically active population. The provision of public health infrastructure, such as water-supply and sewage disposal, also needs to be planned in the light of realistic projections of future demand, an important element of which will be determined by population changes. It can thus be seen that mortality information, as an essential component of population forecasts, is an important element in practically all planning exercises.

The information required is simply current levels and likely future trends in mortality rates specific by age group and sex for population subgroups of interest.

Social description

Mortality levels are correctly regarded as indicators of the general welfare of a national population and its subgroups (they are clearly indicators of the quantity of life and, through links between morbidity and mortality, also reflect the quality of life within quantity). Summary measures of mortality conditions, such as life expectancy at birth or the infant mortality rate, are routinely included in indices of the quality of life—indices that are useful for charting socio-economic development, for identifying population subgroups in need and for making international comparisons. Deeper analysis of conditions of different social groups requires more detailed measures, such as specific mortality rates by age and sex (which permit the study of groups at different stages of the life cycle or of different cohort experiences) and by socio-economic groups.

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*The original version of this chapter appeared as part of document IESA/P/AC.17/4.

**Committee on Population and Demography, United States National Academy of Sciences, Washington, D.C., United States of America.

***Population Division and Statistical Office of the Department of International Economic and Social Affairs.

B. Health sector uses

Planning and development

The sector in which mortality information is most directly valuable is that of health, and the data requirements are more extensive. It should first be noted that for the health sector, mortality information is generally used as a surrogate for measures of morbidity, which more accurately reflect health status but which are also hard to collect and harder to interpret. A comparison of mortality rates from different diseases without allowance for different case-fatality ratios may distort the perception of the relative health risks of the diseases, although overall mortality rates probably reflect the health status of different population subgroups adequately. Thus, the first use of mortality information in the health sector is to identify high-mortality areas and high-risk groups within areas, so that health sector resources can be directed where they are needed and are likely to have most effect. This use requires only fairly simple mortality information, such as mortality rates specific by sex and age group for fairly large population subgroups, for a fairly recent period (since mortality differentials change only slowly over time, the obtaining of current estimates is not a major consideration) and of moderate accuracy, because the differentials of importance will be large.

More detailed information can further improve the efficiency of resource allocation in the health sector, particularly concerning causes of death. Information on deaths by cause for major regions can be used, preferably in combination with some idea of the case-fatality ratios involved, to determine the type of health services that will produce the maximum benefit. It may be noticed that whereas all the other uses so far discussed have required mortality rates, that is, not only information on deaths but information on the population exposed to risk, the structure of deaths by cause, without further age detail or information on exposure, may be sufficient for some planning purposes.

Evaluation of health services and programmes

This use of mortality information, extensively discussed by Ewbank,[2] is based on the idea that the efficacy of general health services and of specific health programmes can be evaluated in terms of observed changes in mortality. It is generally difficult to establish the success of general health surveys in reducing mortality by comparing rates of change with those for an earlier period or those for a country at a similar stage of development because of the usually unknown role of factors other than the health services themselves. The case may be somewhat strengthened by introducing more detail into the comparison, such as disaggregation by area and the demonstration that mortality rates in the areas in which services were concentrated fell faster than elsewhere, or disaggregation by cause and the demonstration that change in cause-specific rates followed service priorities. Thus, the mortality information needed for the evaluation of general health services should be disaggregated by population subgroups and preferably by cause of death; should refer to a recent period, with a suitable earlier period available for comparison; and should be of high accuracy, because the important feature is change rather than level. Even with such data available, the evaluation may be less than conclusive.

For the evaluation of specific health programmes, the problems are somewhat less acute, since such programmes generally focus on particular disease groups. In either case, mortality changes in the target areas or cause groups can be compared with those observed elsewhere or in other cause groups, and marked differences can be attributed to the programme. Mortality information is thus required for one point in time before the programme gets under way and for another point in time sufficiently later for the programme to have had a measurable effect. The data required are of some detail, perhaps age-specific and sex-specific mortality rates for target and control areas that are similar socio-economically and ecologically with similar cause-of-death structures. The data should be of considerable accuracy, since once again it is relative changes that are of importance.

It is clear from the foregoing discussion that the evaluation of health services or programmes requires much more in terms of timing and accuracy of mortality data than do the other uses discussed so far. However, for evaluating specific programmes, national representativeness is not required.

C. Uses for epidemiological and medical research and investigation

Epidemiological studies

Prevention is generally cheaper and less painful than cure, and advances in disease prevention are most likely to come about through a better understanding of disease aetiology. Epidemiology uses observed mortality differentials to suggest links between risk factors and diseases, and to indicate the magnitude of the risks. The chapter by Lynge[3] discusses a number of approaches to the collection of mortality information for the examination of occupational risks. To be useful for such a purpose, the mortality information should be sufficiently disaggregated to identify particular risk groups, be they by occupation, place of residence, personal habits, diet or whatever; and detailed disaggregation by cause is required.

Evaluation of medical procedures

New medical procedures, both preventive, such as innoculations or prophylactics, or curative, such as antibiotics or treatment regimens, require testing for efficacy and side-effects before their widespread adoption, and mortality information represents an important element in both tests. It is not, of course, the only element; in testing a new type of vaccine, for example, the effect on incidence of the disease would be of primary importance, but the effect on case-fatality ratios would also need to be examined. Such evaluation studies require careful design, generally of a follow-up case-control type; and general mortality statistics are of little use. D'Souza[4] describes the work of this type carried out in Matlab Thana, Bangladesh, by the International Centre for Diarrhoeal Disease Research; and Ewbank[5] also refers to similar studies. The mortality information required for such evaluations should be highly detailed by age, sex and cause, and of high accuracy; it must refer precisely to the test and control populations and to a specified period from the beginning of the trial to its completion or until loss from observation. The overall population involved has to be fairly small, given the intensive surveillance required; and it does not have to be nationally representative. The allocation of population to test and control groups should be random, rather than on the basis of volunteers, and should preferably be blind. In conclusion, it should be emphasized that evaluations of this type must be regarded as special exercises rather than as a regular part of procedures for the national collection of mortality data.

Conclusion

The major uses of mortality information in national planning, health sector planning and epidemiological and medical research have been outlined. The various uses have different requirements in terms of detail, accuracy and time reference; and these requirements should be taken into account in considering the merits of the various approaches to the collection of mortality data. In some cases, the requirements are so stringent that they are simply beyond the reach of the existing statistical system, and concentration on that which is feasible rather than on that which is desirable is to be recommended.

Notes

[1]Douglas C. Ewbank, "Uses of mortality data for evaluating the success of specific health and development programmes", chapter IV of the present volume.

[2]*Ibid.*

[3]Elsebeth Lynge, "Experiences in estimating differentials in mortality in developed countries—achievements and shortcomings of the various approaches", chapter XII of the present volume.

[4]Stan D'Souza, "Small-area intensive studies for understanding mortality and morbidity processes: two models from Bangladesh—the Matlab Project and the Companiganj Health Project", chapter XIV of the present volume.

[5]D. C. Ewbank, *op. cit.*

IV. USES OF MORTALITY DATA FOR EVALUATING THE SUCCESS OF SPECIFIC HEALTH AND DEVELOPMENT PROGRAMMES*

*Douglas C. Ewbank***

The goal of health and development programmes is improvement of the health and well-being of a population, and one measure of their success is changes in mortality. Evaluation of programmes that affect mortality (by design or otherwise) should therefore take into account changes in mortality. An evaluation must include two components: measurement of the change; and a test for a causal relationship between the change and the programme. These components will draw on techniques from both demography and epidemiology. Demographers tend to study the overall level and pattern of mortality, while epidemiologists generally study case-fatality rates and mortality from specific diseases. Between these two disciplines lies the study of refined measures of mortality for selected groups that may have been affected by a specific programme.

Evaluation studies must be designed specifically for the purpose of testing for a causal relationship between a programme and any observed change in mortality. The test of causation should consider four factors. First, did the observed mortality change, whether absolute or in relation to existing trends, occur after the programme had begun and when its impact was expected? Secondly, was the mortality change observed for various causes of death consistent with the expected impact of the programme? Thirdly, was the mortality change observed only among, or more pronounced for, population subgroups served by the programme? Fourthly, were there other changes (e.g., economic) closely related to the mortality change and therefore likely alternative contributing causes? An evaluation must also be designed in such a way that programme impact can be compared with stated programme goals and with the impact of other programmes. This comparison may have to be based on different indices of mortality change than those used in the test of causation. Section A of this chapter discusses the role of national data for evaluation studies. Sections B and C discuss the specification of expected programme impact and measurement of actual impact relevant to establishing a link between a programme and subsequent events. Section D considers the special problems associated with assessing the health impact of general development programmes. Section E reviews the advantages and disadvantages for different purposes of different study methodologies and some examples of evaluations are discussed in section F. Issues of sampling are discussed in the annex.

The discussion is limited to issues relevant to health and development planning in developing countries. Although comparisons of the costs and benefits of health interventions in developed countries are of increasing importance in a period of escalating costs and diminishing marginal benefits, the evaluation strategies in developed and developing countries are sufficiently different to require separate treatment.

A. ROLE OF NATIONAL MORTALITY DATA FOR EVALUATION

Few programme evaluations in developing countries have been based on national data even though their results are frequently used for national planning. There are several reasons for this situation. First, national data are rarely accurate enough or available at intervals that are short enough to catch the impact of a specific programme. Apart from a few countries in Asia and Latin America, mortality estimates in developing countries are generally based on data from periodic censuses or sample surveys. Secondly, it is difficult to design research on national data because of the unavailability of control areas. Although national programmes are frequently introduced gradually on a regional basis, the differences between areas and the problem of the frequency of data availability reduce the opportunities for controlling for exogenous changes. Thirdly, there are such a large number of changes that might affect mortality rates at the national level that it is often impossible to single out the effects of a given programme. Lastly, many projects have only a localized impact, either because of limited geographical scope of the programme or because of variations between areas in the severity of the health problems to which the programme is directed.

Although national mortality data are rarely useful for the evaluation of the impact of individual programmes, they play an important role in the planning process. First, national data provide a measure of the country's overall progress in health. Secondly, the level of mortality and patterns of mortality by age, sex

*The original version of this chapter appeared as document IESA/P/AC.17/3.

**Department of Population Sciences, Harvard School of Public Health, Cambridge, Massachusetts, United States of America.

and cause revealed by national data can provide important clues to the health problems that must be attacked by health programmes. For example, high mortality at ages 1-4 indicates the need to improve the nutritional status of children. Once this need has been established, evaluations of programmes in small areas can be used to determine which approaches (e.g., nutrition education, nutrition surveillance, oral rehydration to reduce the impact of diarrhoea or agricultural programmes) are most cost-effective. Thirdly, planners need national data in order to determine the implications of small studies for national policy formation. This information should include a comparison of the levels and patterns of mortality in the study area with similar measures for the entire country.

The following discussion focuses on the evaluation of specific programmes in small areas. In some studies, national data have been used as baseline data for studies in "typical" areas. In a few cases (e.g., the evaluation of the effect of eliminating malaria in Sri Lanka), it has been possible to base evaluations on national data.

B. SPECIFICATION OF EXPECTED IMPACT

The first step in the evaluation of the mortality impact of a programme is to determine its likely nature. This determination includes specification of: (*a*) the subpopulations that should be most affected (e.g., age and sex groups, farmers or coal-miners); (*b*) the causes of death that should change most; (*c*) the expected size of the impact; (*d*) the causal mechanisms of the changes (e.g., a change in the case-fatality rate or change in incidence); and (*e*) the expected timing of the impact (e.g., periodic or constant, immediate or delayed, continued or transitory). It is then possible to design an evaluation strategy that focuses on those measures which are most sensitive to the hypothesized impact. Each of these components is discussed below.

Specification of target subpopulations

For some programmes it is possible to specify which age/sex groups will be most affected by the programme. A simple example of this is a programme of tetanus immunization of pregnant women. (Immunity to tetanus is transmitted to the foetus through the placenta.) Virtually the only mortality impact of such a programme will be on the neonatal mortality rate at ages 5-15 days because the tetanus mortality rate amongst women of reproductive ages is quite low. Similarly, it is frequently possible to specify the population subgroups for which the impact will be largest, as with water-supply programmes, which will affect only those using the new source, and occupational health programmes, which will affect only those in specific occupation groups.

Specification of causes of death most affected

Even the simplest programmes can affect several causes of death. For example, a measles vaccination programme can reduce mortality from pneumonia and malnutrition because a case of measles can seriously affect the overall health of a malnourished child. Therefore, the specification of the causes of death most likely to be affected by a programme must take into account the synergistic relationships among diseases. (Problems with the use of cause-of-death information in the evaluation of programme impact are discussed in section C.)

Specification of likely magnitudes of effects

The best way to estimate the likely magnitude of the change in mortality is to examine the mortality rates for those causes of death which are most likely to be affected. In some programmes, only a few causes will be affected, in which case the expected mortality decline would be some reasonable fraction of deaths to those few causes. For example, tetanus immunization programmes are not likely to affect any other cause of death because tetanus has a high case-fatality rate. A tetanus immunization programme can eliminate virtually all tetanus deaths; therefore, the expected programme impact would be equal to the tetanus mortality rate. However, a midwife training programme might be expected to reduce mortality by only half as much. A rough estimate of the expected magnitude is generally needed for the calculation of required sample size (discussed in the annex).

Specification of mechanisms for change

Demonstration of a causal relationship between a programme and a change in mortality rates is strengthened by specification of the mechanisms through which the programme affects mortality. For example, if the introduction of a spraying campaign to combat malaria is accompanied by a reduction in mortality, it is unlikely that the campaign was responsible for the reduction unless there was also a reduction in the incidence (and subsequently the measured prevalence) of malaria.

Specification of timing of impact

Timing is crucial in the establishment of causal links. The effect should not precede the cause, although it need not follow immediately. Many types of programmes cannot be expected to have an immediate impact. For example, general nutritional education will not achieve its full impact on mortality immediately since it does not save those who are already severely malnourished. The mortality impact may, therefore, only become apparent after several months. Nutrition programmes directed towards the most severely malnourished (e.g., rehabilitation centres) will have a more immediate impact. In the case of occupational health programmes designed to reduce contact with carcinogenic materials, there may not be any noticeable effect for decades.

In addition, there are differences in the length of time for which noticeable mortality effects might be observed. For example, a single round of measles immunization would only be expected to reduce measles cases for a few years, until the population of susceptible children was renewed by subsequent births. The impact on mortality might be observable in the immunized cohorts for a few more years because the prevention of measles in childhood may improve nutritional status and subsequent survival probabilities.

The impact of some programmes may vary by season. For example, immunization programmes against influenza and programmes to stabilize food supplies will have a large impact only during certain seasons. The mortality impact of these programmes can be studied, if data permit, using changes in the seasonal pattern of mortality rates.

C. Problems in measuring impact

Once the potential impact of a programme has been specified, several central issues still must be resolved before the evaluation strategy can be devised. One is the choice of the appropriate indices of mortality change for measuring programme impact and for comparing the effects of different programmes. Many alternatives are available, including the crude death rate, the expectation of life at birth (e^o_0) and the person-years of life saved. The second is definition of the study population. Although the selection of the study population must be related to the target population of the programme, this may not provide sufficient guidance for the researcher if flows of migrants into and out of the area and diffusion of information spread the benefits to other areas. The third is the use of cause-specific mortality rates involving the design of methods for collecting usable cause-of-death data at reasonable cost and the determination of the way in which it can best be used once collected.

Indices for documentation of programme impact

The indices chosen to document the impact of the programme should focus on the expected programme impact in order to strengthen the case for causality. A carefully chosen index can also greatly reduce the sample size needed to demonstrate programme impact. The question of required sample size is discussed in the annex but an example is useful. In 1974, the infant mortality rate in the Matlab study area in Bangladesh was 138 per 1,000 live births and the neonatal mortality rate was 78, including about 20 deaths per 1,000 live births due to tetanus. Evaluation of the impact of a programme to eliminate neonatal tetanus would require a sample size of 1,946 live births in both the test and the control areas to be 80 per cent sure of finding a result that was significant at the 5 per cent level if the true decline in the neonatal rate was 20 per 1,000 (see equation (5) in the annex). Using the infant mortality rate, 3,444 live births in both the test and the control areas would be needed to establish such a 20-point drop. By focusing on the neonatal rate rather than the infant rate, one can thus reduce the required sample size for the study by a factor of almost two. Using a more narrowly defined age group, from 5 to 15 days, during which 90 per cent of all neonatal tetanus deaths occur, a sample size of only about 700 live births would be required. Limiting the test of causation to reported deaths from neonatal tetanus reduces the required sample size even more. Researchers faced with a small sample size and rare events frequently opt for the rate for the larger age group in order to increase the number of observed events. However, this procedure reduces the chance of documenting an actual impact and increases the risk of falsely concluding that there was an impact.

Indices for comparison of programmes

In the context of national policy-making, it is not sufficient to show that a particular programme has an effect on mortality; it is also necessary to make comparison among programmes so as to select those best suited for implementation. For a comparison of programmes that affect different age groups, it is often not possible to use the same indices that are optimal for the tests of causation. For example, a comparison of a programme to prevent neonatal tetanus with a tuberculosis treatment programme can be made using change in the crude death rate or the expectation of life at birth, but not with changes in the death rate at 5-15 days.

The choice of a summary measure for comparing programmes is often based on tradition or on the type of data available. However, this choice can affect the ranking of programmes. For example, Chen[1] shows that a family planning programme can produce a large change in the crude death rate by reducing the number of high-risk infants and children but it is unlikely to have a substantial impact on life expectancy at birth. A similar comparison of the number of lives saved and the person-years of life saved shows that the latter figures gives more weight than the former to the saving of infant lives, a weighting which may not be consistent with social costs.

The weightings implicit in the different indices can be examined using life tables and stable population relationships. A reduction of the mortality rate at age x, μ_x by an amount k will change life expectancy at birth by:

$$de_0 = e^o_x\left[\exp(k\mu_x) - 1\right]\frac{l_x}{l_0} \qquad (1)$$

where e^o_a is the expectation of life at age a; and l_a is the number of life-table survivors at exact age a.

Similarly, the effect of this change on the person-years of life saved per capita is

$$d\frac{PYL}{Pop} = e^o_x\left[\exp(k\mu_x) - 1\right]$$

where p_x is the proportion of the population between ages $x - \frac{1}{2}$ and $x + \frac{1}{2}$. In a stable population, p_x is determined by the life table and population growth rate. Therefore,

$$d\frac{PYL}{Pop} = e^o_x\left[\exp\,(k\mu_x) - 1\right]b\frac{l_x}{l_0}\exp\,(-rx) \qquad (2)$$

where b is the crude birth rate; and r is the stable growth rate. In all stable populations with positive growth rates, the use of equation (2) will give more weight to changes at the youngest ages than the use of equation (1) because of the exp $(-rx)$ term.

In developing countries, the choice of the appropriate index for comparing programmes is a matter of serious concern because the selection of health programmes strictly on the basis of cost-benefit considerations leads to a heavy emphasis on programmes for infants and young children and the relative neglect of adults. For most indices, the weight given to reductions of mortality at the youngest ages is greater in developing countries than in developed. This factor is most evident for such indices as the crude death rate and the person-years of life saved, which depend upon the age distribution. The high population growth rates common in developing countries lead to large relative weights being applied to improvements at the youngest ages. Even the change in the expectation of life at birth give larger relative weights to the youngest ages in developing countries than in developed countries because the ratios l_x/l_0 decline more rapidly with age in high-mortality life tables than in low-mortality tables. One justification for giving relatively large weights to mortality changes at the youngest ages in developing countries is that at high levels of mortality, mortality declines at the youngest ages are often associated with improved nutritional status and the general health of children, with implications for general development and health in later adult years.

One flaw in the use of life expectancy at birth for measuring programme impact is the implicit assumption that those children whose lives are saved by the programme this year will also benefit from the programme throughout the remainder of their lives. Measures of programme impact are usually compared with the costs of the programme, and gains in life expectancy are not ideal for this purpose. One can utilize instead the person-years of life saved, using as the weights the values of e^o_x in the absence of the programme. This use assumes that if the programme ends, mortality rates will return to the old level. In this way, the measured impact of the current year's programme does not include the results of next year's expenditures.

For many programmes, the evaluation of the impact on mortality is only one aspect of the evaluation. In some cases, the impact is to be added to other measures of impact through a calculation of the monetary value of the benefits. In this case, special attention can be given to the saving of years of working (i.e., "productive") years of life.[2] One measure of mortality impact that is compatible with this concept is working years of life saved, which is very similar to the person-years of life saved. The index estimates the number of expected years of life saved between ages 15 or 20 and age 65, a range taken as an approximation of the working years. It still gives a substantial weight to the saving of infant and child lives since survival to age 5 virtually ensures survival to age 20. However, the weight given to deaths prevented at the youngest ages is substantially less than the weight given in the calculation of person-years of life saved.

The concept of person-years of life saved can be modified to incorporate the economic concept of current value or social discounting, that is person-years of expected life saved have less value to the society today if the enjoyment of those years will occur in the future. For example, the saving of the lives of 1,000 infants will save some expected years of life at age 1 next year and at age 51 many years from now. The expected savings 50 years hence have less value to the society today because they will not be enjoyed for a long time. Therefore, less weight should be given to the expected years of life saved many years from now. This calculation would provide an index that is much more compatible with the economic concepts of the benefits of programmes.

The person-years of expected life saved is defined as

$$PYL = \Sigma\, e^o_x \exp\left[(k_x\ \mu_x) - 1\right]$$

where k_x is now the proportional reduction of mortality at age x. The current value of person-years of life saved, $PVPYL$, is therefore defined as

$$PVPYL = \Sigma\, \epsilon_x \exp\left[(k_x\ \mu_x) - 1\right]$$

where ϵ_x is the current value of the expected years of life for persons aged x. Using a standard life-table notation,

$$e^o_x = T_x/1_x = \sum_{y=x}^{w} {}_nL_y/l_x$$

where w is the oldest age in the life table. Following this, one can define ϵ_x as

$$\epsilon_x = \sum_{y=x}^{w} {}_nL_y \exp\left[-r(y + \tfrac{n}{2} - x)\right]/1_x$$

where r is the social rate of discount.

The current value of expected years of life saved has several advantages. First, it is more consistent with the concepts that economists use for project evaluation. Secondly, it lessens the weight given to the saving of lives at the youngest ages, thus perhaps better reflecting the priorities of many societies. This concept can easily be extended to the calculations of the current value of person-years of working life saved.

A full cost-benefit analysis of health programmes would include the relative economic contributions of various age groups. With this approach, the person-years of life saved at each age are weighted by the difference between economic production and consumption at that age in addition to the discounting of future benefits to current values. For example, the saving of an infant life involves increased costs to society until the age at which a child's economic production exceeds his consumption.

The Ghana Health Assessment team developed an index of programme impact that combines the reductions in morbidity with those of mortality.[3] The index is the number of healthy days of life that could be saved by eliminating a given disease. The index combines the person-years of expected life saved and the person-years of illness from a given cause. For example, they have calculated that in Ghana, malaria is responsible for the largest number of healthy days of life lost; of these days, only 54 per cent are days of life lost. The second largest cause of healthy days of life lost is measles, for which 97 per cent of the loss is days of life lost. A comparison of malaria and measles in terms of lost person-years of expected life would reverse the order of importance of these diseases.

Since the impact of a health programme on a particular index may be affected by the age distribution of deaths or the population age distribution, it can be difficult to use the results of a study in one population for planning in a second population. For this reason, published studies should include the changes in the age-specific and, whenever possible, the age/cause-specific death rates so that the potential impact can be calculated for other populations. This information would also be helpful in the comparison of two programmes first evaluated using different indices.

Definition of the study population

The population to be studied for an evaluation of programme impact can be defined either in terms of the programme recipients or in terms of the population of a geographical region covered by the programme. In many instances, these two populations are quite similar, unless the population is subject to high rates of migration. One example is an immunization campaign in an urban slum with very high rates of in-migration and out-migration. Measuring the change in the mortality rate for the population living in the slum will certainly understate the impact of the programme. Some of the children whose lives were saved will have out-migrated and been replaced by children who were never immunized. Even if the analysis could remove the deaths and years of risk of children who entered the area after the immunization campaign or if the programme continued to immunize new migrants, the evaluation would still miss the impact on those who out-migrated.

The definition of the population to be studied also must depend upon the means for carrying out the study. In this regard, in-migrants and out-migrants are quite different. Although it might be possible to exclude the experience of in-migrants or to analyse them separately, it is very difficult to follow the progress of those who out-migrate. Because of the problem of following out-migrants, many evaluations miss some of the programme impact. If the understatement of programme impact is likely to be severe, it may be necessary to follow some or all of the out-migrants.

The inclusion of in-migrants in an evaluation area presents another serious problem: specification of the baseline rates for in-migrants. If the in-migrants come from different areas or belong to different socio-economic groups than the stable residents, their pre-programme mortality rates might be substantially different from those measured in a baseline survey. For example, the evaluation of an agricultural programme might be biased if baseline data are not available for the migrant labourers entering the area in order to benefit from the new opportunities. One way to deal with this problem is to use retrospective techniques for examining differences in pre-programme mortality rates for migrants and non-migrants. Although such techniques might not provide very accurate results, they may be better than any attempts to measure prospectively the rates of potential migrants.

Advantages and disadvantages of cause-specific mortality rates

In programmes that are designed to reduce the incidence or severity of a small number of diseases, the demonstration of a causal relationship between the programme input and mortality trends is strengthened if the target causes of death decline more than other causes. This approach can be very misleading, however, if there are significant synergistic relationships between the target diseases and other causes of death. This is certainly the case with childhood mortality in developing countries.

One approach to handling interactions between causes of death is to classify the deaths according to primary, associated and underlying causes. For example, a child death might be attributed to measles with malnutrition as an underlying cause. Although in theory this helps to solve the problem, it frequently proves to be difficult to apply. First, when causes must be determined from retrospective interviews with surviving relatives, it is difficult to establish even a primary cause of death. Secondly, the introduction of a chain of underlying causes and primary causes complicates the demonstration of causation. For example, a decline in the number of deaths due to influenza with malnutrition as an underlying cause could be produced by either a nutrition programme or the appearance of a less virulent strain of influenza virus. In the absence of information from a control area, there is no way of resolving the issue.

One advantage of examining cause-specific mortality rates is that it may be possible to demonstrate programme success even if the all-cause mortality rates show little or no increase. For example, since maternal mortality is only a part of the mortality among women aged 15-45 years, a reduction of the maternal mortality rate might not show up clearly in the overall mortality trend for this age group. Examination of causes of death could demonstrate that the programme actually had reduced maternal mortality.

The problem associated with cause-of-death information is that it is very difficult to collect. In developing countries, where few deaths occur in hospitals or under the care of a physician, cause-of-death information from registration data is very weak. The experience of the Cholera Research Laboratory with a prospective vital event survey using physicians or specially trained field-workers to carry out interviews of the family immediately after deaths has shown that useful cause-of-death information can be collected, at least for broad categories, but the cost is high and the detail limited.[4]

D. Evaluation of mortality impact of development programme

It is harder to evaluate the impact on mortality of development projects than that of health programmes, since they influence mortality only indirectly. It is difficult both to specify the target population, because the effects of a development project may diffuse well beyond the project area, and to predict the nature and timing of any impact on mortality rates. Well-known examples are irrigation programmes or dam projects, which may raise the incomes and nutritional status of the local population, while altering the ecology both inside and outside the project area in ways that lead to changes in established patterns of disease incidence and prevalence.

Moreover, the major mortality impact of some development projects, such as flood control, road-building, introduction of drought-resistant crops or provision of adequate food-storage facilities, may be the reduction of crisis mortality, that is, short, sharp increases in mortality associated with epidemics, war or natural disasters. The evaluation of such an impact raises special problems because such crises occur at irregular intervals, making it impossible to ensure that a potential crisis would occur during an evaluation study, and because, in general, there is no basis for estimating how severe a crisis would have been in the absence of the project. Most retrospective measurement procedures are of little use in the assessment of the severity of past crises, since they provide only averages of mortality experience over time; and even maternity histories, which appear to provide detailed child mortality sequences, tend to smooth out irregularities as a result of reporting errors. However, the reduction of crisis mortality will also reduce average mortality, so measures of average mortality before and after the institution of the programme will, if they cover sufficiently long periods, indicate the general effect of the programme, if not its specific impact. Similarly, a sequence of annual mortality rates for the periods before and after the institution of the programme may demonstrate its effect if the irregularities in the sequence prior to the programme are much more marked than those of the sequence after the programme.

E. Selection of study methodology

There are numerous approaches to the collection of data for the study of mortality, each with its own advantages and disadvantages in terms of cost, precision, simplicity and ease of linkage with other records. These methods have been used in various combinations and in many versions. The following simple classification of the approaches is used here:

(a) *Prospective:*

(i) National registration system, possibly on a sample of localities;

(ii) Vital events registration and periodic censuses in a special study area for research purposes;

(b) *Retrospective:*

(i) Fertility or pregnancy histories;

(ii) Reports of deaths in the preceding year or series of years;

(iii) Brass type of approaches using data on survival of children, parents or spouse.

Each of these approaches can be used for the evaluation of programmes, but no one approach can be regarded as ideal for all circumstances. The following sections discuss the relative advantages and disadvantages of each approach with regard to the definition of the population; the detail of information concerning age, sex and cause of death; the age range covered; the completeness of recording or accuracy of the information; the cost and the required sample size; and efficiency in assessment of crisis mortality.

Prospective approaches

National (sample) vital events registration

Vital events registration involves the registration of demographic events at the time of or shortly following their occurrence. The usefulness of data on registered events depends upon prompt and complete tabulation, preferably with details on the age, sex and place of usual residence of the deceased, and on the cause of death. The calculation of mortality rates requires information on the population at risk, which must be based on a different data-collection system, usually a national census. Because of the difficulties in developing effective, complete systems for collecting and tabulating vital events data, several countries have attempted to achieve complete registration in a national sample of geographical areas.

The first problem with the use of vital registration data is that few developing countries have systems that approach complete reporting of deaths. The usefulness of registered deaths is severely limited if fewer than approximately 60 per cent of the events are registered. A number of techniques have been developed for estimating the completeness of coverage of registered deaths by age by comparing the age distributions of deaths with the overall population age distribution.[5] However, these techniques are generally ineffective for the adjustment of reported child deaths and for such populations as those of small areas that experience extensive migration. The problem of completeness is especially difficult since coverage often varies with age, sex, cause and area.

A second problem with vital statistics data is the accuracy of reporting. For example, the reporting of cause of death may be poor except for those deaths registered by trained medical personnel, failure to specify the usual area of residence may make it difficult to match reported deaths with the population at risk; and misreporting of characteristics can be a serious problem, particularly if the pattern of misreporting in the death records differs from that in the census data.

Two problems specifically hamper the use of vital registration data for studying programme impact. First, it is often difficult to get tabulations of registered deaths and base populations for areas covered by special research projects. Secondly, registration data provide little information on socio-economic variables and participation in a specific health programme, so that it is often not possible to study rates for those population subgroups most likely to be affected by a given programme.

Despite these problems, vital registration data can be useful for programme evaluation. First, registered deaths can often provide minimum estimates of rates for some age groups or causes and can indicate the presence of a disease as an important cause of death even without appropriate denominators. Secondly, registration data may provide the best basis for estimating the frequency of episodes of crisis mortality. Lastly, it may be possible in some cases to use local death registration files for verifying or correcting retrospectively reported dates of birth and death.

Prospective vital events and population surveys

In some cases, it is necessary to design a prospective study of mortality in the project area to record deaths through periodic surveys of households. When the surveys are frequent enough, this becomes a vital events registration system with active registrars. If the periodic surveys are carried out by a special survey team, this can be an expensive approach to programme evaluation. The intensive surveillance of the population of the Matlab study area cost about one dollar per person per year. Although this cost is far less expensive per interview than that of the World Fertility Survey, it does involve substantial resources. In some community health programmes, community workers collect information on vital events and household residents to ensure complete coverage of the population with health services. In this case, the research costs are only those of extra supervision, coding and tabulation. This approach was used quite successfully in an evaluation of a community health programme in Haiti.[6]

The advantage of periodic surveys is that the data collected can be tailored to match the requirements of the evaluation. Information can be collected and tabulated on relevant socio-economic characteristics, programme participation, health practices and mortality by selected age groups. Data collection can also be linked with nutritional surveillance or with sample epidemiological or socio-economic surveys. Although reporting of cause of death is still a problem, the reporting of causes and symptoms can be adapted to maximize the usefulness of the data for programme evaluation. Another advantage of this approach is that it ensures comparability of numerators and denominators in terms of age, place of residence and other characteristics. The study population can also be defined so as to include or exclude various subgroups, such as temporary migrants.

Successful collection of vital events information depends upon the quality of supervision, the abilities of the interviewers and the co-operation of the population. If complete coverage is not achieved, it is likely that those persons missed in the events survey were also missed by the health programme, leading to a bias in the estimated effects on the health of the entire population.

A frequent objection to this approach is that the sample sizes required to evaluate health programmes are so large that the cost of population surveillance methods becomes prohibitive. The annex to this chapter discusses methods for estimating the sample size requirements based on the size of the expected impact. However, it is important to take note that the cost of a three-year or five-year prospective study of a population of 10,000 is generally small, compared with the amount that may be spent on the basis of the programme evaluation.

Retrospective approaches

Maternity histories

One problem with prospective reporting systems is that they often begin at the same time that programme services begin and therefore provide little or no baseline data. One solution to this problem is to collect maternity histories with dates of births and deaths (or age at death) for all children born to women in the population. The apparent simplicity of this approach is misleading. Maternity histories are subject to several sources of error, including date and age misstatement and omission of children. These reporting errors can lead to serious distortions of levels and trends in both fertility and mortality rates. For example, one common pattern of misreporting leads to a false rise in fertility during the 5-14 years preceding the survey. To some extent, these errors can be reduced through careful interviewing, extensive supervision of the interviewers, matching of reported events with birth registration documents, etc. However, the data from maternity histories should always be approached with considerable scepticism.

In addition to the problems of reporting errors, maternity histories only provide useful information for the first 10-20 years of life and provide little useful data on cause of death. Although maternity histories ensure comparability of numerators and denominators, they do not always provide data for the appropriate population. The tabulated rates include the deaths of some children who died before their mothers migrated into the study area and exclude deaths of children whose mothers have since left the study area. Therefore, maternity histories do not provide exact historical data for an area that has experienced extensive migration. This problem can be lessened by comparing the maternity history for each woman with her migration history, but information on deaths of children of out-migrants is virtually impossible to collect.

Reports of recent deaths

Another approach to the collection of baseline data is to interview each household about deaths of family members during the previous one or two years. Data collected in this way frequently show substantial underreporting of deaths. The completeness of reporting can be studied using the same techniques as those used to analyse vital registration data, although the results are often unsatisfactory due to differences in coverage by age and the methods are not readily applicable to data for small areas affected by migration. Reports of recent deaths are also affected by recent migration and by the frequent dissolution of households following the death of the head of household.

In summary, retrospective reports of recent deaths cannot be regarded as a suitable basis for the evaluation of health projects and are unreliable for collection of baseline data. Ensuring adequate coverage is almost impossible, and the nature of the errors limits the usefulness of the standard adjustment procedures.

Information on survival of close relatives

Survey reports of the survival of close relatives provide indicators of the level of mortality and some indications of the trend in mortality if the age pattern of mortality is known and the trend has been long-term and steady. The most useful of these approaches is the Brass child-survival method, which involves asking women to report their total number of live births and the number of their children who have died.[7] Unlike maternity histories, this approach does not rely upon dates of birth and death for each child, only upon the current age of the mother; the reference period is the mother's lifetime. Therefore, the Brass child-survival method is not affected by reference period errors or dating problems and is less sensitive to age-misreporting. However, it is sensitive to differential underreporting of deceased children, a serious problem in many surveys. The cost of not asking about date of birth and age at death for each child is that the method provides little information on trends and age patterns of mortality. Similar methods involve questions about the survival status of parents and first spouse which provide information on adult mortality. These methods also provide little information about trends and age patterns of mortality.

In summary, reports of the survival of relatives can provide useful baseline data, especially in situations in which mortality has remained relatively constant or changed steadily for the past 10-20 years.

F. Examples of evaluation studies

There are surprisingly few published evaluations of the mortality impact of programmes in developing countries, largely because few such studies have been carried out, although also because some completed studies have never been published in readily accessible forms. This section reviews some important published evaluations, indicating ways in which the issues described in earlier sections have been approached, although without describing the individual studies in detail.

The studies can be classified into three groups. The first group is studies of health interventions directed towards a particular cause of death, generally based on data from special study areas where data-collection systems have been devised to test the impact of a specific programme. The second group covers special studies for evaluating the impact of integrated or general health programmes; these studies are few in number, but they are important because of the current trend towards integration of health services. The third group includes some studies based on national data; few such studies have been made because few countries have data of the quality required for this kind of evaluation, and because few health and development programmes can be expected to have impacts that are large enough and sudden enough to be observable in national mortality rates. A fourth kind of study is unrepresented in the examples given below: studies of the mortality impact of economic development programmes. To the present author's knowledge, there are no good studies of this type, although a few are currently under way. Also unrepresented are attempts to measure the impact on mortality of general development using indicators such as per capita income; such attempts fall outside the scope of this paper.

Health interventions directed towards particular causes of death

The double-blind study[8] of tetanus toxoid and cholera vaccine conducted by the Cholera Research Laboratory (now the International Centre for Diarrhoeal Disease Research) in Matlab Thana, Bangladesh, represents an example of the use of special study areas; the incidence of tetanus is highly age-specific and is best examined with this type of survey. The difference between the neonatal mortality rates for children born to women receiving the different vaccines (cholera and tetanus) is taken as an estimate of the amount of tetanus mortality. This estimate of neonatal mortality from tetanus is slightly less than the estimate from the reports on cause of death. Some of this difference is caused by false attribution of cause; some deaths attributed to diseases described using the same local names as tetanus occurred among children born to women who had received the tetanus vaccine. However, some of the differences may also be due to self-selection of the women who entered the vaccine trials.[9]

An example of the usefulness of mortality data for two study areas at different periods comes from the study[10] of mortality among children aged 1-4 years in the Hanover district of Jamaica, during the introduction of a nutrition programme. The programme was introduced into two study areas at different times; in both cases, the mortality rate at 1-4 years declined substantially immediately following the introduction of the programme but at different time periods. By staggering the beginning of the programme in the two areas, the second area serves as a control area for the first and vice versa.

Another study[11] that made good use of highly age-specific mortality rates best provided by small-scale follow-up surveys evaluates a spraying campaign against malaria in Kenya. In their analysis, the authors examine mortality rates for infants by month of age. They did not expect any impact on mortality during the first months of life since new-borns are protected by temporary (passive) immunity to malaria provided by the mother. During the later part of the infant year, they expected that eliminating malaria might affect the mortality rates, because the risk from a first infection is more serious than an infection in someone with some acquired immunity. Their data on infant deaths for the study area and the control areas show that death rates were the same during the first three months of life (29 per 1,000 live births). However, at 3-11 months of age, the death rate in the control area (132) was much higher than the rate in the study population (66). The case for the impact of the malaria eradication programme is strengthened by the fact that mortality rates in the two areas only differed for the age group of infants where the programme impact was expected, although it should be noted that the accuracy of the data is open to some doubt.

The study[12] of three villages in Guatemala demonstrates the advantages of mixing retrospective data with data from death registration to study the impact of health programmes. By combining the results of prospective recording of infant and child deaths with the retrospective studies carried out by the Institute of Nutrition of Central America and Panama (INCAP), the authors compared the mortality declines with the declines in each of the three villages during the years preceding the introduction of several health and nutrition programmes. The retrospective data and data from official reports aid the interpretation of the results because mortality had been declining at different rates in the three villages before the programme. However, the extra data complicate the analysis and the conclusion. For example, the authors note: "Although the gain was greatest in the treatment village, 36 per cent, this was no more than expected from the decline during the baseline period".[13] Repeated statements of this type reflect both the difficulty of ascribing causation and the problem of combining prospective and retrospective data. Although careful evaluation of programme impact often must rely on retrospective baseline data, it is important to recognize that extensive efforts to document differences in past trends between test and control areas may lead to less satisfying, though possibly less misleading, conclusions. For example, one report summarizes the results of the Guatemala study by stating that "The numerous complications encountered prevented the investigators from reaching what they considered to be unambiguous conclusions about the project's impact on mortality trends".[14] In this case, the complications also included relatively small numbers of prospectively recorded deaths due to the restricted sample size.

An example of what might be termed "evaluation by indirect attribution of cause of death" is the study of the impact of diarrhoea treatment centres in the Cholera Research Laboratory study areas. It was estimated that the case-fatality rate for patients in the centres was less than 1 per cent. This rate was compared with an estimate in 1980[15] that about 47 per cent would have died without treatment. This estimate was based on the assumption that all patients who had lost at least 10 per cent of their body weight in fluid loss would have died without treatment. The estimate was then adjusted for readmissions and for some competing risks. Although this approach can provide only a rough estimate of the number of lives saved by the programme, it is useful for estimating the magnitude of the expected effect of the programme on the overall mortality rates of the area; this estimate can then be compared with the actual trends in mortality.

Another study[16] of cause-specific data from the Cholera Lab areas shows that there was a close relationship between distance to a treatment centre and mortality levels. Communities that were within four miles of a centre had annual mortality from diarrhoea of 100-150 per 100,000 population, while villages that were six miles from a centre had rates of 270 per 100,000. Areas that did not have any medical facilities had rates of 250-300. There was also a significant relationship between distance to a centre and utilization of a centre. This close association with distance to the centres increases the likelihood that the centres were responsible for a drop in mortality. It is interesting to note that the relationship between distance and the crude death rates was not significant; the effect of the programme was only apparent when the cause-specific rates were examined.

Lastly, a note of caution about the use of small-area studies is in order. If the results of such studies are to be used for national planning, it is necessary to try to determine how the programme results would differ if applied nationally as a result of differences in health status, age structure and other relevant differences between the study population and the population as a whole. Since the data on national mortality and health are generally quite limited, careful use must be made of whatever information is available.

Evaluation of integrated health projects

The tendency in health planning during the past decade has been towards health programmes that integrate maternal and child health, nutrition, malaria control, other health programmes and, frequently, family planning. Complete evaluations of this type of programme require two different approaches: (*a*) what might be termed an epidemiological approach, evaluating the impact of each programme component; and (*b*) a demographic approach, evaluating the overall impact.

Results from studies of the impact of programmes directed towards specific diseases have to be used with great care in estimating the overall impact of an integrated health programme. It is not possible to estimate the expected impact of an integrated programme by adding together the expected impacts taken from specific studies of each element of the integrated programme. Because of the complex interactions among diseases, the overall impact of an integrated programme may be less than the sum of their expected individual impacts. The overall impact of an integrated programme thus needs to be measured directly, and it is often very difficult to evaluate the contribution of individual elements of the programme.

The usefulness of the demographic approach in the evaluation of integrated health programmes is demonstrated by an evaluation of an integrated health programme in rural Haiti.[17] That study demonstrates that a programme combining immunization, nutritional surveillance, targeted supplemental feeding, nutritional education, nutritional demonstration, oral rehydration, screening for tuberculosis, deworming and support for traditional birth attendants reduced mortality significantly over a five-year period. Although no attempt was made to measure the individual impact of these separate programme components, examination of trends in cause-specific mortality rates strengthened the contention that the mortality trends were a result of the programme efforts. The demographic approach is most useful for studying the impact of integrated programmes or for cases where several causes of death may be affected by the programme. The epidemiological approach is most important for testing the value of one kind of intervention (e.g., a vaccine) or for comparing two approaches to the same problem (such as malaria prophylaxis and insecticide spraying).

Evaluation of studies based on national data

It has already been noted that national data have not been widely used in the evaluation of health programmes in developing countries, generally because the available data are of insufficient quality, or provide insufficient detail, to support a thorough study. However, two examples of the use of national data are given below, one for a developing country with rather good registration data and one for a disadvantaged subgroup of the population of a developed country.

The first example is the evaluation of the malaria education campaign in Sri Lanka in the late 1940s. The number of deaths registered declined by 37,000 between 1946 and 1947, and the number of deaths from malaria declined by some 8,000. Malaria is a debilitating disease which might be expected to have important secondary effects on death rates from other diseases, so a full evaluation would require some attempt to assess such secondary effects. In a more detailed analysis of the Sri Lanka case, Gray[18] uses additional information from sources other than death registration and attributed 23 per cent of the national post-war mortality decline to the control of malaria. Regression analysis was used to demonstrate that: (*a*) there was no correlation between the availability of health services and district mortality rates before the malaria campaign; (*b*) nutritional differences were not responsible for the mortality differences between malarious and non-malarious zones; and (*c*) the mortality declines were concentrated in the age groups that were most heavily affected by malaria. He thus was able to eliminate health services and nutritional differences as major factors behind mortality differences between malarious and non-malarious areas and to conclude that the apparent effect of eliminating malaria on mortality was real.

The second example is the study by Pool[19] of the Maori in New Zealand. The crude death rate of the Maori declined by 45 per cent between 1945 and 1956, largely as a result of declines in tuberculosis deaths. In 1945, tuberculosis was the leading cause of death between the ages of 5 and 45, whereas by 1956, death rates from tuberculosis had declined to very low levels at all ages under 45. He attributes the decline to the introduction of mobile mass X-ray units, which were testing 10 per cent of the population annually by 1958.

SUMMARY AND CONCLUSIONS

This chapter has considered the difficulties that beset the use of mortality data in the evaluation of health and development programmes. One difficulty is that mortality data alone may not be sufficient for a thorough evaluation; such is clearly the case with development programmes, for which a much wider range of criteria would be required for evaluation. It is also the case even for specific health programmes, for which changes in morbidity not necessarily reflected in mortality figures would be an important element in a complete evaluation. A further problem is in the choice of summary measures to represent programme impact; different indices might give quite different pictures of the impact of a programme, both in absolute terms and in relation to the performance of other programmes. This problem is particularly acute when comparing the value of competing development projects; for such purposes, some attempt must be made to calculate the current social utility of a health programme.

Perhaps the most crucial problem affecting the evaluation of health programmes is that of establishing a causal link between the programme and subsequent mortality changes. Although no complete answer is available, solid support for a causal link in the case of highly specific programmes can be built up by examining changes in mortality by age and sex, by cause and by timing. For such purposes, detailed follow-up surveys covering the period of the programme are the only realistic study design. For more general health programmes, expected impacts at particular ages or on particular causes of death will be less clear-cut; and the use of cheaper survey procedures, although providing much less detail but preferably including the coverage of a control area, may be sufficient. National statistics on deaths rarely provide the basis of more than very impressionistic assessments, in part because of problems of data accuracy and in part because of a severe lack of detail.

Despite the large number of health projects implemented in recent years, careful evaluations are disappointingly thin. This lack undoubtedly arises in part from the fact that expenditure on evaluation is not directly productive and is therefore not accorded high priority. It is no coincidence that several of the most thorough evaluations grew out of small-scale surveys to test particular clinical procedures, where the evaluation was the object of the exercise rather than a sideline. Such surveys are obviously important, providing invaluable information about the potential efficiency of different clinical procedures, but for general monitoring of health projects, something less demanding and less expensive is required. Thus, every health project should include some attempt at assessment, but not every project should try to emulate the work of the Cholera Research Laboratory. The design of the evaluation should take into account the objectives of the project and its likely effects. It is hoped that the discussion in earlier sections may prove useful in the selection of an appropriate evaluation programme.

Notes

[1]Lincoln C. Chen and others, "Estimating and partitioning the mortality impact of several modern medical technologies in basic health services", in *International Population Conference, Manila, 1981* (Liege, International Union for the Scientific Study of Population, 1981), vol. 2, pp. 113-142.

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[3]Ghana Health Assessment Project Team, "Quantitative method of assessing the health impact of different diseases in less developed countries", *International Journal of Epidemiology*, vol. 10, No. 1 (March 1981), pp. 75-80.

[4]Stan D'Souza, "Small-area intensive studies for understanding mortality and morbidity processes: two models from Bangladesh—the Matlab Project and the Companiganj Health Project, chap. XIV of the present volume.

[5]For an excellent review, see Samuel H. Preston, "Use of direct and indirect techniques for estimating the completeness of death registration systems", chap. VIII in the present volume.

[6]Warren L. Berggren, Douglas C. Ewbank and Gretchen G. Berggren, "Reduction of mortality in rural Haiti through a primary-health-care program", *The New England Journal of Medicine*, vol. 304, No. 22 (28 May 1981), pp. 1324-1330.

[7]For a thorough account, see *Manual X. Indirect Techniques for Demographic Estimation* (United Nations publication, Sales No. E.83.XIII.2).

[8]Makhlisur Rahman and Stan D'Souza, *A Review of Findings on the Impact of Health Intervention Programmes in Two Rural Areas of Bangladesh*, Special Publication No 11 (Dacca, International Centre for Diarrhoeal Disease Research, 1980).

[9]Makhlisur Rahman and others, *Reduction of Neonatal Mortality by Immunization of Non-pregnant Women and Women during Pregnancy with Aluminum-Absorbed Tetanus Toxoid*, Scientific Report No. 41 (Dacca, International Centre for Diarrhoeal Disease Research, 1981).

[10]Michael H. Alderman and others, "Reduction of young child malnutrition and mortality in rural Jamaica", *Journal of Tropical Pediatrics and Environmental Child Health*, vol. 24, No. 1 (February 1978), pp. 7-11.

[11]D. Payne and others, "Impact of control measures on malaria transmission and general mortality", *Bulletin of the World Health Organization*, vol. 54, No. 4 (1976), pp. 369-377.

[12]Werner Ascoli and others, "Nutrition and infection field study in Guatemalan villages, 1959-1964; IV. Deaths of infants and preschool children", *Archives of Environmental Health*, vol. 15, No. 4 (October 1967), pp. 439-449.

[13]*Ibid.*, p. 446.

[14]Davidson R. Gwatkin, Janet R. Wilcox and Joe D. Wray, *Can Health and Nutrition Interventions Make a Difference?: The Policy Implications of Field Experiment Experience*, Overseas Development Council Monograph No. 13 (Washington, D.C., 1980), p. 9.

[15]Lincoln C. Chen, Mizanur Rahman and A. M. Sarder, "Epidemiology and causes of death among children in a rural area of Bangladesh", *International Journal of Epidemiology*, vol. 9, No. 1 (March 1980), pp. 25-33.

[16]Makhlisur M. Rahman and others, *Utilization of a Diarrhoea Clinic in Rural Bangladesh: Influence of Distance, Age and Sex on Attendance and Diarrhoeal Mortality*, Scientific Report No. 37 (Dacca, International Centre for Diarrhoeal Disease Research, 1980).

[17]W. L. Berggren, D. C. Ewbank and G. G. Berggren, *loc. cit.*

[18]R. H. Gray, "The decline of mortality in Ceylon and the demographic effects of malaria control", *Population Studies*, vol. 28, No. 2 (July 1974), pp. 205-229.

[19]D. I. Pool, "Post-war trends in Maori population growth", *Population Studies*, vol. 21, No. 2 (September 1967), pp. 87-98.

ANNEX

Sampling variances and calculation of sample size for design of evaluation studies

Because of the expense and organization required to conduct prospective studies of programme impact, most such studies cover relatively small populations. Even for populations of only 10,000 or so, the sampling error associated with total deaths in a year will not be large. However, evaluations of programme impact require more detailed measures, specific by age, sex or causes, than simple changes in the actual number of deaths. For example, in a population of 10,000 with a crude birth rate of 40 and an infant mortality rate of 150, one would expect to find about 60 infant deaths in a year. However, because of the small number of births, the actual number of observed deaths would fluctuate from year to year in the range of from 45 to 75 infant deaths during most years even if the risk of dying stayed constant, so the number of observed deaths could drop from 70 to 50 without a change in the underlying risk. It is therefore necessary to calculate a confidence interval for the risk of dying.

For some mortality indices it is easy to apply standard statistical formulae to calculate sampling variances. For example, rates can be assumed to be distributed binomially and the appropriate tests used to test significance of observed changes in these rates. Keyfitz[a] presents the following equation for the variance of the life expectancy at age x, e^o_x:

$$\mathrm{Var}(e^o_x) = \sum_{y \geq x} \left[\frac{l_y}{l_x} \right]^2 (n - a_y + e^o_{y+n})^2 \mathrm{Var}({}_nq_y) \qquad (1)$$

where l_x is the proportion surviving to age x; n is the width of the age interval; a_y is the average age of death of those dying between y and $y + n$ (usually estimated as $n/2$); and ${}_nq_x$ is the proportion dying between exact ages x and $x + n$ in the life table. The variance of ${}_nq_x$ can be approximated as:

$$\mathrm{Var}({}_nq_x) = n^2 \frac{{}_nM_x (1 - {}_nM_x)}{{}_nP_x} \qquad (2)$$

where ${}_nM_x$ is the age-specific mortality rate for the age group from x to $x + n$; and ${}_nP_x$ is the population on which ${}_nM_x$ is based. If the observed number of deaths in an age group is small (say, less than 5), then Var $({}_nq_x)$ can be estimated using the Poisson distribution for ${}_nM_x$ rather than the binomial:

$$\mathrm{Var}({}_nq_x) = n^2 \frac{{}_nM_x}{{}_nP_x} \qquad (3)$$

Table IV.A.1 presents the variances of the e^o_x values for the life table for males in Matlab in 1974, collected as part of the Cholera Lab studies. The population size has been scaled to a total of 100,000. As can be seen from equations (1) and (2) (or (1) and (3)), the variance of e^o_x is proportional to the reciprocal of the population size given the same age distribution and the same estimated life table, so a sample size of 10,000 in the Matlab example would give rise to a standard error in e^o_0 of about 1.9 years, larger by a factor of $\sqrt{10}$ than that for the 100,000 sample.

The formulae for the sampling variances can be used to determine the sample size needed to test the impact of a programme. In order to calculate the required sample size, it is necessary to specify: (*a*) the level of significance to be used in the statistical test (usually 95 per cent); (*b*) the expected change in the index of impact; and (*c*) the desired probability of finding a significant result assuming that the expected change occurs (the power of the test). If the estimate of the measure of impact can be assumed to be normally distributed around the true value, the required sample size is:

$$N = (Z_\alpha + Z_\beta)^2 \frac{2\sigma^2}{\delta^2}$$

where Z_α is the value of the standard normal deviate corresponding to the selected significance level; Z_β is the value of the standard normal deviate corresponding to the desired power; σ^2 is the population variance of the measure; and δ is the postulated change in the measure. The resulting N is the sample size needed in both the test and the control; therefore, the total sample size is $2N$.[b]

This formula can be used to choose the sample size for an evaluation of a programme that is expected to increase the value of e^o_0. The evaluation should be based on a one-tailed test because one would only be interested in the programme if it increased life expectancy. An appropriate value of Z_α is 1.645, which corresponds to a 95 per cent significance level with a one-tailed test. Z_β can be taken as 0.841, which corresponds to an 80 per cent chance (β) of finding a significant result if the life expectancy really does change by δ years. The choice of β is somewhat arbitrary since, unlike α, there are no firmly established conventions. The value of σ^2 is equal to Var (e^o_0) times the total population size on which the life table is based. It is useful to note that an α of 0.90 and a β of 0.90 give an N only 6 per cent larger than an α of 0.95 and a β of 0.80.

Table IV.A.2 presents the sample sizes needed to test the impact of programmes using the Matlab life table given in table IV.A.1 and a variety of different assumed impacts. The resulting sample sizes are in terms of person-years of observation. For example, the 445,000 corresponding to a β of 0.8 and a change in the life expectancy of one year can be one year of observation for a population of 445,000 in the test area or two years of observation for a test population of 222,500.

If the programme evaluation is to be based on changes in a proportion, e.g., the infant mortality rate or an age-specific mortality rate, a different formula is needed to determine the required sample size. In this case the required sample size can be calculated using an

TABLE IV.A.1. STANDARD ERRORS OF ESTIMATED LIFE EXPECTANCY VALUES FROM A POPULATION OF 100,000 WITH LIFE-TABLE AND AGE DISTRIBUTION OF MALES, MATLAB, BANGLADESH, 1974

Age x	*Life expectancy at age x* e^o_x	*Standard error of* e^o_x
0	53.4	0.60
1	59.5	0.62
5	59.8	0.55
10	56.2	0.53
20	46.7	0.53
30	37.5	0.51
40	28.9	0.48
50	21.0	0.45
60	14.2	0.39

TABLE IV.A.2. SAMPLE SIZES FOR TEST AREA REQUIRED FOR VARIOUS LEVELS OF CHANGE IN LIFE EXPECTANCY AT BIRTH WITH A SIGNIFICANCE LEVEL, α, OF 95 PER CENT AND A POWER, β, OF 80 PER CENT

Change in life expectancy at birth, e^o_0 *(years)*	*Required sample size*[a]
0.5	1 781 000
1.0	445 000
2.0	111 000
3.0	49 000
4.0	28 000
5.0	18 000

[a]Total required sample for test and control is twice this value. Calculations based on Var (e^o_0) = 0.60, taken from table IV.A.1, rounded to the nearest thousand.

equation derived by Miettinen. This equation allows for different sample sizes in the test and control areas. The ratio of N_0 and N_1, the sample sizes in the control and test areas, is set at R. With a postulated change in the rate from P_0 to P_1, and given values of R, Z_α and Z_β, the required sample size is:

$$N_0 = \frac{Z_\beta^2 K + Z_\alpha^2 (A + B)^2 + 2 Z_\alpha Z_\beta (A + B) \sqrt{K}}{(P_1 - P_0)^2 (A + B)}$$

where $K = (A + B)(RA - B) - R(P_1 - P_0)^2$;
$A = P_1(1 - P_0) + P_0(1 - P_1)$; and
$B = (R - 1)P_0(1 - P_0)$.

Table IV.A.3 gives some examples of the sample sizes required for various levels of impact. The baseline values are similar to the actual rates for the Matlab study area in 1974. This table demonstrates the importance of the expected impact of the programme. To

TABLE IV.A.3. SAMPLE SIZES FOR TEST AREA REQUIRED FOR A 95 PER CENT TEST OF SIGNIFICANCE, α, WITH A POWER, β, OF 0.80

Base rate per 1,000 (Unit for sample size)	*Equal sample sizes[a] change in rate*				
	5	*10*	*20*	*30*	*40*
IMR[b] = 140 (live births)	58 650	14 450	3 500	1 500	800
Neonatal = 80 (live births)	35 350	8 550	2 000	800	400
6-23 months[c] = 40 (survivors to 6 months)	17 850	4 150	850	300	-
1-4 years = 25 (person-years)	10 850	2 350	400	-	-

[a]Sample sizes rounded to nearest 50.
[b]Infant mortality rate.
[c]Cohort mortality between ages 6 months and 2 years, per 1,000 survivors to 6 months.

be 80 per cent sure of detecting a significant programme impact if the real impact is a 20-point reduction in a rate of 140 per 1,000, one needs a sample size of about 3,500 in the test area. However, with a real change of 30 points the sample can be limited to 1,500. Table IV.A.3 also makes clear the importance of the level of the rate. Detecting a change of 5 points per 1,000 is easier when the change is from 25 to 20 than when it is from 80 to 75.

In some instances, it can be cost-effective to use a larger sample size in the control than in the test area even though the minimum total sample size is achieved when the two are equal. For example, if existing vital statistics records are to be used for the baseline (i.e., the control), the cost of data collection in the test area might be much higher, even if only in terms of the length of time before sufficient person-years of risk are observed. With an estimated change from a rate of 140 to 120, a sample size of 3,500 is required in the test area if equal sample sizes are used. If the control area has a sample size twice the test area, then the sample in the test area can be 2,600. Although the total sample size increases from 7,000 with equal samples to 7,800 with unequal, the costs of the programme or the differences in the costs of data collection might justify this increase. On the other hand, if there is little time for the collection of baseline data, it might be necessary to set the test sample at twice the control.

More complicated study designs, such as a comparison of two study areas with each other and with a control, require more elaborate formulae for the calculation of required sample sizes. Cohen[c] provides a useful set of tables and numerous examples for use in studies based on correlations, chi-square comparisons, F tests and regression analysis.

NOTES

[a]Nathan Keyfitz, *Introduction to the Mathematics of Population* (Reading, Pa., Addison-Wesley, 1977).

[b]William G. Snedecor and George W. Cochran, *Statistical Methods*, 6th ed. (Ames, Iowa, Iowa State University, 1967), p. 113.

[c]Jacob Cohen, *Statistical Power Analysis for the Behavioral Sciences*, rev. ed. (New York, Academic Press, 1977).

Part Three

OVERVIEW OF APPROACHES FOR COLLECTION OF MORTALITY DATA

V. APPROACHES TO THE COLLECTION OF MORTALITY DATA IN THE CONTEXT OF DATA NEEDS*

*United Nations Secretariat***

There are three basic systems for gathering mortality data on a national basis: the civil registration system; the sample survey; and the population census. In addition, a few variants of these basic methods have also been used for collecting either national data (for example, the sample registration system) or local-area mortality data (for example, the use of lay health workers to monitor deaths and births). The use of the three basic methods and most of the major variants is reviewed in considerable detail in the following chapters. The present chapter deals with issues that affect all data-collection efforts, including the different demands made by data users, the methods of analysis and adjustment available and the general problems of the collection of mortality data. Most importantly, it stresses the essential complementarity of the basic collection methods, by highlighting the relative strengths and weaknesses of each in relation to different needs and situations.

The paper stresses five major points:

(*a*) It is important to take into account the distribution of mortality in any given population when designing the procedures that will be used to measure it;

(*b*) The three basic methods of data collection are more or less well-defined processes with distinctive although somewhat overlapping performance characteristics in terms of the detail, timeliness and accuracy of the data they can generate;

(*c*) The three basic collection methods must be seen as complementary; no one alone can adequately serve all the needs for mortality data;

(*d*) It is important to consider the length of advance planning required for different data-collection activities and to keep this in mind in developing strategies for improving national data-collection capabilities;

(*e*) The methodology for the collection of data cannot be considered in isolation from the methodology available for adjusting data found to be defective.

A. CONTEXT OF DATA COLLECTION

The various uses of mortality data that are reviewed in chapter III[1] have a substantial impact on the types of data required. Different uses imply quite different needs in terms of subject-matter, temporal or geographical detail, as well as the associated demographic, social or economic data required. In addition to the needs of users, the conditions and characteristics of the population being studied have important effects on the data-collection process. In measuring mortality, in particular, it is important to emphasize the sharp differences that exist between the developed and developing countries, both in the aggregate phenomenon being measured and in the conditions of observation. Because of past and current levels of fertility and mortality, mortality in the developed countries occurs primarily among the elderly and rarely among children and infants. In contrast, in developing countries nearly half the deaths occur to those under age 15, and frequently more deaths occur in the first year of life than among those aged 65 years and over.

In addition, the more developed regions are characterized by the greater prevalence of the nuclear family as a living arrangement, greater urbanization and greater availability and use of in-patient health facilities. Collectively, these factors interact with the different age patterns of mortality to accentuate the differences between the measurement situations in the two groups of countries. For example, although all surveys tend to omit the mortality of persons living alone or with non-relatives, this situation is a much larger source of omissions in surveys of developed countries, where deaths are concentrated among the elderly and where many of those over age 65 live alone or with non-relatives. Another example of this problem is that while all surveys tend to underreport deaths of the very young, because few such deaths occur in the developed countries, even very high omission rates have a minor impact on estimates of total mortality in those countries.

The situation is almost reversed in the developing countries. There, high omission rates of the deaths of infants and children have a large impact on mortality estimates, because such a larger proportion of the total deaths are those of infants and young children. Furthermore, the prevalence of multiple-family households increases the likelihood that a census or survey respondent will be someone other than the infant's

*The original version of this chapter appeared as part of document IESA/P/AC.17/4. Statements on data-collection activities and needs, in addition to the papers presented herein, were submitted to the Working Group for eight representative countries (for list, see annex to part one). Reference is made to these country experiences throughout this chapter. The statements are available from the United Nations Secretariat or the authors.

**Population Division and Statistical Office of the Department of International Economic and Social Affairs.

mother and that the infant's death will be subject to the very high omission rates associated with such proxy respondents.

On the other hand, because relatively fewer deaths occur during the oldest ages and because a greater proportion of dwelling-units have residential arrangements other than the nuclear family (which means that fewer people live alone), errors from this age group may be only a minor component of the total error in an estimated crude death rate from a developing country.

Complicating the measurement problem further is the comparative rareness of mortality, even in a high-mortality country. For example, on average, one would expect from about 4 to 14 deaths a year per 100 households in most developing countries. This average figure is subject to very marked seasonal swings in many developing countries. Moreover, in times of national disaster, epidemics, civil disturbances or war, mortality may sharply rise locally if not nationally. These same events are likely to disrupt data-collection efforts, either directly in the case of methods involving contemporaneous recording of deaths or indirectly through increased migration in the case of other data-collection methods. As a result, relatively more deaths are likely to go unrecorded during these peaks than when mortality is at more customary levels.

B. METHODS USED TO OBTAIN MORTALITY DATA

Inventory of data-collection procedures

Several broadly different techniques have been used to detect the occurrence of individual deaths and to assemble this and related information to provide reliable statistics about mortality behaviour in the population in general. The techniques include:

(*a*) Continuous recording of deaths as soon as possible after occurrence;[2]

(*b*) Retrospective questions about individual deaths occurring over some specified period in the past; for example, deaths in the preceding 12 months or maternity histories;[3]

(*c*) Retrospective questions about the cumulative number of events that have occurred (for example, number of children ever born and surviving or number of surviving parents;[4]

(*d*) Compilation of a list of persons living in a household at one time and the follow-up of those persons over time through repeated visits to update them and record individual deaths between visits;[5]

(*e*) Comparison of the number of persons by age and sex (or by certain other characteristics) at one or more points in time to derive information about mortality as an aggregate phenomenon (considered later in this chapter).

These techniques are not necessarily mutually exclusive and are often used together. For example, the method described above in subparagraph (*d*)—which is referred to by various names, including "multi-round survey", "follow-up survey", "household change technique" or "prospective survey"—must be combined with some other method in order to obtain information about the occurrence of live births and related infant deaths occurring between visits. That is, other questions must be asked to ascertain the occurrence of events that are not evident from inquiring about persons on the initial list. Regardless of the specific technique or techniques used to identify the occurrence of deaths, it is essential that data collectors use procedures that are well-defined and well-controlled.

Basic data sources and some major design variants

Table V.1 lists the five techniques for identifying deaths and indicates the degree to which they can be used in the context of each of the three basic data-collection methods. As the table shows, a civil registration system is by definition an application of the continuous-recording technique. Three of the five techniques can be used in connection with a population census. Sample surveys offer the greatest flexibilities in using different types and combinations of the techniques.

In fact, the sample survey method generally offers a very wide range of options, not only in terms of techniques used but in terms of other factors related to the type, design and execution of the survey. These factors include the number of questions asked, whether

TABLE V.1. SUITABILITY OF VARIOUS TECHNIQUES FOR DETECTION OF DEATHS, CLASSIFIED BY DATA-COLLECTION METHOD

	Data-collection method		
Technique	*Civil registration system*	*Sample survey*	*Population census*
(*a*) Continuous recording of deaths	Yes	No[a]	No
(*b*) Retrospective questions about each death	Not applicable	Yes	Yes, but very limited[b]
(*c*) Questions about cumulative number of events	No	Yes	Yes, but limited[c]
(*d*) Household change technique	Not applicable	Yes	No
(*e*) Aggregate population data classified by age and sex	Not applicable	Yes	Yes

Source: Adapted from United States of America, National Academy of Sciences, National Research Council, Panel on Data Collection, *Collecting Data for the Estimation of Fertility and Mortality*, Committee on Population and Demography, Report No. 6 (Washington, D.C., National Academy Press, 1981).

[a]Some variations of a sample survey may include a continuous-recording operation in sample areas or monthly or more frequent interviewing that approaches notions of contemporaneous recording. However, most sample surveys do not use this method.

[b]Suited only for a question relating to deaths in the preceding 12 months or the date of the most recent death.

[c]Often not feasible to use the recommended full battery of six questions (i.e., living in household, living elsewhere, born alive but now dead, each separately for males and females).

the survey involves one visit to each sampled household (single-round survey) or more than one visit (household change technique), whether information collected in the current visit is compared with or reconciled with previously collected information, whether the survey is carried out on an *ad hoc* basis or with the assistance of a permanent household survey organization, whether the survey is carried out by a governmental statistical agency or some other organization, the type and size of sample, the persons used as interviewers and supervisors and the work-loads of each, the extent and nature of the training provided the field staff, the type and layout of the questionnaire used, the type and extent of manual and computer editing, and so on.

