

Economic aspects of communicable diseases

Report on a WHO Working Group

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INTRODUCTION

The WHO Regional Office for Europe, in collaboration with the Government of the Federal Republic of Germany, convened a Working Group on the Economic Aspects of Communicable Diseases, in Trier from 21 to 23 September 1981. The meeting was attended by 20 temporary advisers from 11 countries and 2 members of staff of the Regional Office. The meeting was opened by Dr B. Velimirovic, Regional Officer for Communicable Diseases, on behalf of the Regional Director. Dr G. Kothmann welcomed the participants on behalf of the Government of the Federal Republic of Germany. Professor W. Krug was elected Chairman of the meeting, and Dr M. Sanecki served as Vice-Chairman. Mr M. Parsonage acted as Rapporteur.

Scope and purpose

Health resources in all countries are limited in relation to the need to prevent and control diseases and the growing demand for care. Constraints on the availability of resources have become increasingly apparent in recent years, at a time when a continuing rise in the cost of health care has coincided with a deterioration in the general economic performance of most European countries. To an increasing extent health policy-makers are required to explain and justify their demand for resources in relation to the claims of other sectors in the economy, and to demonstrate that the resources applied to health care are used in the most effective and efficient manner. At the same time and under the same influences, there has developed a growing awareness that ill-health imposes an enormous burden on society, not simply on account of the use of resources in the organized health care sector but also in terms of the effects on productive capacity of morbidity, disability and premature mortality.

In parallel with the increased importance of economic issues in health care, health economics — economics as applied to the health sector — has emerged as a new discipline, and is now widely recognized as having an essential part to play in the planning and delivery of health services. Techniques of economic analysis may be used for a variety of purposes in health care management, and particularly important applications have been found in assessing the economic burden imposed by different diseases and in evaluating alternative methods of prevention and treatment through cost-effectiveness and cost-benefit types of analysis. The assessment of disease costs and the evaluation of control procedures can act as a valuable stimulus to the selection of effective and economical health policies.

For a number of reasons, communicable diseases constitute especially suitable subjects for economic appraisal. First, the natural history and the prevention and control of many communicable diseases have already been intensively studied in medical and epidemiological terms; a sound data base is therefore available in many cases for the application of economic techniques. Due account must, of course, be taken of difficulties in applying economic concepts to health. Second, for many communicable diseases a number of alternative techniques of prevention and control are available, each with different implications for resource use and health outcomes; economic evaluation is therefore needed in helping policy-makers to choose the most cost-effective combination of control measures. And third, more information is needed on the economic costs of communicable diseases to assist policy-makers in the determination of broad health care priorities. Traditional measures of the impact of disease, such as rates of mortality and morbidity, are often misleading when applied to communicable diseases, for example because they fail to take account of the substantial and continuing costs of prevention and surveillance. These costs are incurred even when rates of incidence and mortality are low for particular conditions, such as rabies, and new statistical measures need to be developed to indicate these costs to policy-makers.

To promote better understanding of the above issues, the Regional Office established in 1975 a project on the economic aspects of communicable diseases, with the particular objective of developing and testing standard methods of economic evaluation in the field of communicable diseases. It was originally envisaged that a number of studies would be undertaken analysing the economic aspects of particular conditions, and the main priorities as expressed by Member States were for studies of viral hepatitis, sexually-transmitted diseases and enteric infections. In the event, implementation of this project proved more difficult than anticipated, and only the viral hepatitis study has so far been undertaken. Strong support for the continuation of the project has recently been expressed, particularly by Member States participating in the viral hepatitis exercise. At the same time, it emerged that a number of important studies were being undertaken at the national level into the economic aspects of various communicable diseases.

As a consequence of these developments the present Working Group was convened, with the following objectives: to assess the validity, usefulness and impact of economic studies undertaken or in progress on viral hepatitis, salmonellosis, rabies and hospital infections; to advise European countries on ways to strengthen economic considerations in communicable disease prevention and control; and to make recommendations for promotion and coordination at the international level.

ECONOMIC ASPECTS OF VIRAL HEPATITIS

Soon after its establishment, the World Health Organization recognized viral hepatitis as a major public health problem, and deplored the fact that knowledge of its etiology and epidemiology was limited. Since that time much progress has been achieved in this field with the development of specific laboratory methods for detecting infection. Viral hepatitis is defined as acute inflammation of the liver caused by one of two different viruses, referred to as hepatitis A and hepatitis B, or by other hepatitis viruses (non-A, non-B).

Viral hepatitis A has a worldwide distribution, though the exact incidence is difficult to estimate because of the high proportion of subclinical infections, infections without jaundice, differing patterns of disease, and differences in surveillance and reporting. The degree of under-reporting is believed to be very high. In most European countries, infections occur at all ages, probably about 50% of the clinical cases being in children under the age of 15 years. Some evidence suggests that the incidence of hepatitis A is declining and that a greater proportion of cases is occurring among adults. Hepatitis A virus is spread by the intestinal-oral route, most commonly by close contact, and infection occurs readily in conditions of poor sanitation and overcrowding.

Viral hepatitis B is clinically more important than type A and entails higher rates of complication and mortality. Two main factors distinguish hepatitis B: first, there is a high frequency of chronicity, about 10% of cases having a protracted course with some leading to cirrhosis of the liver and other chronic conditions; and second, infection with the hepatitis B virus may be followed by the persistent carrier state. The survival of the virus is ensured by the reservoir of carriers, estimated at about 120 million. It appears that the prevalence of carriers (a high proportion of whom are blood donors) in northern Europe is 0.1% or less and in central and eastern Europe up to 5%; there is a higher frequency in southern Europe and in countries bordering the Mediterranean Sea. The highest prevalence is observed in the 20-40-year age group. The importance of the parenteral and inapparent parenteral routes of transmission of hepatitis B virus is now well recognized. High-risk groups include persons requiring multiple transfusions of blood or plasma, or injection of blood products, or prolonged inpatient treatment; patients in whom frequent tissue penetration or repeated access to the circulatory system is needed; patients with natural or acquired immune deficiency; and patients with malignant diseases. Viral hepatitis is an occupational hazard among health care personnel and the staff of institutions for the mentally retarded and other closed institutions. High rates of infection have been reported in drug abusers, prostitutes and male homosexuals.

Progress in the specific diagnosis of viral hepatitis has revealed a new type of hepatitis that is unrelated to hepatitis A or B. It appears to be a common

form of hepatitis occurring after blood transfusion. There are no laboratory tests available as yet for identifying this agent or agents. Viral hepatitis non-A, non-B appears to have similar epidemiological characteristics to type B, with a large proportion of carriers.

WHO study of the economic costs of viral hepatitis

Because of its widely recognized importance, a multinational study of the economic costs of viral hepatitis was undertaken as the pilot phase of the project on the economic aspects of communicable diseases. The objective of the study was essentially to develop and test methods for assessing the size or impact of disease in cost terms, and the methods were drawn up on the basis of discussions held during and after the meeting of a panel of experts convened by the Regional Office in Copenhagen in November 1976. A study protocol was circulated to interested Member States in 1977.

