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Evaluating the costs and benefits of national surveillance and response systems

Methodologies and options

EPIDEMIC AND PANDEMIC
ALERT AND RESPONSE

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Acronyms and abbreviations

AIDS	acquired immunodeficiency syndrome
CDC	United States Centers for Disease Control and Prevention
COI	cost of illness
CostIt	Costing Interventions templates (software produced by WHO)
CSF	cerebrospinal fluid
CSR	Department of Communicable Disease Surveillance and Response
DALY	disability-adjusted life year
HIV	human immunodeficiency virus
IHR	International Health Regulations
SARS	severe acute respiratory syndrome
WHO	World Health Organization
WHO-CHOICE	WHO project: CHOosing Interventions that are Cost Effective
WTP	willingness to pay

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Executive summary

This discussion paper reviews the methods and options for research on costs and benefits of surveillance and response systems for epidemic-prone infectious diseases. There have been very few studies of the costs and benefits of surveillance and response systems, yet such research is especially necessary in the light of revisions of the International Health Regulations (IHR). The International Health Regulations (2005), adopted by the Fifty-eighth World Health Assembly (resolution WHA58.3, 23 May 2005), will require many countries to make additional efforts for the surveillance and response of epidemic-prone infectious diseases when they come into effect in June 2007. It is hoped that the new revisions will increase global cooperation and funding for surveillance and response systems, which are important global public goods. Developing countries will need external funding and assistance to implement the required improvements in their surveillance and response systems, and studies of the benefits of surveillance and response systems undertaken from an international perspective would help to justify such funding.

The paper suggests that the first step in such research would be to undertake separate studies of costs and of benefits – since each is of importance in and of itself.

The feasibility of undertaking cost-utility, cost-effectiveness and cost-benefit studies (where costs are divided by a measure of outcome) is felt to be limited at present. There are almost no studies available that estimate the magnitude of benefits of specific improvements in surveillance and response systems; furthermore, many potential improvements to surveillance and response systems do not lend themselves to quantitative measurement where cost and benefit are directly linked.

On the other hand, surveillance and response should be evaluated together because they are so closely intertwined. The costs of response are dependent on the surveillance system, and the benefits of the surveillance system are dependent on response.

The scope of a surveillance and response system to be evaluated needs to be defined at the outset of a study, and practical criteria must be set up for deciding which activities to include as part of the system and which to exclude. The suggested inclusion criteria are that the activity is a core function or support element of the surveillance and response system or that its main purpose is for surveillance and/or response. For activities whose main purpose is only partially for surveillance or response (such as laboratory diagnosis which sometimes serves both clinical and surveillance purposes), rules for apportioning the cost and/or benefit need to be developed and employed. A key decision in this regard will be how to handle the health care treatment given by the routine health services during an outbreak.

Either a checklist approach or a decision-tree approach can be used to identify the elements of a surveillance and response system for costing. Decisions will be needed on whether to include only financial costs or to include opportunity costs as well, and whether to include marginal costs or full costs. Accounting methods need to be specified at the onset of a study to adjust capital and recurrent costs so that they are comparable, to apportion the costs of shared resources and activities, to adjust for differences in the currency in which funds are spent, to value the costs of activities supported by international donors, and to value the costs of locally donated services.

The perspective of a study has to be determined at the outset. Of the many possible options, a study could use the perspective of the health system, the individual or society as a whole, and could be undertaken at the local level, the national level or the international level.

The design of a study should specify a baseline comparator surveillance and response system, the type of data to be used (retrospective, prospective or future scenarios) and the reference time period. The advantages and limitations of different study designs are discussed in detail.

Benefits from surveillance and response to epidemic-prone infectious disease include health benefits from limiting cases, deaths and disabilities, as well as economic, social and psychological benefits which result from averting outbreaks or controlling them at an early stage. Four methods for estimating the number of cases and deaths averted by surveillance and response are discussed in the paper. These include epidemiological models, data from similar situations in nearby areas, historical data from previous outbreaks, and expert judgement.

Different variables can be used to measure the health and economic value of illness averted to the individual. These include disability-adjusted life years (DALYs) saved, a measure that combines morbidity and mortality into a single index; the cost of illness saved (COI), which estimates the economic costs to the individual associated with each case of morbidity and mortality; and willingness to pay (WTP) and contingency valuation methods, which measure the economic value to the individual of averting illness.

Macroeconomic methods can be used to estimate economic losses attributable to economic disruption during outbreaks. More work is needed, however, before such methods can easily be used by countries for this purpose.

There are other benefits of surveillance and response whose value has not yet been measured; for example, the peace of mind that comes with greater health security. In addition, surveillance and response systems have uses and benefits that are not directly related to detecting and controlling epidemics. At present there are very few estimates of the monetary or economic value of these additional benefits and very little is known about them. Country case studies to identify such benefits and estimate their value would be useful.

A detailed hypothetical example is provided, showing how to evaluate the costs and benefits of surveillance and response for meningococcal meningitis in the African meningitis belt, followed by an example of how to evaluate costs and benefits of adding laboratory capacity for detecting *Neisseria meningitidis* W135.

Suggested next steps are:

1. To undertake pilot studies evaluating costs of surveillance and response systems in 2–3 countries in different regions.

2. To undertake pilot studies evaluating benefits of surveillance and response systems in 2–3 countries in different regions.

3. After completion of country pilot studies, and based on this experience, to bring epidemiologists, economists and national policy-makers together to draw conclusions about research priorities and suggest plans for future evaluation and research.

1. Background

This discussion paper is part of a broader effort by the World Health Organization's (WHO) department of Epidemic and Pandemic Alert and Response (EPR) to strengthen the conceptual underpinnings of national capacity-building activities for surveillance and response with regard to epidemic-prone infectious diseases. Its intended audience includes researchers and policy-makers involved in surveillance and response to infectious diseases. A question often asked is whether there is evidence to show that strengthening early warning and response to epidemic-prone infectious diseases is cost effective. While there is a belief that these measures are cost effective, only anecdotal evidence is available. To date, evaluations of surveillance and response systems have focused on functioning and structure and typically judge quality against a series of attributes such as simplicity, flexibility, acceptability, etc. (*1, 2*). There are virtually no studies on how much these systems cost in developing countries and very few empirical studies of their economic and monetary benefits. It is clear that further evaluation of costs and benefits of national surveillance and response systems is necessary. These evaluations require appropriate methodologies – which are the focus of this paper.

The need for evidence of the costs and the benefits of surveillance and response systems for epidemic-prone infectious diseases is likely to take on even greater importance in the future in the light of the International Health Regulations (IHR) revised by the Fifty-eighth World Health Assembly in May 2005, which will take effect in June 2007. Under the revisions, countries will be obliged "to develop, strengthen and maintain their capacity to detect, report and respond to public health events". This includes economically and socially devastating outbreaks such as severe acute respiratory syndrome (SARS) and Ebola haemorrhagic fever, as well as the deliberate release of biological agents.

Since the new obligations implied by the IHR (2005) revisions will require additional efforts and resources for surveillance and response activities in many countries, WHO has an obligation to provide guidance to countries on how best to strengthen their existing surveillance and response capacity. For example, WHO has been requested "to assess the resources that would be needed to achieve the desired level of capacity" and "to assist in mobilization of specific funds to enable Member States to fulfil their obligations during the implementation phase of the revised regulations" (*3*). To do this effectively, methods are needed to assess the costs of raising the capacity of surveillance and response systems to required levels, and to elaborate and evaluate clearly the benefits at the national and international levels. After all, there are many competing demands on financial resources and a scarcity of qualified health staff in many countries.