Although the variations possible in designing and carrying out a population census are considerably fewer than with a survey, variations can and do occur. Some so-called "options" are not real options in all situations, because many features of census organization and design are dictated by external factors. For example, in a country in which most of the population is illiterate, the self-enumeration method of enumeration is not a real option. On the other hand, conditions change, so what can be considered a real option also changes over time.

Continuous-recording systems

The basic design options in continuous recording of deaths can be expressed in terms of a two-by-two classification:[6]

Effort of field staff	*Legal status of system*	
	Civil registration	*Special registration*
Passive		
Active		

"Passive" in this table means that a member of the household or a person closely associated with a household (or with the death, e.g., the physician, hospital staff member or undertaker) brings the information concerning a death to a staff member of the civil registration system. "Active" means that the staff member actually visits households to gather information concerning deaths. Despite the considerable scope afforded by these four alternatives and the large number of countries that have undertaken the task, most efforts at continuous recording of deaths involve an official civil registration system that depends upon passive staff effort (that is, the upper-left cell of the table).

The organization of registration systems varies greatly among countries—for example, which ministry has responsibility for the registration work and which carries out the statistical compilation work; whether notification responsibility falls on the family or on health, religious or local administrative personnel; the hours and location of registration offices; whether the statistical data are compiled locally, regionally or centrally—but within the same country there is much institutional continuity.

In many developing countries, a substantial proportion of deaths do not appear in the final tabulations, either because they are simply not registered or because of transmission losses up the administrative chain from a local registrar to the central processing department. The country statement for Peru[7] submitted to the Working Group estimates that 50 per cent of all deaths in the country do not appear in the published figures, 70 per cent of them because of non-registration and the other 30 per cent because of loss of documents and other adminstrative errors. Although penalties for non-registration have generally not proved effective for improving registration, the requirement of a burial permit has proved useful, particularly in urban areas. The country statement for Hong Kong, citing a negligible level of omission, points out that on such a crowded island it is almost impossible to bury a body illegally. Some countries have improved the coverage of death registration to virtual completeness; for example, the country statement of Cuba indicates that death registration improved during the late 1960s and early 1970s to effective completeness by the late 1970s; that of Sri Lanka reports an improvement through the 1950s and 1960s to 95 per cent completeness; and that of Mexico also shows a steady improvement in registration over the past three decades, although to a still less than satisfactory level. Such experience, however, has by no means been universal; the country statements of Peru and Sierra Leone give little basis for optimism about improving coverage.

Despite institutional continuity, countries whose civil registration systems suffer from substantial incompleteness may be subject to sudden variation in the level of completeness. Although these variations sometimes are attributable to obvious organizational changes, more commonly they are due to subtle changes in detailed procedures or to registration drives. For example, the latter effort often produces a substantial number of delayed registrations with respect to current events. The apparent sharp drop in infant mortality in the early 1970s cited by Mexico in its statement was accounted for by delayed birth registrations which inflated the denominators of the rates.

A national civil registration system that functions as a reliable instrument of mortality measurement is more difficult to establish than a sample survey or a population census because it must be more extensive both in time and in space than either of the other two methods. In other words, a civil registration system must provide a means for detecting and recording all deaths regardless of what time of year or where in the country each event takes place.

Sample surveys

The sample survey, restricted as it is to a small proportion of the population, is in a much better position than either the census or the civil registration system to produce observations made under conditions that approach the ideal of statistical control. This is particularly true when, as is the case with most survey sample designs, the sample is confined to a relatively small number of geographical areas. In that situation, it is possible to train and supervise the field staff more effectively than in either a census or a civil registration system and to insist, where appropriate, on direct rather than proxy interviews. Furthermore, as table V.1 indicates, the sample survey is the most versatile of the three collection processes in terms of the techniques that can be used to detect deaths. Some of these techniques are also applicable to censuses, although they often work best under survey conditions for the reasons just mentioned. Nevertheless, it is indicated here whenever an approach is also applicable to censuses.

Against these advantages must be placed the disadvantages that arise because sampling is being used. Survey estimates are subject to measurable sampling errors if a probability sample is employed; even greater uncertainties arise if some other sampling procedure is used. Thus, new "sampling" designs should not be used to collect fertility and mortality data; standard probability sampling should be employed. User confidence in the estimates is an important issue when data are collected by a sample survey. The impact of sampling errors on mortality estimates is very substantial, particularly with respect to crude rates and age-specific rates based on sample data for a single year. The impact of sampling errors is even more pronounced when mortality differentials cross-classified by age are being studied.

There are four self-contained approaches to the collection of information in a sample survey: (*a*) the inclusion of a question on deaths in each household over the preceding 12 or 24 months in a single-round survey or census; (*b*) the information on the deaths occurring during a given period gathered by following up the population in a household sample through a multiround survey (here termed the "household change technique"); (*c*) the collection of information in a survey or census on the survival status at the time of interview of specified close relatives; and (*d*) the collection of maternity histories of women which provide information on their past experience of childbirth and child survival.

Survey or census questions on household deaths in the preceding 12 or 24 months have, in general, not proved to be very satisfactory. The number of events reported is often manifestly inadequate; some part of the problem may be due to reference period error (failing to report a death because of misdating it or otherwise incorrectly perceiving it as having occurred before the specified period), but some part is generally due to omission, arising from the simple failure to report a death or from structural problems, such as the dissolution and regrouping of households as the result of a death.

A further shortcoming is the amount and quality of information about the deceased and the death that can be collected. In a census, for which the questions have to be made simple to answer and limited in number, it is usually only possible to collect the age and sex of the deceased and the month and year of the death. Somewhat more flexibility is possible with a survey, which usually has better trained interviewers and the possibility of asking a larger number of questions. The accuracy of the information may also be low, since it is recalled retrospectively by a household member who may not necessarily be well-informed.

The household change technique overcomes some of the problems associated with the use of these questions. First, the starting-point of the reference period is fixed by the preceding survey round, an unambiguous point in time that requires no dating by the respondent; reference period error is thus reduced. Secondly, when the household listing from one round is used to check the responses to the next, omissions and discrepancies may be corrected in the field, hence reducing the incidence of error. Thus, since losses of household members between rounds must arise either from emigration (from the household) or from death, careful probing of such losses should control unintentional omission and reduce concealment of deaths. Thirdly, the characteristics of the persons who subsequently die are generally obtained before they die, at earlier survey rounds, thus ensuring consistency between the numerators and denominators of mortality rates, though not necessarily accuracy. These advantages do not, of course, apply to deaths between rounds, to births or to in-movements that occurred between the same rounds. The reporting of infant deaths, however, can be improved by recording the pregnancy status of all women of childbearing age at each survey round and then probing the outcome of reported pregnancies at the subsequent round.

These advantages make the household change technique approach very attractive theoretically, but they have to be set against practical difficulties. The field-work has to be carried out at regular intervals over an extended period of time—a minimum of three rounds separated by six-month intervals implies over a year of continuous field-work—making it difficult to maintain supervision, enthusiasm and commitment, as well as requiring administrative continuity and the long-term use of skilled and well-trained manpower.

The development and use of questions on current survival status of close relatives were impelled by the perception that direct retrospective approaches were unsatisfactory. The longest established and most widely applied of these procedures is that used to estimate child mortality risks from information on the number of children ever borne, and the number surviving at the time of interview, by women classified by age or duration of marriage. The analysis converts the proportions of children dead into probabilities of dying by exact ages of childhood; although the original procedures assumed constant mortality and fertility, recent developments have made it possible to date the mortality estimates under the assumption of regular mortality change, to allow for changing fertility by using the age distribution of children and to obtain period-specific estimates under conditions of changing fertility and mortality when data are available from two surveys.

Information on whether a respondent's mother is alive at the time of interview provides an indicator of adult female mortality, and similar information about fathers provides an indicator of adult male mortality. Models of fertility and mortality have been used to develop methods to make the transformation from tabulated proportions of respondents with surviving mother (father) to standard life-table survivorship probabilities. The original methods assumed constant mortality, an unrealistic assumption in view of the fact that the exposure periods might range up to 50 or 60 years; but a recent development permits the estimation of the reference dates of the survivorship probabilities under the assumption of a regular pattern of mortality change, a somewhat more realistic assumption. Of course, to the extent that actual mortality change did not occur according to the assumed pattern, undesirable biases will arise in the mortality estimates derived, but experience to date suggests that their magnitude is small.

Information on survival of first spouse classified by sex of respondent and by either age of respondent or years since first marriage provides an alternative approach to the estimation of adult mortality. The proportions of ever-married respondents with first spouse alive classified by age or by marital duration are transformed into adult survivorship probabilities for the sex opposite to that of the respondent through use of transformation equations based on nuptiality and mortality models. In general, experience with widowhood questions suggests that the approach should not be relied upon.

Maternity histories collect the date of birth and, if applicable, the date or age at death of each child borne by the women interviewed. Conventional mortality measures can be computed from these data for a considerable period of time prior to the survey, since information is available on deaths by age group and time period and on the numbers exposed for the same age groups and periods. Experience with this approach has expanded greatly over the past eight years as a result of the World Fertility Survey programme.

The maternity history approach has many attractive features. It provides levels and recent trends in mortality up to about age 10; permits the study of mortality differentials by sex of child, characteristics of the mother and characteristics of the household (the recent application of proportional hazard models has increased the sophistication of such studies); and does not rely upon models in the calculation of the basic measures. On the debit side, the data collection requires intensive, lengthy interviews by highly trained staff, thus imposing a small sample size and limiting the depth of possible analysis of differentials. The reported dates of birth, and even more so dates or ages at death, appear to be affected to a greater or lesser extent by systematic errors, distorting trends and age patterns of mortality.

Census-based methods

A population census, while as broad in geographical scope as a continuous-recording system, is a single effort carried out once, or at most twice, each decade. As a result, extensive administrative and technical resources can be specially mobilized in an effort to keep the data-gathering and data-processing operations under as much control as possible. Indeed, such a special mobilization of resources is essential if major errors in coverage and content are to be avoided.

Age and sex distributions of the population obtained from one or more census enumerations can, in certain circumstances, be very useful for providing mortality estimates. As these approaches are not covered in the following chapters, they are dealt with in more detail here. In a population that is closed to migration, the numbers of deaths experienced by successive cohorts between two censuses can be obtained from the changes in cohort sizes between the two censuses; an essentially similar way of treating the same basic information is to derive an intercensal life table from cohort survivorship ratios calculated as the ratios of final cohort sizes to initial cohort sizes. It may be noted that the intercensal-survival approach can be used even with an open population if information on net age-specific intercensal migration is available, although in most cases even less is known about migration than about mortality. In addition, if information is available on place of birth (or a similar characteristic) in both censuses, it may then by possible to define closed subgroups in which to carry out this approach.

The intercensal-survival approach to mortality estimation has been widely used; for instance, a series of intercensal life tables for India have been constructed by applying it to the sequence of decennial censuses available for this century. The approach has certain advantages: its data needs are fairly simple, namely, two or more census enumerations, preferably but not necessarily separated by intervals divisible by five; and the basic analysis does not rely upon any demographic models or assumptions of stability or quasi-stability of uncertain applicability. However, the approach has certain profound practical drawbacks. First, it assumes either negligible net migration or the possibility of adjusting each cohort for net migration; adequate data for such an adjustment rarely exist, so the approach generally assumes no net migration. For many countries, this assumption can be supported at the national level but not at the regional level, making the approach unsuited for the study of differentials by characteristics that can change between the censuses. Secondly, the approach depends critically upon the comparability in terms of coverage of the two censuses; quite small changes in enumeration completeness can introduce substantial errors into the result. The third drawback of the intercensal survival approach is age-misreporting, which can severely distort cohort survivorship ratios for conventional five-year age groups, even to the extent of giving survivorship ratios in excess of unity if the second age group is more attractive to respondents than the initial age group. Various methods are used to smooth the survivorship ratios; one is to average the mortality levels in some system of model life tables; another is to forward-project the initial population, or reverse-project the final population, using different model mortality levels; and to average the mortality levels implied by the cumulated final, or initial, population aged 10 and over, 15 and over, and so on up to 40 and over or 45 and over. Even using these smoothing procedures, however, the effects of age-misreporting on the final estimates can still be substantial, particularly in the face of systematic errors, such as general age exaggeration. It should perhaps be stressed also that the intercensal-survival approach can only be applied to successive census counts, implying an extensive lag before estimates can be made; sample survey estimates of total population are too affected by sampling errors and coverage problems to be used as a basis for the approach.

A somewhat different approach, using the same basic data and subject to some of the same drawbacks, is proposed by Preston.[8] Instead of calculating cohort survivorship ratios, age-specific intercensal growth rates are calculated from the two census age distributions and used to reduce the average intercensal age distribution to a stationary population form from which the levels of life expectancy at successive ages can be obtained. The advantages of the approach are that the age-specific growth rates are unaffected by equivalent age-reporting errors at the two censuses and that it can be applied with equal computational ease regardless of the length of the intercensal interval. However, the approach still suffers from the other drawbacks of the traditional procedure and is still affected by age errors that affect the average intercensal age distribution or that are not equivalent between enumerations, a surprisingly common occurrence.

A single age distribution represents a record of the fertility, mortality and migration effects on a population over an extended period. Extensive net migration will usually make it impossible to extract mortality information from an age distribution, because migration is generally even more poorly documented than mortality. But if a population can be regarded as closed, the age distribution reflects the combined effect only of fertility and mortality. Thus, in a closed, accurately recorded age distribution, the difference in size between the population aged, say, 25-29 and that aged 20-24 reflects the difference in size of the birth cohorts (or the growth rate of births), and the difference in mortality risks from birth to the time of the census or survey. For most age groups, the growth rate of births is easily the predominant factor; and the ages where mortality is relatively important, for the very young and the elderly, are also the ages where age-misreporting is poorest. In order to use the age distribution as a basis for mortality estimation, information is needed about the growth rate of the population, and assumptions are needed about the course of mortality in the past. One approach is stable-population analysis, which assumes that the population has equal growth rates at all ages typical of the fertility and mortality rates it currently experiences and that the stable rate of natural increase is known; if the growth rate is known to have been changing steadily as a result of mortality change, adjustments can be made for quasi-stability. The method can be applied to information from a single census or survey, although some information about the growth rate will be required. Otherwise, however, the method has copious disadvantages as an approach to mortality estimation. The migration assumption makes it inapplicable to the study of differentials; the stability, or quasi-stability, and mortality pattern assumptions may not be suitable; the results may be seriously distorted by age-misreporting and the reference period to which the estimates apply is generally ambiguous under changing demographic conditions. The approach cannot be considered suited for meeting the needs for mortality information in any but the most data-scarce circumstances.

All of the above-mentioned techniques have been treated rather briefly in this overview. Fuller discussions appear in the following chapters and a detailed description of methods of calculations for these techniques is given in a recent United Nations publication.[9]

Related methods of analytical adjustment and assessment of data

No matter which method is chosen, the collected data must be analysed to determine their quality. Mortality and population data can suffer from a variety of limitations, for example, omission of events or persons; inclusion of out-of-scope events, such as those which did not occur within the time period or the geographical area being covered; misstatement of characteristics of persons, such as age, occupation or place of residence. They can also suffer from inconsistencies between recording these characteristics in the death record and the population record, either because of an error in one or the other or because a characteristic changed between the time of recording of the population and the death.

Because of these errors, evaluation and, if necessary, adjustment of the data are always necessary. The evaluation and adjustment procedure is essentially one of examination of the data for consistencies and inconsistencies. The evaluation and adjustment procedures can take place on a microlevel, that is, by examination for consistencies and inconsistencies within individual records, or on a macrolevel, by examination of tabulations cross-classified for various characteristics. In addition, the data can be evaluated internally with respect to the data themselves or externally with respect to other data systems or with demographic models.

Microlevel analysis takes place most often with respect to surveys and censuses, although there is nothing in its nature to limit its use with respect to vital records. It involves essentially the examining of each individual record for omitted data or inconsistent data. Examples of these errors, which may occur at either the interview stage, the recording stage or the coding stage, might include codes out of range or omitted—e.g., a 15-year-old girl recorded as having five live births or more children recorded as surviving than as children ever born. The data may be adjusted by imputation, recoding according to some external or internal model, or by reinterview.

Microlevel evaluation can also take place through matching surveys. The case-by-case matching of individual records is made with records from a separate data system. Through matching of records, events can be located which were omitted from each of the systems and new records, therefore, added. There are various examples of this type of exercise. The survey carried out in Egypt in 1974-1975, and referred to in the country statement submitted to the Working Group, is an example of this approach. In Costa Rica[10] also, the death records in the civil registration system were evaluated by case-by-case matching with hospital records. Deaths were uncovered in the hospital records which did not appear in the vital records system. It was possible not only to add these records to the civil registration but to determine information on the completeness of the registration system and of delays in recording of events. Similar evaluations have taken place in, for example, Sri Lanka[11] and the Philippines,[12] in which surveys have queried births and deaths in the previous months for the purpose of estimating completeness by matching to civil records. In Thailand,[13] during the period 1965-1967 and again during 1974-1976, nationally representative surveys were carried out to record births and deaths. The results of these surveys were matched with the vital registration system, estimates were obtained both of the completeness of the survey and of the civil registration, and accurate life tables were constructed. In Iran[14] and in Nepal,[15] as a part of demographic surveys, a second enumeration was undertaken in a subsample; and after case-by-case matching, estimates were made of the extent of omissions in the survey proper. The best-known example of matching surveys is probably the continuous Sample Registration System, which has been ongoing for over a decade in India.[16]

For the macrolevel approach to data evaluation and adjustment, rather than investigating individual records, such summary measures as means and distribution are examined. Tests are again those of internal consistency and external consistency. Internal consistency checks might involve examination of recorded age patterns of mortality: determination of whether they follow usual patterns or show evidence of underrecording for certain age groups. Omissions or age-misreporting often distort the pattern, particularly for the youngest and oldest age groups; and it may therefore be desirable to adjust certain segments of the age span based on models or other data. Similarly, data can be tabulated by sex or geographical area to determine if recorded differentials are as expected. This latter procedure was carried out as part of the analysis of the Rural Demographic Survey of Nigeria[17] and it was possible to locate several areas where enumeration of events was less satisfactory. However, in the case of surveys, these procedures must often be undertaken with great care as sampling error can often limit such diagnostic use of the data.

Methods developed based on the consistency of population and death distributions are also important for evaluating completeness of death recording in vital registration systems and possibly in sample surveys when the effect of sampling fluctuations is not too great. These methods provide estimates of completeness under the assumptions of non-differential omission of deaths by age and of a closed population. The most important variations of this method are probably those developed by Brass, by Preston and by Bennett and Horiuchi.[18]

The indirect retrospective questions also have their own internal checks. Data on children ever born and children surviving can be tabulated by sex, for example, and the sex ratio at birth by age group of women and/or by duration of marriage group can be examined.[19] Proportions dead by sex can be examined similarly. The implied time pattern of mortality change can also be examined. In fact, tabulations for various population groups can be made to search for unusual, unlikely differentials.

Similar checks are available for orphanhood and widowhood data, although with respect to the orphanhood approach, examination of results based on male respondents and female respondents separately may give further assurance of consistency.

External checks are essentially comparisons of the recorded mortality data with those collected by another data-collection system or by another method within the same system. This process involves comparisons of levels and age patterns of mortality from vital registration systems with those available from both direct and indirect questions in surveys. Comparison of vital registration data on deaths under ages 2, 3 or 5 years with corresponding estimates from data on children ever born and children surviving can be a valuable tool for evaluating the completeness of vital registration systems.[20] In addition, Hill[21] and Arretx[22] show, in their analyses of survey data from Honduras, the value, for analytical purposes, of adding retrospective questions to prospective surveys for mutual comparisons and best estimation of demographic variables.

Other types of external consistency checks necessitate comparative examination of the age distribution of the population with recorded birth and deaths. (When all of these characteristics are collected within a survey, one may consider these checks to be internal). This question concerns whether recorded births and early age deaths are consistent with the recorded population at the young ages. The quality of death statistics in Jordan was evaluated through just such an approach.[23] Conclusions can be drawn from these types of calculations only with great care because inconsistencies do not necessarily inform the analyst which components are wrong (mortality data, fertility data or age distribution data), nor do consistencies necessarily indicate accuracy of the data as errors in two components can counterbalance each other. In addition, international migration can effect comparisons, unless data are available to allow necessary adjustment.

Mortality data collected from vital registration systems or surveys can also be compared with model life tables such as the new United Nations models[24] or the Coale and Demeny models,[25] with corresponding estimation of mortality based on stable-population analysis or intercensal-survival analysis.

In summary, a large variety of demographic techniques is available for adjusting and evaluating collected mortality data. None of the techniques is perfect; all are essentially diagnostic in that they give the analyst clues as to the strengths and weaknesses of the data, in which circumstances the data can more safely be used and in which circumstances less safely. In the final analysis, however, collected data, even after adjustments, must be considered in the face of their inherent plausibility. Are the estimated mortality measures reasonable for what is known of the health conditions of the country? Do the estimated mortality measures differ very much from otherwise similar populations?

C. Factors to be considered in planning collection efforts

A number of factors ought to be considered when planning the collection of mortality data. These factors include the purposes for which the data are needed, the general level and pattern of mortality in a country; previous national experience in census-taking, civil registration and sample survey; the level of development and pattern of organization of the statistical, health and other concerned services of a country; the intrinsic features of the basic methods and major variants for obtaining, assessing and analysing mortality data; and the resources available to carry out any data collection involved. Sometimes a careful consideration of these and other pertinent factors (for example, when the data are needed or special obstacles to data collection) may lead to a decision that the collection of new mortality data is not the best way of proceeding.

For example, in some circumstances, the desired information, or some acceptable approximation of it, may be obtained from the further analysis of one or more data sets that are already available. Frequently, such an effort involves the use of one or more of the techniques discussed in the previous sections.

On the other hand, where new or improved data-collection efforts are required, no single data-collection method can be recommended in all circumstances. Each of the three basic methods—census, civil registration and sample survey—has advantages and limitations. To be most effective, they must be used in concert to gather the various types of data needed for policy-making, administration and research; to provide mutual cross-checks on the accuracy and the completeness of coverage; and to collect the combinations of data that are needed to apply some of the analytical techniques.[26]

Although no single best method for obtaining mortality data can be specified, some indication of the relative strengths and weaknesses of the population census, the civil registration system and the sample survey, in terms of seven specified criteria, is provided in table V.2. A more detailed summary of the advantages and limitations of these three basic sources is given in table V.3.

In both tables, the relative advantages of the three basic sources are shown to be complementary: where one is strong, another is weak. For example, sample surveys can be designed to obtain wide varieties of data with rich content and they can be designed to collect the data relatively accurately. Because they are small, they can be done fairly inexpensively and can provide timely data; but for the same reason, they fail to yield precise estimates for geographical and other subgroups. This last criterion, on the contrary, is the chief virtue of complete censuses (although censuses are by no means immune to coverage problems themselves). Censuses (and well-developed civil registration systems) tend to produce better coverage of the population than do sample surveys, which often suffer from higher non-response (although non-response levels vary greatly between surveys and among individual

TABLE V.2. INTRINSIC CHARACTERISTICS OF THREE BASIC SOURCES FOR PROVIDING DATA NEEDED TO ESTIMATE MORTALITY

Criteria	*Census*	*Civil registration*	*Sample survey*
Topical detail (richness and diversity of subject-matter)	Moderate	Weak	Strong
Accuracy	Moderate	Strong	Moderate
Precision (absence of sampling errors)	Strong	Strong	Weak
Timeliness of data	Weak	Strong	Strong
Geographical detail (subgroups etc.)	Strong	Strong	Weak
Obtaining information on population at risk	Strong	[a]	Strong
Ease of organization in a developing country	Moderate	Weak	Strong

Source: See table V.1.

[a]In general, civil registration systems do not provide information on the population at risk. However, for some measures, such as infant mortality, civil registration systems do provide data on the population at risk. Also, historical analysis is possible when civil registration data from earlier periods are available.

TABLE V.3. SOME ADVANTAGES AND LIMITATIONS OF POPULATION CENSUSES, CIVIL REGISTRATION SYSTEMS AND SAMPLE SURVEYS

Data-collection method	*Advantages*	*Limitations*
Population census ..	1. Data can be tabulated for many local geographical areas 2. Detailed cross-tabulations are not subject to sampling errors for complete-count items and are subject to relatively low sampling errors for sample items 3. Simultaneously obtains information related to enumerated events and population at risk 4. Useful for time-series covering long periods of time	1. Infrequent 2. Limited range and depth possible in the collection data on fertility and mortality as well as on classifying variables 3. Information on "flow" variables (for example, income or deaths) and data from proxy respondents are subject to increased level of response error 4. Persons not at their usual place of residence are subject to high non-response rates (not a problem in *de facto* censuses) 5. Comparatively difficult to control conditions of observation (because it is extensive in space) 6. Costly and massive in scale so relatively inflexible
Civil registration system	1. Data can be tabulated for many local geographical areas 2. Detailed cross-classifications, including deaths by cause, are not subject to sampling error 3. If properly functioning, provides contemporaneous reporting for substantially all events regardless of household status 4. Institutional continuity 5. Well-suited for providing both long-term and short-term time series	1. Need for separate estimated population at risk 2. Limited range and depth possible in the collection of data for most classifying variables 3. Relatively inflexible to changes in content and procedures 4. Very difficult to administer and supervise (because extensive in both time and space) 5. Difficult to establish occurrence of events when deaths (or knowledge of them) are not associated with persons who can serve as informants (for example, health workers or religious personnel)
Sample surveys	1. Simultaneously obtains information relating to enumerated events and population at risk (with the exception of surveys conducted as parts of dual-record systems) 2. Topical flexibility (that is, the depth and range of topics investigated can be altered relatively easily) 3. Conditions of observation are subject to control because of the limited geographical scope of collection operations (that is, because a sample is employed) 4. Relatively easy to initiate, given availability of a survey-taking infrastructure 5. Can be useful for time-series analysis, given comparability in data collected	1. Inability to produce estimates for local areas 2. Detailed cross-classifications are subject to large sampling errors 3. Information on "flow" variables (for example, income, deaths) and data from proxy respondents are subject to increased levels of response error 4. Coverage for the non-household population is very poor and it varies markedly for those who are not members of a primary family (for example, members of secondary families, secondary persons and distant relatives of the household head) 5. Comparisons over time of estimates based on different *ad hoc* surveys are subject to many uncertainties 6. Requires close supervision of field-work.

Source: See table V.1.

items in surveys). Because censuses are large and expensive, however, they are not conducted frequently and often produce data that are partially obsolete because of the time required for collecting and processing the data and disseminating the results. To obtain either rich or accurate data from a census is often not feasible.

Civil registration systems have a different mix of advantages than either surveys or censuses. Once established, civil registration systems can be inexpensive to maintain if some of the costs are considered necessary for administrative purposes, although to date this is the case in only a few of the developing countries. Moreover, civil registration systems can yield precise and detailed information about mortality levels around census dates or whenever other good estimates of the base population are available.

Registration systems can have another important advantage over censuses and most sample surveys in that under registration systems, it is possible to take maximum advantage of the medical certification of cause of death. It must be stressed that this potential advantage is not realizable today in most developing countries, since many deaths go unregistered and many of the registered deaths are not medically attended. Nevertheless, in those instances where users wish to make use of mortality data by cause of death, careful attention should be given to the use of data from the current or an improved civil registration system.

Sample surveys are an important tool for obtaining mortality data and for carrying out demographic research at all stages of statistical development. However, it is a mistake to think of them primarily as an interim means of supplying data in the absence of a reliable civil registration system. Undoubtedly, surveys can be used for this purpose but they can never adequately meet the range of needs served by a national civil registration system. By the same token, even with the most complete and comprehensive civil registration system it is essential to continue an active programme of sample surveys.

As mentioned earlier and described in more detail in a number of the other papers, variants of the three basic sources can be used or two or more sources can be used jointly at the collection or analysis stage. For example, in the case of the census, some items may be obtained only for a sample of persons, dwellings or areas; or the continuous recording of deaths (and births) may be attempted in a national sample or a local study area. These hybrid variants tend to fall between the basic sources from which they are formed in terms of the advantages and limitations indicated in tables V.2 and V.3.

On the other hand, other kinds of joint uses result in a clear gain in what is obtainable from any one source. For example, surveys are a valuable means of testing questions for possible use in censuses, and censuses and surveys can be used to estimate the completeness of a national civil registration system. Such estimates of completeness are not only of substantive importance but may help to spur the further improvement of the civil registration system.

In these circumstances, a co-ordinated approach to data collection is essential because it allows the inherent or temporary deficiencies of any one method to be counterbalanced by the comparative strengths of another. This is as true for countries that have reached a comparatively advanced state of statistical development as it is for countries in which one or more of the data-collection systems is limited in geographical scope, seriously deficient in coverage or otherwise functioning inadequately. For best results, the concepts, definitions and classifications used in the census, the civil registration system and any surveys used to provide mortality data should correspond with one another as closely as possible.[27] In the context of mortality estimation, common, or at least compatible, approaches to age-group classifications, household and residence definitions, and urban/rural and other area classifications are particularly critical. Also of importance are the concepts and classifications used in connection with questions on family relationships, marital status, and children ever born and children surviving.

D. Some factors to be considered at the analysis stages

Combination of data from different sources

In addition to the joint use of data derived from different sources in the estimation of mortality, multiple data sources can be used to further the analysis of mortality data in other ways. Perhaps the most important is the possibility of constructing a data base or data file that contains information derived from two or more sources. In the case of mortality studies, this procedure generally involves linking information concerning individual deaths (from a civil or special registration system) with other information pertaining to the deceased person (from a census, a sample survey or from one or more other administrative reporting systems). The additional information may, for example, relate to the circumstances of a deceased child's birth; the household, family or occupational characteristics of the deceased; or data pertaining to covered disabilities of the deceased as recorded in national social insurance schemes.

Three broadly different methods, referred to as "aggregate linking", "exact matching" and "statistical matching" in a recent United Nations publication,[28] are available for such linkages. The first method, the simplest but least powerful, involves estimating certain cross-tabulations when certain marginal distributions are known.[29] Exact matching can be an important tool for mortality studies[30] but the procedure can be expensive and very time-consuming, particularly when precise identifiers are not available.

The third method, the so-called "statistical matching", is a newer procedure that has not yet been used in mortality studies. It permits the construction of microlevel data files on the basis of information in two or more data files that cannot be linked (for example, because of confidentiality restrictions or because each file represents an independent sample of the same population). As with any analytical procedure, considerable care must be exercised to ensure that basic assumptions of the procedure shall not be violated. Furthermore, experience from statistical matching efforts in other fields indicates that, in some cases, substantial time may be required to prepare the individual data files used in the statistical-matching process. Further information about this procedure is contained in the United Nations report[31] referred to above, which also contains an extensive bibliography and a number of examples of how the procedure has been used in different countries.

Uses of mortality data in light of data errors

The ultimate purpose of studies of mortality is the discovery of the determinants of mortality and the initiation or evaluation of policies and programmes to reduce it among all population groups. Mortality surveys and registration systems do not provide direct information on determinants of mortality; rather, they inform on levels, trends and differentials in mortality. As outlined in the previous sections, some data-collection approaches are preferable to others, depending upon which of these three, or combinations of these three, components of mortality study are of greatest interest.

Most data-collection systems are better at estimating levels of mortality than trends or differentials. This is partially because the methods of data evaluation and adjustment outlined above are mainly applicable for the study of mortality levels either because they are not sufficiently robust to pin-point mortality changes or because their underlying assumptions do not hold for subgroups.

For the measurement of levels of mortality, specific indicators, such as the crude death rate, infant mortality rate and life expectancy at birth, are generally calculated. The crude death rate is certainly the easiest to calculate; but because of the age-distribution effect, it is not always a useful measure for understanding mortality processes. The infant mortality rate and life expectancy at birth are also easy to calculate; but they depend upon age statements of reasonable accuracy, and in the case of direct questions in surveys (deaths in the past months), upon samples of reasonable size.

When measuring trends and differentials, the problems of sample size become more important as does consistency of age-reporting and other characteristics over time and amongst population groups. Differences measured over time and amongst groups are often small in comparison with population and sampling variance of the difference. Consistency is also a factor. Changes in time or differences among groups in age-reporting can lead to erroneous conclusions about differentials. Even more important may be inconsistencies in reporting of other characteristics between population and death records, between groups and over time. Characteristics reported in censuses and vital registration systems can vary due to differences in recording, different definitions or accuracy. Differential omission of events between population groups or over time can also bias results.

Conclusion

There are a number of different approaches to mortality measurement, each with its own mix of strengths and weaknesses for the various purposes for which mortality information is needed. There is no one approach that meets all needs and is universally applicable; the different approaches should rather be seen as complementing one another in providing for the full range of requirements. It should not, however, be regarded as an immediate priority for all countries to deploy the full battery of approaches; decisions should be taken on the basis of the urgency of the need for particular types of information and of the feasibility, given the data-collection context, of implementing particular approaches. This consideration is particularly applicable to the civil registration system. In addition, smaller scale samples or laboratory-like surveys provide for needs in terms of depth and detail that cannot be met in other ways, and their value is independent of other available data sources.

In summary, there is no one best source for obtaining mortality data, no one best design for applying any given data-collection method and no one best method for analysing and assessing the results obtained. If all users with important needs for mortality data are to be effectively served, attention and resources must, at least over the longer run, be directed to a balanced programme of upgrading census, registration and survey capabilities and activities within developing countries. This balanced programme will vary among countries because priorities, time constraints on data needs and planning horizons differ. Even those planning a specific collection effort will do well to consider the full range of collection and analytical options open to them in the light of their specific needs and circumstances. A realistic view must also be taken of the likely effects of data errors on the approaches being considered, efforts made to minimize the errors at both the collection and the processing stages, and thought given to the possibilities for internal and external evaluation and adjustment of the results.

Notes

[1]Kenneth Hill and United Nations Secretariat, "Uses of mortality data for planning and research".

[2]Considered in detail in parts four and five of the present volume.

[3]Considered in John G. C. Blacker, "Experiences in the use of special mortality questions in multi-purpose surveys: the single-round approach"; and John Hobcraft, "Use of special mortality questions in fertility surveys: the World Fertility Survey experience", chaps. IX and X, respectively, of the present volume.

[4]See J. G. C. Blacker, *op. cit.*

[5]A. Adlakha and M. Nizamuddin, "Mortality data collections: a review of integrated multi-purpose household surveys and multi-round demographic surveys", chap. XI of the present volume.

[6]H. Bradley Wells and D. G. Horvitz, "The state of the art in dual systems for measuring population change", in *Developments in Dual System Estimation of Population Size and Growth*, Karol J. Krotki, ed. (Edmonton, University of Alberta Press, 1979), pp. 53-69.

[7]For document numbers of this and other country statements referred to in this chapter, see annex to part one of the present volume.

[8]Samuel H. Preston, "Use of direct and indirect techniques for estimating the completeness of death registration systems", chap. VIII of the present volume.

[9]*Manual X. Indirect Techniques for Demographic Estimation* (United Nations publication, Sales No. E.83.XIII.2).

[10]Costa Rica, Dirección, General de Estadística y Censos; and Centro Latinoamericano de Demografía, *Evaluación del censo de 1973 y proyección de población por sexo y grupos de edades, 1950-2000.* (Santiago, Chile, 1976), pp. 8-10.

[11]Sri Lanka, Department of Census and Statistics, *A Study of the Extent of Underregistration of Births and Deaths in Ceylon* (Colombo, 1970).

[12]Mortel, D. M., "Causes of non-registration of vital events in the Philippines 1973", in *Seminar on Development of Maintenance of a Sample Vital Registration System in the Philippines* (Manila, National Census and Statistics Office, 1975).

[13]Thailand, National Statistical Office, *Report of the Survey of Population Change, 1964-67* (Bangkok, 1970); and *Report of the Survey of Population Change 1974-75* (Bangkok, 1977).

[14]Statistical Centre of Iran, Plan and Budget Organization, *Population Growth Survey of Iran: Final Report 1973-1976* (Teheran, 1978). This country is currently known as the Islamic Republic of Iran.

[15]A. K. Bourini, *The Demographic Sample Survey of Nepal, 1974-1975,* report prepared for the Government of Nepal (Kathmandu, 1976).

[16]See P. Padmanabha, "Use of sample registration systems for studying levels, trends and differentials in mortality: the experience of India", chap. VII of the present volume.

[17]Nigeria, *Rural Demographic Sample Survey 1965-1966* (Lagos, 1968).

[18]See S. H. Preston, *op. cit.*

[19]Kenneth Hill, "An evaluation of indirect methods for measuring mortality", paper submitted to the International Union for the Scientific Study of Population Seminar on Methodology and Data Collection in Mortality Studies, Dakar, Senegal, 7-10 July 1981. To be published in *Methodologies for the Collection and Analysis of Mortality Data,* J. Vallin, J. H. Pollard and L. Heligman, eds.; Dolhain, Belgium, Ordina Editions, forthcoming in 1983.

[20]*Ibid.*

[21]K. Hill, "Estimating adult mortality levels from information on widowhood", *Population Studies,* vol. 31, No. 1 (March 1977), pp. 75-84.

[22]Carmen Arretx, "Comparison between prospective and retrospective demographic surveys to estimate levels and differentials of mortality: the experience of CELADE", paper submitted to the International Union for the Scientific Study of Population Seminar on Methodology and Data Collection in Mortality Studies, Dakar, Senegal, 7-10 July 1981.

[23]Jordan, Department of Statistics, *Analysis of Population Statistics of Jordan,* by Hilde Wander (Amman, 1966), vol. 1.

[24]*Model Life Tables for Developing Countries* (United Nations publication, Sales No. E.81.XIII.7).

[25]Ansley J. Coale and Paul Demeny, *Regional Model Life Tables and Stable Populations* (Princeton, N.J Princeton University Press, 1966).

[26]Väinö Kannisto, "Collection of data on vital events in developing countries", paper submitted to the Working Group on How Many by 2000: Country Births and Deaths, Rijeka, Yugoslavia, 14-18 September 1981.

[27]*The Development of Integrated Data Bases for Social, Economic and Demographic Statistics* (United Nations publication, Sales No. E.79.XVII.14).

[28]*Ibid.*

[29]See, for example, W. Edwards Deming, *Statistical Adjustment of Data* (New York, John Wiley & Sons, 1946).

[30]See, for example, Thea Z. Hambright, "Comparison of information on death certificates and matching 1960 census records: age, marital status, race, nativity and country of origin", *Demography,* vol. 6, No. 4 (November 1969), pp. 413-423.

[31]*The Development of Integrated Data Bases for Social, Economic and Demographic Statistics.*

Part Four

COLLECTION OF MORTALITY DATA THROUGH CIVIL REGISTRATION SYSTEMS

VI. ADVANTAGES AND DISADVANTAGES OF CONTINUOUS REGISTRATION SYSTEMS FOR NATIONAL, SUBNATIONAL AND DIFFERENTIAL MORTALITY ANALYSIS*

*Iwao M. Moriyama***

For many years, there was only one recognized way of producing vital statistics, namely, from birth and death records filed for legal purposes. This limited view was held despite the fact that the statistics derived from these documents in the developing countries were generally so incomplete as to be of little or no value.

Shortly after the Second World War, there arose in developing countries a demand for birth and death statistics for planning, administration and evaluation of health programmes; measurement of population growth for family planning programmes; and for national social and economic development planning purposes. Because the then current civil registration systems were incapable of providing the needed statistics, other ways and means were sought to estimate demographic parameters, leading to the application of retrospective survey methodology and the development of indirect methods of estimating fertility and mortality rates. The availability of these methods for estimating birth and death statistics naturally raises questions about the value of civil registration data for statistical purposes.

It is the purpose of this chapter to discuss the advantages and disadvantages of the current continuous death registration system as a source of data for differential mortality analysis and other mortality studies. To provide a proper perspective to the problem, a historical background relating to the development of mortality statistics is first given; it is followed by brief discussions of the death registration process and the uses of both individual records and statistics derived from the death certificate. Then the advantages and disadvantages of the continuous registration system for the production of national mortality statistics are presented.

A. HISTORICAL DEVELOPMENT

The forerunner of the current civil registers were ecclesiastical registers, in which weddings, baptisms and burials occurring in the parish were recorded. The earliest known compilation of bills of mortality was issued in 1532. These bills were weekly lists of burials; and they included the name of the deceased, the parish in which the burial took place and the cause of death, with particular reference to the plague. The cause of death was determined by the searcher after she had viewed the body. In the more difficult cases, the searcher consulted a physician. The searchers made their reports to the parish clerk, who prepared an account of all the burials every Tuesday night. On Wednesday, the general account was made up and printed. On Thursday, the bills were distributed to subscribers who paid 4 shillings for an annual subscription.

More than a century later, John Graunt conceived of the idea of utilizing the London bills of mortality for analytical studies,[1] which were published in 1662. Despite medical progress, the diagnostic quality of the bills did not improve. Also, interest in the old bills waned. Clerks of many parishes failed to report or reported only irregularly. Even when complete, the bills gave no information about the population of towns and counties.

In 1837, the Registration Act was passed in England, with provisions for the inquiry into the causes of all deaths occurring in the population. In 1839, William Farr was appointed compiler of abstracts in the Registrar General's Office, and he, probably more than anyone else, developed and analysed mortality statistics to delineate the sanitary and health problems of the day. Farr[2] reported on life and death in England, on the possibilities and difficulties of extending human life, on the effects of sanitation on mortality, on mortality and the economic situation, mortality and the water-supply, urban and rural mortality (pointing out healthy and unhealthy districts), mortality at different ages by sex, mortality of illegitimate infants, and on other topics.

Traditionally, official mortality statistics have been derived from the death record filed in compliance with the requirements of the civil registration laws to prevent the illegal disposition or transportation of a dead body. In other words, death statistics are, by and large, by-products of a legal process. An exception to this situation has been the attempt to collect national death statistics in the United States of America by the enumeration method in conjunction with the decennial

*The original version of this chapter appeared as document IESA/P/AC.17/6.

**Deputy Executive Director, International Institute for Vital Registration and Statistics, Bethesda, Maryland, United States of America.

population censuses from 1880 to 1900. It should be noted that death registration laws were already in effect in all the states at that time. However, it was felt that the registration coverage was not sufficiently complete for the compilation of national mortality statistics. Therefore, census interviewers were used to collect, on a retrospective basis, information on deaths that occurred in the household over a period of a year. Unfortunately, the census approach yielded fewer deaths than were abstracted through the death registration process in the states with reasonably good registration systems. The census enumeration procedure was therefore abandoned after the 1900 census, and the United States Death Registration Area was formed specifically to provide national mortality statistics.

It was not until after the Second World War that developing countries felt an acute need for adequate mortality statistics. Death registration data were then found wanting, with little possibility of rapid development of the registration system. Other methods were therefore sought to produce mortality data. The resulting research efforts led in two general directions, one being direct methods of estimation utilizing field surveys or a combination of registration and surveys, and the other techniques of estimation utilizing indirect indicators of mortality.

B. Some aspects of the death registration process[3]

The legal base for death registration is some type of civil law on registration which establishes the compulsory nature of and the requirements for registration of deaths. The law designates the person responsible for registration and the place of registration, and prescribes the time allowed for the registration of the event, the fees required, if any, and the penalty for failure to register.

In most countries, the responsibility for the registration of a death rests with a relative or the head of the family or of the household. Data concerning the deceased are obtained from the informant prior to or at the time of the registration. These data usually include the time and place of death, personal characteristics of the deceased; and characteristics of the parents, the attendants at the death, the informant, the witnesses and the registrar; and the method of interment. Another important datum is provided by the medical attendant, if any, or by the medico-legal authority, on the cause of death.

In most countries, the legal record, usually in the form of books of actas, is brief. For statistical purposes, additional information is collected from the informant at the time of registration. The legal record is placed in a permanent repository, while the statistical transcript is transmitted to the government agency responsible for vital statistics.

In other countries, the legal and the statistical forms are combined into a single death certificate. The original death certificates are bound into books and filed permanently for legal purposes. Provisions safeguarding the confidentiality of information in these documents vary, depending upon the country. However, certified copies of the record are generally issued to individuals upon request.

C. Uses of death records and statistics

The death record provides a proof of death for burial or other means of disposition of the remains, for the settlement of life insurance and social insurance claims and for the adjudication of property ownership and inheritance claims. It also provides legal evidence of the right of a surviving spouse to remarry. The death record has also been used for clearing various types of files, such as social security files, disease case registers, electoral lists, bank accounts and missing persons files.

The death record has been useful in health programmes in identifying cases of certain infectious diseases. In some countries, death certificates of those dying from specified infective and parasitic diseases are routinely referred to the programme unit concerned with their control. Death certificates are also used for investigations into causes of infant and maternal deaths, and as a source of data for various types of epidemiological studies.

Official mortality statistics derived from death records are used extensively for demographic studies and in public health programmes. These studies may deal with mortality differentials by age, sex, occupation, socio-economic characteristics, etc.; or they may deal with the demographic characteristics of the deceased to eliminate the effects of age, sex and ethnicity for studies of mortality-risk factors. For public health purposes, the statistics on causes of death figure prominently. Death statistics have long been used as indicators of health, as measures of the magnitude of health problems and for the evaluation of health programmes, despite certain limitations of mortality data for this purpose. The availability of mortality statistics on a routine basis for the various political subdivisions of a country is of central importance to the utilization of death statistics for these manifold purposes.

An important use of mortality statistics is in the study of determinants of disease. For example, Pool and Chan[4] observed the differential decline in the tuberculosis mortality rate for the Maoris and attributed the decline to the disadvantageous position of the Maoris in New Zealand society until the 1940s. Poverty, poor diet and failure to seek medical treatment were cited as causes of the high mortality rate for the Maoris; and the decline was attributed to improved medical technology in the post-war period. Mass X-ray campaigns and the use of antibiotics were said to have contributed to the accelerated rate of decline.

Another example may be cited as a result of post-war experiences in a number of countries where national malaria control programmes were carried out and where significant reductions in the general mortality rate occurred. Data for six countries where such programmes had been in operation for at least five years and for which adequate data were available showed that in all the countries a rapid decline in the crude death rate and in the infant mortality rate invariably followed the countrywide application of dichlorodiphenyltrichloroethane (DDT).[5] The decline in mortality was most striking in Sri Lanka, where the crude death rate dropped from 20.3 to 14.3 per 1,000 population in a single year, 1946/47, after the beginning of the malaria eradication programme. Although there appeared to be little question about the dramatic decline in mortality in Sri Lanka, there was not general agreement as to the cause of the reduction. Meegama[6] attributed part of the decrease to malaria control and the rest to the establishment and provision of health and medical services. Fredericksen[7] found similar mortality reductions in nonmalarious areas not protected by pesticides, and concluded that the decline in mortality was associated with economic development and the consequent rise in the level of living. Newman,[8] on the other hand, took the position that it was not possible to disentangle the effects of the various factors that were operating at that period.

There are many other examples of epidemiological studies based on official mortality statistics. A study[9] was made of cancer mortality in countries where certain industries were located; and excessively high death rates were found for bladder, lung, liver and certain other cancer sites in 139 countries where the chemical industry was centred. In another study,[10] lung cancer mortality in counties in the United States of America where paper, chemical, petroleum and transportation industries were located was compared with that for adjacent counties where there were no such industries. Excessively high lung cancer death rates among males were observed in the counties where these industries were located, which may account for part of the rapid rise of lung cancer reported for the southern coastal counties in the United States. It was suggested that these particular industrial operations should be studied to ascertain the aetiology of lung cancer.

In the studies described thus far, the observed changes and differentials resulted in inferences leading to hypotheses about disease causation. There are also studies that begin with a hypothesis about a disease and accumulate data to test it. For example, in an effort[11] to ascertain whether naturally occurring asbestos resulted in increased risk of cancer mortality, the various counties in the United States with asbestos deposits were identified. Each of these counties was then matched with two others in the vicinity that did not have known asbestos deposits. The comparison of cancer mortality rates for the two sets of counties gave no evidence that naturally occurring asbestos is a hazard to the general population.

All the studies that have been cited have one characteristic in common: the investigations are based on traditional or official mortality statistics. As such, the data represent the result of various forces of mortality impinging on the general population as well as the special risk factors. Therefore, it is not possible to determine the effect of any particular factor. However, descriptive epidemiology is valuable in suggesting hypotheses or leads for further investigation.

For the testing of epidemiological hypotheses, it is necessary to include in the study measures of specific risk factors. This is the basis of the case control or the retrospective epidemiological study and the prospective epidemiological study.

In case-control mortality studies, the death certificate is employed to identify cases of a specific disease for retrospective epidemiological study. A follow-back is made to a data source for retrospective information on the specific aetiological factor under study, and a comparison is made between the exposed and the control group to establish whether the factor is associated with one group and not with the other. In this manner, retrospective studies[12] have been made of leukaemia and childhood exposure to X-rays, using the death certificate as the starting-point for the study. More recently, a case-control study[13] was undertaken to identify the factors associated with the unusually high lung cancer death rate among the male residents of coastal Georgia. It was found that the increased risk was associated with employment in the shipyards during the Second World War. It was also found that cigarette smoking produced a synergistic effect. The findings suggested that exposure to asbestos and possibly to other materials during wartime employment accounted for part of the excess mortality from lung cancer in the south-eastern coastal areas of the United States of America.

Prospective studies begin with a hypothesis about a disease and data are collected for two defined populations, the "experimental" group and the comparison or "control" group. These two population cohorts are then followed until an event (i.e., death in the case of mortality studies) occurs. The use of matched controls, that is, two populations similar in all controlled characteristics except for the factor being tested, provides a stronger base than retrospective studies for showing the effects of risk factors on mortality from a particular disease. Follow-up studies[14] or mortality from lung cancer among asbestos workers found lung cancer to be a specific environmental hazard of certain asbestos workers. A number of studies[15] on smoking and lung cancer were conducted on a prospective basis, as is the still ongoing investigation[16] of the delayed effects of ionizing radiation from the atomic bomb explosions at Hiroshima and Nagasaki. None of these studies would be possible without access to death records.

D. Advantages of a continuous registration system

A major advantage of a continuous registration system is the fact that once the system has been established on an adequate basis there will be a continuous flow of death records from the local registration units to a permanent repository to serve legal purposes. This flow makes possible the transcription or transmission of copies of death records to a central agency for data processing and statistical compilations.

Registration data deal with the entire universe of events, and many of the needed statistics are readily available annually. This availability is an invaluable feature of registration statistics in providing detailed all-purpose reference tables for various segments of the population that can be tapped for specific studies. It makes possible the conduct of analytical studies on numerous topics, either on a cross-sectional basis or over a period of time. The availability of trend data is a very important advantage of a continuous registration system.

The general availability of mortality data by various personal characteristics of the decedent, such as age, sex and ethnicity, for the country as a whole and for the different geographical divisions down to the smallest political subdivision, makes possible the utilization of mortality data for many purposes, as illustrated previously. Shapiro[17] points out that for local health planning purposes the availability of data for the past and present—and the likely availability for the foreseeable future—for geographically disaggregated levels down to subdivisions of a city makes up for many of the defects that may be present in mortality statistics. The question posed to the user of mortality data for planning purposes is how to maximize the utility of this resource, although conceptual and technical issues still remain.

The compiled data will, at least for developed counties with well-established systems, generally be comparable from place to place within a country, and from one time period to another. Such internal consistency is one of the remarkable characteristics of registration data. Also, because the definitions and classifications used in vital statistics are usually international in nature, there is a considerable amount of comparability in the data for the various countries.

The availability of statistics on causes of death and the possibility of obtaining other medical information through the follow-back procedure make registration statistics virtually indispensable for public health and medical programmes. Even developing countries may be able to generate useful cause-of-death data through a system of lay reporting. This is not as far-fetched as it may sound because in developing countries a large proportion of all deaths occur in the childhood years, and the common diseases of childhood are sometimes recognized by the mother or present characteristic symptoms that the mother can describe. These cases, plus accidental causes, do not require medical training for an adequate description of the cause of death.

It is difficult to ascertain the cost of registration statistics because a large part of the collection cost is borne by the legal registration process. However, it is probably fair to say that the unit cost of registration data from an established system is considerably less than that of data obtained from interview surveys.

The continuous flow of data on a permanent basis obviates the necessity of mounting periodic surveys with attendant high costs and possible changes in survey personnel, objectives, procedures and definitions. In addition to the statistics, the death registration system provides death records which make possible the identification of deaths of persons for use in communicable disease control and in other public health programmes, such as those covering maternal and child health. It also makes available death records for retrospective and prospective epidemiological studies. The General Register Office of England and Wales gives invaluable assistance in notifying epidemiologists of deaths occurring to members of a study cohort. In the United States, the National Center for Health Statistics is now establishing a national death index to provide similar services to those engaged in scientific investigations. These services make it possible to conduct epidemiological studies that would otherwise be impossible to carry out, except at exorbitant cost.

E. Disadvantages of a continuous registration system

There are a number of possible disadvantages to a continuous registration system. In developing countries, the most serious of these disadvantages is incompleteness of coverage. In most developing countries, access to the local registration offices is difficult in the rural areas. In many countries, special problems are posed by nomadic and indigenous populations. To complicate matters still further, there is very little incentive to register vital events even if there is awareness of the need to register deaths. The absence of the need for death certificates and the lack of awareness on the part of the public of the necessity to register deaths have been cited by civil registration authorities[18] as the greatest obstacles to registration improvement. Incomplete death registration, especially outside the major cities, is a primary impediment to the use of the data for mortality analysis. Another major factor is the quality of the local registration personnel in developing countries. Sometimes they are scarcely literate; almost always they are inadequately paid and untrained. As a result, the completeness and quality of the collected data are adversely affected. In addition, dealing with an illiterate population presents special problems in eliciting seemingly simple information, such as the age of the deceased; and the poor quality of the information concerning the characteristics of the deceased represents a further major complication in the use of the data for mortality studies.

The monolithic nature of the registration system, dealing with the total population of a country, is a definite disadvantage in any effort to make changes or otherwise to improve the system. Changes come slowly. The United States of America, an industrialized country with a literate population, took over 30 years to qualify all the states for the national death registration area.

In view of these problems, virtually all developing countries find themselves without adequate death statistics in their period of greatest need for data for social and economic planning and for health planning and administration of health programmes. Some countries are adopting other means of collecting data to fill the gap, while others are still struggling along with the registration of vital events.

F. Discussion

The continuous registration system offers data possibilities that cannot be achieved in any other way. Single-round and even multi-round surveys have not, in general, been successful in obtaining adequate counts of deaths.[19] A discussion[20] of the limitations of single-round surveys points out that mortality data for Algeria, the Niger, Uganda and the United Republic of Tanzania were never published because of the obvious defects in the information on deaths obtained from single-visit retrospective surveys. The basic problem is that it is extremely difficult to identify retrospectively persons who are no longer present. For example, deaths occurring in single-person households are not identifiable in retrospective surveys. Dissolution of the family or household may also occur upon the death of the head of the family or household, or of one of the spouses. In addition, there may be taboos or general reluctance about revealing the facts of death, especially to strangers. In all countries, it is difficult to obtain information on deaths of infants who die soon after birth. Other non-sampling problems also are encountered in social surveys, such as recall problems, erroneous dating of events and misreporting of age.

The indirect estimation methods are based on characteristics, mainly concerning the survival or otherwise of close relatives, of the living population obtained in a census or a survey. These data, such as proportions of surviving children of mothers at various ages or of persons at various ages with surviving mother, are transformed into mortality estimates for childhood and adulthood. The results of indirect estimation techniques are subject to errors from the above-mentioned non-sampling problems arising in census and social survey interviews. The validity of the estimates also depends upon the assumptions underlying the analytical development of the methods. In some cases, it is clear that the conditions were not met; while in others, it is difficult to judge the validity of the assumptions, although, in general, it has been found that typical deviations from the assumptions have only a modest impact on the estimates obtained.

For countries with no data at all or very inadequate mortality statistics, even the limited mortality measures provided by the combination of surveys and indirect estimation techniques are valuable for certain purposes. Also, estimates of the completeness of death reporting provided by indirect methods that have been developed[21] are useful approximations for assessment purposes. On the other hand, it seems apparent that the limitations of the survey and indirect methods of estimation are such that they cannot ever provide the type and amount of statistical data that are obtainable from death registration data. The advantages for analytical purposes of the data provided by a continuous registration process are so substantial that other methods cannot be regarded as adequate long-term substitutes for death registration data, although in the short and medium terms such other methods may represent the only feasible source of mortality data for some countries.

If there are no satisfactory alternatives to the continuous registration process, what are the possibilities of developing registration data within a reasonable time frame? This question is not easy to answer because there have not been outstanding developments in civil registration parallel to those in survey methodology and indirect estimation methods over the past 15-20 years. Perhaps this is because changes and improvements cannot be obtained quickly in a continuous registration system. To try to establish and improve a national registration system is simply too large a task for the usual staff and budget. Also, some problems are amenable to solution and others are not, depending upon the state of social and economic development of the country. Problems of civil registration have been classified by Linder[22] as follows:

(*a*) Relatively intractable problems: problems that can be solved within the framework of long-range social and economic development, but can scarcely be solved by short-range actions taken within the civil registration system itself;

(*b*) Problems that are soluble but require national or outside technical assistance funds;

(*c*) Soluble problems: problems that can be solved within the national domain with relatively small financial requirements.

Instead of tackling all the problems at once, Linder suggests that certain tasks should be deferred. One approach to improving the data is the adoption of registration areas. For example, the death registration area was established in the United States in 1900, beginning with 10 states (out of 48) and the District of Columbia. As the states qualified by adopting a standard death certificate form and by demonstrating that 90 per cent or more of deaths were registered, they were included in the registration area. By 1933, the registration area covered all the population in the country.

For developing countries, a beginning might be made with the capital city and major efforts devoted to the establishment of a satisfactory death registration system. After the registration system in the capital city is deemed operational, efforts should then be transferred, one by one, to the other major cities, leaving the difficult and sometimes sparsely settled rural areas to the last. A problem with this approach is that until coverage has become fairly extensive, the data will be limited to urban experience.

Another possible approach is that suggested by Hauser,[23] who proposed that a national sample vital statistics system be established comprising a sample of complete primary registration units or combinations thereof. This system would make possible the focusing of energy and funds on a limited number of primary registration units instead of dealing with all the units in the country at once. Data from a representative sample are certainly more desirable than data limited to urban areas, but it would be more complicated administratively to work on a number of non-contiguous primary registration units simultaneously. In addition, a review[24] of the experiences of a number of countries undertaking sample registration projects observes that most of the recent sample registration schemes have departed from the original concept and have established a sample system independent of the existing legal system. This is an unfortunate departure in that it defeats the original purpose of obtaining continuous improvement in the registration system.

As a strategy to improve civil registration in a country, it would appear to be sensible to concentrate activities on problems most amenable to solution in geographical areas with the greatest population where government services are more likely to be available to the public. Because of the nature of registration problems, a fully operational system cannot be expected overnight. A good deal of patience and persistence is needed.

The development of a death registration system requires a satisfactory legal base and an administrative organization of local offices. It also requires the understanding and co-operation of the public, of medical attendants and others in the healing arts, of hospitals and clinics, of undertakers and of those in charge of burial places and crematoria. An active and innovative programme is needed—not a passive waiting for death certificates to be filed. It is a long road to success but the reward at the end is worth while in terms of an invaluable data source to serve the health and demographic needs of the country.

Summary

Over the years, mortality statistics derived from the civil registration process have been used extensively for the delineation of public health problems and for various analytical studies for health and demographic purposes. In addition, the individual death record has been useful in identifying infective foci of disease as well as in the epidemiological studies of chronic diseases. Examples of various analytical uses of mortality statistics are also given. The most important feature of registration statistics is that they can provide detailed all-purpose reference tables annually, for various segments of the population, which can be tapped for specific studies. For public health purposes, a most valuable datum relates to causes of death.

The continuous registration system offers data possibilities that cannot be attained in any other way. On the other hand, death statistics for developing countries are frequently of limited usefulness because of incompleteness of the registered events. The improvement of completeness and quality of official death statistics in these countries is a difficult task requiring time and effort. Some suggestions have been made on steps that might be taken to develop and improve national death registration systems.

Notes

[1]John Graunt, *Natural and Political Observations Made upon the Bills of Mortality*, edited with introduction by Walter F. Willcox (Baltimore, Md., Johns Hopkins Press, 1939).

[2]William Farr, *Vital Statistics: A Memorial Volume of Selections from the Reports and Writings of William Farr*, introduction by Mervyn Susser and Abraham Adelstein (Metuchen, N.J., Scarecrow Press, 1975), History of Medicine Series, No. 46, published under the auspices of the Library of the New York Academy of Medicine. Reprint of the 1885 edition edited by Noel A. Humphreys and published by the Offices of the Sanitary Institute of Great Britain.

[3]For a full description of the civil registration procedure, see *Handbook of Vital Statistics Methods* (United Nations publication, Sales No. 55.XVII.1).

[4]D. I. Pool and K. K. Chan, "Differential declines in tuberculosis mortality", in *International Population Conference, London, 1969*. (Liège, International Union for the Scientific Study of Population, 1969), vol. II, pp. 1006-1012.

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[8]Peter Newman, "Malaria eradication and its effect on mortality levels: a comment", *Population Studies*, vol. 23, No. 2 (July 1969), pp. 285-288.

[9]William J. Blot and Joseph F. Fraumeni, Jr., "Geographic patterns of lung cancer: industrial correlations", *American Journal of Epidemiology*, vol. 103, No. 6 (June 1976), pp. 539-550.

[10]Robert Hoover and Joseph F. Fraumeni, Jr., "Cancer mortality in the U.S. counties with chemical industries", *Environmental Research*, vol. 9, No. 2 (April 1975), pp. 196-207.

[11]Thomas R. Fears, "Cancer mortality and asbestos deposits", *American Journal of Epidemiology*, vol. 104, No. 5 (November 1976), pp. 523-526.

[12]For example, A. J. Stewart, J. Webb and J. Hewitt, "A survey of childhood malignancies", *British Journal of Hospital Medicine*, vol. 1 (1978), p. 1495; Henry S. Kaplan, "An evaluation of somatic and genetic hazards of the medical uses of radiation", *American Journal of Roentgenology, Radium Therapy and Nuclear Medicine*, vol. 80, No. 4 (October 1958), pp. 696-706; and Brian MacMahon, "Prenatal X-ray exposure and childhood cancer", *Journal of the National Cancer Institute*, vol. 28, No. 5 (May 1962), pp. 1173-1191.

[13]William J. Blot and others, "Lung cancer after employment in shipyards during World War II", *The New England Journal of Medicine*, vol. 299, No. 12 (21 September 1978), pp. 620-624.

[14]Richard Doll, "Mortality from lung cancer in asbestos workers", *British Journal of Industrial Medicine*, vol. 12, No. 2 (April 1955), pp. 81-86; and J. F. Knox and others, "Mortality from lung

cancer and other causes among workers in an asbestos textile factory", *British Journal of Industrial Medicine*, vol. 25, No. 4 (October 1968), pp. 293-303.

[15] For example, Richard Doll and A. Bradford Hill, "Lung cancer and other causes of death in relation to smoking: second report on mortality of British doctors", *British Journal of Medicine*, vol. 2 (10 November 1956), pp. 1071-1081; and Harold F. Dorn, "Tobacco consumption and mortality from cancer and other diseases", *Public Health Reports*, vol. 74, No. 7 (July 1959), pp. 581-593.

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[17] Sam Shapiro, "A tool for health planners", *American Journal of Public Health*, vol. 67, No. 9 (September 1977), pp. 816-817.

[18] International Institute for Vital Registration and Statistics, *Major Obstacles to Achieving Satisfactory Registration of Vital Events and the Compilation of Reliable Vital Statistics*, Technical Papers, No. 15 (Bethesda, Md., 1981).

[19] See W. Parker Mauldin, "Estimating rates of population growth", in *Family Planning and Population Programs: A Review of World Development*, Bernard Berelson and others, eds. (Chicago, Ill., University of Chicago Press, 1966), pp. 635-654; and William Brass, "A critique of methods for estimating population growth in countries with limited data", *Bulletin of the International Statistics Institute; Proceedings of the 38th Session*, vol. 44, No. 1 (1971), pp. 397-412.

[20] Anders S. Lunde, *The Single-Round Retrospective Interview Survey*, International Program of Laboratories for Population Statistics Scientific Report Series, No. 24 (Chapel Hill, N.C., University of North Carolina, 1976).

[21] See, for example, Samuel H. Preston and others, "Estimating the completeness of reporting of adult deaths in populations that are approximately stable", *Population Index*, vol. 46, No. 2 (Summer 1980), pp. 179-202.

[22] Forrest E. Linder, "Problems of improving vital registration systems in developing countries", in *International Population Conference, Manila, 1981* (Liège, International Union for the Scientific Study of Population, 1981), v. 3, pp. 305-320.

[23] Philip M. Hauser, "The use of sampling for vital registration and vital statistics", *Bulletin of the World Health Organization*, vol. 2, No. 11 (1954), pp. 5-23.

[24] Forrest E. Linder, "Measurement of population control programs: design problems of sample registration systems", in *Contributed Papers: 37th Session, International Statistical Institute, London, 1969* (The Hague, 1969), pp. 50-52.

VII. USE OF SAMPLE REGISTRATION SYSTEMS FOR STUDYING LEVELS, TRENDS AND DIFFERENTIALS IN MORTALITY: THE EXPERIENCE OF INDIA*

*P. Padmanabha***

Mortality is one of the principal components of population change. An accurate measurement of mortality is required in order to analyse the demographic status of a population and its potential growth, to meet administrative needs relating to public health programmes, to formulate policy and to evaluate health programmes, with particular reference to preventive measures. Mortality statistics yielding information on the number of deaths in a year by geographical divisions also help to identify areas that require greater medical and health facilities. Mortality statistics classified by age, sex and socio-economic characteristics permit the identification of vulnerable and target groups of the population for whom the necessary health and medical care must be provided. Data on causes of death form the basis for taking preventive and curative measures against communicable and other diseases and, in general, for improving the health conditions of the people in a given area.

The main sources of mortality data in India are: (*a*) the civil registration system; (*b*) population censuses; and (*c*) sample surveys, including both the Survey on Cause of Death and the Sample Registration System. In this chapter, the civil registration system, population censuses and the Survey on Cause of Deaths are briefly reviewed; the Sample Registration System is then discussed in detail.

A. Civil registration system

The civil registration system is a conventional method of obtaining data on vital events in which events are reported and recorded shortly after their occurrence. This system is a potential source of mortality data. Because in the civil registration system these events are, in theory, reported and recorded when they occur, the coverage should normally be more complete and the accuracy of the information better than in a reporting system that depends upon a later visit by an interviewer and involves recall of facts by a respondent.

The registration of vital events, which is basically the recording of births and deaths, has been in effect in India for over 100 years and the administrative system for civil registration is fairly well established. Through enforcement of the Registration of Births and Deaths Act of 1969, the recording of such vital events and the compilation of vital statistics throughout the country has been systematized. However, the registration system cannot be said to have been firmly established throughout the country and there is considerable scope for improvement in terms of coverage and accuracy.

Efficient operation of the civil registration system depends upon the co-operation and co-ordination of staff drawn from the various departments engaged in the collection of such data and, to a very great extent, upon the awareness among the people of the need for registering such vital events. In India, the collection of vital events through the traditional civil registration system is handicapped by low levels of literacy, particularly in the rural areas, and by insufficient appreciation of the utility of such registration and the general inadequacy of the registration hierarchy. The system is continuously monitored and evaluated, and steps for improvement are being undertaken, but complete coverage under the Act is not likely to be achieved in the very near future.

Mortality data provided by the civil registration system include the age, sex, nationality and religion of the deceased; the place of death, the cause of death, whether the cause of death was medically certified and the type of medical attention received at the time of death. Information on stillbirths is also collected separately. The data on mortality are tabulated broadly by: (*a*) age and sex; (*b*) month of occurrence; (*c*) cause, age and sex; (*d*) infant deaths by age and cause; and (*e*) maternal deaths by age at death.

Cause-of-death statistics from civil registration system

In India, the Registration of Births and Deaths Act of 1969 provides for medical certification of the cause of death. The introduction of such certification procedures is left to the state governments, depending upon the facilities available in a given area. The Act provides for medical certification of the cause of death by the medical practitioner who attended the deceased during the illness; and wherever this procedure is introduced, registration of a death is dependent upon the availability of such a certificate. The provisions of

*The original version of this chapter appeared as document IESA/P/AC.17/7.