Methods

Disease costing represents an attempt to estimate all the financial consequences of a given disease. A number of studies of this type have been undertaken in European countries, but the need was perceived for a more systematic and widely applicable approach, and the study protocol for viral hepatitis was drawn up against this background. The protocol consists of a detailed series or checklist of headings, each one relating to a different component of cost, and one of the aims of the exercise was to test the feasibility of building up estimates of total disease costs using a consistent method but on the basis of the data sources available in different countries.

In the checklist of cost headings, the protocol follows the practice of other studies in drawing a broad distinction between the direct and indirect costs of disease. Direct costs relate essentially to the value of health service resources expended as a result of a given disease, while indirect costs measure the wider effects on the economy as a whole, in terms of the loss of output resulting from morbidity, disability and premature mortality. Concerning direct costs, the protocol distinguishes the following categories:

(a) preventive activity (promotion of environmental health, health education, early diagnosis and screening, immunization and prophylaxis);

(b) curative and follow-up activity (outpatient care, hospital care and convalescence); and

(c) supportive activity (research, identification of high-risk groups, development of health information systems, and training of health personnel).

Concerning indirect costs, a broad approach is recommended, with the inclusion of a number of non-monetary indicators for comparative purposes. Four main headings are distinguished:

- (a) rates of incidence;
- (b) rates of mortality;
- (c) rates of disability (temporary and long-term); and
- (d) loss of earnings and production.

Only the last of these relates to measurable financial costs, but the other items are clearly relevant for an assessment of the overall impact of disease. The measurement of indirect costs raises a number of difficulties both practical and conceptual, for example relating to the measurement of output losses due to premature mortality and to the treatment of sickness benefits paid through social security schemes. The protocol does not, however, specify precise methods of measurement for these items, the intention being to provide a broad framework rather than a rigid blueprint for assessing costs.

Findings

The main findings of the costing study can be summarized under the following heads, covering both method and substantive results.

1. *Response.* Of the ten Member States represented at the meeting of experts held in 1976, six returned cost estimates based on the agreed protocol. These varied considerably in the degree of detail reported. This variability reflects the fact that estimates of disease costs are not usually produced by routine health service statistics. As a result, special studies may need to be undertaken based, for example, on sample surveys of patients or other prospective methods of data collection.

2. *Methods of measurement.* For most components of cost it was found by the participating countries that estimates are most conveniently built up by bringing together independent information on numbers of cases and on average or unit costs (e.g. average cost per hospital inpatient day, average daily wage, etc). This method of calculation emphasizes the need, in disease-costing studies, for good underlying epidemiological data. Estimates of total disease costs are likely to be much more sensitive to variations in estimated numbers of cases than in estimated unit costs. In one country study, it was found preferable to base the estimates of incidence in the country as a whole on a population survey carried out in a single geographical

area, rather than on the published national statistics of incidence, which were found to be subject to a large degree of under-reporting and misdiagnosis.

3. *Calculation of cost components.* Evidence from the individual country returns showed that some cost components are much more difficult to calculate than others. Concerning direct costs, the most problematic items are those relating to the overhead costs of health services (essentially those defined as preventive and supportive activity in the protocol), as against the costs of specific forms of treatment given to individual patients. Overhead costs are often difficult to attribute to specific diseases other than on an arbitrary basis. Concerning indirect costs, most countries were able on the basis of established administrative statistics to give estimates of lost earnings resulting from sickness absence and also of cash benefits paid to individuals. There is a much less secure base for estimating some other items, notably the economic costs of change of work situation due to disability, and of loss of work due to premature mortality.

4. *Value of direct costs.* Although the participating countries found it easier to estimate treatment costs than overhead costs, it is clear that overheads form only a relatively small proportion of total direct costs, the average figure being about 20%. Concerning treatment costs, hospital inpatient care accounted for the bulk of expenditure in all countries but with considerable variation depending on whether or not hospitalization of viral hepatitis patients is compulsory. Treatment costs are about twice as high on average for hospitalized patients as for non-hospitalized patients. Treatment costs also varied between cases of hepatitis A and B, cost per case being up to 50% higher for type B, partly because of higher rates of hospitalization and also because of longer average length of stay. In absolute terms, treatment costs per case (all types), in the participating countries, ranged between US\$250 and \$1250 (1978 values). With an approximate addition for other costs (preventive and supportive activity), the corresponding figures for all direct costs were \$300 and \$1500. Multiplying these unit cost figures by the number of cases, it can be estimated that, in broad terms, the direct cost of viral hepatitis ranged between \$20 000 and \$75 000 per 100 000 population in the participating countries. On average, about two thirds of these costs can be attributed to hepatitis A.

5. *Value of indirect costs.* The measurement of indirect costs raises a number of major difficulties, and the participating countries adopted widely differing procedures in attempting to value these broader economic effects. Among those countries which adopted the broadest basis of measurement, it was found that the indirect costs of viral hepatitis amounted to twice the value of direct costs. At the other extreme, one country included only a single component of indirect costs, namely loss of output resulting from

short-term sickness absence; even so, it was found that this measure of indirect costs amounted to over half the value of direct costs.

Assessment of the WHO study

The primary objective of the WHO study was to develop and test methods for estimating the economic costs of disease, and the Working Group acknowledged the valuable contribution made by the participating countries in helping to meet this objective. The Working Group reached the following conclusions in its review of the main findings derived from the costing exercise.

1. The protocol for the WHO study provides a comprehensive framework for assessing direct and indirect costs, but the coverage and estimation of these costs will always vary from one country to another, depending on the availability of statistics, national accounting conventions and so on. The scope for international comparisons of disease costs is therefore limited, and the main value of costing studies lies in the opportunity provided for making cost comparisons within individual countries, where consistent methods and sources of data can be used for different diseases. The full value of costing studies is only likely to be realized with the achievement of a broad coverage of cost estimates across the main disease groupings. A comprehensive set of disease costs of this sort would greatly assist in the setting of health service and research priorities and in the effective deployment of health care resources.

2. The country studies for the WHO exercise were undertaken in the mid-1970s. Since that time there have been major developments in serological techniques, allowing the separate identification of viral hepatitis type A as well as type B. Because the serological identification of hepatitis A was not possible in many countries when the studies were undertaken, the incidence of type B, being based solely on epidemiological data, was probably underestimated. This is important for two reasons: first, since hepatitis B has a relatively high frequency of chronicity, long-term costs were probably understated in the costing studies; and second, since different methods of intervention and control are required for hepatitis A and B, underestimation of the incidence of type B may lead to a misallocation of health care resources.

3. Some country studies were based on prospective methods of data collection, others on retrospective methods. Both methods have their uses: prospective methods may provide more reliable information, but they are costly and time-consuming, whereas retrospective studies can provide useful information, particularly on long-term trends. In some countries retrospective data were not reliable or were available on only a limited basis.