Poorer countries in particular will need to know how much it will cost to set up and maintain the expected additional surveillance and response activities, because these countries typically face extreme constraints so that many worthwhile health and other activities are not undertaken for want of sufficient resources. If high income countries are to convince their own national parliaments to allocate funds to surveillance and response efforts in poorer countries, they need to know the economic and health benefits of surveillance and response systems both to the poorer countries that they are funding and to themselves (there are considerable benefits to higher income countries of national efforts in poorer countries that stop the spread of disease across national boundaries). These considerations are all the more important because the surveillance and response to epidemic-prone infectious diseases is a global public good, and such goods by their very nature often face difficulties in obtaining sufficient financial funding. This point is discussed in more detail in Section 2.

This document is an important step in providing evidence of the costs and the benefits of surveillance and response systems for epidemic-prone infectious diseases, in that (1) it reviews the strengths and weaknesses of a variety of methods for evaluating the costs and benefits of such systems and (2) suggests appropriate approaches for undertaking future research.

At the outset, it is important to note that this paper focuses primarily on costs and benefits related to early detection, investigation and response to epidemic-prone infectious disease. The major objectives of early detection of an infectious disease outbreak and the response to it are the limitation of its spread, together with early provision of prevention and treatment. Effective action can result in substantial health benefits in terms of fewer cases and deaths and in substantial economic and social benefits associated with avoiding larger epidemics and further spread to other areas.

This emphasis is taken with knowledge that surveillance information has other uses and value, in addition to enabling early response to a potential outbreak. Other typical uses of surveillance information described by Teutsch (*4*) include estimating the size of a health problem in a population, documenting the distribution and spread of disease, understanding the natural history of a disease, evaluating control strategies, identifying research needs and facilitating planning. This paper does not consider in great detail the economic value of these additional benefits of surveillance information, because they do not lend themselves well to estimates of quantitative health and social outcomes or monetary economic benefits.

A step by step approach to cost and benefit analysis is used in the document. Section 2 focuses on the International Health Regulations. Section 3 discusses issues in specifying the scope and design of cost and/or benefit studies. It covers the scope of surveillance and response systems, distinguishing between perspectives of the health system and society as a whole as well as between local, national and international perspectives. This section also covers comparisons with baseline surveillance systems; retrospective, prospective and future scenario study designs; and reference time frames. Section 4 focuses on measuring the costs of surveillance and response systems, while Section 5 is concerned with evaluating their benefits. Sections 6 and 7 provide hypothetical examples of costs and benefits for surveillance and response to meningitis, illustrating the steps required for an analysis of costs and/or benefits of a surveillance and response system. Section 8 sums up the conclusions.

It should be emphasized that the amount of work required in order to develop methodologies and, eventually, guidelines for the analysis of costs and benefits of surveillance and response systems should not be underestimated. Many of the methods suggested in this paper require considerable adaptation before they can be used. The intention at this stage is to lay the groundwork for discussion and further empirical work at the local, national and international levels.

2. International Health Regulations

This section discusses the International Health Regulations (IHR) and their importance for studies of the costs and benefits of national surveillance and response systems. It begins with a brief overview of the IHR. Discussion follows of why national surveillance and response systems should be viewed as global public goods and the role played by international agreements such as the IHR. This is the context within which the costs and benefits of national surveillance and response systems need to be considered.

2.1 Implications for surveillance and response systems

The International Health Regulations are a set of practices agreed to by countries with the aim of preventing the international spread of disease using measures that interfere as little as possible with international trade and travel. The IHR have recently been revised in the wake of new challenges posed by emerging and re-emerging infections, increased international travel and trade, and changes in communication.

The revised IHR – known as IHR (2005), which will come into effect in June 2007 – will require states to notify WHO of events that constitute a potential public health emergency of international public health concern. States also must respond to requests from WHO regarding verification of suspected outbreaks. Many countries (especially developing countries) will need to upgrade their surveillance and response systems in order to be able to comply with the IHR requirements to detect and verify such events (see Annex).

WHO will provide technical guidance and assistance to Member States as necessary to enable them to upgrade their surveillance and response systems and to respond to potential public health emergencies. WHO will also make recommendations for appropriate actions to be taken, when a country faces a potential public health emergency of international concern.

The revised International Health Regulations are expected to play an important role in improving the surveillance and response to epidemic-prone infectious diseases. They will enhance national surveillance and response and will increase international communication and cooperation. The implications for the benefits of surveillance and response systems are important, as these benefits will be enhanced by improved worldwide practices and cooperation.

2.2 Surveillance and response as global public goods

Surveillance and response to infectious disease belong to a class of economic goods known as public goods, the two key characteristics of which are:

- there is no practical way of restricting use of the good to those who pay;
- use of the good by one individual does not reduce its use by others.

Clean air is a good example of a public good. There is no practical way in which the use of clean air could be restricted to the individuals who pay for the antipollution measures required for air to be clean. In addition, the fact that one person uses the clean air does not prevent another person from using it. (This is unlike food, for example, which is used up when eaten, so that the same food cannot be eaten by more than one person.)

Because the use of public goods cannot be limited to only those who pay for it, it is often difficult to convince all individuals who benefit from the public goods to pay for them. After all, individuals will benefit whether they pay for the public good or not – provided that someone else pays. This is known as the "free rider" problem. For this reason, public goods are usually paid for by governments rather than by individuals; otherwise the public good would be grossly underfunded.

It is easy to see why preventing the spread of infectious disease by surveillance and response is a public good. Many people benefit from the preventing the spread of infectious disease – but there is no practical way to restrict the benefits to those who pay for maintaining the surveillance and response system. Consequently, there is no practical way to oblige those who benefit from preventing the spread of disease to pay for this benefit – especially if they think that they will be able to obtain the benefits without paying for them – unless it is done by the government. For this reason, it is best if the surveillance and response of infectious diseases is funded by governments rather than by individuals.

The "public good" properties of surveillance and response systems for epidemic-prone infectious diseases also apply at the international level. The benefits of a national surveillance and response system go beyond national borders, because an undetected or uncontrolled outbreak is more likely to spread to other countries. In addition, the reporting requirements and information-sharing mechanisms of the IHR enhance the international benefits of the detection of outbreaks, because they provide for informing other countries of any serious public health risks that may spread internationally. For many infectious diseases there is worldwide risk, for which it is appropriate to consider surveillance and response as a **global** public good.

2.3 International agreements and global public goods

There is no practical way to oblige any country to pay for the benefits it receives from the surveillance and response system of another country; other countries benefit automatically even if they do not help to pay for the system. Unlike at the national level, at the international level there is no government responsible for providing public goods. Instead, countries must cooperate and develop agreements and treaties, such as the IHR, if such goods and services are to be provided at the level that would be warranted based on the benefits received by all countries. The IHR framework, by obliging all states to have core capacities for surveillance and response and to report potential emergencies of international concern to WHO, means that countries will act together in this regard, and so there will be few (if any) free-riders.

Developing countries will need external funding and assistance, however, to implement the required improvements in their surveillance and response system, because they face many competing demands on their scarce resources. In light of the benefits for both higher and lower income countries and the global public good represented by national surveillance and response systems in lower income countries, it is hoped that the IHR framework and associated international cooperation will overcome the financing problems of poorer countries. For this to happen, well-documented studies of costs and benefits of surveillance and response systems for epidemic-prone infectious diseases, from an international perspective, will be important.

3. Defining the scope and design of studies

There are a number of issues involved in defining the scope and design of studies on the costs and benefits of surveillance and response systems, and they need to be considered before deciding on the most appropriate research methods to use. These issues include:

1. whether separate studies of costs and benefits would be useful;
2. whether it is advisable at the present time to undertake cost–utility, cost–effectiveness or cost–benefit analyses;
3. whether surveillance systems and response systems should be studied separately or together;
4. which activities should be included in surveillance systems;
5. which activities should be included in response systems;
6. the extent to which services provided by the routine health facilities during an outbreak should be considered to be part of response;
7. which perspective should be considered: that of the government, the health sector, the economic sector, individuals, families or society as a whole;
8. whether local, national or international perspectives should be used;
9. which baseline surveillance and response system should be used as a comparator to evaluate costs and benefits;
10. the use of retrospective, prospective and future scenarios for evaluation of costs and benefits;
11. the reference time period to be used to evaluate costs and benefits.

