FOURTH EDITION

SHORT TEXTBOOK OF PUBLIC HEALTH MEDICINE FOR THE TROPICS

ADETOKUNBO O. LUCAS
HERBERT M. GILLES

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4th edition

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DEDICATION

To Kofo and Mejra

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PREFACE

When the first edition of this book was published in 1973, it was designed to serve the needs of public health students in developing countries. Standard textbooks that were produced for use in developed countries in Europe and North America covered the basic principles of public health but the illustrative examples were drawn mainly from situations in advanced developed countries. Such textbooks did not adequately cover issues of concern to public health practitioners in developing countries of the tropics. This new edition retains the aims of previous editions of the textbooks but it also responds to important changes that have occurred in public health over the past three decades.

First, the process of epidemiological and demographic transition has altered the pattern of disease in developing countries. On the one hand, there has been steady progress in controlling the traditional health problems – childhood diseases and communicable diseases. On the other hand, chronic diseases such as cancers, cardiovascular diseases and diabetes are becoming increasingly prominent causes of morbidity and mortality. With the rising expectation of life, developing countries have to pay increasing attention to health problems of adults and the disabling disorders of the aged.

Second, important changes have also occurred in the scope and content of public health practice. Until recently, the role of public health was narrowly defined as being mainly concerned with programmes that were designed to promote health generally and to prevent specific diseases. The links of public health practitioners to the delivery of health care was largely confined to organizing community-based services as for example in maternal and child health programmes. Over the past few decades, public health work has expanded its scope to embrace broader issues with regard to policy making, planning and monitoring of health services including quality control, financing of health care, and equity throughout the entire health system.

The new edition has responded to these changes. Whilst retaining a strong emphasis on the control of communicable diseases, the section on chronic diseases has been significantly expanded. For example, there is a new section on the abuse of tobacco, a global problem that is having an increasing impact in developing countries. On the widening mandate of public health, the introductory chapter includes an analysis of the modern definition of public health and its functions. The authors have also thoroughly revised the chapter on the organization of health services and a guest author has produced a new chapter on health economics.

The textbook does not attempt to be a comprehensive reference manual on all aspects of public health; it provides illustrative models of the public health approach to identifying and solving health problems. Rather than offering stereotyped prepackaged answers, the textbook provides the logical basis for analysing problems and devising appropriate solutions. For example, it provides guidelines for the national programmes for the control of HIV/AIDS and the principles involved in the control of occupational diseases which can be used as templates for devising programmes that are relevant and appropriate in the context of the local situation.

One new feature of the 4th edition is the inclusion of colour plates that illustrate some of the ecological situations in the tropics as well as photographs of vectors, tools for disease control and other pictures that facilitate the understanding of matters described in the text.

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CHAPTER ONE

CONCEPTS IN PUBLIC HEALTH AND PREVENTIVE MEDICINE

- The dimensions of public health
- Modern public health
- Key public health functions
- The tropical environment
- The ecological approach to public health
- References and further reading

When this textbook was first published in 1973, it was designed to fill a gap in the medical literature. It directed attention to the special problems of disease prevention in the tropics and it emphasized major health problems peculiar to the tropics with particular reference to parasitic infections and other communicable diseases that are prevalent in warm climates. However, it was not a textbook of parasitology or microbiology in that it provided epidemiological approaches to disease control. In effect it approached public health from the viewpoint of tropical countries.

Over the past few decades, the science and practice of public health has evolved and its mandate has been enlarged. Rather than being strictly confined to limited role in disease prevention, public health has progressively become a central feature of the health sector through its involvement in policy-making, management and evaluation at every level of the health services.

The evolution of the discipline has highlighted the confusing nomenclature that is used to describe public health and its component elements. The oldest term, hygiene, embodied the early knowledge about value of sanitation and personal cleanliness. The name still persists in the title of some old institutions (e.g. London School of Hygiene and Tropical Medicine). As knowledge grew, the term hygiene was felt to be too narrow and a broader term public health was used more widely. The term public health did not survive unchallenged as new terms were introduced to define special aspects of the discipline. Some used the term 'preventive medicine'; others preferred 'social medicine', 'community medicine', or 'community health'.

Winslow's classical definition suggests that the term 'public health' encompasses all the ideas contained in the newer names (Box 1.1).

In a modern interpretation of Winslow's definition, Beaglehole and Bonita (1997) identified the following essential elements of modern public health:

- collective responsibility;
- prime role of the state in protecting and promoting the public's health;
- partnership with the population served;
- emphasis on prevention;
- recognizing underlying socio-economic determinants of health and disease;

Box 1.1: Winslow's definition of public health

'… the science and art of preventing disease, prolonging life, and promoting physical health and efficiency, through organized community efforts, for the sanitation of the environment, the control of community infections, the education of the individual in the principles of personal hygiene, the organization of medical and nursing service for the early detection and preventive treatment of disease, and the development of the social machinery which will ensure to every individual in the community a standard of living adequate for the maintenance of health.'

- identifying and dealing with proximal risk factors;
- multidisciplinary basis for action.

Or succinctly, Acheson summarized public health as: '*the science and art of preventing disease, promoting health and prolonging life, through organized effort of society*'.

The dimensions of public health

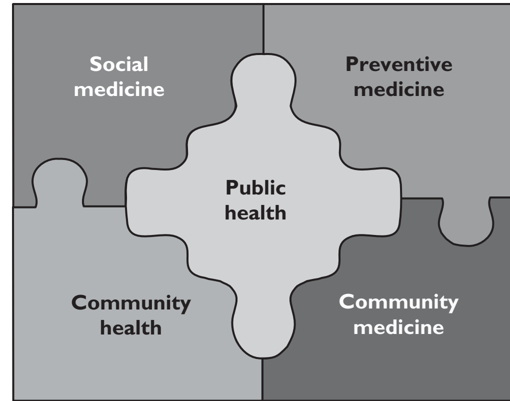


Figure 1.1: The dimensions of public health.

It would be useful to explore the concepts contained in the four terms that are commonly used to describe different aspects of public health (Fig. 1.1):

- preventive medicine;
- social medicine;
- community health;
- community medicine.

Preventive medicine

Prevention is better than cure is one of the prime messages of public health. It differentiates public health from the clinical disciplines that are primarily involved with the care of the sick, whilst public health emphasizes the avoidance of illness. Prevention was initially construed narrowly in terms of protective measures like vaccination and improved nutrition that target only healthy people with the aim of preventing the onset of disease. This concept was extended to cover the early diagnosis and treatment of sick persons with the aim of preventing advanced diseases and in the case of communicable diseases, in preventing the spread within the community. A further extension of the definition covers the treatment of sick individuals aimed at reversing damage and restoring function. This concept led to the classification of prevention into three levels later to be differentiated into five stages (Table 1.1).

Social medicine

'The poor die young'

The rise of social medicine coincided with increasing realization of the links between social status and the health of individuals and communities. Statistical analyses of mortality and morbidity data show strong correlation between the social stratification in society and the pattern of health and disease. At one end of the scale, the affluent educated privileged groups, including professional persons, senior managers, employers, enjoy significantly better health than the poor, deprived, illiterate and unemployed. Numerous studies in many countries confirm this association and point to the need for social interventions to complement biomedical tools in improving the health of the deprived sections of the community. The objective of social medicine is to identify the social determinants of health and disease in the community and to devise mechanisms for alleviating suffering and ill health through social policies and actions. Social medicine is based on certain fundamental assumptions:

- *Health as a birthright*. Everyone has the right to enjoy the highest possible level of health.
- *The responsibility of the state*. It is the duty of governments to ensure that the people have the basic elements that would enable families and individuals to maintain good health and that they have access to good quality health care.
- *Development and health are inter-related.* Good health promotes development, and development promotes health.
- *Education promotes health*. The strong association between health and level of education is particularly marked with regard to women's education. It affects their health status and behaviour as well as that of their children.
- *Social factors have a profound influence on health*. Culture, behaviour, social organization,

Table 1.1: Two classifications of preventive medicine

Three levels of prevention	Five stages of prevention
PRIMARY ■ *Target population*: entire population with special attention to healthy individuals ■ *Objective*: prevent onset of illness ■ *Methods*: education, immunization, nutrition, sanitation, etc.	**1** *General health promotion* ■ *Target population*: entire population with special attention to healthy individuals ■ *Objective*: prevent onset of illness ■ *Methods*: education, nutrition, sanitation, life style changes, etc. **2** *Specific prophylaxis* ■ *Target population*: entire population with special attention to healthy individuals ■ *Objective*: prevent onset of specific diseases ■ *Methods*: education, immunization, nutritional supplement (vitamin A, iodine), chemoprophylaxis (e.g. against malaria)
SECONDARY ■ *Target population*: sick individuals ■ *Objective*: early diagnosis and treatment to prevent further damage to the individual and in cases of infectious diseases, spread to the community ■ *Methods*: screening of high risk groups e.g. Pap smears, sputum examination for TB; monitoring of vulnerable groups – children, pregnant women	**3** *Early diagnosis and treatment* ■ *Target population*: sick individuals ■ *Objective*: early diagnosis and treatment to prevent further damage to the individual and in cases of infectious diseases, spread to the community ■ *Methods*: screening of high risk groups e.g. Pap smears, sputum examination for TB, blood test for HIV; monitoring of vulnerable groups – children, pregnant women
TERTIARY ■ *Target population*: sick patients ■ *Objective*: reduce damage from disease and restore function ■ *Method*: clinical care and rehabilitation	**4** *Limiting damage* ■ *Target population*: sick patients ■ *Objective*: limit damage from disease ■ *Methods*: skilled clinical care and social support to limit physical and social damage from the disease **5** *Rehabilitation* ■ *Target population*: convalescent patients ■ *Objective*: restore function and capability ■ *Methods*: physical and social rehabilitation

allocation of family resources, healthcare seeking behaviour, etc.