4. A number of conclusions were reached with regard to the costing methods recommended in the protocol. First, the distinction between direct and indirect costs is an important and useful one, and should be maintained in all costing studies. Second, direct costs have a more precise meaning than indirect costs, and the estimation of direct costs provides valuable data both on the overall level of health service resources devoted to specific diseases, and on the distribution of resources among different cost complexes (preventive measures, hospital treatment, etc). Third, the estimation of indirect costs is less straightforward. As in the protocol, this is traditionally based on the value of production losses in the economy resulting from ill-health, but a number of problems arise; for example, no costs are attributed to sickness among the elderly or other non-employed groups. It would therefore be incomplete to take indirect costs as a measure of the benefits arising outside the health sector from the reduced incidence of disease. The main value of improved health is in terms of the quality of life, and not just or even mainly of increases in the national income. Estimates of economic costs therefore provide only one indicator of the impact or burden of disease on society, and need to be supplemented or partially replaced by other, non-monetary indicators. Fourth, all estimates of disease costs must be related to specific contexts. There is no objective or definitive list of costs to be included in all costing studies; much will depend on whose costs are being considered, on whether costs are related to short-term or long-term values, and so on.

5. Notwithstanding the above qualifications, the country studies undertaken for the WHO exercise have fulfilled a valuable function in indicating to national policy-makers and health administrators the broad order of economic costs arising from viral hepatitis and, in the wider context, in testing the feasibility of a general costing framework.

Areas for future research

The main need for future economic research related to viral hepatitis is in the cost-effectiveness analysis of alternative methods of prevention and treatment. There are two aspects to this: first, evaluation of individual control measures, and second, determination of the optimal strategy in terms of the combination of individual control measures. Dealing first with specific interventions, the following list was drawn up by the Working Group.

Prevention

1. *Environmental measures (sanitation)*. Improved sanitation represents a long-term investment in reducing the incidence of infectious diseases, though problems arise in attributing the costs and benefits of general sanitation programmes to specific conditions. There are, however, some specific

environments where particular improvements could be made, such as day-care centres, hospitals, and institutions for the mentally retarded.

2. *Screening.* Consideration should be given to extending the coverage of screening not only to blood donors but also to other high-risk groups, such as health personnel (especially dentists and staff in dialysis units) and dialysis patients. A policy of mass screening for hepatitis B would have major social implications and would probably suffer from a low response rate in those population groups, such as drug addicts and homosexuals, where the incidence is high.

3. *Specific prophylaxis by immunoglobulin.* The high cost of immunoglobulin indicates the need for very judicious use. For viral hepatitis B there are probably no cost-effective uses for general pre-exposure prophylaxis, while for type A use should be restricted to selected high-risk groups, including populations in certain closed institutions.

4. *Vaccines.* Trials with newly developed vaccines for hepatitis B indicate a high degree of effectiveness but also extremely high costs. High-risk groups need to be identified.

5. *Hygiene in hospitals.* Measures may be undertaken at relatively low cost to prevent the spread of parenteral infection, for example by the use of disposable syringes and other surgical instruments, and by imposing stricter and more frequent hygiene measures in dialysis units.

6. *Health education.* Health education aimed specifically at viral hepatitis may prove highly cost-effective.

Treatment

1. *Diagnostic procedures.* The importance of accurate diagnosis through serological testing was emphasized, since appropriate treatment methods depend on it.

2. *Hospitalization.* In the majority of cases of viral hepatitis A, home treatment is as effective as hospital treatment, is less costly and is no less efficient in reducing the risk of the spread of infection. Consideration should therefore be given to restricting hospitalization to particular groups, such as serious cases and patients with a poor home environment. Concerning treatment given within hospitals, the high cost of unnecessarily isolating patients in single rooms was also noted.

Each of these specific interventions may be evaluated in cost-effectiveness terms, though detailed priorities for research will vary among countries, as will the assessment of optimal strategies or combinations of individual interventions.

ECONOMIC ASPECTS OF SALMONELLOSIS

The term "salmonellosis" covers a complex group of foodborne infections affecting both man and animals. In recent years there has been a substantial increase in the incidence of *Salmonella* infections in a number of industrialized countries. This is not simply the result of improved diagnostic methods or better reporting, and has alerted public health authorities to the need for improved measures of intervention and hygiene in industry and for the consumer. In a number of countries, and also at the international level, expert groups have been set up to propose methods for combating salmonellosis, though so far these measures have had only partial success.

Associated with the increased incidence of salmonellosis, there has also developed a greater awareness of the economic damage caused by *Salmonella* infections, including the cost of interrupted production and trade, and this has led to the undertaking of specific studies on the economic aspects of the disease. Results of some of these studies were reported to the Group, and particular attention was paid to the study being undertaken on behalf of the Government of the Federal Republic of Germany at the University of Trier over a period of four years. This study is of particular interest in its discussion of methods which may prove to be relevant to the study of other communicable diseases, and the following section describes general methods for the economic analysis of infectious disease control, based on the Trier work.

Methods for the economic analysis of salmonellosis

In undertaking an economic analysis of measures to combat and control salmonellosis it is necessary first, to initiate a full and soundly-based study of the relevant epidemiological factors; second, to list and analyse in detail the specific control methods to be used in relation to each factor; and third, after a comparison of all acceptable and economically viable methods, to determine an optimal combination or package of effective and minimum-cost measures. In the Trier study, an optimization model has been developed to study and analyse the problem in these three stages and to prepare corresponding solutions. The modelling approach is particularly necessary in the case of salmonellosis because of the complexity of the infection cycle, with multiple sources of infection and methods of transmission.

The cycle of infection in the present state of knowledge constitutes the basis for examination of the problem in the initial stage. In the case of

salmonellosis this will include, as components, water (including sewage), feedstuffs, animals, foods and humans. The frequency and sequence in which salmonellae occur in each of these components of the cycle need to be examined, as does the connection between the individual components in the overall infection chain, determining not only the direction of the *Salmonella* flow but also its empirical importance. In undertaking this epidemiological analysis, a variety of data sources will need to be used, including *ad hoc* surveys and expert opinion, as well as routine official statistics.

The first phase of the analysis should also include an assessment of the losses caused by *Salmonella* infections. For this purpose, a contamination/infection analysis has to be carried out for each individual component of the infection cycle, by which is meant an exact examination of the possible course of contact of the particular component with the salmonellae. This partial analysis yields two items of information: one on the empirical significance of the different clinical forms, and the other on the assessment of the salmonellae released by the particular component into the cycle as a whole. Both these items are necessary not only for evaluating the effects of possible control measures but also for calculating economic losses. All costs — direct and indirect — can be determined and assessed in quantitative terms on the basis of the individual clinical forms and their empirical significance.

A wide range of measures, some competing and some complementary, are available for the control of salmonellosis and for the avoidance of infection and contamination in the individual fields. On the basis of the above analysis, these various measures can be allocated to relevant points of intervention in the infection chain. This will reveal where control measures are currently being undertaken and where there are gaps. Individual cost-benefit or cost-effectiveness analyses now have to be applied to the alternative measures, which apply at the same points of intervention, and the optimal measure can thus be determined in each case. This classification and assessment of individual control measures constitutes the second phase of the analysis.