Each of these issues is discussed below, solutions are suggested and the rationale for them is provided. As some of the issues are controversial and several reasonable approaches are possible, suggested solutions should be seen as providing what the author feels would be the most productive path for the near future, given the current state of the art and information requirements.

3.1 Should there be separate studies of costs and benefits?

Issue 1 – Given the current state of knowledge, and current scarcity of evidence and appropriate methods, would separate unlinked cost and/or benefit studies be valuable on their own?

At present there is a lack of information on both the costs and the benefits of surveillance and response systems for epidemic-prone infectious diseases. This means that improved information and knowledge on costs and benefits would be valuable.

Concerning costs, there is very little information on the costs of the major components of surveillance and response systems in different country settings, yet such information is vital for setting up and sustaining an effective surveillance and response system. It is also necessary information for the many countries that will be expected to improve their surveillance and response system as part of the revised IHR. Therefore, studies of the cost of surveillance and response systems would be useful in themselves, even if they do not address benefits at the same time. Studies of costs will not be easy to do: they will need to be complex and innovative. In the first instance, it would be quicker and easier to study costs without regard to benefits, in the author's opinion.[1]

Concerning benefits, WHO's Member States will need this information in order to justify significant increases in funds needed for the increased surveillance and response capacity-building implied by the IHR (2005) provisions. There have been very few studies that directly value the benefits of surveillance and response activities. Benefit studies will not be easy to carry out either, given the variety of potential objectives and benefits and the difficulty of attributing benefits to specific surveillance and response activities. This means that separate studies of the economic benefits at the local, national and international levels could potentially provide valuable contributions to knowledge.

Suggested solution for issue 1. At the present time, separate studies of costs and of benefits would be valuable in their own right.

Issue 2 – Would it be advisable at present to undertake cost–effectiveness, cost–utility and/or cost–benefit analyses?

Cost-effectiveness, cost-utility and cost-benefit analyses are used to compare the costs of a health intervention with its benefits. The estimates are made by dividing the costs of a health intervention by the outcome (i.e. the benefit) of the intervention. They differ in the way in which they measure outcomes.

Cost–effectiveness analysis is used to facilitate choice between several competing alternatives. For-example, in order to select the best value per dollar spent among alternative methods of preventing cases of an infectious disease, cost-effectiveness analysis would indicate the method that costs the least per case prevented. Cost-effectiveness analysis works best when there is only one primary outcome of an intervention, because it compares like with like. For example, for a surveillance and response system, one might use cost-effectiveness analysis to help identify (among several alternatives) the most cost-effective method for the early detection of outbreaks. Cost-effectiveness analysis might theoretically answer the question of which surveillance method is more cost effective in detecting outbreaks – routine surveillance, sentinel surveillance, or computerized surveillance methods using a ratio of cost per outbreak detected. A prerequisite to cost–effectiveness analysis, however, is the availability of well-documented studies and evidence on the outcomes of each alternative intervention. At the present time such studies are lacking for the surveillance methods commonly used; therefore, the use of cost–effectiveness analysis for surveillance and response methods will need to wait for improved evidence and a greater body of knowledge about surveillance methods to become available.

Cost-utility analysis is similar to cost–effectiveness, except that the outcome used is quality-adjusted life years. This measure combines morbidity and mortality in a single index.

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[1] An argument against doing cost studies that do not consider benefits is that, if the resulting costs are high, these studies might discourage spending on surveillance and response activities – because potential benefits are not estimated. Arguments along this line could be handled by listing the potential benefits, without necessarily quantifying them.

Disability-adjusted life years (DALYs) are one form of quality-adjusted life years that has been used extensively by WHO to evaluate health interventions. Cost–utility analysis is suitable when the outcomes of the intervention are directly related to either morbidity or mortality, or both. Unlike cost–effectiveness analysis, cost–utility analysis can handle mortality as well as several different morbidity outcomes at the same time. For example, it might be possible to use cost–utility analysis to evaluate the cost per DALY saved by early detection and response to a meningitis outbreak. First, one would need to calculate the costs of early detection and response. Then one would need to use epidemiological models to judge the number of cases of meningitis prevented by early detection and response. One would also calculate the number of deaths prevented and the number of cases with disabling sequalae prevented and combine these into DALYs. The costs of early detection and response would then be divided by DALYs saved to give the cost of early detection and response per DALY saved. The result could be compared with the cost per DALY saved for other health interventions, in order to identify interventions with the best value for money in terms of health outcomes (morbidity, mortality and disability).

This is a complicated process. Calculating DALYs saved requires sophisticated epidemiological modelling in order to be able to say with confidence how many deaths and cases would have occurred in the absence of early detection and response. Such models are available for some diseases (an example for meningitis is provided in Section 6 of this document), but not for all epidemic-prone infectious diseases. An important limitation of cost–utility analysis is that only the health costs and the health benefits to the individual are considered, and it is not suitable for considering other costs and benefits, though one major benefit of surveillance and response systems is the avoidance of economic costs attributable to lost business and commerce associated with outbreaks.

Cost–benefit analysis measures all benefits in monetary terms. It does not require one intervention to be compared with another, because when the cost to benefit ratio of an intervention is less than one, this implies that the intervention will result in a net saving and hence is worth while. Assigning specific monetary values to improved health and increased life expectancy, however, is controversial. Economists have developed a number of methods to do this (such as willingness to pay, cost of illness and the value of foregone income, as described in Section 5), but each method has disadvantages and none has been widely used and validated in developing countries.

Suggested solution for issue 2. Comparison of costs and benefits is desirable, but the extent to which it is feasible to set costs of a specific aspect of surveillance and response systems against the benefits from this aspect (using cost–effectiveness, cost–utility or cost–benefit analysis) is limited at present. One reason is that it is difficult to attribute specific benefits to specific aspects of surveillance and response system. For example, public health laboratories are crucial for early warning and response to outbreaks, as they are required for identification of disease pathogens and thus for efficacious response. Improvements in public health laboratories should therefore result in more timely response because time would not be lost by sending specimens abroad for identification. However, there are no well-documented scientific studies that estimate the amount of time saved for specific laboratory improvements. Without evidence from such studies it is not possible to use cost–effectiveness, cost–utility or cost–benefit analysis to identify those improvements in public health laboratories that represents the best value for money. Similar problems arise for other improvements to surveillance and response systems, such as streamlining the list of reportable priority diseases, improving feedback, or integrating disease surveillance. Until there are scientific studies where the magnitude of specific benefits is attributed to specific changes in the surveillance and response systems, it will not be possible to set the benefits of such improvements against costs in a quantifiable way, and therefore to use cost–effectiveness, cost–utility or cost–benefit analysis.

While it may be possible in the future to do quantifiable studies of the costs and benefits of some improvements to surveillance and response systems, others do not easily lend themselves to the types of analyses described here. For example, the costs and benefits of reorganizing a surveillance and response system would be very difficult to measure quantitatively, and results from one setting are unlikely to be generalizable to other settings.

Given the problems inherent in cost–effectiveness, cost–utility and cost–benefit analyses, and the scarcity of empirical work on quantifying the benefits of surveillance and response systems, it would seem wisest, in the author's opinion, to concentrate at present on separate studies of costs and of benefits rather than combining them into cost–effectiveness, cost–utility or cost–benefit studies. This paper therefore concentrates on methods for measuring costs and benefits separately and gives less attention to comparing costs with benefits. In the future, when both the costs and benefits are better measured and understood, comparisons of costs with benefits might be more fruitful for some aspects of surveillance and response.