- *Health begins at home*. Many of the interventions required for promoting health in developing countries begin at home through changes in individual behaviour and lifestyle, in families and in households.
- *Poverty* is a major underlying cause of ill health (Table 1.2).

The overall goal is to achieve equity in health. As noted in the Declaration at Alma Ata (p. 304):

> 'The existing gross inequality in the health status of the people particularly between developed and developing countries as well as within countries is politically, socially and economically unacceptable and is, therefore, of common concern to all countries'.
>
> Alma Ata Declaration, WHO (1978)

Health and human behaviour

Human behaviour is an important dimension of social medicine. The link between health and human behaviour is a major area of interest in public health with medical anthropologists and sociologists providing specific professional expertise. The link between lifestyle and health is gaining more attention as chronic diseases increasingly dominate the epidemiological pattern. The risk factors associated with cancers, cardiovascular diseases, diabetes and other chronic diseases relate

Table 1.2: Comparing some health indicators of the poor versus the non-poor in selected countries. Source: WHO (1999)

Country	Percentage of population in absolute poverty*	Probability of dying per 1000				Prevalence of tuberculosis	
		Between birth and age 5 years, females		Between ages 15 and 59 years, females			
		Non-poor	Poor : non-poor ratio	Non-poor	Poor : non-poor ratio	Non-poor	Poor : non-poor ratio
Chile	15	7	8.3	34	12.3	7	8.0
China	22	28	6.6	35	11.0	13	3.8
Ecuador	8	45	4.9	107	4.4	25	1.8
India	53	40	4.3	84	3.7	28	2.5
Kenya	50	41	3.8	131	3.8	20	2.6
Malaysia	6	10	15.0	99	5.1	13	3.2

*Poverty is defined as income per capita less than or equal to $1 per day in dollars adjusted for purchasing power.

to such lifestyle choices as the use of tobacco and alcohol, diet, nutrition and exercise. The pandemic of HIV/AIDS has highlighted the health importance of sexual behaviour, making sex literally a matter of life and death: life in its reproductive function and death in its association with the risk of acquiring deadly diseases.

Access to and utilization of health services

Behavioural scientists are also interested in health-care seeking behaviour of individuals and families ranging from the self-treatment at home, to consultations with traditional or orthodox medical practitioners.

Information about beliefs, attitudes and behaviour provides the rational basis for developing programmes of health education for individuals and communities. Social medicine emphasizes the relationship between social factors and health status. It draws attention to the need for a multidisciplinary approach to health with deep involvement of social and behavioural scientists, economists, ethicists and political scientists.

Community health

Community health deals with the services that aim at protecting the health of the community. The interventions vary from environmental sanitation including vector control to personal health care, immunization, health education and such like. It includes an important diagnostic element – 'community diagnosis' – aimed at surveying and monitoring community health needs and assessing the impact of interventions.

Community medicine

This usually refers to services that are provided at the community level and is now often encompassed in the new term primary care. Community physicians, nurses and other health-care personnel are involved in providing care at clinics, health centres and in people's homes.

Modern public health

The modern concept of public health includes all these elements – preventive medicine, social medicine, community medicine, community health. Important features of modern public health include the following characteristic features. It is:

- multidisciplinary;
- multisectoral;
- evidence-based;
- equity-oriented.

Multidisciplinary

Although medical practitioners constitute a vital segment of the public health practitioners, the contributions from other health-related disciplines are absolutely essential for achieving the goals of public health. Thus, the public health team would include, as required, doctors, nurses, midwives, dentists and pharmacists; anthropologists, economists and other social scientists; philosophers, ethicists and other experts on moral sciences, as well as educationists, communications experts and managers. It is noteworthy that at the peak of its achievements, the late James Grant, a lawyer by profession, led UNICEF. Leadership in public health has to be earned from demonstrated ability and performance and not granted as a matter of course to the individual with a medical degree.

Multisectoral

The health sector has two distinct roles. It is primarily responsible for planning and delivering health services. It also has an important leadership function in mobilizing intersectoral action. It should work with other ministries: with public works on water and sanitation; with education on the health of school children and health promotion; with transport on the control of road traffic accidents; and with agriculture on food security, nutrition, use of pesticides and the control of zoonotic infections.

Evidence-based

Modern public health demands that decisions should be science-based and knowledge-based. As far as possible, policy-making should be made only after objective analysis of relevant information. Where information is lacking, there is a clear indication for gathering data and carrying out research to inform decision-making. It is often stated that researchers should present their results in a way that decision-makers can apply their findings. By the same token, policy-makers have the responsibility to ensure that their decisions are based on the best available scientific evidence. Both researchers and policy-makers with their common interest in promoting the health of the population need to work closely together in generating and using sound evidence as the basis of decision-making.

Equity-oriented

Public health programmes must be designed to promote equity as the ultimate goal of all health action. The aim is to ensure for each member of society the highest possible level of health. Public health programmes should actively monitor equity and make necessary corrections. Public health practitioners must adopt a strong advocacy role in persuading decision-makers and influential members of society that, in the long run, equity in health is to everyone's advantage as a means of securing sustainable development and strengthening the social contract among citizens from a wide variety of backgrounds and between them and their governments. It should be made clear that solidarity with the poor is not merely an act of charity but a mechanism for promoting the welfare of all peoples (p. 284).

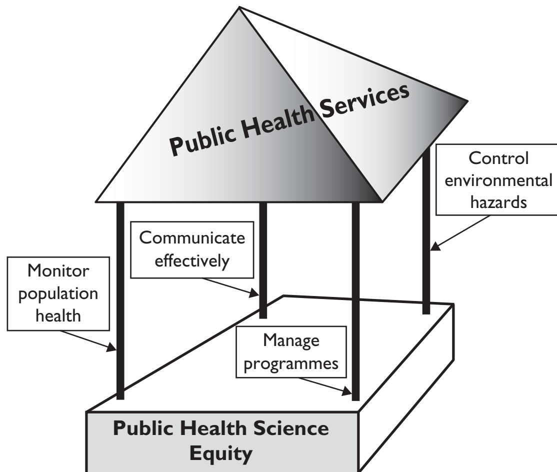
Key public health functions

Public health services perform a wide range of functions, which can be classified as four key elements (Fig. 1.2):

- assessing and monitoring of the health of the population;
- planning, implementing and evaluating public health programmes;
- identifying and dealing with environmental hazards;
- communicating with people and organizations to promote public health.

Assessing and monitoring of the health of the population

The objective is to identify and deal with health problems of the population. The activities range from the investigation of an acute epidemic outbreak to longer-term definition of the priority health problems and their determinants. The



Key public health functions:
- Founded on a solid base of science to provide evidence-based decision-making
- Equity as the explicit goal
- Four pillars of support to the health services: monitoring population health, protecting against environmental hazards, designing and managing public health progammes and communicating effectively in support of public health.

Figure 1.2: Graphic representation of the role of public health.

public health approach also includes a ranking of problems in terms of their contribution to the burden of disease and their amenability to control through cost-effective interventions. The information gathered provides a sound basis for making decisions about the best approach for dealing with an acute emergency such as an outbreak of an epidemic disease like cholera; it also provides the basis for broader and longer-term decisions about policy, priorities and programmes (see Chapter 2).

Planning, implementing and evaluating public health programmes

Public health practitioners are also concerned with the design and management of public health programmes at district, regional and national levels. Their role is dominant at the primary health-care level but they are also involved in decisions that affect services for the referral and specialist services (see Chapter 10).

Identifying and dealing with environmental hazards

Protection of the population against environmental hazards including accidents is a prime function of public health. This is a well-recognized traditional role of public health with regard to the provision of safe water, the disposal of wastes, control of vectors and modern hazards from toxic wastes and radioactive chemicals (see Chapter 13).

Communicating with people and organizations to promote public health

Effective communication is an important tool that public health workers use to bring about change in the behaviour of individuals and communities as well as in advising organizations within and outside the public sector (see Chapter 13).

The tropical environment

The total environment of human beings includes all the living and non-living elements in their surroundings. It consists of three major components: physical, biological and social. The relationships of human beings to their environment is reciprocal in that the environment has a profound influence on them and they in turn make extensive alterations to the environment to meet their needs and desires (Fig. 1.3).

Physical environment

This refers to the non-living part of the environment – air, soil, water, minerals – and climatic factors such as temperature and humidity. The physical environment is extremely variable in the tropics covering deserts, savannahs, upland jungle, cold dry or humid plateaux, marshlands, high mountain steppes or tropical rainforest.

Climatic factors such as temperature and humidity have a direct effect on humans, their comfort and their physical performance. The physical environment also exerts an indirect effect by determining the distribution of organisms in the biological

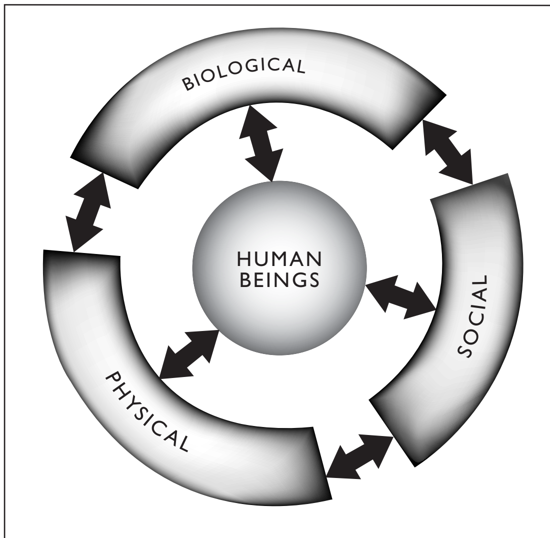


Figure 1.3: The interaction between human beings and their environment.

environment: plants and animals which provide food, clothing and shelter; animals which compete with humans for food; and parasites and their vectors which produce and transmit disease.