The outcome of the investigations up to this point is a proposal for theoretically optimal measures based on cost-benefit criteria relating to the individual components of the infection cycle. It does not necessarily follow, however, that in relation to the complete cycle an optimal situation will only be reached if these partially optimal solutions are implemented in all fields. To clarify this question, it is necessary to measure and incorporate in the analysis the intensity of the flow of salmonellae between the individual components in the infection chain. Given empirical evidence on these connections, Markov chain analysis or other statistical techniques can be used to simulate and extrapolate the effect from a single component in the infection chain to the infection chain as a whole. It is possible on the basis of this calculation to estimate the overall economic costs that will be incurred after implementation of the proposed set of measures. The resulting economic benefit is

the difference between the level of economic costs in the original situation and those obtained as a result of the calculation. The value of these benefits may then be compared with the total costs of the measures in question. An excess of costs over benefits does not, however, necessarily signify that the proposed set of measures is unjustified, since less easily quantifiable factors such as the general value of human and animal health have to be taken into account. Detailed supporting evidence, for example on rates of incidence by age and sex among people, therefore needs to be included in the analysis to allow judgement to be made on non-monetary benefits.

The model of economic analysis outlined above is in principle a simulation and optimization model which enables the effect of different measures to be traced, and evaluated in relation (a) to their efficacy, (b) to the intensity of the connection between the individual components of the infection chain, and (c) to the cost and feasibility of implementing measures to control infection. An important advantage of this optimizing approach is its capacity to demonstrate, for example, that as long as action concentrates on the essential influencing variables in the infection chain, it may be possible to dispense with a large number of individual measures in order to achieve a predetermined ratio of costs and benefits. Analysis of individual control measures in isolation may lead to a result which is suboptimal in the aggregate.

Empirical evidence on the costs and benefits of control

The preliminary results of the study being undertaken in the Federal Republic of Germany have revealed a level of economic costs, relating to the incidence of salmonellosis in man, of about DM 180 000 per 100 000 inhabitants for 1977, equivalent to approximately DM 108 million for the population as a whole. This estimate was calculated on the basis of the number of registered cases of *Salmonella* infections plus a percentage of undetected cases. The percentage of undetected cases was determined according to a computer forecast model based on data on cases of diarrhoea. The estimate covers both direct and indirect economic costs including, for example, wage losses attributable to morbidity and consequent absence from work.

Concerning *Salmonella* infections in animals, the following estimates of total costs were obtained (also for 1977): cattle DM 84 million, calves DM 29 million, and pigs DM 6 million. These include the costs of faecal specimen analyses and of isolating herds, losses in relation to meat and milk marketing, special costs for individual slaughtering operations, and expenses in connection with bacteriological analyses on animal cadavers. In addition to the losses for cattle, calves and pigs, expenses of the order of DM 13 million were incurred in the poultry sector.

Table 1 compares the estimated costs for individual control measures according to the findings of the Trier study, together with the respective

Table 1. The estimated cost and expected success of recommended measures for combating and controlling *Salmonella* infections.

Recommended measures	Cost	Expected success
1. Education and training		
1.1 Education of consumers	low	moderate
1.2 Training and control of personnel in the food industry and catering establishments	high	high
2. Development of early warning systems on a regional basis, with a central unit for rapid transmission of information in the case of incidents of supraregional importance	low	low
3. Improvement of hygiene in the manufacture and processing of foods		
3.1 Investigations to determine routes of transmission in the food industry	moderate	moderate
3.2 Pilot studies on the elimination of sources of infection and/or contamination	moderate	moderate
3.3 Development of quality control systems in the food industry, with official supervision	high	high
3.4 Medical care and selective bacteriological control of personnel employed in food production and processing, who are a source of particular risk	moderate	low
4. Improvement of hygiene and control of catering establishments	low	moderate
5. Hygiene measures among farm animals and pets		
5.1 Hygiene advisory service for farmers and for chiefs of catering establishments, where pets are kept, and of pet shops	moderate	low
5.2 Investigations on the influence of modern animal keeping systems and feeding installations on the spread of salmonellae,	moderate	moderate
5.3 Pilot studies on the elimination of known sources of infection and on the raising of <i>Salmonella</i> -free animals.	moderate	moderate
5.4 Government support of hygiene measures in animal quarters and pasture	unknown	low
5.5 Compliance with precautionary measures during the fertilization of lawns, pastures, etc. with sewage and sewage sludge	low	moderate
5.6 Use of feeds of good hygienic quality	unknown	low

Table 1 (contd)

Recommended measures	Cost	Expected success
6. Feed hygiene		
6.1 Establishment and implementation of microbiological quality standards for feed components and mixed feeds	low	low
6.2 Training and education of feed manufacturers on the choice of feed components and on the production, packing and storing of feeds	low	low
6.3 Control of factory hygiene in feed manufacturing plants by the development of official quality control systems	high	low
6.4 Support of industrial decontamination measures for individual components and/or mixed feeds, and the award of quality seals for the use of recognized effective decontamination procedures	high	low
6.5 Education of farmers and farm workers on the risks of mixed feed production on the premises, using untreated components that may contain salmonellae and on the use of outside mixed feeds which do not meet quality standards.	low	low
7. Liquid and solid wastes		
7.1 Decontamination of hazardous sewage and wastes from factories subject to particular contamination	high	low
7.2 Prohibition of, and/or compliance with waiting periods after, fertilization of farming areas with <i>Salmonella</i> -infected and non-decontaminated sewage sludge	low	moderate
7.3 Compliance with waiting periods before the delivery of agricultural products normally contaminated with salmonellae, and especially for liquid manure between application and harvest	low	moderate
8. Research (development of new methods for the prophylaxis and treatment of <i>Salmonella</i> infections)	high	uncertain

success expected. It should be noted that not all the proposed measures can be carried out at any one time, and optimal combinations of measures have to be worked out on the basis of overall costs and benefits, including non-monetary benefits, as described above. Allowance also has to be made for the different conditions obtaining in different countries, such as differences in the means of accommodating animals and of obtaining and processing foods, in consumption habits and in the medical and veterinary infrastructure.

Areas for future research

The Working Group identified the following areas suitable for future research and study relating to the economic aspects of salmonellosis.

1. On the basis of the experience and results of the investigations into the economic aspects of the control of salmonellosis performed in the Federal Republic of Germany, similar studies should be conducted in other European countries with comparable problems.

2. Efforts should be made to extend and link national studies to take account of the cross-boundary spread of *Salmonella* infections arising from international trade and migration.

3. An assessment should be made of the relevance and applicability of the economic methods developed in the above-mentioned study to other problems of health policy, such as nosocomial infections, sexually transmitted diseases and respiratory diseases.

4. Government control and restrictive measures should be subjected to a critical evaluation after a certain period of application and, if necessary, be changed or abolished. Resources and funds thus made available could then be spent on more promising methods of *Salmonella* control.

5. The following focal points of research in the field of salmonellosis should be paid special attention under their scientific as well as economic aspects:

- cycles of infection and pathogenesis of the most frequently occurring *Salmonella* species
- prophylaxis by vaccination in man and animals (including dietetic and biological measures)
- specific methods of treatment

Close interdisciplinary collaboration of all concerned fields of science and administration is a prerequisite for the realization of these investigations and measures.