3.2 What should be included in a surveillance and response system?

Before beginning a cost or benefit analysis, it is necessary to clarify what is included in the surveillance and response system and what is excluded; only then is it possible to evaluate costs or benefits. In addition, one needs to know whether the evaluation is going to be of an entire system or of a subsystem such as a weekly or monthly surveillance and response system.

Surveillance and response activities are diverse, and spread over many layers of the health care system. This is natural because of the variety of pathogens and associated natural histories, the diversity of public health objectives, and differing political, administrative, legal and medical systems found in the world today. All of these factors affect the way in which surveillance and response are carried out.

Most countries have several surveillance and response systems running simultaneously. Some are aimed at early detection, verification and response to public health events of potential importance such as outbreaks of serious epidemic-prone diseases; others focus on monitoring disease trends, and still others have specific programme objectives such as the eradication or elimination of specific diseases. There may be weekly and monthly reporting systems as well as laboratory reporting systems. There may be compulsory reporting systems for some diseases, and sentinel reporting systems for other diseases. There may be several vertical surveillance and response systems as well as partially integrated systems. Systems may use different methods of data collection and analysis, cover different geographical areas, and be partially or fully overlapping. Indeed, every surveillance and response system is complex. This means that it is always necessary to define the scope of the surveillance and response system to be evaluated before undertaking a cost or benefit analysis.

Cost and benefit studies also differ in the specific aspects of surveillance and response systems they evaluate. A review of the literature did not find any studies that evaluated the cost and benefits of an entire national surveillance and response system. Instead, the studies that were identified measured the costs and/or benefits of specific surveillance and response activities. This means that the few studies that have been made have evaluated some parts of surveillance and response systems (particular features or subsystems) or the potential costs and/or benefits of changes to an existing surveillance and response system.

Decisions on what should be included in the system under evaluation are crucial for defining the scope of cost and benefit analyses. This section gives some general guidance on these decisions, but in practice each situation is different. In general, the objectives of the system under evaluation should be the basis for defining scope of study to evaluate costs or benefits.

Issue 3 – Would it be better to evaluate the costs or the benefits of surveillance separately from the costs or the benefits of response? Or should surveillance and response activities be evaluated together?

It might seem easier to treat surveillance and response separately, because the functions (and their costs) that constitute surveillance are distinct from the functions (and costs) that constitute response. Therefore if one looked only at costs, it would be possible to evaluate a surveillance system separately from a response system. However, because surveillance often triggers response activities, the cost of response depends partly on the way in which the surveillance system is functioning. A surveillance system that triggers too many false alarms will add to the cost of response. In contrast, a surveillance system that provides warnings of potential epidemics which are followed up by early response will lower the cost of response, because the outbreaks will be controlled early. In terms of costs, therefore, the response system is closely linked with the surveillance system, so it makes sense to study the costs of surveillance and response systems together.

In terms of benefits, it is not possible in practice to separate the value of the benefits of surveillance from the value of the benefits of response. The main purpose of surveillance information is to inform public health decisions in order to provide a better response. (Response in this situation is considered in its broadest sense: actions and decisions that are taken based on surveillance information.) One can think of the value of information as being the difference in value between the decisions taken with the information available and the decisions that would have been taken had the information not been available. For example, if a surveillance system signals an outbreak of a serious infectious disease and no action is taken based on this information, the information does not have any tangible value that could be measured. It is the conclusion of the author, therefore, that it would not be reasonable to separate the value of surveillance from the value of response when analysing benefits.

A philosophical argument can be made that surveillance information is knowledge, and that knowledge has intrinsic value in and of itself, even if no action is taken as a result. However, even if it is agreed that there is some intrinsic value in this knowledge, that value would be impossible to measure.

Suggested solution for issue 3. Although it is possible to cost the surveillance system separately from the response, the cost of the response system depends, at least in part, on the information that is provided (or not provided) by the surveillance system. In addition, the benefits of surveillance are closely linked to – and difficult to separate from – the benefits of response. Therefore, it makes sense for surveillance and response systems be considered together for analysis of their costs and benefits.

Issue 4 – What elements and activities should be included in a surveillance system?

In order to determine the costs and benefits of a surveillance and response system, it is necessary to have a clear idea of which activities are included in surveillance and which are excluded. The main emphasis in this section is to separate information-gathering activities that are part of surveillance, and those that are not.

Surveillance has been defined in the *Dictionary of epidemiology* (*5*) as "systematic ongoing collection, collation and analysis of data and the timely dissemination of information to those who need to know so that action can be taken".

The basic core functions of surveillance systems have been listed by McNabb, Chungong, Ryan, and others (*2*) and include:

- case detection;
- case registration;
- case confirmation (including verification of rumours);
- reporting;
- data analysis and interpretation;
- feedback.[2]

Basic support elements needed for the basic core functions to work well are also listed as follows:

- standards, norms and guidelines;
- training;
- supervision;
- resources (including staff, laboratories and other resources).

In addition to the above generally accepted definition and lists of key components, further criteria are required to determine whether specific activities should be considered part of the surveillance system. For example, despite the fact that many outbreaks are detected during normal patient visits to health facilities, each study will need to determine the extent to which the cost of running health facilities should be included in the cost of the surveillance system. Should the time and cost to diagnose and treat patients be considered part of the surveillance system, such as the activities involved in sending a specimen to the laboratory for testing, or the time the doctor takes to record the diagnosis? While activities such as these are critical for surveillance, they would be carried out in any case as part of the diagnosis and treatment of patients.

One possible way to decide whether an activity should be considered part of a surveillance system is to make a judgement as to whether the activity is a core function or a support element, as listed above. If so, or if its main purpose is for surveillance, it makes sense to include the cost of the activity in the cost of the surveillance system; if not, it makes sense to exclude the cost. Using this approach, if an activity is one of the six core activities or four support elements or its main purpose is surveillance, its cost should be included in the cost of the surveillance system. If an activity is important for surveillance but its main purpose is different, its cost should be excluded. For example, even though the news media often bring outbreaks to the attention of health officials, they are not part of the surveillance system per se, because their main function is reporting news and not surveillance. However, the investigation of media reports and their

[2] Dissemination was not listed separately as a surveillance function. It would be reasonable to consider dissemination as part of feedback.

verification by health officials should be considered part of surveillance. Likewise, activities carried out in the course of routine health services, such as diagnosing and treating patients in health facilities, would not normally be considered as part of the surveillance system unless they were specifically undertaken for surveillance purposes. However, reporting activities carried out by the routine health services would be included.

Even with these extra criteria, some activities serve several purposes. For example, sending specimens for testing may serve both surveillance and treatment purposes. Methods of allocating a proportion of costs or benefits for some activities to surveillance and response will often be required.

Suggested solution for issue 4. Include in surveillance those activities that are part of the six core functions or four support activities listed above, or whose main purpose is surveillance. Despite the fact that this inclusion criterion may be ambiguous for some activities, it provides a workable approach. The core and support activities are well understood and well accepted. At a later time, after a few country studies have been carried out and there is greater experience with this process, it should be possible to refine the inclusion criterion and to provide clear examples of how to deal with ambiguous activities. Proportional allocation of costs and benefits may be necessary for some activities.

Issue 5 – What elements and activities should be included in a response system?

It is also necessary to decide which activities are parts of a response system. An outbreak investigation is the first step in outbreak response. According to WHO (6), this typically includes activities such as:

1. confirming the diagnoses;
2. active case finding;
3. taking clinical and environmental samples;
4. analysing and interpreting data;
5. formulating and testing hypotheses about sources of exposure and modes of transmission.