Humans alter the natural characteristics of the physical environment sometimes on a small scale but often on a very large scale: from clearing a small patch of bush, building a hut and digging a small canal to irrigate a vegetable garden to the building of large cities, draining of swamps, irrigating arid zones, damming rivers and creating large artificial lakes. Many such changes have proved beneficial but some aspects of these changes have created new hazards.

On the global scale, there is increasing concern that human activities are steadily leading to a significant rise in the earth's temperature with forecasts of dire results.

Biological environment

All the living things in an area – plants, animals and micro-organisms – constitute the biological environment. They are dependent on each other and ultimately, on their physical environment. Thus, nitrogen-fixing organisms convert atmospheric nitrogen into the nitrates that are essential for plant life. Plants trap energy from the sun by photosynthesis. A mammal may obtain its nourishment by feeding on plants (herbivore) or on other animals (carnivore) or both (omnivore). Under natural conditions, there is a balanced relationship between the growth and the size of the population of a particular species, on the one hand, and its sources of food and prevalence of competitors and predators, on the other hand.

Humans deliberately manipulate the biological environment by cultivating useful plants to provide food, clothing and shelter, and raising farm animals for their meat, milk, leather, wool and other useful products. They hunt and kill wild animals, and destroy insects which transmit disease or which compete with them for food.

In many parts of the tropics, insects, snails and other vectors of disease abound and thrive. This is partly because the natural environment favours their survival but also because, in some of these areas, relatively little has been done to control these agents.

Social environment

This is the part of the environment that is entirely made by humans. In essence, it represents the situation of human beings as members of society: family groups, village or urban communities, culture including beliefs and attitudes, the organization of society – politics and government, laws and the judicial system, the educational system, transport and communication, and social services including health care.

Health and development

The close link between health and development in other sectors is clearly recognizable. There is a clear correlation between economic, industrial and other indices of development and the health status of populations and communities. At one end of the spectrum are the industrialized, affluent developed countries and at the other end are the least developed countries that still rely largely on traditional agricultural practices and simple crafts. The term 'developing countries' is used to describe countries that have not as yet achieved a high level of industrial and economic development. Characteristic features of developing countries include relatively

low income, low literacy rates, low access to electricity and other modern sources of energy, and high mortality rates among vulnerable groups (children, pregnant women). These factors interact: illiteracy is associated with poverty; poverty predisposes to ill health; and ill health aggravates poverty. The World Bank summarized the key indicators of the development gap:

- of the world's 6 billion people, 1.2 billion live on less than $1 a day;
- about 10 million children under the age of 5 years died in 1999, most from preventable diseases;
- more than 113 million primary school age children do not attend school – more of them girls than boys;
- more than 500 000 women die each year during pregnancy and childbirth from complications that could have been easily treated or prevented if the women had access to appropriate care;
- more than 14 million adolescents give birth each year.

The World Bank, the International Monetary Fund, the members of the Development Assistance Committee of the OECD, and many other agencies have adopted International Development Goals which set targets for reductions in poverty, improvements in health and education, and protection of the environment (Box 1.2).

There is much variation in the extent of technical development in the various countries in the tropics. Some of these countries are now highly developed whilst others are still in the early stages. Some of the developing countries show certain common features: limited central organization of services, scattered populations living in small self-contained units, low level of economic development, limited educational facilities, and inadequate control of common agents of disease. Some of these communities are still held tightly in the vicious circle of ignorance, poverty and disease (Fig. 1.4).

Two maps illustrate the diversity in income, life expectancy and fertility rates (Plates 1 and 2).

Many areas in the tropics are in transition. Rapid economic development and the growth of modern industries are causing mass migrations from rural to urban areas. Faster means of transportation, progress in education, the control and eradication of major endemic diseases, and other developments are effectively breaking the chains of disease, poverty and ignorance. At the same time new problems are emerging, including those resulting from the social and psychological stresses imposed by these bewildering changes and their destructive effects on traditional family life and communal relationships.

In these transitional societies there have been marked changes in the patterns of disease. Noncommunicable diseases and conditions are now

Box 1.2: International development goals

Source: World Bank, World Development Indicators (2001)

- Halve the proportion of people living in extreme poverty between 1990 and 2015.
- Enroll all children in primary school by 2015.
- Empower women by eliminating gender disparities in primary and secondary education by 2005.
- Reduce infant and child mortality rates by two-thirds between 1990 and 2015.
- Reduce maternal mortality ratios by three-quarters between 1990 and 2015.
- Provide access to all who need reproductive health services by 2015.
- Implement national strategies for sustainable development by 2005 so as to reverse the loss of environmental resources by 2015.

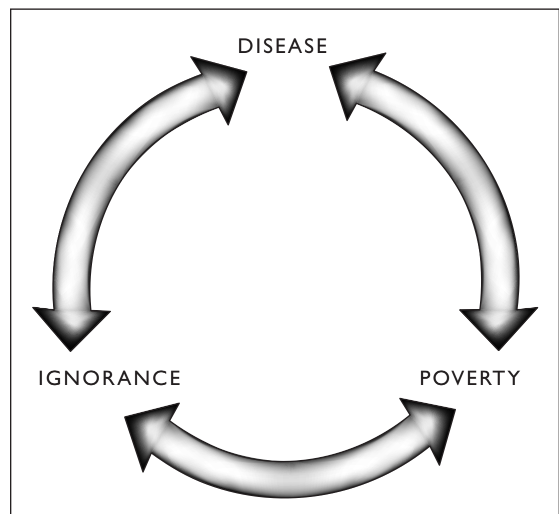


Figure 1.4: The cycle of ignorance, poverty and disease.

replacing communicable diseases which were formerly the predominant causes of disability, disease and death. Malnutrition in the form of the deficiency of specific nutrients is being succeeded by problems resulting from over-indulgence, thus obesity is replacing marasmus as the predominant nutritional problem. Alcoholism and drug abuse are emerging as manifestations of social stresses and tensions.

THE ECOLOGICAL APPROACH TO PUBLIC HEALTH

In public health, it is useful to consider the reciprocal relationship between humans and their total environment. In the search for the causes of disease, it is not sufficient merely to identify the specific agent of a disease, such as a virus or a parasite, but it is desirable to identify the influence of environmental factors on the interaction between humans and the specific agent. For example, the typhoid bacillus (*Salmonella typhi*) is known to be the causative agent of disease but the occurrence of outbreaks of typhoid is determined by various environmental factors: water supply, methods of sewage disposal, prevalence of typhoid carriers, personal habits of the people (cleanliness), use of raw water, attitude to and use of medical services, including vaccination. Similarly, a specific nutritional deficiency, such as ariboflavinosis, should not be viewed merely as a discrete metabolic defect but it should be seen in the context of the food habits of the community including food taboos, the level of education and income of the population and the local agriculture.

From this ecological approach, one can derive a rational basis for the control of disease within the population. Typhoid control should go beyond the treatment of the individual patient, to include immunization of susceptible groups, protection of water supplies, safe disposal of waste and improvement of personal hygiene. Malnutrition is managed not only by giving pills containing concentrated nutrients but also by giving suitable advice about diet and promoting the cultivation of nutritional foods both commercially by farmers and privately in home gardens; in more complex situations management may extend to promotion of welfare services such as unemployment benefits and food supplements for the needy. *The health worker* should seek suitable opportunities for improving the health of the people through action on the environment. It is important that these lessons should be repeatedly emphasized.

The individual and the family can do much about the cleanliness of the home and its immediate surroundings, thereby reducing the occurrence of a number of infectious diseases. Domestic accidents, especially in such high-risk areas as the kitchen and the bathroom, can be prevented by careful attention to the environment in the home. The individual needs to recognize *how* the environment in the home affects the health of the family, *why* each person must act to improve the situation and *what* the individual and the family can do to deal with the problem.

The community should be approached as a whole to deal with the widespread problems that affect many families, and also for help with those problems which require action beyond the means of individual families. For example, certain environmental situations may require organization at the community level and must be designed in the context of the culture of the local community:

- collection and storage of water to ensure that each family has an adequate supply of safe water;
- disposal of human and other wastes;
- control of other environmental hazards (see Chapter 12).

In most developing countries, modern development projects and urbanization are introducing new risks (Plates 3–5). It is therefore necessary to ensure that these new initiatives should be carefully examined at the community level with regard to their appropriate siting and safe management, with minimal risk to the environment.

At the national and international level, large-scale projects such as the creation of artificial lakes, irrigation projects and mining of minerals including oil, require careful assessment of their environmental impact. The adverse effects can best be minimized by careful planning so that as far as possible protective measures can be incorporated into the design of these projects.

Some developed countries facing problems of disposing of toxic chemicals and radioactive waste have resorted to dumping them in developing countries. The serious concerns raised by these events should lead to tighter international controls.

Developing countries are also involved in dealing with environmental issues which are of global dimensions: the denudation of the tropical forest and its probable adverse effects on climate; the use of chlorofluorocarbons (CFCs) that destroy the ozone layer; and the extensive use of fossil fuel and consequent increase in greenhouse gases identified as the main cause of global warming.

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Addendum added at reprint

Millennium Development Goals

At the Millennium Conference in New York in 2000, all 191 United Nations Member States have pledged by 2015 to:

1 Eradicate extreme poverty and hunger:
- Reduce by half the proportion of people living on less than a dollar a day;
- Reduce by half the proportion of people who suffer from hunger.

2 Achieve universal primary education:
- Ensure that all boys and girls complete a full course of primary schooling.

3 Promote gender equality and empower women:
- Eliminate gender disparity in primary and secondary education preferably by 2005, and at all levels by 2015.

4 Reduce child mortality:
- Reduce by two-thirds the mortality rate among children under five.

5 Improve maternal health:
- Reduce by three-quarters the maternal mortality ratio.

6 Combat HIV/AIDS, malaria and other diseases:
- Halt and begin to reverse the spread of HIV/AIDS;
- Halt and begin to reverse the incidence of malaria and other major diseases.