**Registrar General, Ministry of Home Affairs, New Delhi, India.

the Act are being tested through a scheme of "Medical Certification of Cause of Death", which envisages the gradual introduction of medical certification beginning with institutional deaths. To date, the scheme has been introduced mainly in district and teaching hospitals and it is still at an experimental stage. The form of certificate contains the particulars available in the international form suggested by the World Health Organization (WHO). The data on medically certified cause of deaths are available for about 7 per cent of total registered deaths in 1977. The data are classified according to the "A" list of the International Classification of Diseases.[1]

Evaluation of civil registration system

The data generated from civil registration systems are often deficient, both qualitatively and quantitatively. Births and deaths are often not reported because there is no overt advantage from such registration of events. In particular, infant deaths are often missed. Methods have been devised to estimate the extent of underreporting of such events. One of the methods is the matching of events recorded in the registration records with the results of an independent survey using a set of matching criteria. Another analytical technique developed by Brass[2] makes use of census age distributions and child survivorship data.

In India, the Office of the Registrar General conducted an underregistration survey in 1966 in rural areas of various states. The sample units were those selected for a sample census which was then in operation. The vital events occurring to normal residents present and to visitors were copied from the sample census schedules and matched with events that were registered in the civil registration records. By assuming that events recorded by the survey that could not be matched in the registration records represented omissions from the registration records, the extent of underreporting of vital events was estimated. In the 342 villages covered, the survey revealed that the extent of underregistration of deaths was 41.5 per cent at the national level. At the state level, the extent of underregistration varied over a considerable range.

On the basis of the technique developed by Brass, the birth and death registration during the period 1961-1971 was evaluated for the major states of India and for the country as a whole. At the national level, the extent of underregistration of deaths of children in age group 0-9 years was found to be 64 per cent; and it varied from state to state. Table VII.1 shows the extent of underregistration among children aged 0-9 years as estimated by this technique for the major states.

TABLE VII.1. UNDERREGISTRATION OF DEATHS OF CHILDREN UNDER AGE 10 BY CIVIL REGISTRATION SYSTEM FOR THE PERIOD 1961-1971 ON THE BASIS OF THE 1971 CENSUS POPULATION, USING THE BRASS TECHNIQUE, STATES OF INDIA

(Percentage)

State	*Underregistration of child deaths 1961-1971*
Andhra Pradesh	71
Assam	94
Bihar	76
Gujarat	55
Haryana and Punjab (combined)	22
Kerala	70
Madhya Pradesh	70
Maharashtra	23
Karnataka	59
Tamil Nadu	44
Uttar Pradesh	78
West Bengal	72
India	64

Source: Calculations from Office of the Registrar General, India.

B. POPULATION CENSUSES

One source for mortality measurement is the national population census, which provides data on the age composition of the population from which the level of mortality can be estimated. Direct data on deaths are not generally obtained in a census; it is difficult to gather information on deaths by including a question relating to those who had died in the year immediately preceding the census, since the recording of a death depends heavily upon whether there were survivors of the deceased in the household and whether the survivors recall the event as having occurred during the correct time period. The reporting of deaths of young children is particularly sensitive to such problems. In a large-scale operation like a census, it would not be feasible to carry out probes at the time of data collection.

Mortality data from censuses

The decennial censuses of India, *inter alia*, provide data on the distribution of the population by age and sex. On the basis of such data from two consecutive censuses, it is possible to estimate the general level of post-childhood mortality during the intercensal period by using intercensal-survival techniques. However, the census age returns are subject to age-misreporting. Problems with age-misreporting and age-heaping can be partially solved by resorting to cumulation or with the aid of polynomials. Other techniques based on census age distributions are the application of stable- and quasi-stable-population techniques. Although these techniques are useful in many developing countries, their assumption of constant fertility requires serious consideration. Table VII.2 shows estimates of the crude death rate for India for intercensal periods from 1881 to 1971, derived from the application of intercensal-survival procedures to successive pairs of census age distributions, with additional information concerning childhood mortality.

Limitations of censuses

The census does not provide estimates of mortality, on a current and continuing basis, of the type needed to measure short-term changes in population growth for various purposes, such as projection of population

TABLE VII.2. ESTIMATED ANNUAL DEATH RATES, INDIA, 1881-1891—1961-1971, *(Per 1,000 population)*

Period	*Death rate*
1881-1891	41.3
1891-1901	44.4
1901-1911	42.6
1911-1921	48.6
1921-1931	36.3
1931-1941	31.2
1941-1951	27.4
1951-1961	22.8
1961-1971	19.0

Sources: For periods up to 1941, as estimated by Kingsley Davis, *The Population of India and Pakistan* (Princeton, N.J., Princeton University Press, 1951); for periods after 1941, as calculated by the Census Actuary, India.

and evaluation of various health and child care programmes. There is a constant need for this type of data, necessitating the development of other sources. Household demographic sample surveys provide an alternative source for the collection of mortality statistics.

C. SURVEY ON CAUSE OF DEATH

The Survey on Cause of Death has been introduced in 982 primary health centres in rural areas of India. These statistics are obtained through a system of lay reporting, which is still being tried out. The field-work is carried out by paramedical personnel (referred to as "field agents") stationed at these centres. The field agent is usually a Sanitary Inspector or a Health Inspector. The number of primary health centres selected for this survey is based on the norm of at least one unit per million population; currently, almost all the districts in India are covered by the survey.

In this system, the field agent contacts local resident informants regularly at short intervals. He obtains the addresses of the households where deaths have occurred since his last visit, and he visits those households to investigate the symptoms and conditions preceding the death in accordance with a non-medical list. The instructions prescribe the procedures on the basis of which the field agent would be able to arrive at the probable cause of death. A list comprising 11 major cause groups and their conspicuous symptoms, with subdivisions into numerous possible specific diseases, is provided to the field agent, who must first ascertain the major cause group in which the death may fall and then determine the specific cause by investigation of the symptoms. The non-medical list provided to the field agent maintains comparability with the major cause groups in the WHO International Classification of Diseases.

To achieve greater qualitative and quantitative reliability, the data are reviewed through inspection by an independent agency. All the events observed by the field agent in a month are reported to the recorder in the primary health centre and the recorder is required to check consistencies in the reports he receives. The doubtful cases are referred back to the field agent. The process of checking may involve clerical corrections of the record or a revisit to the concerned household for verification of the cause of death. After this initial check at the level of the recorder, the Medical Officer in charge of the primary health centre scrutinizes the reported causes of death in greater detail. He is required to reinvestigate at least one out of every 10 deaths in a month through a personal visit. Such rechecks have two advantages: they ensure the accuracy of the data; and they promote a sense of discipline and responsibility among the field agents.

At the end of every six-month period, a cross-check survey is conducted by the recorder or an agency other than the field agent. In this survey, events occurring during the previous six months are recorded; these data are then tallied with those recorded by the field agents. The unmatched events are jointly investigated and a corrected list of events is compiled. This biannual survey helps both to update the information about the number of events and to reveal deficiencies in the work of particular field agents.

One of the difficulties in implementing this scheme is that very little direct verification can be made of the information obtained and recorded by the field agent. The biannual surveys and the checks made by the Medical Officer are indirect methods for ensuring reliability of the data. There are certain constraints in any inquiry about the cause of death. In certain circumstances, social and other considerations affect the process of determining the probable cause of death. Errors may also arise from the bias of the respondent, from the predilections of the interviewer or from incorrect interpretation of replies. Nevertheless, the checks introduced in the system for detection and evaluation undoubtedly help to minimize gross misreporting. Another limitation of this survey is that the collection of data is currently restricted to the headquarters village of the primary health centre; the data do not, therefore, provide a true picture of the mortality pattern at either the state or the national level.

The data obtained through this system are tabulated by age, sex and the following major cause groups: (*a*) accidents and injuries; (*b*) childbirth complications; (*c*) fevers; (*d*) digestive disorders; (*e*) disorders of the respiratory system; (*f*) disorders of the central nervous system; (*g*) diseases of the circulatory system; (*h*) other clear symptoms; (*i*) causes peculiar to infancy; (*j*) senility; (*k*) other causes.

D. SAMPLE SURVEYS ON BIRTHS AND DEATHS

Because of the difficulty of obtaining dependable data on vital rates, on a current and continuing basis, from the combination of a civil registration system and periodic censuses, alternative methods of obtaining such information have been devised through the use of sample surveys. These methods include single-round retrospective surveys, multi-round prospective surveys and dual-record systems. In single-round retrospective surveys, information is collected on vital events that occurred to members of the households during a fixed reference period, usually the 12 months preceding the inquiry. Experience in censuses and surveys has shown that it is difficult to obtain reliable information about vital events that occurred during a given reference period by inquiring about them in a single-round retrospective survey, because of recall lapse. Multi-round surveys consist of making periodic observations in the same set of sample areas through repeated interviews. The dual-record system makes use of two independent records of vital events based on continuous registration and prospective household surveys. The two records are matched event by event and the doubtful cases are reverified in the field to attempt to obtain an unduplicated and exhaustive count of vital events.

Earlier surveys in India

Most of the earlier studies on mortality in India were fragmentary in nature and were restricted to local areas; hence, they did not provide usable estimates at the state or the national level. The sample censuses conducted by the Office of the Registrar General during 1960, 1964 and 1965-1967 also collected information on deaths. The data obtained from the sample censuses were found to be unreliable due to response bias. Single-round retrospective surveys conducted by the National Sample Survey Organization (NSSO) since 1958 have attempted to provide comprehensive data on all aspects of the population. Information has been collected on vital events that occurred to members of sample households during the 12 months preceding the inquiry.

Such single-round retrospective surveys may be expected to suffer from recall lapse and dating errors. Although methods have been devised to adjust for such shortcomings of the data, these methods cannot always be considered universally applicable, because the pattern of errors is unlikely to be consistent in space and time. The data on mortality obtained through various rounds of the National Sample Survey are presented in table VII.3.

TABLE VII.3. ESTIMATED DEATH RATES AND INFANT MORTALITY RATES OBTAINED FROM THE NATIONAL SAMPLE SURVEY, INDIA, JULY 1958-JUNE 1959—JULY 1968-JUNE 1969

	Death rate (per 1,000 population)		*Infant mortality rate (per 1,000 live births)*	
Period	*Rural*	*Urban*	*Rural*	*Urban*
July 1958-June 1959	19.0	. .	146	. .
Re-enumeration Survey, 1959	21.2	. .	. .	. .
July 1959-June 1960	15.1	. .	. .	. .
July 1960-June 1961	. .	7.8	. .	69
Sept. 1961-July 1962	12.0	8.0	111	81
Feb. 1963-June 1964	12.4	8.1	128	90
July 1964-June 1965	15.1	8.5	141	99
July 1965-June 1966	12.2	5.5	108	67
July 1966-June 1967[a]	11.1	7.1	112	80
July 1967-June 1968	11.3	7.2	111	78
July 1968-June 1969	10.1	7.4	87	70

[a]Data relate to the first subround covering July-August 1966.

E. SAMPLE REGISTRATION SYSTEM

The Sample Registration System in India is a dual-record system; its main objective is to provide reliable estimates of birth and death rates at the national and subnational levels. The system was initiated by the Registrar General in 1964/65, on a pilot basis, in a few selected states. It currently covers almost the entire country. The Sample Registration System is based on the concept that with an adequate machinery for recording of births and deaths as they occur, together with a prospective survey and proper supervision at all levels, it is possible to obtain reliable estimates of vital rates. It combines the advantages of both continuous registration and prospective survey procedures.

Structure of the system

The field investigation of the Sample Registration System consists of continuous recording of births and deaths by an enumerator and an independent survey every six months by an investigator. The data obtained through these two operations are then matched. The unmatched and partially matched events are reverified in the field in order to obtain an unduplicated count of births and deaths.

An initial complete listing of houses and households is done by the enumerator; the list is then updated at each biannual survey by the investigator to obtain the current population. One enumerator (recorder), who is a schoolteacher normally resident in the area, is appointed in each sample unit and is paid a small honorarium for this work. He is expected to record the births and deaths occurring in the sample unit as well as those occurring to usual residents while outside the sample areas. Events to visitors occurring within the sample area are also noted but are not considered in computing vital rates. Thus, the events to be recorded by the enumerator cover: (*a*) the usual resident present in the sample unit (URP); (*b*) the usual resident absent from the sample unit (URA); (*c*) visitors living in the sample unit (V). In order to ensure a complete recording of events, the enumerator uses several means to keep himself informed about the occurrence of events in the sample areas. These means include use of an informant system in which the enumerator receives help from a village midwife (*dai*), a village priest or a watchman (*chowkidar*), who reports the occurrence of events; maintenance of a list of pregnant women; house-to-house visits once a month in urban areas and quarterly in rural areas; and visits to hospitals, primary health centres and burial grounds.

The investigator conducts the retrospective survey in January and July of each year. He is expected to list all births and deaths pertaining to usual residents (both URP and URA) and to visitors (occurring within the sample unit) during a fixed period of six months. Simultaneously, he updates the household population listed in the household schedule by adjustment for births, deaths and migration. He also pays periodic visits to the sample unit for supervising the work of the enumerator and for providing necessary guidance and clarifications.

After the completion of the six-month survey, the two sets of records of the enumerator and the investigator are matched event by event at the state or district headquarters and are classified as matched, partially matched or unmatched. Matching is done on the basis of the location of the household, the name of the head of the household, the name of the mother for births and the name of the decedent in the case of deaths, residential status (URP, URA or V), sex of the child or the decedent and the month in which the event occurred. After the initial matching is completed, the partially matched and unmatched events are reverified in the field to determine the correct position. The reverification is usually carried out by an independent official. In this way, an unduplicated count of births and deaths is obtained. Thus, the essential features of the Sample Registration System are:

(*a*) A baseline survey of the sample unit to obtain the usual resident population of the sample area through a household schedule;

(*b*) Continuous (longitudinal) recording of vital events pertaining to the usual resident population by a locally resident enumerator (recorder);

(*c*) An independent biannual survey of births and deaths by an investigator and the updating of the household schedule;

(*d*) Matching of events enumerated by continuous recording and those listed during the biannual survey;

(*e*) Field reverification of unmatched and partially matched events.

Sample design

A single-stage, stratified simple random sample has been adopted for rural areas. Each state was first stratified on the basis of natural divisions, which were further substratified by size classes of population. Inhabited villages were classified into four population size classes on the basis of the 1961 census: (*a*) fewer than 500; (*b*) 500-999; (*c*) 1,000-1,999; (*d*) 2,000 and over. Villages with a population of over 2,000 were broken up into segments having approximately equal population and not exceeding 2,000 each. The sample units were allocated to the different strata in a proportion of stratum population. The sample unit is a village or a segment of a village if it had a population of over 2,000 in 1961.

In the urban areas, the sample design comprises a two-stage stratified simple random sample with towns or cities as primary sampling units and census blocks as second-stage units. The population of a census block ranges between 750 and 1,000. Towns and cities within a state were first stratified according to 1961 census population as:

(a) *Stratum I:* towns with a population of 100,000 and over;

(b) *Stratum II:* towns with a population of 50,000-99,999;

(c) *Stratum III:* towns with a population of 20,000-49,999;

(d) *Stratum IV:* towns with a population under 20,000.

Sample units were allocated over the four strata in proportion to their population. All cities in stratum I were included. The other towns and the blocks were selected on a simple random-sample basis. In allocating the number of sample blocks to these cities and towns, it was ensured that each area should have at least two blocks.

The sample size for rural areas was determined by using a binomial model assuming the value of the parameter to be 0.04 (or a birth rate of 40 per 1,000) with a coefficient of variation of 1 per cent. In each of the major states, there were 150 sample units in rural areas. In urban areas, the sample size varied from 60 to 100 census blocks.

The Sample Registration System originally operated in 3,700 sample units selected from the 1961 census frame, of which 2,400 units are in rural areas. It covered a population of 4.2 million, representing about 0.7 per cent of the rural population and 1 per cent of the urban population. Recently, another 1,700 sample units were added from the 1971 census frame to the existing sample units, with a view to increasing the precision of the estimates. Of these additional units, 1,252 are in rural areas. Thus, the total population covered is over 5.7 million.

The Registrar General of India is responsible for overall co-ordination and implementation of the system. In the states, the system is under the control of one of three agencies—the Director of Census Operations, the Bureau of Economics and Statistics or the Directorate of Health Services—depending upon the availability of suitable field personnel at the time the scheme is initiated in a state. A nucleus staff is provided at the state headquarters for overall direction and administration of the project.

In addition to information by age, sex and marital status as collected in the household schedule, data on births and deaths are also recorded.

The data on births include:

(*a*) Place of birth;

(*b*) Data of birth;

(*c*) Live birth or stillbirth;

(*d*) Single or multiple birth;

(*e*) Sex;

(*f*) Particulars of the mother: (i) residential status (URP, URA or V); (ii) age; (iii) religion;

(*g*) Type of attention at delivery.

The following data are obtained for deaths:

(*a*) Place of death;

(*b*) Date of death;

(*c*) Particulars of the deceased: (i) name; (ii) relation to head of household; (iii) residential status (URP, URA or V); (iv) sex; (v) age at death; (vi) marital status; (vii) religion; (viii) medical attention before death.

Sources of errors in Sample Registration System

The Sample Registration System is subject to three sources of errors: (*a*) sampling errors; (*b*) non-sampling errors; (*c*) matching errors.

Sampling errors

The standard error and the coefficient of variation for death rates have been pooled for the years 1975-1977 and are presented for major states in table VII.4. The sampling variability measured by the coefficient of variation of death rates in urban areas is higher than that of rural areas. At the national level, the coefficient of variation of the death rate is slightly over 1 per cent. At the state level, it varies from 2 to 6 per cent.

Non-sampling errors

In any survey, non-sampling errors require attention. Such errors are of particular importance in the Sample Registration System because of the variety of hierarchies involved and the repetitive nature of the survey. Among the causes contributing to non-sampling errors in this system are the fact that some of the sample units are not easily accessible, which often results in the enumerator attempting to avoid carrying out the survey in full; the lack of rigour in supervision due to the survey deteriorating into a routine, which, incidentally, also affects training; the ennui of the enumerator over a period of time due to the long retention of a given sample; and the decrease in the interest of the household itself due to the constant visits of the enumerator. The non-sampling errors that are owing to these contributory causes cannot be quantified but they do have an effect on the quality and, consequently, on the results of the survey.

Many of these causes could be removed by continuous administrative evaluation and review. Several measures have been taken to minimize these causes of error; some of these measures are indicated below:

(*a*) Each investigator has been assigned 10 sample units. He is required to carry out regular inspection of the work of the enumerator who does the continuous enumeration. Higher level staff, such as a Tabulation Officer, an Assistant Director or the State Supervisory Officer, also supervise the work of the enumerators and investigators. Corrective steps are taken in those units where the work is found to be unsatisfactory. The investigator and the supervisory officer are required to submit an inspection report in a prescribed format. The performance of the enumerators and investigators is evaluated on the basis of the inspection report and corrective steps are taken when necessary;

(*b*) An assessment of the efficiency of the enumerators and investigators is made by classifying the total number of events recorded as: (i) common events; (ii) events recorded by the enumerator but missed by the investigator; (iii) events recorded by the investigator but missed by the enumerator; (iv) events missed by both. Units where the number of events is low over a period of time are identified and inspection of those units is carried out by higher level staff;

(*c*) Periodic training workshops are conducted for supervisory staff and enumerators. These workshops cover such aspects as concepts and definitions, duties and mode of operation of the basic field-workers, type of events missed and type of probing questions to reduce omission of events and type of check to be exercised by the field staff. To ensure uniform concepts and a high standard of work, four manuals have been prescribed separately, for enumerators, for supervisors, for headquarters staff and for matching;

(*d*) The Sample Registration System envisages a built-in check of the enumerators' work through the biannual retrospective survey by the investigator. In order to ensure that there shall be no collusion between the enumerator and the investigator, the monthly records of births and deaths of the enumerators are withdrawn from the sample unit before the investigator conducts the biannual survey. Furthermore, he exercises supervision over 10 sample units, but he conducts the biannual survey in another set of 10 units;

(*e*) The well-defined boundaries of the geographical area of the sample unit, the maps of the sample areas and the permanent house-numbering system are designed to ensure a true estimate of the population at risk. Since the population in the sample area is being updated at six-month intervals and births and deaths, as well as in-migration and out-migration, are recorded, it is possible to make an arithmetic check; the investigators are required to do so.

Matching errors

In the Sample Registration System, matching is done in two phases. The first phase is the initial matching or desk matching, event by event, on the basis of the five characteristics or criteria listed above. It is neither feasible nor necessary to select all items of information on each vital event collected under the two methods; therefore, only a few core items are selected for matching purposes. The items are such that it is possible to identify the event unambiguously,

TABLE VII.4. SAMPLING VARIABILITY OF SAMPLE REGISTRATION SYSTEM DEATH RATES, STATES OF INDIA, 1975-1977

State	*Death rate (per 1,000 population)*	*Standard error*	*Coefficient of variation (percentage)*
Andhra Pradesh	14.7	0.43	2.9
Assam	14.9	0.86	5.7
Gujarat	15.2	0.45	3.0
Haryana	13.0	0.63	4.8
Karnataka	11.3	0.39	3.5
Kerala	7.9	0.19	2.5
Madhya Pradesh	17.6	0.66	3.8
Maharashtra	11.8	0.35	2.9
Orissa	15.3	0.70	4.2
Punjab	10.9	0.40	3.7
Rajasthan	15.1	0.61	4.1
Tamil Nadu	14.4	0.39	2.7
Uttar Pradesh	20.7	0.56	2.7
India	15.2	0.17	1.1

with no difficulty in matching. The second phase consists of the reverification of partially matched and unmatched events, usually by a third party through a field visit, in order to reconcile discrepancies.

Principal results and evaluation

Mortality indicators: comparison with other sources

The Sample Registration System has provided estimates of death rates and of infant mortality and its components since 1970, at both the state and national levels. It has also yielded mortality differentials by age and sex. Table VII.5 presents the death rates and infant mortality rates for rural and urban areas at the national level.

Alternative mortality estimates have been calculated by the Census Actuary for the periods 1951-1961 and 1961-1971. For the period 1961-1971, the death rate and infant mortality rate derived by the Census Actuary are 19.0 and 129, respectively. The levels on the basis of the Sample Registration System for the period 1970-1974 are 15.5 and 131, respectively. A comparison of these estimates would indicate that there has been a definite decline in mortality from the level of 19.0 in 1961-1971 to 15.5 during the period 1970-1974. However, the infant mortality rate, 131, on the basis of the Sample Registration System for the period 1970-1974 is the same as that for the period 1975-1978, indicating that the level of infant mortality has remained more or less constant. The estimates of the Sample Registration System can thus be seen to be consistent with the alternative estimates developed by the Census Actuary. Furthermore, the death rate from the Sample Registration System for the period 1975-1978 is 15.0, which supports the view that mortality has continuously declined.

Another method to evaluate the completeness of death registration by the Sample Registration System is the application of the "growth balance equation" proposed by Brass,[3] which is based on the equation:

$$P(Y)/P(Y+) = r + f\,D(Y+)/P(Y+)$$

where $P(Y)$ = number of persons of exact age Y;

$P(Y+)$ = total number of persons aged Y and over;

r = annual growth rate;

$D(Y+)$ = number of deaths occurring to persons aged Y and over;

f = reciprocal of the completeness of death registration.

The assumptions involved in this technique are that the population is stable, that coverage is the same at all ages and that age-reporting is accurate. The use of cumulation is likely to smooth out some of the effects of age errors. It has been found[4] that the bias introduced in estimating the degree of completeness of death registration is relatively small when stable populations are destabilized by prolonged mortality changes that occur slowly. The effects of recent changes in fertility affect mainly the younger age groups and as such would have little impact on the performance of this method of estimation. In a population where mortality has been declining, the method gives a lower limit of the degree of completeness of death registration.

This method has been applied to the Sample Registration System data for deaths for 1976/77 separately for males and females. The points corresponding to $P(Y)/P(Y+)$ and $D(Y+)/P(Y+)$, when plotted on a graph, show in general a linear trend, excluding the final point. The results indicate that the completeness of death registration is 0.970 for males and 0.965 for females. Thus, the application of this method suggests that death registration by the Sample Registration System is almost complete for both sexes.

Infant mortality by sex: evaluation of results

Table VII.6 presents the infant mortality rates by sex at the national level. The rates for each year from 1970 to 1978 for both sexes shown in this table suggest little or no trend, although there are some fluctuations from year to year.

An indirect method of evaluating the levels and trends of infant mortality as obtained from the Sample Registration System is the application of Feeney's method[5] of estimating infant mortality rates from child survivorship data by age of mother. The method uses the proportions of children dead, Q, by age group of

TABLE VII.5. RURAL AND URBAN DEATH RATES AND INFANT MORTALITY RATES AT NATIONAL LEVEL, INDIA, 1970-1978

Year	Death rate (per 1,000 population)			Infant mortality rate (per 1,000 live births)		
	Rural	Urban	Total	Rural	Urban	Total
1970	17.3	10.2	15.7	136	90	129
1971	16.4	9.7	14.9	138	82	129
1972	18.9	10.3	16.9	150	85	139
1973	17.0	9.6	15.5	143	89	134
1974	15.9	9.2	14.5	136	74	126
1975	17.3	10.2	15.9	151	84	140
1976	16.3	9.5	15.0	139	80	129
1977	16.0	9.4	14.7	141	81	130
1978	15.3	9.4	14.2	136	70	125

Source: India, Sample Registration System.

TABLE VII.6. INFANT MORTALITY RATES AT NATIONAL LEVEL, BY SEX, INDIA, 1972-1978
(*Per 1,000 live births*)

Year	Infant mortality rate: Male	Female	Both sexes
1972	132	148	139
1973	132	135	134
1976	124	135	129
1977	124	135	130
1978	120	131	125

Source: India, Sample Registration System.

mother and the mean age of childbearing, M. The estimates of the infant mortality rate and the corresponding reference period are obtained from a set of relations that are functions of Q and M.

The accuracy of the estimates derived by this method depends upon the reliability of the data collected on the total number of children born alive and the children surviving. If data on child survivorship are not accurately recorded, the levels of infant mortality obtained by this method are likely to be affected.

Feeney's method has been applied to data on child survivorship obtained from the Survey on Infant and Child Mortality undertaken in 1979 in a subsample of 25 per cent of the Sample Registration System households. The results, by sex, shown in table VII.7, indicate no appreciable change in the level of infant mortality in the recent past for either males or females. Although the levels of infant mortality are lower than those obtained by the Sample Registration System, possibly due to recall bias in the reporting of child survivorship data, the trend indicated by the method agrees with that observed in the Sample Registration System. It is also interesting to note that infant mortality among females, in general, is higher than that among males. The high estimate of infant mortality based on information obtained from the youngest women is a typical feature of such analyses, possibly arising from selection bias (although it may partially be due to better recording in this age group).

Age-specific death rate of children aged 0-4 years: evaluation of results

Table VII.8 shows the age-specific death rates of children in age group 0-4 years for representative years, based on the Sample Registration Survey.

TABLE VII.7. ESTIMATED INFANT MORTALITY RATES AND REFERENCE PERIODS,[a] BY AGE GROUP OF REPORTING WOMEN, INDIA
(*Rate per 1,000 live births*)

Age group of women	Males: Infant mortality rate	Males: Reference period[a]	Females: Infant mortality rate	Females: Reference period[a]
20-24	125.2	2.2	111.6	2.8
25-29	103.8	4.4	102.4	4.8
30-34	99.5	6.6	103.1	7.1
35-39	100.3	9.1	107.4	9.7
40-44	100.0	12.1	108.9	12.8
45-49	99.7	15.3	109.3	16.0

Source: India, 1979 Survey on Infant and Child Mortality.
[a]Number of years prior to the survey to which estimates refer.

TABLE VII.8. DEATH RATE OF CHILDREN AGED 0-4 YEARS, BY SEX, INDIA, 1971-1978
(*Per 1,000 population*)

Year	Death rates for age group 0-4: Male	Female	Both sexes
1971	49.2	54.8	51.9
1972	53.2	61.7	57.3
1973	48.9	56.0	52.3
1974	47.0	53.4	50.0
1976	49.6	51.9	51.0
1977	47.5	54.5	50.9
1978[a]	49.9	50.4	50.1

Source: India, Sample Registration System.
[a]Figures taken from Survey on Infant and Child Mortality, based on a 25 per cent subsample of Sample Registration System households.

The proportion of deaths of children in age group 0-4 to total deaths according to the Sample Registration Survey is given in table VII.9.

It can be seen that nearly 47 per cent of the total number of deaths is attributable to deaths in age group 0-4. Any improvement in child mortality would considerably reduce the general death rate in India, because child mortality is a very important component of the level of that rate.

An indirect method of estimating childhood mortality from child survivorship data has been developed by Trussell.[6] The procedure converts the proportions of children dead among children ever born reported by women in successive five-year age groups in the reproductive period into probabilities of dying before attaining certain exact childhood ages. Thus, if $D(i)$ denotes the proportion of children dead among children ever born to women in the ith age group and $q(x) = 1 - l(x)$ is the probability of dying between birth and exact age x, the basic relation is of the form:

$$q(x) = K(i) \cdot D(i)$$

where $K(i)$ is a multiplier. The multiplier $K(i)$ is obtained by a relation of the form:

$$K(i) = a(i) + b(i)\,[P(1)/P(2)] + c(i)\,[P(2)/P(3)]$$

where $a(i)$, $b(i)$ and $c(i)$ are constants estimated by regression analysis of a large number of model cases for different model life tables; and $P(i)$ is the average parity among women in the ith age group. The reference period to which the childhood mortality relates is also obtained using a similar equation with regression-derived constants.

The values of $q(x)$ obtained by applying the Trussell method to the child survivorship data from the 1979 Survey on Infant and Child Mortality were smoothed using a logit transformation of the Brass general standard life table. The reference periods and the smoothed values of $q(x)$ are shown in table VII.10.

The values of $q(x)$ have been converted into mortality levels in the Coale and Demeny West model life-table system. If child mortality in the recent past has been constant and the data are accurate, one should normally expect the levels of mortality corresponding to each value of childhood mortality to be roughly sim-

TABLE VII.9. PROPORTION OF DEATHS OF CHILDREN AGED 0-4 YEARS TO TOTAL DEATHS RECORDED BY SAMPLE REGISTRATION SYSTEM, BY SEX, INDIA, 1976 AND 1977
(Percentage)

Year	Rural			Urban			Total		
	Male	*Female*	*Both sexes*	*Male*	*Female*	*Both sexes*	*Male*	*Female*	*Both sexes*
1976	45.97	51.75	48.92	37.14	39.57	38.25	44.88	50.43	47.69
1977	46.87	50.26	48.58	34.51	37.65	36.02	45.25	48.75	47.01

TABLE VII.10. SMOOTHED VALUES OF PROBABILITY OF DYING BETWEEN BIRTH AND AGE x, ACCORDING TO REFERENCE PERIOD,[a] BY SEX, INDIA

Age x	Males			Females			Both sexes		
	Probability of dying q(x)	*West model level*	*Reference period*[a]	*Probability of dying q(x)*	*West model level*	*Reference period*[a]	*Probability of dying q(x)*	*West model level*	*Reference period*[a]
1	0.1233	14.1	0.96	0.1062	13.9	0.94	0.1152	14.0	0.95
2	0.1483	14.2	2.12	0.1418	13.5	2.11	0.1453	13.8	2.12
3	0.1590	14.3	3.89	0.1584	13.3	3.90	0.1588	13.8	3.90
5	0.1691	14.4	6.05	0.1747	13.3	6.08	0.1718	13.8	6.06
10	0.1793	14.6	8.47	0.1915	13.3	8.53	0.1851	13.9	8.49
15	0.1867	14.7	11.12	0.2041	13.3	11.20	0.1950	14.0	11.16
20	0.1992	14.8	14.11	0.2255	13.2	14.19	0.2116	14.0	14.15

[a]Number of years prior to the survey to which estimates refer.

ilar. It can be seen that the levels of mortality corresponding to the estimates of childhood mortality show little general trend, suggesting that childhood mortality has remained more or less constant over the past years for both sexes. It is also interesting to note that the levels of childhood mortality among females are lower than those among males, indicating higher child mortality in relation to the model differentials among females. The results in regard to the trend in childhood mortality brought out by the indirect method are consistent with those of the Sample Registration System, although once again indicating lower child mortality; the child death rates given in table VII.8 indicate West model mortality levels of about 13 for males and about 11 for females.

Special surveys

The Sample Registration System frame has been utilized for undertaking special surveys on several aspects of fertility and mortality. The Survey on Infant and Child Mortality referred to above was carried out in 1979 in a subsample of Sample Registration units; it has provided estimates on infant and child mortality, their differentials and their interrelationship with other socio-economic factors. The survey also collected information on health and child care, including cause of death of infants and children, in addition to information on fertility differentials. The investigators were provided with a list of selected causes of death and the information from the respondent was reported without any further investigation. The limitations of such data on causes of death are well known. The investigators are not oriented or trained for the collection of such specialized information on causes of death and it is doubtful whether any feasible amount of training would make them very efficient or equivalent to paramedical staff.

Operational problems in the Sample Registration Survey

The efficiency of the Sample Registration System as a source of information on vital rates is conditioned by four factors: the size of the sample; the operational efficiency of the enumerator and the investigator; the adequacy of supervision; and the constant monitoring of results.

The sample units were selected on the 1961 census frame. Some of these sample units, especially those which had a population of just over 1,500 in 1961, have now crossed the limit of 2,000, with the result that such units have become rather large for the enumerator. Also, over a period of time, villages have been reclassified as urban units; and, in a few cases, urban units have been declassified and rendered rural. Such changes necessitate a constant monitoring of the sample itself. Large units have to be segmented into manageable size or additional enumerators have to be assigned to areas. The assignment of new enumerators is not always possible because of lack of staff at the field level for this purpose. It is also essential to ensure that fresh sample units shall be selected periodically without loss of continuity of results. This process is necessary because over a period of time the continuation of the sample units introduces a "conditioning effect", as a result of which the enumerator tends to lose interest in the work and the households themselves tend to give routine responses, not always with sufficient accuracy. Furthermore, retention of the same sample indefinitely may lead to the loss of its representative character.

The "conditioning effect" referred to above is rather important because experience does seem to indicate that over a very long period of time the enumerator develops set sources of information upon whom he comes to depend totally in order to avoid field-work. Also, the households themselves tend to regard the continuous inquiry as an unnecessary imposition on their goodwill. In either circumstances, the results tend to be unreliable.

The original sample size in the Sample Registration Survey was 3,700 units based on the 1961 census frame. An additional sample of 1,700 units, selected from the 1971 census frame, was added in 1976/77. In view of the constraints mentioned earlier, it is now proposed to update the sample over a three-year period, replacing one third of the sample units every year on the basis of the 1981 census frame, so that after three years all the sample units will be on the 1981 census frame. One additional advantage of this change-over would be the simplification of the procedures for computing estimates based on two different time-frames.

The second aspect that has an influence on the reliability of Sample Registration System results is the efficiency with which the enumerator and the investigator perform their duties. Closely connected with this aspect are the adequacy and efficiency of the supervisory levels. The long retention of the same sample unit appears to erode the efficiency of the enumerator and quite often the adequacy of the investigation is insufficient. Despite the fact that original records are withdrawn before the biannual survey by the investigator, it has been noticed that an element of collusion is possible, which again tends to decrease the utility of the results.

The efficiency and intensity of supervision are, therefore, key factors which determine the validity of the results in the Sample Registration System. The hierarchy has to be so structured that continuous supervision is possible, including test checks and field verification wherever necessary. Continuous improvement of the field operations has been a matter of concern and constant attention. Some of the steps taken to improve the quality of the data are briefly indicated below:

(a) *Trends in total events recorded*. The comparison of the total number of events recorded in each unit since the commencement of the scheme with those recorded independently in each biannual survey is often helpful in locating units where the work is not quite satisfactory. Sample units that show large variations in the number of events recorded are identified and the implementing agencies are required to take corrective steps after a detailed review of the work of the field staff;

(b) *Performance of enumerators and investigators*. An assessment of the efficiency of the enumerators and investigators is made by classifying events by unit on the basis of common events, events listed by the enumerator but missed by the investigator, events listed by the investigator but missed by the enumerator and events not listed by either. A comparison of the total number of events in each of these categories over a number of years will provide an idea of the efficiency of the enumerators and investigators. Corrective steps can be taken wherever the work is not satisfactory;

(c) *Control limits*. A watch on the quarterly figures of births and deaths by unit is maintained by the state headquarters. A higher-level agency inspects units where the figures recorded by the enumerators differ from control limits by a margin of 50 per cent. The control limits are determined for each state on the basis of a three-year moving average at the stratum level separately for each half-year;

(d) *Intensive inquiry*. In view of the importance of the Sample Registration System as the only source of reliable information on vital events, it is proposed to conduct intensive inquiries by using a special questionnaire. This inquiry is proposed to be conducted by higher-level staff in the system in a 10 per cent sub-sample of the system's units. The intention of such an inquiry is to obtain a correction factor for vital rates and also to identify types of missed events;

(e) *Technical Advisory Committee*. This committee was established in 1973 to evaluate the Sample Registration System and to suggest improvements. The committee was reconstituted very recently and its scope was expanded to cover vital statistics and surveys of the Office of the Registrar General. The committee is expected to provide the high-level technical direction necessary for improvement of the scheme.

Monitoring the completeness of the Sample Registration System is a basic issue. Several built-in checks have been adopted to ensure full coverage. These include lists of pregnant women, maintenance of lists of informants in rural areas, quarterly field-rounds by the enumerators who, during these rounds, contact socially important persons for information etc. Also, an overlapping reference period of one year is adopted at the time of the biannual survey in order to detect events that might have been missed in the earlier biannual survey. For example, the survey conducted in January, in effect, covers the whole of the preceding year. However, despite these built-in checks, it has been noticed that both the enumerators and the investigators sometimes fail to record some events. Studies have revealed that the types of events missed by the enumerator are usually those which have occurred to usual residents outside the sample area (usual resident absent). This is due to various reasons, including the fact that expectant mothers usually go to the home of their parents for delivery; and, in the case of hospitals, people are transferred to hospitals located outside the sample area. Unless the field inquiry is thorough, such events are likely to be missed. Another type of event that is frequently missed is perinatal deaths (foetal deaths and deaths of the new-born within seven days). Single-member households constitute a third situation where events are likely to be missed by both the enumerator and the investigator. Such omissions are minimized by training the enumerators on the basis of a set of probing questions. Table VII.11 indicates the percentage of deaths recorded by the different categories of staff.

TABLE VII.11. PERCENTAGE OF DEATHS RECORDED BY ENUMERATORS AND INVESTIGATORS, INDIA, 1975-1977

	Percentage of deaths recorded			
Year	*Common*	*Recorded by enumerator; missed by investigator*	*Recorded by investigator; missed by enumerator*	*Missed by both enumerator and investigator*
1975	71.23	8.19	19.26	1.31
1976	74.52	6.32	18.09	1.07
1977	72.22	6.34	20.82	1.12

The table indicates that about 75 per cent of events are recorded by both the enumerator and the investigator. About 6-8 per cent are recorded by the enumerator but missed by the investigator, while 18-20 per cent are recorded by the investigator but missed by the enumerator. It would therefore appear that the investigator records more events than the enumerator, apparently because the investigator who conducts the biannual survey visits every household at the time of this survey and has access to the household form wherein all the members of the household are listed on the basis of the previous biannual survey. The enumerator does not visit every household but goes to houses only when events occur there. It is only in the quarterly round in the rural areas and in the monthly round in the urban areas that the enumerator is expected to visit all households; and unless this routine is followed meticulously, he will record a smaller proportion of events. In order to make the system more effective, it is necessary to devise ways and means to maximize the independence between the continuous recording and the survey. The various measures described earlier are meant to achieve this result. The Chandrasekharan and Deming formula for estimating vital events missed by both the enumerator and the investigator is not applied since the conditions necessary for the application of this formula are not fully met by the Sample Registration System. Moreover, since a large proportion of the events are even now being recorded by both the enumerator and the investigator, the application of this formula would not appear to be necessary. It must, however, be stressed that by intensifying the supervision and by ensuring complete independence between the continuous recording by the enumerator and the biannual survey by the investigator, the number of events missed can be progressively reduced.

CONCLUSION

The Sample Registration System is the largest demographic survey undertaken in India. Its distinguishing feature is the longitudinal registration procedure which ensures the continuity of the recording of vital events by local resident enumerators. The system attempts to minimize the recall bias while the biannual survey by the investigator ensures full coverage of vital events. Effective supervision, adequate control over field staff and constant monitoring are necessary to ensure the complete recording of events and the validity of the results. The establishment and maintenance of such a system are comparatively more expensive than a multi-round survey.

Unlike the multi-round survey, the Sample Registration System, which is a dual-record system, has the advantage of being self-evaluating. There is a built-in procedure for the comparison of data collected by two different agencies, thus lending credibility to the results because the probability of events being missed by both agencies is low. To that extent, the Sample Registration System is more reliable than a multi-round survey.

The Sample Registration System provides reliable estimates of mortality indicators and has great potential for a variety of demographic studies. Special studies undertaken with its framework have yielded reliable data on fertility and mortality differentials by socio-economic group. The system has been the main source for dependable data on vital demographic measures.

The utility of the information obtained from the Sample Registration System scarcely needs any emphasis. Information on the number of deaths by place of occurrence helps the study of the geographical distribution of deaths in relation to local health conditions. The number of deaths by type of medical attention received at the time of death provides an indicator of the extent of use or availability of medical facilities in different regions. The distribution of deaths by age is essential in identifying the vulnerable age groups in order to help formulate detailed public health measures to reduce mortality. The data are also useful for the construction of life tables.

The data from the Sample Registration System have numerous uses in policy and programme formulation in the health sector. The infant mortality rate is a general indicator of the availability and quality of child health services and it is also a measure of the health and sanitary conditions in a given area. It is a critical indicator for measuring progress in the reduction of infant deaths. Infant mortality broken down into its two components of neonatal mortality and post-neonatal mortality are important from the point of view of medical research, and information on post-neonatal mortality is useful for environmental and medical control programmes. Data on perinatal mortality also serve as an indicator to the public health authorities with regard to the facilities necessary or available to expectant mothers. The Sample Registration System has uses not merely in policy formulation for health measures but for other analytical needs. For example, its frame is adopted in evaluatory surveys, such as the census evaluation study. The system also provides data for the evaluation of the impact of the family planning programme in terms of its ultimate objective of reduction of fertility. Another sector in which data obtained in the system could be used is in determining underregistration in the civil registration system through matching procedures. It is these numerous uses of the Sample Registration System for policy formulation and determination of programme content that make it extremely important.

The federal structure in India results in a multi-level organization for implementation of the Sample Registration System, which requires close co-ordination. The responsible agencies in the states are the Directorates of Health Services or the Bureaux of Economics and Statistics. These agencies have their own priorities in terms of what their states consider important; and as the implementing agencies, they usually have their own ongoing statistical schemes. Therefore, there is some element of competition for attention between the regular work of these agencies and the Sample Registration System; the technical personnel of the agencies generally are inclined to pay more attention to the department's regular work. This administrative reality has to be recognized and it necessitates a high degree of co-ordination and centralized monitoring.

In implementing the Sample Registration System, the major consideration is more administrative than technical because controlling the quality of the results would essentially mean controlling non-sampling errors. Although sound design and sample selection can, by and large, be ensured, the efficiency of the system critically depends upon the availability of well-trained personnel; firm control over the phases of the field operations, including the biannual surveys; meticulous attention to monitoring of performance; adequate supervision to instil discipline and to ensure that no attempt shall be made to avoid work and the careful processing of data. It would seem that while giving honorariums to the enumerators, who in the Indian context are generally schoolteachers, is to some extent an inducement, the payment itself does not seem to serve as a major motivation unless the quantum is high. The sheer size of the sample in the Sample Registration System imposes financial constraints and the cost-effectiveness of the system would be open to doubt if very high levels of honorariums were required. In any case, the payment of honorariums is a self-perpetuating evil because continuous demands for increases would arise and a high initial honorarium would also make it difficult to replicate the scheme on a larger scale.

The Sample Registration System is a relatively expensive technique for the determination of vital rates when compared with the single-round retrospective survey or the multi-round survey, and it is also more difficult to administer. However, the organizational and operational problems of the system dealt with in this chapter are not uncommon in any large-scale demographic survey. To the extent that these problems are solved and the management of the system is improved, the quality of the data collected will be enhanced. The Sample Registration Survey also provides the additional advantage of a ready-made frame for carrying out special demographic surveys. The experience of India would support the view that because of its built-in evaluative capabilities and cross-checking features, the system offers a reliable procedure for obtaining vital rates, particularly in the context of a weak civil registration system. The development of a sound civil registration system is undoubtedly a continuing and dominant concern; but in the short run, it must be given a lower priority and emphasis should remain on the development of an alternative system for obtaining sound estimates of vital rates. It is the latter need that the Sample Registration System meets.

NOTES

[1]World Health Organization, *Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death, 1965 Revision*, 8th rev. (Geneva, 1967).

[2]William Brass, *Methods for Estimating Fertility and Mortality from Limited and Defective Data* (Chapel Hill, N.C., University of North Carolina, Laboratories for Population Statistics, 1975).

[3]*Ibid.*

[4]Hoda M. Rashad, "The estimation of adult mortality from defective registration data", unpublished doctoral dissertation, University of London, 1978.

[5]Griffith Feeney, "Estimating infant mortality rates from child survivorship data by age of mother", *Asian and Pacific Census Newsletter*, vol. 3, No. 2 (November 1976), pp. 12-16.

[6]T. James Trussell, "A re-estimation of the multiplying factors for the Brass technique for determining childhood survival rates", *Population Studies*, vol. 29, No. 1 (March 1975), pp. 97-108; and *Manual X. Indirect Techniques for Demographic Estimation* (United Nations publication, Sales No. E.83.XIII.2).

VIII. USE OF DIRECT AND INDIRECT TECHNIQUES FOR ESTIMATING THE COMPLETENESS OF DEATH REGISTRATION SYSTEMS*

*Samuel H. Preston***

This chapter reviews briefly the direct and indirect means of estimating the completeness with which deaths are recorded in a civil registration system. In accordance with the instructions of the organizers of the Meeting, it was designed as an adjunct to the paper presented by Moriyama,[1] on continuous registration systems. It should be noted that the methods can be used with little modification for systems other than civil registration, for example, survey reports on household deaths in the past year. The methods are important not simply because they provide performance measures for statistical systems. More important are the opportunities they offer for adjusting or "calibrating" those systems to provide better estimates of mortality conditions. The fact that a registration system is "incomplete" has often been used to justify ignoring its products, but if the degree of incompleteness can be accurately assessed, the system becomes virtually as useful as one that is "complete". It may be mentioned, however, that the less complete the underlying registration of deaths, the less tenable become the assumptions used in assessing the completeness level. As a rough rule of thumb, a registration system that records 60 per cent or more of deaths represents a very useful source of mortality information; if completeness is much below this level, however, problems of non-representativeness sharply limit the value of the data.

It should be stated at the outset that any estimate of "true" crude or age-specific death rates implicitly provides an estimate of the completeness of death registration. Many methods of estimating the true mortality conditions have been devised, and the United Nations[2] recently published a review of these methods.

These alternative estimates are usually based on surveys containing retrospective questions on the survival of children or of other kin. The surveys may include event histories complete with dating of events, as in the World Fertility Survey; or they may be limited to reports of cumulative numbers of events, in which case the proper dating may be assigned through indirect procedures. In either case, it is clear that comparisons can be made between the frequency of events during a particular period that were reported in the survey and those reported in civil registration. This chapter does not consider these independent methods for estimating mortality, which are the subject of several other papers submitted to the Meeting. Instead, it is confined to methods for evaluating completeness that use the data from the registration system itself as input to the evaluation procedure. These data are always used in conjunction with other information. If the other information consists of an independently constructed listing of deaths, then the evaluation is considered to be "direct". If it consists of other data on the population, particularly its age distribution or growth rate, then it is considered to be "indirect". Indirect procedures are reviewed first.

A. INDIRECT METHODS

More than a half dozen indirect methods are currently available for estimating the completeness of death registration; most have been developed in the past two years. More are undoubtedly on the way. Each of the methods makes use of the age distribution of reported deaths within a certain age range, which may extend from birth to age 100 but which usually begins at 5 or 10 years of age. Each of them also assumes the population to be closed to migration. In addition, some other data or assumptions are used in conjunction with the age distribution of deaths. The possibilities employed to date are various combinations of:

*D*1: data on the age distribution of the population at one point in time (numbers by age corresponding to the date for which death information is available);

*D*2: data on the age distribution of the population at two points in time;

*A*1: assumption of population stability; the population is assumed to be characterized by constant mortality and exponential growth in the annual numbers of births;

*A*2: assumption of quasi-stability; the population is assumed to be characterized by a history of "typical" mortality decline that has destabilized a population that was at first stable;

*A*3: assumption that registered or reported deaths represent a constant proportion of true deaths at each age within the age range considered.

*The original version of this chapter appeared as document IESA/P/AC.17/8.

**Chairman, Graduate Group in Demography, Population Studies Center, University of Pennsylvania, Philadelphia, Pennsylvania, United States of America. The author is grateful to Shiro Horiuchi and Larry Heligman for their comments on an earlier draft.

These methods are discussed below in more or less the chronological order in which they were developed.

Brass "growth balance method"

In any closed population, the following equation applies in the Brass "growth balance method":

$$r^T_{x+} = b^T_{x+} - d^T_{x+} \tag{1}$$

where r^T_{x+} = true growth of the population aged x and over;

b^T_{x+} = true "birthday rate" of the population aged x and over, i.e., the number of people reaching their xth birthday in a particular year divided by the number of person-years lived above x during that year;

d^T_{x+} = true death rate of the population over age m x, i.e., the number of deaths in a certain year at age x last birthday and above, divided by the number of person-years lived above x during that year.

The superscript T is used to denote "true" values in the population; the superscript is omitted when dealing with recorded values.

Equation (1) can be rewritten:

$$b^T_{x+} = r^T_{x+} + d^T_{x+} \tag{2}$$

Brass uses the assumption of population stability, $A1$, so that the growth rate is constant with age and the $x+$ on r can be dropped. By assumption $A3$ that the completeness of death registration is invariant to age within the range specified,

$$d_{x+} = C \cdot d^T_{x+}$$

where C is the completeness of death recording. Making these two substitutions, one has

$$b^T_{x+} = r^T + \frac{1}{C} d_{x+} \, . \tag{3}$$

Equation (3) is a linear equation the parameters of which are r^T, the intercept, and $1/C$, the slope; d_{x+} is simply the recorded death rate above age x; and b^T_{x+} is conventionally estimated by

$$b^T_{x+} = \frac{{}_5N_x + {}_5N_{x-5}}{10 \cdot N_{x+}}$$

where ${}_5N_x$ is the number of persons recorded in the age interval from x to $x + 5$.

In theory, r and C could be identified by choosing any pair of ages x, since one would have two equations and two unknowns. In practice, it is more sensible to recognize that both the b_{x+} series and the d_{x+} series contain errors, particularly those resulting from age-misreporting. So one may take advantage of the linearity of equation (3) and estimate its parameters by linear regression on many data points or by other suitable fitting procedures. Note, however, that measurement errors in the death rate variable (e.g., from age-misreporting) bias the slope estimated by ordinary least squares towards zero.[3] Because estimated completeness is the reciprocal of the slope, it is biased upward by such error. The equation can also be written so that d_{x+} is on the left-hand side and C is estimated as the coefficient of b^T_{x+} but in this case C will be biased downward by error in b^T_{x+}. In general, it seems best to avoid least-squares estimates and to use alternative and simpler procedures.[4]

There are two basic problems with the Brass procedure:

(*a*) Errors in the data can create a scatter of points such that very different estimates of completeness can be produced by arbitrarily excluding various combinations of available data points from the fitting procedure. Usually, points for the highest ages will be most vulnerable to error, but these points are critical for estimation because they provide the highest values of b_{x+} and d_{x+}. Changes in values of b_{x+} and d_{x+} at younger ages tend to be quite small so that different points add very little new information;

(*b*) Results are sensitive to violation of the assumption of stability. Currently, declining fertility is usually not a serious problem because the initial age at which estimation begins can be chosen in such a way as to exclude cohorts that have been reduced in size by fertility decline. However, most populations have had declining mortality for several decades and the declines affect all ages.

In her investigation of the sensitivity of Brass results to declining mortality, Martin[5] finds that mortality decline produces estimates of completeness that are too low. For example, in a population with a gross reproduction rate of 2.5 that begins with a life expectancy of 45.0 and moves steadily to one of 66.4 after 20 years, the completeness estimated at the end of the period will be only 87 per cent of the true completeness.[6] Slower declines and shorter declines, of course, produce smaller biases.

Martin provides a way of adjusting the Brass estimates for mortality decline. The procedure requires that one know the speed and duration of mortality decline, $A2$. Estimating these factors is, of course, likely to involve a circularity because the aim of the exercise is to estimate current mortality conditions. Also, the recommended procedure for estimating duration of decline requires a set of age-specific growth rates; and if these rates are available, a number of alternative techniques can be used.

Preston and Coale method

In using the Preston and Coale method, by dividing both sides of equation (1) by d^T_{x+}, one has

$$\frac{r^T_{x+}}{d^T_{x+}} = \frac{b^T_{x+}}{d^T_{x+}} - 1 = \frac{C \cdot r^T_{x+}}{d_{x+}} \, ,$$

or

$$C = \frac{d_{x+}}{r^T_{x+}} \left[\frac{b^T_{x+}}{d^T_{x+}} - 1 \right]. \tag{4}$$

The Preston and Coale procedure is based on the recognition that the ratio of the birthday rate above x to the death rate above x is, in a stable population, completely a function of the age distribution of deaths above that age and of the growth rate. In particular,

$$\frac{b^T_{x+}}{d^T_{x+}} = \int_x^\infty d_x(a)e^{r(a-x)}da \qquad (5)$$

where $d_x(a)$ is the proportion of deaths above x that occur at age a. The logic of equation (5) is the following. If B_x persons reach age x in a particular year, the number of deaths that occur to that cohort during the rest of their lives must also be B_x. Future deaths in a stable population $(a - x)$ years hence will equal this year's deaths at that age, $D(a)$, times an exponential growth factor, $e^{r(a-x)}$. Summed over all future ages, then, one must have

$$B_x = \int_x^\infty D(a)e^{r(a-x)}da.$$

Dividing both sides by the sum of this year's deaths above x gives equation (5). Substituting (5) into (4), one has

$$C = \frac{d_{x+}}{r_{x+}}\left[\int_x^\infty d_x(a)e^{r(a-x)}da - 1\right] \qquad (6)$$

This formula can be applied directly and does not require any fitting procedure. However, in reducing arbitrariness it also reduces flexibility; data for particular ages above x cannot be discarded because they are believed to be faulty. Note, in particular, that the summation goes to the highest age achieved and that deaths at high ages will be heavily weighted by the exponential-growth term. The method is thus vulnerable to age-misstatement and omission at the older ages, where these errors are most likely. Coale has accordingly paid much attention to developing procedures for minimizing the effects of error in the oldest age groups.[7]

The Preston and Coale procedure requires as input estimates of growth rates, rather than of the age distribution of the population as used by Brass. These growth rates are often not known with much precision even when two censuses are available, and results are sensitive to the value of r adopted. Fortunately, their sensitivity varies considerably with age, being greater when the initial age of estimation, x, is younger, so the results themselves provide an indication of the suitability of the growth rate used. Thus, Preston and Hill[8] suggest experimenting with different growth rates and choosing that which produces the most "level" sequence of completeness estimates, i.e., the sequence that varies least with age. This procedure seems to work well in El Salvador,[9] but in general may not be satisfactory. The problem is that errors at the older ages (e.g., overstatement of age at death) will also produce different errors in completeness estimates at different initial ages.[10] The pattern of estimates that results from error at the very old ages is easily confused with a pattern of error produced by an incorrect choice of r. It is, of course, possible to use the growth rate that emerges as a by-product of the Brass procedure as input for the Preston and Coale procedure. Experimentation with this approach in numerous countries has shown that the resulting estimate of C rarely differs from the Brass estimate by more than 0.03, so that, as a rule, little new information is gained.

Estimates of completeness derived by this method are also sensitive to violations of the assumption of stability, introduced in equation (5). In general, they appear to be somewhat less sensitive to these violations than the Brass results. In a direct comparison of the two methods applied to population with a simulated mortality decline, the Preston and Coale procedure produced errors less than half as large as the Brass procedure.[11]

Bourgeois-Pichat method

There are other ways to write the basic stable equations in order to provide formulae for estimating the completeness of death registration. One such way is called here the "Bourgeois-Pichat method", although it is implicit rather than explicit in his work. In a stable population,

$$c(a) = be^{-ra} \cdot e^{-\int_o^a u(t)dt} \qquad (7)$$

where $c(a)$ = proportion of the population at age a;
r = annual growth rate;
b = birth rate;
$u(t)$ = force of mortality (age-specific death rate) at age t.

By assumption, $A3$,

$$u^R(t) = C\,u(t)$$

where $u^R(t)$ is the recorded death rate at age t. Making this substitution and taking logs,

$$\ln c(a) = \ln b - ra - \frac{1}{C}\int_o^a u^R(t)\,dt. \qquad (8)$$

One now has a linear equation that can be estimated by least-squares techniques. One independent variable is age, the other is the sum of age-specific death rates from birth. The coefficient of the latter variable is the reciprocal of estimated registration completeness. The procedure can be used from any arbitrary beginning age, in which case a must be redefined as distance from that beginning age.

The procedure requires identifying three parameters: the two estimated by Brass, r and C, plus the birth rate, which Brass estimates directly. Unfortunately, the two independent variables are very highly correlated and estimates of the two coefficients are therefore quite unstable. The only application of this procedure attempted to estimate r and C in separate steps, but an apparent error in procedures renders results inconclusive.[12]

Bennett and Horiuchi method

The Bennett and Horiuchi[13] method provides an important development of the Preston and Coale technique that discards the assumption of stability. They note that the ratio of the birth rate over age x to the death rate over age x can be written for any closed population as

$$\frac{b_{x+}}{d_{x+}} = \int_{x}^{\infty} d_x(a) e^{\int_x^a r(t)dt} da \qquad (9)$$

where $r\ (t)$ is the growth rate of population aged t. Thus, equation (5) is seen to be a special case of equation (9) in which r is constant above x. Substituting equation (9) into equation (4), which made no resort to stable assumptions, one has

$$C = \frac{d_{x+}}{r_{x+}} \left[\int_{x}^{\infty} d_x(a) e^{\int_x^a r(t)dt} da - 1 \right] \qquad (10)$$

The technique embodied in equation (10) was shown to work very well when applied to data from the Republic of Korea and from Sweden.[14] Like the Preston and Coale procedure, it requires a (set of) growth rates as input and it provides opportunity for experimenting with different values of the growth rate and choosing a set that provides a sequence of C estimates that shows minimal variance with age. The method is so recent that no other applications of the Bennett and Horiuchi approach are known to this author.

The main advantage of the approach is in its relaxation of the assumption of stability. The authors show that the Preston and Coale procedure would have given erratic results for the highly destabilized case of Sweden, whereas their procedure produced remarkably consistent and good results. Sweden is, of course, an extreme example, but it is often the case that the $r(t)$ sequence in developing countries shows systematic departures from constancy. However, when errors in the data are abundant, the analyst may still wish to impose the stability assumption in order to "discipline" the data.

Preston and Hill method

Two censuses are required in order to obtain the set of age-specific growth rates needed for the Bennett and Horiuchi procedure. If these censuses are available, an alternative method proposed by Preston and Hill[15] can also be applied. This procedure makes use of accounting identities relating the size of cohorts in the two censuses to intercensal deaths. For example, for censuses taken at time t and time $t + 10$,

$$TN_{x+10}^{t+10} = TN_x^t - TD_x^c \qquad (11)$$

where TN_x^t = true number of persons aged x at time t;
TD_x^c = true number of deaths between t and $t + 10$ to cohort aged x at time t.

Preston and Hill then invoke assumption $A3$, that registered deaths by age are a constant proportion of true deaths:

$$D_x^c = C \cdot TD_x^c ,$$

and that the completeness of enumeration for the population was $E(t)$ at time t and $E(t + 10)$ at time $t + 10$, both terms constant with age:

$$N_x^t = E(t) \cdot TN_x^t$$
$$N_{x+10}^{t+10} = E(t + 10) \cdot TN_{x+10}^{t+10} .$$

Making these substitutions into equation (11) and rearranging, they produce a linear equation:

$$\frac{N_{x+10}^{t+10}}{N_x^t} = \frac{E(t + 10)}{E(t)} - \frac{E(t + 10)}{C} D_x^c . \qquad (12)$$

The intercept of this equation is the relative enumeration completeness of the two censuses; the coefficient of intercensal deaths is the enumeration completeness at the second census divided by the death registration completeness. To estimate mortality rates correctly, it is only necessary that the completeness of deaths be calibrated to the completeness of the censuses, so the presence of $E(t + 10)$ in the coefficient poses no problem.

This method can be made more flexible by defining "cohorts" to be all persons over age x at time t. It gave good results when applied to Thailand, in the sense that it produced estimates of registration completeness similar to those obtained in a direct inquiry and to those of the Preston and Coale procedure.[16] Bennett and Horiuchi[17] found that the method gave quite similar results to their own in the Republic of Korea. However, extensive application of the procedure in Latin America by the Centro Latinoamericano de Demografía (CELADE) gave quite poor results, with completeness estimates often implausibly above unity. It appears that systematic overstatement of age between one census and the next inflated cohort size at the second census and thus reduced "expected" deaths, so that recorded deaths formed too high a fraction of the expected deaths. The method may only prove workable for developing countries within the Chinese-Japanese cultural sphere, where age-reporting is typically quite good. The Bennett and Horiuchi procedure, for which calculations pertain to particular age groups rather than to particular cohorts, has clear practical advantages in situations of extensive and directional age-misreporting and can also readily accommodate intercensal periods that are not integer multiples of five. Note, however, that if intercensal growth rates are used, the Bennett and Horiuchi (and the Preston and Coale) procedures should also be used with intercensal deaths and not simply with deaths centred on one of the two censuses.

United Nations method

If age-specific growth rates are available as in d and e, as well as the age distribution of the population, it is possible to employ equation (1) directly. The expected death rate over age x is simply $\hat{d}_{x+} = b_{x+} - r_{x+}$, and the ratio, $d_{x+}/\hat{d}_{x+}$, is a direct estimate of registration completeness for ages x and over. No fitting procedure is required. Since b_{x+} is measured with considerable error, however, it is best to combine results for different ages, perhaps by calculating the geometric mean of estimates of C or by choosing a median. The former procedure was used by the United Nations[18] in the only application of this method that this author has seen. The conclusion reached after applying it to many data sets was that, "More generally, the estimates obtained from this modified procedure have not proved very helpful, there being a very noticeable tendency for estimated completeness to exceed 100 per cent, sometimes seriously".[19] One explanation for this result may be that b_{x+} is consistently underestimated because of age overstatement.

General remarks on indirect methods

Each of the indirect methods identifies the completeness of death registration by attributing an inconsistency between registered deaths and some other element of the population—its age distribution, its growth rate or its intercensal cohort changes—to registration incompleteness. However, inconsistencies also may be produced by the other elements and attributing all of the disparities to death registration alone can lead to serious problems. Four of the most important of these sources of error are discussed below.

International migration

None of the methods is able to deal with an open population unless corrections for migration are made. Thus, the methods should not be used when international migration is substantial and populations are unadjusted.

Age overstatement of deaths at higher ages

When too high a proportion of deaths appears at the older ages, mortality conditions (for a given r or population age distribution) appear to be better than they in fact are, and observed deaths will thus constitute a higher fraction of expected deaths. C is biased upward. Methods for dealing with this problem in the Brass, Bourgeois-Pichat, and Preston and Hill techniques are fairly straightforward: ignore observations at the ages where problems are most likely to be encountered. In the Bennett and Horiuchi and the Preston and Coale procedures, however, the highest ages must (apparently) be included. Recommended procedures when they are believed to contain erroneous data are to employ an open-ended interval that begins at a relatively low age (say, 60) even though detailed data may be available for higher ages. Various models of age patterns of mortality are then introduced to estimate true mortality levels in this open-ended interval.

A pattern of registration completeness that increases with age, contrary to assumptions, will also bias completeness estimates upward.

Note that all but two of the methods provide estimates of registration completeness that pertain to all ages over some minimum age, under the assumption that completeness is constant over that age. They do not provide an estimate of completeness within a particular age range; even though certain observations may be discarded (e.g., in the Brass approach), the mathematical development has still utilized the assumption of no differential incompleteness by age. The exceptions are what have been called the "Bourgeois-Pichat method" and the "Preston and Hill method". It is possible that this difference accounts for some of the unusually high estimates of C often yielded by these two techniques.

The other procedures can also be modified to yield completeness estimates that pertain to a restricted age range. To begin, equation (1) can be rewritten as:

$$r^T_{xy} = b^T_{x|y} - d^T_{xy} - n^T_{y|x}$$

where r^T_{xy} = true growth rate of population between ages x and y;

$b^T_{x|y}$ = true birthday rate into the population aged from x to y, i.e., number of persons reaching their xth birthday annually divided by person-years lived between x and y;

d^T_{xy} = true death rate of the population between ages x and y;

$n^T_{y|x}$ = true departure rate by aging from the population aged from x to y, i.e., number of persons reaching their yth birthday annually divided by person-years lived between x and y.

It is now clear that the Brass method can be recast for application to the restricted age range from x to y as

$$b_{x|y} - n_{y|x} = r - \frac{1}{C} d_{xy}. \qquad (3')$$

Observations can be generated by varying x or y, or both. Such a modification has been suggested by Somoza.[20]

The United Nations method can also be modified in a straightforward way as

$$C = \frac{d_{xy}}{b_{x|y} - r_{xy} - n_{y|x}}$$

Tailoring the Preston and Coale and the Bennett and

Horiuchi procedures to a restricted age range is less straightforward. One may state without proof the following results. For the Preston and Coale method, in the age range from x to y,

$$C = \frac{d_{xy}}{r_{xy} + n_{y/x}(1 - e^{r(y-x)})}\left[\int_x^y e^{r(a-x)} d'(a)da - 1\right] \quad (6')$$

and for the Bennett and Horiuchi method,

$$C = \frac{d_{xy}}{r_{xy} + n_{y/x}\left[1 - e^{\int_x^y r(t)dt}\right]}$$

$$\left[\int_x^y e^{\int_x^a r(t)dt} d'(a)dt - 1\right] \quad (10')$$

where $d'(a)$ is the proportion of recorded deaths between x and y that occurs at age a:

Census underenumeration

Each of the methods yields an estimate of registration completeness that is relative to the completeness of census enumeration. This result is explicit in the Preston and Hill procedure. For the others, it is only necessary to imagine that the population enumerated was arbitrarily reduced by 50 per cent. Registered death rates would rise by a factor of two and completeness would appear higher by this factor. The procedures do not give absolute but rather relative performance measures of the civil registration system. In countries where censuses miss substantial fractions of the population, it is useful to bear this caveat in mind. Normally, however, the analyst is interested in estimating mortality in the form of crude or age-specific death rates. For these purposes, what is needed is precisely an estimate of registration completeness in relation to census completeness.

Death registration completeness varying with age

In the Brass, Bourgeois-Pichat, and Preston and Hill methods, registration completeness is inferred from the slope of a line fitted to data. If registration completeness varies with age, that slope will be biased. Increasing completeness with age will bias upward the estimated C, and decreasing completeness will bias it downward.