Control measures during outbreaks are aimed at:

- eliminating or reducing the source of infection;
- interrupting or reducing transmission;
- eliminating or reducing exposure and personal risk;
- diagnosis and clinical management of cases.

These measures typically include all or some of the following activities:

- case management, including infection control;

- contact tracing;
- analysis and dissemination of laboratory information;
- environmental control measures;
- mass prevention;
- behaviour modification;
- communication;
- social mobilization.

In addition to the above control measures, there would probably be broad agreement to include in response systems activities related to epidemic preparedness (such as creating operational plans and stockpiles for emergencies) and emergency services specifically used during an outbreak (such as a cholera treatment camps or meningitis vaccination campaigns).

Suggested solution for issue 5. It makes sense to include as part of outbreak response any activities that have as their main objective the aim of investigating or controlling outbreaks. This includes activities specific to emergency planning, plus activities or emergency services that are only used in the wake of an outbreak, such as cholera camps and emergency vaccination campaigns.

It is important to realize that information that signals a potential outbreak may not necessarily originate from the surveillance system, or even from the health system. Nevertheless, investigations and actions taken on the basis of any information should be considered as part of response, no matter where the information comes from.

Issue 6 – To what extent should routine health services be considered as part of a response system?

A key decision for any study will be the extent to which the routine health services provided to individuals during an outbreak should be considered as part of a response to the outbreak. (Discussion of issue 4 above concluded that reporting by routine health service providers should be considered part of surveillance.) On one hand, routine health services are ongoing whether or not there is an outbreak: this argues for their not being considered part of the outbreak response system. On the other hand, during most outbreaks, the routine health facilities and health services provide a large proportion of treatment services, often well beyond their normal workloads. They are thus an integral part of response, without which outbreaks would be difficult to control, and it is difficult not to consider them as part of outbreak response.

There are three possible ways of handling routine health services provided during an outbreak when evaluating the costs or the benefits of surveillance and response systems.

1. One could exclude routine health services completely, arguing that they would be present even without a response system and that the response system refers to emergency services that are only used during an outbreak (such as cholera camps).
2. One could count routine services for the outbreak disease during the outbreak (thus during a meningitis outbreak the cost of all meningitis cases seen by the routine health services would be included). The argument for this approach is that the routine services are the ones that usually bear the brunt of outbreak control, and that outbreak response is a key function of routine services.

3. One could count only the extra cost of treating cases incurred during an outbreak (that is, the cost of treatment over and above the usual cost for the time period). This would require detailed data that are often not available.

Given that all three of the above ways of considering routine health services are reasonable, depending on the situation, ranges of values should be provided based on different assumptions. An example of this is provided by Van Damme & Van Lerberghe (*7*) who differentiated between the costs and the benefits of emergency and routine services during outbreaks in one prefecture in Guinea using models and assumptions. While their assumptions were subjective, they seemed reasonable.

Suggested solution for issue 6. The reporting of health events to the next higher level, which is routinely carried out by the health services, should be considered as part of surveillance activities (see discussion of issue 4). In addition, activities in which health staff from the routine services participate in outbreak investigation and emergency planning for outbreaks should also be considered as part of surveillance and response. The extent to which the provision of services by the routine health services during an outbreak should be considered as a response activity will depend on the purpose of the study undertaken and the perspective used. For example, if the perspective of the health services only is being used, the argument that the routine services are always available and therefore there is no extra cost involved in the provision of these services during an outbreak may be acceptable. If, in contrast, the perspective of the whole society is used, there will be an opportunity cost to society of the extra services provided during an outbreak. Studies that include part of the routine services provided during outbreaks as response activities should estimate the amount (and the opportunity cost) of extra work (over and above the usual workload) done by the routine services during an outbreak.

3.3 Whose perspective should be used?

Issue 7 – Whose costs and whose benefits should be considered? Should it be the individual, the health system, or society as a whole?

A key decision in an analysis of either costs or benefits is which perspective to consider. Whose cost – and whose benefit? This has to be the starting point of any analysis.

For example, individuals benefit from the avoidance of outbreaks brought about by effective surveillance and response in different ways, the most obvious of which are the health benefits from cases and deaths averted. Another benefit is time not spent caring for the sick by family members. There are also economic and social benefits from outbreaks avoided, especially for businesses involved in travel and trade. The health care system benefits by reduced treatment burden and less disruption of services.

Costs are also different depending on which perspective is used. For example, from the point of view of a finance officer in the health administration, only financial costs are important. If so, then adding additional reporting burdens on health service providers that would not have any financial cost (because the health service providers are employed whether or not they take on additional tasks) are not of concern to the finance officer in this example. However, these additional reporting tasks would not be costless from the point of view of society, because additional tasks generally take time away from other duties. So even though the additional reporting by health service providers may not increase the financial cost of health services, the time it takes them to report may be costly in opportunity costs such as the lost opportunity to perform other tasks.

Whether or not to include opportunity costs, and whose opportunity costs to include, will depend on the purpose of a study. In the above example, if a cost study is done to provide a finance officer with an estimate of the money needed to pay workers, the opportunity costs of the health care worker should probably not be included in the study. If, on the other hand, the purpose of the study is to determine the costs of additional surveillance reporting on society as a whole, these opportunity costs should be included.

The decision on which perspective to take therefore has important implications for which costs or benefits to include in the study. A narrow point of view might consider only direct costs to the health system and direct health benefits of the avoidance of cases and deaths to individuals. A wider point of view would also consider social, health and economic costs and/or benefits (including opportunity costs) to individuals and to society as a whole. Most studies would fall somewhere in between. It probably will not be feasible to include all costs or all benefits to everyone in a study, and strategic choices will be needed for selecting the most appropriate perspective.

***Suggested solution for issue** 7.* The decision on whose viewpoint to adopt will need to be taken on a case by case basis and will depend on the reason for doing the study and the likely audience.

Issue 8. Should the perspective for a study be local, national or international?

Another key decision is whether to include only the costs and benefits to the local area, to the country as a whole or to the international community. The national level is the most appropriate one if the key audience for the evaluation is national policy-makers in the country. A case can be made for a local evaluation, when policy-makers at the local level make up the key audience.

A case can also be made for using an international perspective even when a local or national surveillance and response system is being studied. As has been shown only too clearly in recent outbreaks of poliomyelitis and severe acute respiratory syndrome (SARS), diseases do not respect national boarders. The surveillance and response system in any one country is therefore of considerable value to other countries and to the international community as a whole. Furthermore, surveillance and response costs in poor countries often need to be subsidized by resources from developed countries. The international perspective is thus a valid one for evaluating both costs and benefits of national and local surveillance and response systems.

***Suggested solution for issue 8**.* The decision on which viewpoint to take will vary across studies. There is increasing recognition of the benefits of surveillance and response systems at the national (and local) levels for other countries. The perspective to take in any one study will ultimately depend on the purpose of the study and its intended audience.

3.4 Study design

Issue 9 – When evaluating the costs and benefits of a surveillance and response system, what should be the baseline comparator system?

The evaluation of a surveillance and response system requires comparison with a baseline system, so as to measure the difference that the surveillance and response system makes to the outcome of outbreaks of epidemic-prone diseases. Even without a surveillance and response system, an outbreak of a serious epidemic-prone disease would eventually be recognized and responded to if it became large enough. Comparing surveillance and response systems with a baseline system is analogous in some ways to comparisons made during clinical trials in which particular medical interventions are compared with placebos, and to trials of new interventions in which the new interventions are compared with "current practice".

Different baseline systems could be selected as the comparators depending on the scope of the system under evaluation. Possible comparators include the current system, the current system without the particular features under evaluation, and the null system. Examples of the use of baseline systems for comparison are presented below.