7 Ensure environmental sustainability:
- Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources;
- Reduce by half the proportion of people without sustainable access to safe drinking water;
- Achieve significant improvement in the lives of at least 100 million slum-dwellers, by 2020.

8 Develop a global partnership for development:
- Develop further an open trading and financial system that is rule-based, predictable and non-discriminatory. Includes a commitment to good governance, development and poverty reduction – nationally and internationally;
- Address the least developed countries' special needs. This includes tariff- and quota-free access for their exports; enhanced debt relief for heavily indebted poor countries; cancellation of official bilateral debt; and more generous official development assistance for countries committed to poverty reduction;
- Address the special needs of landlocked and small island developing States;
- Deal comprehensively with developing countries' debt problems through national and international measures to make debt sustainable in the long term;
- In cooperation with the developing countries, develop decent and productive work for youth;
- In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries;
- In cooperation with the private sector, make available the benefits of new technologies – especially information and communications technologies.

For more information on the Millennium Development Goals, see the following web sites: www.un.org/millenniumgoals; www.undg.org/login.cfm.

CHAPTER TWO

HEALTH STATISTICS: INFORMATION FOR HEALTH

- Types of data
- Collection of data
- Notification of diseases
- Analysis of data
- Modern information technology
- Geographical Information System (GIS)
- Presentation of data
- References and further reading

The assessment of the health of the individual is made on clinical grounds by medical history, physical examination, laboratory tests and other special investigations. Theoretically, one could assess the health of a whole community by conducting repeatedly a detailed clinical examination of each individual. In practice, the health status of the population is assessed less directly by the collection, analysis and interpretation of data about important events that serve as indicators of the health of the community – deaths (mortality data), sickness (morbidity data) and data about the utilization of medical services. The lack of reliable data in developing countries is an important obstacle to the effective management of health care and other social services. It is necessary to develop and improve information systems which decision makers and health-care givers can use for planning, implementing and evaluating services.

TYPES OF DATA

VITAL STATISTICS

These are records of vital events – births, deaths, marriages and divorces – obtained by registration (see p. 14). The data are used for generating birth and mortality rates for whole populations or subgroups.

MORBIDITY STATISTICS

Data on the occurrence and severity of sickness in a community may be obtained from a number of sources within the medical services (see Table 2.1). They are both more difficult to collect and to interpret than the data of vital statistics (see p. 19 and Fig. 2.2) but allow a more detailed analysis of health status and services.

HEALTH SERVICE STATISTICS

Two types of data can be derived from the operation of the health services:

- resources data;
- institutional records.

RESOURCES

For the efficient management of health services, it is useful to collect and analyse data about the resources available for the delivery of health care. The inventory should include data on all health

institutions, both government and private (hospitals, health centres, dispensaries, medical clinics) and details of the numbers of various types of health personnel (doctors, nurses, midwives, etc.). The distribution of these resources in relation to the population should also be noted. This would show, for example, how far people in each community have to travel to reach the nearest institution which can provide them with various types of care. For example, how far is the nearest antenatal clinic, the referral centre at which caesarean section can be performed or blood transfusion given?

Institutional records

Records generated by health facilities can provide much useful information about the demand for and utilization of health services and about the extent to which various target groups within the population are being served. For example, what proportion of eligible children have been immunized? How many pregnant women received antenatal care and gave birth under the supervision of trained personnel? Such information can be used to plan, monitor and modify the health services. By relating the performance of the institutions to their resources, one can monitor efficiency and guide health policy. For a discussion of the use of statistics in monitoring the performance of health services, see Chapter 10.

Data from other sectors

Apart from data derived from the health services, information relevant to health can be obtained from other sectors of government:

- education (literacy rates, especially in girls and women);
- public works (housing, water supply, sanitation);
- agriculture (food production and distribution);
- economic planning and development (poverty, economic indicators).

Collection of data

A variety of mechanisms are used for the collection of the data which form the basis of health statistics (Table 2.1). In order that health statistics from various communities can be compared, standardization of these methods is essential nationally and desirable internationally.

Census of the population

This is required to provide the essential population base for calculating various rates. The census usually includes not only a total count of the population but also a record of the age and sex distribution, and some other personal data.

Population pyramid

The age and sex structure of the population is often displayed in the form of a histogram showing the percentage distribution of each sex at 5-year age intervals. In the past, the shape of this diagram was roughly pyramidal in all parts of the world: the base, representing the youngest age group, tapering to a narrow peak in the oldest age group. In developing countries, the shape of the pyramid is determined by the high birth rate and high child death rate in these communities (Fig. 2.1a): with a broad base and a rapid tapering off in the older age groups. In more developed countries, the population pyramid shows more gradual decline, indicating the relatively older population with a low death rate in childhood (Fig. 2.1b).

National censuses

In most countries, national censuses are held periodically, usually every 10 years. In addition to the standard demographic information about age and sex, the census may also be used to gather additional information that can be used for planning in health and other sectors.

Local censuses

The public health worker may need to conduct a census on a small scale in a local area where national census data are unobtainable or not sufficiently

Table 2.1: Sources of different types of health statistics

Source	Examples	Type of data
Census	Local, national	Total count; age, sex distribution
Epidemiological surveys		
Questionnaires	Sickness surveys	Sickness absence from work/school
Physical examination	Nutritional survey Goitre survey	Anthropometric measurements Physical examination
Special investigations	Serological surveys Tuberculosis survey	Prevalence of HIV infection Tuberculin sensitivity established
Medical institutions		
Outpatient clinics	Health centre	Clinical records – pattern of diseases
Special clinics	Specific groups: e.g. maternal and child welfare Specific disease clinic: e.g. tuberculosis, sexually transmitted diseases	Attendance records Health profile of women and children Clinical and epidemiological features
Inpatient services	General hospitals Specialist hospitals	Clinical records, laboratory results, autopsy data
Data collected for other purposes		
Routine medical examination	School entrants Pre-employment/army recruits Insurance	Nutritional status, immunization rates Profile of health status of young adults Baseline data, prevalence of risk factors
Sickness absence records	Schools, industry	Early warning of epidemics

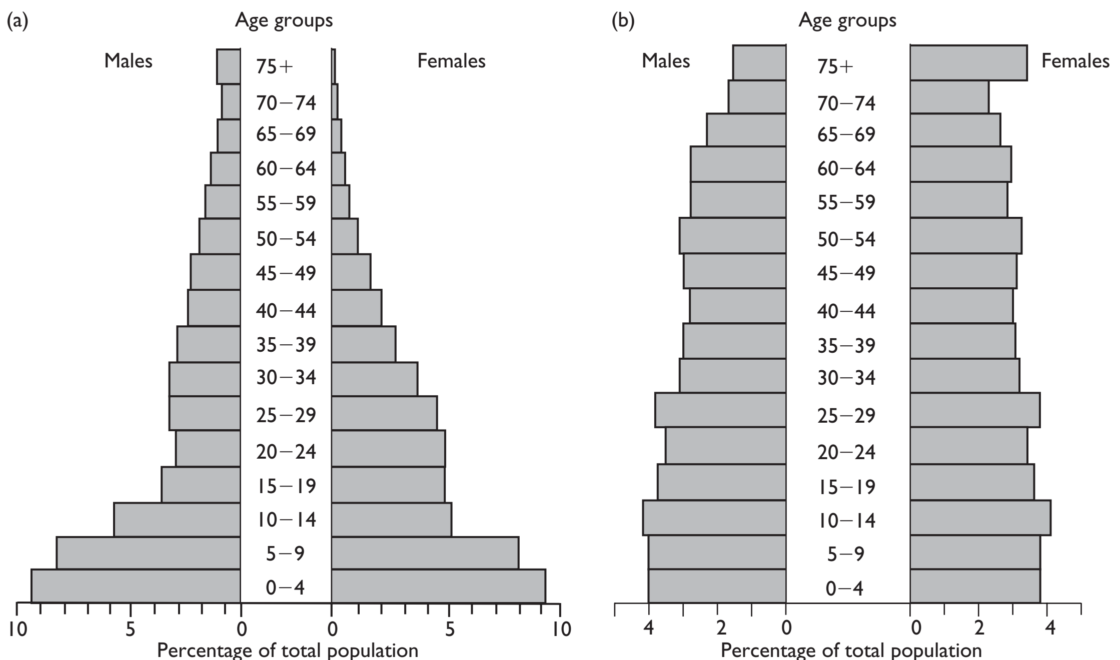

Figure 2.1: Population pyramids showing the distribution of males and females amongst different age groups (a) in a developing country, (b) in an industrialized country.

accurate for a proposed epidemiological survey. For some studies, the census is conducted on the basis of the number of persons who are actually present on the census date in the defined area; this *de facto* population may include temporary residents and visitors but may exclude permanent residents who happen to be away. For other studies, especially where a longitudinal survey is planned, the census enumerates all persons who are normally resident in an area; that is, this *de jure* population would exclude temporary residents and visitors but include permanent residents who are temporarily away.

Registration of births and deaths

The registration of births and deaths is compulsory in the developed countries but only in some of the developing countries. Births and deaths are two important events which can be clearly recognised by lay persons and as such the data can be collected and recorded by trained literate persons. In addition to recording the fact of death, it is useful to establish the cause of death. The certification of the cause of death is done at various levels of sophistication, ranging from simple diagnoses that can be made by health auxiliaries to more difficult diagnoses that can only be obtained from elaborate investigations of the patients by highly trained personnel and post-mortem examination by competent pathologists.

Methods to improve registration

In many developing countries it is difficult to obtain a complete registration of births and deaths. Even where the local laws make such registrations compulsory, the enforcement of these regulations is difficult and unpopular. Various devices have been tried to improve the quality of the data.

REGISTRATION CENTRES

These should be conveniently sited so that each person has reasonable access to the registration centre in his or her district. The registration centre should be adapted to the local social structure, using such persons as village heads, heads of compounds, religious scribes, or institutions that are appropriate in the particular area.