However, in the Preston and Coale and the Bennett and Horiuchi methods, the estimated value of C will be a weighted average of the age-specific values of C actually prevailing. Since this feature is important and has not been noted previously, it is worth demonstrating despite the laborious mathematics. Let $J(a)$ represent the actual completeness of registration at age a. Suppose that one applies Preston and Coale equation (6) to data in which $J(a)$ varies with age. Equation (6) can be rewritten as

$$C = \frac{\int_x^\infty D^T(a)\, J(a)da}{N_{x+} r_{x+}}\left[\frac{\int_x^\infty D^T(a)\ J(a)\, e^{r(a-x)}}{\int_x^\infty D^T(a)\ J(a)da} - 1\right] \quad (6')$$

Recognizing that $N_{x+} \cdot r_{x+}$ is equal to $N(x) - \int_x^\infty D^T(a)da$ and that $N(x) = \int_x^\infty D^T(a)\, e^{r(a-x)}da$, one can substitute into equation (6′) and simplify, giving

$$C = \frac{\int_x^\infty D^T(a)\ J(a)\, e^{r(a-x)}dx - \int_x^\infty D^T(a)\ J(a)da}{\int_x^\infty D^T(a)\, e^{r(a-x)}\, dx - \int_x^\infty D^T(a)da}$$

or

$$C = \frac{\int_x^\infty J(a)\left[D(a)\left[e^{r(a-x)} - 1\right]\right]da}{\int_x^\infty D(a)\left[e^{r(a-x)} - 1\right]da}$$

$$= \int_x^\infty J(a)\, F(a)da. \quad (6'')$$

Thus, C as estimated by equation (6) will be a weighted average of the actual age-specific completeness of registration over age x, $J(a)$. The weights are the difference between cohort deaths expected at age a and current deaths at a, divided by the sum of this difference over all ages higher than x. Older ages are clearly being heavily weighted in this process. In the Bennett and Horiuchi procedure, the weighting factor is identical except that $e^{r(a-x)}$ is replaced by $e^{\int_x^a r(t)dt}$. That C estimated through these procedures is functioning as a weighted average of age-specific completeness increases their value in relation to other methods, although marked variation in completeness with age will make the refinement of growth rate estimates on the basis of the internal pattern of results problematical.

The Brass and the Preston and Coale procedures have been widely applied. They were used on many data sets in the model life-table construction project of the United Nations[21] and in that of the Organisation for Economic Co-operation and Development (OECD).[22] They have been applied to almost all of the countries for which the United States National Academy of Sciences has formed panels or working groups, including the two largest countries—India[23] and China.[24] They are providing information on inconsistencies between reported deaths and other features of the population structure. Results cannot, of course, be accepted blindly, because inconsistencies can be produced by many sources, as discussed above. However, the information they generate on these inconsistencies, taken together with other information, usually brings the demographic circumstances of a population into sharper focus.

Among the other techniques described here, that of Bennett and Horiuchi appears particularly promising. It requires nearly the same input as the Preston and

Coale method and is based on similar mathematical development, but it dispenses with the assumption of stability; and it shares with the Preston and Coale method the absence of dependence on the assumption that registration is invariant to age. A summary of the salient features of these procedures is presented in table VIII.1. Experience with truncated versions of these procedures (except those of Bourgeois-Pichat and Preston and Hill) is too limited to allow a general assessment of their performance.

It should be mentioned that another indirect technique is available to measure completeness.[25] Rather than relying on the demographic accounting framework of the other methods, it assumes that the age pattern of mortality in the population being studied belongs to a particular set of model relationships. It then solves for the "level" of mortality in that model life-table system which is consistent with the recorded age pattern of mortality. The population need not be stable or even closed. This advantage is purchased at a considerable cost, however, because the United Nations model life-table project has found age patterns of mortality in developing countries to be highly variable. The method also appears to be very sensitive to age-reporting patterns.

B. Direct estimation of completeness

An alternative way of estimating the completeness of death registration is to use an independent source of information on the number of deaths that occurred. If the alternative source itself is known to be complete, then an estimate of registration completeness follows directly from a comparison of totals, but there is no chance that such a source will be available. Instead, the alternative source will itself be suspected of being incomplete. Nevertheless, if it is statistically independent of death registration, it can be used to estimate registration completeness. Statistical independence simply means that the likelihood that an event will be recorded in the alternative system is not affected by whether it was registered. If independence is a tenable assumption, then the completeness of registration is estimated by

$$C = \frac{D_{R,A}}{D_A} \tag{13}$$

where $D_{R,A}$ = deaths that appeared both in registration and in the alternative recording system;

D_A = total deaths in the alternative recording system.

This equation follows directly from the definition of statistical independence.[26]

In order to estimate completeness by equation (13), it is clearly necessary to perform a case-by-case examination of records from both recording systems. Only by "matching" records from the two sources can $D_{R,A}$ be established. Two major possibilities exist for the alternative system: surveys asking questions about deaths in the household in the same time-frame and space-frame to which registered deaths pertain; and an "active" recording of events by knowledgeable persons more or less continuously present in the community. Note that what have come to be known as "dual-record systems" use the two alternative systems and bypass civil registration altogether.[27]

Direct estimation of completeness has considerable theoretical appeal. Its logical basis is simple and

TABLE VIII.1. SUMMARY OF MAJOR FEATURES OF SIX METHODS FOR ESTIMATING COMPLETENESS OF DEATH REGISTRATION

Method	*Assumptions*	*Data required in addition to age distribution of deaths*	*Strengths and weaknesses encountered in applications*
Brass	Stable population	Age distribution of population	Arbitrariness in choice of points for fitting; biased by declining mortality; flexible and requires least data.
Preston and Coale	Stable population	Number of persons and population growth rate above initial age	Sensitive to growth rate chosen; biased by overstatement of age at death; provides diagnostics for errors of data and assumption; less biased by mortality decline than the Brass method; does not require assumption that completeness is invariant to age.
Bourgeois-Pichat	Stable population	Age distribution of population	Limited experience with method; seems to overestimate completeness because of age overstatement at high ages; requires least data; automatically provides estimates within truncated age range.
Bennett and Horiuchi	Closed population	Age-specific growth rates (i.e., age distributions of two censuses)	Sensitive to growth rate chosen; biased by overestimation of age at death; provides diagnostics for errors of data; unbiased by mortality or fertility change; flexible in implementing for irregular intercensal periods; does not require assumption that completeness is invariant to age.
Preston and Hill	Closed population	Age distributions of two censuses	Seems to overestimate completeness when age overstatement prevalent; awkward to use for irregular intercensal periods; arbitrariness in choice of points for fitting; flexible; automatically provides estimates within truncated age range.
United Nations	Closed population	Number of persons and population growth rate initial age	Limited experience with method; seems to give erratic results.

straightforward, unlike many of the indirect methods. Like the indirect methods, however, it is subject to error of assumption, data and implementation. The only assumption involved is that of independence of the two statistical systems, but there are many reasons why that assumption might be violated. The likelihood of a death being reported in either system probably varies in many populations with characteristics of the deceased (religion, socio-economic group, literacy). If deaths that are not recorded in one system are more likely than average to be omitted from the other, then completeness will be overestimated. A solution frequently suggested for dealing with this problem is first to make completeness estimates within (preferably homogeneous) population strata and then to aggregate the strata to estimate the number of deaths. Deliberate concealment of child death by some women, which appears to have occurred in a region of the Philippines, will also bias completeness estimates upward if the concealment enters both systems.[28] Concealment of death—or, more accurately, reluctance to mention a recent grief-provoking event—has also been noted in a completeness evaluation in Turkey.[29]

Independence of the two systems may also be difficult to attain administratively, since the recording of an event in one system may call its attention to the other system. It is suggested that a third party be responsible for matching of records to avert any problems resulting from either system's desire to look more complete. But such procedures are "slow and costly".[30] In the largest and longest attempt to maintain two record-keeping systems, the Sample Registration System in India, it has been decided that independence of the systems is an impractical goal.

Perhaps more serious, in general, than errors of assumption are data and implementation errors. This reference is not to incompleteness of records, since the procedure is designed to deal with these. Rather, data errors result from the presence of events in the alternate system that are "out of scope", i.e., that refer to periods or regions other than those to which registered deaths pertain. For example, if events in the alternative system refer to a 15-month period encompassing a 12-month period of death registration, then completeness estimates are biased downward because the denominator of equation (13) is increased by the three-month extension whereas the numerator is not. (Note that use of a period shorter than 12 months in the alternative system would not necessarily introduce any bias.) Since civil registration of deaths often occurs substantially later than the event, there can be confusion about the correct reference period for the alternative estimator. In addition, death often occurs elsewhere than the deceased's place of legal residence. Confusion about where to register such a death is widespread in Thailand, for example,[31] and also increases the chances for "out-of-scope" reports.

The most important problem in many applications of this procedure is identifying what constitutes a true match of records in the two systems. If true matches are underestimated in equation (13), the completeness estimate will obviously be too low. One of the most important criteria for establishing a match is the name that appears on the death certificate and on the other record. In the Republic of Korea and in Trinidad and Tobago, frequent repetition of a few popular names confounds the matching process. Variability in the reporting of infant names has been noted in Saint Lucia. In many countries, a child dying in early infancy has been given no name.[32] Another common criterion for the match is place of residence, but in many countries there is no formal address. Scores can, of course, be assigned on the basis of similarity of reports on different items in the two sets of records and a "match" created when the total score equals or exceeds a required minimum, but it will be rare that complete confidence could be attached to all matches and to all non-matches alike. It is possible, of course, to use probabilistic matches in which a score between 0 and 1 is assigned to a particular record in the alternative system in forming the numerator of equation (13).

An extensive literature has accumulated on matching studies. The interested reader may consult reviews in Marks, Seltzer and Krotki,[33] in Wells[34] and in Myers.[35] Carver's[36] work is an extensive bibliography of matching studies. Seltzer and Adlakha[37] provide a formal evaluation of the sensitivity of results to certain kinds of error. It should be noted that matching studies are also used to estimate birth rates and to evaluate birth registration completeness. Studies of births seem to be more common; for example, the first study[38] mentioned above lists twice as many matching studies of births as of deaths. The advantages of studying births instead of death are obvious: in the case of birth, usually two people who experienced the event (the child and the mother) will be present at the time of survey to report on or serve as a reminder of the event, whereas the decedent is no longer a household member; death may lead more frequently than birth to a reconstruction of the household or to migration; and the frequency of birth is usually from two to four times greater than the frequency of death in developing countries, so that the same size of population sampled will lead to greater reliability in the case of birth matching studies.

C. Comparative features of direct and indirect procedures

Direct and indirect approaches are not necessarily to be viewed as substitutes for each other. Ideally, both approaches would be applied to the same set of data, so that the analyst could base his or her final estimates on both sets of results. In some instances, such as Thailand, the results have been very similar:[39] in others, such as Liberia, they were disparate.[40] However, it will not always be possible to utilize both approaches, and they have rather differing strengths and weaknesses. What follows is a brief list of the relative advantages of each approach.

Areas of advantage for direct methods

Timeliness

The indirect procedures usually require a population census to provide input into the techniques. These are obviously available only sporadically in developing countries and are often processed slowly. In addition, several techniques yield only intercensal estimates, which require two censuses and assure that results pertain to periods that are, on average, 5–10 years distant. Direct procedures can, in theory, be used with a more or less continuous survey system and can yield results that are as current as data processing permits.

Socio-economic and geographical differentials

The indirect techniques all utilize the assumption of a closed population. Therefore, they are not suited for estimating completeness with respect to characteristics with changing distributions. These characteristics usually include socio-economic group and region of residence. Age-specific inflows and outflows among these groups clearly violate the assumption of closure. Exceptions are characteristics fixed at birth, such as race, ethnicity, sex and region of birth, for which indirect procedures are completely applicable. The direct procedures can yield estimates of differentials with regard to any characteristic desired as long as it appears on the death certificate and the sample size is adequate. In practice, it is rare to see completeness estimates differentiated by characteristics other than age, sex and rural/urban residence.

Estimates of infant and child mortality

The indirect procedures generally use the assumption that completeness is invariant with age above some beginning age; however, the tendency to omit a higher fraction of neonatal and infant deaths is so pervasive that analysts rarely make use of estimates that begin at age zero. Thus, the indirect methods usually give estimates of registration completeness of later childhood and adults. This restriction often means that from one quarter to one half of the deaths occurring are not subject to investigation of completeness. The possibility of estimating registration completeness among infants and young children is one of the strongest arguments for direct procedures. Excellent advantage of this possibility was taken in a large study by the Pan American Health Organization.[41] Completeness of infant death registration was estimated for 13 areas in Latin America by comparing registered deaths to information from a wide variety of sources, including a household survey, hospital records of maternity admissions and births and foetal death certificates. The results are among the only examples of completeness estimates by fine categories of age in the first year of life.

The main competitor of direct completeness estimates for estimating childhood mortality is not indirect completeness methods but the survey-based retrospective procedure of Brass. An exceptionally interesting comparison has been made of dual-record results and the Brass type of results in a region of the Philippines.[42] The Brass results appear to be somewhat better, perhaps because they do not require a direct report on death (only on the numbers surviving) and because the events of death are more distant on average and hence less emotion-laden.[43]

Areas of advantage for indirect methods

Coverage of population

Estimates of mortality are usually desired at the national level. The indirect methods are well-suited for providing this level of coverage because they usually compare national-level deaths to national-level census information. In order for the direct methods to yield nationally representative results, it is necessary that extensive geographical stratification be introduced in the alternative system. Even if it is successful in the sense of providing nationally unbiased estimates, the sampling required introduces sampling error that is not present in the indirect procedures. Areal sampling also introduces the possibility of geographical out-of-scope biases that are not present in a system of national scope.

Administrative and financial costs

Mounting an independent survey to evaluate registration completeness is a costly undertaking. One must determine the sampling strategy to be used, develop the appropriate maps, prepare questionnaires, statistical forms and manuals for field-workers, recruit and train interviewers, pretest the procedures, code both sets of data and match the records. While some use may be made of pre-existing apparatus and personnel and of international experience in the conduct of such surveys, the costs will nevertheless be much greater than for indirect procedures. For the latter methods, all that is required is the appropriate data, which are usually routine products of a country's statistical system, and an effort of from several days to several weeks duration by a well-trained analyst. The cost factor is surely the major advantage of indirect procedures.

D. Discussion

An important feature of estimates of registration completeness is not discussed in the foregoing account: the sensitivity of mortality estimates to error in estimates of registration completeness. The estimated crude death rate corrected for completeness of registration is, of course, simply the registered crude death rate divided by C. In the author's judgement, sufficient accuracy can be attained in the estimation of C, whether by direct or indirect means, so that the corrected crude death rate will usually be within 10 per cent, and almost always within 18 per cent, of its true value. This is clearly a subjective assessment using imprecise language.

What may not be clear to the reader is that life expectancy estimates are much less sensitive to error in estimates of completeness than are crude death rates. The reason for this differential response is the bunching of deaths (in the life table) at the higher ages in almost all populations. Suppose in the life table that one inappropriately "saves" 10 per cent of the persons who should have died at age 65–69 because C has been overestimated and mortality thus underestimated. These persons will not be expected to live an additional 65–69 years (which would result in an inflation of 10 per cent in e_0^0) simply because they are entering ages of very high, even if underestimated, mortality. An investigation[44] of this feature of mortality measurement concludes that the proportionate change in life expectancy at birth is only 10–40 per cent of an equiproportionate change introduced into all age-specific death rates. Thus, if one comes within 10 per cent of the true value in the corrected estimates of age-specific death rates, one should be within 1–4 per cent in the corresponding estimates of life expectancy at birth. At a life expectancy at birth of 55, typical of developing countries, the error introduced by a 10 per cent error in estimates of $1/C$ is only 0.5–2.2 years. The insensitivity of life expectancy to error in C is even greater for ages beyond zero because the bunching of life-table deaths at high ages is more extreme. This relative insensitivity of life-expectancy measures is an important reason to capitalize on the vital registration data available on deaths by age in developing countries, in combination with estimates of registration completeness.

NOTES

[1]Iwao M. Moriyama, "Advantages and disadvantages of continuous registration systems for national, subnational and differential mortality analysis", chap. VI of the present volume.

[2]*Manual X. Indirect Techniques for Demographic Estimation* (United Nations publication, Sales No. E.83.XIII.2).

[3]Eric A. Hanushek and John E. Jackson, *Statistical Methods for Social Scientists* (New York, Academic Press, 1977), p. 287.

[4]Several are described in *Manual X. Indirect Techniques for Demographic Estimation.*

[5]Linda G. Martin, "A modification for use in destabilized populations of Brass's technique for estimating completeness of death registration", *Population Studies*, vol. 34, No. 2 (July 1980), pp. 381–395.

[6]*Ibid.*, compiled from table 1.

[7]Samuel H. Preston and others, "Estimating the completeness of reporting of adult deaths in populations that are approximately stable", *Population Index*, vol. 46, No. 3 (Summer 1980), pp. 179–202.

[8]S. Preston and K. Hill, "Estimating the completeness of death registration", *Population Studies*, vol. 34, No. 2 (July 1980), pp. 349–366.

[9]"Model life tables for developing countries; an interim report" (ESA/P/WP.63), January 1979.

[10]S. H. Preston and others, *loc. cit.*

[11]*Ibid.*, pp. 189 and 192.

[12]Organisation for Economic Co-operation and Development, Development Centre, *Mortality in Developing Countries*; tome II. *Data Bank*; vol. III. *Evaluation*, by Julien Condé, Michele Fleury-Brosse and Dominique Waltisperger (Paris, 1980).

[13]Neil G. Bennett and Shiro Horiuchi, "Estimating the completeness of death registration in a closed population", *Population Index*, vol. 47, No. 2 (Summer 1981), pp. 207–221.

[14]In applications and development of the method, Bennett and Horiuchi, *loc. cit.*, use a different functional form of equation (10) but one that can be shown to be mathematically equivalent. Results may differ slightly because of different discrete approximations required in the different formulae.

[15]S. Preston and K. Hill, *loc. cit.*

[16]*Ibid.*

[17]Private correspondence with the author.

[18]"Model life tables for developing countries: an interim report".

[19]*Ibid.*, p. 36.

[20]Jorge Somoza, "An evaluation of the performance of indirect estimation techniques in the analysis of defective data, in *International Population Conference, Manila, 1981* (Liège, International Union for the Scientific Study of Population, 1981), vol. 3, pp. 375–396.

[21]*Model Life Tables for Developing Countries* (United Nations publication, Sales No. E.81.XIII.7).

[22]Organisation for Economic Co-operation and Development, *Mortality in Developing Countries*; vol. II. *Data Bank;* vol. III. *Evaluation.*

[23]Samuel H. Preston, John Hobcraft and Nancy Chen, "Preliminary report on application of techniques for estimating death registration completeness to data from the Indian Sample Registration System, conference paper submitted to the Meeting of the Panel on India of the United States National Academy of Sciences, New Delhi, November 1979.

[24]Judith Banister and Samuel H. Preston, "Mortality in China", *Population and Development Review*, vol. 7, No. 1 (March 1981), pp. 98–110.

[25]Youssef Courbage and Philippe Farques, "A method for deriving mortality estimates from incomplete vital statistics", *Population Studies*, vol. 33, No. 1 (March 1979), pp. 165–180.

[26]Eli S. Marks, William Seltzer and Karol J. Krótki, *Population Growth Estimation: A Handbook of Vital Statistics Measurement* (New York, The Population Council, 1974), pp. 14–15.

[27]Robert J. Myers, *The Dual Record System: An Overview of Experience in Five Countries*, Laboratories for Population Statistics Scientific Series, No. 26 (Chapel Hill, N.C., University of North Carolina, 1976), p. 6.

[28]Francis C. Madigan and Alejandro N. Herrin, *New Approaches to the Measurement of Vital Rates in Developing Countries*, Laboratories for Population Statistics Reprint Series, No. 18 (Chapel Hill, N.C., University of North Carolina, 1977), p. 61.

[29]Eliska Chanlett, *Organization and Methods of the Dual-Report System in Turkey*, International Program of Laboratories for Population Statistics, Scientific Report Series, No. 2 (Chapel Hill, N.C., University of North Carolina, 1971), p. 20.

[30]H. Bradley Wells, *Data Collection System, National Dual Record and Related Systems*, International Program of Laboratories for Population Statistics, Scientific Series, No. 15 (Chapel Hill, N.C., University of North Carolina, 1974), p. 16.

[31]United States of America, Department of Health, Education and Welfare, Office of International Statistics, *Vital Registration Systems in Five Developing Countries: Honduras, Mexico, Philippines, Thailand, and Jamaica*, National Center for Health Statistics Series 2, No. 79 (Washington, D.C., 1980), p. 101.

[32]E. S. Marks, W. Seltzer and K. J. Krótki, *op. cit.*

[33]*Ibid.*

[34]H. B. Wells, *op. cit.*

[35]R. J. Myers, *op. cit.*

[36]Jane S. Carver, ed., Systems of Demographic Measurement: the Dual Record System: *Bibliography on the Dual Record System*, International Program of Laboratories for Population Statistics, Occasional Publication (Chapel Hill, N.C., University of North Carolina, 1976).

[37]William Seltzer and Arjun Adlakha, *On the Effect of Errors in the Application of the Chandrasekar-Deming Technique*, Laboratories for Population Statistics Reprint Series, No. 14 (Chapel Hill, N.C., University of North Carolina, 1974).

[38]E. S. Marks, W. Seltzer and K. J. Krótki, *op. cit.*, p. 54.

[39]S. Preston and K. Hill, *loc. cit.*

[40]In particular, application of the Brass and the Preston and Coale

procedures to the "corrected" death rates from the Population Growth Survey of Liberia, 1969–1972, found completeness levels substantially above unity, raising the possibility that the matching procedure had underestimated true completeness. The unpublished analysis was performed by K. Burns, Population Studies Center of the University of Pennsylvania.

[41]Ruth R. Puffer and Carlos V. Serrano, *Patterns of Mortality in Childhood: Report of the Inter-American Investigation of Mortality in Childhood*, Pan American Health Organization Scientific Publication, No. 262 (Washington, D.C., 1973).

[42]F. C. Madigan and A. N. Herrin, *op. cit.*, chap. 5.

[43]See also E. Chanlett, *op. cit.*, p. 20.

[44]Nathan Keyfitz and Antonio Golini, "Mortality comparisons: the male-female ratio", *Genus*, vol. 31, Nos. 1–4 (1975), pp. 1–34.

Part Five

COLLECTION OF MORTALITY DATA THROUGH SAMPLE SURVEY APPROACHES

IX. EXPERIENCES IN THE USE OF SPECIAL MORTALITY QUESTIONS IN MULTI-PURPOSE SURVEYS: THE SINGLE-ROUND APPROACH*

*John G. C. Blacker***

Multi-purpose surveys may take a wide variety of forms; indeed, the term "multi-purpose" itself is open to a variety of definitions. Almost any survey that includes among its objectives the collection of information on a variety of topics could be so described, and the question arises as to how varied in their nature these topics should be before the designation "multi-purpose" may be regarded as appropriate. Most population censuses could legitimately be seen as a special form of multi-purpose survey. Post-enumeration surveys and "built-in" samples associated with censuses could also be included in these terms of reference. The so-called "demographic sample surveys", conducted in the French-speaking countries of Africa in the late 1950s and early 1960s, were in reality multi-purpose, in so far as they included among their objectives the investigation not only of age and sex structure, fertility, mortality and migration, but of such topics as housing, education, religion and employment. Some multi-purpose surveys involve the use of multi-stage sampling, in such a way that different topics are investigated at the different stages of the sample enumeration. For example, in the 1968-1969 Rural Household Consumption and Expenditure Survey in Lesotho, a first-stage sample of enumeration areas was drawn and the populations of the areas were completely enumerated. Some simple questions on fertility and mortality should be included in the enumeration schedule at this stage. A second-stage sample of households was then drawn from the lists compiled in the first stage, and the particulars of consumption and expenditure were collected in the course of the re-enumeration of those selected households. In some countries, this basic idea of using the same sample for a variety of purposes has been taken a step further. In Kenya, for example, a National Sample has been constructed, such that the basic listing of the population in the first-stage clusters has been used for drawing several subsamples for different types of surveys on a variety of topics, such as household consumption and expenditure, agriculture, nutrition and employment. This procedure opens up interesting possibilities of cross-tabulating the data obtained in one survey against those obtained in others. In general, since births and deaths are relatively rare events, and therefore require large samples for their investigation, questions on fertility and mortality have usually been asked in the first stage of such multi-stage, multi-purpose investigations.

The term "single round" also requires definition. It implies the use of surveys wherein the selected respondents are interviewed once only. This procedure may therefore be contrasted with "follow-up" or "longitudinal" surveys, wherein the same respondents or households are interviewed repeatedly, with a view to ascertaining events which may have taken place between the interviews. Thus, single-round surveys must rely essentially upon retrospective questions about events that took place before the survey interview, as against the "prospective" methods of longitudinal surveys. The restriction of this paper to single-round surveys does not, however, imply that one should exclude from this discussion the fact that the value of such surveys can be greatly enhanced if they are repeated at regular intervals. Such repetition does not necessitate re-interviewing the same households or clusters; all that is required is that the successive samples should all be representative either of the country as a whole or of the same subdivisions within it. An entire new battery of analytical techniques, involving the use of "synthetic cohorts", can be deployed when the results of such successive surveys are available.[1]

Because of their dependence upon retrospective questioning, single-round surveys are particularly susceptible to errors of recall or memory lapse. Thus, special questions have been devised, and special techiques of analysis developed, in order to minimize the effect of such errors; and the retrospective questions of single-round surveys have become particularly associated with the use of "indirect methods" of demographic analysis. Therefore, any discussion of experiences in the use of special mortality questions in these circumstances must necessarily involve a discussion of how well these methods have worked. It is not proposed, however, to include in this chapter a detailed account of how the methods should be applied; such accounts can be found in the relevant manuals.[2] It could also be argued, in view of the foregoing definitions of "multi-purpose" and "single-round", that this chapter should also include a discussion of the data on infant and child mortality derived

*The original version of this chapter appeared as document IESA/P/AC.17/9.

**Senior Research Fellow, Centre for Population Studies, London, United Kingdom of Great Britain and Northern Ireland.

from birth histories obtained in fertility surveys, such as those conducted under the auspices of the World Fertility Survey. However, to subsume such surveys under the general heading "multi-purpose" would be to stretch the use of the term beyond its normally accepted meaning; and since the analysis of the World Fertility Survey data is covered in another paper presented to this meeting, it is not proposed to trespass on this field. The discussion here does cover, however, some experiences gained from the use of the World Fertility Survey household schedule, which included questions of a type frequently asked in multi-purpose surveys.

A. Deaths in the past 12 months

Retrospective questions on deaths among members of a household during the 12 months preceding the survey are among the oldest questions to be included in demographic surveys. They were clearly seen as providing a substitute for information normally obtained through civil registration, so that all the standard indices of mortality, including age-specific rates and life tables, could be calculated directly. Such questions were included in censuses of the United States of America in the nineteenth century when the civil registration there was known to be defective.[3] In more recent times, the question was included in the famous pioneer survey in Mysore State in India in 1951[4] and in the surveys of French-speaking countries of Africa in the late 1950s and early 1960s.[5] Life tables were duly calculated from these data, with what now seems somewhat naïve acceptance of the results at their face value.

More critical analysis, however, quickly demonstrated that the results of these questions were subject to enormous errors, attributable to a variety of causes, including recall lapse, faulty estimation of the reference period, massive misreporting of ages and sometimes complete misunderstanding of the nature of the question. Nor was the incidence of these errors necessarily uniform by sex or age. For example, in the case of the Demographic Survey of Chad in 1964, the enormous disparity between the male and female mortality rates obtained from this question clearly suggested that while the male deaths had been overreported, those of females had been underreported.[6] The question therefore fell into disfavour for some years, being regarded as more or less doomed to failure.

However, the development by Brass[7] of the "growth balance method" and the other variations that have been evolved from this theme[8] gave questions on recent deaths a new lease of life: it was found that corrections could be made to the data which would produce results that could be accepted with a fair degree of confidence. Thus, in the Retrospective Survey of Fertility and Mortality in Bangladesh in 1974, questions were asked about deaths during the 24 months preceding the survey; the application of the growth balance method to the data on deaths for the preceding 12 months suggested that those for males aged 5 years and over had been underreported by 43 per cent and those for females by 52.5 per cent.[9] The data and calculations of this simple technique are shown in table IX.1, and the plot of the partial birth and death rates is given in figure IX.1; the correction factors are derived from the slopes of the fitted lines.

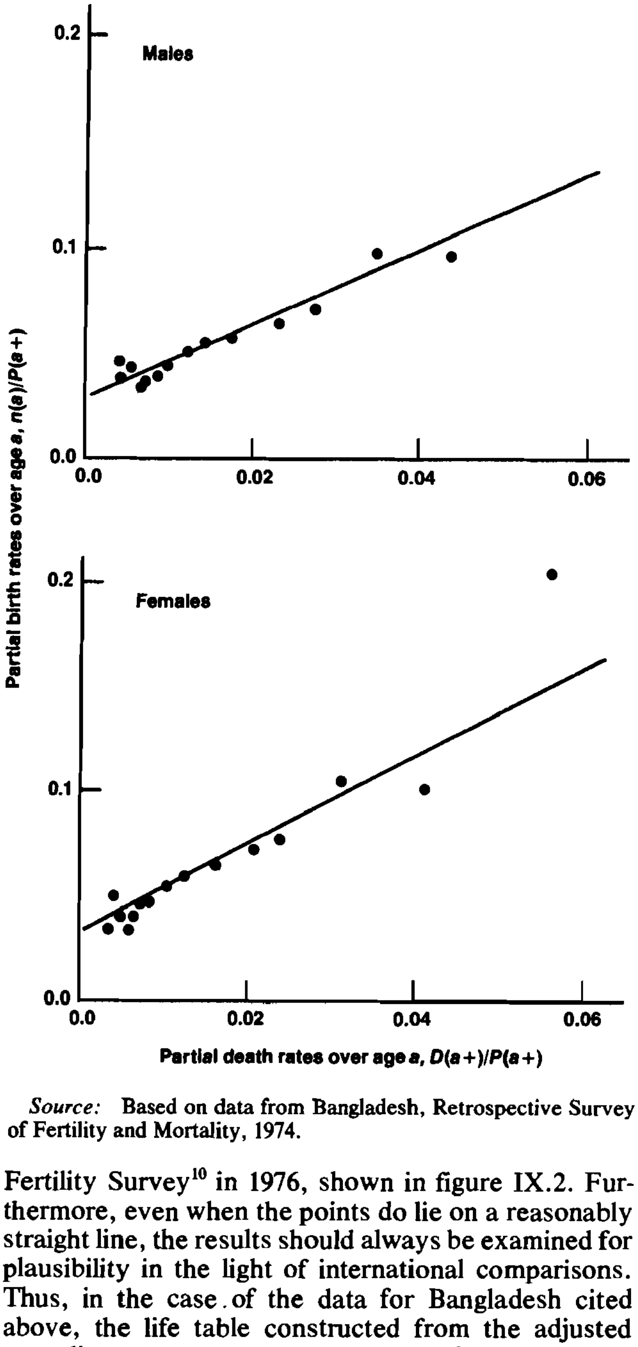
Thus, the use of the growth balance method provides some justification for the inclusion of these questions in a suitable survey, but there is still no guarantee that it will give usable results. All too often the plot of the partial birth rates against the partial death rates provides a series of points which by no stretch of the imagination could be regarded as lying on a straight line, as was the case, for example, with the data obtained from the household schedule of the Jordan

Table IX.1. Population and deaths, by sex and age, and derived partial birth and death rates, Bangladesh, 1974

Age group (a, a + 4)	Males: Population (hundreds)	Males: Reported deaths (hundreds)	Males: Age a+ partial birth rate	Males: Age a+ partial death rate	Females: Population (hundreds)	Females: Reported deaths (hundreds)	Females: Age a+ partial birth rate	Females: Age a+ partial death rate
0-4	53 520	2 202			54 900	1 785		
5-9	61 850	115	0.0365	0.0040	62 000	158	0.0405	0.0038
10-14	53 480	70	0.0454	0.0045	46 750	73	0.0480	0.0042
15-19	33 230	53	0.0432	0.0053	30 150	84	0.0427	0.0049
20-24	26 480	35	0.0357	0.0061	26 530	53	0.0378	0.0053
25-29	25 760	41	0.0371	0.0070	26 070	52	0.0427	0.0060
30-34	21 010	31	0.0406	0.0082	20 160	63	0.0475	0.0071
35-39	20 730	39	0.0443	0.0097	17 720	41	0.0491	0.0081
40-44	17 240	47	0.0517	0.0119	14 800	36	0.0548	0.0099
45-49	13 680	58	0.0550	0.0147	11 350	33	0.0587	0.0123
50-54	12 160	73	0.0608	0.0180	10 490	57	0.0657	0.0156
55-59	7 940	83	0.0663	0.0228	6 070	64	0.0728	0.0202
60-64	8 770	127	0.0746	0.0272	6 970	94	0.0783	0.0237
65-69	4 390	77	0.0965	0.0354	3 250	36	0.1054	0.0311
70-74	4 680	131	0.0982	0.0439	3 290	87	0.1016	0.0411
75+	4 560	274	0.2029	0.0602	3 150	178	0.2045	0.0565

Source: Bangladesh, Retrospective Survey of Fertility and Mortality, 1974.

Figure IX.1. Derived partial birth and death rates over successive ages, by sex, Bangladesh, 1974



Source: Based on data from Bangladesh, Retrospective Survey of Fertility and Mortality, 1974.

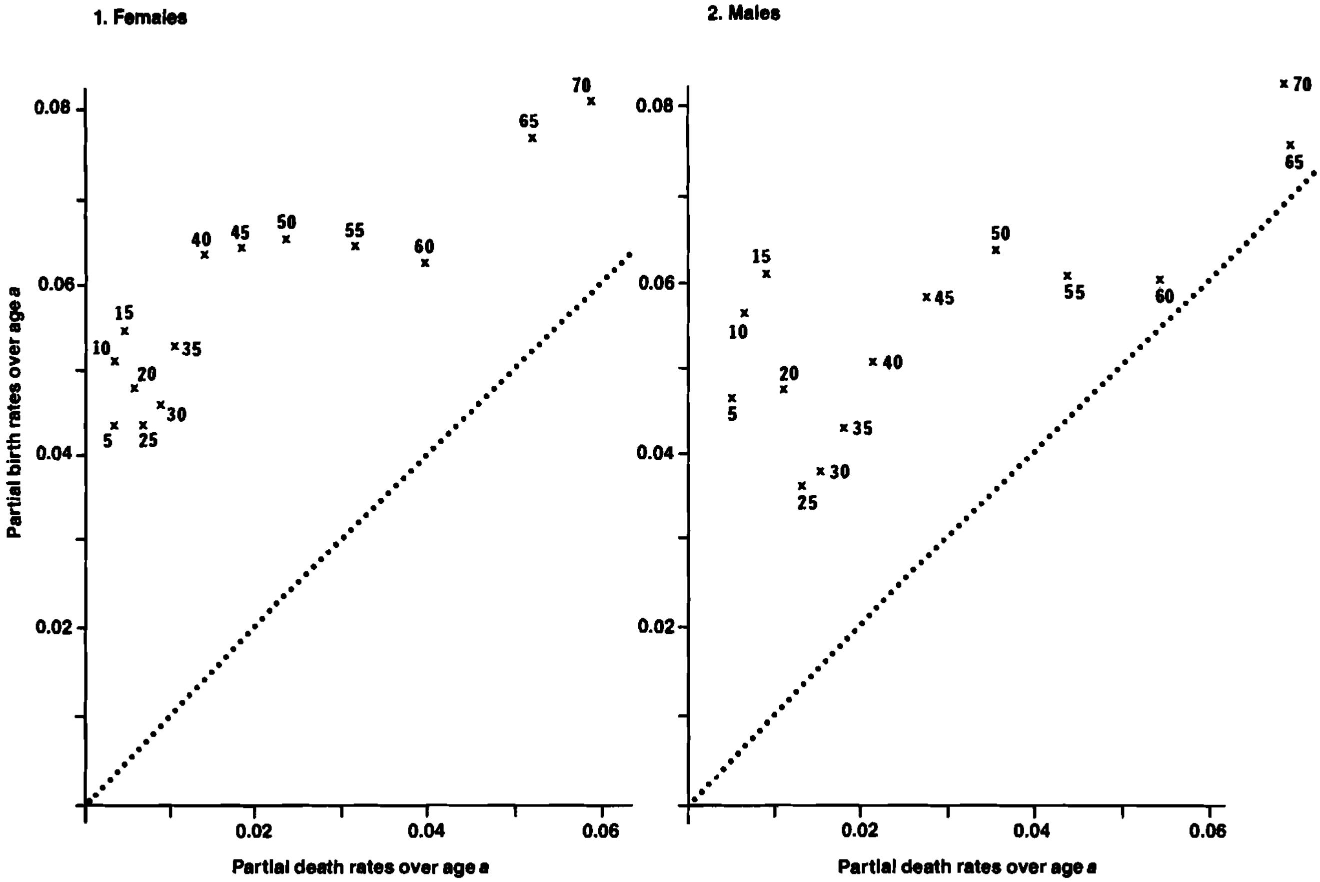
Fertility Survey[10] in 1976, shown in figure IX.2. Furthermore, even when the points do lie on a reasonably straight line, the results should always be examined for plausibility in the light of international comparisons. Thus, in the case of the data for Bangladesh cited above, the life table constructed from the adjusted mortality rates gave an expectation of life for males aged 45 years that was higher than that for males in England and Wales during the same period—a result which caused at least some eyebrows to be raised. Lastly, it should be remembered that the method can normally only be used for the estimation of adult mortality; it can rarely, if ever, be used for the correction of errors in infant and child deaths.

B. Proportions dying among children ever born

Questions asked of adult women as to the number of children they have borne, the number still living and the number dead are also among the oldest to be included in multi-purpose inquiries. They were asked, for example, in censuses of the United States of America in the late nineteenth century, in the 1911 census of England and Wales, and the 1930-1932 "medical census" of Nigeria.[11] It was not until the 1960s, however, that techniques for converting the proportions of children dying, tabulated by five-year age groups of mothers, into life-table functions were first developed by Brass,[12] with subsequent modifications by Sullivan[13] and Trussell.[14] Further refinements have also been developed by Preston and Palloni,[15] using the age distribution of surviving children; and by Feeney[16] and Trussell,[17] who have devised methods of locating in time the mortality estimates derived from each age group of mothers. The inclusion of the relevant questions in censuses and surveys and the use of the analytical techniques have been so widespread that they now constitute the principal source of information on infant and child mortality in the great majority of the countries where birth and death registration is defective.

The Brass estimates of mortality in the first two years of life obtained from proportions of children dying to mothers aged 20-24 were first tested empirically with data from Canada and Hungary, where they were compared with the mortality rates derived from death registration;[18] the test showed very satisfactory agreement between the Brass estimates and the registered rates. More recently, Somoza[19] has made similar comparisons from data for Chile and Costa Rica. Estimates of both levels and trends derived from the use of Trussell's regression equations were compared with the equivalent registered rates; again, generally satisfactory agreement was found provided the estimates were based on proportions of children dying to mothers between the ages of 25 and 50. The data for mothers under age 25 tended to give overestimates of mortality, which is attributed to the "fact that mortality of children of very young mothers . . . is higher than the average".[20] Another recent empirical test, under more extreme conditions, is that made by Garenne,[21] using data from a rural area of Senegal, where not only was the general level of infant and child mortality very high (nearly half the children born alive died in the first five years of life), but the age-specific pattern of mortality diverged from that depicted by any of the usual model life tables, the probability of dying between the ages of 1 and 5 years being substantially higher than that in the first year of life. In this test, the Trussell estimates of mortality in the first two years of life (q_2) based on proportions of children dead to mothers aged 20-24 years agreed well with the observed mortality rates, except when the regression equations based on the North model life tables were used; these equations gave an appreciable underestimate of mortality. However, the estimates of q_3 and q_5 based on the data for mothers aged 25-29 and 30-34, respectively, all tended to underestimate mortality, the bias being most serious when the North equations were used. The figures are shown in table IX.2.

Figure IX.2. Partial birth and death rates over successive ages, by sex, derived from data on deaths in the past 24 months using the growth balance method, Jordan



Source: Based on data from *Jordan fertility survey, 1976: Principal Report,* World Fertility Survey report (Amman, 1979), household schedule.

The data for Senegal discussed above may represent an extreme mortality pattern, but some of the conclusions reached confirm the present writer's experience with other data for Africa, to the effect that the North equations tend to give not only lower mortality estimates than those based on the other model life table families but estimates that are less internally consistent. This feature becomes most starkly apparent when each value of q_x is equated to a given mortality level of the model life-table system and plotted against the time-location estimates derived by the Feeney or Trussell methods. The progressive underestimation of mortality given by the North equations for the older age groups of mothers simulates a rise in mortality which may be obviously at variance with the fact that data obtained for the same country at different periods clearly show a decline in the proportions of children dying. The data from the 1966 and 1976 censuses of Swaziland, shown in table IX.3 and illustrated in figure IX.3, expressed in terms of the infant mortality rate, provide an example, although the use of an alternative mortality pattern, the West model, also fails to show a clear mortality trend.

Spurious rises in mortality of this type, however, should not be attributed solely to defects in the analytical procedures. Progressive underreporting of dead

TABLE IX.2. IMPACT OF THE MODEL AND AGE PATTERN OF MORTALITY ON ESTIMATES OF PROBABILITY OF DYING, $q(x)$, SENEGAL, 1963-1973

Probability of dying	Actual values at Ngayokheme, 1963-1973[a]	Predicted values using various models in conjunction with "true" proportion dead, by age of mother and true values of fertility: Brass		Sullivan				Trussell			
		P1/P2	P2/P3	West	North	East	South	West	North	East	South
$q(1)$	0.2390	0.2575	0.2409					0.2598	0.2529	0.2634	0.2450
$q(2)$	0.3721	0.3699	0.3572	0.3674	0.3504	0.3717	0.3649	0.3717	0.3544	0.3735	0.3703
$q(3)$	0.4496	0.4095	0.4162	0.3928	0.3715	0.3952	0.3964	0.3989	0.3780	0.4030	0.4046
$q(5)$	0.4894	0.4384	0.4314	0.4162	0.4045	0.4236	0.4232	0.4249	0.4119	0.4273	0.4301
${}_4q_1$	0.3290	0.2436	0.2510	..	..	..	..	0.2230	0.2128	0.2225	0.2452

Source: M. Garenne, "Problems in applying the Brass method in tropical Africa; a case study in rural Senegal", paper submitted to the International Union for Scientific Study of Population Seminar on Methodology and Data Collection in Mortality Studies, Dakar, Senegal, 7-10 July 1981.

[a]Corrected for omission of deaths in the first month of life.

TABLE IX.3. TRENDS IN INFANT MORTALITY ESTIMATED USING TRUSSELL'S REGRESSION EQUATIONS, SWAZILAND, 1966 AND 1976

			"North" equations			"West" equations		
Based on census of	*Age group of mothers*	*Proportion of children surviving*	*Mortality level*	*Infant mortality rate (per 1,000 live births)*	*Time location*	*Mortality level*	*Infant mortality rate (per 1,000 live births)*	*Time location*
1966	15-19	0.8277	8.64	176	1965	9.72	180	1965
	20-24	0.8021	10.54	147	1963	11.01	159	1963
	25-29	0.7979	11.61	133	1961	11.59	150	1961
	30-34	0.7738	12.01	127	1959	11.70	148	1959
	35-39	0.7577	12.12	126	1956	11.65	149	1956
	40-44	0.7295	11.80	130	1954	11.24	155	1953
	45-49	0.7110	11.97	128	1951	11.37	154	1950
1976	15-19	0.8319	9.42	164	1975	10.42	169	1975
	20-24	0.8092	10.85	143	1974	11.32	154	1974
	25-29	0.8025	12.11	126	1972	12.12	142	1972
	30-34	0.7870	12.35	123	1970	12.10	142	1969
	35-39	0.7760	12.62	120	1967	12.22	141	1967
	40-44	0.7522	12.43	122	1965	11.93	145	1964
	45-49	0.7365	12.68	119	1962	12.11	142	1961

Source: Based on data from Swaziland, censuses of 1966 and 1976.

children by older mothers may well be a factor, and Somoza's[22] suggestion that the data recorded for mothers under age 25 may give overestimates of mortality may also be applicable. A very frequent feature of child survival data from developing countries, clearly illustrated by the example of Swaziland delineated in figure IX.3, is that the estimates of q_2 based on data for mothers in age group 20-24 imply a higher level of mortality than the q_3 and q_4 estimates derived from mothers in age groups 25-29 and 30-34, no matter what conversion technique or model life table is used. To illustrate this point, data from the 1970 Population Change Survey in Malawi and the 1973 census of the Sudan have been cited elsewhere by the present writer.[23]

Children borne by mothers aged 20-24 consist largely of first-order births, which are generally subject to higher mortality than those of second, third and fourth orders. The same argument applies *a fortiori* to data for mothers aged 15-19, and any estimates of infant mortality derived from these data should be regarded with the utmost distrust.

Further research on these potential biases is being undertaken, and it is to be hoped that the results of this research will permit the margins of error in the estimates of child mortality derived from these questions to be further reduced.

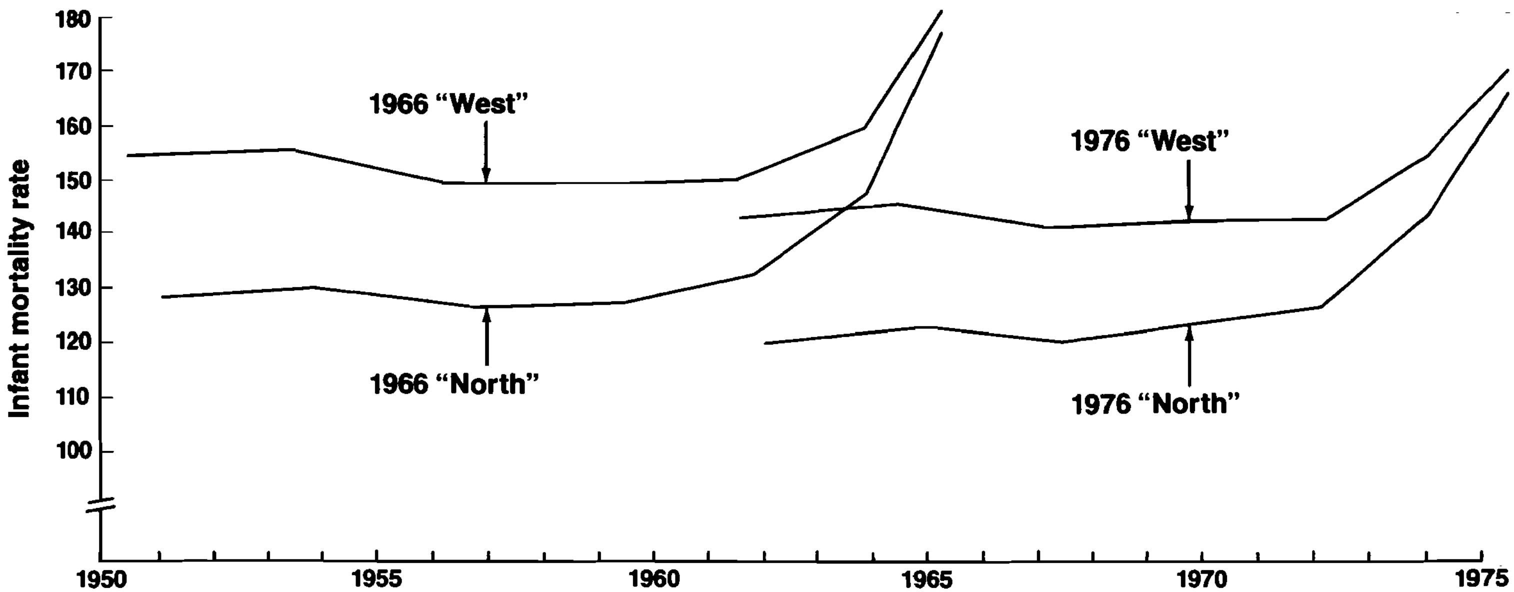
C. MORTALITY OF CURRENT BIRTHS

Several censuses and surveys have included questions on current fertility, either in the form of a direct question about births occurring in the previous 12 months or by asking for the date of the woman's most recent live birth, from which women bearing children during the preceding 12 months can be readily extracted. These questions have sometimes also been accompanied by one asking whether or not the child concerned is still alive. The mortality rates derived from these data have generally been regarded as constituting serious underestimates. For example, in the 1971 census of Botswana, 48 per 1,000 of the children born during the preceding 12 months were shown to have died. If this figure is taken as representing approximately two thirds of the infant mortality rate, it implies a value for the latter of some 72 per 1,000; estimates based on lifetime fertility data, however, indicated that the true value could not be much less than 100 per 1,000, so that the mortality of current births was being underreported by some 25 per cent.

Similar data and similar calculations for the 1973 census of the Gambia likewise indicated an underreporting of such deaths by at least 25 per cent. A study of the tape-recordings made of the census interviews[24] showed clearly how such omissions occurred: the questions were simply not being asked. In about one third of the tape-recorded interviews concerning eligible women, the question on the date of the most recent live birth was not asked. Yet, in the majority of such cases, entries were in fact being made on the census schedule; and it must be presumed that the enumerators were inferring the answers on the basis of other information, such as the age of the youngest child in the household. This procedure would clearly lead to error if the woman had subsequently borne another child who had either died or was living elsewhere, but the follow-up question on the survival of the last-born child, which had been included in an attempt to forestall this type of error, was also not being asked—this time in almost half of the relevant interviews.

This dismal result, however, has not been the universal experience. In the 1974 Retrospective Survey of Fertility and Mortality in Bangladesh, the reported mortality of children born during the preceding 12 months was 97 per 1,000, implying an infant mortality rate of 145 per 1,000; this figure in fact agrees well with estimates derived from other sources, most of which indicated that infant mortality in Bangladesh is of the order of 150 per 1,000 or fewer.

Figure IX.3. Trends in infant mortality estimated by use of Trussell's regression equations with data from Swaziland



Source: Based on data from Swaziland, censuses of 1966 and 1976.

In contrast, the mortality of current births recorded in the Survey of Mauritania in 1975 gave an estimate of the infant mortality rate that was almost twice the figure derived from the data on lifetime fertility. It is clear that the results of these questions should always be regarded with cautious scepticism.

D. ORPHANHOOD

In contrast to the types of questions discussed above, the orphanhood questions are of more recent origin. The idea of estimating adult mortality in developing countries by asking questions about whether persons' fathers and mothers are still alive was first proposed by Henry[25] in 1960, and was first put into practice in the sample surveys conducted in Chad, Mauritania and the United Republic of Cameroon (West Cameroon only) in the mid-1960s. At about the same time, Brass developed various techniques for converting the data so obtained into standard life-table probabilities of survival. His results were made available to interested persons, although they were not officially put before the public until 1973.[26] Since then, further modifications of the analytical procedures have been developed.[27] In the meantime, the questions have grown in popularity, perhaps largely as a result of their simplicity and in the light of the encouraging nature of the results, which appeared, at first sight at least, to be both plausible and internally consistent;[28] they have thus been included in several censuses and surveys in Africa, Asia and Latin America.

It was recognized from the outset, however, that the entire procedure would be subject to a variety of potential biases. These biases included the "adoption effect" (i.e., the substitution of foster parents for true parents in the response), selectivity arising from correlation between the mortality of the respondents' generation and that of their parents, multiple reporting of the same parents by more than one offspring, the effect of declining mortality, misreporting of the respondents' ages and the divergence of the patterns of fertility and mortality in the population under examination from those of the models used for the calculation of the conversion factors.

The magnitude of the bias due to the adoption effect varies among different parts of the less developed regions and is probably most serious in Africa, where the terms "father" and "mother" are often used loosely to denote not only a person's biological parents but foster parents, older relatives acting, perhaps temporarily, *in loco parentis*, or simply as terms of respect for members of an older generation. Some indication of the possible magnitude of the adoption bias may sometimes be gleaned by comparing the numbers of persons reporting their mothers as alive with the numbers of living children reported by mothers in response to questions on lifetime fertility. In the absence of migration, the two figures should agree. Table IX.4 shows these comparisons for some selected developing countries. When looking at these comparisons, it is necessary to consider other possible causes of the discrepancies. In the first place, it is often thought that the numbers of living children reported by mothers, particularly by older women, tend to be understated. Secondly, there are the effects of migration: in countries experiencing net emigration, the numbers of living children reported by mothers would normally be greater than the number of persons reporting their mothers as alive, and vice versa in the case of immigration. Thus, the large discrepancy shown by the 1973 census of the Gambia can certainly be attributed, in part at least, to immigration, as the census shows about 55,000 persons born outside the country. (In these circumstances, it would clearly be useful to have the orphanhood data tabulated by the birthplace of the respondent.) On the other hand, the very good agreement shown by the 1971 census of Botswana may well have been the result of compensating errors; some overreporting of mothers alive due to the adoption effect may have been compensated by an appreciable net emigration. In the case of Jordan, where the population has been much influenced by substantial migratory movements in both directions, the close agreement would seem to owe something to good luck.

TABLE IX.4. COMPARISON OF NUMBERS OF PERSONS WHO REPORTED MOTHERS ALIVE WITH NUMBERS OF LIVING CHILDREN REPORTED BY MOTHERS, SELECTED DEVELOPING COUNTRIES, VARIOUS YEARS

Country	*Year*	*Persons who reported mothers alive*	*Living children reported by mothers*	*Percentage discrepancy*
Bangladesh	1974	54 253 678	50 306 167	+ 4.8
Bolivia	1975	39 883	39 428	+ 1.2
Botswana	1971	458 071	455 555	+ 0.5
Gambia	1973	345 948	306 113	+13.0
Honduras	1972	24 270	24 488	− 0.9
Jordan	1976	81 540	82 063	− 0.6
Kenya	1979	12 898 552	12 274 265	+ 4.8
Peru	..	35 803	37 567	− 4.9
Syrian Arab Republic	1978	82 264	82 001	+ 0.3

There is no doubt that the group of respondents most susceptible to the adoption effect are young children enumerated in the same household as adults who are shown, in answer to the question on relationship, as being the parents of the children; in these circumstances, enumerators rarely bother to probe whether the children are the true offspring of these so-called "parents" and automatically record the fathers and mothers as being alive without asking the questions. In almost all censuses and surveys where the orphanhood questions have been asked, the proportions of children under age 15 for whom the mothers were shown as being dead have been so small as to imply unacceptably low levels of mortality. The bias is less conspicuous in the data for fathers, and it could be argued that the adoption effect is less serious in the case of paternal orphanhood than it is in the case of maternal.

The rejection of the orphanhood data for children under age 15 means that the first usable data are those for an age group of respondents who represent the survivors of a birth cohort that has already been substantially depleted by mortality. Thus, any correlation between the mortality of the respondents' birth cohort and that of their parents will lead to an underestimation of mortality by the orphanhood method. The problem may be illustrated by the data from the 1979 census of Kenya, shown in table IX.5, where the maternal orphanhood and child survival data have been cross-tabulated by the education of the respondent. Large differentials are clearly apparent in both sets of data. However, it is comforting to note that the implied bias in the overall figures is, in this case at any rate, negligible. If one assumes that the respondents' birth cohort has been subject to a level of mortality commensurate with that indicated by the child survival data, it is possible to reconstruct the size of the original birth cohorts for each education group; the proportions with mothers alive for each education group can then be reweighted by the number of births of which the respondents represent the survivors, rather than by the number of respondents themselves. The overall proportion with mother alive so obtained differs from the unweighted proportion by 0.2 per cent. Similar calculations for older age groups of respondents yielded similarly trivial differences, more especially since the proportions of respondents with any form of education diminished rapidly with increasing age. In this respect, therefore, education is perhaps not the best variable to take to examine the possible selectivity bias; geographical differentials might well have a greater effect, but it still seems unlikely that this particular source of bias can be very serious.

The bias due to multiple reporting remains entirely problematical and no satisfactory method has yet been devised of measuring it; indeed, it still is not entirely clear whether this bias would be more likely to cause an overestimate or an underestimate of mortality. Attempts have been made in some countries to overcome this problem by asking an additional question as to whether the respondent is the oldest among his or her living siblings; a separate analysis of the orphanhood data for the eldest surviving children was then made in the hope of thereby securing only one report on each parent. Unfortunately, in all the countries where this question has been asked, there has been clear evidence that too many people claim to be the eldest surviving child of their parents. This error would tend to give an overestimate of mortality, since the average age difference between parents and their true eldest surviving children, to which the models involved in applying the method would be fitted, would be lower than that between parents and reported eldest surviving children; a higher proportion of parents would thus have died, giving rise to exaggerated mortality estimates.

The exclusion of the data for the younger age groups due to the adoption effect, described above, also has the effect that the only usable data represent the cumulated mortality experience of a considerable number of years preceding the survey. Brass and Bamgboye[29] have recently developed a method of time location for the orphanhood and widowhood estimates, comparable with the procedures devised by Feeney and Trussell for child mortality. On the basis of their results, the orphanhood estimates derived from data for respondents between the ages of 20 and 50 years (which are normally regarded as the most reliable) may be taken as representing mortality levels for a period between 8 and 15 years before the survey. Thus, if adult mortality is thought to be falling, some type of projection will be needed to bring the mortality estimates up to date. When the levels of mortality derived from the orphanhood estimates from different age groups of respondents are plotted against the time-location estimates derived from the Brass and Bamgboye method, they have frequently shown such steep falls in mortality as to be unacceptable. This feature becomes more starkly apparent when two or more series of orphanhood data are available from different censuses or surveys. Figure IX.4 shows such results for Kenya, where three sets of orphanhood data are available: from the 1969 and 1979 censuses; and from the National Demographic Survey of 1977. In this illustration, the general level of mortality has been represented by the use values of life expectancy at birth in the right-hand margin (a lower level of alpha implies a lower level of mortality). The fact that the lines are parallel clearly demonstrates the mutual incompatability of the estimates. Another procedure that may be applied when two or more sets of orphanhood data are available is the synthetic-cohort method suggested by Zlotnik and Hill;[30] application of this technique to data from Peru also yielded very low estimates of mortality, which they regarded as unacceptable, thus shaking their faith in the usefulness of orphanhood data in general.

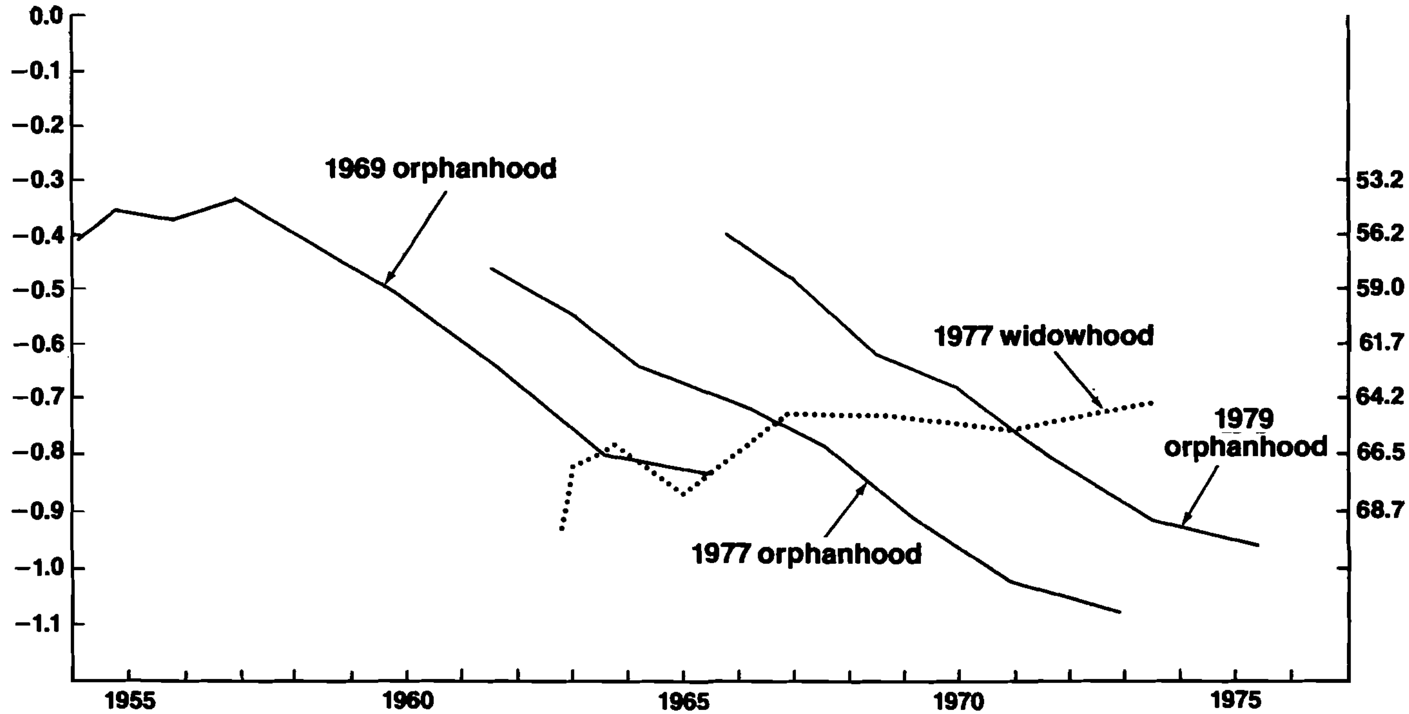
In the opinion of the writer, however, such scepti-

TABLE IX.5. DIFFERENTIALS IN ORPHANHOOD AND CHILD SURVIVAL, BY EDUCATION OF RESPONDENT, KENYA, 1979

Age group	*Proportion of females with mother alive, by education of respondent*			*Proportion of children dead, by education of respondent*		
	No schooling	*Primary*	*Secondary*	*No schooling*	*Primary*	*Secondary*
15-19	0.9124	0.9573	0.9730	0.1479	0.1009	0.0613
20-24	0.8655	0.9257	0.9565	0.1610	0.1054	0.0604
25-29	0.8039	0.8866	0.9267	0.1749	0.1116	0.0585
30-34	0.7103	0.8342	0.8886	0.1954	0.1198	0.0567
35-39	0.6367	0.7767	0.8074	0.2062	0.1324	0.0635
40-44	0.5226	0.6821	0.7744	0.2363	0.1539	0.0727
45-49	0.4198	0.5766	0.5949	0.2689	0.1844	0.0851

Source: Kenya, 1979 census.

Figure IX.4. Trends in female adult mortality estimated from orphanhood and widowhood, Kenya



Source: Based on data from Kenya, censuses of 1969 and 1979; and National Demographic Survey, 1977.

cism is not entirely justified, and further research is needed on techniques that will minimize the bias due to age-misreporting. Since the proportions of persons with parents alive decline rapidly with age, even a modest amount of overstatement of age can introduce a serious bias into the proportion orphaned. It is thought that this is the principal reason that the proportions with parents alive reported by male respondents are consistently higher than those reported by females, since, in Africa in any rate, there is a greater tendency for males to exaggerate their ages than there is for females. Further evidence of the effect of age-misreporting can be seen in the extremely low mortality levels implied by the proportions orphaned reported by older age groups of respondents, where age exaggeration on the part of the respondent becomes increasingly prevalent. Analytical techniques based on cumulated numbers, rather than age-specific proportions, offer greater hope of minimizing the effect of such bias. Techniques of applying such procedures when two or more series of orphanhood data are available are currently being investigated.

A more encouraging assessment of mortality estimates based on orphanhood data comes from Somoza,[31] who compares such estimates for Chile, Costa Rica, Guatemala and Panama with the corresponding measures of mortality derived from civil registration. His figures show reasonable agreement.

E. Widowhood

The idea of deriving estimates of adult mortality from proportions of persons widowed pre-dates the development of the widowhood method proper. It was used, for example, by Koblenzer and Carrier[32] to estimate the mortality of an indigenous tribe in Sabah, Malaysia. However, the method as it is now generally applied was only developed by Hill in the early 1970s.[33] Although not adopted as widely as the orphanhood approach, the necessary questions have, nevertheless, been asked in several developing countries. Because of the bias due to remarriage, mortality cannot normally be estimated from conventional data on current marital status. The widowhood method therefore requires special questions to be asked as to whether a person has been married more than once, and, if so, whether the first spouse is still alive. This procedure, in itself, introduces a potential source of bias, since in some circumstances earlier marriages may be concealed or otherwise underreported. It is thought that this is particularly liable to happen when male heads of households are providing information on behalf of their wives. Thus, in the Jordan Fertility Survey in 1976, only 3 per cent of women aged 25-29 years were reported as widowed in their first marriages in the household schedule, as against 10 per cent shown by the individual questionnaires. It is thought that this difference may be attributed to the fact that the information for the household schedule was usually provided by the heads of households, whereas the individual questionnaires were answered by the women themselves. Another source of bias arises in the case of populations where sexual unions are informal and unstable, thus generating confusion as to what should constitute an earlier marriage. For this reason, the questions are perhaps more suited to countries of Asia and Northern Africa than they are to those of sub-Saharan Africa or parts of Latin America.

Apart from these difficulties, the widowhood method has certain advantages over that of orphanhood. Except in rare cases, such as polygamous unions, the issue of multiple reporting does not arise. Nor is there any exact equivalent of the adoption effect, unless the underreporting of earlier marriages could be seen in this light. The fact that in most developing countries first marriages are clustered over a relatively short age range also helps to limit the effects of deviations from the patterns of the demographic models used in developing the analytical procedures.

The time-location procedures developed by Brass and Bamgboye for the orphanhood data are also applicable to widowhood. Since the requisite questions were asked in the 1977 National Demographic Survey in Kenya, the trends shown by these data are also plotted on figure IX.4. In contrast to the orphanhood data, those on widowhood show no general downward trend, although there is reason to think that the general level of adult female mortality indicated by this procedure constituted an underestimate.

Somoza has also made comparisons between widowhood estimates and mortality indices derived from death registration for Chile and Panama. For Chile, the widowhood estimates for both sexes tended slightly to underestimate mortality; for Panama, good agreement was secured.

Conclusion

All the mortality questions discussed in this chapter are relatively simple and are suited for inclusion in censuses or other forms of multi-purpose survey. They take up little space on the questionnaires, and the data so obtained are simple to code, punch and tabulate. Thus, when reliable indices of mortality are not available from other sources, there is much to be said for including such questions whenever there is a suitable opportunity. However, the mortality estimates derived from them are all subject to biases of one type or another. With well-conducted field-work, the results will generally show reasonable agreement so that they can be accepted with a reasonable degree of confidence. Sometimes, however, they show wide discrepancies, so that any conclusions that are drawn must be both tentative and determined by the subjective judgement of the analyst. There is still no method of estimating either fertility or mortality in developing countries lacking reliable vital registration which can be guaranteed to give accurate results.

Notes

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[2]*Manual IV. Methods of Estimating Basic Demographic Measures from Incomplete Data* (United Nations publication, Sales No. E.67.XIII.2); William Brass, *Methods for Estimating Fertility and Mortality from Limited and Defective Data* (Chapel Hill, N.C., University of North Carolina, Laboratories for Population Statistics, 1975); *Manual X. Indirect Techniques for Demographic Estimation* (United Nations publication, Sales No. E.83.XIII.2).

[3]Frank Lorimer, *Demographic Information on Tropical Africa* (Boston, Mass., Boston University Press, 1961).

[4]*The Mysore Population Study: Report of a Field Survey Carried Out in Selected Areas of Mysore State, India* (United Nations publication, Sales No. 61.XIII.3).

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[6]Chad, Service de statistique. *Enquête démographique au Tchad, 1964: résultats définitifs* (Paris, published jointly by Secrétariat d'état aux affaires etrangères chargé de la coopération, Mission démographique du Tchad; and Institut national de la statistique et des études économiques, 1966).

[7]W. Brass, *op. cit.*

[8]Hoda M. Rashad, "The estimation of adult mortality from defective registration data", unpublished doctoral dissertation, University of London, 1978; William Brass, *Methods for Estimating Fertility and Mortality from Limited and Defective Data*, International Program of Laboratories for Population Statistics, Occasional Publication (Chapel Hill, N.C., University of North Carolina, 1975); S. Preston and K. Hill, "Estimating the completeness of death registration", *Population Studies*, vol. 34, No. 2 (July 1980) pp. 349-366; Linda G. Martin, "A modification for use in destabilized populations of Brass's technique for estimating completeness of death registration, *Population Studies*, vol. 34, No. 2 (July 1980), pp. 381-395; Samuel H. Preston and others, "Estimating the completeness of reporting of adult deaths in populations that are approximately stable", *Population Index*, vol. 46, No. 2 (Summer 1980), pp. 179-202.

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[11]Olusola Ayeni, "Demographic characteristics of Nigeria: an analysis of population data from 1931-1965", unpublished doctoral dissertation, University of London, 1975.

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[13]Jeremiah M. Sullivan, "Models for the estimation of the probability of dying between birth and exact ages of early childhood", *Population Studies*, vol. 26, No. 1 (March 1972), pp. 79-97.

[14]T. James Trussell, "A re-estimation of the multiplying factors for the Brass technique for determining childhood survival rates", *Population Studies*, vol. 29, No. 1 (March 1975), pp. 97-108.