ECONOMIC ASPECTS OF RABIES

Of the 33 Member States in the European Region, 11 are at present altogether free of rabies (mainly the countries of northern Europe and the British Isles, as well as Portugal and Malta). In central Europe, wildlife rabies is the predominant form of the disease, and a large volume of scientific data is now available to demonstrate that foxes are the main victims and at the same time also the main vectors of the infection in this region. Other animal species are only secondarily involved and no independent cycles of transmission of infection have been demonstrated. Canine rabies still prevails in eastern and south-eastern Europe and in the Mediterranean region. In these areas dogs, particularly stray dogs, are the most important reservoir of infection. In certain countries of eastern and south-eastern Europe canine rabies exists together with local foci of wildlife rabies.

Bites by rabid dogs are responsible for the vast majority of all human cases of rabies – 90% or more – and a similar proportion of post-exposure treatment occurs in countries affected with canine rabies. In central Europe, where wildlife rabies prevails, only a few cases of human rabies are encountered. In recent years great progress has been made in developing vaccines and immunoglobulins for the prevention of rabies in man, before and after exposure. Very potent vaccines have been developed in tissue culture, which offer improved safety over earlier types. This is particularly true of vaccines grown in human diploid cell (HDC) cultures which, by concentration, can be made highly immunogenic. If properly prepared and administered, they have very few side-effects.

In terms of the traditional measures of incidence and mortality in man, rabies cannot be considered an important disease in comparison with many other conditions. These measures may not, however, give an accurate indication of the *economic* costs of rabies. First, even where incidence is zero, significant and continuing costs are incurred for the surveillance and prevention of outbreaks, such as quarantine regulations, publicity campaigns and the investigation of persons exposed outside the country. Second, sizeable resources are committed in many countries to control the incidence and spread of infection among animals, both domestic and wild. Third, in infected areas there may be significant indirect costs, whereby the presence of rabies lowers the national income from tourism and various forms of agriculture, because of fear of infection.

Little is known about the size and incidence of these costs in different countries, and only a few studies have focused on the problem. A study in North Rhine-Westphalia, Federal Republic of Germany, under conditions of moderate contamination (718 infected animals in 1974), estimated the cost of rabies in 1974 at DM 4 million (1). Of this total, direct costs accounted for DM 3½ million, representing the costs of prevention, surveillance, control, treatment and follow-up. Indirect costs were estimated at DM ½ million, relating to

condemned animals and absence from work. These figures, particularly the estimate of indirect costs, should be regarded as approximate, and more disease costing studies are required.

In undertaking such studies, a realistic forecast of costs should allow for feedback between the health sector and the rest of the national economy, for instance the impact of economic development on rabies and therefore on its costs. It is likely that increased urbanization, the more widespread practice of camping, and increased international travel by man and transfer of animals, will increase the rabies risk. Where such feedback, as well as the interaction between the health economy and the overall economy, can be disregarded, forecasts will be made easier by obtaining cost figures for relevant rabies surveillance and control units. Cost estimates require a detailed knowledge of disease programmes, epidemiology, behavioural effects and data sources. It should be an interdisciplinary task rather than the concern of economists alone.

Similar considerations apply to the evaluation of policy measures for prevention, control and treatment. The economic aspects should be an important consideration in every rabies surveillance and control programme. In national planning and evaluation a working group should be set up to ensure that the relevant aspects and disciplines are taken into account in decision-making. Approaches in rabies surveillance and control among countries also need to be standardized given the multinational dimension of the rabies problem and the risk of infection spreading across national boundaries.

Solution of the rabies problem in man and animals depends on the control and eventual elimination of the disease from reservoir and vector populations in nature. Practical success depends on carrying out carefully planned and well executed programmes, and on using effective vaccines and control procedures for the common vector species. In planning such programmes, particular attention needs to be paid to the dynamic aspects of the epidemiology and ecology of rabies. Thus in central Europe, where wildlife rabies prevails, the incidence of the disease is very closely linked to the overall fox population density. Cyclic increases and decreases in the epidemic, parallel to changes in the population density, have been observed in most affected areas, and in general the fox population today is abnormally high compared with former times. If this could be corrected the rabies problem might disappear, but there is little chance of such a change occurring naturally.

Evidence from the study of the costs and control of rabies undertaken in North Rhine-Westphalia indicates that in that area a systematic programme of gassing fox dens is the most cost-effective method of control. This finding may not apply to the same extent, however, in other areas of central Europe, where there may be differences in topographical conditions and in the denning habits of foxes. Consideration also needs to be given to the wider ecological aspects of major changes in the fox population. More generally, it is to be noted that in planning control programmes the key question to be

answered is not whether to implement a certain approach, such as the gassing of fox dens, but rather to determine the appropriate combination of several approaches towards surveillance and control. It is to be expected that the optimal composition of control measures will differ between countries, depending on their epidemiological, socioeconomic and other conditions. In future studies, account will also have to be taken of the ecological and environmental impact of rabies control measures.

In areas affected by canine rabies, pre-exposure vaccination of the dog population, as an integral part of an overall control programme, has generally proved to be cost-effective. In some countries, however, inadequate mass cover, mainly because of the large number of stray dogs, has rendered this method ineffective. In such circumstances, policies designed to control and eliminate strays may be required. In some areas, the licensing of dogs may help in reducing the dog population, although in the short term this runs the risk of increasing the number of ownerless dogs. In all countries, general education of the public and the provision of specific information to the veterinary and medical professions, concerning rabies outbreaks and the measures to be implemented, are essential to successful control.

Concerning rabies in man, the costs of services provided by physicians and other qualified staff are particularly heavy. A great deal can probably be saved by concentrating mainly on preventive measures, on reducing the incidence of exposure and on the proper assessment of exposure episodes, in order to economize on pre- and post-exposure treatment. In several countries there is a marked difference in the ratio of cases in animals and post-exposure treatment in man. This is a cause for concern, as it may involve costly and unnecessary post-exposure treatment.

As noted earlier, there has been substantial progress in recent years in the development of vaccines and immunoglobulins for human protection, including in particular the manufacture of HDC vaccine. This new vaccine is more potent than its predecessors but is also considerably more expensive. The comparison of vaccines must, however, include all cost components of the various vaccines and their application, including the cost of complications and side-effects, such as hospitalization and absence from work among injected patients. The survey carried out in North Rhine-Westphalia provides appropriate data for such a cost assessment, and it was found that when allowance is made for all cost factors HDC vaccine is less costly than, for example, duck-embryo (DE) vaccine. This is because the higher production costs of the HDC vaccine are more than offset by the higher incidence of vaccine-induced risks and complications associated with the DE vaccine. Among 616 persons receiving DE vaccinations in the survey, there were 58 cases of persons having to take time off work because of complications, for an average of 10 days each, and there were also 7 patients requiring hospital inpatient treatment, for an average period of hospitalization of 12 days each. No vaccine-induced

risks or complications leading to disability or hospitalization were associated with the HDC vaccine.