REWARDS AND PENALTIES

In some countries the population is induced to register births by attaching rewards to the possession of birth certificates. For example, the government free primary school may be available only to children whose births have been registered. Unduly harsh penalties against defaulters are not to be recommended because such actions may antagonize the public and alienate them from other public health programmes and personnel. The system should emphasize positive inducements ('carrots') rather than sanctions ('whips').

Education

Regardless of the method of registration adopted, the success of the scheme will depend on being able to get appropriate and sufficient information to the general public about the programme. They must know why the procedure is considered necessary and what benefits it may bring to both the individual and the community.

Notification of diseases

National notification

In every country there is a list of certain diseases, cases of which must be reported to the appropriate health authority. It includes communicable diseases, but in addition there are specific regulations about the reporting of certain industrial diseases. The notification of acute epidemic diseases is designed to provide the health authorities with information at an early stage so that they can take urgent action to control outbreaks of these infections. For example, the early notification of a case of typhoid would enable the health authorities to confine the epidemic to the smallest possible area in the shortest possible time. The notification of chronic and non-epidemic infections provides information which can be used in the long-term planning of health services and also in the assessment and monitoring of control programmes.

The validity of notifications

Various factors may limit the usefulness of notifications in the control of disease. These problems, and their possible solutions, are summarized in Table 2.2.

Concealment of cases

Fear of forcible confinement in an isolation hospital, or of ostracism by the community (in diseases that carry a social stigma, e.g. leprosy, HIV/AIDS, other sexually transmitted diseases) may result in concealment of disease. This may be avoided by *education* to explain how notification can help both the individual and the community. *Feedback* of the compiled data allows those who contributed to see how this information is being used (see Table 2.2).

Errors of diagnosis

In well-equipped hospitals and health centres, laboratory and other diagnostic services facilitate clinical diagnosis: haematology, microbiology, histopathology, radiology, etc. These facilities are usually more limited in small peripheral institutions such as the primary health-care clinics in remote rural areas. In such situations, and sometimes in poorly equipped hospitals in developing countries, health personnel have limited access to laboratory services and have to rely on their clinical skills.

Under these conditions, diagnosis may be missed, particularly in cases that are atypical, mild or subclinical. In certain diseases, a high proportion of those infected do not feel or appear ill but may transmit infection (i.e. they act as carriers). Over-diagnosis may also occur. The quality and comparability of the diagnoses obtained in such situations may be improved by:

- providing good laboratory services – with particular emphasis on simple techniques which the staff can use effectively and on equipment which can be maintained locally;
- training health personnel to improve their clinical and laboratory skills;
- establishing standard diagnostic criteria – including the use of simple algorithms.

Table 2.2: Factors limiting the usefulness of notification and how to overcome them

Problems	Solutions
Concealment of cases	Education Feedback
Errors of diagnosis: ■ Missed diagnosis ■ Over-diagnosis	Improved diagnosis: ■ Laboratory services ■ Training ■ Standard diagnostic criteria
Incomplete reporting	Simple forms Better supervision

Incomplete reporting

Correctly diagnosed cases may remain unreported due to ignorance or negligence on the part of the health worker. Simple forms assist case reporting. Where levels of literacy are low, health officials have used colour-coded cards carrying the address of the health office; the local informant can alert the health authorities about new cases of the reportable illnesses simply by dropping a card of the right colour in the post box. The village head can notify a case merely by posting a card of the appropriate colour.

International notification

A few diseases are subject to notification on the basis of international agreement. These internationally notifiable diseases, known also as 'quarantinable' or 'convention' diseases, are governed by International Sanitary Regulations. Formerly, six diseases were included (smallpox, plague, cholera, yellow fever, louse-borne typhus and louse-borne relapsing fever). Diseases currently notifiable to the World Health Organization are:

- plague;
- cholera;
- yellow fever.

Where health services are poorly developed, many cases of notifiable diseases are not recognized and are not reported. Thus, the official records include an incomplete and uncertain proportion of the cases that have occurred. In some instances, national authorities are reluctant to publicize outbreaks of communicable diseases for fear that such information could affect their tourist industry or have other damaging effects on the image of the country. The World Health Organization is therefore putting emphasis on strengthening the

capabilities of developing countries to carry out effective surveillance of major communicable diseases, and on its co-ordinating role in collecting information about infections which tend to spread from country to country (e.g. influenza, HIV infection). Some national authorities who suppress public health information that they find embarrassing sometimes frustrate these mechanisms for international exchange of information. Thus, notifications of diseases such as cholera and dengue are delayed or censored. For a long time, many African countries denied the occurrence of HIV/AIDS or grossly understated the number of cases in their countries. This led to long delays in instituting effective preventive measures.

Data from medical institutions

Hospitals, health centres, clinical laboratories and other medical institutions provide easily accessible sources of health statistics (see Table 2.1), but such institutional data must be used and interpreted most cautiously.

Limitations

The pattern of disease, as seen in hospitals and in other medical institutions, is distorted by many factors of selection which operate from the patient's home to the point of being seen and the condition diagnosed in an institution (Fig. 2.2). The patient's action depends on awareness of being sick and knowledge that relief is available at a particular institution. The person then makes a choice of treatment from the available alternatives:

- self-treatment with traditional or modern drugs;
- treatment by traditional healers;
- treatment by quacks or other unqualified persons;
- modern medical treatment by a private medical practitioner or at the dispensary, health centre or hospital.

Factors in the institutions that can influence the pattern of disease include:

- the types of services offered by the institution;
- accessibility of the institution including such factors as the distance from home and the fees charged;

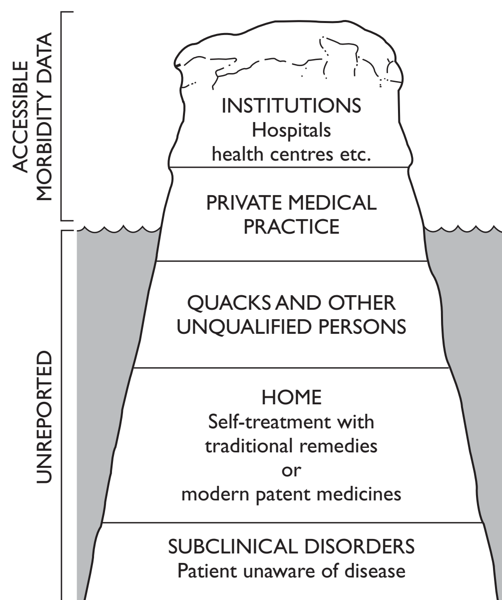

Figure 2.2: The iceberg phenomenon of morbidity assessment. Data from institutions such as hospitals represent an unknown proportion, and in some cases a very small proportion, of the cases in the community. Institutional cases are often no more than the tip of the iceberg; the nature and extent of the larger mass beneath the surface can only be discovered by well-designed epidemiological studies.

- the special interests and reputation of the personnel.

Thus, for example, the establishment of a bacteriological laboratory in a hospital might lead to an increase in the frequency with which certain diseases such as typhoid are diagnosed. The appointment of a specialist obstetrician in a hospital may lead to a concentration of difficult obstetric problems as a result of referrals from other doctors and self-selection by patients who have heard of the specialist's reputation. A free clinic may attract large numbers of patients, including relatively large numbers of the poor, whereas mainly the rich will use an expensive private clinic and those who have financial provision through insurance.

In addition to these selection effects, another defect of institutional data is that although the numerator (i.e. number of cases) is known, the denominator (i.e. the population at risk) is not

easy to define. Comparisons from community to community on the basis of institutional data are difficult and fraught with the danger that erroneous conclusions may be based on the distorted pattern of hospital data.

In spite of these limitations and dangers, the information derived from medical institutions can usefully supplement data from other sources (see Table 2.1).

Analysis of data

Rates

Health statistics may be presented as absolute numbers but they are often expressed as rates (i.e. the number of events are related to the population involved) and, in order to simplify comparisons, rates are usually expressed in relation to an arbitrary total (e.g. 1000, 100 000 or 1 000 000).

$$\text{Rate} = \frac{\left[\begin{array}{c}\text{No. of persons affected or}\\ \text{number of events}\end{array}\right]}{\text{Population at risk}} \times 1000$$

Crude rates

Rates which are calculated with the total population in an area as the denominator are known as crude rates (Table 2.3). Crude rates from different populations cannot be easily compared, especially where there are striking differences in the age and sex structure of the population. Thus, the crude death rate may be relatively high in a population which has a high proportion of elderly persons compared with the rate in a younger population. If the death rate is to be used as an indicator of the health status of a population, adjustment of the crude rate is required. Standardizing the crude rate for age, sex or other peculiarities of the population may do this. The adjustment is made to a standard population.

Specific rates

Alternatively, rates may be calculated using data from specific segments of the population. These rates, using the particular population at risk as the denominator, are called specific rates (Table 2.3). For example:

Age/sex specific death rate

$$= \frac{\left[\begin{array}{c}\text{No. of deaths in people of}\\ \text{a specified age/sex}\end{array}\right]}{\left[\begin{array}{c}\text{No. of people in the specified}\\ \text{age/sex group}\end{array}\right]} \times 1000$$

The age-specific death rate in a total population may be analysed separately for each sex in 1-year age groups, or more conveniently, in 5-year or 10-year age groups.

VITAL STATISTICS: MORTALITY RATES

The various rates calculated from vital statistics may be used either to reflect the health status of a community as a whole, or to study the health problems and needs of specific groups. For example, rates of maternal death, stillbirth and perinatal mortality are of value in the analysis of obstetric problems and obstetric services.

The overall health of the community may be assessed using standardized death rates, although in practice, the mortality rates of the most susceptible age groups have proved to be more sensitive indicators.

INFANT MORTALITY RATE

The infant mortality rate is widely accepted as one of the most useful single measures of the health status of the community.