[15]Samuel H. Preston and Alberto Palloni, "Fine-tuning Brass-type mortality estimates with data on ages of surviving children", in *Population Bulletin of the United Nations, No. 10-1977* (United Nations publication, Sales No. E.78.XIII.6), pp. 72-87, and Alberto Palloni, "Estimating infant and childhood mortality under conditions of changing mortality", *Population Studies*, vol. 34, No. 1 (March 1980), pp. 129-142.

[16]Griffith Feeney, "Estimating infant mortality rates from child survivorship data by age of mother", *Asian and Pacific Census Newsletter*, vol. 3, No. 2 (November 1976), pp. 12-16; and "Estimating infant mortality trends from child survivorship data", *Population Studies*, vol. 34, No. 1 (March 1980), pp. 109-128.

[17]See *Manual X. Indirect Techniques for Demographic Estimation*.

[18]*Manual IV. Methods of Estimating Basic Demographic Measures from Incomplete Data.*

[19]Jorge Somoza, "An evaluation of the performance of indirect estimation techniques in the analysis of defective data", in *International Population Conference, Manila, 1981* (Liège, International Union for the Scientific Study of Population, 1981), v. 3, pp. 375-396.

[20]*Ibid.*, p. 382.

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[23]J. G. C. Blacker, "The application of indirect techniques for the estimation of fertility and mortality to African data", paper submitted to the [United Nations] Expert Group Meeting on Fertility and Mortality Levels, Patterns and Trends in Africa, Monrovia, Liberia, 26 November-1 December 1979.

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[25]Louis Henry, "Mesure indirect de la mortalité des adultes", *Population*, vol. 15, no. 3 (June-July 1960), pp. 451-466.

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[27]K. Hill and J. Trussell, "Further developments in indirect mortality estimation", *Population Studies*, vol. 31, No. 2 (July 1977), pp. 313-333; and *Manual X. Indirect Techniques for Demographic Estimation*.

[28]J. G. C. Blacker, "The estimation of adult mortality in Africa from data on orphanhood", *Population Studies*, vol. 31, No. 1 (March 1977), pp. 107-128.

[29]William Brass and E. A. Bamgboye, *The Time Location of Reports of Survivorship: Estimates for Maternal and Paternal Orphanhood and the Ever-Widowed*, Centre for Population Studies working paper, No. 81-1 (London, London School of Hygiene and Tropical Medicine, 1981).

[30]H. Zlotnick and K. Hill, *loc. cit.*

[31]J. Somoza, *op. cit.*

[32]P. J. Koblenzer and N. H. Carrier, "The fertility, mortality and nuptiality of the Rungus Dusun", *Population Studies*, vol. 13, No. 3 (March 1960), pp. 266-277.

[33]Kenneth Hill, "Indirect methods of estimating adult mortality levels", unpublished doctoral dissertation, University of London, 1975; and "Estimating adult mortality levels from information on widowhood", *Population Studies*, vol. 31, No. 1 (March 1977), pp. 75-84.

X. USE OF SPECIAL MORTALITY QUESTIONS IN FERTILITY SURVEYS: THE WORLD FERTILITY SURVEY EXPERIENCE*

*John Hobcraft***

As indicated by its name, the World Fertility Survey was not primarily intended as a mortality survey. Yet, its results probably constitute the richest body of data on infant and child mortality currently available for developing countries. Much of the potential of these data has only recently begun to be exploited and much remains to be done.

The intentions of this chapter are to review briefly the nature of the information relevant to the study of mortality which has been collected in the World Fertility Survey, to review the various assessments of the quality of data on infant and child mortality, to discuss the relative advantages and limitations of retrospective maternity histories for the study of infant and child mortality, to provide some highlights of findings to date from comparisons across a large number of countries, to give some preliminary findings on the interplay between individual and household factors in determining levels of infant and child mortality and to outline some of the major directions for future utilization of these data.

A. WORLD FERTILITY SURVEY DATA ON MORTALITY

Infant and child mortality

At the heart of every survey in the World Fertility Survey programme is a complete birth history for each woman included in the individual interviews. This history attempts to provide reliable information on the time of occurrence of each live birth (and stillbirth), its sex, whether still alive; and, if dead, the time that the child lived. The actual procedures used to obtain the dating vary among countries; a summary for the first 19 countries is given in table X.1. In general, attempts were made to get a month and year for the occurrence of each birth; and in all cases, either a calendar year or an age were recorded (except for 0.2 per cent of maternities in Guyana). Table X.2 summarizes the distribution of births by the form in which their dates were reported for all maternities that resulted in live births for the subset of the first 19 countries for which this information was available. In all instances, a date in months and years was imputed, subject to relevant constraints, where not reported. This imputation procedure cannot by itself misplace births seriously in time, at least for purposes of studying infant mortality. Equally, the imputation procedure used on births has no effect on the age at death for non-surviving children.

Ages at death or length of life of dead children are, of course, not always accurately known. In particular, for deaths in the first year of life, heaping on exact years (with zero months) is by no means easy to detect, as deaths in the first month of life (neonatal mortality) are likely to be frequent. For many of the surveys, there is evidence of heaping on exact years of age at death, or perhaps non-reporting of months. In so far as such heaping represents an age at death in completed years, this will have little effect on conventional mortality calculations. However, a tendency to report late infant deaths as occurring at age 1 would result in a downward bias in estimated infant mortality rates. Similarly, though to a lesser extent, upward transfer across exact year-of-age boundaries at higher ages of death would also affect mortality estimates.

The apparent degree of accuracy of the ages at death available to the analyst of infant and child mortality with World Fertility Survey data varies somewhat between surveys. Most frequently, the ages at death are coded in single months and years. Of the 23 countries that have published their reports, for which some results are given later, 12 fall into this category: Bangladesh; Fiji; Guyana; Haiti; Jamaica; Jordan; Kenya; Malaysia; Nepal; the Philippines; the Republic of Korea; Senegal. For a substantial number of the remaining countries, deaths in infancy are coded into four categories: under 1 month; 1-2 months; 3-5 months; and 6-11 months. In all these cases, deaths are then presented at age 1 and then for ages 2-4 years combined, but there are minor variations over age 5. In Colombia, Costa Rica, Indonesia, Mexico, Panama and Sri Lanka, the groups 5-9 years and over 10 years are used; in Peru and Thailand, there is no subdivision over age 5; and in Pakistan, the groups are 5-14 years and over 15 years. Lastly, for the Dominican Republic and Venezuela, deaths are coded by single years of age, with no further subdivision, even in infancy.

All World Fertility Survey reports also contain a range of other information relevant to the study of infant and child mortality. First, all the demographic

*The original version of this chapter appeared as document IESA/P/AC.17/10.

**Chief, Comparative Analysis Section, World Fertility Survey, London, United Kingdom of Great Britain and Northern Ireland.

TABLE X.1. QUESTIONS AND TECHNIQUES USED TO OBTAIN DATES IN THE MATERNITY HISTORY, 19 WORLD FERTILITY SURVEY COUNTRIES

Major area and country	Dating of births: Month and year	Season	Number of years ago	Age of child	Age of respondent	Duration of interval	Dating of deaths of children: Month and year	Season	Age at death[a]	How long child lived[b]	Number of years ago	Age of respondent
Asia												
Bangladesh	Yes	..	Yes	..	..	..	Yes	..	..	..	Yes	..
Indonesia	Yes[c]	..	Yes[d]	..	..	Yes[e]	..	..	Yes	..	..	..
Jordan	Yes	..	Yes	..	..	..	..	..	..	Yes	..	..
Malaysia	Yes	..	Yes	..	..	..	Yes	..	..	..	Yes	..
Nepal	Yes	Yes	Yes	Yes	Yes	..	Yes	..	..	Yes	..	..
Pakistan	Yes	Yes	Yes	..	..	..	..	..	..	Yes	..	..
Philippines	Yes	..	Yes	..	..	..	Yes	..	Yes	..	..	..
Republic of Korea	Yes[f]	Yes	Yes	Yes	Yes	..	Yes[f]	Yes	..	..	..	Yes
Sri Lanka	Yes	..	Yes	..	..	..	..	..	..	Yes	..	..
Thailand	Yes	..	Yes	..	..	..	..	..	..	Yes	..	..
Latin America												
Colombia	Yes	..	Yes	..	..	..	..	..	..	Yes	..	..
Costa Rica	Yes	..	Yes	..	..	..	..	..	..	Yes	..	..
Dominican Republic	Yes	..	..	Yes	..	..	..	..	Yes	..	..	..
Guyana	Yes	..	Yes	..	..	..	Yes	..	..	..	Yes	..
Jamaica	Yes	..	Yes	..	..	..	Yes	..	..	Yes	..	..
Mexico	Yes	..	..	Yes	..	..	..	..	..	Yes	..	..
Panama	Yes	..	Yes	..	..	..	..	..	..	Yes	..	..
Peru	Yes	..	Yes	..	..	..	..	..	..	Yes	..	..
Oceania												
Fiji	Yes	..	Yes	..	..	..	..	..	..	Yes	..	..

Source: Christopher Scott and S. Singh, "Problems of data collection in the World Fertility Survey", paper submitted to the World Fertility Survey Conference, London, 7-11 July 1980.
[a]The question was: "How old was the child when he/she died?".
[b]The question was: "How long did the child live?".
[c]Year and month asked separately.
[d]Months and years ago.
[e]The question was: "How many years and months after your (first marriage, previous birth) . . . ?".
[f]A battery of questions was asked.

TABLE X.2. DATE OF ALL MATERNITIES: PERCENTAGE DISTRIBUTION ACCORDING TO FORM OF REPORTING, SELECTED WORLD FERTILITY SURVEY COUNTRIES

Major area and country	Percentage distribution according to form of reporting: Month and year	Year only	Number of years ago only	Total number of fertile pregnancies (100 per cent)
Asia				
Bangladesh	12.3	2.5	85.2	25 515
Indonesia	46.5	10.4	43.1	32 014
Jordan	66.5	11.2	22.3	19 351
Malaysia	86.2	13.8[a]	0.0	26 473
Pakistan	79.8	20.2	0.0	20 943
Philippines	96.2	3.8	0.0	45 238[b]
Sri Lanka	73.4	17.5	9.1	26 889
Thailand	84.2	12.6	3.2	14 899
Latin America				
Guyana[c]	91.2	3.6	5.0	16 716[b]
Jamaica	90.6	0.1	9.3	10 766[b]
Panama	97.7	2.3	0.0	12 474
Peru	93.1	6.9	0.0	25 326
Oceania				
Fiji	86.3	13.7	0.0	18 634

Source: See table X.1.
[a]Including some with only years ago stated.
[b]Total number of pregnancies, including non-fertile pregnancies.
[c]No date was given for 0.2 per cent of fertile pregnancies.

information—such as the date of the child's death, age of the mother at that time, sex of the child, birth order, whether a multiple birth, length of the subsequent birth interval, length of the previous birth interval, survivorship status of the previous child and marital status of the mother at the birth of the child—permit extremely useful studies of demographic differentials. Moreover, all surveys include a basic range of background variables, such as the mother's education, place of residence, childhood place of residence and work history variables; and the current husband's education, occupation, work status and employment status. Several surveys included additional questions on such topics as religion, ethnicity, language and migration for the women; and age, income and migration for the husband.

In addition, information is available on length of breast-feeding for the two most recent births in all countries except Fiji, where it is only available for the most recent birth. In Pakistan and the Republic of Korea, the length of breast-feeding was obtained for every live birth.

Three of the 23 countries obtained some information on maternal and child health. The Dominican Republic asked questions of all women who had a pregnancy in the previous year, whereas Peru and Mexico asked all women about their most recent or current pregnancy. The information collected varies in its exact nature but includes type of medical care during pregnancy, place of delivery and who assisted at the delivery (excluding the Dominican Republic); whether, and if so where, the child was taken to a physician; and whether, and if so when, vaccinated.

Two further sources of information are relevant to the study of infant and childhood mortality in the

World Fertility Survey: the household and community questionnaires. Several countries included questions on children ever born and children surviving in the household surveys, permitting the indirect study of infant and child mortality, usually on a larger sample of women. This is the case for Colombia, the Dominican Republic, Jordan, the Republic of Korea, Senegal and Venezuela; and it is effectively so for the non-World Fertility Survey household surveys, from which the World Fertility Survey samples were drawn, for Indonesia, Kenya and Thailand.

In some countries—Jamaica, Jordan, Malaysia, Mexico, Panama, the Philippines and Sri Lanka—questions were asked about the source of drinking-water and, in four cases, cooking-water. Equally valuable, in Haiti, Jordan, Malaysia, Mexico, Panama, the Philippines and Sri Lanka, questions were asked about lavatory facilities.

Community-level questionnaires were not used in all countries and were, as a rule, only used in rural areas because of the problems of defining community in urban areas (Mexico was an exception). Of the 23 countries discussed here, Bangladesh, Jordan, Malaysia, Mexico, Pakistan, Peru, the Philippines, the Republic of Korea and Thailand used community-level questionnaires, although they varied widely from country to country. They all included some information on availability or accessibility of various health care facilities, including hospitals, clinics, doctors, nurses etc. Bangladesh, Jordan and the Republic of Korea included specific but limited information on maternal and child health care; and Bangladesh included a specific question on vaccination facilities. In addition, Bangladesh, Malaysia, Mexico, Pakistan, Peru and the Philippines all asked specific questions on water-supply; and Malaysia, Mexico and Peru also asked about sewerage. In Bangladesh, a question was included on availability of a communal latrine; and in Malaysia, a question was included on garbage disposal. In Peru, the altitude was recorded. Lastly, Malaysia included a series of questions on disease prevalence in the community, covering malaria, tuberculosis, cholera, dengue and helminthic ailments (or worm infestations), and a general question on what were the most prevalent diseases.

Adult mortality

In general, the World Fertility Survey has not set out to collect information on adult mortality. All the individual surveys contain a complete union history, which, in principle, permits the calculation of widowhood rates (i.e., death rates of husbands) by age of woman and gives some information about male mortality, although an adjustment would be required to relate it to age of the male and the range of ages covered is very limited.

More importantly, an attempt has been made in several countries, particularly for the more recent surveys in Africa, to obtain estimates of adult mortality using the mortality module. This effort relies mainly on indirect estimation procedures, including questions on maternal and paternal mortality (orphanhood), with a question on whether the (sometimes proxy) respondent was the eldest surviving child of the parent; whether the first spouse was still alive (widowhood); and deaths in the previous two years, obtaining the sex and age at death of the deceased and the date of death. These questions were included in full in Jordan (and also are included in the forthcoming surveys for Lesotho, Mauritania, Morocco, the Sudan, the Syrian Arab Republic, the United Republic of Cameroon and Yemen). The Republic of Korea used the questions on orphanhood and recent deaths, the Dominican Republic asked about maternal orphanhood only, and Mexico and the Philippines asked only about recent deaths in a 12-month period.

In view of the limited experience in analysing data on adult mortality from the World Fertility Survey, it is discussed here, while the bulk of the remainder of the chapter considers infant and child mortality. A preliminary report on the Jordanian data indicates that the recent deaths were grossly underreported (this seems to be a general problem with such data) and that widowhood was also substantially underreported; but results from the orphanhood data seem consistent and plausible. There are preliminary indications that the results from the survey in the Syrian Arab Republic are much better, showing mutual consistency between the orphanhood and widowhood estimates. The study of differentials is always problematical with indirect estimation procedures, particularly when the events may have occurred a long time in the past. In early adulthood, death rates are fairly low, which also makes the study of differentials problematical. The greatest problem of all with the study of differentials in adult mortality from the types of data considered here is that the limited information on characteristics of households, communities and persons in the household rarely refer to the experience of the deceased. This deficiency is clearly particularly true of orphanhood but is also problematical for previous spouses.

B. DATA QUALITY

A review of all known reports on infant and child mortality using World Fertility Survey data, including the relevant chapters of the evaluation reports, shows that the data for the 22 countries concerned are generally of remarkably high quality. In no single instance was there a demonstrably better source of information on infant and child mortality at the national level. The only major exception to this generalization is that there is some evidence, mainly from internal consistency checks, of increasing differential omissions of dead children beyond 15-20 years prior to the surveys for several countries.

In view of the widespread lack of reliable registration data in developing countries, these evaluations very often had to rely on purely internal consistency checks. A good example of a thorough check of internal consistency is Somoza's[1] illustrative analysis for

Colombia. Screening procedures usually include: plausibility of age patterns, compared with model or other life tables; examination of sex ratios; examination of time trends in sex ratios and for subgroups of the population; and study of patterns by age of mother or birth order. In virtually every country so far, the Survey data survive these screening procedures remarkably well, giving at least moderate confidence in the results.

The other form of checking, which can be carried out in fewer countries, involves comparison with data sources other than the World Fertility Survey. In a few countries, especially Costa Rica and Malaysia, good vital registration data exist and the Survey data compare quite well. In many other countries fragmentary information from a variety of censuses or surveys exists, especially child survivorship questions which give indirect estimates but also other more detailed surveys. Again, there has been no instance of estimates based on the Survey data being seriously deficient when compared with these other sources. Indeed, in many countries, the estimates based on the maternity histories obtained in the Survey are demonstrably superior to those from other sources.

For example, the Panel on Thailand of the United States National Academy of Sciences concludes that "the results from SOFT (WFS), taken between the rounds of the second SPC and therefore referring to a similar time period are consistently higher, perhaps indicating a lower omission of dead children using the pregnancy history question".[2] For Mexico, the Survey data were found to be "remarkably free of inconsistencies, especially for the twenty years prior to the survey" and demonstrably better than estimates derived from the subsequent Contraceptive Prevalence Survey.[3] For the 1975 survey in the Dominican Republic, evidence was found[4] of omissions prior to 1960, but only of infant deaths and not of child deaths, suggesting omission of early deaths. In addition, the results were remarkably close to other estimates and there was no evidence of selective omissions, for example, by education or residence. In 1980, the Dominican Republic, with technical assistance from the World Fertility Survey, carried out a second-round survey, which replicated the birth history questions (among others). In a preliminary analysis of the survey,[5] it was possible to compare estimates for the same calendar periods from the two surveys. The consistency was generally reassuring, with the omissions apparent before 1960 in both surveys, but there was some evidence that mortality decline may have been slightly overstated in the 1975 survey.

It should be stressed that the view here is that all evidence accumulated so far points to World Fertility Survey data being generally at least as good as and often better than other national data sources. This is not a claim of perfection. It is quite plausible that all retrospective surveys omit some early infant deaths and thus understate infant and child mortality, as also occurs in many registration systems. Internal consistency checks are not certain to pick up evidence of such omissions, although it would be surprising indeed if omissions were constant across time, educational groups, urban/rural categories, sex of child etc. Thus, one may have a fair degree of confidence in these data.

Problems of evaluation can be illustrated by reference to Senegal. In general, the data pass internal consistency checks, although they suggest some problems with the recording of neonatal deaths. The only reliable external source[6] of data on infant and child mortality is the longitudinal survey in an area centred on the village of Ngayokheme in Siné Saloum Province, Senegal, which gives an estimated $_5q_0$ of 0.467 for births in the period 1963-1973. For births in the period 1968-1973, the Senegal Fertility Survey gives a $_5q_0$ of 0.275 for the country as a whole and 0.286 for Siñe Saloum Province as a whole; even allowing for the possible omission of neonatal deaths, these values would scarcely exceed 0.810. The question is what does one make of these differences: is Ngayokheme representative of mortality in Síne Saloum Province as a whole? If so, the World Fertility Survey data would be manifestly deficient; yet, for Casamance, the Senegal Fertility Survey gives a $_5q_0$ of 0.361 for births in the period 1968-1973. If this figure were deficient by an amount similar to the apparent discrepancy for Síne Saloum, child mortality would be astoundingly high in Casamance. Nevertheless, one must stand by the assertion that these data are the best available national data source for Senegal (though the competition is not stiff). It is impossible to assess their accuracy against the one external source, and the internal consistency, with the exception of neonatal deaths, is good.

C. Design issues

This section outlines some of the comparative merits of maternity histories for the analysis of infant and child mortality. In particular, there is a series of issues connected with the retrospective nature of the data which require discussion. As the quality of the results on infant and child mortality obtained from the World Fertility Survey have already been considered and a positive conclusion reached, these issues are not addressed again.

A major source of information on infant and child mortality for developing countries has been through the use of the retrospective questions on children ever born and children surviving in a large number of censuses and household surveys. These data are used to produce indirect estimates of life-table functions of mortality with the Brass procedure or its subsequent modifications. This effort involves a number of assumptions about the age pattern of mortality, constancy of fertility over time, lack of differentials by age of mother (or birth order) etc. It is only very recently that it has become possible to estimate time trends, on the assumption of a fixed pattern of mortality change.

Good maternity history data provide a much richer potential for analysis than could ever be contemplated from summary retrospective questions. For example, it is possible to estimate directly mortality levels and trends for, say, the 20 years prior to the survey.

Trends in the different components of infant and child mortality can be examined separately, with separation of neonatal, post-neonatal and child rates or even finer subdivision. (The age range of women covered in a typical World Fertility Survey country is 15-49, which restricts the age range covered in earlier periods to progressively younger upper limits.) A fascinating range of demographic differentials in infant and child mortality can also be considered singly and conjointly. These include differentials by sex of child, age of mother at the birth, birth order, single versus multiple confinements, interval since previous birth (optionally by its own survival status), interval to subsequent birth and consequent effects and marital status of the mother at birth (using the marriage history). In addition, although presenting more complex analytical problems, the relation between breast-feeding and infant mortality for the two most recent births can be partially examined. In many instances, it is also possible to examine at least partial time trends for these differentials. This list of topics on its own gives a formidable advantage to maternity histories as a source of data on infant and child mortality, when compared with simpler retrospective questions. Although relatively few detailed analyses have yet been published on these issues, it is clear that the Survey data will make a major contribution to the knowledge of such differentials and that more elaborate multivariate analyses should considerably enhance understanding of the interrelations between these variables. Studies of this topic are already well under way or in press for several countries, including Bangladesh, Kenya, the Republic of Korea and Sri Lanka, as well as a comparative study on several countries of Latin America. At the World Fertility Survey, work is well advanced on a cross-national summary of these demographic differentials, and some results from this effort are presented later in this chapter.

Moving beyond purely demographic differentials is clearly of major policy interest and the Survey data can make a major contribution here as well. However, the cross-sectional nature of the country surveys does impose greater limitations upon the analysis of socio-economic and other differentials. Almost all of the information collected on these background variables refers to status at the time of the country survey. This factor poses few problems, even for analysis over long periods, in the cases of education, ethnicity and, perhaps, religion of the mother, which are relatively fixed attributes, even by the beginning of childbearing. The same relative fixity for childbearing experience is also true for the mother's usual type of place of residence during childhood and work status and occupation prior to marriage, although greater care in interpretation is required when examining differentials in infant and child mortality by these variables. The woman's (or mother's) work status, occupation and place of work since marriage are vaguely defined in time; and differentials in infant and child mortality will thus be imprecise for these variables, although still of interest. Most of the other variables that can be used are current status variables, such as region or type of place of residence; and current or last husband's characteristics, including childhood type of place of residence, education level, literacy, occupation and work status (for women still in their first union with no pre-union births, some of these husband's characteristics are fixed). Equally, if one moves beyond the individual-level attributes to household attributes or community-level variables, these again represent the current situation.

It is clear from the foregoing discussion that considerable care is required in examining socio-economic or other differentials from retrospective data. An obvious approach to minimizing the difficulties is to restrict analysis to a recent period and to exercise caution in interpreting the results. Perhaps regarding the current attributes as being at least a good indicator of past socio-economic status is the easiest way out. Yet, it is clearly of considerable interest to attempt examination of the effects of each variable and the interplay between them. Some judgement and caution are required, but the returns to careful analysis will still be substantial and the results from studies so far are encouraging. The World Fertility Survey has recently begun work on a cross-national summary of differentials in infant and child mortality by the standard background variables, and a comparative project on the interrelations between these factors is also at the development stage.

One of the most interesting policy areas on which the Survey data can throw some light is the interplay of individual and health attributes at both the household and community levels. This study cannot be done for all countries but is a fascinating topic for those where such household and community data exist. Only one study utilizing this interplay has been published so far, although another project is well advanced in Jordan. A few indicative results from Meegama's[7] work on Sri Lanka and some further exploratory work are presented later in this chapter.

D. Some results

This section first presents some indicative key results for all 23 countries with a published report and then presents an illustration of some work on the interplay between individual and household attributes in determining infant and child mortality.

Comparative results

The tables given here are a subset of those which will be included in the forthcoming World Fertility Survey cross-national summaries on infant and child mortality and have been made available by Shea Rutstein, one of the co-authors. Table X.3 presents the estimates of levels of several mortality indicators for a period of 0-4 years prior to the survey with countries ranked by their values of ${}_5q_0$. These results confirm that infant and child mortality is extremely high in Sen-

TABLE X.3. CURRENT LEVELS OF INFANT AND CHILD MORTALITY IN THE PERIOD 0-4 YEARS PRIOR TO THE SURVEY, 23 WORLD FERTILITY SURVEY COUNTRIES
(Rates per 1,000)

Country	Date of survey	Infant mortality rate (1)q(0)	Neonatal mortality rate	Post-neonatal mortality rate	Mortality rates for children: Under age 5 (5)q(0)	Aged 1 year (1)q(1)	Aged 2-4 years (3)q(2)
Senegal	1978	111.8	49.6	62.1	262.4	73.9	103.4
Nepal	1976	142.3	75.4	66.9	234.6	53.7	57.0
Bangladesh	1975/76	135.0	73.7	61.3	221.6	34.6	67.9
Pakistan	1975	139.0	79.9	59.0	207.2	33.1	47.8
Haiti	1977	122.7	60.5	62.2	191.1	29.5	49.9
Indonesia	1976	94.6	47.3	47.3	158.5	26.4	45.4
Peru	1977/78	96.5	43.8	52.7	149.3	31.3	28.0
Kenya	1977/78	86.6	37.8	48.8	141.6	27.9	33.3
Dominican Republic	1975	88.6	[a]	[a]	128.5	25.3	18.9
Colombia	1976	69.6	33.5	36.2	107.9	18.5	23.0
Mexico	1976/77	71.6	40.9	30.7	96.0	12.5	14.0
Philippines	1978	58.3	24.5	33.7	92.9	15.5	21.6
Thailand	1975	65.1	38.9	26.2	90.9	8.6	19.2
Sri Lanka	1975	59.9	36.9	23.0	86.1	8.2	19.7
Jordan	1976	65.6	27.5	38.1	79.7	9.3	5.8
Guyana	1975	57.6	34.3	23.3	77.2	11.7	9.2
Venezuela	1977	53.1	[a]	[a]	63.7	5.5	5.7
Costa Rica	1976	53.3	24.8	28.5	61.3	3.9	4.6
Fiji	1974	47.0	[a]	[a]	58.5	5.4	6.7
Republic of Korea	1974	41.7	23.0	18.7	56.1	6.9	8.1
Jamaica	1975/76	43.0	23.9	19.1	55.8	8.1	5.3
Malaysia	1974/75	36.1	13.9	22.2	49.8	5.5	8.7
Panama	1976/77	32.8	20.5	12.3	45.7	5.6	7.9

NOTE: Countries are ordered by level of (5)q(0).

[a]Rate not calculable.

egal, Nepal, Bangladesh, Pakistan and Haiti. The relationships between neonatal and post-neonatal mortality rates suggest that neonatal deaths were underreported in Senegal in relation to the other countries; and the neonatal rates for the Philippines, Jordan and Malaysia also seem low, perhaps indicating omissions of neonatal deaths or upward transfers into the post-neonatal age range. Mexico has relatively low child mortality, whereas that of Guyana is relatively high. Of greatest note are the child mortality rates recorded for Senegal, which confirm long-held opinions and fragmentary evidence, at least at the national level. It should be mentioned again that no subdivision of infant deaths is possible for the Dominican Republic and Venezuela, and that this situation is effectively true for Fiji, owing to an error in the coding rules.

Table X.4 shows the relative change in infant and child mortality rates over time, with the period 0-4 years prior to the survey set to 100. This table is restricted to experience of mothers aged 20-29 years at the time of the birth, in order to control for the progressive truncation of age ranges that would occur for the more remote periods. In this and subsequent tables in this subsection, values are given in parentheses when any of the exposures used in the synthetic-cohort calculations falls below 500. Even with this restriction one must mention that the rates are subject to quite large sampling fluctuations and that not too much weight should be placed on minor variations. Of the 23 countries, 11 exhibit infant mortality rates at least 30 per cent higher 15 years prior to the most recent period considered (probably 12 if one includes Costa Rica, which exhibits a deficiency of infant deaths 15-19 years prior to the survey, as do the Dominican Republic, Senegal and, perhaps, Haiti). Several countries exhibit extraordinarily rapid declines in childhood mortality, including Costa Rica, the Republic of Korea, Venezuela and especially Jordan. Even for Jordan, though, the value for $_3q_2$ for the period 15-19 years prior to the survey is a still plausible 47 per 1,000. In general, the declines in childhood mortality are dramatic and fairly consistent, with 15 countries having levels of $_1q_1$ and 13 having levels of $_3q_2$ at least 50 per cent higher in the period 15-19 years prior to the survey than for the most recent period. In Guyana, the time patterns of child mortality are somewhat strange, particularly for $_3q_2$, although this finding may simply reflect a rather high value for the most recent period. Bangladesh may well be expected to have had high mortality, perhaps especially child mortality, in the five years prior to the survey, due to the war and several natural disasters.

For the period 15-19 years prior to the survey, the overall values of $_5q_0$ have been examined, except that the period 10-14 years prior was considered for the Dominican Republic, Haiti and Senegal, and for infant mortality in Costa Rica. The values of $_5q_0$ (per 1,000) are approximately 300 for Nepal and Senegal; about 250 for Bangladesh, Haiti and Pakistan; about 200 or more for Indonesia, Jordan, Kenya and Peru; about 150 for Colombia, the Dominican Republic, Mexico and Thailand; and approximately 100 for Costa Rica, Guyana, Jamaica, Malaysia, the Philippines, the Republic of Korea and Sri Lanka; and about 75 for

TABLE X.4. RELATIVE CHANGE IN INFANT AND CHILD MORTALITY RATES OVER TIME, CHILDREN WITH MOTHERS IN AGE GROUP 20-29 AT TIME OF THE BIRTH, 23 WORLD FERTILITY SURVEY COUNTRIES

		Number of years prior to the survey											
		0-4			5-9			10-14			15-19		
		Infant mortality rate	Mortality rate of children:		Infant mortality rate	Mortality rate of children:		Infant mortality rate	Mortality rate of children:		Infant mortality rate	Mortality rate of children:	
Country	Date of survey	(1)q(0)	Aged 1 year (1)q(1)	Aged 2-4 years (3)q(2)	(1)q(0)	Aged 1 year (1)q(1)	Aged 2-4 years (3)q(2)	(1)q(0)	Aged 1 year (1)q(1)	Aged 2-4 years (3)q(2)	(1)q(0)	Aged 1 year (1)q(1)	Aged 2-4 years (3)q(2)
Senegal	1978	100	100	100	115	110	108	108	113	125	99	93	118
Nepal	1976	100	100	100	108	93	101	126	114	134	127	113	160
Bangladesh	1975/76	100	100	100	92	67	77	109	60	84	117	100	96
Pakistan	1975	100	100	100	99	94	83	104	155	104	119	175	120
Haiti	1977	100	100	100	123	103	117	129	123	156	123	122	(173)
Indonesia	1976	100	100	100	101	132	105	131	162	124	132	198	147
Peru	1977/78	100	100	100	114	117	118	121	158	150	132	170	189
Kenya	1977/78	100	100	100	110	129	117	116	124	121	146	123	156
Dominican Republic	1975	100	100	100	115	102	106	123	130	139	84	99	(134)
Colombia	1976	100	100	100	104	97	93	120	145	106	142	202	104
Mexico	1976/77	100	100	100	114	156	123	120	177	149	125	204	245
Philippines	1978	100	100	100	99	92	88	98	127	103	99	130	92
Thailand	1975	100	100	100	134	101	138	151	154	153	160	202	160
Sri Lanka	1975	100	100	100	96	124	77	99	120	95	110	151	153
Jordan	1976	100	100	100	102	191	165	121	344	322	174	487	818
Guyana	1975	100	100	100	96	57	84	108	114	60	128	166	47
Venezuela	1977	100	100	100	89	137	166	82	212	117	89	257	(348)
Costa Rica	1976	100	100	100	139	366	153	158	400	173	113	431	324
Fiji	1974	100	100	100	112	86	60	114	106	99	137	140	75
Republic of Korea	1974	100	100	100	139	194	196	147	272	347	161	281	406
Jamaica	1975/76	100	100	100	88	109	107	97	102	160	170	236	205
Malaysia	1974/75	100	100	100	109	127	86	153	131	147	207	196	274
Panama	1976/77	100	100	100	152	147	91	135	266	136	178	271	127

Notes: Countries are ordered by level of mortality rate for children under age 5, (5)q(0). Figures in parentheses indicate fewer than 500 exposures.

Fiji, Panama and Venezuela. Most of these values are reasonable. Venezuela appears to have the most dubious data on trends. For the Philippines, however, the very slight decline gains added plausibility from the fact that the survey data show steep declines more than 20 years prior to the survey.

One of the strongest and most persistent demographic differentials to emerge from analyses of data on infant and child mortality is that in relation to the previous birth interval. This has been found in country studies for Nepal and the Republic of Korea, and table X.5 presents a summary for the 23 countries considered here. Intervals from the previous birth are subdivided into those of length under two years, from two to three years and four years or longer. Twins are necessarily excluded from this analysis. For previous intervals of less than two years, two sets of results are presented: the first relates to all births of this type; the second relates only to those cases where the previous birth either lived to age 2 or outlived the subsequent birth. The latter restriction generally ameliorates the differentials. The magnitude of the excess infant mortality for children born after a short birth interval is really quite astonishing. What is even more noteworthy is the general persistence of this disadvantage beyond the first year of life, usually affecting even the chance of surviving from age 2 to age 5. Indeed, for ${}_{1}q_{1}$, rather curiously, it is only in Malaysia and Senegal that the differential does not appear to persist beyond infancy. Perhaps this finding is again to be taken as indicative of omissions of dead children in Senegal, particularly fairly early deaths to children born at short intervals from the previous birth. It is also somewhat surprising that children born at intervals of four or more years after previous births seem to have a widespread but not universal advantage in survival chances even compared with the group for intervals from two to three years. As will be obvious from the number of values given in parentheses for the interval of four or more years, there are not large numbers of births at these relatively longer intervals in many of the countries.

It is always tempting to draw policy conclusions from such an analysis. In this case, the apparent lesson seems to be "if only we could persuade women to stop having short intervals, their children would have better survival chances". Yet, without considerable further analysis one cannot really be sure that this is the case. These short intervals almost certainly occur differentially to relatively disadvantaged women (or families) and the observed differentials in survival status by previous birth interval may reflect a complex of other factors, such as education, public health provision, income and housing conditions, which are also associated both with the length of birth intervals and with infant and child mortality. Nevertheless, analysis to clarify this question is clearly desirable, as the differentials are both large and internationally persistent.

As mentioned earlier, the World Fertility Survey data permit the study of many other demographic differentials. Owing to space limitations, however, it is not possible to present these results in detail, but some of the major findings based on analysis for the 10 years prior to the surveys are briefly summarized below.

Births to teen-age mothers usually experience considerably higher infant mortality (often about 20 or 30 per cent higher than for births to mothers aged 20-29). Births to women over 30, especially those over age 40, generally experience higher infant mortality. In most countries, the disadvantage for births to teen-age mothers persists well into childhood, as it also does for births to older mothers in about half the countries surveyed.

Male infants generally show higher mortality (with the Dominican Republic and Jordan as notable exceptions), with the excess often being 20-30 per cent. As may be expected, the sex ratio of child mortality is more balanced, with a clear male advantage in Bangladesh, Nepal, Pakistan, Panama, the Philippines and Sri Lanka, but a clear female advantage in Indonesia, Jamaica and Malaysia.

Births of order seven or higher experience substantially higher infant mortality in almost all countries, with some indications of a lower effect in those countries lacking a clear indication of fertility decline. Perhaps this situation results in part from picking up differentials brought about by other factors also associated with fertility differentials. Again, it is noteworthy that these differentials usually persist beyond infancy into childhood, which perhaps supports the supposition that it is the socio-economic conditions of the women reaching high birth orders which bring about these differentials. The patterns for birth order one are more curious. In about half the countries considered here, they experience higher mortality than birth orders two and three; but in the remaining countries, they exhibit lower mortality. It is possible that lower mortality of the first-born for these countries is genuine, but an alternative worthy of further exploration is that prior infant deaths have been omitted. Moreover, recent first births are more likely to have occurred to educated women in recent periods than are higher-order births, owing to the rapid increase in education over time for many of these countries.

Multiple births experience infant mortality rates from two and one half to six times higher than singleton births, although these results are inevitably based on a small number of cases. In general, the relative disadvantage of multiple births persists well into childhood, which is hardly surprising.

This survey of demographic differentials may be completed by noting that in those 10 countries where consensual unions were distinguished from more formally married, children born in formal marriage had a relative advantage in survival chances at all ages up to 5 years. In general, children born to women not in a union at the time of the birth also experienced higher mortality, although few countries had a large enough exposure for these calculations.

To illustrate further the value of the World Fertility Survey data, infant and child mortality by the mother's

TABLE X.5. RELATIVE MORTALITY BY INTERVAL SINCE PREVIOUS BIRTH FOR THE PERIOD 0-9 YEARS PRIOR TO THE SURVEY, 23 WORLD FERTILITY SURVEY COUNTRIES
(Rate for interval: 24-27 months = 100)

		Infant mortality rate, (1)q(0), by interval in months				Mortality rate of children aged 1 year, (1)q(1), by interval in months				Mortality rate of children aged 2-4 years, (3)q(2), by interval in months			
		Less than 24				Less than 24				Less than 24			
Country	*Date of survey*	*(A)*	*(B)*	*24-47*	*48+*	*(A)*	*(B)*	*24-47*	*48+*	*(A)*	*(B)*	*24-47*	*48+*
Senegal	1978	130	100	100	77	83	68	100	54	97	95	100	(96)
Nepal	1976	153	139	100	54	144	138	100	73	98	103	100	37
Bangladesh	1975/76	208	181	100	65	147	156	100	34	131	145	100	44
Pakistan	1975	178	147	100	69	123	118	100	50	137	146	100	55
Haiti	1977	167	142	100	(81)	159	157	100	(165)	104	117	100	(77)
Indonesia	1976	180	152	100	73	155	147	100	37	130	126	100	70
Peru	1977/78	158	140	100	63	149	141	100	60	113	109	100	48
Kenya	1977/78	173	144	100	87	143	131	100	53	121	120	100	77
Dominican Republic	1975	140	117	100	(80)	158	145	100	(85)	149	151	100	(68)
Colombia	1976	154	135	100	72	141	132	100	102	131	127	100	(88)
Mexico	1976/77	155	137	100	113	152	139	100	66	80	81	100	42
Philippines	1978	160	150	100	119	136	128	100	42	142	141	100	59
Thailand	1975	209	182	100	81	200	194	100	77	138	146	100	99
Sri Lanka	1975	131	117	100	81	141	147	100	107	99	102	100	58
Jordan	1976	244	218	100	107	187	184	100	12	185	206	100	(187)
Guyana	1975	160	133	100	103	130	132	100	19	109	111	100	(43)
Venezuela	1977	180	163	100	143	163	165	100	(128)	257	263	100	(109)
Costa Rica	1976	155	136	100	78	137	123	100	76	98	104	100	0
Fiji	1974	159	154	100	113	107	116	100	104	94	95	100	38
Republic of Korea	1974	175	132	100	101	203	191	100	106	104	127	100	41
Jamaica	1975/76	185	168	100	89	153	135	100	56	323	320	100	(153)
Malaysia	1974/75	134	119	100	92	82	77	100	74	110	111	100	82
Panama	1976/77	157	142	100	103	109	110	100	91	71	66	100	78

Notes: Countries are ordered by level of mortality rate for children under age 5, (5)q(0).

For intervals of less than 24 months, column (*A*) shows the relative mortality for all births while column (*B*) is restricted to the experience of those whose immediately prior sibling survived at least two years or to the death of the infant concerned. Twins are excluded.

Figures in parentheses indicate fewer than 500 exposures.

level of education is now considered as an example of socio-economic differentials. Table X.6 presents the ratios of mortality rates for births to mothers with varying levels of education to the rates for a baseline group with 4-6 years of education. Attention is drawn to the fact that all the ratios for Haiti, Nepal, Pakistan and Senegal are given in parentheses because the exposures relating to mothers with 4-6 years of education were below 500 at some point in the calculations. All these countries have enough cases to calculate rates for the lower groups, but they lack educated women. The disadvantages for the child in having an uneducated mother (and other related disadvantages) are striking and very large. The general persistence of these larger differentials into childhood is again noteworthy and it is perhaps here that education of the mother could best be used to alleviate some of the worst effects of the generally hostile environment these children experience.

Individual and household attributes

This section presents some preliminary results from ongoing work on the interplay between individual and household variables in determining infant and child mortality. The starting-point is table X.7, which shows the neonatal and post-neonatal mortality rates cross-tabulated by three dichotomous variables, namely, mother's literacy, husband's education and lavatory availability in the household. To clarify relations within this table, log-linear rates models were fitted to the observed counts of deaths with adjustment for the exposure. For neonatal mortality, a model containing main effects for lavatory access and husband's education gives an extremely good fit ($\chi^2 = 3.8$, 5 degrees of freedom), suggesting that mother's literacy has no effect and that the husband having less than five years of education raises neonatal mortality by 31 per cent and lack of access to a lavatory by 28 per cent. For post-neonatal mortality, an even simpler model suffices, with only lavatory access appearing significant ($\chi^2 = 3.1$, 6 degrees of freedom), with the addition of a main effect for husband's education giving too good a fit ($\chi^2 = 1.0$, 5 degrees of freedom). Again, the wife's literacy appears to have no role, and even the husband's education is doubtful. Not having a lavatory raises post-neonatal mortality rates by about 45 per cent (or 40 per cent if the husband's education is added, with fewer than 5 years of education raising neonatal mortality a further 18 per cent).

In view of these interesting findings and the obvious limitations of dichotomous variables and of considering the entire period 1948-1974 and only rural areas, a slightly more elaborate analysis was carried out both for Sri Lanka and for Mexico; there are plans for further work on these and other countries. For both Sri Lanka and Mexico, elaborate cross-tabulations of neonatal, post-neonatal and child deaths and of survivors at the beginning of each interval have been generated, for births occurring 5-14 years prior to the survey.

The tables cross-classify by five variables: lavatory facility (yes/no); piped water-supply (yes/no); mother's and husband's education (none, 1-3, 4-6 or 7 or more years); and residence (for Sri Lanka, urban/rural/estate; for Mexico, 500,000+/2,500-500,000/under 2,500 population). These cross-classifications lead to a possible 192 combinations of attributes, although births actually occurred in only 162 of these cells in Sri Lanka and 172 in Mexico. For Sri Lanka, there were 27,412 births; and for Mexico, 28,775. Naturally, there was an uneven distribution of exposure across the cells, with only 32 cells for Sri Lanka and 35 cells for Mexico having more than 100 births. Use of a rates model, which takes account of the exposure in each cell and models the counts of death assuming an underlying Poisson process, means that these larger cells will correctly dominate in determining the effects of the individual and household attributes on infant and child mortality.

A range of models has been explored for the experience contained in these fairly elaborate tables; the most parsimonious models containing only the main effects are presented in table X.8. In each case, addition of the missing main effects fails to improve the fit significantly.

For Sri Lanka, a child born to a mother whose husband is uneducated and is currently resident on an estate is 5.2 times (= exp (0.995 + 0.691)) as likely to die in the first month as one born to a mother whose current husband has seven or more years of education and is currently resident in an urban area (rates of 114 and 22 per 1,000, respectively). The dominant factors in determining neonatal mortality (among those examined) are current husband's education and current place of residence of mother, which seems to indicate that socio-economic status prevails in determining neonatal mortality in Sri Lanka. Post-neonatal mortality appears to be more susceptible to current availability of lavatory facilities (perhaps a surrogate for other public health or housing standard conditions). Not having current access to a lavatory is associated with a 41 per cent excess in post-neonatal mortality, while the mother having an uneducated current husband is associated with a 78 per cent excess compared with having a highly educated current husband. The mother currently being in a rural area carried a relative advantage of 71 per cent after the first month (although this finding may reflect differential misstatement of ages at death in rural and urban areas), but her being currently resident on an estate still carried a relative disadvantage (24 per cent), compared with urban residence. Being maximally disadvantaged gives a post-neonatal probability of death of 59 per 1,000, while being maximally advantaged generates a rate of only 11 per 1,000. Rather interestingly, it is the mother's education which seems to predominate in determining child mortality, instead of her current husband's education. A child of an uneducated mother is two and a quarter times more likely to die between ages 1 and 5 than is a child of a highly educated mother. In addition, not currently having a lavatory raises child mor-

TABLE X.6. DIFFERENTIALS IN INFANT AND CHILD MORTALITY BY EDUCATION OF MOTHER FOR THE PERIOD 0-9 YEARS PRIOR TO THE SURVEY, 23 WORLD FERTILITY SURVEY COUNTRIES

(Rates for births to mothers with 4-6 years of education = 100)

Country	Date of survey	Infant mortality rate, (1)q(0), by education of mother				Mortality rate of children aged 1 year, (1)q(1), by education of mother				Mortality rate of children aged 2-4 years, (3)q(2), by education of mother			
		None	1-3 years	4-6 years	7+ years	None	1-3 years	4-6 years	7+ years	None	1-3 years	4-6 years	7+ years
Senegal	1978	(128)	(76)	(100)	(33)	(318)	(281)	(100)	(29)	(669)	(98)	(100)	(160)
Nepal	1976	(125)	(114)	(100)	(80)	(283)	(393)	(100)	(45)	(248)	(42)	(100)	(101)
Bangladesh	1975/76	119	115	100	(101)	121	101	100	(26)	197	149	100	(34)
Pakistan	1975	(113)	(93)	(100)	(90)	(258)	(162)	(100)	(22)	(174)	(86)	(100)	(52)
Haiti	1977	(81)	(72)	(100)	(42)	(78)	(56)	(100)	(21)	(209)	(144)	(100)	(68)
Indonesia	1976	126	133	100	67	114	129	100	29	140	157	100	33
Peru	1977/78	202	175	100	67	365	268	100	29	362	229	100	33
Kenya	1977/78	126	109	100	84	203	179	100	116	156	130	100	81
Dominican Republic	1975	145	109	100	71	194	132	100	22	219	115	100	(37)
Colombia	1976	185	174	100	87	141	131	100	69	205	155	100	37
Mexico	1976/77	137	122	100	73	388	228	100	55	462	207	100	23
Philippines	1978	156	119	100	63	215	153	100	48	113	137	100	47
Thailand	1975	136	(108)	100	(26)	194	(111)	100	(62)	160	174	100	(22)
Sri Lanka	1975	131	120	100	67	93	123	100	56	193	127	100	55
Jordan	1976	102	78	100	64	178	112	100	84	431	107	100	62
Guyana	1975	(65)	(118)	100	78	(51)	(83)	100	100	(158)	(154)	100	64
Venezuela	1977	142	104	100	67	205	176	100	22	229	206	100	47
Costa Rica	1976	163	115	100	52	323	163	100	75	341	194	100	0
Fiji	1974	119	101	100	70	14	90	100	63	55	96	100	87
Republic of Korea	1974	127	114	100	91	180	116	100	38	178	181	100	92
Jamaica	1975/76	(152)	(129)	100	78	(195)	(89)	100	55	(124)	(154)	100	73
Malaysia	1974/75	104	87	100	60	237	130	100	29	227	169	100	27
Panama	1976/77	212	186	100	100	259	213	100	44	456	268	100	85

Note: Countries are ordered by level of mortality rate for children under age 5, (5)q(0). Figures in parentheses indicate fewer than 500 exposures.

TABLE X.7. NEONATAL AND POST-NEONATAL MORTALITY RATES, BY HUSBAND'S EDUCATION, MOTHER'S LITERACY AND LAVATORY FACILITIES, RURAL SRI LANKA, 1948-1974
(Rate per 1,000 live births)

	Mother illiterate				Mother literate			
	No lavatory		Lavatory		No lavatory		Lavatory	
Husband's education	*Rate*	*Number of births*[a]	*Rate*	*Number of births*[a]	*Rate*	*Number of births*[a]	*Rate*	*Number of births*[a]
Neonatal mortality								
Up to 5 years of education	43	2 402	33	2 237	48	2 261	39	3 929
Over 5 years	41	600	32	819	36	1 303	26	5 009
Post-neonatal								
Up to 5 years of education	26	2 299	17	2 164	25	2 153	18	3 777
Over 5 years	19	576	19	793	21	1 256	15	4 881

Source: S. A. Meegama, *Socio-economic Determinants of Infant and Child Mortality in Sri Lanka: An Analysis of Post-war Experience*, World Fertility Survey Scientific Report, No. 8 (Voorburg, The Hague, International Statistical Institute, 1980).

[a]Number of births on which rates were based.

TABLE X.8. PARAMETER VALUES AND GOODNESS OF FIT FOR SELECTED LOG-LINEAR RATES MODELS OF NEONATAL, POST-NEONATAL AND CHILD MORTALITY FOR BIRTHS OCCURRING 5-14 YEARS PRIOR TO THE SURVEY, SRI LANKA AND MEXICO

	Sri Lanka			Mexico		
Variable	*Neonatal mortality rate (per 1,000 live births)*	*Post-neonatal mortality rate (per 1,000 live births)*	*Child mortality rate (per 1,000 population)*	*Neonatal mortality rate (per 1,000 live births)*	*Post-neonatal mortality rate (per 1,000 live births)*	*Child mortality rate (per 1,000 population)*
Grand mean	−3.126	−3.391	−3.611	−2.829	−3.309	−3.272
Lavatory	-	0.000	0.000	-	-	0.000
No lavatory	-	0.347	0.480	-	-	0.710
Piped water	-	-	-	-	-	-
No piped water	-	-	-	-	-	-
Education of mother						
None	-	-	0.000	0.000	0.000	0.000
1-3 years	-	-	−0.168	−0.122	0.034	−0.522
4-6 years	-	-	−0.255	−0.414	0.028	−0.663
7+ years	-	-	−0.810	−0.611	−0.872	−0.886
Education of husband						
None	0.000	0.000	-	-	0.000	0.000
1-3 years	−0.233	−0.079	-	-	0.024	−0.155
4-6 years	−0.314	−0.114	-	-	−0.026	−0.402
7+ years	−0.691	−0.578	-	-	−0.873	−1.370
Residence						
Urban (Sri Lanka)/500,000+ population (Mexico)	0.000	0.000	-	-	-	-
Rural (Sri Lanka)/2,500-500,000 population (Mexico)	0.167	−0.535	-	-	-	-
Estate (Sri Lanka)/under 2,500 population (Mexico)	0.955	0.214	-	-	-	-
χ^2 value	180	131	161	263	149	149
Residual degrees of freedom	156	155	157	168	165	164
χ^2 value for grand mean model	254	178	206	285	193	336
Residual degrees of freedom	161	161	161	171	171	171

tality by a further 62 per cent, which leads to extreme rates of 44 and 12 per 1,000.

Turning to Mexico, one finds quite different relationships. The major factor in determining neonatal mortality appears to be the mother's education, although it should be mentioned that this is the only table for which it has not been possible to find a satisfactory model. Children of uneducated mothers are 84 per cent more likely to die in the first month than are children of highly educated mothers (rates of 59 and 32 per 1,000 respectively). Post-neonatal mortality seems to be strongly affected by the education of both the mother and her husband, with the only important effects being associated with both parents being at the highest education level. Having parents with up to six years of education appears to have little effect on post-neonatal mortality, but having either parent highly educated conveys a major advantage (a rate of 15 per 1,000, compared with 37 for neither educated) and having both highly educated a huge advantage (a rate of 6.4). Lastly, the education of both the mother and her husband also has a major impact on levels of child mortality, as does currently having a lavatory available. Here, possessing parents with even a little education conveys an advantage, particularly where it is the mother: even from one to three years of education reduces child mortality to 59 per cent of that for children with uneducated mothers. Again, the mother's current husband having seven or more years of education clearly conveys a special advantage. A child born 5-15 years before, to an uneducated mother whose current husband has no education and who currently lives in a household with no lavatory, experienced child mortality of 77 per 1,000; having a highly educated mother alone reduces this figure to 32 per 1,000; if the mother's current husband has seven or more years of education alone, child mortality becomes 20 per 1,000; if the mother currently lives in a household with lavatory facilities alone, it becomes 38; and having a highly educated mother whose current husband is also highly educated and having current access to a lavatory generates a child mortality rate of only 4 per 1,000 for children born 5-15 years earlier.

An attempt has been made to indicate the interpretational problems by pedantically careful wording. The mother's education is fixed. Her current or most recent husband's occupation is also fixed for him, but he may not have been her current husband at the time of all her births in the 5-15-year period prior to the survey or during their subsequent life to death or age 5. In general, husbands do not change frequently, especially in Sri Lanka; and it would be possible to restrict analysis to births of women still in their first marriage, although this has not yet been attempted. At the very least, the current husband's educational level is likely to be a fairly good surrogate for the woman's entire marital socio-economic experience in most if not all cases. Current type of place of residence may equally not reflect previous residence, although this is probably more problematical for urban than for rural areas and may well ameliorate differentials. Here, it is possible to use the childhood type of place of residence partially to clarify this issue. Current access to a lavatory consistently came out as a strong effect once the earliest stages of life were over. Yet, again one cannot be sure that these lavatory facilities were available over the entire 15-year period, nor that the place of residence had not changed. Similar remarks apply to the current availability of water-supply, although there was no indication of apparent links. There is no way to clarify these issues from World Fertility Survey data.

At this stage, one is left with intriguing suggestions and cannot be sure whether the lavatory variable, in particular, is really picking up an aspect of public health or is just indicative of differences in levels of living more generally. It is intended to pursue this question further, using some of the other household characteristics data available from Survey reports.

There are intriguing and as yet unexplained differences between Sri Lanka and Mexico, although the estate workers complicate comparisons. Perhaps the most noteworthy contrast is between the different relative importances of the two education variables. In the first year of life, the husband's education seems to affect survival chances in Sri Lanka. Yet, in Mexico, the wife's education predominates in the first month and both affect the next 11 months. In both countries, however, it appears that having a parent with seven or more years of education makes the key difference in post-neonatal survival chances. For early childhood, the mother's education predominates in Sri Lanka; yet, both are again relevant in Mexico. There is a striking consistency in the behaviour on the two "public health" variables. In neither country does current availability of a piped water-supply seem to be related to previous mortality of children under age 5. Yet, in both countries, current access to a lavatory does have a clear relationship after the earliest stages of life. It remains to be seen whether the planned work on other countries confirms similarities and differences.

CONCLUSION

It should by now be readily apparent that the World Fertility Survey does indeed constitute a uniquely rich data source on infant and child mortality (as on many other topics). In particular, it is the ability to assemble comparable results for many countries which will lead to a better understanding of the determinants of child survival. But the glamour of the cross-national comparative analyses should not blind one to the other major contribution, namely, that in general, for the countries studied, the World Fertility Survey results represent a data source on infant and child mortality at the national level as good as, or better than, any previously in existence. Even for those very few countries that have a good registration system, providing information on levels and trends, many analyses are possible with the Survey data which could not be carried out using the registration data.

It is always tempting to dwell on the limitations of any data source, but this should never prevent one exploiting available sources to the full. No data source could ever answer all problems on infant and child mortality, and the World Fertility Survey reports are generally unable to answer questions on medical and nutritional aspects of childhood mortality. Equally, it is mortality up to age 5 that can most fruitfully be studied from these data, although increasing use of the adult mortality module in more recent surveys should improve the extremely limited knowledge of adult mortality, especially in Africa. For some purposes, the Survey samples are too small, but again this is a matter for concern rather than abandonment. Maternity histories are unlikely to be perfectly recorded retrospectively, but skilled and careful analysis can overcome most of the problems. Indeed, the evidence so far is of surprisingly good-quality data, which are eminently valuable.

Over the next several years, the confident view is that the understanding of relations between infant and child mortality and an entire series of demographic, socio-economic and, to a lesser extent, household and community factors will be enormously enhanced by full exploitation of the unique resource provided by the many studies of the World Fertility Survey.

NOTES

[1]Jorge L. Somoza, *Illustrative Analysis: Infant and Child Mortality in Colombia,* World Fertility Survey Scientific Report, No. 10 (Voorburg, The Hague, International Statistical Institute, 1980).

[2]United States of America, National Academy of Sciences, National Research Council, Panel on Thailand, *Fertility and Mortality Changes in Thailand, 1950-1975,* Committee on Population and Demography Report, No. 9 (Washington, D.C., National Academy Press, 1981).

[3]Manuel Ordorica and Joseph E. Potter, "An evaluation of the demographic data collected in the Mexican Fertility Survey", paper submitted to the International Union for the Scientific Study of Population Seminar on the Analysis of Maternity Histories, London, April 1980.

[4]José Miguel Guzman, *República Dominicana: estimación de la mortalidad basada en la Encuesta Nacional de Fecundidad, 1975,* CELADE Series C, No. 1007 (San José, Costa Rica, Centro Latinoamericano de Demografía, 1978.)

[5]John Hobcraft and Germán Rodríguez, *The Analysis of Repeat Fertility Surveys: Examples from Dominican Republic,* World Fertility Survey Scientific Report, No. 29 (Voorburg, The Hague, International Statistical Institute, 1982).

[6]M. Garenne, "The age pattern of infant and child mortality in Ngayokheme (rural West Africa), African Demography Working Paper, No. 9, Philadelphia, Pennsylvania, University of Pennsylvania, Population Studies Center, 1981.

[7]S. A. Meegama, *Socio-economic Determinants of Infant and Child Mortality in Sri Lanka: An Analysis of Post-war Experience,* World Fertility Survey Scientific Report, No. 8 (Voorburg, The Hague, International Statistical Institute, 1980).

XI. MORTALITY DATA COLLECTIONS: A REVIEW OF INTEGRATED MULTI-PURPOSE HOUSEHOLD SURVEYS AND MULTI-ROUND DEMOGRAPHIC SURVEYS*

*A. Adlakha** and M. Nizamuddin****

The need to study levels, changes and differentials in mortality has been increasingly realized by public health administrators and policy makers since the Second World War. This renewed interest in mortality studies has arisen from the realization that effective measures to reduce mortality can best be taken in the light of adequate knowledge about the health risks in existence, from a need to assess the efficacy of intervention programmes and from recent concern about a possible deceleration in the rate of mortality decline in some regions.

Many aspects of mortality remain unexplored or unexplained for the majority of populations in developing countries. There are several reasons for this, from lack of trained manpower to collect, analyse and interpret mortality data to the inadequacies and complexities of methodologies for collecting and analysing such data. On the whole, the inadequacy of data, whether due to unavailability or unreliability, seems to be the major problem in the developing countries.

The traditional sources of mortality data have been civil registration systems and population censuses. The combination of a complete civil registration system and periodic reliable censuses provides much of the information needed for basic mortality studies. However, the problems of incompleteness, delays in aggregating the data and biases introduced by the registrars at the local level in reporting events make the civil registration system of little immediate value in many developing countries. Household sample surveys thus represent, in many countries, the most practicable response to the growing need for data on a variety of subjects. Especially during the past 30 years, several developing countries have resorted to household sample surveys for obtaining information on a number of topics, including fertility, mortality and migration. It has been argued that a household survey is the most flexible data collection method available to national statistical institutions.[1]

The methodology of household sample surveys in terms of basic concepts, field procedures and sampling techniques has expanded and improved considerably over the years. Various types of surveys covering a range of subjects and spanning different periods can produce needed data for planning and evaluating development programmes.

Multi-subject or multi-purpose surveys cover a wide range of subjects, such as income and expenditures, health and nutrition, employment and vital events. Great flexibility can be exercised in the selection of subject matter or sample size. The National Sample Survey in India, the Pesquisa Nacional por Amostra de Domicilos in Brazil and the National Integrated Sample Survey Programme in Kenya, described in the next section, are good examples of multi-subject household survey programmes. Special-purpose surveys, on the other hand, are designed to cover a single subject or to examine a single issue, although they may sometimes be implemented as part of an ongoing national survey programme. Both types of survey can be retrospective, prospective or a combination of both; and there are variations within each type which make the sample survey approach to data collection flexible enough to cover almost any subject for any given length of time. For mortality estimation, it is useful to distinguish between two distinct survey approaches, the multi-round or prospective survey, whereby an enumerated sample population is followed for a period of time with the continuous or periodic recording of vital events, and the single-round retrospective survey, whereby a sample population is interviewed once only, with the recording of vital events during some prior period such as the year or two years preceding the survey. Although, in theory, either approach can be used in single- or multi-purpose surveys (and both can be used in the same survey), in practice, the multi-round approach has rarely been used except in single-purpose demographic surveys.

Section A of this chapter describes the multi-purpose survey approach, illustrated by three examples, with a discussion of how successful the surveys seem to have been in collecting mortality information. Section B then describes the basic features of the multi-round survey approach, illustrated by two examples, and goes on to examine the reliability of mortality information collected in this way and to compare the efficacy of the approach with that of single-round surveys. The final section draws some general conclusions about the suitability of the available method-

*The original version of this chapter appeared as document IESA/P/AC.17/11.

**Deputy Director, International Program of Laboratories for Population Statistics, University of North Carolina, Chapel Hill, North Carolina, United States of America.

***Demographic Advisor, United Nations Development Programme, Amman, Jordan.

ologies to provide the types of mortality information required.

A. MULTI-PURPOSE HOUSEHOLD SURVEY PROGRAMMES

Multi-purpose household survey programmes represent an attempt to co-ordinate the collection of the socio-economic information required for planning purposes. Although the programmes in existence exhibit substantial diversity, their common features generally include: (*a*) a nationally representative master sample, generally with built-in subsamples to be used for certain purposes; (*b*) the creation and training of a permanent staff of interviewers; (*c*) the conducting of surveys on certain topics at regular intervals; and (*d*) the conducting of surveys to cover special topics from time to time during the existence of the programme. For the purposes of collecting mortality information, such multi-purpose programmes offer a number of advantages over the single-purpose survey. First, the interviewers are regularly employed in survey work, thus being experienced and needing only specific training. Secondly, the survey cost is reduced since many start-up costs, such as sampling and household identification, are spread over a number of surveys. Thirdly, the inclusion of a mortality (or demographic) study in an integrated survey programme reduces the bureaucratic problems often encountered. Fourthly, and perhaps most important, the other elements of the survey programme can provide a wealth of socio-economic background information about the population being studied, in some ways comparable to one of the advantages offered by the multi-round survey approach, although it should be noted that the ways in which subsamples are drawn from the master sample often complicate the transfer of information between surveys. The possible organizational disadvantages of the multi-purpose approach are that the interviewers may come to regard the work as routine, not putting much effort into it, and that the population of the master sample areas may become resistant to repeated surveying. A further disadvantage specific to mortality studies is that the single-round retrospective survey approach is generally used, and this approach has certain practical disadvantages.

The single-round retrospective survey approach can only collect direct mortality information in the form of deaths occurring to household members or relatives over some specified period. Usually, a household member is asked about deaths in the household over the preceding 12 or 24 months, and is asked to give the age, sex and date of death of each deceased. Widespread experience has shown that such information is deficient not only in coverage (deaths may be omitted for single-person households, as a result of a household disintegrating because of the death of a member, as a result of reference period error or as a result of intentional concealment) but with respect to such details as age. Coverage is often particularly poor for deaths of infants and young children. Fortunately for the single-round retrospective survey approach, two developments, one in survey methodology and one in analytical methodology, have greatly increased the usefulness of direct information on deaths for mortality studies. First, the widespread collection of maternity histories, whereby women of reproductive age are questioned concerning the dates of birth and, if applicable, dates of death of all of their live-born children, has greatly improved the reliability of information on infant and child mortality. A large number of such surveys have been carried out under the auspices of the World Fertility Survey, and the mortality findings of these surveys have been reviewed by Hobcraft;[2] in several cases, including Kenya from the examples discussed below, these surveys have been conducted within the framework of multi-purpose household survey programmes. Secondly, the development of a range of procedures for assessing the completeness of reporting of adult deaths by comparison with reported age distributions[3] has greatly increased the usefulness of survey information on recent deaths. Thus, the combination of a small-scale, carefully conducted maternity history survey and a large-scale household survey collecting data on deaths by age and sex in the previous 24 months now represents a viable solution to the problem of mortality estimation in many developing countries. The large-scale household survey also offers the opportunity for the collection of data needed for the application of a number of other indirect mortality estimation procedures. Examples of the application of such procedures, based on information concerning the proportions surviving of children ever born by women classified by age or duration of marriage, the proportions of mothers and of fathers surviving classified by age of respondent and the proportions of first spouses surviving by age or marital duration of respondents, are given by Blacker.[4] Such methods use demographic models to transform the deserved proportions surviving into conventional life-table measures and to obtain reference dates for the measures.[5]

Three examples, from Kenya, India and Brazil, are given below of the collection of mortality information in multi-purpose household survey programmes.

Kenya

Kenya is one of the few countries of Africa that has had considerable experience with a multi-purpose household survey programme. The Central Bureau of Statistics first launched the National Integrated Sample Survey Programme during 1975, to run to 1979. Under this programme, a series of socio-economic and demographic surveys were conducted using a common sample covering 95 per cent of the country's population. The primary objective of the sample frame was to ensure that all the surveys conducted under the programme should yield reliable estimates on population changes and information on labour force characteristics, the agricultural sector and other socio-economic variables. The sample was designed to provide representative results for seven of the eight provinces of Kenya; the eighth province, a sparsely populated and backward area of north-eastern Kenya, was excluded from the frame. Surveys conducted under the programme have covered income, expenditure, employment, nutrition, rural land use and wealth, as well as demographic topics. The two surveys with important components for the study of mortality are the 1977 National Demographic Survey and the Kenya Fertility Survey, 1977/78, part of the World Fertility Survey programme. The former survey was conducted in the entire primary sample, covering about 50,000 households, whereas the latter was conducted in one of the six blocks into which each primary sampling unit was divided and covered about 8,000 women aged 15-49. The fertility survey differed in execution from standard survey rounds in that specially recruited and trained female interviewers were used instead of the regular teams of the National Integrated Sample Survey Programme.

The National Demographic Survey collected information relevant only to the application of indirect mortality estimation procedures, specifically concerning survival of children (by sex), parents and first spouses. No direct information was collected about household deaths. The Kenya Fertility Survey only collected information about child mortality in the form of maternity histories, obtaining the date of birth and, if applicable, the date of death of each child reported by the women surveyed.

Blacker[6] analysed data on mortality collected in these two surveys and compared the results with the previous two population censuses, in 1962 and 1969. The indirect estimates of infant and child mortality derived from the proportions of children dying, by age of the mother, obtained from these four different sources, indicate clear and consistent evidence of a substantial decline during the period covered by the data, a trend further supported by the results of the 1979 population census. These results also broadly corroborate the direct estimates of infant mortality obtained from the Kenya Fertility Survey birth histories. It may be mentioned in passing, however, that the results of both the National Demographic Survey and the Kenya Fertility Survey indicated somewhat lower child mortality than did the censuses. The evidence on the trends and levels in adult mortality from the various surveys is neither consistent nor reliable,[7] and it appears that the indirect approaches to the estimation of adult mortality are less satisfactory than those available for estimating child mortality.

India

India introduced the National Sample Survey in 1950. It is a large-scale programme covering all the geographical area of India, comprising a series of socio-economic surveys. Although the National Sample Survey was primarily designed to obtain data on economic indicators, such as employment, income and expenditures, some rounds have been devoted to data on fertility, mortality and migration. The second round of 1950 was used to collect a small amount of data on fertility with the objective of studying fertility levels and trends. Later, realizing the limitations of the vital registration system and the questionable reliability of the estimates of demographic variables derived from it, the National Sample Survey included a fertility section in the subsequent rounds until 1953. In the seventh round in 1954, a revised and more detailed section on demographic data was used to collect information on the births, marriages and deaths in the 12 months preceding the survey and on illness in the sample households. The Survey has since continued to devote some survey rounds to obtaining demographic data. Some methodological variations were introduced in different rounds, although the major approach has remained the single-round retrospective survey.