In spite of the cost savings associated with these reduced levels of vaccine-induced complications, the new vaccines are still extremely costly, and further research needs to be carried out to evaluate the extent to which identical immunization results can be obtained using less vaccine and/or fewer injections. In countries where rates of human exposure continue to be relatively high, detailed evaluation needs to be undertaken of the costs and benefits of providing prompt vaccination for all exposed persons, compared with eliminating or reducing animal rabies. This underlines the point made earlier, that in planning anti-rabies policies the key issue is to determine the optimal combination of measures, and not simply whether to implement a single approach.

ECONOMIC ASPECTS OF HOSPITAL INFECTIONS

Evidence from a number of countries suggests that about 5% of all hospital inpatients acquire infections during treatment in hospital (2,3,4). The most common of these are urinary tract, wound and respiratory tract infections, infections of the skin and subcutaneous tissue, and septicaemia. In terms of the relative importance of these infections, evidence can be cited of a prospective study of approximately 40 000 patients undertaken in a 2200-bed university hospital in the Federal Republic of Germany. This study found an average nosocomial infection rate of 4.4%, with urinary tract infections accounting for 40% of the total, wound infections for 25% and respiratory infections for 16%. Associated with the incidence of nosocomial infection are: first, increased exposure of patients arising from the use of invasive techniques such as catheterization; second, impaired defences of the body arising from the use of drugs or radiation; and third, increased use of antibiotics, causing an increase in the number of resistant organisms in the body. Patients undergoing treatment in intensive care units are particularly at risk. Thus in the above-mentioned study, a separate prospective analysis of about 6000 patients receiving intensive care found an average infection rate of over 12%, with urinary tract infections accounting for about a quarter of the total and septicaemia for a fifth. The incidence of infection was found to be very closely related to average length of stay in the intensive care unit. Despite the importance of nosocomial infections, adequate training on this subject is rarely given to doctors and other hospital staff, and direct or indirect contact with hospital staff is a major cause of infection.

A reduction in the rate of hospital-acquired infections would bring substantial benefits, in terms both of improved health among the population and of savings in hospital expenditure. For example, it has been estimated (5) that in the United States each year nosocomial bacteraemia develops in

about 194 000 patients, and some 75 000 of these die. Hospital-acquired infections are thus a significant cause of mortality, and other substantial indirect costs arise from losses of output due to absence from work and changes of work due to disability. Concerning the direct costs of nosocomial infections, there are about 34 million admissions to general hospitals in the United States every year; approximately 5% of patients develop hospital-acquired infections, each of which adds four days to the length of stay and about \$600 in extra costs (3). Hospital-acquired infections are therefore responsible for the expenditure of around \$1000 million yearly, due to the cost of excess hospitalization. There are similar figures for other countries; it has been calculated, for example (Daschner, F., unpublished data), that decreasing the nosocomial infection rate in the Federal Republic of Germany by a quarter could result in savings of hospital expenditure of up to DM 800 million a year. It has also been noted, however, that hospital administrators in the Federal Republic of Germany may not be overly interested in infection control. The reason for this is simple: the insurance funds which finance health services pay the same amount of money for each day of hospitalization, but because patient care is more expensive during the early days of hospitalization than later on, there is a financial incentive for patients to be kept in hospital longer than necessary. The longer patients stay in hospital, the higher the chance of acquiring an infection. A significant reduction in infection rates could therefore be achieved by more appropriate policies of hospitalization and hospital financing, aimed at reducing the incentives to admit and retain patients in hospital.

From the economic point of view, it would thus seem that substantial savings in expenditure could be made if the incidence of nosocomial infections could be decreased. In order to elucidate the economic aspects of hospital-acquired infections, incidence or prevalence studies should first be undertaken to determine the nature and role of nosocomial infections in each country. The epidemiological data should include analyses of nosocomial infections and their causative organisms in different hospitals, especially in areas at high risk (such as intensive care units); of patient groups at high risk (such as premature babies, old people, and patients with terminal illnesses); of high-risk procedures (such as catheterization, artificial respiration and certain operative procedures); and of the use or abuse of antibiotics in each hospital.

So far, very few controlled studies have been done on the costs and effectiveness of control measures for nosocomial infections. Studies on the economic aspects of nosocomial infections should therefore concentrate on the following questions.

1. Can infection control programmes reduce the incidence of nosocomial infections?

2. How many nosocomial infections must be prevented by a national infection control programme in order for it to be cost-effective?

3. What are the most cost-effective control methods?

4. Which infection control procedures are ineffective in terms of reducing nosocomial infections, and thus cannot be economically justified?

Current information indicates that hand washing and hand disinfection are the most effective and economic infection control procedures. Costly investments such as laminar air-flow systems, architectural designs for zoning operating theatres, separate wards or buildings for infected patients, and separate operating theatres for septic and aseptic procedures, have not yet been shown to reduce cross-infection.

In many countries routine floor disinfection and fogging of rooms with disinfectants are recommended as important infection control procedures. Several investigators have shown however that, one to two hours after floor disinfection, bacterial counts identical to those prior to disinfection are reached (6,7,8). In one study, the floors of the intensive care units in a large hospital were cleaned for six months with disinfectants and for six months with detergents only (7). The rate of hospital-acquired infections was found to be exactly the same in the two periods. The national health authorities in Denmark, the Netherlands, Sweden and the United Kingdom, as well as the World Health Organization, recommend the disinfection of floors only in certain hospital areas and certain situations, such as immediately following significant contamination of the floor with blood, sputum, urine, etc. In the Federal Republic of Germany, DM 40--50 million are spent annually on routine floor disinfection, and it has been estimated that half this amount could be saved without increasing the nosocomial infection rate.

Another significant area of saving is in the use of disposable items in hospitals. Disposables are usually considered to be more expensive than hospital-prepared reusable materials, but in one study (9) the cost of industry-produced dressing material was much lower than the cost of dressing material prepared in the hospital, if costs for personnel, autoclaves, containers, sterilization, etc. are taken into account. It was also found that sterile disposable nebulizer systems, although very expensive, are cheaper than conventional nebulizers if they can be used for more than four days (10). On the other hand, certain very expensive disposable materials such as catheters for pulmonary artery or heart catheterization must be resterilized to become cost-effective. It has been demonstrated that disposable catheters can be resterilized without any harm to patients.

Studies from many countries indicate that between 30% and 60% of all antibiotics used in hospitals are not indicated, are chosen inappropriately or are given in the incorrect dosage (11,12). This is especially true for antibiotic prophylaxis. Several well-controlled investigations have demonstrated the equal effectiveness of a single pre-operative dose, and of one-day or several-day peri-operative prophylaxis, to reduce post-operative wound infections.

Control of the use and abuse of antibiotics is one of the most cost-effective measures in the control of nosocomial infections. Each hospital should develop antibiotic policies and adjust them regularly to the most effective and cheapest substances available.