The infant mortality rate may be very high in communities where health and social services are poorly developed. Experience has shown that it can respond dramatically to relatively simple measures. Thus, with the establishment of maternal and child health services, the infant mortality rate may fall from being very high (200–300/1000 live births) to a moderate level (50–100/1000 live births).

In the most advanced nations the rate is low (below 20/1000 live births). Even in these developed communities, the infant mortality rate shows striking differences in the different socioeconomic groups: it may be as low as 10 deaths/1000 live births in the upper socioeconomic group whilst it is 40 deaths/1000 live births in the lower socioeconomic group of the same country.

Table 2.3: Some commonly used mortality rates in public health

Rate		Calculation (×1000)
Crude rates		
Crude birth rate	=	No. of live births in a year / Mid-year population
Crude death rate	=	No. of deaths in a year / Mid-year population
Natural increase rate	=	No. of live births minus no. of deaths in a year / Mid-year population
Specific rates		
Pregnancy and puerperium		
Fertility rate	=	Total no. of births in a year / No. of women aged 15–49 years
Maternal mortality ratio	=	[Annual no. of maternal deaths due to pregnancy, childbirth and puerperal conditions] / Total no. of births in a year
Stillbirth rate	=	Annual no. of foetal deaths after 28 weeks' gestation / Total no. of births in a year
Perinatal mortality rate	=	Annual no. of stillbirths and deaths in the first 7 days / Total no. of births in a year
Infants and children		
Neonatal mortality rate	=	Annual no. of deaths in the first 28 days / No. of live births in a year
Postneonatal mortality rate	=	Annual no. of deaths between 28 days and 1 year / No. of live births in a year
Infant mortality rate	=	Annual no. of deaths in the first year / No. of live births in a year
Child death rate	=	Annual no. of deaths between 1 and 4 years / No. of live births in a year
Under five mortality rate	=	Annual no. of deaths under 5 years / No. of live births in a year

NEONATAL AND POSTNEONATAL MORTALITY

The infant mortality rate is usually subdivided into two segments: the neonatal and the post-neonatal death rates (Table 2.3).

The neonatal death rate is related to problems arising during:

- pregnancy (congenital abnormalities, low birth-weight);
- delivery (birth injuries, asphyxia);
- after delivery (tetanus, other infections).

Thus, neonatal mortality rate is related to maternal and obstetric factors. The postneonatal mortality rate on the other hand is related to a variety of environmental factors and especially to the level of child care.

Improvement in maternal and child health services brings about a fall in both the neonatal

and the postneonatal death rates, but the fall occurs more dramatically in the latter rate. Thus, at high infant mortality rates (200 deaths/1000 live births), most of the deaths occur in the postneonatal period but at very low levels (20 deaths/1000 live births), a high proportion of the deaths are neonatal and are mainly due to such problems as congenital abnormalities and immaturity.

UNDER FIVE MORTALITY RATE

In developed countries, the first year of life represents the period of highest risk in childhood and the death rate is very low in older children. In many tropical developing countries, although the first year does represent the period of highest risk, a high mortality rate persists in the older children. Thus, the infant mortality rate taken by itself underestimates the loss of child life. The under five mortality rate (U5MR), defined as the annual number of deaths of children under 5 years of age/1000 live births, is used to complete the picture.

The U5MR is low (below 20/1000) in developed countries, but shows a wide range in developing countries. Some developing countries – Chile, Costa Rica, Cuba – have achieved low U5MRs comparable with the rates in developed countries. However, the rates are above 150/1000 in a number of developing countries, especially in Africa.

The United Nations Children's Fund (UNICEF) advocates the use of U5MR as 'the single most important indicator of the state of the world's children'. UNICEF made this choice because it found that:

> U5MR reflects the nutritional health and the health knowledge of mothers; the level of immunization and ORT[1] use; the availability of maternal and child health services (including prenatal care); income and food availability in the family; the availability of clean water and safe sanitation; and the overall safety of the child's environment.

LIFE TABLES

By applying age-specific death rates to a cohort of persons, one can generate a life table which shows the probability of survival at different ages. A life table from birth – *life expectancy at birth* – shows the average longevity of the population. In developed countries, life expectancy at birth is over 70 years but it is under 50 years in some developing countries.

[1] ORT, oral rehydration therapy.

MORBIDITY STATISTICS

In addition to vital statistics, data about the occurrence of sickness within the community can provide more detailed assessment of the health of the community.

Collecting morbidity data

Morbidity data are more difficult to collect and interpret than the records of births and deaths (see Table 2.2).

- Lay persons can easily recognize and record births and deaths. Success in the collection of morbidity statistics depends on the extent to which individuals recognize departures from health and also on the availability of facilities for the diagnosis of illnesses. Thus, the quality of morbidity statistics depends on the extent of coverage and the degree of sophistication of the medical services.
- Whereas each vital event of birth and death can occur only on one occasion in the lifetime of any person, sickness may occur repeatedly in the same person. In addition one person may suffer from several disease processes concomitantly.

Table 2.4 gives examples of sources of morbidity data.

Morbidity rates

In describing the pattern of sickness in a community, various morbidity rates are calculated (Table 2.4). These fall into four major groups.

INCIDENCE RATES

These describe the frequency of occurrence of new cases of a disease or spells of illness. The incidence rate may be defined in terms of numbers of persons who start an episode of sickness in a particular

Table 2.4: Morbidity rates

Rate		Calculation (× 1000)
Incidence rate (persons)	=	$\frac{\text{No. of persons starting an episode of illness in a defined period}}{\text{Average no. of persons exposed to risk during the period}}$
Incidence rate (episodes)	=	$\frac{\text{No. of episodes of illness starting during the defined period}}{\text{Average no. of persons exposed to risk during the period}}$
Prevalence rate	=	$\frac{\text{No. of persons who are sick at a given time}}{\text{Average no. of persons exposed to risk}}$
Fatality rate	=	$\frac{\text{No. of deaths ascribed to a specified disease}}{\text{No. of reported cases of the specified disease}}$
Average duration of illness	=	$\frac{\text{Sum of duration of illness of cases in the sample}}{\text{No. of cases in the sample}}$

period, or alternatively, in terms of the number of episodes during that period.

PREVALENCE RATE

The prevalence rate of illness can be defined as the number of persons who are currently sick at a specific point in time.

FATALITY RATE

This is the number of deaths in relation to the number of new cases of a particular disease. It is, in part, a measure of the severity of the disease, efficacy of therapy and the state of host immunity.

DURATION OF ILLNESS

The average duration of illness can be calculated per completed spell of illness, per sick person, or per person. For example, in an outbreak of guinea worm infection, record the duration in weeks of disability for each case (defined arbitrarily as the period when the infection prevented attendance at work, school or usual occupation). Find the average duration of disability per case by dividing the sum by the number of affected persons.

NEW STATISTICAL APPROACHES IN HEALTH

Policy-makers are using new statistical tools to provide an objective basis for their decisions:

- measurement of the burden of disease;
- estimates of the cost-effectiveness of interventions;
- analysis of national health accounts.

Burden of disease

New methods of measuring the burden of disease are increasingly being used to make objective decisions for setting priorities in the health sector. These new indicators attempt to summarize the impact of specific health problems in terms of disease, disability and premature death. In Ghana, Morrow and his colleagues developed a summary that was based on the calculation of the number of useful days of life lost from premature death (mortality) and from disability (morbidity) (Ghana Health Assessment Project Team, 1981). A new measure, disability-adjusted life years (DALYs), an advance on the Ghana model, similarly combines losses from death and disability, but also makes allowance for:

- a discount rate, so that future years of healthy life are valued at progressively lower levels;
- age weights, so that years lost at different ages are given different values.

Quite understandably, there are relatively good-quality data from the developed countries and the more advanced developing countries, but in the least developed countries data are scanty, and some of the estimates of the global burden of disease were derived from extrapolations. The results showed that in developing countries communicable

diseases and perinatal problems accounted for the largest part of the burden of diseases, whereas in the industrial countries chronic diseases were the predominant causes of loss of DALYs (Plate 6).

The DALY is proving a useful tool, for ranking diseases and conditions and to estimate the cost-effectiveness of interventions by comparing the cost of averting a DALY. More work is required to refine and simplify it. Refinements of the DALY have been developed to emphasize specific aspects of the burden of disease. For example, disability-adjusted life expectancy (DALE) measures the number of years lived without disability.

Estimation of cost-effectiveness

Policy-makers use cost-effectiveness analyses to compare different interventions for the same condition. Such analyses provide the basis for selecting the interventions that give the largest gain in DALYs per unit cost, and how to modify interventions and make them more cost-effective. The most cost-effective interventions like vitamin A supplementation or measles vaccination require US$1–10 per DALY gained; but more expensive interventions like the treatment of leukaemia may require US$1000–10 000 per DALY gained.

National health accounts

This is a new valuable tool for monitoring the flow of financial resources for health. The analysis of national health accounts provides a comprehensive overview of health expenditures, both public and private. It extends the analysis of health financing beyond spending within the public sector to include private spending through insurance, corporate arrangements and employee schemes, and out-of-pocket spending. It combines data on health spending from all sources – public and private, corporate and personal – into comprehensive health accounts. The results affect the choices made within the public sector and influence the public role in providing guidelines to the private sector and communities on the most cost-effective uses of their personal expenditures. It also provides useful guidance for promoting equity by identifying those in greatest need as specific targets for public funds.

National health accounts are usually presented in the form of a matrix. The columns of the matrix list all sources of health spending: public (taxation and national social insurance) and private sources, including employment-based schemes, privately financed insurance, and out-of-pocket expenditure. The rows of the matrix show the distribution of expenditure for personal health care, public health and environmental sanitation services, and administration.

In more detailed analyses, the items in the columns and rows are subdivided, thereby providing more detailed information about the sources and patterns of spending. The analyses can show variations by time, by geography, by population subgroups, or by any other policy-relevant variables. The data from African countries show that a relatively heavy proportion of health expenditure is derived from private sources and out-of-pocket spending.