A distinctive feature of the Survey is that its sample units are arranged in the form of an interpenetrating network of subsamples, each of which is surveyed and/or processed in different but comparable operational units. This technique was introduced three decades ago, by P. C. Mahalanobis of the Indian Statistical Institute. The technique provides two or more independent, but equally valid, estimates of each variable under study (and also of any derived functions, such as vital rates). Thus, the design of the subsample network can be used to examine the differences arising from two or more sources of error, such as two or more interviewers or types of questionnaires.

In the fourteenth round of the National Sample Survey (July 1958-June 1959), the Government of India accorded very high priority to the collection of information for estimating current birth and death rates. Consequently, a separate schedule was developed specifically for the study of fertility and mortality, covering population, births and deaths; the sex, age at death, date of death, place of death and relationship of the deceased to the head of the household were collected for each reported death of a household member over the 24 months preceding the survey. The household roster also included background information on the parent(s) of the children who died during the period. The special schedule was administered in each and every household of the selected geographical area. Each state was divided into a number of strata; and from each rural stratum, two independent subsamples of six villages were drawn systematically. In addition to the separate schedules, the survey design was also modified. The survey year was divided into six subrounds, each of two months' duration; and the same two investigators worked in a particular stratum during the entire survey period. By this method, the independent and interpenetrating subsamples were obtained for each of the six subrounds. In the first two subrounds, detailed demographic information for each member of the sample household was collected, while in the subsequent subrounds, only summary information on a household basis was obtained; the block of information relating to births and deaths was the same in all the subrounds. Information on deaths in single-member households was sought from neighbors and responsible persons in the village, as well as from every tenth household surveyed. The reference period for births and deaths was extended to two years in this round, so that in the final estimation of birth and death rates, the data relating to a shorter period, such as the preceding year, could be used while the information relating to a longer interval would be available for an assessment of the effect of recall lapse and timing bias.[8]

In the fifteenth round (July 1959-June 1960), data on births and deaths were obtained from the same set of sample villages. The reference period was again the two years preceding the interview date, so what was "last year" in the fourteenth round became the "year before last" in the fifteenth. A detailed analysis of data on births and deaths obtained from these two survey rounds provides some measure of relative under-reporting of vital events, as one passes from the last year to the year before last.

Infant mortality and age-specific death rates were calculated from the two interpenetrating subsamples in any given round for both the year before the survey and the year preceding that. The reporting of deaths in the National Sample Survey was found to suffer a higher degree of "recall lapse" than the reporting of births;[9] and the mortality rates calculated from the Survey, when compared with those of the Sample Registration System, appear to be too low.[10] Thus, the National Sample Survey programme, though it has been able to produce timely and useful data on many socio-economic variables, has produced less than satisfactory information on mortality, a common failing of the retrospective methodology used.

Brazil

Brazil, like many other countries in Latin America, has had a vital registration system since the beginning of this century, although the statistics produced by this system have, in general, been deficient. However, the quality of data-gathering and analysis seems to have improved since the Government officially assigned the task of processing and publication of vital statistics to the Fundação Instituto Brasileiro de Geografia e Estadistica (FIBGE) in 1971.[11]

Apart from the efforts to improve the vital registration system, a series of annual national household survey programmes, Pesquisa Nacional por Amostra de Domicilos, was initiated in 1967. The series was primarily designed to measure employment trends. In 1970, the programme was expanded to cover other socio-economic and demographic topics which could be varied from round to round. Although the surveys were national in coverage, the sample was designed with the explicit objective of producing regional estimates. Since 1970, these surveys have included several questions that could generate data for the indirect estimation of child mortality using techniques proposed by Brass and his colleagues.[12] In addition to basic information on age and sex, the rounds of the Pesquisa Nacional in 1972, 1973, 1976 and 1977 collected information on children ever born and children surviving; the 1977 round also collected information on survival of mother, but no other information relevant to the estimation of adult mortality has been collected. During the period 1974-1975, no survey was undertaken by the Pesquisa Nacional because a large-scale survey, the Estudo Nacional da Despesa Familiar, was conducted by FIBGE during that period. The main purpose of the survey was to collect data on household expenditures and nutrition, but it also collected more extensive information on mortality than the rounds of the Pesquisa Nacional, covering children ever born and children surviving by sex, and deaths in the household during the preceding 12 months. However, due to the fact that the major emphasis of the Estudo Nacional da Despesa Familiar was on collecting information on household expenditures and nutrition, and also because the demographic questions were placed at the end of the questionnaire, the quality of the mortality data appears to have suffered. Nevertheless, both of these surveys have been able to generate demographic data suited for the application of a number of the indirect estimation techniques currently available.

As mentioned earlier, all surveys in the Pesquisa Nacional por Amostra de Domicilos were designed to produce both national and regional estimates. The sample design used was a multi-stage probability sample, with households as the ultimate sampling units. Because the surveys were multi-purpose in nature, the interviewers were instructed to administer the questionnaires to the head of household or, in his or her absence, to any other household member who could provide the required information. As a result, data on children ever born and children surviving to women in the household were not generally provided by the women themselves.

The child survival data from the two surveys discussed above have been used by the United States National Academy of Sciences[13] to estimate levels and trends of child mortality in Brazil. Results indicate that, in general, child mortality in Brazil had been declining, although at the regional level the estimates do not show consistent patterns of decline across surveys, and the Pesquisa Nacional surveys seem to be yielding lower levels of child mortality than the estimates from the Estudo Nacional da Despesa Familiar and the censuses. Furthermore, the National Academy of Sciences analysis of urban/rural child mortality differentials based on census data indicated practically no differentials for Brazil as a whole, whereas the estimates obtained from the sample surveys suggest that urban/rural differentials in childhood mortality do exist. In summary, it may be said that although the child mortality estimates by region, derived from the series of Pesquisa Nacional surveys, have proved useful as indicators of levels and trends of mortality in Brazil, they have not been consistent enough to be entirely unambiguous. The estimates of female adult mortality obtained from information on survival of mother from the 1977 survey proved to be much less satisfactory, indicating an unacceptably rapid mortality decline over time.

Conclusions concerning multi-purpose household surveys for mortality estimation

Integrated household survey programmes have been instituted primarily for the collection of socio-economic data; and, as such, they have often been used to generate needed data on demographic parameters, including mortality. All the programmes herein described, excluding the Pesquisa Nacional por Amostra de Domicilos, have accorded prominence to demographic data collection either by earmarking to it separate rounds or by using a separate schedule (as in India) for demographic data. As a result, numerous sets of demographic data from different rounds are available and provide an opportunity to study levels, trends and differentials of mortality, as well as the potential to link the information on diverse topics from successive rounds. This review, however, also finds several problems. To date, these programmes have generated only limited data on mortality. Most analyses have been limited to the estimation of levels and trends of child mortality, providing little information on adult mortality or mortality differentials. The latter deficiency has arisen in part from the fact that the surveys did not collect detailed information for the study of differentials, but also, in many instances, the data collected have not been fully analysed.

On an overall basis, this limited review indicates that multi-purpose household survey programmes, because of their flexibility in sample designs and the availability of field infrastructure, funds and staff on a continuing basis, can be used to generate cost-effective and timely data for estimating mortality as well as for other demographic parameters and may fill many of the existing data gaps in these areas.

B. Multi-round demographic surveys

Multi-round demographic surveys are generally single purpose, although the single purpose generally includes fertility and migration as well as mortality. The multi-round survey, as its name implies, involves repeated visits to the same sample of households. This approach was devised to minimize the deficiencies in coverage exhibited by single-round retrospective surveys in which questions are asked about events that have occurred in a fixed reference period (usually one or two years prior to the survey). The multi-round survey approach is described in detail in the literature.[14] Although variations exist, the multi-round survey usually consists of an initial round at which the characteristics of the sample population are recorded, followed by two or more subsequent rounds which update the household listings, using changes in household composition to prompt inquiry about vital events since the previous round. The multi-round survey approach, in essence, uses a combination of retrospective and prospective approaches for the collection of data on occurrence of events.

The most distinctive feature of the multi-round survey is that it uses a reference period bounded by the visit to the household at the previous round, whereas the single-round retrospective survey uses a reference period bounded by a date or length of time, a much vaguer delimiter. Thus, instead of asking the respondent whether a death has occurred in the previous 12 or 18 months, the interviewer asks about each person listed in the previous round, i.e., whether that person is still residing in the household, has migrated or has died.[15] The recall of events is bounded by the previous interview; thus, errors of dating and of erroneous inclusion of deaths are minimized.

During the past two decades, several local and national multi-round inquiries have been carried out in Africa, Asia and Latin America. An inventory of large-scale surveys since 1960 was compiled by the World Fertility Survey.[16] Of 175 surveys studied, 26 per cent were multi-round surveys. Cantrelle[17] describes the evolution of the approach in francophone countries of Africa. An inventory that he prepared lists 23 distinct regional and national inquiries that had been carried out by 1974 in Africa. In the 1960s the Centro Latinoamericano de Demografía (CELADE) independently developed and tested the multi-round survey. Two experimental surveys were carried out: one in the State of Guanabara, Brazil, in 1960/61; and another in Cauquenes, Chile, in 1964-1966. The results from these experiments were found to be satisfactory. Encouraged with the results of these experiments, a multi-round demographic survey was carried out the first time in Honduras in 1970-1972. Surveys analogous to Honduras were followed in Panama in 1974/75 and in Peru in 1974-1976.

A brief description of the survey in Honduras and a multi-round survey undertaken in Iran in 1973-1976 are given below as examples of multi-round surveys in general, followed by a discussion of the relative merits for mortality studies of the multi-round and the single-round approaches.

Honduras National Demographic Survey, 1970-1972

The Honduras National Demographic Survey of 1970-1972, conducted by the Director General de Estadística y Censos (DGEC), with technical assistance from CELADE, was the first national implementation of the multi-round survey methodology tested by CELADE in experimental surveys in the State of Guanabara, Brazil, in 1960/61; and in Cauquenes, Chile, in 1964-1966. The objectives of the survey were to obtain estimates of fertility, mortality and migration for the country as a whole and for urban and rural areas.[18] The survey included some 98 per cent of the national population, the very sparsely populated and poorly developed area in the eastern part of the country being excluded because of its inaccessibility. A stratified cluster sample was drawn with the objective of obtaining a study population of about 35,000 people; in all, 134 clusters were surveyed. Four survey rounds were conducted, the first between December 1970 and March 1971, the second from April 1971 to July 1971, the third between September 1971 and December 1971, and the fourth between July and October 1972. The intervals between rounds were thus between 6 and 10 months, the interval between the third and fourth rounds being longer than originally intended as a result of financial constraints. Four teams, each consisting of a supervisor and two interviewers, carried out the field-work, with the teams being rotated to avoid the same team always visiting a given sample area. The first round collected baseline information on the initial population, covering household characteristics; the age, sex and marital status of each member; the pregnancy status for each female aged from 12 to 50 years; and the date of interview. Subsequent rounds collected information on changes affecting the population, covering the arrival of immigrants (with origin), departure of emigrants (with destination), births, deaths, pregnancy status and marital status; in all cases, the round by which the change had occurred and the date of the change were recorded. At each round after the first, the information from the previous round or rounds was available to the interviewer. By collecting the dates of changes, it was possible at the analysis stage to compute rates on the basis of the true person-years lived by the survey population, taking account of entry and exit. Over the survey period, there were a total of 51,855 entries, made up of the 34,444 persons first enumerated, 2,520 births and 14,891 immigrants; when classified by exit, 33,688 of the 51,855 persons registered remained in the population at the last round; 725 had died and 17,442 had emigrated.

The results of the survey indicated a crude death rate of 14.2 per 1,000 population and an infant mortality rate of 117 per 1,000 live births; comparable figures calculated from the vital registration system were 8 and 37, respectively, indicating that the multi-round survey approach represented a major improvement over the conventional statistics. Rather marked mortality differentials by urban/rural residence and socio-economic group were also found, the crude death rate for urban centres (8.2) being less than half that for the western region (19.7), and the corresponding infant mortality rates being 85 and 133, respectively.

The mortality estimates derived from the multi-round survey can be evaluated by a number of indirect techniques, since the fourth survey round included an additional questionnaire collecting information on children ever born and children surviving, survival of parents and survival of first spouse. The internal consistency check of the age distribution of the population against the age distribution of deaths suggests some underrecording of adult deaths, of the order of 10 to 15 per cent, although the discrepancy could arise from sampling error, given the small number of deaths. The indirect estimates of child mortality indicated a somewhat higher level of child mortality than that obtained by the survey, though the difference was only some 5-10 per cent. Thus, in general, the multi-round survey seems to have recorded deaths adequately, though a somewhat larger sample would have been advantageous.

Population Growth Survey in Iran, 1973-1976

The Population Growth Survey in Iran was carried out by the Statistical Centre of Iran with advice from a United Nations technical advisor.

Detailed descriptions of the survey organization, methodology and results have been given by the Statistical Centre[19] and by Tamrazian.[20] The Population Growth Survey was a multi-round follow-up survey which covered a nationally representative population of about 100,000 persons. The sample design was a 1/300 self-weighted sample of city districts (in urban areas) and *dehestans* (in rural areas). This choice of a self-weighted sample greatly eased data processing and analysis. An initial baseline survey of the population was taken in October 1973. The baseline survey obtained name, relationship to head of household, residential status, sex and date of birth or age, duration of residence, orphanhood status, marital status, births and deaths that occurred in the household during the previous 12 months; and for females below age 50, pregnancy status. After this initial baseline survey, households were visited six additional times at six-month intervals to determine births, deaths and moves in or out of the household during the interval between rounds. The interview technique was that of follow-up: the interviewer asked the respondent about the status of each person recorded at the previous round as living in the household; that is, whether he/she was still living there or had moved out or died. The respondent was then asked about any births or other additions to the household that might have occurred during the interval.

The interviewing was carried out by a permanent interviewing staff. In order to enhance quality, no interviewer visited the same sample unit more than once. Nevertheless, in order to ensure the quality of the survey operation, control checks were carried out after the third, fifth and seventh rounds. After each of these rounds, in a subsample of the survey areas, field supervisors duplicated the interviews and matched the results of these interviews against the originals. The Chandraskaran and Deming approach was then used to estimate the number of events that were missed by the original interview and correction factors were calculated which were applied to the recorded births and deaths. These completion checks indicated that 5.5 per cent of births and 9 per cent of deaths were missed by the interviewing procedure. The adjustments are incorporated in the published results.

For the period 1973-1976, the Population Growth Survey showed a crude death rate of 11.5 per 1,000 population and an infant mortality rate of 105 per 1,000 live births. Life expectancy at birth was approximately 57 years for both males and females, the lack of a sex differential being one of the interesting findings from the survey. Large urban/rural differentials in mortality were also indicated by the survey; the crude death rate varied from 14 per 1,000 in rural areas to 8 in urban areas, and the infant mortality rate from 126 in the rural areas to 62 among urban populations.

The existence of questions on orphanhood status and household births and deaths in the baseline surveys give the possibility of producing comparative mortality estimates based on retrospective techniques. Unfortunately, tabulations based on these questions have not been published.

Advantages of multi-round surveys

The major advantage of the multi-round approach over the simple retrospective reference period approach is that it reduces the burden placed on the respondent's memory. Rather than having to recall births and deaths and try to place them in a time-frame, the respondent merely has to update the list of household members; and since the reference period is bounded by the date of the first interview, there are fewer errors of either inclusion or exclusion of deaths due to faulty dating of the event. In addition, it is more difficult for a respondent intentionally to conceal the occurrence of a death because the interviewer asks about each person who was present at the previous round, one by one.

The multi-round approach has no marked advantage over the single-round retrospective survey in the reporting of "double" events occurring to the same person between rounds, such as a baby who is born and dies or an immigrant who dies. In these cases, the approach relies upon retrospective questioning and is thus as prone to incomplete reporting of deaths as any other retrospective method, although the measurement of early infant mortality may be improved if information on the pregnancy status of each woman of childbearing age is obtained in each round and the outcome of the pregnancy is investigated in subsequent rounds. For example, Cantrelle[21] reports that estimates of infant mortality in the Siñe Saloum Survey in Senegal were much higher when information on pregnancy outcome was used to supplement reports of infant deaths.

In general, empirical findings bear out this theoretical advantage of multi-round surveys, although the necessary data for such comparisons are available for very few surveys. However, several multi-round inquiries in Africa provide two sets of estimates of annual death rates: (*a*) estimates from the initial or baseline survey based on retrospective information on deaths in the 12 months before the survey; and (*b*) estimates based on the information on deaths from the follow-up rounds after the baseline survey. Tabutin[22] compares results of the two approaches for selected countries in terms of crude death rates and infant mortality (see tables XI.1 and XI.2); the multi-round survey gives higher rates in every case except for the crude death rate in Morocco. The higher death rates

TABLE XI.1. COMPARISON OF CRUDE DEATH RATES FROM THE MULTI-ROUND APPROACH AND THE RETROSPECTIVE REFERENCE PERIOD APPROACH, SELECTED COUNTRIES

(Per 1,000 population)

		Crude death rate	
Country	Period	Multi-round approach	Retrospective reference period approach
Morocco ...	1961-1963	21.0	23.1
Tunisia	1968/69	13.8	11.9
Algeria	1969-1971	16.2	12.9
Senegal	1970/71	22.0	13.7

Source: Dominique Tabutin, "Avantages comparés des enquêtes à passages répétés et passage unique pour la mesure de la mortalité dans les pays en développement", paper submitted to the International Union for the Scientific Study of Population Seminar on Methodology and Data Collection in Mortality Studies, Dakar, Senegal, 7-10 July 1981. To be published under the title "Comparison of single- and multi-round surveys for measuring mortality in developing countries", in *Methodologies for the Collection and Analysis of Mortality Data*, J. Vallin, J. H. Pollard and L. Heligman, eds., Dolhain, Belgium, Ordina Editions, forthcoming in 1983.

TABLE XI.2. COMPARISON OF INFANT MORTALITY RATES FROM THE MULTI-ROUND APPROACH AND THE RETROSPECTIVE REFERENCE PERIOD APPROACH, SELECTED COUNTRIES

(Per 1,000 live births)

		Infant mortality rate	
Country	Period	Multi-round approach	Retrospective reference period approach
United Republic of Cameroon			
North Cameroon-Foulbe	1965-1968	85	43
North Cameroon-Dourou	1965-1968	194	120
Senegal			
Siné Saloum	1963-1965	238	165
Thienaba	1966/67	247	135
Algeria	1969-1971	142	112
Tunisia	1969-1971	135	115

Source: See table XI.1.

obtained from the multi-round survey than the single-round retrospective survey approach at least suggest that the former approach provides a better coverage of deaths than the latter. Similarly, in an analysis[23] of data collected in the multi-round survey of Morocco in the period 1961-1963, it was found that a survey with two rounds completely eliminated the inclusion of out-of-scope deaths and considerably minimized the underenumeration of deaths.

Although the multi-round approach has clear advantages over the single-round collection of recent deaths, its advantages over estimates of mortality derived indirectly from data obtained in single-round retrospective surveys are less clear. The final rounds of the multi-round surveys carried out by CELADE in Honduras, Panama and Peru included retrospective questionnaires for obtaining suitable data for indirect estimation. Arretx[24] provides results on child mortality and adult mortality using indirect estimation techniques based on child survival, parental survival and spouse survival, and compares them with the results from the follow-up approach, with results shown in tables XI.3 and XI.4.

In two of the three comparisons, the estimates of mortality from the follow-up approach are lower than those obtained by the use of indirect methods. Although the two sets of estimates refer to somewhat different periods, it would appear that the multi-round approach resulted in an underestimation of mortality.

Analysis of mortality differentials

In one respect, the multi-round survey approach is better suited for studying differentials of mortality than any single-round survey approach, with or without indirect techniques, since information can be obtained about all household members, so that background characteristics of a person who subsequently dies, such as age, education or income, can in many cases be obtained from the persons themselves prior to death, rather than from proxy reports from others after the death. It is unfortunate that most multi-round surveys, because of concern for keeping costs manageable and the questionnaire brief, have used relatively small samples and have not collected much information on socio-economic characteristics, thus losing an excellent opportunity to study differential mortality risks.

The study of differentials by indirect procedures, although possible as demonstrated by the series of studies of child mortality in Latin America carried out by CELADE on the basis of the 1970 round of censuses, suffers from some inherent problems. Most indirect estimates are based on measures of the cumulative experience of a particular age cohort, spread over a long exposure period, while information on characteristics for classification usually pertains to the time of the survey. This discrepancy between the time references for characteristics and for mortality estimates creates difficulty for a valid study of differentials, especially when characteristics are not unchanging.

Simplicity of analysis

The initial analysis of mortality data collected from a multi-round survey is relatively straightforward, with conventional mortality measures being computed

TABLE XI.3. COMPARISON OF LEVELS OF CHILDHOOD MORTALITY IN TERMS OF PROBABILITY OF DYING FROM BIRTH TO AGE *x*, ESTIMATED FROM DATA COLLECTED IN MULTI-ROUND AND RETROSPECTIVE SURVEYS IN HONDURAS, PANAMA AND PERU

	Probability of dying, q(x)					
	Honduras		*Panama*		*Peru*	
Age x	*Multi-round survey*	*Retrospective (indirect) survey*	*Multi-round survey*	*Retrospective (indirect) survey*	*Multi-round survey*	*Retrospective (indirect) survey*
2	0.148	0.164	0.045	0.051	0.156	0.135
3	0.167	0.192	0.049	0.065	0.167	0.147
5	0.182	0.200	0.057	0.072	0.178	0.159

Source: Carmen Arretx, "Comparison between prospective and retrospective demographic surveys to estimate levels and differentials of mortality: the experience of CELADE", paper submitted to the International Union for the Scientific Study of Population Seminar on Methodology and Data Collection in Mortality Studies, Dakar, Senegal, 7-10 July 1981. To be published in *Methodologies for the Collection and Analysis of Mortality Data*, J. Vallin, J. H. Pollard and L. Heligman, eds., Dolhain, Belgium, Ordina Editions, forthcoming in 1983.

TABLE XI.4. DEATH RATES BY FIVE-YEAR AGE GROUPS DERIVED FROM INFORMATION COLLECTED IN MULTI-ROUND AND RETROSPECTIVE SURVEYS, HONDURAS, PANAMA AND PERU

	Death rate					
	Honduras		*Panama*		*Peru*	
Age group	*Multi-round survey*	*Retrospective survey*	*Multi-round survey*	*Retrospective survey*	*Multi-round survey*	*Retrospective survey*
5-9	0.0048	0.0037	0.0010	0.0016	0.0023	0.0030
10-14	0.0030	0.0027	0.0005	0.0012	0.0011	0.0022
15-19	0.0024	0.0046	0.0011	0.0021	0.0025	0.0038
20-24	0.0028	0.0063	0.0010	0.0031	0.0048	0.0051
25-29	0.0056	0.0065	0.0017	0.0033	0.0055	0.0053
30-34	0.0044	0.0068	0.0024	0.0038	0.0041	0.0056
35-39	0.0064	0.0076	0.0014	0.0042	0.0042	0.0063
40-44	0.0045	0.0091	0.0046	0.0054	0.0062	0.0075
45-49	0.0085	0.0115	0.0055	0.0073	0.0053	0.0096
50-54	0.0153	0.0154	0.0043	0.0102	0.0124	0.0130
55-59	0.0165	0.0209	0.0082	0.0154	0.0122	0.0178
60-64	0.0253	0.0308	0.0134	0.0246	0.0156	0.0266
65-69	0.0262	0.0443	0.0188	0.0405	0.0363	0.0391
70-74	0.0446	0.0702	0.0219	0.0698	0.0446	0.0634
70^e5	57.19	54.20	63.95	59.44	59.01	56.27
Difference ..	2.99		4.51		2.74	

Source: See table XI.3.

directly from recorded deaths and person-years of exposure. The time reference of the measures is unambiguous—the survey period—and no reliance is placed on models except in some cases for local smoothing. For a secondary analysis of completeness, models will normally be invoked. A similar advantage clearly applies to single-round retrospective survey data on deaths in a defined preceding period. Indirect estimation procedures applied to the single-round data, on the other hand, although involving only simple tabulation and calculation, rely heavily upon assumed models of demographic phenomena; and, under conditions of changing mortality, produce estimates of an uncertain period, unless a further assumption covering the regularity of the mortality change is introduced.

Disadvantages of multi-round surveys

Complexity of operations

The major disadvantage of the multi-round approach is that the field-work is relatively complex and places heavy demands on financial and skilled manpower resources in countries where such resources are typically scarce. The enumeration units have to be clearly identified and mapped because the approach entails follow-up visits to the same units. The questionnaire is generally more complex and often there may be problems of transcription of the questionnaire for the follow-up visits.[25] The survey operation is spread over an extended period of time and may be disrupted by political or administrative changes. The multiple visits to the same units may result in respondent and interviewer fatigue, adversely affecting the quality of data. Thus, the multi-round survey requires a highly trained and motivated field staff and a close supervision of all aspects of the field-work, a costly undertaking for many developing countries.[26] The single-round retrospective survey, on the other hand, requires only a short period of field-work, does not require the reidentification of households and entails less demand for skilled manpower and administrative continuity.

Delay to availability of results

In its pure form, the multi-round survey produces no useful information until its second round, since events are only recorded between rounds; and it generally produces no firm results until its final round, because of sample size problems. Thus, there is a substantial delay between the beginning of the field-work and obtaining the results. The single-round retrospective survey, on the other hand, can produce final results within a few months of the field-work and is thus very convenient for a quick assessment of the mortality conditions of a country.

Larger sample size

Since death is a rate event, multi-round surveys need a large sample if rates are to be measured with adequate precision. A United Nations manual[27] on sample surveys in Africa recommends a minimum sample size of 100,000 persons or 20,000 households for a demographic household survey. A multi-round survey should thus aim for 100,000 person-years of exposure, although the sample size can be reduced by extending the period of observation. Even this large sample may not be sufficient for a detailed study of differentials of adult mortality.

A systematic study of sampling errors for estimates from indirect techniques does not exist. However, most indirect measures are based on measures of cumulated lifetime experience, thus greatly increasing the number of events included in the analysis; for example, in orphanhood techniques, respondents of a given age x report information on survivorship of their parents over a period of x years. Thus, effective sample size is much greater than the number of persons surveyed, generally resulting in greater statistical precision.

Higher cost

In terms of cash outlays, a multi-round survey is more expensive than a single-round retrospective survey of identical sample size. For example, the data-collection cost of a multi-round survey with R rounds will be roughly R times the cost of a single-round survey. The follow-up rounds may cost less than the initial baseline survey but this saving will be more or less compensated for by the additional costs that would be involved for clear identification of the units required for follow-up visits. Thus, even if costs for other items, such as data processing and analysis, do not differ between the two types of surveys, a multi-round survey will cost more than a single-round retrospective survey, particularly when the sample size benefits of the latter survey are considered.

SUMMARY AND CONCLUSIONS

This chapter has described two survey approaches to mortality measurement in developing countries, one a generally retrospective approach incorporating mortality studies in multi-purpose household survey programmes, and the other an essentially prospective approach, generally single-mindedly demographic in purpose, using multi-round surveys.

The utility of including a mortality element in multi-purpose survey programmes appears to be non-controversial. The mortality risks to which population subgroups are exposed are important socio-economic characteristics of the groups, and other elements in the survey programme can provide useful background information for the study of mortality. What remains controversial is the way in which mortality information should be collected. The single-round retrospective survey collecting only information on deaths in the preceding 12 or 24 months has rarely given satisfactory results; and even though recent analytical developments offer the possibility of assessing and adjusting such information on post-childhood deaths as long as coverage reaches some 60 per cent, the approach should not be used on its own, since it is likely to be particularly defective for childhood deaths. Happily, two retrospective approaches seem capable of providing information about levels, trends and to some extent differentials in child mortality, namely, the maternity history (direct) and the survival of children ever born (indirect). The latter approach is cheaper, but the former provides much more information about differentials and trends, so the choice for a particular survey must depend upon its objectives.

The multi-round survey is expensive, cannot produce quick results and demands an institutional commitment and continuity hard to achieve in many areas. On the other hand, it can produce mortality information of adequate coverage and with great potential for the analysis of differentials, given the longitudinal nature of such studies.

Advances in survey methodology have undoubtedly contributed to the improvement of mortality statistics in developing countries. There is no one method that can be regarded as a panacea, however; and the methodology for a particular survey must depend upon its objectives, while recognizing the efficiency of pick-a-backing mortality studies on surveys of other population characteristics. Further experimentation is also required in important areas where the current methodologies are weak, such as the study of adult mortality differentials (difficult because the events are rare) and the collection of usable cause of death data.

This chapter has briefly described the multi-round survey approach to data collection and has discussed some of its strengths and its weaknesses. Several other approaches to the collection of mortality data are also available, some of which have been examined by the other participants of this Working Group. No single approach to data collection can be identified as being most suited for all situations. Obviously, a number of factors—including local statistical infrastructure and the availability of resources, in terms of money, and competent and experienced staff—will determine the suitability of a particular survey approach.

Multi-round surveys, when well organized and properly executed, can provide a wealth of data for mortality analysis. The multi-round survey has distinct advantages over the single-round retrospective survey in terms of obtaining reliable data for studying levels and differentials of mortality. However, multi-round surveys are complex and require substantial input of money, skilled manpower and a high level of administrative organization. Needless to say, these are among the scarcest resources in many developing countries, which adds to the difficulty of mounting such surveys.[28]

Notes

[1]United Nations, Department of Technical Co-operation and Statistical Office, "Handbook of household surveys", part one, revised draft, 1981.

[2]John Hobcraft, "Use of special mortality questions in fertility surveys: the World Fertility Survey experience", chap. X in the present volume.

[3]Samuel H. Preston, "Use of direct and indirect techniques for estimating the completeness of death registration systems", chap. VIII in the present volume.

[4]John G. C. Blacker, "Experiences in the use of special mortality questions in multi-purpose surveys: the single-round approach", chap. IX in the present volume.

[5]*Manual X. Indirect Techniques for Demographic Estimation* (United Nations publication, Sales No. E.XIII.2).

[6]John G. C. Blacker, paper on Kenya prepared for the United States National Academy of Sciences, 1982.

[7]*Ibid.*

[8]Murarimohan Majumdar, "Estimation of vital rates in the Indian National Sample Survey", in *World Population Conference, Belgrade, 1965; Vol. III. Projections, Measurement of Population Trends* (United Nations publication, Sales No. 66.XIII.7), pp. 159-162.

[9]Ranjan K. Som, "On recall lapse in demographic studies", in *International Population Conference, Vienna*, Druck: Christoph Reisser's Söhne, for the International Union for the Scientific Study of Population, 1959.

[10]Pravin M. Visaria, "Mortality and fertility in India, 1951-1961", *The Milbank Memorial Fund Quarterly*, vol. XLVII, No. 1 (January 1969), part 1, pp. 91-116.

[11]United States of America, National Academy of Sciences, National Research Council, Committee on Population and Demography, "Preliminary report of the Panel on Brazil", Washington, D.C., 1980.

[12]William Brass and others, *The Demography of Tropical Africa* (Princeton, N.J., Princeton University Press, 1968).

[13]United States of America, National Academy of Sciences, National Research Council, Panel on Brazil, *Levels and Recent Trends in Fertility and Mortality in Brazil*, Committee on Population and Demography Report, No. 21 (Washington, D.C., National Academy Press, 1983).

[14]Carmen Arretx and Jorge I. Somoza, *Survey Methods. Based on Periodically Repeated Interviews Aimed at Determining Demographic Rates*, International Program of Laboratories for Population Statistics, Reprint Series, No. 8 (Chapel Hill, N.C., University of North Carolina, 1973); Pierre Cantrelle, *La méthode de l'observation démographique suivie par l'enquête à passages répétés*, International Program of Laboratories for Population Statistics, Scientific Report Series, No. 14 (Chapel Hill, N.C., University of North Carolina, 1974); and United Nations, Economic Commission for Africa and United Nations Educational, Scientific and Cultural Organization, *Manual on Demographic Sample Surveys in Africa* (E/CN.14/CAS.7/17/Rev.2), Addis Ababa, 1974.

[15]In some multi-round surveys, interviews are carried out without any recourse to information collected in the previous round. At a later stage, data from the rounds are reconciled by matching information from different rounds. Such matching is time-consuming and problematical, and there appears to be little to recommend the "blind" procedure.

[16]Samuel Baum and others, *World Fertility Survey Inventory*, World Fertility Survey Occasional Papers, Nos. 3-6 (Voorburg, The Hague, International Statistical Institute, 1974).

[17]P. Cantrelle, *op. cit.*

[18]For a detailed description of the survey methodology, see K. Hill and others, *Encuesta Demográfica Nacional de Honduras: methodology results; indirect estimates*, CELADE Series A, No. 156 (Santiago, Chile, Director General de Estadística y Censos de Honduras and Centro Latinoamericano de Demografía, 1977).

[19]Statistical Centre of Iran, Plan and Budget Organization, *Population Growth Survey of Iran: Final Report 1973-1976* (Teheran, 1978). This country is currently known as the Islamic Republic of Iran.

[20]Seza Tamrazian, "Population Growth Survey in Iran: three years of experience, 1973-1976", spontaneous paper submitted to the General Conference of the International Union for the Scientific Study of Population, Mexico City, 8-13 August 1977. This country is currently known as the Islamic Republic of Iran.

[21]P. Cantrelle, *op. cit.*

[22]Dominique Tabutin, "Avantages comparés des enquêtes à passages répétés et passage unique pour la mesure de la mortalité dans

les pays en développement", paper submitted to the International Union for the Scientific Study of Population Seminar on Methodology and Data Collection in Mortality Studies, Dakar, Senegal, 7-10 July 1981; to be published under the title "Comparison of single- and multi-round surveys for measuring mortality in developing countries", in *Methodologies for the Collection and Analysis of Mortality Data,* J. Vallin, J. H. Pollard and L. Heligman, eds.; Dolhain, Belgium, Ordina Editions, forthcoming in 1983.

[23]George Sabagh and Christopher Scott, *A Comparison of Different Survey Techniques for Obtaining Vital Data in a Developing Country,* International Program of Laboratories for Population Statistics, Reprint Series, No. 10 (Chapel Hill, N.C., University of North Carolina, 1973).

[24]Carmen Arretx, "Comparison between prospective and retrospective demographic surveys to estimate levels and differentials of mortality: the experience of CELADE", paper submitted to the International Union for the Scientific Study of Population Seminar on Methodology and Data Collection in Mortality Studies, Dakar, Senegal, 7-10 1981; to be published in *Methodologies for the Collection and Analysis of Mortality Data,* J. Vallin, J. H. Pollard and L. Heligman, eds.; Dolhain, Belgium, Ordina Editions, forthcoming in 1983.

[25]*Manual on Demographic Sample Surveys in Africa;* Christopher Scott, *Technical Problems of Multiround Demographic Surveys,* International Program of Laboratories for Population Statistics, Reprint Series, No. 11 (Chapel Hill, N.C., University of North Carolina, 1973).

[26]C. Arretx, *op. cit.*

[27]*Manual on Demographic Sample Surveys in Africa.*

[28]Etienne van de Walle, "The role of multiround surveys in the strategy of demographic research", in *Population in African Development,* Pierre Cantrelle and others, eds. (Liège, International Union for the Scientific Study of Population, 1971), vol. 6, pp. 301-310.

Part Six

DATA COLLECTION FOR INTENSIVE MORTALITY STUDIES

XII. EXPERIENCES IN ESTIMATING DIFFERENTIALS IN MORTALITY IN DEVELOPED COUNTRIES—ACHIEVEMENTS AND SHORTCOMINGS OF THE VARIOUS APPROACHES*

*Elsebeth Lynge***

In recent years, interest in mortality differentials in developed countries has revived. There are two main reasons for this concern. The first reason is the observation in the post-war period in some developed countries of a stagnation or even an increase in male mortality. This unfavourable change has taken place simultaneously with an expansion in health care expenditures and has led to such concepts as "the diminishing return from health investments"[1] and "the medical nemesis".[2] The second reason is the general threat of ecological catastrophes caused by side-effects of technological innovations, especially from new chemicals and atomic energy.

The study of mortality differentials in developed countries today therefore serves to identify high-risk groups or unfavourable trends, which in turn indicate areas in which preventive interventions are likely to be fruitful. Valuable supplements to such mortality studies are studies of health factors other than mortality, such as cancer incidence, sterility, spontaneous abortions and congenital malformations, and studies of the effectiveness of treatment and prevention strategies.

All mortality studies share certain traditional elements, and well-tried techniques still have a role to play; but during the 1970s important methodological innovations were introduced into epidemiological studies of occupational risks, smoking, side-effects of drugs etc. This chapter gives a short description, illustrated with examples, of each of the methods currently available for the study of mortality differentials.

A. DETECTION OF MORTALITY DIFFERENTIALS BY PLACE AND TIME FOR POPULATION GROUPS

First indications of areas where health intervention may be fruitful can often be obtained through the comparison of mortality rates, particularly if specific by age, sex and cause, for different geographical areas and different times. The data for such comparisons are generally readily available and involve large numbers of events.

The study of the geographical variations in mortality is relatively simple, requiring only consistency in data quality, the definitions used and the calculations. Consistent calculations of life expectancy for different countries are published by the World Health Organization (WHO).[3] In Europe, the highest levels of life expectancy for men are observed in the Scandinavian countries and in Greece, showing that there is no simple geographical gradient in the mortality in Europe. Similarly, the study of time trends in mortality rates requires only consistency in data quality, definitions and calculations.

Variability over place and time can also be studied jointly. Figure XII.1 illustrates the stagnation/increase in mortality for middle-aged men in Europe. The age-adjusted mortality for males aged 40-64 years in the Netherlands increased in the 1950s and 1960s. In England and Wales, mortality declined throughout the period, whereas it remained nearly unchanged in the Federal Republic of Germany. Hungary experienced a decline in mortality in the 1950s and 1960s, but a steep increase in the 1970s.

Although the examination of very broad differentials such as these indicates undoubted differentials in risk factors to which the populations are exposed, it provides little or no indication of what the risk factors may be. For such purposes, the study of mortality rates specific for age, sex and cause of death, either over time or for much smaller geographical units than countries, is likely to be rewarding. Marked differential mortality from some particular cause between two adjacent areas may indicate some particular environmental or occupational risk factor present in one area but not in the other. Similarly, a marked change over time in a particular age-, sex- and cause-specific mortality rate may indicate important behavioural changes: trends in lung cancer deaths are an obvious example.

A study[4] conducted at Chicago (United States of America) provides an example of the use of small-area information to examine socio-economic differentials in mortality. Five socio-economic groups within the city of Chicago were defined by assigning residents of each of the census tracts at Chicago to a socio-economic group on the basis of the median rent (1930 and 1940) or median family income (1950 and 1960) of the tract. The authors conclude that:

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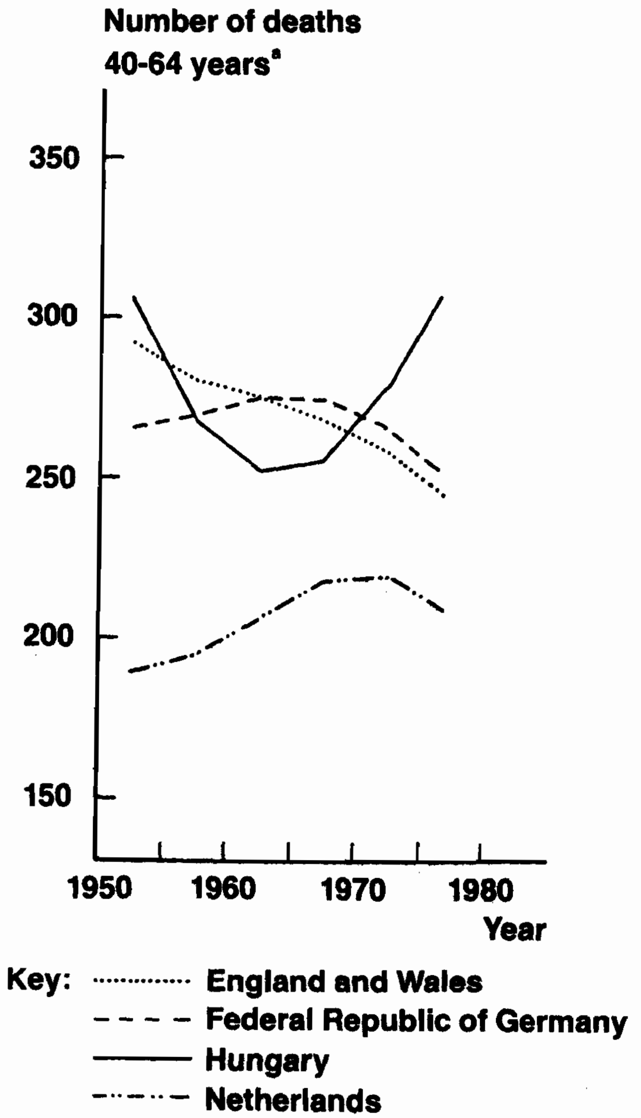
*The original version of this chapter appeared as document IESA/P/AC.17/5.

**Danish Cancer Registry, Copenhagen, Denmark.

"In general, despite the limitation of this approach which attributes to each individual residing in a given census tract the average characteristics for the tract as a whole, it has demonstrated that there are wide variations in mortality by socio-economic status within metropolitan areas. These studies, as those based on individual characteristics, reveal an inverse relationship between mortality and socio-economic status."[5]

The possible pitfalls of examining small-area differentials are illustrated by a report[6] from Finland on cancer incidence in relation to socio-economic characteristics of municipalities. This study found an increasing incidence of cervical cancer with increasing average income and percentage in the two highest social classes. This result is not in accordance with earlier studies, and the authors comment:

Figure XII.1. Age-adjusted mortality for males aged 40-64 years, England and Wales, Federal Republic of Germany, Hungary and the Netherlands



[a]Age-standardized number of deaths in a world standard population of 100,000.

"The apparently conflicting results with regard to cancer of . . . the cervix uteri might be explained simply by the fact that, in the main, the population of the municipalities are heterogeneous, i.e., high-risk sections with a low standard of living are found even in modern industrialized environments. This also shows the problems involved in the interpretation of the results of studies like this."[7]

The detection of differentials is only a first step in identifying the health problems involved. The second step in the process is to associate the observed differentials over place or time with behavioural or environmental differences or changes. Such studies are sometimes called "correlation studies". However, detailed individual-level studies have not always confirmed the apparent link between excess mortality and environmental or behavioural factors found in correlation studies. There are several examples of apparent relationships which it has not been possible to confirm at the individual level. One such example is a positive correlation at the national level between the incidence of cancer of the rectum, and to some extent also colon cancer, and beer consumption per capita; this relationship could not be confirmed in a follow-up study[8] of brewery workers in Denmark having a beer consumption above the average.

B. Cross-sectional studies of mortality differentials by individual characteristics

Mortality differentials between areas and time periods have proved very useful for suggesting the existence of specific health problems but, as has been demonstrated by the examples in the previous section, the possible confounding effects of uncontrolled factors on such differentials limits their value in establishing causal links. For such purposes, individual-level studies with more elaborate experimental designs are essential. This section and that which follows it describe and illustrate the principal approaches in current use. Their main characteristics are summarized in table XII.1.

Conventional cross-sectional studies

The cross-sectional study uses information on deaths and population for a particular point in time to examine mortality differentials by individual characteristics. The typical data sources are registered deaths to provide numerators and a population census to provide denominators. The decennial studies on occupational mortality for England and Wales provide typical examples. They are based on census data and data from death certificates. The population distribution by sex, age and occupation is known from the census and is used as the denominator in the calculations. The distribution by sex, age and occupation of persons dying in a period of three or five years around the census date is taken from the death certificates and is used as the numerator in the calculations. William Farr[9] pioneered this type of study, first applied using the

TABLE XII.1. CHARACTERISTICS OF METHODS FOR THE STUDY OF OCCUPATIONAL MORTALITY DIFFERENTIALS

	Characteristics of method			
Method	*Linking*	*Occupation known at different points in time*	*Mortality followed long after registration of occupation*	*Examples*
A. Cross-sectional studies .	No	No	No	United Kingdom decennial survey
B. Follow-back surveys ...	No	No	No	United States, 1980s study
C. Matched-record studies .	Yes	No	No	United States, 1960s study
D. Follow-up studies; census data	Yes	No	Yes	Scandinavian studies United Kingdom and France, samples
E. Longitudinal studies	Yes	Yes	Yes	Norway
F. Follow-up studies; cohort data	Yes	Yes	Yes	Occupational medicine, e.g., United Kingdom, polyvinylchloride workers

Sources: For method A, United Kingdom, Office of Population and Censuses and Surveys, *Occupational Mortality: the Registrar General's Decennial Supplement for England and Wales, 1970-1972,* Series DS, No. 1 (London, H.M. Stationery Office, 1978; for method B, Evelyn M. Kitagawa, "Present shortcomings and knowledge gaps in U.S. studies", in *Socio-economic Differential Mortality in Industrialised Societies* (Paris, United Nations, World Health Organization and Committee for International Co-ordination of National Research in Demography, 1981), vol. 1; for method C, Evelyn M. Kitagawa and Philip M. Hauser, *Differential Mortality in the United States: A Study in Socioeconomic Epidemiology* (Cambridge, Mass., Harvard University Press, 1973); for method D, Norway, Statistisk Sentralbyrå, *Yrke og Dødelighet, 1970-1973* (Occupation and mortality, 1970-1973), Statistiske Analyser, No. 21 (Oslo, 1976); Denmark, Danmarks Statistik, *Dødlighet og Ehrverv 1970-1975* (Mortality and occupation 1970-1975), Statistiske Undersøgelser, No. 37 (Copenhagen, 1979); Hannele Sauli, *Kuolleisuus: Ammati ja Kuolleisuus 1971-75* (Occupational mortality in 1971-75), Tilastokeskus Studies, No. 54 (Helsinki, 1976); A. J. Fox, "Prospects for measuring changes in differential mortality", in *Proceedings of the Meeting on Socioeconomic Determinants and Consequences of Mortality,* El Colegio de Mexico, Mexico City, 19-25 June 1979 (New York and Geneva, United Nations and World Health Organization, 1980), pp. 516-561; Guy Desplanques, *La mortalité des adultes suivant le milieu social, 1955-71,* Les Collections de l'INSEE, Series D, No. 44 (Paris, Institut national de la statistique et des études économiques, 1976); for method E, Lars B. Kristofersen, *Yrke og Dødelighet* (Occupational mortality), report No. 79/19 (Oslo, Statistisk Sentralbyrå, 1979); for method F, A. J. Fox and P. F. Collier, "Low mortality rates in industrial cohort studies due to selection for work and survival in the industry", *British Journal of Preventive and Social Medicine,* vol. 30, No. 4 (December 1976), pp. 225-230.

1851 data; and the existence of a social class gradient in mortality has been documented for more than a century, as is shown in figure XII.2.

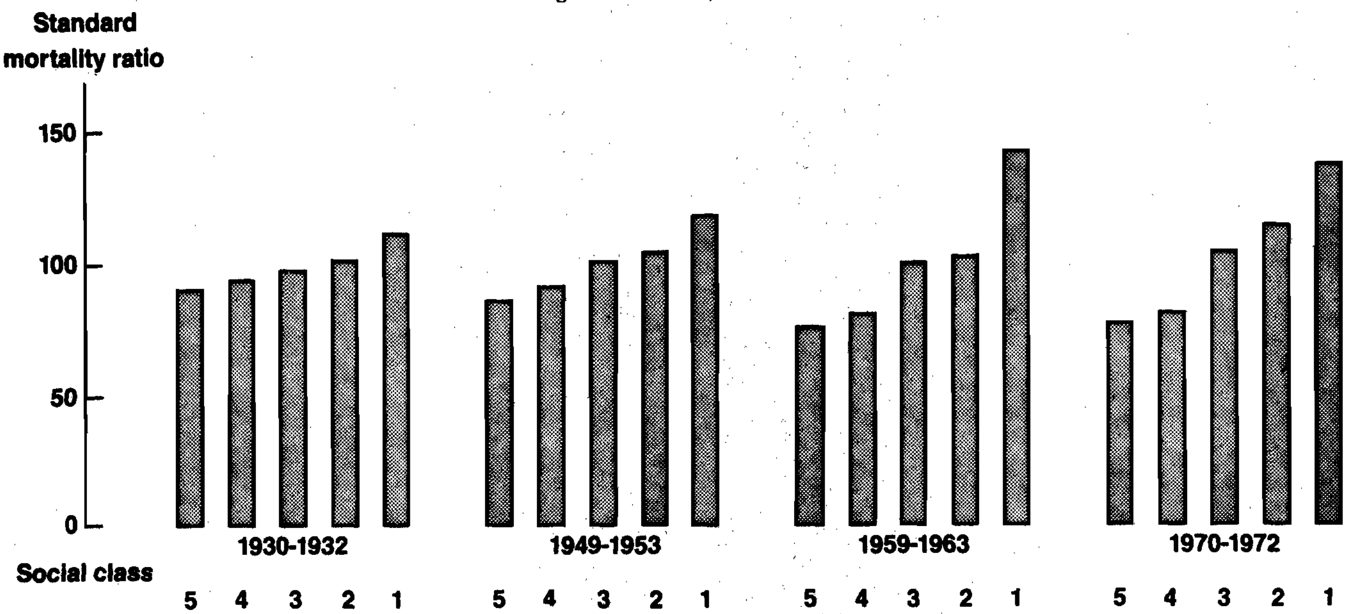
Some of the ambiguities inherent in geographical studies are avoided by the use of this approach, but problems remain. The definitions used for recording occupation on the census forms and on the death certificates have been co-ordinated so that both sets of data refer to last full-time occupation. However, discrepancies are discovered when death certificates are linked to individual census records. Among 607 men aged 15-64 years at the census in April 1971 who died in 1971, 233 were allocated to different occupational orders at the census and on the death certificate, and 62 were allocated to different occupational units within the same occupational order. More men were allocated to "inadequately described occupations" or "unoccupied" at the census than at death. A higher percentage than expected from pure chance of men "unoccupied" in the census were classified as labourers not elsewhere classified, miners or farmers on the death certificate, leading to an overestimation of mortality in these occupations.[10]

The importance of the documentation of persistent mortality inequalities in societies from studies such as these cannot be overestimated. The publications "represent an assessment of the current position. That coal miners die from pneumoconiosis is not a novel discovery—that they continue to die from this disease is a sad reflection on the inadequacy of preventive measures over the past 30 or so years".[11] However, due to the inconsistencies in the occupational classifications described above and the lack of information about possible exposure to risk factors earlier in life, such studies are less valuable for the identification of specific occupational or other risk factors. Different types of linking techniques have been devised in order to overcome this deficiency.

Retrospective unlinked studies

The problems arising from combining death certificate and census data in the analysis can partially be met by collecting data for deceased persons which are equivalent to the data collected for the risk population at the census. Such an approach will be used in the

Figure XII.2. Mortality for males aged 15-64, by social class, England and Wales, 1930-1970



(Standard mortality ratio = standard all men)

United States of America for the study of mortality differentials in the early 1980s. A mail questionnaire will be sent to relatives of a sample of 50,000-70,000 deceased persons. The occupational data for these deceased persons will be coded according to the 1980 census classifications, and the census data from a sample of 69,000 households will be used to provide denominators.[12]

If this approach is extended to include information on exposure to risks earlier in life both for the deceased and for the household sample, the design is equivalent to a case-control study with population controls (see section D).

Matched-record studies

The approaches described above are not true individual-level studies, but rather attempts to classify events and exposure for relatively homogeneous population subgroups. As such, they benefit from large numbers of captured events, given the simple design, but suffer from the small number of factors that can be allowed for. The matched-record study, whereby the census records for a sample of persons dying in a particular period are linked to the death records, provides greater scope for disaggregation, although still on a cross-sectional basis. A study undertaken in the United States in 1960 provides an example.[13] Deaths occurring in the United States during the period from May to August 1960 were manually matched to the individual census records from April 1960, using addresses. However, the census data on socio-economic characteristics were coded for only 25 per cent of the census population and mismatching therefore occurred at two stages in the mortality study: in the linking of death certificates to the general census records; and in the subsequent linking to socio-economic records for the deceased persons supposed to be included in the 25 per cent coded sample. Consequently, only 75 per cent of the death certificates were ultimately matched.

C. FOLLOW-UP STUDIES

Cross-sectional studies suffer from a limitation in that they provide little information about the earlier experience of the deceased. If death is regarded as the culmination of continuous exposure to various risks, such information is clearly of value. The follow-up study, whereby a population is defined by a census or baseline survey and then followed up for a period of time, provides such information and avoids biases introduced by, for example, disease-related changes in occupation prior to death. However, the costs of these advantages are long delays before results can be obtained and relatively small numbers of events to work with.

Follow-up studies based on census data

Censuses can be used to identify the base population to be followed up. The central technical problem in such a case is the matching of subsequent deaths to the initial study population. Personal identification numbers facilitate this process. In France, the Répertoire national d'identification des personnes—which is a manual register—has been used for a 17-year follow-up study of mortality in a sample of 500,000 men from the 1954 census.[14]

The Central Population Registers in the Scandinavian countries have been used for mortality follow-up studies of the total 1970 census populations, three-year follow-up studies in Norway[15] and five-year follow-up studies in Denmark[16] and Finland.[17]

The National Health Service Central Register for England and Wales—which is a manual register like that in France—has been used for a five-year follow-up study of mortality in a sample of 500,000 persons from the 1971 census.[18]

In the Federal Republic of Germany, a one-year follow-up study of mortality is based on data collected from a sample of 181,000 households included in two successive labour force sample surveys, also called micro-censuses.[19]

In each of the studies, mortality in the follow-up period has been analysed by occupation at the time of the census. The Scandinavian studies show that the 10 per cent of the men who were aged 20-64 years and economically inactive at the time of the census have a mortality that is 2.5 times the rate for the economically active. Within the economically active part of the population, male unskilled workers have a 40-50 per cent excess mortality in the younger age groups. This excess decreases with increasing age and disappears towards the pensionable age (see the diagrams from Denmark and Norway in figure XII.3).

One of the purposes of occupational mortality studies is to generate hypotheses about occupational risks. For this purpose, detailed tabulations by occupation and cause of death are necessary. The Danish study has, for instance, revealed an excess risk for lung cancer among butchers. This association is, however, not seen when all workers in the food and beverage industry are studied together.[20] Detailed tabulations require large numbers; and although the total national populations are included in the Scandinavian studies, prolongation of the follow-up periods will obviously improve the analytical possibilities.

Another limitation in the census-based studies is that only the occupation at one point in time is known. Selection mechanisms influencing the composition of the labour force at the time of the census therefore have to be taken into account in the interpretation of the results. The problem is clearly illustrated by the mortality pattern among women: housewives have a 40 per cent excess mortality in comparison with economically active women, suggesting a strong health selection in the labour force rather than exposure to differential risks.

Continuous longitudinal studies

The follow-up approach can be modified to avoid some of the pitfalls of selection effects by recording not only deaths but important changes affecting the living through regular monitoring of the study population. Such continuous longitudinal studies require intensive and lengthy field-work, but they also offer control of a wide variety of factors. For example, selection out of the labour force of unhealthy persons can be accounted for to a certain extent in the analysis of occupational mortality by inclusion of data on previous employment.

In Norway, individual records from the 1960 and 1970 censuses have been linked together. Based on this linked file, the mortality differentials in the period 1970-1973 for occupational and social groups have been studied, including both persons who were economically active in 1970 and persons who were economically inactive in 1970 but were members of the labour force in 1960.[21] Figure XII.4 shows the difference in the mortality between men in social group D (unskilled workers) and men in social group A (professionals) in Norway in 1970-1973. The graphs show that the recorded difference in mortality between the two social groups is enlarged when the persons who were economically active in 1960 but retired in 1970 are included in the respective social groups. This suggests that the narrowing of the social difference in mortality in the older age groups can be explained in part by early retirement of unhealthy manual workers.

However, the data from Norway also show that even when early pensioners are included in the analysis, the excess mortality of male unskilled workers is greater in the younger than in the older age groups. The same pattern is observed in England and Wales and in Denmark.

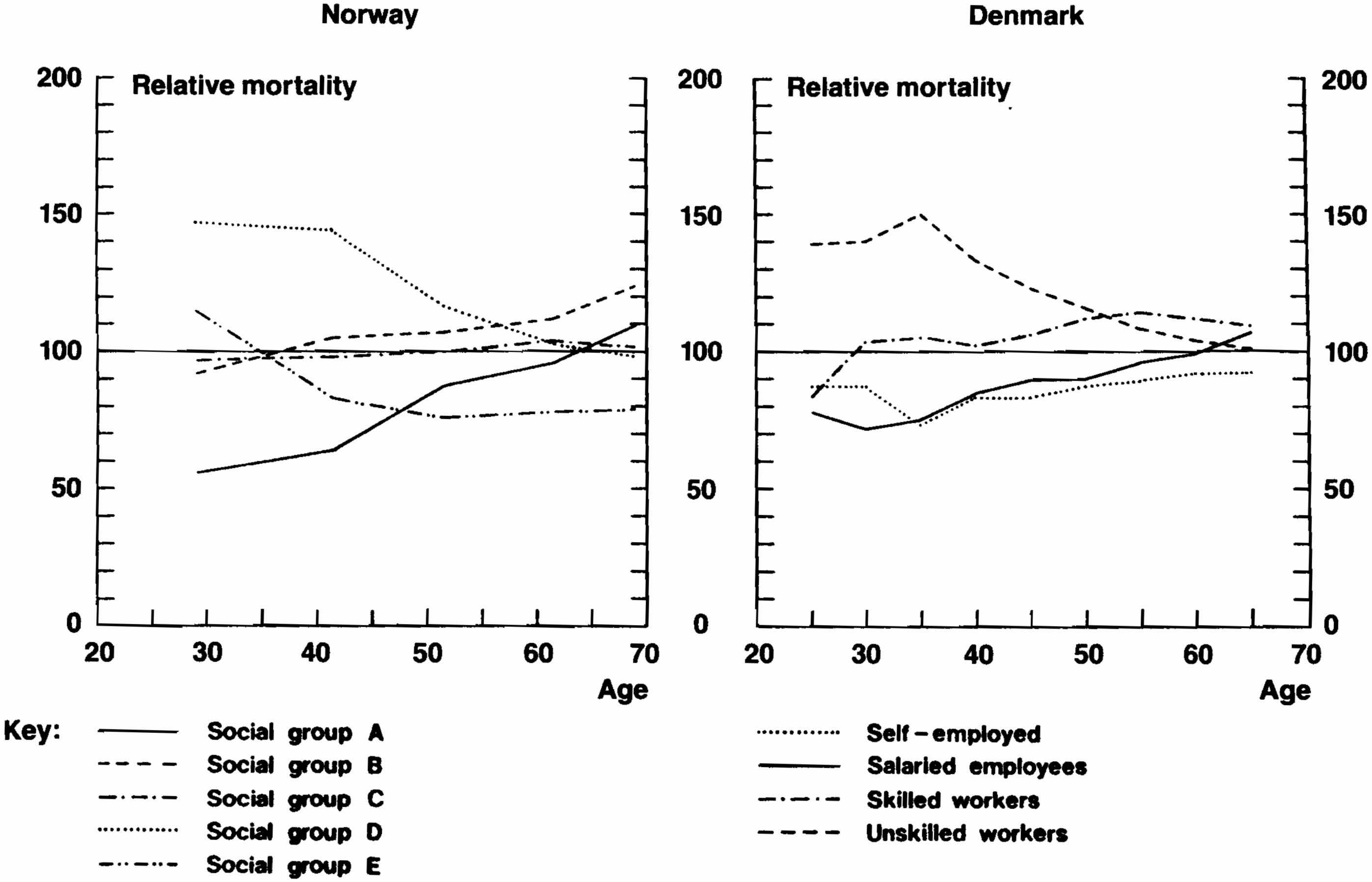
Several factors seem to contribute to this characteristic pattern in the mortality of male unskilled workers: first, an unfavourable health selection in the younger age groups; secondly, an excess mortality from violent deaths; thirdly, the early retirement of unhealthy manual workers; and lastly, almost no social difference for men over age 50 in mortality from circulatory diseases; at this age, half the number of deaths are due to circulatory diseases.[22]

Follow-up studies based on cohort data

The difficulties in interpretation of cross-sectional mortality data can also be reduced by registration of persons from the moment when they enter a particular exposure group, such as an industrial or occupational category. This technique has been widely used in occupational medicine, especially in the United States of America and in the United Kingdom of Great Britain and Northern Ireland.

Supplementation of the data on date of entry to the cohort with data on date of exit provides the possibility for the study of mortality in relation to length of exposure. A well-known example is the British study[23] of workers in the polyvinylchloride industry. Selection mechanisms have been illustrated by data for cohorts of such workers. Table XII.2 shows mortality for male polyvinylchloride workers by age and length of time since entry to the industry. The mortality among men aged 25-44 during the first five years after they entered the polyvinylchloride industry is only half the national rate, with a standardized mortality ratio of 45, but reaches the average level 15 years after entry to the

Figure XII.3. Mortality for males, by occupational groups, Norway, 1970-1973; and Denmark, 1970-1975



(Standard = all occupied men)

Figure XII.4. Mortality for males in social groups D and A, Norway, 1970-1973

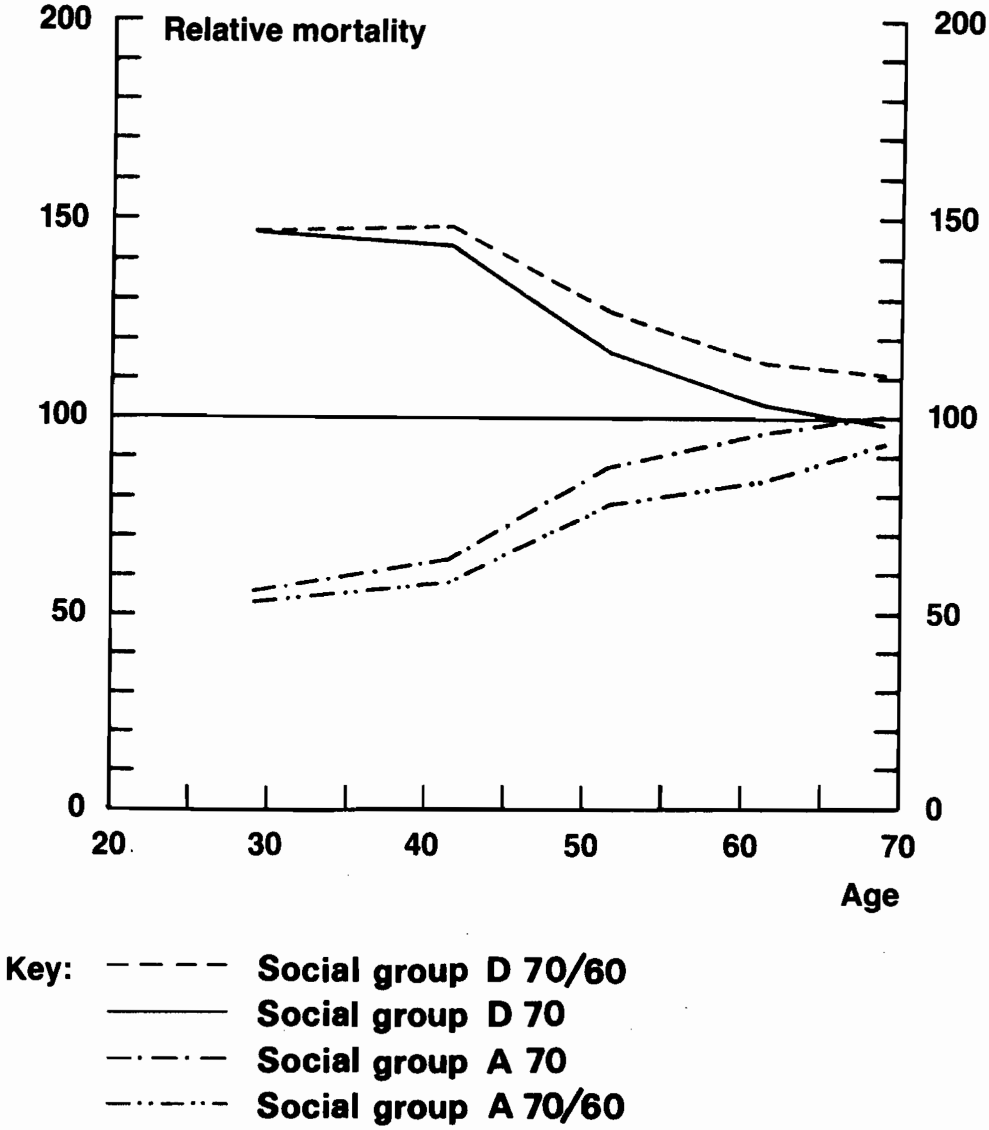


TABLE XII.2. STANDARDIZED MORTALITY RATIOS AMONG MALE POLYVINYLCHLORIDE WORKERS, BY AGE AND LENGTH OF TIME SINCE ENTERING THE INDUSTRY, ENGLAND AND WALES

Age group	Length of time since entering industry (years)				
	0-4	5-9	10-14	15+	Total
25-44	45	73	57	104	62
45-54	37	79	70	74	65
55-64	32	51	99	92	79
65-74	23	30	76	112	96
TOTAL	37	63	75	94	75

Source: A. J. Fox and P. F. Collier, "Low mortality rates in industrial cohort studies due to selection for work and survival in the industry", *British Journal of Preventive and Social Medicine*, vol. 30, No. 4 (December 1976), pp. 225-230.

industry (standardized mortality ratio of 104). The health selection at entry is even more pronounced in the older age groups; the standardized mortality ratio for men aged 65-74 is only 23 during the first five years after entry.

Selection out of the industry of unhealthy workers is illustrated by the mortality data for current and past employees, respectively, 15 years after both groups entered the industry. The recorded standardized mortality ratio for current employees is then 74 in contrast to 108 for past employees.

The selection into the industry of healthy workers and the selection out of the industry of unhealthy workers complicate the study of the effect on mortality of length of exposure to vinylchloride monomers—the very aim of the study. A method for analysis suggested in the polyvinylchloride study in order to overcome these difficulties is to look at the mortality by length of exposure among workers who were all alive 15 years after entry and who had all left the industry by that time. By limiting the analysis to this group, both the effect of the selection into the industry and the effect of selection out of the industry are taken into account. The analysis showed a slight increase in mortality by length of exposure, the standardized mortality ratios being 104 for workers exposed 0-4 years, 116 for workers exposed 5-9 years and 117 for workers exposed 10-14 years.

The example given above clearly illustrates the problems in assessing the effects on health of exposure to potentially hazardous substances.

D. Mortality studies based on numerators rather than rates

All the methods described above refer to situations where data both for the cases or the deceased and for the populations at risk are known, making possible the calculation of conventional rates. Proportional mortality studies and case-control studies are methods for bypassing the need for information about the populations at risk in situations where only data for cases or the deceased are known.

Proportional mortality studies

In a proportional mortality study, the proportion of deaths due to a certain cause in a specific occupational or other group is compared with the proportion of deaths due to the same cause in the total population. The method is valuable in the search for excesses in mortality from rare causes of death. However, it is important in the interpretation to remember that no conclusion concerning the absolute mortality level can be inferred from the data. The following example illustrates the problem.

A study[24] made in Switzerland showed that the number of deaths due to ischaemic heart disease in relation to the number of deaths due to other natural causes among men aged 45-65 was highest for professionals and lowest for unskilled workers. An index equal to 100 for all men was 156 for the professionals and 82 for the unskilled workers. Mortality rates from England and Wales, however, show an excess in mortality from ischaemic heart disease for unskilled workers; and Scandinavian studies show almost equal rates for different social groups for males over age 50. The Swiss data do not necessarily indicate a risk distribution for ischaemic heart disease that is different from the distribution observed in other countries; the apparently conflicting results can be explained by the excess mortality for unskilled workers from other natural causes of death, which results in low proportional mortality figures for ischaemic heart disease even though their absolute rates are equal to or above the average.

Case-control studies

Case-control studies consist of matched samples of cases, i.e., persons with a specific disease; and of controls, i.e., persons from whom it is possible to estimate the proportion of persons in the population exposed to a specific risk. It is important to stress that although controls in case-control studies are often selected among patients with diseases other than those being studied, the purpose of the series of controls is to estimate the exposure rate in the population. Consequently, series of controls are selected for instance among patients with a disease supposedly unaffected by the exposure in question.