Many more carefully controlled, prospective, randomized studies need to be undertaken to investigate whether commonly used or recommended infection control methods should be replaced by equally effective but cheaper and more cost-effective ones. In the implementation of more cost-effective control procedures, an essential prerequisite is the employment of specially trained personnel in hospitals (infection control nurses, hospital epidemiologists, etc.). Employment of such staff is costly, but only a relatively small reduction in the nosocomial infection rate is required to justify these outlays in economic terms alone. Thus according to the SENIC (Study on the efficacy of nosocomial infection control) project (8) being undertaken in the United States, it has been estimated that, at 1975 salaries, to employ a full-time infection control nurse and a part-time hospital epidemiologist, with appropriate clinical assistance and miscellaneous other expenses, would cost a hospital about \$20 000 a year for every 250 beds. Since there are some 900 000 hospital beds in community hospitals in the United States, about 3600 such infection control programmes would be needed, at an overall annual cost of around \$72 million. A nationwide infection control programme on this scale can be self-financing, in terms of savings in hospital expenditure, if the nosocomial infection rate is reduced from 5% to 4.7%. In practice it is possible that significantly greater reductions in the infection rate could be achieved by effective control procedures, and it is believed that between 20% and 50% of all hospital-acquired infections could be prevented. The main benefits of reduced infection rates are of course improved health among hospital in-patients, but economic analysis can be used to demonstrate to hospital administrators that control programmes can also lead to substantial savings in direct hospital expenditure. Economic studies should also be undertaken to determine which are the most cost-effective control procedures among the alternatives available.

ECONOMIC ASPECTS OF COMMUNICABLE DISEASES AS A WHOLE

The pattern of disease in society is continually changing, partly under the influence of improvements in medical practice and partly under the influence of social and economic factors such as standards of living, occupational structures and personal lifestyles. Changes in these variables may interact with changes in the health of the population in a variety of ways, and their effects may differ considerably depending on the manner in which the impact of disease and ill-health is assessed. Over the last 50 years there has been a substantial decline, in the industrial societies of Europe and elsewhere, in the

incidence of mortality attributable to communicable diseases. This decline has reflected both sets of influences mentioned above. Thus there have been major advances in medicine, such as the development of vaccines and new therapeutic treatments, while general improvements in economic conditions have brought in their train a number of changes such as better standards of personal and public hygiene and sanitation, improved housing conditions and better nutrition, all of which have contributed to the decline in mortality attributable to infectious diseases. In consequence there has been a general shift in the leading concerns of policy-makers in the health field, to the point where in a number of European countries communicable diseases are now considered relatively unimportant.

Economic costs of communicable diseases

Without seeking to question the underlying causes of this shift, it needs to be emphasized that communicable diseases continue to impose a substantial economic burden on society. Perhaps more important, this burden is probably underestimated by many health administrators. There are a number of reasons for this.

1. The overall cost of communicable diseases may be understated because of inappropriate classifications. For example, the International Classification of Diseases (ICD) is not suitable for assessing the total cost of disease, as a number of major communicable diseases are not listed in Chapter I (Infective and parasitic diseases); influenza, for instance, is included under conditions of the respiratory system (Chapter VIII). Similarly, hospital-acquired infections are often overlooked as communicable diseases, despite their importance.

2. It is often overlooked that many chronic conditions have their origins in communicable diseases. For example, it was noted earlier that about 10% of cases of viral hepatitis B have a protracted course, some leading to cirrhosis of the liver and other chronic conditions. Similarly, if untreated in the early stages of infection, syphilis can cause permanent damage to any tissue or organ in the body, and may lead to potentially fatal conditions such as syphilis of the heart. Thus even if the immediate impact of a given disease appears to be relatively small, there may be substantial secondary effects to be taken into account, if the comparative costs of different diseases are to be correctly calculated.

3. For some communicable diseases such as rabies, the incidence in terms of rates of mortality and morbidity is small (or even nonexistent in some European countries), but substantial continuing costs may be incurred in prevention, surveillance, health education and training.

4. For some communicable diseases, for example salmonellosis and rabies, responsibility for preventive and control measures may fall to agriculture or other ministries outside the health sector. Where direct costs are dispersed in this way, the overall costs may be underestimated by health ministries. Appropriate health priorities and policies should be based on an assessment of total costs relating to each disease grouping, and not simply those costs falling on one sector of the economy.

5. In addition to direct costs, allowance must be made for the indirect costs of communicable diseases, whether measured by production losses in the economy or in other ways. These costs may be substantial. For example, as indicated in the WHO study of viral hepatitis, indirect costs may amount to as much as twice the health service costs.

6. As with direct costs, the distribution of indirect costs relating to communicable diseases may be spread over a number of sectors of the economy. For example, salmonellosis is costly to the food industry, both because of the need to destroy infected animal stock or other food products for human protection, and because salmonellosis is an overt animal disease which can cause great losses in animal husbandry.

For all these reasons, more work is needed in assessing in a systematic way the burden imposed by communicable diseases. The WHO study of the economic costs of viral hepatitis has played a valuable part in indicating to national policy-makers and health administrators the broad order of economic costs relating to one particular condition, and also in providing a framework to be used for other communicable diseases. More studies of this type are needed, with the objective of achieving in each country a broad coverage of cost estimates, across the main disease groupings, based on comparable methods and sources of data within individual countries. A comprehensive set of disease costs on this basis would provide essential information for the setting of appropriate health priorities.

Economic evaluation of control programmes

Disease costing studies provide broad estimates of the total potential benefits to be derived from the prevention or cure of particular diseases. Economic analysis is also required, at a more detailed level, to discover the most economical and effective means of obtaining these benefits. For many communicable diseases, a number of alternative methods of prevention and control are available, and each alternative has different implications in terms of its impact on the incidence of disease and on the use of health service resources. Evaluative research, aimed at clarifying the costs and benefits of different control programmes, is therefore needed to ensure that the best

combinations of measures are chosen. So far very few controlled studies have been undertaken of the cost and effectiveness of programmes for the prevention and treatment of communicable diseases, but such evidence as is available indicates that a number of current interventions are of doubtful effectiveness in relation to cost and that improved strategies of control could have substantial advantages in terms of cost savings and better health outcomes. Detailed research thus offers the prospect of sizeable benefits from more appropriate control policies.

In undertaking evaluative studies, a number of considerations need to be taken into account about methods. First, due attention must be given to the dynamic aspects of communicable diseases, reflecting the continuous changes that occur over time in the incidence of different diseases, in the spread of infections between different groups in the population and in the patterns of disease under different control strategies. In recent years significant progress has been made in the formulation of strictly quantitative epidemiological models of communicable diseases, showing the natural history of diseases in dynamic form and movements of the population between epidemiological classes. Such models have been used to demonstrate, for example, that various communicable diseases behave quite differently in their dynamic aspects. Thus some viral diseases, such as polio and measles, have a tendency to maintain high incidence levels unless control measures are constantly maintained, whereas typhoid is subject to self-elimination when a threshold level of infection is reached and thus may not require investment in additional control measures.