STATISTICAL CLASSIFICATION OF DISEASE

The use of standard classification of diseases and injuries has greatly aided the statistical analysis of morbidity and mortality data. Through the United Nations and the World Health Organization, an internationally recommended classification has been evolved, which is periodically revised. Although this classification may be extended or modified to suit local and national conditions, the essential structure for international comparisons must be preserved.

The cause of death can be defined as 'the morbid condition or disease process, abnormality, injury or poisoning leading directly or indirectly to death. Symptoms or modes of dying such as heart failure, asthenia, etc. are not considered to be the cause of death for statistical purposes'. These causes of death are classified broadly under seventeen main sections (Table 2.5).

In the rural areas of the tropics where facilities are limited and autopsies infrequent (e.g. in many provincial hospitals), the use of individual headings gives an impression of precision to diagnoses which is often not justified. The use of cause groups (e.g. diarrhoeal disease) in these circumstances permits a more valid estimate of the size of the problem, focuses on the necessity for corrective action and makes it easier to detect change over a period of time.

Table 2.5: Classification of diseases. Based on the International Classification of Diseases, 10th Revision, WHO.

I	Infective and parasitic diseases
II	Neoplasms
III	Allergic, endocrine, metabolic and nutritional diseases
IV	Diseases of the blood and blood-forming organs
V	Mental, psychoneurotic and personality disorders
VI	Diseases of the nervous system and sense organs
VII	Diseases of the circulatory system
VIII	Diseases of the respiratory system
IX	Diseases of the digestive system
X	Diseases of the genito-urinary system
XI	Complications of pregnancy, childbirth and the puerperium
XII	Diseases of the skin and cellular tissue
XIII	Diseases of the bones and organs of movement
XIV	Congenital malformations
XV	Certain diseases of early infancy
XVI	Symptoms, signs and ill-defined conditions
XVII	Accidents, poisoning and violence*

*Alternative classifications of items in group XVII are: E XVII (external cause) and N XVII (natural cause). The E and N classifications are independent and either or both can be used.

Certification of the cause of death

This is usually provided by the physician who was in attendance on a sick patient during his or her last illness. The certificate is made out on a form which is usually based on the international form of medical certificate of cause of death. This form is in two parts (Fig. 2.3).

In many developing countries, only a small proportion of deaths occur under the supervision of trained doctors. In the other cases, a certificate of death may be provided by other categories of staff including health auxiliaries. Attempts have been made to evolve for the use of such staff simple classifications of causes of death, based mainly on symptoms and broad descriptions. Such methods of recording crude causes of death can be of great value if the data are interpreted with care. These statistics should, however, be tabulated separately from certifications from qualified physicians.

Modern information technology

Major advances in information technology make new effective tools available to public health

CAUSE OF DEATH		Approximate interval between onset and death
I Disease or condition directly leading to death	(a) .... due to (or as a consequence of)	
Antecedent causes Morbid conditions, if any, giving rise to the above cause, stating the underlying condition last	(b) .... due to (or as a consequence of) (c)	
II Other significant conditions contributing to the death, but not related to the disease or condition causing it	....	

I This does not mean the mode of dying, e.g. heart failure, asthenia, etc. It means the disease, injury, or complication which caused death.

Figure 2.3: International form of the medical certificate for the cause of death. Details vary from country to country but usually include the items in this example.

practitioners. These new developments including computers and the internet offer many different applications that are increasingly accessible in developing countries.

Computers in health services

Computers are being used for storing and analysing data in public health programmes, epidemiological surveys and community-based research projects. Technical advances in recent years have made available compact, affordable computers that are simple to operate ('user friendly'). New, small, laptop models are more powerful than some large mainframe computers of a few decades ago which cost 10 times as much. Hand-held equipment is being used in the field for the direct entry of data which is subsequently transferred to larger machines for storage, analysis and mathematical modelling. Used imaginatively, computer technology is a powerful management tool for monitoring and evaluating health programmes and special projects.

The new technology should be introduced cautiously. Before selecting hardware and software, there should be a careful analysis of needs, capabilities of staff, reliability of power supplies and facilities for servicing equipment. There should be provision for the training of staff so that they can follow established procedures in a disciplined manner.

The internet

The internet is a global network that makes it possible for an individual to have access to information that is stored in computers all over the world. The specific interest is in the World Wide Web (WWW) which allows access to material that is stored at various web sites. The typical storage mechanism is a web page that includes graphics and texts; important features of such home pages are the links to related sites. Home pages on the WWW use the hypertext markup language (HTML).

Public health workers are exploring many innovative applications of modern information technology. In essence, the various systems provide facilities for holding, transferring and retrieving information. These mechanisms are helping to overcome the isolation of health workers in developing countries by giving them access to information and opportunities for interaction with their peers throughout the world.

Public health workers can use the internet to:

1 Access information provided by major organisations:
- United Nations agencies – World Health Organization, UNICEF, FAO;
- major health initiatives (Mectizan Donation Programme, International Trachoma Initiative, Children's Vaccine Programme, International AIDS Vaccine Initiative, etc.);
- private foundations (Ford, Melinda and Bill Gates, Rockefeller foundations and the Wellcome Trust);
- academic institutions – (most universities and large academic institutions e.g. London School of Hygiene and Tropical Medicine, Institute of Tropical Medicine, Amsterdam);
- scientific databases – MEDLINE, Cochrane database (Box 2.1);
- scientific publications – e.g. *Lancet*, *British Medical Journal*, *International Journal of Epidemiology* – abstracts and/or full texts available free or on payment of fee;
- news agencies – CNN, British Broadcasting Corporation, major newspapers in developed and developing countries.

2 Communications:
- electronic mail – send and receive messages;
- list servers – this provides a group of people with facility for on-going communications with each other. Enrolling on a list server of a particular group may provide the individual with regular information on a particular topic of interest.
- electronic networks – communication linkage among persons sharing a common interest for exchanging information and ideas.

Geographical Information System (GIS)

Geographical Information System is a newly developed tool for combining geographical and other variables in a database for display as maps and other graphical or textual format. Advances in satellite and computer technologies have facilitated the acquisition, storage and analysis of data in electronic form. Public health applications of GIS

Box 2.1: The Cochrane database

Abstracted from the Cochrane website: http://www.cochrane.org/cochrane/.

In 1979, Archie Cochrane, a British physician, criticized the medical profession for not having established a system for producing up-to-date summaries of the results of reliable research about the effects of health care. He recognized that people who want to make more informed decisions about health care do not have ready access to reliable reviews of the available evidence. In 1979, he wrote:

> *It is surely a great criticism of our profession that we have not organised a critical summary, by specialty or sub-specialty, adapted periodically, of all relevant randomized controlled trials.*

The Cochrane Collaboration was founded in 1993 to respond to Cochrane's challenge. Cochrane reviews (the principal output of the Collaboration) are published electronically in successive issues of *The Cochrane Database of Systematic Reviews*. Preparation and maintenance of Cochrane reviews is the responsibility of international collaborative review groups. The members of these groups – researchers, health-care professionals, consumers, and others – share an interest in generating reliable, up-to-date evidence relevant to the prevention, treatment and rehabilitation of particular health problems or groups of problems. How can stroke and its effects be prevented and treated? What drugs should be used to prevent and treat malaria, tuberculosis and other important infectious diseases? What strategies are effective in preventing brain and spinal cord injury and its consequences, and what rehabilitative measures can help those with residual disabilities?

have evolved over the past three decades. For example, by combining physical information with climatic data, epidemiologists are now producing GIS maps showing the distribution of risks of transmission of malaria, schistosomiasis and other vector-borne diseases. GIS maps can also be applied to the study of health services by relating epidemiological, demographic transportation and other variables with the aim of designing the most cost-effective organization of services.

Presentation of data

The aim of presenting data is to produce a precise and accurate demonstration of the information, summarized to simplify and highlighted to draw attention to the most important features. This may be achieved both numerically and graphically. Computer-based tools are available for data entry, analysis and presentation (Box 2.2).

Numerical presentation

At its simplest, numerical presentation may be no more than an arrangement of the figures in order of magnitude, so that the range of the data from the smallest to the largest is clearly displayed.

Box 2.2: Statistical and epidemiological packages

EPI-INFO, a statistical and epidemiological package, is widely used with over 100 000 users globally. It is particularly popular with health departments. Originally written for the DOS operating system, the current version, EPI-INFO 2000 is based on Windows operating system. The US-based Center for Diseases Control, Atlanta, which produced the package and updates it, has placed the product in the public domain; it can be acquired by downloading it free from their website or installed from a CD-ROM. It provides user-friendly processes for data entry and backup as well as flexible analytical tools and numerical and graphical presentations. EPIMAP, a companion tool, is used for drawing maps to show disease distribution and other health data.

Summary statistics

Simple statistical calculations can indicate salient features of the data. For example, a series of values can be summarized by calculating statistics such as:

- Mean, median or mode. Each is a single value which is representative of the series of figures, (i.e. an average).
- Range or standard deviation. These are measures of dispersion which show the degree of variability within the series of values.

Tabulation

For tabular presentation, data are sorted, arranged, condensed and set out in such a way as to bring out the essential points. Often the raw data are classified, compressed and grouped into a frequency distribution. For example, rather than showing the individual ages of persons, data may be classified into 5-year or 10-year age-groups, with a record of the number of persons in each group. For effective presentation, a few simple rules must be observed:

- *Title*. This should clearly describe the material contained within the text. Three elements commonly featured in the title are: (i) What? – the material contained in the table; (ii) Where? – location of the study; and (iii) When? – time of the study.
- *Labelling*. Each column and each row should be clearly labelled and the units of measurement stated. If a rate is used, the base of measurement and the number of observations must be stated.
- *Totals*. The totals for columns and rows should be shown where appropriate.
- *Footnotes*. Abbreviations and symbols should be explained in footnotes except when they are well known and universally familiar (e.g. £, $, etc.).