Case-control studies are especially suited for the study of risk factors in rare diseases. A case-control study[25] in Sweden, for instance, revealed a relative risk of from five to six for soft-tissue sarcomas among men exposed to phenoxyacids and chlorophenols. Men selected from the population and death registers and matched with the cases on age and municipality constituted the series of controls. Persons who died from cancer were excluded from the controls because phenoxyacids and chlorophenols might also cause types of cancer other than soft-tissue sarcomas. Fifty-two cases diagnosed over an eight-year period were included in the study. Due to the rareness of this disease, it is very unlikely that this excess risk would have been discovered in a follow-up study.

However, spurious results can arise from case-control studies if strict rules for selection of controls are not followed. For example, data from the United States Third National Cancer Survey were analysed on a case-control basis, the fraction exposed to certain risk factors among persons with one type of cancer being compared with the fraction exposed to the same risk factors among persons with other types of cancers. This analysis "indicates an inverse association between breast cancer and smoking which illustrates an artifact caused by inclusion of exposure-biased patients in the control group (lung and other smoking-associated cancers)".[26]

E. Evaluation of methods

Methods for the study of mortality differentials must be evaluated in relation to the purpose of the study. In relation to data on occupational mortality, it is decisive for the evaluation of the method whether the purpose is to sharpen the awareness of social inequalities in societies, to generate hypotheses about occupational risks or to lay the basis for specific preventive interventions.

The cross-sectional method used in the decennial supplements in the United Kingdom is, as illustrated, sufficiently precise for the detection of social-class differences in mortality. The method is generally considered to be inexpensive because it is based on already existing data. However, when computerized registrations with personal identification numbers are available, linking of individual census records and death certificate records is no doubt both less expensive and more precise than the separate coding of occupational information on death certificates. Unfortunately, the linking of individual records for total national populations is at the moment possible only in the Scandinavian countries, and the use of cross-sectional or sample-based linking studies should therefore be recommended in other countries.

The generation of hypotheses about occupational risk has normally been stated as the main purpose of information systems on occupational mortality. The experience from the United Kingdom decennial supplement is, however, short of examples and—in addition to the documentation of the social-class differences—the supplements have mainly functioned as a monitoring system for already established or suspected associations between occupational exposures and specific diseases.[27]

It may be reasonable to expect a broader field of applications for studies of the linked type where there is no problem concerning misclassifications of occupations at death and where the calculations are demographically more exact.

The Danish occupational mortality study, which is a five-year follow-up study of mortality in the 1970 census population, has revealed an excess lung cancer risk in, e.g., butchers (standard mortality ratio, 196), bakers (209), plumbers (180), cooks (234) and dental mechanics (741). These observations are clues that should be followed up by studies in these industries.

However, the linked census-based studies are generally not specific enough to form the basis for standards, norms or other preventive interventions. In studies where the occupation is only known at one point in time, caution is needed in interpretation of mortality figures for certain occupations. Elevated lung cancer figures in Denmark for taxi-drivers (standard mortality ratio of 272) and caretakers (158) are probably due to a selection of health-disadvantaged persons into these relatively protected jobs, which are often used for rehabilitation.[28]

Methodological demands on epidemiological studies in relation to decisions on preventive interventions have been especially pronounced in relation to cancer.

A recent review in the journal *Cancer Research* states that sufficient evidence of carcinogenicity is a causal association between exposure and human cancer:

> "Three criteria must be met to infer a causal association between exposure and human cancer: (*a*) there is no identified bias which could explain the association; (*b*) the possibility has been ruled out that the association is due to another uncontrolled variable (often called a confounding variable) that is associated with both the cancer and the presumed causal agent; (*c*) the association is unlikely to be due to chance.
>
> "In general, while a single study may be indicative of a cause-effect relationship, confidence in inferring a causal association is increased when several independent studies all show the association, when the association is strong, when there is a dose-response relationship, or when a reduction in exposure is followed by a reduction in the incidence of cancer."[29]

The classic example of an association fulfilling these criteria is the association between cigarette smoking and lung cancer. The relationship between lung cancer mortality and smoking habits among British doctors studied by Doll and Peto[30] can be explained by neither confounding nor chance biases. Additionally, several other studies—e.g., of veterans and volunteers in the United States of America—have shown the same association. The association is strong, and the risk for smokers in relation to that for non-smokers increases with the number of cigarettes smoked. Lastly, when the British doctors stopped smoking, their lung cancer rate approached the rate for non-smokers.

However, few studies of the relationship between specific exposures and the development of human cancer fulfil all the criteria listed above. It is also important to remember that although true negative studies exist, epidemiological studies often have an inherent bias towards a negative result, primarily due to the selection mechanisms on the labour market as discussed above in section C.

Concerning decisions on preventive interventions, therefore, mortality studies have to be supplemented mainly with experimental data and with data for earlier detectable human reactions through mortality studies. Subsequently, mortality data are needed in order to monitor the effect of interventions.

As discussed in the foregoing sections, it is possible to overcome some of the shortcomings in studies of mortality differentials by the use of record linkage, registration of occupation at different points in time, prolongation of follow-up periods, etc. Therefore, it is strongly recommended that occupational data from censuses, unions, industries, etc., should be collected and stored in ways which would make it possible to meet these methodological demands.

Summary

Mortality studies in developed countries serve to identify high-risk groups and unfavourable trends. During the 1970s, important methodological innovations have come from studies of occupational risks, smoking, side-effects of drugs, etc. Advantages and shortcomings of the different methods must be evaluated in relation to the purpose of the study. Methodological demands of mortality studies in relation to decisions on preventive interventions have especially been discussed within the field of cancer. It is strongly recommended that occupational data should be collected and stored in ways which would make it possible to overcome shortcomings in the design of mortality studies.

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XIII. EXPERIENCE OF THE PAN AMERICAN HEALTH ORGANIZATION IN USING DEATH CERTIFICATES FOR INTENSIVE STUDIES OF MORTALITY*

*Ruth R. Puffer***

Many challenges for the improvement of vital statistics systems and of health programmes have resulted from the findings of two large investigations of mortality[1] based on death certificates. This chapter is primarily concerned with the experience gained from the Inter-American Investigation of Mortality in Childhood in relation to the basic data needed for international programme planning. The findings were very revealing—far more so than expected—as they showed the need not only for improving the basic data but for reorienting maternal and child health programmes to place more emphasis on producing healthy products of pregnancy, able to survive the hazards of the environment. For family planning programmes, they showed the most favourable age groups for childbearing and the value of spacing pregnancies to reduce mortality risks.

The development of studies of mortality in widely differing areas has many advantages but also distinct problems. Standard definitions and procedures must be followed to attain comparability. Since the United Nations and the World Health Organization (WHO) have been assigned such responsibility, it is logical that they sponsor studies to promote quality in the basic vital statistics. Only through operational in-depth studies will the problems be discovered. Comparison of results from differing areas raises many questions and provides clues as to causation.

In this discussion, the methodology of the regional programme is presented first, followed by a section showing the wide variation in death rates and the completeness of the data. Then some of the highlights of the Investigation, principally those from the study of multiple causes of death and multiple factors related to reproduction, are given. In the last section, the experience gained is shared for the benefit of future studies in the Americas as well as in other regions of the world.

A. METHODOLOGY

The overall objective of the Inter-American Investigation of Mortality in Childhood was to carry out in selected communities of the Americas research projects designed to establish death rates for infancy and childhood that would be as complete and accurate as possible, taking into account biological as well as nutritional, sociological and environmental factors. For adults, the results of the Inter-American Investigation of Mortality,[2] carried out in the period 1962-1964 in 12 cities, indicated the advisability of utilizing the experience gained in that large geographical study of diseases for an ambitious programme of research into mortality in childhood. Early in 1966, the protocol and procedures for a comprehensive investigation of mortality in infancy and early childhood were developed by the Pan American Health Organization (PAHO). The United States Agency for International Development (USAID) awarded funds for the pilot-testing phase.

In order to agree on a questionnaire and to establish testing procedures, a working group meeting was held with participants from six countries. Field-testing was carried out in five areas and the first 700 completed questionnaires from the pilot projects were analysed in 1967. The analyses revealed incompleteness of registration of deaths in the first day of life in two areas, thus indicating the need for application of the WHO definition of a live birth.[3] Deficiencies in the completeness of the clinical data in hospitals pointed to the need for improving the records systems of hospitals in areas where the Investigation was to be carried out, and also for providing short courses for personnel in charge of medical records.

Difficulties were encountered in regard to the fieldwork in two rural areas, principally due to the lack of diagnostic evidence and medical attention. It was clear that the plan of the Investigation necessitated selection of rural areas that had local health services and were in close proximity to medical centres, so that satisfactory clinical data would be available for a high proportion of the deaths. Medical interviewers would be needed to make thorough investigations of the causes of death.

On the whole, the public health nurses and social workers proved to be competent interviewers in obtaining complete histories of the pregnancies of the mother. Because of incomplete data on birth weights, efforts had to be made to introduce weighing of infants as a routine practice in hospitals. Standard procedures for the assessment of nutritional status were devised.

*The original version of this chapter appeared as document IESA/P/AC.17/12.

**United States of America.

A second working group, whose members had participated in the field-work, reviewed the results of the pilot testing and drew up several sections of the Manual of Procedures. The planning and pilot-testing phase resulted in valuable contributions to the design and operation of the research programme.

Early in 1968, USAID approved the plans for the programme, as proposed for the period 1968-1972, and awarded funds for its initiation. The programme called for 27 months of field-work for the collection of data on deaths occurring in 24 consecutive months. Projects were designed for 13 areas of Latin America. High-altitude communities, areas with serious health problems and both rural and urban areas were selected so that all types of problems would be represented and the results would be of value to health authorities in the major area. Since projects were desired also in Northern America, other sources of funds were sought; and projects were established in California, United States of America, and in Quebec Province, Canada. Thus, the Inter-American Investigation of Mortality in Childhood comprised research projects in 15 different, widely separated areas in 10 countries of the Americas (see figure XIII.1). Although the programme included the collection of data on a sample of households for the same 24 months, this report is restricted to the studies of mortality.

To reach agreement on procedures for the conduct of the Investigation, a planning conference of the principal collaborators was held in March 1968. In the selection of the study areas, the first consideration was to find a suitable health leader to serve as principal collaborator and assume responsibility for the direction and conduct of the field-work and later for utilization of the results by both health services and schools of health sciences in the area concerned. The requisite qualifications included professional standing and experience in the direction of field-work. The design of each project, the planning of its activities and the preparation and implementation of its budget for the 27 months of field-work were essentially the responsibility of the principal collaborator. Planning conferences for the medical interviewers also were convened as well as another for principal collaborators for discussion of rules for classification and coding of multiple causes of death in accordance with a new manual.

The wide distribution of the 15 projects over the Americas can be seen in figure XIII.1. The Sherbrooke project in Quebec Province has the northernmost location and the Chilean project the southernmost, lying at the other extreme of the hemisphere. The six projects shown by circles are confined to cities while the other nine shown by squares include suburban and/or rural areas. The 25 specific areas of the 15 projects with estimated populations under 5 years and 1-4 years of age and estimated live births for the two years[4] to serve as the bases for rates are given in table XIII.1. Eight of the projects have divisions into urban, suburban and/or rural areas, while six are urban areas, either an entire city or districts of a city, as at Recife. Although the Sherbrooke project in Canada included suburban and rural areas, it was always treated as a whole because it was too small for subdivision. In five projects, sampling was necessary. For example, at São Paulo, the sampling ratio was 1 in 4.25 deaths; and at Medellín, 1 in 3, while in the Santiago, Cali and Monterrey projects, the ratios were increased in order to complete the work with existing staff. In the principal report,[5] the projects are described to aid in understanding the wide diversity of the material.

The development of estimated populations and estimated live births was difficult for some of the areas. All available local material from censuses, surveys and reports was used; and the central staff worked with the principal collaborators to ensure the adequacy of these bases. For the 15 projects, the estimated population under age 5 for the two years was 2,098,890 and the total number of live births was 474,050. The project at São Paulo had the largest estimated population under 5 years, namely, 243,710, and 58,160 live births. The smallest area was Viacha, the rural community on the *altiplano* in Bolivia, with an estimated population under 5 years of 3,350 and 850 live births.

In each project, the principal collaborator directed a team of medical interviewers, public health nurses or social workers and others who assisted in the field-work. The 27-month schedule for field-work was divided as follows: one month of preparatory work and trial interviewing; 24 months for collection of data on deaths; and two months for completion of the programme. For the 13 projects in Latin America, data were collected for deaths for 24 months beginning in June, July, August or September 1968. The California and Sherbrooke projects were begun in 1969 and 1970, respectively.

As soon as a death occurred and was known to the project staff, a nurse or social worker made a visit to the household concerned to obtain data on housing conditions, members of the family, parents of the deceased child, mother's reproductive history, prenatal care, delivery, breast-feeding and provision of foods and medical attention to the index child. After this portion of the questionnaire (the first three pages) was completed, a medical interviewer sought clinical and pathological information in the hospitals, health centres or private physicians' offices where medical attention had been provided. If information was not available or was not satisfactory, the medical interviewer visited the home to obtain the history of illness.[6]

The death certificate was usually the starting-point for the investigation, although in two projects, deaths were investigated before death certificates were available, through the assistance of a public health nurse or hospital.

Early in the programme, deficiencies in registration of deaths occurring in the first day of life were noted in several projects. In one of them the principal collaborator was amazed to find that the difficulty was in his own large central hospital. He immediately improved

Figure XIII.1. Location of 15 projects in the Inter-American Investigation of Mortality in Childhood

the procedures in that hospital and more complete registration was achieved in the second year of the project. The change in registration procedures in Colombia resulted in difficulties in all three projects; and although the principal collaborators searched for unreported deaths and found many, probably several were missed.

Measures for evaluating the completeness of inclusion of deaths were introduced and the rate of 10 deaths in the first day of life per 1,000 live births maintained in the United States from 1950 to 1964[7] served as a measure for judging completeness. In nearly all the projects, the registered foetal deaths were investigated routinely to distinguish those with evidence of life after birth. The clinical records for women admitted to obstetrical wards of hospitals and the "delivery books" proved to be an excellent source for discovering deaths that occurred soon after birth. Certain hospitals buried unclaimed bodies without official death certificates being filed.[8]

B. Death rates and completeness of data

For the two years of the Investigation, 35,095 deaths of infants and other children under 5 years of age were studied in the 15 projects. The number of deaths varied

TABLE XIII.1. SPECIFIC AREAS, METHOD OF SELECTION OF DEATHS, PERIOD AND ESTIMATED POPULATION BASES FOR TWO YEARS[a] IN 15 PROJECTS[b]

Country, central city and other area	Selection of deaths of residents	Period[a]	Estimated population base (two years)[a]: Under 5 years of age	Aged 1-4 years: Total	Aged 1-4 years: 1 year	Aged 1-4 years: 2-4 years	Live births
Argentina							
1. Chaco Province project—Total ..	-	-	76 800	60 320	15 940	44 380	17 600
Resistencia (urban), San Fernando Department	All	Aug. 1968-July 1970	41 740	32 530	8 940	23 590	9 800
Rural departments: Comdte. Fernández, Genl. Donovan, Libertad, Presidencia de la Plaza, 1 de Mayo, Quitilipi	All	Aug. 1968-July 1970	35 060	27 790	7 000	20 790	7 800
2. San Juan Province project—Total	-	-	104 460	84 180	21 040	63 140	23 360
San Juan (urban), capital department	All	Aug. 1968-July 1970	25 240	20 220	5 060	15 160	5 820
Suburban departments: Chimbas, Rawson, Rivadavia, Santa Lucia	All	Aug. 1968-July 1970	35 540	28 620	7 160	21 460	7 920
Rural departments: rest of Province	All	Aug. 1968-July 1970	43 680	35 340	8 820	26 520	9 620
Bolivia							
3. Bolivia project							
La Paz (urban)	All	July 1968-June 1970	154 700	120 100	33 100	87 000	36 760
Viacha (rural community)	All	July 1968-June 1970	3 350	2 580	710	1 870	850
Brazil							
4. Recife project—three urban districts:							
Beberibe, Casa Amarela, Encruzilhada	All	July 1968-June 1970	123 910	95 810	26 820	68 990	30 400
5. Ribeirão Prêto project							
Ribeirão Prêto (city)	All	July 1968-June 1970	42 630	33 670	8 810	24 860	9 310
Franca (interior city)	All	July 1968-June 1970	22 340	17 550	4 650	12 900	5 090
Communities (suburban/rural): Batatais, Brodosqui, Cravinhos, Jardinópolis, Sertãozinho ..	All	July 1968-June 1970	17 530	13 850	3 610	10 240	3 840
6. São Paulo project (urban)	1 in 4.25	June 1968-May 1970	243 710	188 400	54 140	134 260	58 160
Canada							
7. Sherbrooke project[c]	All	Jan. 1970-Dec. 1971	91 060	74 320	17 000	57 320	16 970
Chile							
8. Chile project							
Santiago (urban)	1 in 5	July 1968-Feb. 1969					
	1 in 3	Mar. 1969-June 1970	191 650	154 500	37 130	117 370	40 180
Comunas (suburban/rural): Colina, Lampa, Quilicura, Til-Til	All	July 1968-June 1970	16 120	13 000	3 120	9 880	3 400
Colombia							
9. Cali project (urban)	1 in 2	July 1968-June 1969					
	1 in 3	July 1969-June 1970	101 200	80 900	20 200	60 700	21 100
10. Cartagena project (urban)	All	July 1968-June 1970	86 000	68 800	17 200	51 600	17 900
11. Medellín project (urban)	1 in 3	July 1968-June 1970	93 300	74 600	18 600	56 000	19 400
El Salvador							
12. El Salvador project							
San Salvador (urban)	All	Sept. 1968-Aug. 1970	103 860	80 040	22 850	57 190	25 620
Rural *municipios:* Apopa, Nejapa, Quezaltepeque	All	Sept. 1968-Aug. 1970	21 430	16 550	4 510	12 040	5 400
Jamaica							
13. Kingston-St. Andrew project—Total	-	-	183 240	143 570	39 110	104 460	40 960
Metropolitan Kingston (urban) ..	All	June 1968-May 1970	167 530	131 260	35 770	95 490	37 450
St. Andrew (rural)	All	June 1968-May 1970	15 710	12 310	3 340	8 970	3 510
Mexico							
14. Monterrey project (urban)	All	Aug. 1968-July 1969					
	2 in 3	Aug. 1969-Jan. 1970					
	1 in 2	Feb. 1970-July 1970	217 940	169 820	45 020	124 800	53 010
United States of America							
15. California project							
San Francisco (urban)	All	June 1969-May 1970	43 050	32 800	8 500	24 300	11 310
Suburban sections of Alameda, Contra Costa and San Mateo counties	All	June 1969-May 1970	160 610	128 180	31 530	96 650	33 430

[a]Excluding the California project, which was for one year.
[b]The 15 projects are listed by the name that is used in referring to them throughout this chapter. For four projects—Bolivia project, Chile project, El Salvador project and California project—these names are used when reference is made to the combination of urban, suburban and rural areas included in those projects.
[c]The Sherbrooke project includes a large rural area but the number of deaths is too small for subdivision and the project is included with the cities.

from 371 at Sherbrooke, Canada, to 4,312 at São Paulo and 4,276 in the Bolivia project (table XIII.2). The size of the project, as well as differences in birth rates and infant death rates, account for these wide variations. Of these deaths, 27,602 or 78.6 per cent were of infants and only 7,493 were of children aged 1-4 years. The numbers of deaths with rates in these three age groups for the 25 areas are given to show the magnitude of our projects and, likewise, the wide variations in mortality. Following the presentation of death rates, the completeness of registration of deaths is indicated by the death rates in early life. This discussion is followed by material showing the availability of birth weights and clinical data concerning cause of death.

Death rates in infancy and under 5 years of age

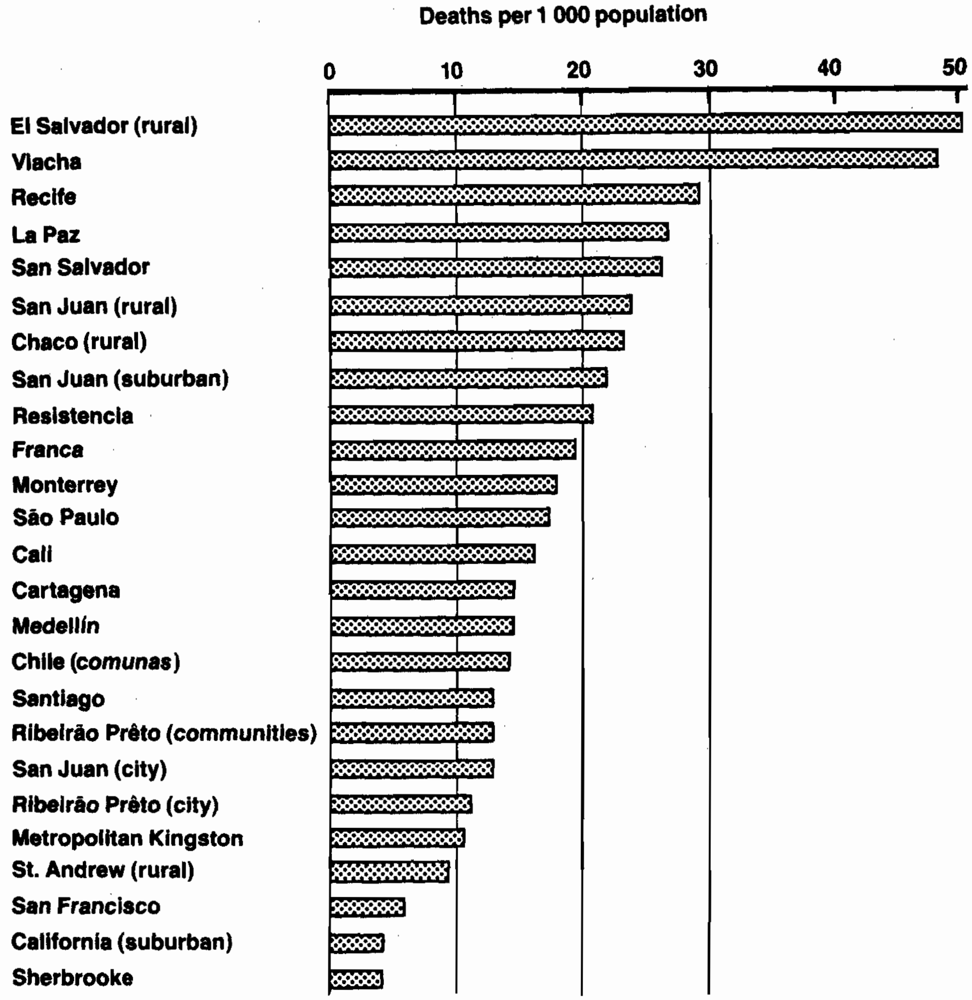
Mortality in the period from birth to age 5 is discussed first in general terms to illustrate the variations found in urban, suburban and rural areas of the 15 projects. There are 25 distinct areas, as shown in figure XIII.2, according to the size of the death rates, which range from a high of 50.5 per 1,000 population to a low of 4.1. The two areas with exceedingly high rates were the rural *municipios* of El Salvador and the rural community of Viacha, Bolivia. The three with the next highest rates were cities: Recife, Brazil; La Paz, Bolivia; and San Salvador, El Salvador. At the other end of the scale were three areas with very low rates. San Francisco and the suburban counties of California, United States; and Sherbrooke, Canada. The rates given refer to known deaths, including those not registered.

In the five areas with very high rates under age 5, the mortality rates were relatively high in age group 1-4, as well as in infancy. Although the study of mortality in this age group was most informative, in general, it showed that the health problems were more

TABLE XIII.2. MORTALITY RATES FOR CHILDREN UNDER AGE 5, INFANTS AND AGE GROUP 1-4 YEARS, 25 AREAS IN 15 PROJECTS

	Under 5 years		*Infant*		*1-4 years*	
Country, project and area	*Number of deaths*	*Rate (per 1,000 population)*	*Number of deaths*	*Rate (per 1,000 live births)*	*Number of deaths*	*Rate (per 1,000 population)*
Total	35 095		27 602		7 493	
Argentina						
Chaco Province						
Resistencia	864	20.7	747	76.2	117	3.6
Rural departments	837	23.9	663	85.0	174	6.3
San Juan Province						
San Juan (city)	326	12.9	295	50.7	31	1.5
Suburban departments	780	21.9	696	87.9	84	2.9
Rural departments	1 050	24.0	909	94.5	141	4.0
Bolivia						
La Paz	4 115	26.6	2 685	73.0	1 430	11.9
Viacha	161	48.1	105	123.5	56	21.7
Brazil						
Recife	3 635	29.3	2 773	91.2	862	9.0
Ribeirão Prêto						
Ribeirão Prêto (city)	464	10.9	400	43.0	64	1.9
Franca	434	19.4	364	71.5	70	4.0
Communities	228	13.0	195	50.8	33	2.4
São Paulo	4 312	17.7	3 788	65.1	524	2.8
Canada						
Sherbrooke	371	4.1	310	18.3	61	0.8
Chile						
Santiago	2 489	13.0	2 207	54.9	282	1.8
Comunas	225	14.0	197	57.9	28	2.2
Colombia						
Cali	1 627	16.1	1 153	54.6	474	5.9
Cartagena	1 255	14.6	856	47.8	399	5.8
Medellín	1 348	14.4	924	47.6	424	5.7
El Salvador						
San Salvador	2 738	26.4	2 094	81.7	644	8.0
Rural *municipios*	1 082	50.5	648	120.0	434	26.2
Jamaica						
Metropolitan Kingston	1 754	10.5	1 478	39.5	276	2.1
St. Andrew (rural)	149	9.5	111	31.6	38	3.1
Mexico						
Monterrey	3 953	18.1	3 220	60.7	733	4.3
United States of America						
San Francisco	234	5.4	209	18.5	25	0.8
California (suburban)	664	4.1	575	17.2	89	0.7

Figure XIII.2. Mortality rate of children under 5 years of age, 25 areas in 15 projects



serious in infancy. Mortality from diarrhoeal disease and nutritional deficiency was greater in infancy. Since for studies of mortality and for health programmes, knowledge of the problems in infancy is especially important, data in this chapter are limited principally to deaths under 1 year of age.

The infant mortality rates for 24 areas,[9] ranked according to level, are given in table XIII.3 and shown in figure XIII.3, with division into those under 1 day, 1-27 days and 28 days-11 months. The variation in these infant mortality rates was great—from 17.2 per 1,000 live births in the suburban counties of California to over 100 in two rural areas, Viacha in Bolivia and the rural *municipios* in El Salvador.

Much of the variation occurred in the post-neonatal rates (28 days-11 months), which ranged from 4.5 per 1,000 live births in suburban counties of California to 83.9 in the rural *municipios* of El Salvador. This high post-neonatal mortality is due principally to infectious diseases and nutritional deficiency, and it indicates the importance of these serious problems. Mortality in the neonatal period showed less variation, ranging from 12.7 per 1,000 live births in suburban counties of California to rates three and four times higher—44.6 in suburban departments of San Juan Province and 49.4 in Viacha. The first four weeks of life constitute a critical period for the child's growth and development.

The first day of life is the most hazardous period and more than half of the neonatal deaths in the projects in the California and Sherbrooke projects occurred in the first 24 hours after birth. For obtaining comparable information on deaths of all those born alive in accordance with the WHO definition, this is the critical period. The death rates in the first day of life in the 24 areas varied from 6.5 per 1,000 live births in the *comunas* of Chile to 14.1 in Viacha. As was pointed out earlier, the standard of 10 deaths in the first 24 hours of life per 1,000 live births was used to assess the completeness of data in each project. Because the attainment of complete data on deaths in the neonatal period is so essential for the attainment of comparable death rates, as well as for understanding the seriousness of health problems, the registration problems discovered are presented in some detail.

Completeness of registration

Of the total of 35,095 deaths, 32,700 or 93.2 per cent were believed to have been registered and thus

TABLE XIII.3. INFANT MORTALITY RATE BY AGE GROUP, 24 AREAS[a] IN 15 PROJECTS
(Per 1,000 live births)

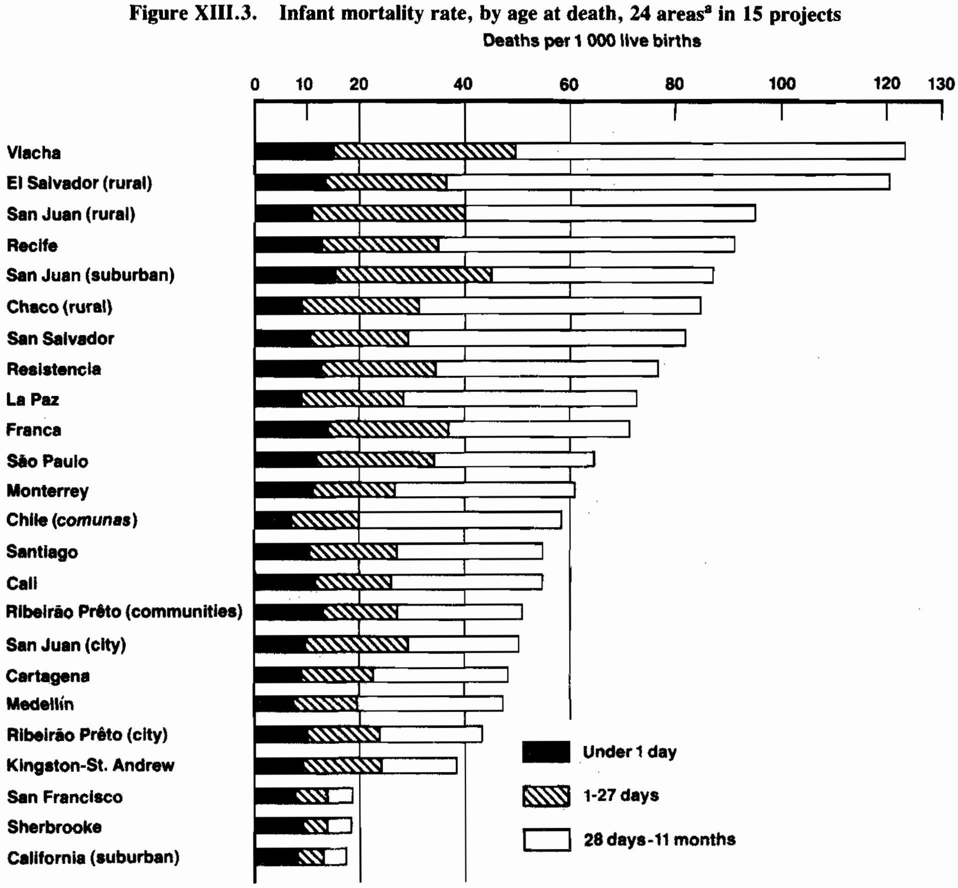
Area	Infant	Neonatal	Under 1 day
	Age group		
Viacha	123.5	49.4	14.1
El Salvador (rural)	120.0	36.1	12.6
San Juan (rural)	94.5	39.6	10.1
Recife	91.2	35.3	11.7
San Juan (suburban)	87.9	44.6	13.8
Chaco (rural)	85.0	30.9	8.8
San Salvador	81.7	28.2	9.3
Resistencia	76.2	33.4	11.9
La Paz	73.0	28.5	8.3
Franca	71.5	36.9	13.4
São Paulo	65.1	33.7	10.7
Monterrey	60.7	26.0	10.6
Chile (*comunas*)	57.9	19.4	6.5
Santiago	54.9	27.2	10.0
Cali	54.6	25.4	10.4
Ribeirão Prêto (communities)	50.8	27.1	12.0
San Juan (city)	50.7	29.6	8.9
Cartagena	47.8	22.4	8.2
Medellín	47.6	19.7	7.0
Ribeirão Prêto (city)	43.0	24.0	10.2
Kingston-St. Andrew	38.8	24.2	7.9
San Francisco	18.5	13.0	7.2
Sherbrooke	18.3	13.5	8.6
California (suburban)	17.2	12.7	7.4

[a]The Kingston-St. Andrew project is treated as a whole because of small numbers.

included in the official statistics, and 2,395 were not registered. In the projects in Latin America, the percentages of deaths registered varied from 79.8 to 99.6, with five projects having less than 90 per cent registered. Each principal collaborator found deaths that had not been registered. Several introduced intensive searches to find missing deaths. In the Sherbrooke project in Canada, 94.3 per cent of the deaths were registered; and for the California project, death certificates were the only source of information used, as a search for unregistered deaths was not considered necessary. The report included all deaths that were known, both unregistered and registered. To illustrate the problem, table XIII.4 and figures XIII.4 and XIII.5 show the deficiencies in registration in four age groups.

In only three projects were many unregistered deaths found in age group 1-4, namely, 8.8 per cent in the Bolivia project, 6.0 per cent at Cartagena and 17.8 per cent in the Jamaica project. The situation was more serious for infant mortality. In six projects, 10 per cent or more of infant deaths were not registered. Within the neonatal period, deaths in the first day of life were the most seriously affected, with those unregistered reaching 10 per cent or more in 10 projects. In four of these projects, the percentages were very high: 65.1 at Cartagena; 45.6 in the Chile project; 41.3 in the El Salvador project; and 39.1 in the Bolivia project.

Figure XIII.3. Infant mortality rate, by age at death, 24 areas[a] in 15 projects



[a]The Kingston-St. Andrew project is treated as a whole because of small numbers.

TABLE XIII.4. NUMBER AND PERCENTAGE OF UNREGISTERED DEATHS OF CHILDREN UNDER AGE 5, IN FOUR AGE GROUPS

Project	Age group: Under 1 year			Under 1 day			1-27 days			1-4 years		
	Number of deaths	Unregistered		Number of deaths	Unregistered		Number of deaths	Unregistered		Number of deaths	Unregistered	
		Number	Percentage		Number	Percentage		Number	Percentage		Number	Percentage
Total	27 602	2 107	7.6	4 543	977	21.5	8 131	690	8.5	7 493	288	3.9
Argentina												
Chaco Province	1 410	77	5.5	186	36	19.4	382	14	3.7	291	8	2.7
San Juan Province	1 900	219	11.5	258	81	31.4	648	88	13.6	256	3	1.2
Bolivia project	2 790	367	13.2	317	124	39.1	774	106	13.7	1 486	131	8.8
Brazil												
Recife	2 773	78	2.8	357	14	3.9	716	18	2.5	862	23	2.7
Ribeirão Prêto	959	4	0.4	209	4	1.9	306	-	-	167	-	-
São Paulo	3 788	26	0.7	625	26	4.2	1 333	-	-	524	-	-
Canada												
Sherbrooke	310	21	6.8	146	13	8.9	83	6	7.2	61	-	-
Chile project	2 404	344	14.3	425	194	45.6	735	149	20.3	310	-	-
Colombia												
Cali	1 153	60	5.2	220	44	20.0	316	16	5.1	474	-	-
Cartagena	856	229	26.8	146	95	65.1	255	105	41.2	399	24	6.0
Medellín	924	45	4.9	136	18	13.2	247	19	7.7	424	6	1.4
El Salvador project	2 742	290	10.6	305	126	41.3	612	111	18.1	1 078	36	3.3
Jamaica												
Kingston-St. Andrew	1 589	160	10.1	323	36	11.1	667	43	6.4	314	56	17.8
Mexico												
Monterrey	3 220	187	5.8	563	166	29.5	814	15	1.8	733	1	0.1
United States												
California project	784	-	-	327	-	-	243	-	-	114	-	-

Figure XIII.4. Percentage of deaths of infants and of children aged 1-4 years without registration

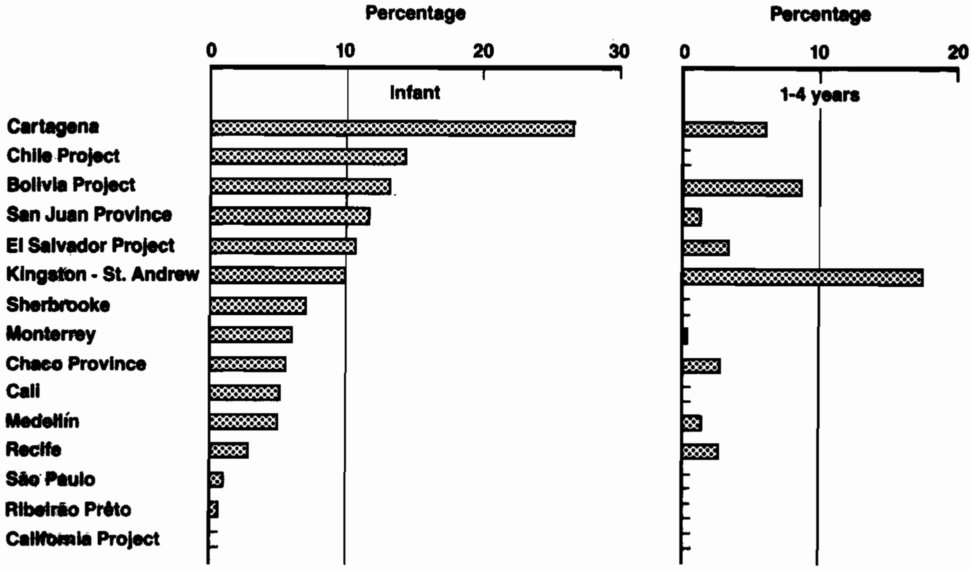
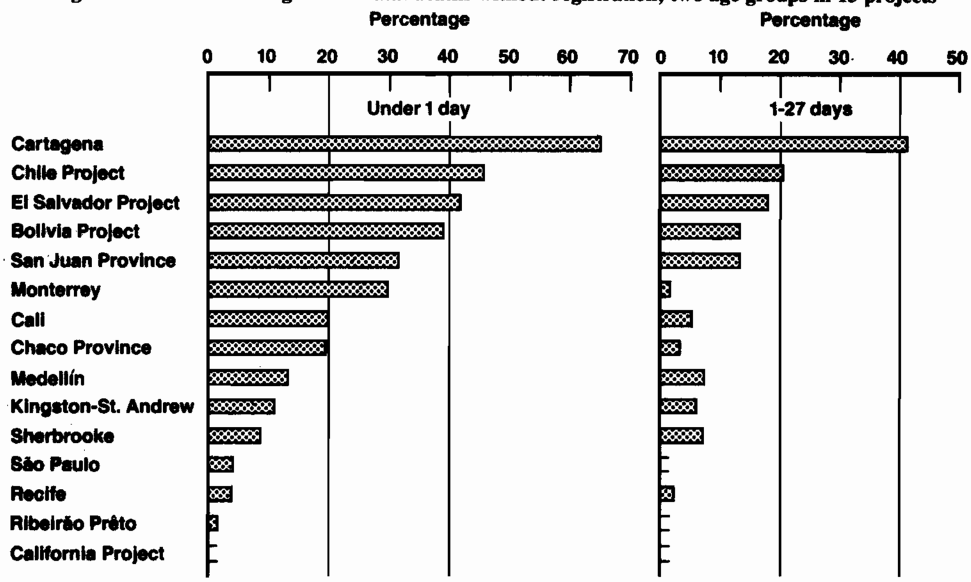


Figure XIII.5. Percentage of neonatal deaths without registration, two age groups in 15 projects



A major problem of incomplete registration of deaths (and likewise of births) was thus uncovered by the research programme, with unregistered deaths discovered in the Sherbrooke project in Canada and in all the projects in Latin America. At Santiago, Chile, it was found[10] that 56 per cent of the babies born in six large maternity sections of hospitals who died in the neonatal period were not registered. As the families did not claim the bodies for burial, death certificates were not filed in the office of civil registry; and, likewise, birth certificates were not filed. Although 53 per cent of these babies with age of death known died within 24 hours of delivery, 10.5 per cent lived at least a week. Changes in procedures are essential to ensure that birth and death certificates shall be filed and also that the hospital statistics shall be accurate and complete. Since the family may not be told that a baby is born alive, the responsibility must be placed on the attendant in the hospital for birth and death certificates. This example shows the need for an educational programme for the introduction of WHO definitions as well as the need for improving and modernizing registration procedures.

Soon after the completion of the Investigation, the group at Recife[11] initiated a study of all products of pregnancy in three maternity hospitals. In this experience, the death rate in the first day of life was 14.3 per 1,000 live births; and in Maternity No. 1, which had the best quality records, the rate was 19.1. These findings indicate that the death rate in the first day of life may be higher than recorded in the studies and as published for many areas of the world. Operational research must be stressed as an essential element for understanding the completeness and accuracy of the basic data in both developing and developed countries.

Completeness of other information

In considering the completeness of information for deaths in the Investigation, recording of the place of birth, hospitalization, birth weights and clinical data gives some leads as to quality.

Of the 27,602 infant deaths, the place of birth was specified for 91.1 per cent. However, in four projects—Bolivia, Recife, Cali and Medellín—the place was not known for more than 10 per cent, the lowest percentage being for the Bolivia project (29 per cent).

Of the infant deaths with place of birth known, in all projects combined, 79 per cent of those who died had been born in hospitals and the rest at home. Of the total, 45 per cent were known to have been delivered by physicians in hospitals and 25 per cent by midwives in hospitals. The attendant was not specified in 9 per cent. In the Sherbrooke and California projects, nearly all the deceased infants with place of birth stated had been born in hospitals and nearly all had been attended by physicians. In the Bolivia project, only 44 per cent of infant deaths with place of birth specified at La Paz were of babies born in hospitals and only 15 per cent at Viacha. Of the other urban areas, Cali had the lowest percentage of hospital births of these deceased infants, 52. Thus, there was marked variation in the availability of data from hospital records completed at the time of birth.

One of the intriguing findings of the Investigation in regard to neonatal mortality was the unusually high proportion of deaths of infants of low birth weight. The percentages of those dying in the neonatal period with birth weights of 2,500 grams or less were surprisingly high, and the percentages in the higher weight groups of 2,501 or more were much lower than found in the birth-cohort study in the United States in 1950[12] and in the British perinatal mortality survey in 1958,[13] indicating very different distributions of births by birth weight.

Because weight at birth is a key element in evaluating the state of health of the new-born, efforts were made to obtain birth weights of all babies. In one area, this effort meant providing scales for the hospital. Weights were used only when recorded in hospitals and clinics. Table XIII.5 gives the number and percentage of neonatal deaths with birth weights stated.

Birth weights were stated for three fourths of the infants who died in the neonatal period (74.5 per cent). In only four of the projects were at least 90 per cent of the birth weights known; the percentages were low for Bolivia (41.7), Cali (51.9), Recife (53.5) and Chaco Province (58.6).

Efforts were made to obtain a complete record of the past history and fatal illnesses of the child, results of laboratory and other examinations and autopsy findings, in order to determine the underlying and

TABLE XIII.5. NUMBER AND PERCENTAGE OF NEONATAL DEATHS WITH BIRTH WEIGHTS STATED, 15 PROJECTS

Project	Number of deaths	Weight stated	
		Number	Percentage
Total	12 674	9 446	74.5
Argentina			
Chaco Province	568	333	58.6
San Juan Province	906	819	90.4
Bolivia project	1 091	455	41.7
Brazil			
Recife	1 073	574	53.5
Ribeirão Prêto	515	414	80.4
São Paulo	1 958	1 678	85.7
Canada			
Sherbrooke	229	222	96.9
Chile project	1 160	1 089	93.9
Colombia			
Cali	536	278	51.9
Cartagena	401	290	72.3
Medellín	383	319	83.3
El Salvador project	917	643	70.1
Jamaica			
Kingston-St. Andrew	990	842	85.1
Mexico			
Monterrey	1 377	925	67.2
United States of America			
California project	570	565	99.1

associated causes of death, that is, the multiple causes. The medical interviewers obtained information from hospitals, clinics, private physicians and autopsy records; if no medical attention had been provided or if no satisfactory record was available, a visit was made to the family to try to obtain the pertinent data. Table XIII.6 gives the number and percentage of deaths of children under age 5, for which clinical information was available (with and without autopsy), those which could be investigated through medical interview of the family and those for which the only source available was a death certificate or an incomplete record of death (without official death certificate).

In four projects, information from clinical records or autopsy reports was available for over 90 per cent; and in these projects, medical interviewers brought the percentages with acceptable data to at least 98 per cent. In several projects, the medical interviewers did an excellent job in finding families and obtaining data. For example, in the El Salvador project, clinical or autopsy information was obtained for only 52.9 per cent, but visits were made to the homes of an additional 44.4 per cent by a very competent medical interviewer. There are other examples of fine work in obtaining data on the fatal illnesses. In the Bolivia project, where some of the deaths were known only by burial in the large cemetery, the problems of finding data were serious. In general, the quality of the information was good and valuable for the purposes of the Investigation.

On the last page of the questionnaire, the medical interviewer prepared a summary of the illnesses leading to death. The principal collaborator of each project reviewed the completed questionnaires and stated his opinion of the underlying and associated causes of

TABLE XIII.6. SOURCES OF MEDICAL INFORMATION FOR ASSIGNMENT OF CAUSES OF DEATH OF CHILDREN UNDER 5 YEARS OF AGE, 15 PROJECTS

Project	Number of deaths	Clinical information or autopsy		Medical interview only		Death certificate or other record	
		Number	Percentage	Number	Percentage	Number	Percentage
Total	35 095	25 989	74.1	6 711	19.1	2 395	6.8
Argentina							
Chaco Province	1 701	1 049	61.7	505	29.7	147	8.6
San Juan Province	2 156	1 942	90.1	174	8.1	40	1.9
Bolivia project	4 276	2 305	53.9	1 273	29.8	698	16.3
Brazil							
Recife	3 635	2 548	70.1	822	22.6	265	7.3
Ribeirão Prêto	1 126	1 056	93.8	61	5.4	9	0.8
São Paulo	4 312	4 170	96.7	92	2.1	50	1.2
Canada							
Sherbrooke	371	330	88.9	34	9.2	7	1.9
Chile project	2 714	2 340	86.2	245	9.0	129	4.8
Colombia							
Cali	1 627	1 087	66.8	345	21.2	195	12.0
Cartagena	1 255	1 074	85.6	123	9.8	58	4.6
Medellín	1 348	870	64.5	298	22.1	180	13.4
El Salvador project	3 820	2 019	52.9	1 696	44.4	105	2.7
Jamaica							
Kingston-St. Andrew	1 903	1 649	86.7	190	10.0	64	3.4
Mexico							
Monterrey	3 953	2 653	67.1	852	21.6	448	11.3
United States of America							
California project	898	897	99.9	1	0.1	-	-

death. Upon completion of the questionnaires they were forwarded to the Pan American Health Organization in Washington, D.C.

In the central office, the data were coded and transferred to punch cards. Dr. Carlos Serrano, who, with the present writer, was in charge of the Investigation, was responsible for the final classification of underlying and associated causes of death. Fortunately, he had the assistance of several members of the staffs of the projects. A new computer service was available which facilitated exploratory tabulations of the multiple causes and factors involved in these deaths.

C. MULTIPLE CAUSES OF MORTALITY

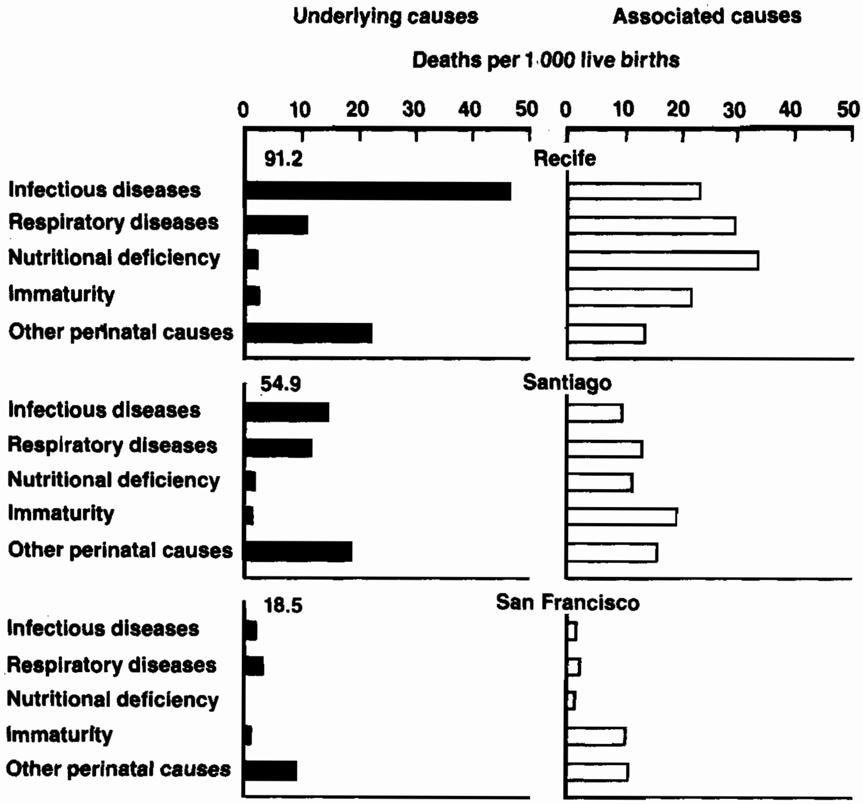
An outstanding feature of the Investigation was the utilization of multiple causes of death. The first Inter-American Investigation of Mortality[14] (in adults) indicated the need for studying multiple causes and combinations of causes of death for discovering aetiologically significant associations. The results of the research showed that selection of one underlying cause governed by arbitrary rules meant that valuable information was discarded. Experimentation was required using modern computer techniques for study of the epidemiology of diseases not as isolated entities but as combinations of pathological states. Experimentation in the Inter-American Investigation of Mortality in Childhood resulted in the unique findings of the seriousness of immaturity and nutritional deficiency in the first year of life. The interrelationship of factors affecting the mother and the infant constitutes an extremely important field for analysis of the multiple causes and conditions responsible for morbidity and mortality and of the chain of events leading to death.

The assessment of multiple causes was based on all the clinical and pathological information collected for each death. The starting-point was selection of the underlying cause of death in accordance with the definitions and rules for selection and modification set forth in the WHO International Classification of Diseases.[15] After the underlying cause was established, other causes were classed as associated causes. The underlying and associated causes are given in detail in the principal report of the Investigation.[16] To illustrate the value of associated causes as well as underlying causes in planning and evaluating health programmes, the experience in three cities has been used (see figure XIII.6). The death rates from five broad groups of causes are shown. Infant mortality varied widely for the three cities, from 91.2 deaths per 1,000 live births at Recife to 54.9 at Santiago to 18.5 at San Francisco. The death rates from the groups of underlying causes are shown by the bars in the left-hand section and those from the associated causes in the right-hand section.

At Recife, which had a very high infant mortality rate, over half of the infant deaths were due to infectious diseases as the underlying cause, the rate for this group being 46.4 per 1,000 live births. This rate was much higher than the rates from respiratory diseases, nutritional deficiency and immaturity, and over twice the mortality rate of 21.9 from certain perinatal causes (excluding immaturity).

As can be seen from figure XIII.6, at San Francisco, very few infant deaths were due to infectious diseases and half of the deaths were due to perinatal causes. At Santiago, the mortality rates had a different pattern: the mortality rate from infectious diseases was less than one third the rate at Recife and 10 times the rate at San Francisco.

Figure XIII.6. Broad groups of underlying and associated causes of infant mortality in three cities



NOTE: For each city, the infant mortality rate is given in the left-hand corner of the panel.

The international rules for classification specify that immaturity is not to be assigned as an underlying cause if any other cause of perinatal mortality is reported. Thus, the death rates with immaturity as an underlying cause are very small.

The patterns of associated causes of death are distinctly different from those of the underlying causes and death rates varied markedly in these three cities. The data on immaturity and nutritional deficiency have been processed so as to provide only one assignment for each, that is, either immaturity (777) or nutritional deficiency (260-269) as an underlying or associated cause. Thus, it was possible to obtain the number of infant deaths in which one of these causes of death was present. At Recife, the death rate from nutritional deficiency as an associated cause of 34.0 per 1,000 live births was very high. At Santiago, however, the rate of 11.4 was much lower and in fact was lower than the rates from respiratory diseases, immaturity and other perinatal causes. At San Francisco, the death rate from nutritional deficiency as an associated cause was exceedingly low (0.6) and the two principal associated causes were immaturity (9.9) and other perinatal causes (10.5).

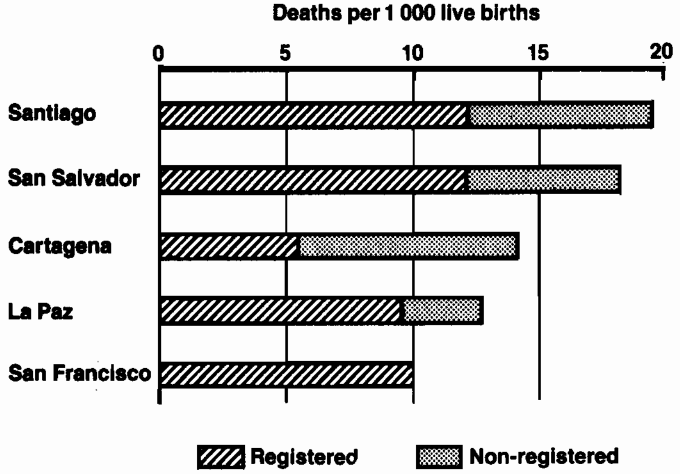
The Investigation disclosed that immaturity is a serious problem in many areas of Latin America. In its definition of maturity, WHO states: "For the purpose of this Classification an immature infant is a live born infant with a birthweight of 5 1/2 pounds (2,500 grams) or less, or specified as immature".[17] This condition can be considered the most important factor in vulnerability to disease and death in the neonatal period. Its involvement as an underlying or associated cause was limited principally to that period.

The uncovering of this problem of immaturity was due in part to the discovery and inclusion of unregistered neonatal deaths. Neonatal mortality from immaturity according to official registration of the deaths is shown in figure XIII.7 for four cities in Latin America and for San Francisco for comparison. If the unregistered deaths had not been included for Santiago, the death rate due to immaturity as an underlying or associated cause would have been 12.2 per 1,000 live births, while with the addition of 303 unregistered deaths found through searches of hospital records, the rate was 19.7, nearly double the rate of 10.2 per 1,000 live births for San Francisco.

The death rates from immaturity as an underlying or associated cause of infant deaths for the 24 areas of the 15 projects are shown by the black bars in figure XIII.8. They were surprisingly high in several areas, exceeding 20 per 1,000 live births in five. In all the projects in Latin America, the rates were in excess of 11 per 1,000 live births, varying from 11.8 to 29.9. However, in the California and Sherbrooke projects, the rates were only 10.1 and 9.8.

Infants with immaturity who survive the first month of life often develop a superimposed nutritional deficiency state. Likewise, nutritional deficiency develops in many infants weighing 2,501 grams or more as a

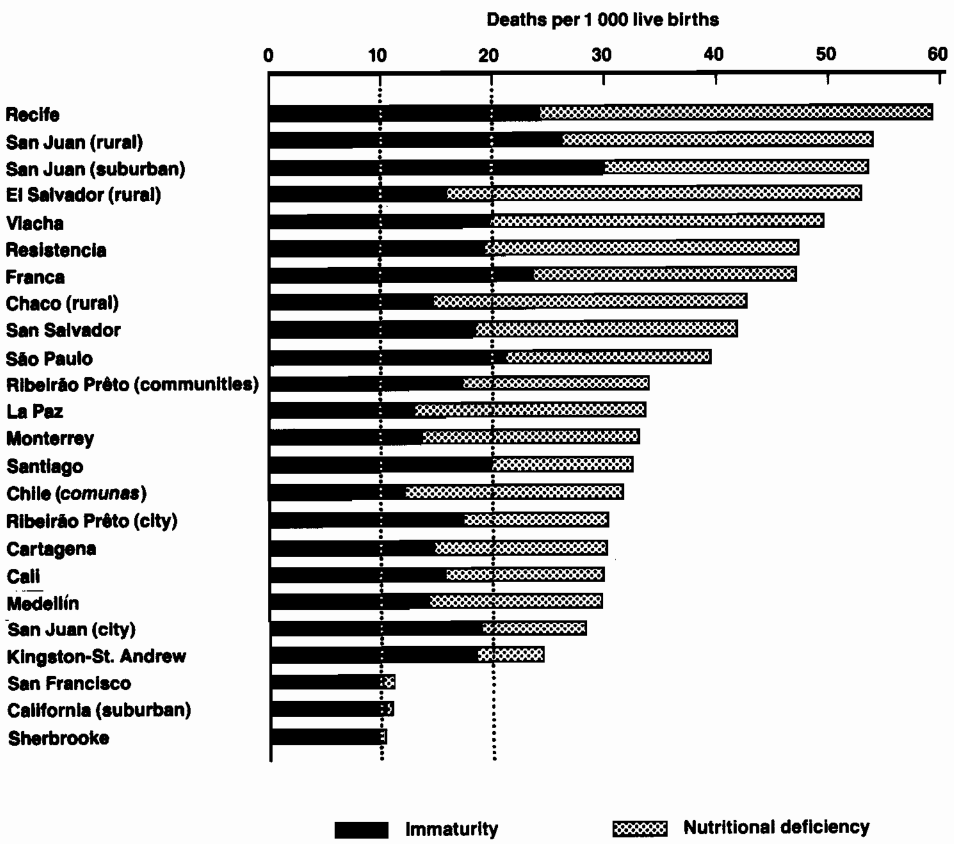
Figure XIII.7. Neonatal mortality with immaturity as underlying or associated cause, according to registration in five cities



result of repeated attacks of diarrhoeal disease or other morbid conditions, usually associated with inadequate intake of proteins and calories. In the areas of Latin America, the infant deaths with nutritional deficiency as an underlying or associated cause, as shown by the shaded sections of the bars in figure XIII.8, varied from 5.9 per 1,000 live births at Kingston-St. Andrew to 35.5 at Recife and 36.7 in the rural *municipios* of El Salvador.

When the deaths from immaturity and nutritional deficiency are combined, it is apparent that relatively high proportions of infant deaths have this important evidence of insufficient growth and development. In nine areas, in fact, the number of infant deaths caused by these conditions was at least 40 per 1,000 live births. These high rates clearly point to the need for preventive measures to combat these serious conditions.

Figure XIII.8. Infant mortality rates with immaturity and nutritional deficiency as underlying or associated causes, 24 areas in 15 projects

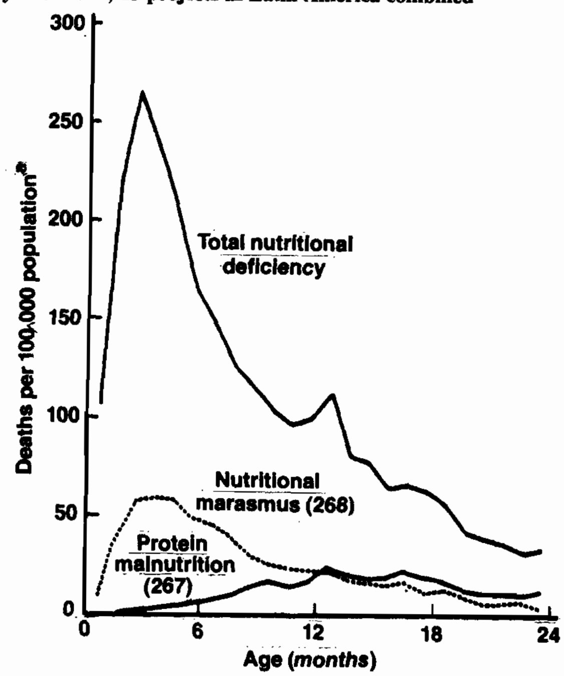


Differences in the size of these problems in urban and rural areas were evident in two projects with relatively complete data, namely, San Juan Province and El Salvador. In San Juan, the rates of 53.8 and 53.5 for the two causes combined in the rural and suburban departments were 1.9 times the rate in the city of San Juan (28.0). In El Salvador, the rate for the rural *municipios* (52.6) was higher than that in the city of San Salvador, which was also high (41.6). These results suggest that many rural areas have more serious problems in these fields than do cities in the same countries.

Nutritional deficiency was found to be a cause of excessive mortality in the post-neonatal period and in early childhood. In all the projects in Latin America, the death rates from nutritional deficiency were higher in the first year of life than subsequently. However, very high rates were noted in the second year of life in the rural areas of the Bolivia and El Salvador projects. Relatively high rates in the second year of life were also found in the cities of Recife, La Paz and San Salvador, in the three cities of Colombia and in rural Chaco Province, Argentina.

For the 13 projects in Latin America combined, figure XIII.9 shows the role of the various types of nutritional deficiency as underlying or associated causes of death by age (in months) of children under age 2. The rates for all types combined were highest at 2 and 3 months of age; it then declined for the older age groups. Protein malnutrition was diagnosed for three infants aged 2 months; the rates steadily increased to the age range 12-16 months and decreased thereafter.

Figure XIII.9. Mortality from nutritional deficiency, protein malnutrition and nutritional marasmus, by month of age in first two years of life, 13 projects in Latin America combined



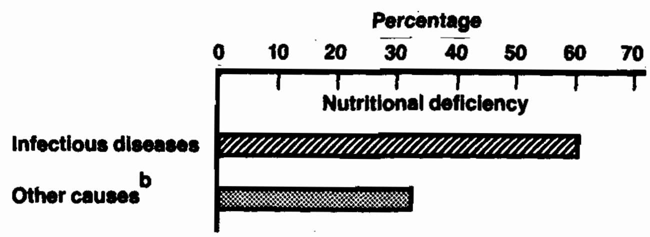
[a]Under 1 year of age per 100,000 live births.

Although mortality from protein malnutrition increased to the highest rates in the second year of life, the rates from nutritional marasmus reached a peak at 2, 3 and 4 months of age and then gradually declined.

Since for all forms of nutritional deficiency combined, the highest mortality was in infants 2 and 3 months of age (263.4 and 235.0 per 100,000 live births, respectively), there is clear evidence of the development of severe forms early in life. This finding is important, for in the past emphasis has been placed on deficiencies in the second year of life. Because the incidence of protein and calorie malnutrition is high at an early age when rapid growth and development take place, irreparable damage may be found in the survivors. These analyses using the multiple-cause approach should lay the foundation for new and effective approaches to the study of measures for prevention of such deficiency.

The relationship of nutritional deficiency as an associated cause of deaths due to infectious diseases as the underlying cause and to other causes for the 13 projects in Latin America combined can be seen in figure XIII.10. Nutritional deficiency was an associated cause of 60.9 per cent of the deaths from infectious diseases, as compared with only 32.7 per cent of deaths from other causes. These findings are in accordance with previous research, indicating the importance of the nutritional state of the host in the development of disease.

Figure XIII.10. Nutritional deficiency as an associated cause of death due to infectious diseases and other causes, children under 5 years of age,[a] 13 projects in Latin America combined



[a]Excluding neonatal deaths.
[b]Respiratory diseases and other causes combined.

What is now known about nutritional deficiency as well as about low birth weight and immaturity would seem to indicate that the deficient nutritional state of populations is perhaps the most important cause of excessive mortality in less developed regions. A vicious cycle is established whereby mothers who have been handicapped since early life by nutritional deficiency and other environmental factors give birth to low-weight babies. Many of these infants die from infectious diseases because of their increased vulnerability, and those who survive continue being at greater risk of the hazards of the environment and of nutritional deficiency than those born with satisfactory weight. Measures to break this vicious cycle through adequate nutrition of future mothers and their offspring are required to improve the survival chances of the children.

D. Other highlights concerning causes of death

It should be pointed out before presenting further results based on causes of death that the original information on cause was substantially revised by the Investigation methodology. Only 52.5 per cent of the underlying causes stated on death certificates were in general agreement with those assigned on the basis of additional clinical and pathological information from hospitals and autopsy records and during interviews conducted in the homes of deceased children.

The role of infectious diseases as underlying causes of death of children under 5 years of age has been clarified, with diarrhoeal disease being found as the principal cause and measles second in importance. The death rate from infectious diseases was shown to be 23 per cent higher than indicated by the official death certificates. Failure to include the infectious diseases on death certificates, even when the evidence of them is available on clinical records, has restricted knowledge of the importance of infectious diseases as health problems in many areas. In the case of measles, for example, mortality in five projects was found to be more than double that recorded on death certificates.

The pattern of mortality from measles was surprising; the highest rate was for children aged 12-14 months and there were many deaths in infancy. Of the 35,095 deaths under 5 years of age, 2,107 or 6.0 per cent were due to measles as the underlying cause. If the neonatal period is excluded, the percentage comes to 9.4. In the second year of life, measles accounted for 19.9 per cent of the deaths from all causes, and in one project (Recife) for 29.7 per cent. Soon after the beginning of field-work, many deaths from measles were reported in two projects, Recife and Bolivia. Vaccine was obtained for a massive programme at Recife in the second year of the study and vaccination against measles was begun at La Paz.

The relationships of abnormal conditions in the mother before and during childbirth, complications of pregnancy and childbirth and their effects on the child were measured for the first time through the multiple-cause approach. Maternal conditions and difficult labour as underlying causes were increased sixfold by the additional information collected; other complications of pregnancy and childbirth were increased more than tenfold and conditions of placenta and cord over four times.

In three projects, the Investigation discovered excessive frequencies of deaths from congenital anomalies of the nervous system. In two projects in Latin America—El Salvador and Monterrey, Mexico—research into the causation of spina bifida is essential in order to determine if some type of nutritional deficiency or a toxic or environmental factor is involved. Since some deaths from spina bifida and other anomalies of the nervous system occur before birth and thus are foetal deaths, only a limited part of this problem may have been uncovered. Moreover, damage other than that causing death should be explored in the surviving children. At the Sherbrooke project in Canada, anencephalus was found to have an excessive frequency, the causes for which should be sought.

Marked variations in patterns of mortality were noted for certain other causes and groups of causes, such as diseases of the nervous and respiratory systems, malignant neoplasms, external causes and the sudden-death syndrome. Mortality from malignant neoplasms in childhood was greater than that revealed by mortality statistics of the respective countries and thus the groundwork was laid for studies on causation of these conditions.

E. Links between reproduction factors and child mortality

The findings on immaturity and nutritional deficiency in infancy and early life indicate the need to explore the factors in reproduction that are responsible for excessive mortality and to determine why these rates are so high. Age of the mother, birth order and birth weight are all probably determinants; therefore, the data available on these factors—although currently limited, especially with respect to birth weight—are discussed below. The interval since the previous birth, though probably also important, could not be studied given the data available from the Investigation.

Maternal age

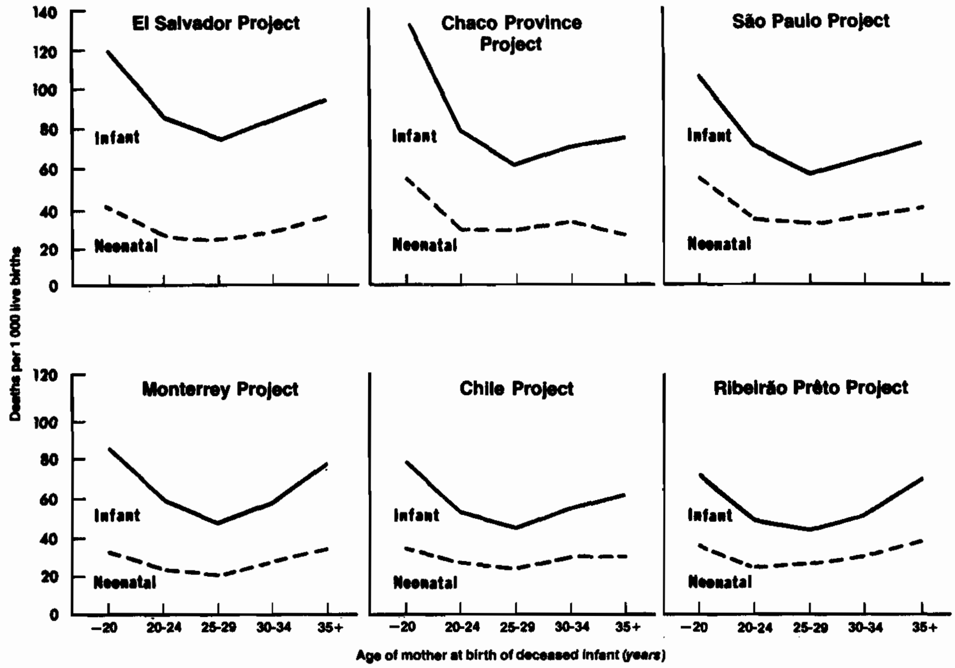
The calculation of death rates by maternal age group is dependent upon obtaining the distribution of live births by age of the mother for the same areas, the denominator for infant mortality rates. Fortunately, this information was available for six of the projects in Latin America; even though the information on births may not be perfect, differentials in infant mortality by age of mother are unlikely to be substantially distorted.