The study of salmonellosis being undertaken in the Federal Republic of Germany provides a good example of how dynamic epidemiological models can be constructed and calibrated, using both hard and soft epidemiological data. From the economic viewpoint a major characteristic of this model is that it indicates action or intervention points in the chain of infection, at which specific measures of prevention or treatment can be applied. As a result, alternative strategies of intervention can be modelled and simulated in terms of their feasibility, effectiveness and cost. The development of dynamic epidemiological models represents an important advance, although the specification of these models may require substantial improvements in the underlying epidemiological data base, particularly for communicable diseases with multiple sources of infection and methods of transmission. Wherever possible, evaluative studies of control measures should be based on a dynamic epidemiological model of the disease concerned.

Having developed a sound epidemiological data base, the next stage in the economic evaluation of control programmes is to undertake detailed studies of costs and benefits for individual methods of prevention, control and treatment. For all communicable diseases a number of methods of control are available but in many cases little is known about the relative costs and effectiveness of the alternatives. It is important that evaluative studies

be undertaken not only for proposed new methods of control, such as the introduction of a new vaccine, but also for existing methods, particularly those of a routine kind. A number of studies have indicated that as the incidence of a given disease changes over time, established forms of treatment may lose their original justification and they should then be phased out or reduced in favour of cheaper alternatives. Particular attention may need to be given to the routine use of hospital treatment, as the hospital sector accounts for the bulk of total health expenditure in all countries, and over recent years hospital costs have tended to rise faster than other health care costs.

In undertaking economic analyses of individual control methods, the following points need to be noted.

Measurement of costs and benefits. In principle the classification and measurement of the *costs* of control policies are relatively straightforward, as these costs largely relate to inputs of physical resources such as manpower, buildings and equipment, provided and financed by public authorities. The prices of these resources are generally known, though there may be practical difficulties of apportionment and allocation in the costing of specific policies. The measurement of *benefits* is, however, much more difficult, and it is neither practicable nor desirable to attempt to measure all the benefits of alternative control methods on a monetary basis. The principle objective of health policies is to improve the health of the population, and improvements of this kind cannot be valued solely in terms of additions to the national income. Non-monetary indicators of outcome therefore need to be developed as well, relating to such aspects as mortality, morbidity and disability; changes in these indicators should then be related to the monetary costs and benefits of alternative control methods. In brief, evaluative studies should be based on cost-effectiveness methods of analysis rather than cost-benefit methods, which suggest an attempt to measure all effects on a common monetary basis.

Distribution of costs and benefits. In addition to showing the overall costs and benefits of alternative control policies, evaluation studies should also indicate the distribution of these costs and benefits, for example between the public and private sectors, and among different agencies within the public sector. In the field of infectious disease control, responsibility for decision-making does not always lie with health ministries alone, and the attitude of other public sector bodies will depend very much on the incidence of costs falling on their own budgets and on possible expenditure savings and other related benefits. Evidence on the distribution of costs and benefits is therefore required if health ministries are to bargain effectively for scarce resources within the public sector.

Timing. The incidence of costs and benefits over time may often differ between alternative methods of disease control. For example, under many preventive programmes the benefits may only accrue a number of years after a large initial input of resources; conversely, under programmes based on treatment at the symptomatic stage, the incidence of costs and benefits may be spread more evenly over time. This differential timing of costs and benefits should always be allowed for by using, for example, the technique of discounting, whereby different weights are attached to costs and benefits occurring at different points in time. The value of the relevant discount factor is often determined by finance ministries for the public sector as a whole, although special considerations may apply in the health sector, particularly relating to the discounting of (non-monetary) health benefits.

Uncertainty. Estimation of the consequences of alternative control methods will require assumptions to be made about crucial parameters which affect the size, scope and likely effects of the measures concerned. Because of the inherent uncertainty of these assumptions, sensitivity analysis should be undertaken in all evaluative studies, varying the key assumptions within a range to discover whether the results are significantly affected. Sensitivity analysis is particularly desirable when discounting is involved, because of the special considerations relating to health benefits.

Multidisciplinary aspects. Wherever possible all evaluative studies of individual methods of infectious disease prevention and treatment should be undertaken on the basis of controlled clinical trials, covering the medical and social as well as the economic aspects of the measures concerned. This requirement emphasizes the fundamental need for a multidisciplinary approach in evaluative research, with the economist showing how to minimize the costs of intervention, and the clinician and epidemiologist indicating how to maximize its impact or benefits.

The final stage of evaluative research, building on the two previous stages of epidemiological modelling and individual cost-effectiveness studies, is to assess the feasibility, costs and outcomes of alternative control *programmes* (a control programme being the combination of a number of specific methods of prevention and treatment). As noted in the section on the economic aspects of salmonellosis, it does not follow that a particular set of measures, each of which is cost-effective when evaluated alone, is necessarily the best in combination. Allowance also needs to be made for possible interactions among the measures concerned when these are implemented simultaneously. The Trier study of salmonellosis control has made the important finding that, when control policies are assessed in terms of an overall programme or strategy, it may prove possible to reduce or dispense with some individual methods of intervention because of their overlap with other control techniques. This in turn suggests the possibility of achieving the desired benefits at lower overall

costs. The assessment of control programmes is therefore a potentially valuable exercise, though necessarily demanding in terms of data requirements and analytical skills, and the Trier study has developed methods which may have useful applications both in other countries and to other infectious diseases.

Training and education in economic methods

The Working Group emphasized two main points. First, with the development and application of increasingly complex scientific techniques, there is a growing need for a multidisciplinary approach at all levels in health service planning, delivery and research. Second, in most European countries there is no established or routine means for physicians and scientists to receive a basic training in economic methods. In some respects the gap between the disciplines of clinical medicine, epidemiology and economics is closing but it is still too large.

RECOMMENDATIONS

In addition to the detailed recommendations for policy and research relating to individual communicable diseases, as given in the previous sections, the Working Group made the following general recommendations.

1. All countries should seek to establish the overall importance of communicable diseases, including nosocomial infections, and also the relative importance of different types of communicable disease. The protocol recommended in the WHO study of viral hepatitis provides a convenient framework for assessing the direct and indirect costs of different conditions, but individual countries will need to determine the applicability of this framework to their own contexts.

2. All countries should seek to promote the introduction and development of sound epidemiological models for individual diseases. Such models should take into account wherever possible the dynamic aspects of disease, and should also attempt to show action or intervention points for specific control measures.

3. Because experience with such models is limited, and in view of the cross-national spread of communicable diseases, exchange of information and analytical techniques among countries should be promoted.

4. Building on the epidemiological models just described, studies should be undertaken of alternative strategies of intervention for communicable

diseases, involving different combinations of individual policy measures. Evaluation should primarily be based on cost-effectiveness techniques of analysis.

5. Research should be undertaken to improve and develop non-monetary indicators of health outcomes, and to relate these indicators to alternative policy interventions and strategies.

6. Institutional arrangements, such as the allocation of health and health-related activities and costs between the public and private sectors, can act as a barrier to the implementation of research findings. Studies aiming at identifying such barriers and the possible ways of overcoming them should be undertaken.

7. Medical students in universities and postgraduate schools of medicine should be given an appreciation of health economics as routine training.

8. Given the need for a multidisciplinary approach in planning and research, short training courses, seminars and briefings should be provided in order to disseminate a basic understanding of economic methods among qualified physicians and related professionals.

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