Example 1

To evaluate a new feature of a surveillance and response system, it would make sense to use the current situation as a baseline for comparison. This requires some projections (or at least informed expert judgement) about how the new feature is expected to change the functioning of surveillance and response – including attributes such as timeliness and effectiveness of responses. Is the new feature expected to increase the timeliness of a system so that it can detect outbreaks more quickly? Will there be more or fewer false positives? Will response be earlier or more effective when the new feature is in place? Issues such as these will need to be factored into the calculations of the costs and benefits of the surveillance and response system.

Although it may be impossible to know beforehand how a new feature of a surveillance system will change the timeliness and effectiveness of response, the direction of the change should be predictable. If necessary, Delphi methods can be used to develop a consensus regarding the magnitude of likely effects of the changes on the surveillance and response system.

When expected effects of the proposed changes have been established, the costs and benefits of the surveillance and response system with and without the new feature can be evaluated over time. This can be done using retrospective data from the recent past and elaborating the costs or benefits had the new system been in place during that time (for an example see Kaninda et al. (*8*)) or by developing likely future epidemiological scenarios and comparing projected costs and benefits of the new system with the projected costs and benefits of the current system.

Example 2

One might evaluate features recently adopted in a surveillance and response system, by comparing the current operations of the system with how it functioned in the past before the new features were adopted. It would be necessary to be sure that the changes measured could be clearly attributed to the new features of the system – something that will generally be difficult to do in practice.

Example 3

Another alternative would be to evaluate a whole surveillance and response system with respect to the null system (i.e. the counterfactual situation that no surveillance and response system is in place). The null system has been used to evaluate interventions in the context of national level priority-setting in the health sector (*9*). The advantage of using the null system as a comparator is that it allows for the evaluation of the surveillance and response system as a whole. A disadvantage is that it is difficult to quantify and provide evidence for what would have happened under the null system.

Suggested solution for issue 9. It will be necessary to select a baseline surveillance and response system for comparison. The system selected will depend on the purpose of the study and the types of data and models available.

Issue 10 – Should retrospective data, prospective data or future scenarios be used for the evaluation of surveillance and response systems?

There are three main study designs that can be used for evaluation, namely, retrospective studies (how the surveillance and response system performed in the past), prospective studies (the functioning of the current system on an ongoing basis) and studies that use models and future hypothetical scenarios (to project how the system will function in the future, based on past experience and expert judgement).

Each study design has strengths and weaknesses. Retrospective studies often have problems in obtaining the data needed, since such data may not be available or may not have been collected in sufficient detail. Retrospective data might not be easy to find, and accuracy is often difficult to verify. Prospective studies avoid some of the problems of retrospective studies in that data are collected on an ongoing basis. Prospective studies take time to complete, however, and they are often more expensive than retrospective studies because they require active data collection. Studies of features or systems that are not yet operational must be based on assumptions, models and hypothetical future scenarios. As they are not based on experimental evidence, the quality of such studies is largely reliant on the realistic quality of the assumptions and future scenarios. The costs and benefits of the system under the selected scenarios would be compared with the costs and benefits of the baseline system under the same scenarios.

Suggested solution for issue 10. Retrospective studies, prospective studies and hypothetical future scenarios can all be used for evaluation of costs and benefits of surveillance and response systems. The choice of study design will depend on the purpose of the study and the data and resources available. In some situations it might make sense to do more than one type of study. For example, a retrospective or a prospective study can be supplemented by hypothetical future scenarios to see how the system might function under conditions that it has not actually faced.

3.5 Time period to use for a study

Issue 11 – What reference time period should be used?

The period used to evaluate the costs and benefits of surveillance systems should be relatively long for a number of reasons.

1. Surveillance systems are typically long-standing systems deeply embedded in the general health care system of a country. Any changes made to such routine systems are therefore likely to be long lasting.

2. New features of surveillance and response systems may take time to become effective. There is a gap between the time when information begins to be collected and the time when it is used for research and policy purposes. New features of surveillance and response systems should therefore be evaluated over a long enough time for changes to have become effective.

3. An important function of a surveillance system is to detect outbreaks of new diseases, and thereby to prevent the spread of serious new infectious diseases with epidemic potential. Most new diseases do not result in large epidemics – but some do, such as HIV/AIDS. Because such epidemics are rare events, the reference period needs to be long enough to include such events.

4. Many common epidemic-prone diseases have multiyear cycles. Several years need to be considered for the estimates of costs and benefits to be robust and not dependent on the characteristics of the particular years reviewed.

For all these reasons, it is desirable to use a fairly long reference time period.

Suggested solution for issue 11. The reference time period to use will depend on the purpose of the study and the availability of data. For an evaluation of the costs and benefits of early warning systems for epidemic-prone disease, the reference period should ideally include enough time for at least one and preferably more outbreaks of each major cyclical disease. Time periods of several decades would be desirable, especially for hypothetical scenarios and modelling studies.

It may not always be feasible to have very long reference periods – although such long periods will not cause difficulties for studies that use modelling and future scenarios since the reference period is not limited by either cost or data availability.

4. Measuring the costs of surveillance and response systems

4.1 Introduction to cost measurement

This section evaluates the strengths and weaknesses of a number of methods that can be used to evaluate the costs of a surveillance and response system. Three main steps are covered: ways to break down the components of the surveillance and response system into elements that can be priced, so that the total cost of the system can be calculated; accounting principles for analysis of costs and benefits; and finding or estimating the cost elements that have been identified. Sensitivity analysis and validation are also briefly covered.

Costs may be estimated retrospectively (for a programme that existed at some time in the past), prospectively (for an ongoing programme or one that is just setting up) or by using models and assumptions (to project future costs). As explained in discussion of the study design, above, each method has its strengths and weaknesses. Retrospective studies face the constraint that data is often difficult to obtain – and the data are not necessarily broken down into the components needed for the study. Prospective studies offer the opportunity of providing data in the form needed by the researcher, but they may be costly and often require a relatively long period for data collection. Projections of future costs are subject to uncertainty and therefore all assumptions and models used in these studies should be clearly stated and justified.

4.2 Identifying the cost elements

A country's surveillance and response systems function at many different levels – from the national to the district and local levels. A separate estimate of costs needs to be made for each level, by looking at the activities of the system and, for each activity, identifying the capital costs and the recurring costs of inputs into the system.

There are two ways in which this can be done. In the checklist approach, a list can be developed of the basic activities typically done in national surveillance and response systems. The checklist will need to be modified for each country.

In the decision-tree approach, a diagram (sometimes called an event pathway) is drawn for each disease and for each intervention that would be made when an outbreak is suspected. The decision-tree should include forks for every possible event that could occur as part of surveillance and response. In this way, the decision-tree identifies activities that are integral to the surveillance and response system.

These two approaches are complementary. The checklist can be used first to identify typical core data elements of surveillance and response systems. The decision-tree is useful in verifying that the checklist is complete and that responses are included for each situation.

The following three steps are necessary to estimate costs, once all the activities that constitute surveillance and response have been identified:

- estimate the likelihood of each activity;
- estimate the monetary cost of each activity;

- calculate the total cost by summing the products of likelihood of each activity and its cost.

For example, suppose one needed to estimate the cost of cholera camps. It would be necessary to estimate how often cholera camps would be (or were, if the study is retrospective) set up during the reference time period. A review of past experience would be an important part of the exercise. Because the response is variable, for any prospective study it would be advisable to develop a range of costs corresponding to different scenarios from favourable to worst case scenarios. In all situations, expert judgement would be required.

4.3 Accounting principles

4.3.1 Financial and opportunity costs

There are many ways of evaluating costs. The most simple is to consider only financial cost – how much money is paid for resources used. This method is sometimes used when only costs to the health system are being considered. Its advantage is its simplicity; its disadvantage is that it ignores non-financial costs, which may be considerable.