Graphic representation

Statistical data can be summarized and displayed in the form of graphs, geometric figures or pictures. The aim of the graphic representation is to provide a simple, visual aid such that the reader will rapidly appreciate the important features of the data.

Bar chart

A bar, the length of which is proportional to the absolute or relative frequency of events, represents each item in the group. It is particularly useful in representing discrete variables (Fig. 2.4).

Histogram

A histogram is a special type of bar chart used to display numerical variables. The variable of interest is shown on one axis as a continuous scale split into

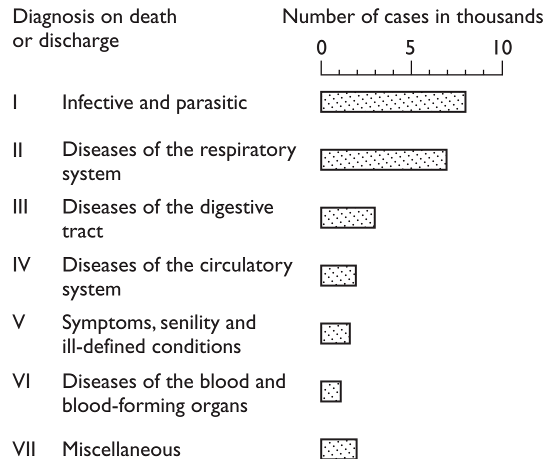

Figure 2.4: Bar chart analysis of the cases admitted to Laciport Hospital in 1989.

classes. Adjoining bars are drawn, their areas representing the frequency of events. If the class intervals are constant, the frequency may be given on the other axis (Fig. 2.5). The age and sex distribution of a population may be displayed in the form of a histogram to produce a population pyramid (see Fig. 2.1).

Pie chart

This consists of a circle, which is divided into sectors, with the area of each sector proportional to the value of each variable (Fig. 2.6).

Graphs

The simplest graph shows two variables: one on the horizontal axis and the other on the vertical axis (Fig. 2.7).

The use of health statistics

There is a tendency to over-emphasize the collection of statistics and to pay insufficient attention to their use. Much information collected at great cost remains unused in the archives of health departments. A few examples illustrate how statistics can be used in a dynamic way to identify and deal with problems affecting the health of the community.

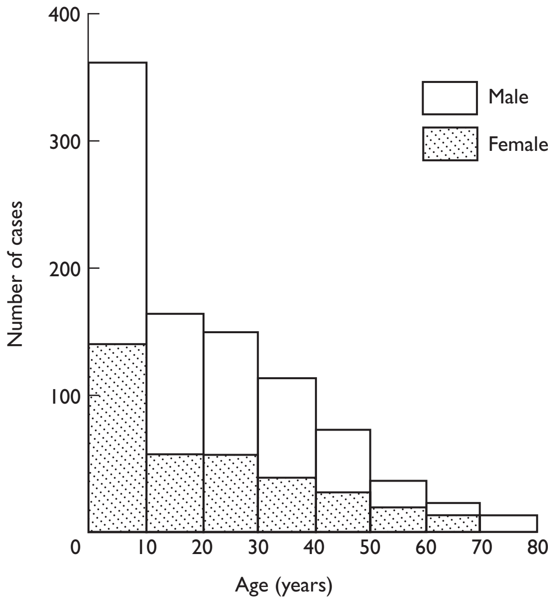

Figure 2.5: Histogram showing the age and sex distribution of cases of tetanus, Laciport Hospital 1986–89 inclusive.

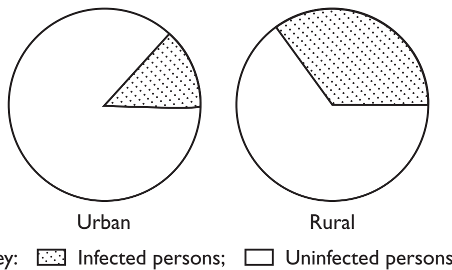

Figure 2.6: Pie chart showing the prevalence of hookworm infection in Laciport State in 1989.

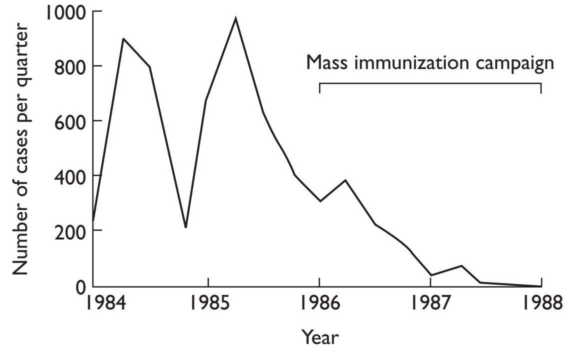

Figure 2.7: Graph of the numbers of cases of poliomyelitis notified in Laciport State from 1984–88.

Local uses

The delivery of health care at the primary level generates much raw data. At the health post, the dispensary, the maternal and child welfare clinic and the general practitioner's clinic, data can be collected and used in a simple but effective manner. For example, the pattern of diseases seen at the clinic can be summarized using simple classification in broad diagnostic groups. In this way the proportion of attendances due to common problems – diarrhoeal diseases, acute respiratory infections, minor injuries – can be monitored. A sudden change can call attention to an epidemic, and trends over time can also be observed.

At a health centre, for example, each service unit should collect and display statistics on high priority problems. The section of the clinic, which treats sick patients, could, for example, show cases of acute diarrhoea in a simple graph so that comparisons can be made day by day, week by week, and month by month. These statistics may alert the staff of the institution to sudden changes in the number of cases of a particular disease and it could provide some assessment of the performance of the services. The child welfare clinic should display the number of children they have immunized to show both the uptake over time (by comparing vaccination and birth rates) and the proportion completing the course (by indicating the numbers entering and finishing the programme).

No specific list can be prescribed for all centres but each centre should select a few priority problems for careful scrutiny. These data can form the basis of discussions among the staff and with the community for the strategy to deal with specific problems.

District and national collation and planning

In addition to the collection of data for local use, the primary health-care unit should also pay attention to the need to contribute accurate data for use at the district and national level.

DISTRICT LEVEL

The district health team should use the data derived from peripheral units to obtain an indication of the

pattern of diseases and operation of the health services. Trends that may not be apparent in one local unit may become obvious on compilation of data from several villages or communities. For example, an outbreak of diarrhoeal disease may be confined to a small area involving one or two villages, but an increase in the number of cases over a wider area may call attention to a more serious problem.

The district officer should also select data that would give information about the health problems within the district and the operation of the health services should be examined. What proportion of children are being immunized community by community? What proportion of pregnant women receive antenatal care and how many deliver their babies under skilled supervision? Scrutiny of such information would enable the district officer to assess the performance of the health teams, and to gauge the community response.

NATIONAL LEVEL

At the national level, the statistical unit serving the Ministry of Health can be a most valuable resource for decision-making. Data that are carefully collected, evaluated and interpreted should form the basis of defining the priorities for health care, for allocating resources and for monitoring progress. Such national data can be analysed to show distribution by geography, and other relevant variables. National health data can also be compared with data from other countries especially with countries that have a similar ecological setting.

Management information systems

'Information for action'

Rather than deal with health information as discrete pieces of data, it is best to develop a Management Information System (MIS). The objective of the MIS is to generate information that decision-makers and managers can use to support health programmes. The aim is to collect, analyse data and interpret findings as the basis for making decisions, monitoring trends and evaluating programmes. A good MIS depends on:

- careful identification of the users and their needs;
- the specific information that they require;
- a data collection system using appropriate tools;
- an analytic process for interpreting the data; and
- a mechanism for disseminating information to those who need to know.

The MIS may combine the routine reporting system with epidemiological surveillance and special surveys.

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CHAPTER THREE

EPIDEMIOLOGY

- Disease distribution
- Epidemiological methods
- Epidemiological data
- The uses of epidemiology
- General introduction
- Infectious diseases and development
- Epidemiology of communicable diseases
- Control of communicable diseases
- The use of drugs in the control of infections
- Antimicrobial resistance
- Surveillance of disease
- Epidemiology of non-infectious diseases
- References and further reading

Originally, the term 'epidemiology' meant 'the study of epidemics', but the techniques that were originally used in the study and control of epidemics have also been usefully applied in the study of other types of diseases including non-communicable diseases and accidents. In its modern usage, the term epidemiology refers to the study of the distribution of disease in human populations, against the background of their total environment. It includes a study of the patterns of disease as well as a search for the determinants of disease. It exploits the technologies from other disciplines – microbiology, parasitology, social sciences, etc. in analysing the frequency, distribution and determinants of health and disease in populations. New advances in genetics and molecular biology have stimulated the development of *molecular epidemiology*; it investigates the contributions of genetic and environmental risk factors that are identified at the molecular level in the aetiology and distribution of health and disease in groups and populations.

The modern definition of epidemiology includes three important elements:

- *All diseases included*. The term is no longer restricted to the study of infections but it includes cancer, malnutrition, road accidents, mental illness and other non-communicable diseases. Epidemiological techniques are also being applied to the study of the operation of health services.
- *Populations*. Whereas clinical medicine is concerned with the features of disease in the individual, epidemiology deals with the distribution of disease in populations, communities or groups.
- *Ecological approach*. The frequency and distribution of disease are examined against the background of various circumstances in man's total environment – physical, biological and social. This is an ecological approach: the occurrence of disease is examined in terms of the interrelationship between human beings and their total environment.

Table 3.1 lists examples of applications of epidemiology in various types of diseases.

DISEASE DISTRIBUTION

Three major questions are usually asked in epidemiology:

- *Who*? What is the distribution of the disease in terms of persons?
- *Where*? What is the distribution of the disease in terms of place?
- *When*? What is the distribution of the disease in terms of time?

Answers to these questions provide clues to the factors which determine the occurrence of the disease.