Neonatal and infant mortality rates are shown for the six projects, according to the mother's age group, in figure XIII.11. The rate for the El Salvador project, 88.4 per 1,000 live births, was the highest, while that for Ribeirão Prêto, 52.6, was the lowest. In these projects, the death rates for infants of young mothers (under age 20) were very high: 133.5 per 1,000 live births in Chaco Province; 116.6 in El Salvador; and 104.1 at São Paulo. The lowest death rates were for the children of mothers in age group 25-29; this age period therefore appears to be the most favourable in terms of child survival. The patterns of neonatal and infant mortality in the California and Sherbrooke projects were, in general, similar but at a much lower level. In California, the infant death rate for babies born to mothers under age 20 was 26.2 per 1,000 live births, 71 per cent higher than the lowest rate of 15.3 for those born to mothers aged 25-29 years.

Birth order

Another factor that would be used in combination with maternal age is birth order. In the Investigation,

Figure XIII.11. Neonatal and infant mortality rates, by age group of mother, six projects in Latin America



birth order was based on the total number of children born alive or dead, the desirable definition for considering the effect of the number of pregnancies on its outcome and the health of the child. Unfortunately, for tabulations in vital statistics systems, often only live births have been used in obtaining birth order.

Neonatal and infant mortality rates were calculated by birth order for three projects in Latin America—Chile, Monterrey and El Salvador. In these projects, the rates were lowest for first births and increased to high rates for those of fifth or higher birth orders.[18]

For the El Salvador project, these rates were calculated for the five maternal age groups. Even the infant mortality rate for the first births was high for mothers under 20 years of age (89.6 per 1,000 live births); and for third births of young mothers, it was in excess of 300 per 1,000 live births. For the first-born, the rates were lowest for babies of mothers in age groups 25-29 and 30-34. For all maternal age groups, the infant mortality rates were, in general, lower for first births and increased with increasing birth order to exceedingly high rates for higher birth orders. Other studies, such as that of a cohort of over 140,000 live births in New York City,[19] have revealed similar patterns.

Birth weights

The high rates of deaths with immaturity as an underlying or associated cause raised questions concerning the distributions of live births by birth weight in these areas in Latin America. The first concrete evidence of a slightly high frequency of births of low weight came from the Ribeirão Prêto project.[20] In that project, it was found that 8.7 per cent of the live births had birth weights of 2,500 grams or less, which is higher than the percentages for the United States or European countries.

Figure XIII.12 shows death rates in the first day of life and in the first 28 days (neonatal period), by birth-weight group, for the Ribeirão Prêto and California projects. For comparison, data for the live-birth cohort of the United States in 1960[21] are shown. For the weight group 2,501-3,000 grams, the death rates were at least twice the rates for the most favourable weight group, 3,501-4,000 grams.

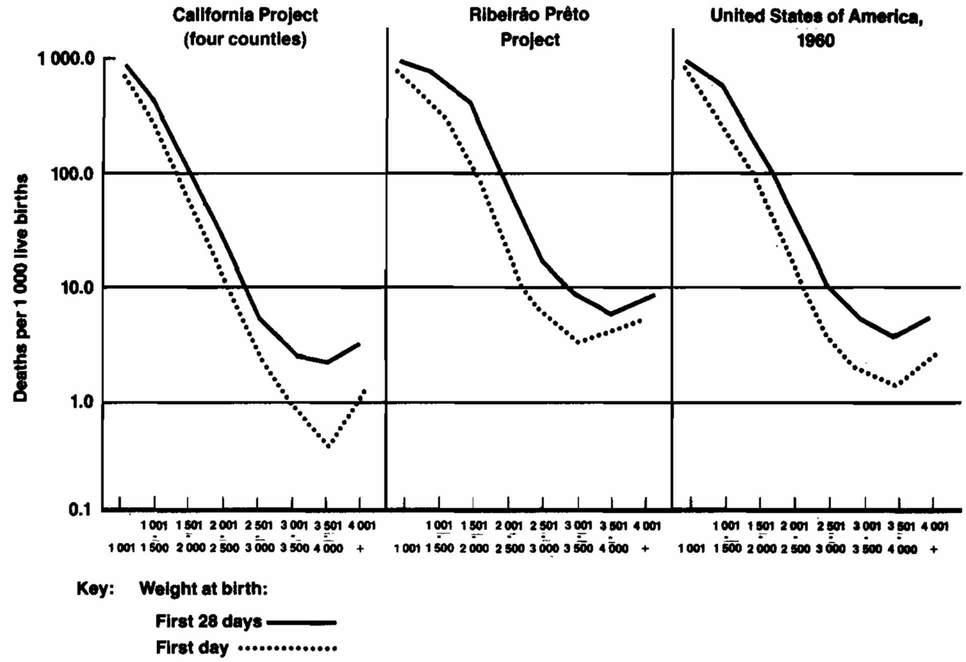
The frequencies of low and deficient birth weights vary with the age of the mother at the birth of the child. Mothers under age 20 have a higher frequency of babies with low birth weight than do mothers in the other four age groups, as shown in figure XIII.13.

In the experience of a hospital at Mexico City,[22] 53.1 per cent of the babies of the young mothers had low and deficient birth weights. The percentages were lower in the Ribeirão Prêto project and were much lower in the birth cohort of the United States in 1960,[23] and they declined by age group to a low of 24.5 for the group of mothers at least 35 years of age, in the experience of the United States.

F. Comments from experience of the Pan American Health Organization

First, the experience of the geographical studies undertaken by the Pan American Health Organization has been tremendously rewarding and yet revealing of how much remains to be learned. The multiple-cause approach led into the problems of immaturity and

Figure XIII.12. Infant mortality rate in first day and in first 28 days of life, by birth weight, California and Ribeirão Prêto projects; and in the birth cohort of the United States of America, 1960

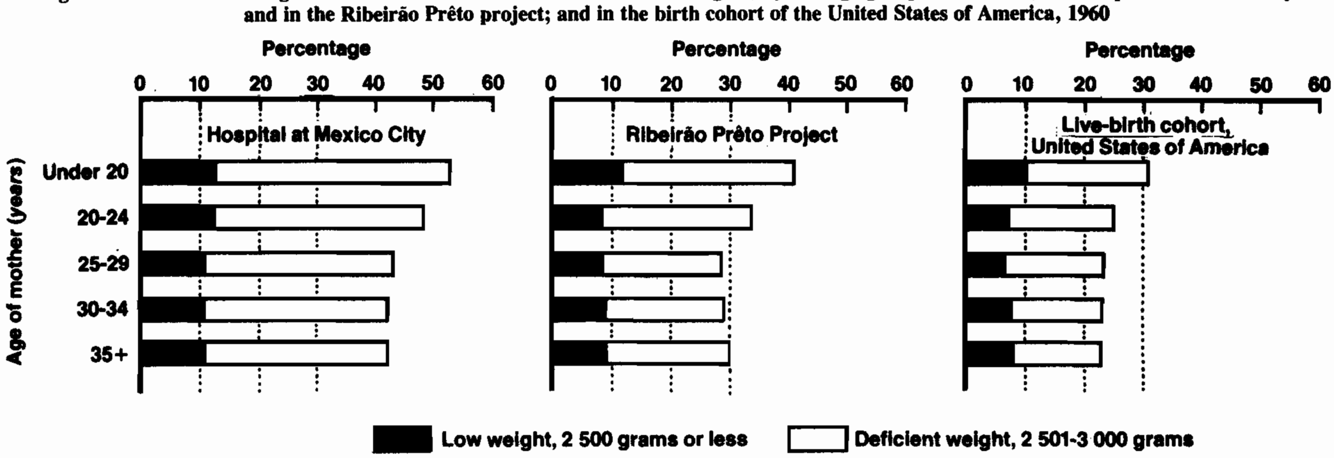


nutritional deficiency and, likewise, into the problem of low and deficient birth weights and the multiple factors to be studied in reproduction.

Undoubtedly, the greatest challenge resulting from the findings discussed here and from subsequent studies is for the introduction of programmes for the prevention of immaturity and nutritional deficiency. These two conditions are endangering the survival and hampering the growth and development of infants and children. The challenge is to develop the necessary research and preventive action to ensure—to the extent possible—the birth of healthy babies with optimal chances for survival. Following birth, the necessary nutrients must be supplied for prevention of nutritional deficiency and susceptibility to infectious diseases. The question needs to be answered as to how community-centred programmes can reduce the incidence of low birth weights. Since such preventive programmes are needed in areas without hospitals, physicians and nurses—and the problems appear to be especially serious in rural areas—educational programmes will be required.

Secondly, official mortality statistics fail to show the magnitude of health problems in early life. Registration of neonatal deaths was found to be so incomplete that it is certain that mortality in this period of life has not been sufficiently known, even in developed countries. In a study[24] of vital signs present at birth in five

Figure XIII.13. Percentage of live births with low and deficient birth weights, by five age groups of mothers, in a hospital at Mexico City and in the Ribeirão Prêto project; and in the birth cohort of the United States of America, 1960



Sources: For Mexico City, Carlos V. Serrano and Ruth R. Puffer, "Utilization of hospital birth weights and mortality as indicators of health problems in infancy, *Bulletin of the Pan American Health Association,* vol. 8, No. 4 (1974), pp. 325-346; and for United States, Robert J. Armstrong, *A Study of Infant Mortality from Linked Records by Birth Weight, Period of Gestation, and Other Variables,* Vital and Health Statistics Series 20, No. 12 (Washington, D.C., Department of Health, Education and Welfare, National Center for Health Statistics, 1972).

hospitals in New York City, it was found that four of the 40 deaths in the first week of life had been registered as foetal deaths. Also, underlying causes of death as certified fail to show the size and nature of many health problems.

In regard to specific comments from the present experience for studies in other areas, the work discussed here could be repeated in whole or in part in many areas of the world. The approach using death certificates for the basic data has the advantage of providing an assessment of the quality of the registration system. For areas with incomplete registration of births and deaths, studies would include procedures for finding and registering each birth and death in accordance with accepted international definitions. One of the goals would be the establishment of a satisfactory system. The responsibility would need to be shared by the family, attendant, hospital and local authority. As discovered in the Investigation, for hospital deaths the family may not know whether a baby is born alive or dead and may not obtain the body for burial. It may be noted, however, that since the main objective of such a study is to examine mortality differentials rather than levels, some degree of undercoverage of deaths may not affect the results greatly as long as coverage does not vary greatly.

The advisability of collecting clinical data for study of multiple causes would depend upon the availability of the necessary infrastructure. The pilot testing in the Investigation revealed such a deficiency in the quality of information in one rural area that it was discarded. Although the proportion of infant deaths with clinical data in the rural communities of one project was relatively low, the painstaking work of the local medical interviewer resulted in findings of value. For this phase of a similar investigation, pilot testing would determine its feasibility.

Studies such as that discussed here would benefit from an extended planning phase and pilot testing of questionnaires, definitions and procedures. Comparison of the findings for areas with distinctly different environmental conditions—both rural and urban—at different stages of development has proved to be an excellent method for discovery of problems and clues for their solution and for further in-depth studies. It is recommended that several areas of a region be incorporated into a co-ordinated project. Co-operation between the local principal collaborators of projects, through planning conferences and meetings, is beneficial for the conduct of the research. The feasibility would be tested in each area; and if changes were needed, they would be introduced before the study began.

As concerns the cost of the Investigation, each principal collaborator developed a proposal and budget. The collaborator knew the local costs for medical interviewers, nurses or social workers, a secretary and, if needed, a chauffeur. Provision was also made in the budget for equipment and supplies. The budgets for 12 months of field-work during 1968/69 varied from about $20,000 to $30,000. As the field-work included the collection of information on a sample of living children under age 5, the costs for the study limited to deaths would be somewhat lower. Although all coding and processing were performed at the central office at Washington, some decentralization would be advisable for the benefit of local personnel and would lower the costs of analysis.

Similar investigations of mortality in other regions of the world would make valuable contributions to the improvement of the quality of the basic data and to the understanding of health problems. In all projects, the problems of unregistered deaths will probably be discovered and, likewise, the incompleteness of certification of causes of death. Thus, such studies would clarify the levels of death rates, the underlying causes, the associated causes and many factors responsible for high death rates.

Notes

[1]Ruth Rice Puffer and G. Wynne Griffith, *Patterns of Urban Mortality: Report of the Inter-American Investigation of Mortality*, Pan American Health Organization Scientific Publication, No. 151 (Washington, 1967); and Ruth R. Puffer and Carlos V. Serrano, *Patterns of Mortality in Childhood: Report of the Inter-American Investigation of Mortality in Childhood*, Pan American Health Organization Scientific Publication, No. 262 (Washington, D.C., 1973).

[2]R. R. Puffer and G. W. Griffith, *op. cit.*

[3]World Health Organization, *Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death, 1965 Revision*, 8th rev. (Geneva, 1967), vol. 1.

[4]Excluding California, where estimates are for one year.

[5]R. R. Puffer and C. V. Serrano, *op. cit.*

[6]For reproduction of the questionnaire, *ibid.*, appendix 1.

[7]Sam Shapiro, E. R. Schlesinger and R. E. L. Nesbitt, *Infant, Perinatal, Maternal and Childhood Mortality in the United States*, American Public Health Association Vital and Health Statistics Monograph (Cambridge, Mass., Harvard University Press, 1968).

[8]For further information on the problems encountered, see R. R. Puffer and C. V. Serrano, *op. cit.*

[9]The Kingston-St. Andrew project is treated as a whole because of small numbers.

[10]Adela Legarreta, Amparo Aldea and Lucía López, "Omissions in the registration of deaths in maternity hospitals in Santiago, Chile", *Bulletin of the Pan American Health Organization*, vol. VII, No. 4 (1973), pp. 35-40.

[11]R. M. Nunes, "Estudo e açoes sobre reprodução humana e nutrição em Recife", *Boletín de la Oficina Sanitaria Panamericana*, vol. 81, No. 4 (October 1976), pp. 304-312.

[12]Sam Shapiro and Jeanne Unger, *Weight at Birth and Its Effect on Survival of the Newborn in the United States, Early 1950*, National Center for Health Statistics Series 21, No. 3 (Washington, D.C., United States Department of Health, Education and Welfare, 1965).

[13]Neville R. Butler and Dennis G. Bonham, eds., *Perinatal Mortality: the First Report of the 1958 British Perinatal Mortality Survey*, published under the auspices of the National Birth Trust Fund (Edinburgh and London, E. and S. Livingstone, Ltd., 1963).

[14]R. R. Puffer and G. W. Griffith, *op. cit.*

[15]Definitions, rules and category numbers are those given in World Health Organization, *Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death, 1965 revision*.

[16]R. R. Puffer and C. V. Serrano, *op. cit.*

[17]World Health Organization, *Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death.*

[18]Ruth R. Puffer and Carlos V. Serrano, *Birth-weight, Maternal Age and Birth Order: Three Important Determinants in Infant Mortality,* Pan American Health Organization Scientific Publication, No. 294 (Washington, D.C., 1975).

[19]David M. Kessner and others, *Infant Death: An Analysis by Maternal Risk and Health Care* (Washington, D.C., National Academy Press, 1973).

[20]J. R. Teruel, U. A. Gomes and J. L. Nogueira, "Investigación interamericana de mortalidad en la niñez: peso al nacer en la región de Ribeirão Prêto, São Paulo, Brasil", *Boletín de la Oficina Sanitaria Panamericana,* vol. 79, No. 2 (August 1975), pp. 139-145.

[21]Robert Armstrong, *A Study of Infant Mortality from Linked Records by Birth Weight, Period of Gestation, and Other Variables,* Vital and Health Statistics Series 20, No. 12 (Washington, D.C., United States Department of Health, Education and Welfare, National Centre for Health Statistics, 1972).

[22]Carlos V. Serrano and Ruth R. Puffer, "Utilization of hospital birth weights and mortality as indicators of health problems in infancy", *Bulletin of Pan American Health Organization,* vol. VIII, No. 4 (1974), pp. 325-346.

[23]R. Armstrong, *op. cit.*

[24]Helen C. Chase, Louis Weiner and Joseph Garfinkel, *Vital Signs Present at Birth,* National Center for Health Statistics, Data Evaluation and Methods Research Series 2, No. 46 (Washington, D.C., United States Department of Health, Education and Welfare, 1972).

XIV. SMALL-AREA INTENSIVE STUDIES FOR UNDERSTANDING MORTALITY AND MORBIDITY PROCESSES: TWO MODELS FROM BANGLADESH—THE MATLAB PROJECT AND THE COMPANIGANJ HEALTH PROJECT*

*Stan D' Souza***

Vital registration systems are practically non-existent in a number of developing countries. Some countries have only a sample registration system, such as that in India. In Bangladesh, vital registration is very poor, providing little information of value at the national level. On the basis of the Second Population Census,[1] conducted from 6 to 8 March 1981, the current population of Bangladesh has been estimated at 89,940,000. Although intercensal growth rates have been calculated on the basis of census population totals for 1961, 1974 and 1981, such growth rates, while useful, are not very effective in documenting the changes in vital rates that occur during a particular decade. Over the past decade, Bangladesh has experienced pronounced fluctuations in birth and death rates due to war and famine. Intercensal growth rates and vital estimates based on retrospective methods do not in such circumstances provide an adequate demographic picture for the country.

This chapter describes two small-area studies in Bangladesh in which a detailed monitoring of changes in birth and death rates has been possible because of intensive data-collection methods. The two areas are Matlab Thana (a *thana* is a minor administrative unit), situated in Comilla District, and Companiganj Thana in Noakhali District. There are 474 *thanas* in Bangladesh, with an average population in 1981 of 190,000. The methodologies utilized in the two areas are different and represent different procedures of data collection intended to study mortality and disease processes.

In 1963, the International Centre for Diarrhoeal Disease Research, Bangladesh (formerly known as the Cholera Research Laboratory), initiated the Demographic Surveillance System in selected villages within and adjacent to Matlab Thana. The System combines periodic censuses of the study population with continuous registration of vital events—births, deaths and migrations. In 1966, a census was conducted in the Matlab Demographic Surveillance Area, covering a population of 110,000 residing in 132 villages, constituting the old trial area. The area was doubled in 1968 with addition of another 101 adjacent villages, forming the new trial area. At the most recent census in 1974, the population of the entire Demographic Surveillance Area was 264,000, residing in 233 villages. In October 1978, the study area was reduced to 159 villages containing an estimated 1974 population of 160,000. All the villages retained are within Matlab Thana.[2]

The population of the study area is 88 per cent Muslim and 12 per cent Hindu. The average household consists of six persons. Households of patrilineally related families are grouped in clusters (*baris*) having a common courtyard. Landholding is skewed, with 18 per cent of the households owning 47 per cent of the land. About 40 per cent of the males and 16 per cent of the females over age 15 have completed four years of schooling. About 70 per cent of the males and 6 per cent of the females are classified as "economically active". Over the past decade, the Matlab Demographic Surveillance System has generated an enormous volume of unusually reliable data. Censuses of the population are available for the old trial area in 1966 and 1970, for the new trial area in 1968 and for the entire surveillance area in 1974. Vital events have been registered since 1966 in the old trial area and since 1968 in the new trial area. In January 1975, the continuous registration of marital unions and dissolutions was introduced. Depending upon the census, selected socio-economic information is available for all households.

The long-range goal of the Matlab Demographic Surveillance System is to obtain reliable information on demographic and other selected characteristics of the Matlab study population and to monitor changes of these characteristics over time. Research products include, among others, studies on: cholera and other infectious diseases; epidemiology; vaccine effectiveness and development; beliefs concerning food, feeding and health; social relationship and community structure; biosocial determinants; and correlates of fertility, mortality, migration and marriage. These studies are made possible by the quality and breadth of the data base.

The immediate objectives of the Matlab project are:

(*a*) To provide a small-area registration system suited for assessment of the effectiveness, safety and acceptability of maternal and child health and family

*The original version of this chapter appeared as document IESA/P/AC.17/14.

**Scientific Programme Head, International Centre for Diarrhoeal Disease Research, Dacca, Bangladesh.

planning technologies (contraception, oral therapy, nutrition and immunization) to be used within the context of national programmes in the region and in other developing countries;

(*b*) To undertake research related to diarrhoeal diseases and on the measurement and determinants of fertility and mortality within one specific field site of the region. This research should help facilitate the formulation of more effective programme strategies and policy planning, both in Bangladesh and elsewhere;

(*c*) To develop a demographic field site that can be used for training of programme planners, researchers and implementors of national and "developing country" programmes.

Companiganj Thana is located in Noakhali District, 100 miles south-east of Dacca on the coast of the Bay of Bengal. As previously mentioned, 88 per cent of the people are Muslims, who are known to be highly conservative. Most women do not leave the household during the day. When they do go out, a veil (*burqa*) is commonly worn. The southern part of the *thana* is "Char-land"—new land, formed by the deposit of silt in the Bay of Bengal. This land is quite saline and can sustain only one crop per year: the Aman rice crop. There are not many large landholders; nevertheless, large inequalities exist in the distribution of land and, unfortunately, most of the outside income is earned by members of the families that have the larger landholdings.

The Companiganj Health Project began as a joint venture of the Government of Bangladesh and a voluntary agency. It was designed to establish a model of the National Integrated and Family Planning Programme of 1973 in a single *thana*. In this model, it was proposed that various features of the government programme would be tested and evaluated, and that there would be experimentation with certain modifications, in particular, local recruitment of women to work in their own unions (a subunit of a *thana*) and the development of a maternal and child care programme.

In September 1974, a separate evaluation unit was established, which carried out a 10 per cent enumeration survey and began monthly vital registration to record all births, deaths and migrations in a 10 per cent sample of houses. The objective was to observe changes in vital rates that might occur as a result of project interventions and to provide basic information on demographic and health variables in a defined population.[3]

Intensive data collection for small areas has also been undertaken in other developing countries to investigate mortality and disease processes. The Institute of Nutrition of Central America and Panama (INCAP), located in Guatemala, a scientific institution affiliated with the Pan American Health Organization (PAHO), provides an example.

The member countries of INCAP are Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama. It serves as a specialized centre for the study of the nutritional problems of the area, seeking solutions to these problems and collaborating, through technical co-operation, with the member Governments to put into effect the measures recommended. It also contributes to the training of professionals in the field of nutrition and food sciences. A longitudinal study conducted under the auspices of INCAP has provided data on infant mortality for several years. Some of these data have been collected in rural communities in eastern Guatemala.[4]

Another longitudinal epidemiological study area has been established in the north-western part of the Machakos district of Kenya, involving approximately 4,000 rural households—24,000 people—in an area of 87 square kilometres. The various objectives of Joint Project Machakos were based on the collection of comprehensive field data intended to assist in the formulation of policy to improve the health of mothers and children in rural areas.[5] Specific objectives of the Machakos project can be summarized as follows:

(*a*) To obtain accurate data on morbidity and mortality from a number of acute infectious diseases and on the outcome of pregnancy, and to investigate nutritional factors and factors of the social, biological and physical environment which may have a bearing on the observed disease pattern;

(*b*) To develop a system of registration of births, deaths and morbidity which is suited for use in a district in Kenya having limited resources.

The study was intensively carried out up to 1977; the project is currently being phased down. At first under the scientific supervision of scientists from the Netherlands, the programme is now being transformed into a collaborative project with the Government of Kenya.

This chapter is restricted to a description of methods and results from the two study areas in Bangladesh referred to above. Although reference is made to other "areas" in the discussion, no detailed description of the organizational structure and data-collection methodologies is provided.

A. Methods and procedures

Matlab Project

The scientific support work of the International Centre for Diarrhoeal Disease Research in Bangladesh is undertaken by "branches", each branch having a specific technical role. The Demographic Surveillance Systems has three branches—the Field Station in Matlab, and the Data Management Branch and the Computer Information Services Branch, both at Dacca.

The Demographic Surveillance Programme of the Matlab Field Station, headed by a Field Research Officer (Grade I), is responsible for the field operation and collection of the surveillance data. The Data Management Branch is responsible for the editing, processing and initial tabulation of the demographic field data. The newly created Computer Branch is responsible for the computerization of data on the IBM System 34 at the International Centre.

An operational diagram of the programme activities is presented below:

Field Station, Matlab		*Data Management Branch, Dacca*		*Computer Branch, Dacca*
Field operations and data collection	→	Editing, coding	→	Data entry, preliminary tabulations
				↓
Verification	→	Verification	→	Verification
	←		←	↓
		Preparation of annual reports	←	Final tabulations

In progress: full computerization of the data-processing system and creation of a computerized population register.

The current data-collection system under the Demographic Surveillance Programme of the Matlab Field Station is a three-tier system. Detection of vital events is primarily the responsibility of 110 female village workers. Eighty of these workers undertake the primary detection of the vital events in half of the surveillance area as part of their work in providing village-based maternal and child health and family planning services. Each of the workers covers approximately 300 households and visits each family fortnightly. In the remaining half of the Matlab study area, 30 female village workers—covering approximately 500 households each—undertake only demographic surveillance work and visit each household weekly. All these workers have at least a seventh-grade education. They inquire about births, deaths, migrations, marriages and marriage dissolutions (divorces), and record these events in register books. The work of the female village workers is checked by 12-16 male field assistants who, accompanied by the female workers, visit each household monthly[6] to review the completeness of the registration and to record the vital events on standard registration forms. The area covered by a field assistant is called a "field unit" and contains about 16,000 people (2,800 households). The work of the field assistants is again checked by three or four senior field assistants, who visit each household at least three times each year. All of these workers are supervised by the Field Research Officer, who, along with two Assistant Supervisors, randomly checks on the quality and completeness of the fieldwork.

Companiganj Health Project

The Companiganj *thana* had a 1974 population of 113,730. The area covered by the *thana* was divided into 28 small units called "sub-subsectors" with an average population size of slightly over 4,000. The Malaria Eradication Programme had established maps for the area. These maps were used as the basis for selecting the sample.[7] Monthly visits to the selected houses were to be scheduled for the next five years. After adjustment for abandoned houses and public utilities, 10 per cent of the houses were selected in each of the 28 sub-subsectors. A house number in each of the areas was randomly selected and used as a starting-point from which 10 per cent of the houses were chosen systematically. If a house number identified on the map proved to be non-existent when visited, the next higher number was taken. The overall accuracy of the malaria maps was about 85 per cent, which was adequate for the purpose for which they were being used.[8]

A baseline survey was undertaken during the period from January to March 1975 in the sampled houses, using a *de jure* method. Two teams, consisting of two trained field investigators and a qualified supervisor, were employed in each sub-subsector. A female fieldworker assisted each team. Data were obtained from the head of household or responsible members of the household. Each family was assigned a family number and each person was given an individual number. After completion of the survey, supervisors made a 10 per cent check of the data collected.

As in other parts of the sub-continent, the assessment of age was difficult for those aged 5 and over. A calendar of locally important historical events was used to ascertain approximate age for persons over 5 years of age. A census volume was developed and a copy was returned to the field for recording subsequent vital events. A family card was given to each family listing the persons in the family. Migrants were defined as people who were either in or out of the area for a six-month period.

In each sub-subsector, a woman was selected to work part-time, to record vital events in the sample households. The women were often illiterate and needed help from neighbours and relatives to record events. Male field investigators visited each household independently once a month to record births, deaths and migration. These records were checked against those maintained by the women interviewers. All fieldworkers were supervised by two senior field investigators, who visited each household four times a year to check past events. In addition to vital events, data were collected on pregnancy status and related questions.

Two censuses of the sample population were carried out, the first in the period January-March 1975 and the second in the period January-February 1978. Family landholding was determined by asking a family member the total amount of land owned as well as the amount of cultivable land owned. Death rates in 1975 and 1976 were calculated for landholding groups according to the amount of cultivable land owned at the 1975 census. The 1978 census was used for the 1977 and 1978 death rates. The second census was important because there was very high out-migration among the poor (15 per cent net out-migration of the landless in 1975 and 1976) and because there were major shifts in land ownership (the proportion of the population with a family holding over three acres of land rose from 17 per cent to 21 per cent between 1975 and 1978).[9]

Causes of death were determined retrospectively by family interviews, which were reviewed by a committee of physicians. Immediate and underlying causes of death were recorded. Where some doubts remained, a physician was sent to interview the family. As field investigators became more proficient, fewer visits by physicians were necessary—the percentages of such visits required for the years 1975, 1976, 1977 and 1978 were 78, 62, 37 and 25, respectively.[10]

B. Some results

The results given in this section were obtained from the two areas under surveillance in Matlab and Companiganj, respectively. In Matlab, although the surveillance is directed primarily towards vital registration, it is possible to use the data for studies of particular aspects of mortality or morbidity because a population base is available. In-depth epidemiological studies related to diarrhoea and nutrition have also been conducted in Matlab, in keeping with the objectives of the International Centre for Diarrhoeal Disease Research.

In the case of Companiganj, in-depth studies have not been undertaken since the main objective was the monitoring of vital rates. However, in view of the famine that took place in the years 1975-1976, a linkage of death rates and economic conditions represented by landholding provides extremely interesting results from a policy viewpoint. Some of these results are presented in this section.

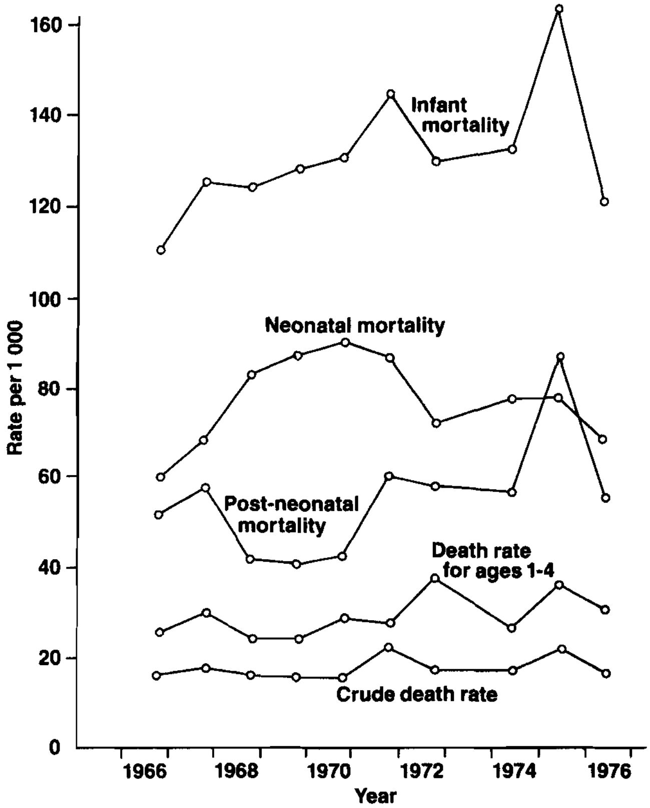
Matlab project

The vital registration data for Matlab show that little improvement in the level of mortality has taken place over the past decade. In fact, there are some suggestions that the levels have risen since the early 1970s. In 1971, the country went through a period of stress because of the war. Later, in 1974-1975, famine conditions existed in several parts of the country. The infant mortality rates shown in figure XIV.1 reflect these changes.

Table XIV.1 shows that the greatest contribution to the current overall mortality rate is from diarrhoeal diseases, which account for as many as one third of all deaths; and that another one quarter of all deaths result from other infectious diseases for which medical science has a decisive prevention. A heavy burden of the deaths from these diseases falls on children. About 30 per cent of all deaths occur during infancy and an additional 25 per cent occur at ages 1-4.[11]

The data from Matlab provide conclusive documentation of higher female than male mortality shortly after birth and thereafter through childhood and childbearing ages. Data from many countries suggest that higher male mortality risks in the neonatal period continue through childhood and adolescence. In Matlab, mortality differentials are reversed during the post-neonatal period with female mortality exceeding that of males by as much as 50 per cent.[12] Data for a number of countries in Latin America indicate a similar pattern, although less extreme.

Figure XIV.1. Infant[a] mortality rate, mortality rate of children aged 1-4 years and crude death rate, Matlab, Bangladesh, 1966-1977



Source: Lincoln C. Chen, Mizanur Rahman and A. M. Sarder, "Epidemiology and causes of death among children in a rural area of Bangladesh", *International Journal of Epidemiology*, vol. 9, No. 1 (March 1980), pp. 25-33.

[a]Neonatal and post-neonatal.

A study of food distribution within the family shows that a sex bias exists with regard to the intake of calories and protein. Table XIV.2 shows that at all age groups males have a higher intake of both calories and proteins. This feeding pattern might partially explain the higher mortality rates among female children.[13]

A socio-economic census was taken in the Matlab

Table XIV.1. Adjusted percentage distribution of deaths, by age and cause, Matlab, Bangladesh, 1975-1977

Cause of death	*Infants (0-11 months)*	*Children (1-4 years)*	*All ages*
Diarrhoea	16.0	45.0	33.7
Tetanus	25.5	1.4	8.1
Respiratory	7.0	5.0	6.6
Fever	5.0	8.4	7.6
Measles	2.0	12.7	3.8
Other	44.5	27.5	40.2
All causes	100.0	100.0	100.0

TABLE XIV.2. INTAKE OF CALORIES AND PROTEIN, BY AGE AND SEX, MATLAB, BANGLADESH, JUNE-AUGUST 1978

Age group	Number of calories			Protein (grams)		
	Male	Female	Ratio Male/female	Male	Female	Ratio Male/female
0-4	809	694	1.16	23.0	20.2	1.14
5-14	1 590	1 430	1.11	50.9	41.6	1.22
14-44	2 700	2 099	1.29	73.6	58.8	1.25
45+	2 630	1 634	1.61	71.8	46.9	1.53

area in 1974. Table XIV.3 shows the mortality rates for children in the period 1974-1977, by education of household head compared with occupation of household head, area of dwelling, number of cows owned and use of fixed latrine.[14] Controlling for various socio-economic variables, this table allows an assessment of the impact of education of household head on child mortality. In a rural society that has been traditionally rather conservative, education of household head beyond primary level shows a marked effect on child mortality, irrespective of whether the family is poor or comparatively rich. Better socio-economic conditions, as may be expected, have an additional favourable effect, depressing child mortality further. This finding is obviously important for policy orientation.

An oral-therapy field trial was conducted in the Matlab area from January 1979 to December 1980. Figure XIV.2 shows diarrhoea incidence data for the period from January 1979 to August 1980 for two areas of Matlab Thana, each with an approximate population of 40,000, in which different oral-therapy interventions were arranged.[15] Average incidence rates were around one episode per 100 person-weeks. Since an episode of diarrhoea is recorded as reported by the persons or local informants in the household, the results do not represent a clinical appraisal of diarrhoea rates. The reported rates are probably lower than would have been appraised under an intense surveillance. However, the maintenance of a longitudinal data set provides at least a lower bound to the incidence of this type of disease, a piece of information not available for most developing countries.

Figure XIV.3 illustrates an outbreak of measles in terms of the number of cases occurring per month in the Matlab area over the period from November 1979 to October 1980. From a fairly low 200 cases per month in November, the outbreak reached a peak in March with over 1,500 cases reported. There was a rapid fall over the next two months but an interesting feature is the presence of cases of measles in every month of the year.[16] Measles is an important cause of death in many developing countries, and programmes of maternal and child health tend to include a measles vaccine where feasible. An inhibiting factor is that an expensive "cold chain" to maintain measles vaccine is necessary.

Figure XIV.4 illustrates the effects of a tetanus immunization intervention programme in the Matlab area. Neonatal death rates between September 1978 and December 1979 were significantly lower for infants born to mothers who had been immunized.[17]

The data base provided by the Demographic Sur-

TABLE XIV.3. CHILD MORTALITY RATES, BY EDUCATION OF HOUSEHOLD HEAD AND OTHER HOUSEHOLD CHARACTERISTICS, MATLAB, BANGLADESH, 1974-1977

	Education of household head				
		I	II	III	
	Total of I, II and III	No schooling except religious education (Maktab)	1-6 years	7 or more years	Ratio I:III
Occupation					
Agricultural labourer ..	31.2	32.8	26.9	9.5	3.5
Owner-worker etc.	19.9	23.0	18.5	13.5	1.7
Land-owner	13.5	20.4	8.9	10.4	2.0
Area of dwelling (*square feet*)					
Under 169	28.9	31.4	24.8	17.0	1.8
170-242	23.5	26.7	19.6	19.6	1.4
243+	16.2	18.3	16.2	11.5	1.6
Number of cows owned					
None	25.3	29.0	22.0	14.3	2.0
One or two	19.6	22.6	17.6	13.1	1.7
Three or more	14.8	16.9	14.0	10.0	1.6
Use of fixed latrine					
Yes	20.6	24.3	18.7	12.6	1.9
No	26.0	28.7	19.6	16.0	1.8

Figure XIV.2. Incidence rates for diarrhoea, all ages by two-month periods, Matlab, Bangladesh, January 1979-August 1980

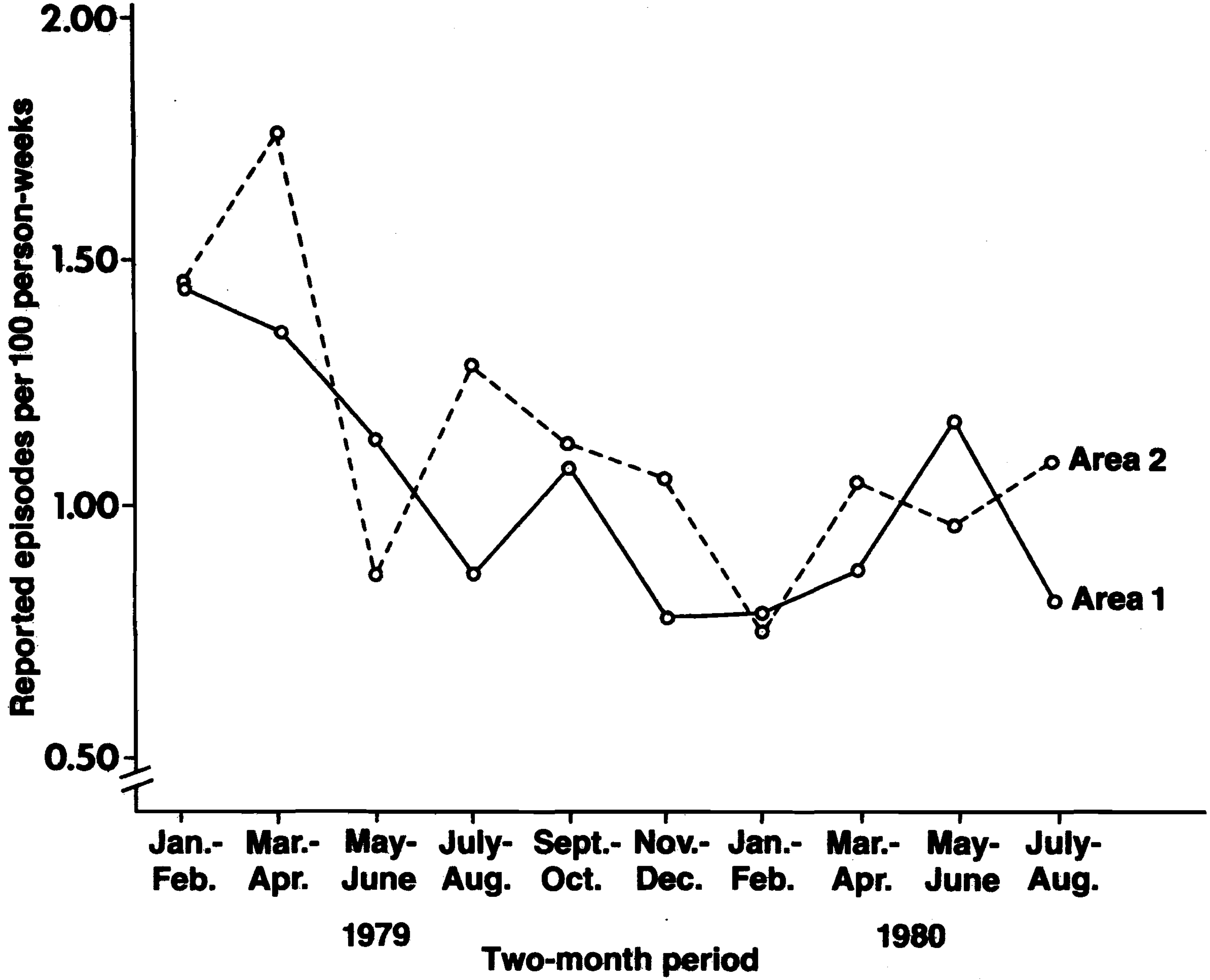
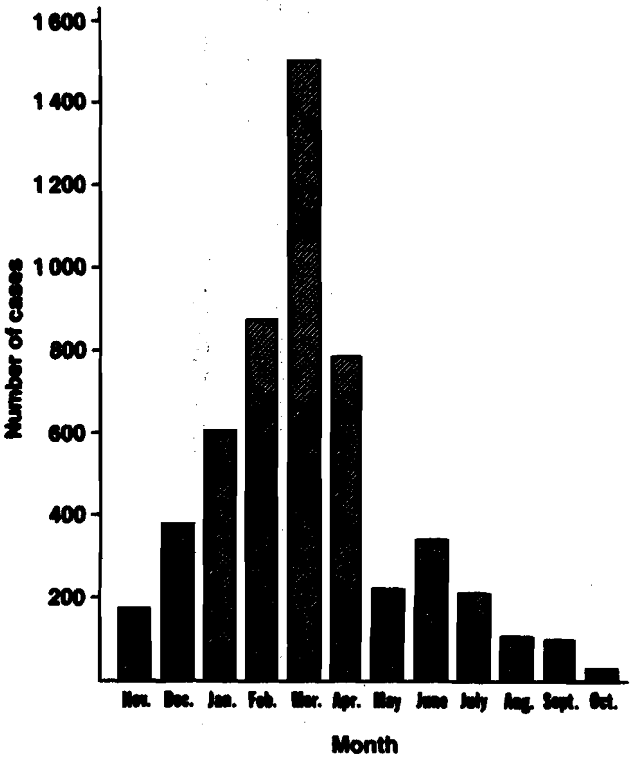
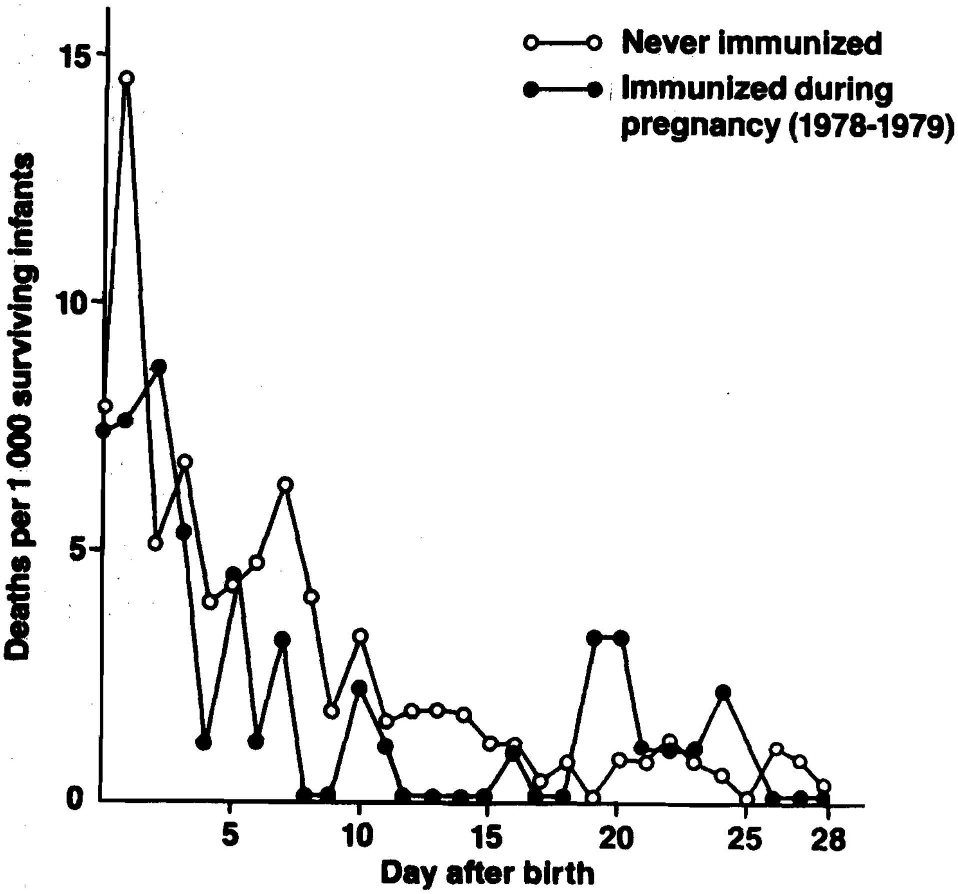


Figure XIV.3. Number of measles cases, by month, Matlab, Bangladesh, November 1979-October 1980



veillance System has been shown to be of great value in the evaluation of health intervention programmes. An extremely important component of the System consists of accurate information on the whereabouts of particular persons within a rural setting. This element makes it possible to set up studies in which follow-up methods are part of the investigation. In the case of the cholera vaccine trial conducted in 1974, a serological survey was conducted among volunteers of every thirty-third family that had participated in the field trial. The total number of volunteers was 92,838. The selected families were visited immediately prior to the first injection and six weeks after the first and second injections. In this way, levels of vibriocidal titre could be detected and compared with cholera cases that occurred and were seen in the hospital situation at the Matlab treatment centre.[18] The follow-up approach was also used in a survey of sterilization acceptors in the Matlab area. The survey collected information using a two-part questionnaire. The first part of the questionnaire was completed at an interview conducted at the clinic prior to sterilization and the second part was completed at the client's home one month after sterilization. In this way, information was obtained concerning motives for the choice of sterilization as a contraceptive method as well as making possible studies of the side-effects and attitudes of the client and her relatives after the operation.[19]

Figure XIV.4. Neonatal death rates by age at death for infants born between 1 September 1978 and 31 December 1979, according to maternal tetanus immunization status, Matlab, Bangladesh



Companiganj Health Project

Causes of death have been studied in greater detail in the Companiganj Health Project than in the Matlab area. Table XIV.4 shows deaths by sex and cause for the years 1957-1978.[20] The most frequent causes of death were diarrhoea, malnutrition, pneumonia and birth-associated causes (premature birth, birth injury, neonatal asphyxia and neonatal tetanus).

The landholding variable proved to be very important in the understanding of mortality rates in the Companiganj area. Households were grouped into four classes: the landless; those holding from 0.01 to 1 acre; those with between 1 and 3 acres; and those with more than 3 acres. The evaluation unit had been set up to monitor changes in birth and death rates due to the programme. In fact, the famine that was prevalent throughout the country proved to be the most important variable in terms of change in vital rates. The years 1975 and 1976 were crisis years, and 1977 and 1978 are considered to be "normal" years. Figure XIV.5 shows that the crude death rates per 1,000 population were twice as high for the landless, over 30 per 1,000, as for those holding more than 3 acres of land; they were 15 per 1,000 during the famine years 1975-1976. These differences were smoothed during the normal years 1977-1978, being approximately 15 per 1,000 for all categories of landholding. In view of the fact that emigration was taking place, it is possible that those remaining among the landless were, in fact, a selected group.

Figure XIV.6 shows that landholding is inversely correlated, particularly for the famine years, with child mortality rates. Infant rates, however, are highest for the landless as expected, yet for some uninvestigated reason, they are also high for those families holding more than 3 acres of land. One explanation of this pattern sometimes put forward is that these families own large animals and tetanus deaths are related to the presence of such animals.

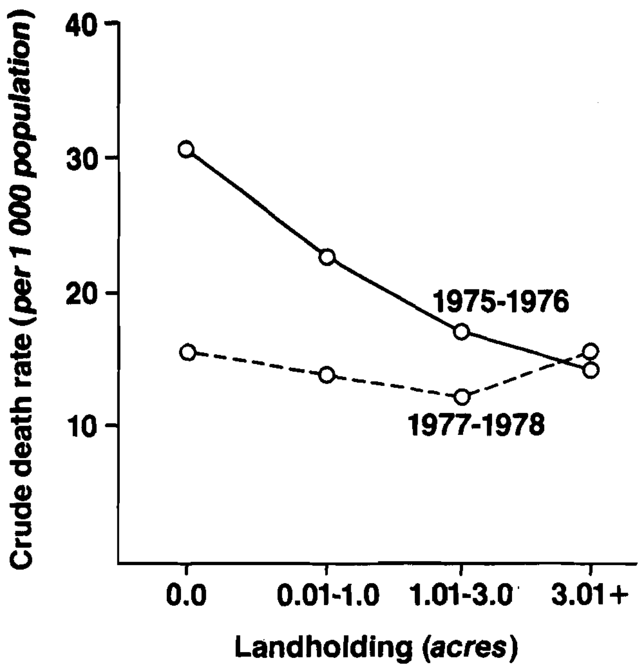
If one relates causes of death to landholding, one can better understand the variations in death rates that took place over the years 1975-1978. Diarrhoea and malnutrition account for most of the observed variation in mortality over those years and of differences

TABLE XIV.4. DEATHS BY SEX AND CAUSE, PERCENTAGE AND RATE PER 100,000, COMPANIGANJ, BANGLADESH, CUMULATIVE FOR 1975-1978

Causes of death	*Number of deaths*			*Percentage*	*Rate per 100,000*
	Male	*Female*	*Total*		
All causes	385	392	777	100	1 791.9
Diarrhoeal diseases	50	77	127	16.3	292.9
Malnutrition	50	52	102	13.1	235.2
Pneumonia	39	45	84	10.8	193.7
Prematurity/birth injury/asphyxia etc.	39	28	67	8.6	154.5
Senility	24	23	47	6.0	108.4
Tetanus	19	15	34	4.4	78.4
Cardio-vascular diseases	17	18	35	4.5	80.7
Pulmonary tuberculosis	18	8	26	3.3	60.0
Fever	10	11	21	2.7	48.2
Measles	10	11	21	2.7	48.2
Drowning	10	10	20	2.6	46.1
Heart diseases	12	5	17	2.2	39.2
Chronic lung disease[a]	10	6	16	2.1	36.9
Maternal death	0	12	12	1.5	27.7
Acute abdominal intestinal obstruction	6	3	9		
Cancer	5	4	9		
Injury/accident	3	5	8		
Liver disease	4	3	7		
Anaemia	2	5	7		
Skin infection/abscess	4	2	6		
Whooping cough	3	2	5		
Acute nephritis	2	3	5		
Burns	1	3	4	10.4	186.3
Meningitis	2	2	4		
Peptic ulcer	4	0	4		
Suicide/homicide	0	3	3		
Diphtheria	2	0	2		
Chicken-pox	1	1	2		
Rheumatic fever	1	1	2		
Sore mouth	1	1	2		
Brain tumour	0	1	1		
Congenital deformity	1	0	1		
Others	12	6	13	2.3	41.5
Unknown	23	26	49	6.3	113.0

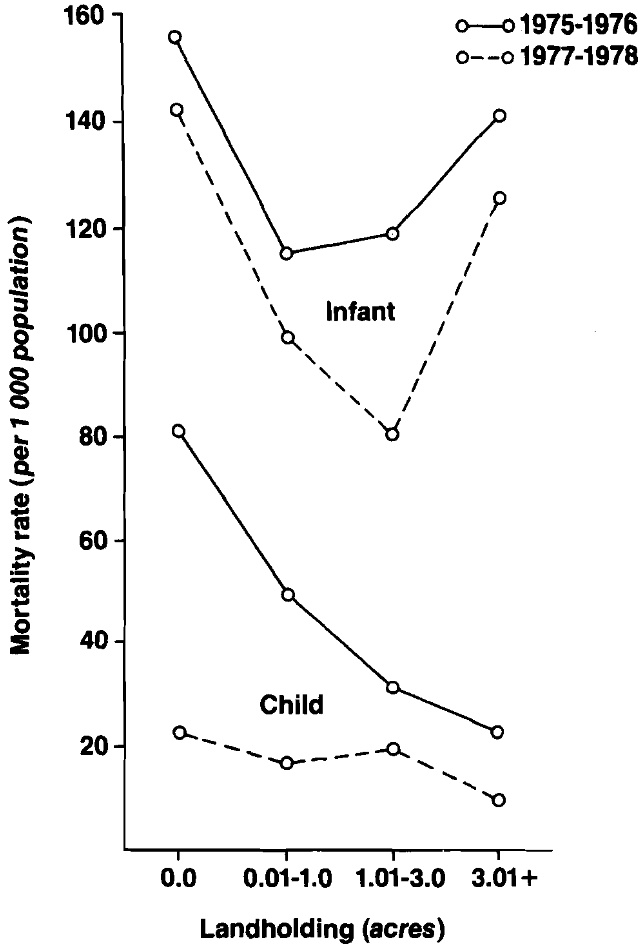
NOTES: Denominator is 43,362.
Individual percentages and rates have not been calculated for frequencies under 10.
[a]Not including tuberculosis.

Figure XIV.5. Crude death rates, by landholding status, Companiganj, Bangladesh, 1975-1976 and 1977-1978



Source: C. McCord and others, *Death Rate and the Price of Rice 1975-1978,* Evaluation report, No. 04 (Dacca, Christian Commission for Development in Bangladesh, 1980).

Figure XIV.6. Infant and child mortality rates, by landholding status, Companiganj, Bangladesh, 1975-1976 and 1977-1978



Source: See figure XIV.5.

between the various landholding groups (figure XIV.7). Families with over 3 acres of land had very few deaths from those causes but they had a high death rate from birth-associated conditions. Deaths from diarrhoea were highest among the poorer groups. Better sanitation among more affluent families may have played a role, although such differences as exist are not great. The drop in deaths from diarrhoea among the landless from the crisis years (1975-1976) to the normal years (1977-1978) is remarkable. On this evidence, it is more likely that the difference in diarrhoea death rates between richer and poorer groups is due to better nutrition.

C. Advantages and disadvantages of the projects

The results presented show some of the potential of the Demographic Surveillance System in the Matlab area, and the Companiganj Health Project. The initial part of this discussion focuses on the System.

The Demographic Surveillance System constitutes one of the most valuable institutional resources of the International Centre for Diarrhoeal Disease Research in Bangladesh; it is vital for the conduct of certain types of field research in diarrhoeal diseases, nutrition, population and health care.

Seven broad areas in which the System possesses distinct comparative advantages have been identified:

(*a*) The Matlab Surveillance System is necessary for health, nutrition and demographic research, which requires an accurate account of the population. Such demographic information is essential for the computation of rates. Vital and other rates are essential for field research, particularly for the assessment of the impact of various programmatical or technological interventions (e.g., vaccine, oral therapy, conraceptives);

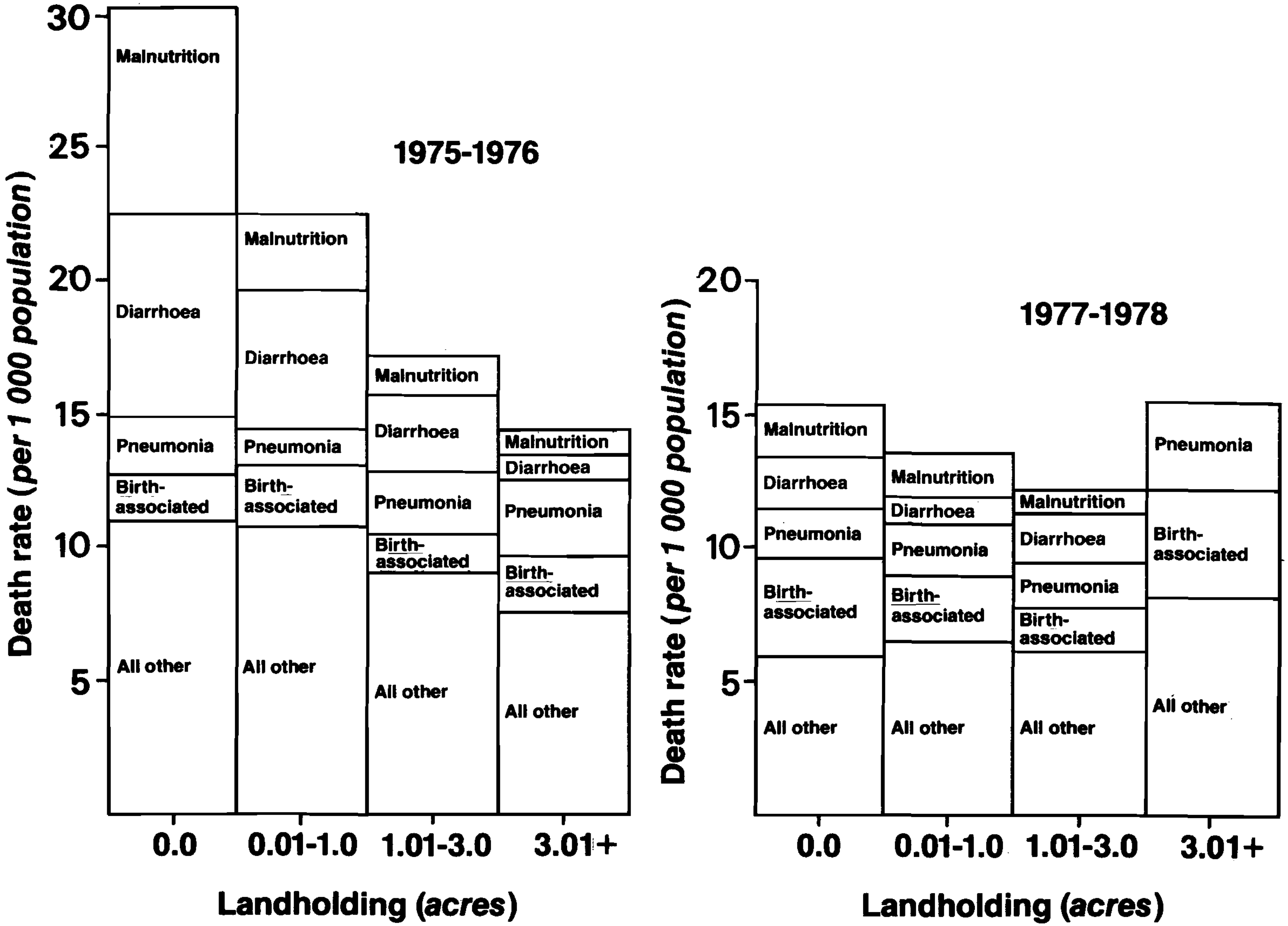
(*b*) The Matlab Surveillance System provides accurate sampling frames for sample surveys or in-depth studies;

(*c*) Because the Demographic Surveillance System has been operational since 1966, the age of most children under 14 years is known with accuracy in most of the area. Precise age data strengthen selected research on nutrition, population and infectious diseases;

(*d*) Because of the continuous relationship of the International Centre for Diarrhoeal Disease Research with the Matlab population, including the provision of health and diarrhoeal disease prevention services, some studies requiring client co-operation may be more easily conducted in this area, as compared with other areas;

(*e*) The longitudinal nature of the surveillance system facilitates prospective research designs, including the documentation of time trends;

Figure XIV.7. Death rates, by landholding status and cause of death, Companiganj, Bangladesh, 1975-1976 and 1977-1978



Source: See figure XIV.5.

(*f*) The demographic data may reflect national trends, if not national levels, and thus may be useful for national planning purposes;

(*g*) The Demographic Surveillance Area may be used as a field training area in epidemiological, population, nutrition and health care research.

Five limitations of the system are:

(*a*) The Demographic Surveillance System is an expensive research instrument operated by an institution that enjoys a high level of antonomy. It does not necessarily represent a replicable model for others who may require surveillance systems for other purposes;

(*b*) The System provides reliable measurements of outcome variables (such as births and deaths) but contains little information on antecedent biosocial causes or processes responsible for the observed outcomes. Except where study designs take this factor into account, only inferences may be made about the determinants of the observed outcomes;

(*c*) The data collection of the surveillance systems is hierarchical and depends upon close supervision. There is insufficient community participation in the data collection or in the use of the information generated;

(*d*) Past intervention research, current health services and multiple concurrent research designs are only several of the factors that may "contaminate" the study design of any individual study in the Demographic Surveillance Area, sometimes introducing an unquantifiable bias into research results;

(*e*) Detection and correction of errors are slow and annual reports are delayed. The most recent report is for 1978. Formal quality control systems external to the Demographic Surveillance System have yet to be established.

D. Directions of future development

The recent acquisition of a computer should make possible the transformation of the Demographic Surveillance System into a population registration system. Plans are now under way at the International Centre for Diarrhoeal Disease Research to effect this change. Thus far, the System is being conducted in two independent operations: (*a*) the registration of births, deaths, migration, marriages and divorces; and (*b*) occasional censuses. The System can be transformed into a full-scale register with population count outputs and vital registration returns as a by-product of the operation. There are important implications of this change in terms of the operation and management of the System. The register could also make use of the possibility of automatic checks and quality control so that some of the current defects in detecting errors and making corrections would be alleviated. Currently, the use of the Demographic Surveillance System is not efficient enough due to the fact that important data files are not easily accessible for the study on morbidity and for epidemiological studies because they are not linked with the System. The population register would permit timely preparation of annual reports.

Table XIV.5 presents a comparison of some of the main items distinguishing the Matlab and Companiganj health projects. One striking element is clearly the difference in cost. The System has been budgeted to cost about $300,000 per annum, in comparison with $20,000 per annum for the Companiganj project. On a per capita surveyed basis, however, the costs are not very different.

Table XIV.5. Comparison of characteristics of the Matlab project and the Companiganj Health Project

Item	*Matlab project*	*Companiganj Health Project*
1. Population ...	160,000	114,000
2. Cost per annum	$300,000	$20,000
3. Type	Longitudinal	Longitudinal
4. Sample	100 per cent	10 per cent systematic
5. Lowest level data-collection personnel ...	Educated female workers	Uneducated female workers
6. Purpose	Research-oriented with special reference to diarrhoeal diseases	Programme evaluation-oriented with reference to integrated and family planning programmes
7. Studies undertaken	Vital rates/several in-depth studies	Vital rates/causes of death
8. Time period .	1966-present	1975-1980
9. Scope	Related to national and international programmes	Related to national programmes
10. International staff	Presence continuing	Present for first few years

Efforts are being made to reduce the costs of the Demographic Surveillance System. An integral part at the moment is supervision of staff which is effected by speedboats. The rising costs of petrol make intense supervision a costly affair; 20 per cent of the budget has been allocated to transport costs. Personnel costs also are high, accounting for nearly half of the overall budget. Cheaper surveillance systems are clearly necessary. The question remains whether the type of intensive field check-ups, both in the terms of vital registration and of in-depth studies, that can be done in Matlab are feasible with less expensive surveillance systems.

The Companiganj Health Project has been conducted on a sample basis. The evaluation unit costs about $20,000 per annum. Some of the advantages of the Matlab project are shared by the Companiganj Health Project. However, intensive field case-control studies have not been carried out in Companiganj, since the orientation of the two projects is quite different. Of interest in the Companiganj project is the fact that an evaluation unit can be attached to a health intervention programme without much additional cost.[21] If one needed vital rates and changes only, evaluation units of the Companiganj type would be sufficient. Similar inverse relations between mortality and socio-economic status were recorded within Matlab and Companiganj. However, even in Companiganj, due to the size of the effects of the famine, it has not been possible to separate the effects of the programme from those due to the famine.

Limitations of the Matlab project would also apply to the Companiganj Health Project. For instance, if a long-term use of the same sampled areas were envisaged, a "contamination" effect would set in. To avoid this situation, some type of sample rotation would be necessary. In fact, the Companiganj evaluation unit has been closed for want of funding. The Companiganj project also suffered from inadequate data-reporting: the first full-scale reports were issued in 1980, covering the five-year period. This aspect of data processing is one which is overlooked in many projects in developing countries. The time-lag between data collection and publication of reports is often as long as from three to five years. The value of the results is thus diminished.

Data processing has also constituted a major bottleneck in the Machakos experience and in other longitudinal studies.[22] In Matlab, most of the data processing at the early stages was done at Johns Hopkins University in the United States of America. One of the major goals of an agreement recently drawn up between that university and the International Centre for Diarrhoeal Disease Research, Bangladesh, was to transfer the data files to Dacca.

As in the case of the International Centre, the Machakos study area in Kenya was set up under the auspices of expatriate scientists, mainly from a single country. In view of the changing availability of funds, increasing national aspirations and awareness of the importance of the data resource, there has been a transformation of both projects. In Matlab, the former Cholera Research Laboratory, set up largely as a result of scientific initiative in the United States, has been developed into an international centre, whereas the Machakos programme is now being conducted by the Government of Kenya.

At the inception of the Matlab project, health intervention was limited to the needs of research projects focusing primarily on vaccine trials. Currently, the limited health interventions in the maternal and child health and family planning areas constitute a serious attempt to combine service and research goals. Nutrition studies have been made but major nutritional interventions, apart from education, have not been carried out. Education, especially of the mother, is an important indicator of mortality differentials. During the difficult years of 1974-1977, children under age 3 who had mothers with no education suffered mortality rates five times higher than children of mothers with seven years or more of education. Health care delivery systems have to take into account the social stratification of the community. The national health policy will have to focus on selected health care items that reach the economically disadvantaged segments of the population with the highest mortality rates.

The International Centre is studying the possibility of setting up surveillance systems that are based on repeated cross sectional surveys. Studies of this type have been undertaken in various countries. Elements of the Matlab health intervention programmes that can be replicated within a framework of normal government inputs and evaluated through a low-cost mechanism are being investigated.

A growing need is being felt for field studies to include information on development as well as health services, in order to evaluate the relative cost efficiency of different strategies for reducing mortality.[23] At the International Centre, studies are being undertaken relevant to this issue. The fall in neonatal mortality rates due to tetanus immunization of pregnant mothers would indicate that particular preventive measures are in fact more efficacious, in the short term, in lowering infant mortality rates than alternative policies oriented towards more general development. The relationship between nutrition, morbidity and mortality is currently being studied; the morbidity indicators that would enable health planners to determine particular sectors of the population at high risk of mortality may be isolated. Intervention programmes could then be better focused if a set of simple input points could be identified.

A review of table XIV.1 shows that over 40 per cent of the causes for death for all ages are classified under "other". Deaths are classified by cause on the basis of reports by field-workers, who have no formal medical training and hence are not qualified to provide a precise diagnosis as to the cause of death. Plans are being made at the International Centre to train workers to identify with greater precision the "causes of death". Lay reporting is now considered an extremely important part of the statistical information system for health care in developing countries.[24] This information is useful both for early warning of the emergence of epidemics and for planning and evaluation of health care delivery, especially in rural areas. The minimal mortality and morbidity lists suggested by the World Health Organization will be tested in the Matlab situation.

The Demographic Surveillance System has been utilized as an overall vital registration system for the study area in Matlab. Intervention and "control" areas have been set up without close study of individual village characteristics. With the arrival of the computer, it is now possible to investigate in detail the "structure" of the various elements forming the study population. Data can be tabulated by village, *bari* and family. Health monitoring at the village level through female village workers will be more effective when sufficient account is taken of other factors, such as community organization, participation of the community in the health field, type of health services provided, and water-supply. "Structural variables" will be included in a social and economic status (SES) census to be undertaken in 1981. Family information studies are under way in five villages. It is believed that the combined effect of efficient data processing and such studies will improve the overall capacity of the Demographic Surveillance System to provide the data base necessary for understanding of the processes of mortality and morbidity.

Conclusion

The small-area studies conducted in two areas of Bangladesh have provided immensely valuable data about a wide range of health and population issues. The careful supervision made possible by the small-area nature of the surveys is largely responsible for the high quality of the basic data (although considerable credit must go also to the responsible organizations and personnel) and thus for the usefulness of the studies. However, the small-area nature of the studies makes them of limited use for monitoring national trends, and they cannot be regarded as full substitutes for national registration systems or surveys. It is to be hoped that the research results of these studies can be utilized by other countries with similar problems, since the overall return of such studies is unlikely to be directly proportional to their number. For many types of medical research, however, such studies are the only feasible approach.

Notes

[1]Bangladesh, Bureau of Statistics, *A Preliminary Report on Population Census 1981* (Dacca, 1981).

[2]Stan D'Souza, "Population laboratories for studying disease processes and mortality", paper submitted to the International Union for the Scientific Study of Population Seminar on Methodology and Data Collection in Mortality Studies, Dakar, Senegal, 7-10 July 1981. To be published in *Methodologies for the Collection and Analysis of Mortality Data*, J. Vallin, J. H. Pollard and L. Heligman, eds., Dolhain, Belgium, Ordina Editions, forthcoming in 1983.

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Litho in United Nations, New York
83-41199—February 1984—5,825

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ST/ESA/SER.A/84