Other types of costs called opportunity costs reflect additional costs of opportunities missed that are not necessarily reflected in the financial cost. For example, if a health care worker spends time reporting a disease, she might not do another valuable job such as treating an additional patient. It can be argued that the cost of not treating an additional patient should be considered as part of the cost of a surveillance and response system.

The type of cost that should be considered depends on the purpose of the study and the perspective used. For example, if one were costing a potential improvement to an existing surveillance and response system for budgetary purposes, one would only need to know how much the improvement would cost in monetary terms. In this case financial costs would suffice. If, however, one is interested in weighing costs of the improvement against potential benefits from the point of view of society, then it would better to include opportunity costs as well.

4.3.2 Marginal and full costs

Marginal cost is appropriate when one is interested in evaluating the cost of adding a new feature – such as the reporting of a new disease – to an existing surveillance and response system. Full cost is appropriate when one wants to evaluate the cost of an entire system.

Marginal costs (often referred to as incremental costs) are less than full costs, as they refer only to the cost of adding an additional feature onto the surveillance system, and so do not include fixed overhead costs of the system. The decision whether to consider only incremental costs or full costs will depend on the analysis undertaken.

4.3.3 Capital and recurrent costs

Capital costs (sometimes known as fixed costs) and recurrent costs are handled differently. Capital costs consist of the cost of goods that last for a long time, such as buildings, vehicles and equipment. Capital costs also include the cost of activities that occur once or only rarely, such as training involved with initializing a new system. These costs need to be amortized over many years. There are standard methods for doing this.

Recurrent costs (sometimes known as variable costs) are such items as personnel costs, supplies, operation and maintenance of capital goods (buildings, vehicles and equipment), and recurrent training or social mobilization costs. Recurrent costs would include recurrent costs of surveillance as well as the costs of investigating and responding to outbreaks.

Clear criteria for distinguishing between capital and recurrent costs need to be used. A common criterion is whether or not the costs are incurred less often than once a year. Under this criterion, costs that occur every year are treated as recurrent costs, whereas those that do not occur at least annually are treated as capital costs.

4.3.4 Adjustment of capital and recurrent costs

There are well-established accounting principles that adjust costs for different dates and for inflation. There are also established methods of discounting costs that will occur in the future, so that they can be compared with more immediate costs. Decisions will need to be taken on how to do this (exactly which inflation rate to use, which rate should be used for discounting future expenditures, etc.). Any study costing surveillance and response will need to contain clear guidance on these issues. Details are not provided in this document because the principles are well established and would not add much to a discussion of the conceptual framework itself.

4.3.5 Shared resources and activities

Many resources and activities for surveillance and response are shared with other programmes. Principles will need to be established, therefore, on how to apportion the cost of shared resources and activities. As these principles will have an important effect on cost estimates, they will need to be considered carefully on a case by case basis.

4.3.6 Differences in currency

As far as is practical, goods and services purchased should be valued in local currency. Goods and services purchased with foreign currency should be calculated in local currency at the exchange rate on the date of purchase. In countries with limited foreign currency at their disposal, however, resources spent in foreign currency should be noted separately.

4.3.7 Activities supported by international donors

The way in which goods and services funded by international donors should be handled will depend on the perspective taken, the purpose of the study and the terms of the donation. For example, how should one value donations that come “with strings attached” such as requiring that they are used to purchase goods and services from the donor country? What if the donation is in kind rather than in cash? For example, how should one cost a CDC epidemiologist assisting in the control of the outbreak of Marburg fever in Angola? Should his or her services be valued at the price that CDC is paying or at the price of a locally recruited Angolan epidemiologist with equivalent skills? How should one value expertise that is not available in the country at any price?

The solution to this type of problem depends on the study objectives. If a study is being done for the international community or a high income country, the cost of the goods or services to the donor should be used. If a study is being done for a recipient country, the value of such foreign donations may be very different from their value according to the donor country.

4.3.8 Locally donated services

Locally donated goods can be assigned their value in the local market. In terms of locally donated services, namely volunteer work, the easiest approach is to value work done by volunteers at the rate needed to pay for equivalent services locally. Methods for valuing the cost of volunteer labour are similar to methods for valuing the cost of unpaid household work (see Goldschmidt-Clermont (*10*) and Dixon-Mueller & Anker (*11*)).

For the most part, surveillance and response are government-sponsored activities, and the cost of the work of volunteers will generally not be large in comparison to the other costs for the surveillance and response system. There may be some situations, however, in which volunteers constitute an important cost.

4.4 Estimating costs

4.4.1 Sources of data

It is important for any handbook on implementing a cost analysis of surveillance and response systems to include a list of common international, national and local sources that can be used for costing the surveillance and response system. Valuable information is available on the WHO web site[3] concerning costs of health-related items and costing assumptions for health; for example, costs per bed day and per outpatient visit at primary, secondary and tertiary hospitals and health centres in 13 geographical areas. Typical programme costs are also given, such as personnel costs, transport costs, and costs of common resources consumed per full-time equivalent of personnel in terms of materials and supplies, equipment, office space, equipment and maintenance and utilities. There are also tables listing the prices of tradable goods and the useful lives of capital items, and the costs of shipping and handling for traded goods for different levels of population coverage. Also available from WHO is the CostIt software (costing interventions templates) to record and analyse cost data, which provides separate templates for costs at the programme, hospital, primary health facility and household levels. The availability of these data and software and WHO expertise in this area should greatly facilitate studies on the costing of surveillance and response systems.

4.4.2 Rules of thumb

There are several well-established guidelines and rules of thumb for evaluating costs, such as: to collect information at the highest level for which it is available if the quality is good, to avoid double counting for data collected at several levels, to place the greatest effort into finding costs of the largest input categories, and to use expenditure records rather than budget records (*12*).

Translating these conventions into precise guidance, illustrated by examples of what to do in specific situations, would be useful in a handbook on costing surveillance systems. Ideally, the examples should be based on experience in doing cost studies under field conditions, and should provide a thoughtful rundown of different choices that need to be made during field work.

4.4.3 Sampling

As it is not practical to estimate costs in every district and every health facility, it would be useful to discuss sampling techniques and principles for selecting sample districts and health

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[3] WHO-CHOICE is available at http://www3.who.int/whosis/menu.cfm?path=whosis,other,cea&language=english

facilities to study. Here again, there are standard techniques that would need to be elaborated in any handbook for carrying out cost studies.

4.5 Sensitivity analysis and validation

It is important for any costing to include a sensitivity analysis which indicates how sensitive the estimated total cost is to assumptions made in the analysis about prices of goods and services and the discount rates and inflation rates used. Such analysis would entail estimating the costs of surveillance and response systems under a range of plausible values for each assumption. This would allow the identification of those assumptions that have a large effect on the estimated costs. It also makes sense to check the reasonableness of a costing by comparing it with other known costs.

5. Evaluating the benefits of surveillance and response systems

To date, not much work has been done on evaluating the benefits of surveillance and response systems. There is no standard method for evaluating benefits. The relatively little work that has been done has evaluated surveillance and response systems according to their attributes (timeliness, simplicity, flexibility, sensitivity, specificity, etc.) or their structure and functioning, but not according to their impact. An analysis of benefits must by definition look at impact by characterizing and quantifying the benefits.

5.1 Benefits from surveillance and response to epidemics

Benefits from surveillance and response to epidemics go well beyond the health benefits of limiting cases, deaths and disabilities from disease. Epidemics affect economic activity at all levels – the micro (individual and household), meso (establishment, village or city) and macro (national and international) levels.

At the household level, illness impacts not only on the individual affected but also on other family members who commonly care for the sick person and do extra work to make up the work not done by him or her. Because of different gender roles of men and women, the cost of illness within a family is different from the male perspective than from the female perspective. In addition, costs associated with treatment and wages lost during illness may be substantial. If more than one adult family member is ill at the same time, the cost to the family may be greater than if the illnesses had occurred one at a time, because there may be no one to do important household tasks or to bring in sufficient income. This is happening all too often in the current HIV/AIDS pandemic, where large gaps are left in household functioning if husbands and wives are both affected, including caring for children.

By their nature, epidemics involve higher than usual incidence of disease. This means that large numbers of people become ill at the same time, often clustering in particular areas and segments of society. If the affected people cannot easily be replaced, the mechanisms that are normally used to cope with illness can be overwhelmed and can cause a breakdown in normal activity, resulting in far greater economic loss than if the same number of days lost to illness were spread over a longer period of time. This situation can occur in health settings for epidemics which are transmitted from person to person, because it is difficult to replace quickly large numbers of doctors and nurses; even if such replacement workers were found, there would be considerable costs involved.

Fear of an epidemic can cause significant economic disruption in terms of trade and travel to and from the affected area. For example, tourists may be reluctant to visit an area with an ongoing epidemic, and trade of products from an epidemic area may be problematic. In addition, disruption can occur if people flee the area in large numbers.[4] These disruptions may be more related to perceptions about the epidemic (especially about transmissibility and

[4] During the plague epidemic in Surat, India, in 1994 large numbers of people fled the city, causing considerable economic disruption to Surat (a city of over two million people) and surrounding areas.

severity) than to the actual situation. For new diseases, as knowledge is gained about the disease and how to prevent or treat it, people's reactions to the disease change and might result in fewer unnecessary disruptions to tourism and trade. In some instances, however, reactions are at least partly the result of irrational fears and stigma, which may be more difficult to overcome.

In summary, the benefits from surveillance and response to epidemics can include the following:

- benefits derived from averting cases;
- benefits derived from averting deaths;
- benefits of fewer social and economic disruptions (including disruptions to trade and tourism) when epidemics are averted;
- social and psychological benefits stemming from less apprehension and greater peace of mind when large outbreaks of serious infectious diseases are rare or non-existent.

5.2 Measuring improved health outcomes

5.2.1 Numbers of cases and deaths averted

Numbers of cases and deaths averted are conceptually simple to understand. They need to be measured separately for each disease and each response. For example, treatment for cholera can lower the case-fatality rate to less than 1%, whereas treatment for meningococcal meningitis is unlikely to reduce mortality to much lower than 10%.

Information on cases and deaths caused by outbreaks is often derived from reported numbers; as these are often only a small proportion of actual cases and deaths that occurred, multiplication factors are typically used to adjust for underreporting. Unfortunately, the evidence base for multiplication factors is weak and is often based more on judgement than on actual studies, so they vary greatly even for the same disease in areas with good data. For example, for the 1977 epidemic of dengue haemorrhagic fever in Puerto Rico, estimates of the ratio of clinical cases of dengue to reported cases was between 17:1 and 49:1 in one study, 60:1 in another, and between 17:1 and 21:1 in a third (*13*). Data from serological tests can shed some light on these multiplication factors, provided there is an estimate of the ratio of infection to disease.

The number of cases prevented by surveillance and response is hypothetical, so any estimate would need to use models and judgement rather than solid data measuring actual experience. Four methods seem promising: epidemiological models, data from similar situations, historical data from previous outbreaks, and expert judgement. A combination of these methods might result in reasonable estimates of numbers of cases averted by surveillance and responses to outbreaks.

Epidemiological models. For some outbreaks, it should be possible to use epidemiological transmission models of the outbreak and the response to estimate the size of the outbreak in the absence of any response. Such models exist for most – but not all – epidemic-prone infectious diseases. Section 6 gives an example of using such a model for estimating cases and deaths prevented by surveillance and mass vaccination for meningitis.

There are good temporal models for modelling epidemics in a geographical area over time, and there are also good geographical models that model epidemic spread from one area to another. As yet, however, there are no models that adequately account for the spread of epidemics in both time and place simultaneously. This is an important limitation.

Data from similar situations. As far as possible, data from nearby areas should be used to tell if a larger outbreak was averted. For example, if one district vaccinated their population for meningitis and had few cases, whereas a nearby district with very similar conditions did not vaccinate, it may be possible to make some reasonable assumptions about what the attack rate might have been in the absence of response.

Historical data from previous outbreaks. This information might provide a basis for estimating the number of cases averted by surveillance and response, especially if there were previous outbreaks without surveillance and response, or with very late response.

Expert judgement. If adequate data or models were not available, it should be possible to survey expert opinion of public health officials about the impact of outbreak responses using one of the following methods.

- Delphi techniques could be used to estimate the number of cases averted for each outbreak. This is a novel approach, and it would need to be further developed and tested.

- Focus group discussions, in-depth interviews or surveys (or a combination of these methods) could assist in identifying the main characteristics of outbreaks and the responses to them that helped to determine their impact. Based on the results of such studies, it might be possible to develop criteria for determining whether outbreaks could have been much larger in the absence of response to determine whether an outbreak was of potential international health importance.

This is an important area for further study. During the course of their work, those responsible for surveillance and response are obviously making judgements about whether a response averted a larger outbreak. It would be extremely useful to gather and collate this valuable experience and knowledge and to compare those judgements with empirical evidence as well as evidence from models.

After estimating the number of cases averted by surveillance and response, there are two steps required to estimate the number of deaths averted. The first step is to estimate the number of deaths that would have occurred had surveillance and response not limited the number of cases. This would simply require multiplying the number of cases averted by the case-fatality rate for the outbreak.

The second step is to estimate the number of deaths prevented by case management and treatment by services that were part of outbreak response. For most epidemic-prone diseases, there is good information on what case-fatality rates would be if there had been no treatment. The difference between the actual case-fatality rate for the outbreak and the case-fatality rate in the absence of treatment should be used to calculate deaths averted attributable to treatment for those treated by the response services. Section 3 discusses the extent to which treatment by the routine health services should be considered part of response.

Van Damme & Van Lerberghe (*7*) estimated cases and deaths averted by emergency response systems for meningitis, measles and cholera outbreaks in Manceta prefecture, Guinea, between 1993 and 1995. They combined several methods, including reviewing available data; where crucial information was missing, they used estimation and modelling to fill the gap with an estimate. The advantage of combining methods in this way is that the calculations are transparent and based on actual experience where possible. The disadvantage is that this approach is complex and different for each disease.

Good data and models are not always available. Nonetheless, this approach is worth using to help build up a body of knowledge for different situations and diseases.

5.2.2 Disability-adjusted life years saved

Disability-adjusted life years (DALYs) were developed to identify inefficiencies in resource allocation within the health sector, and they are commonly used to compare interventions for different diseases. DALYs combine physical impairment caused by ill-health, duration of illness, and premature death into one measure of burden of disease. They determine years lost to disease through physical impairment and premature death (this is one form of quality-adjusted life years[5]). The burden of disease averted by a surveillance and response system could theoretically be calculated if one knew the number and age distribution of cases and deaths averted for each disease because of a surveillance and response system.

In order to calculate DALYs, physical impairments and disabilities caused by the disease are assigned weights according to their severity. The weights are scaled from 0 to 1, where death carries a weight of 1 and no disability is weighted 0. The more severe the disability the higher the weight assigned. DALYs are then calculated based on the proportion of cases with each type of disability, the expected duration of each disability, disability weights, and the age and sex distribution of cases.

The value given to each disability-free life year lived is a function of age. Disability-free life years lived at different ages are valued differently, with the values increasing until a peak at age 25 and decreasing thereafter. Future years of life from present age are discounted by 3% per year compared with the present. For the calculations of DALYs, the assumed life expectancy is 82.5 years for females and 80 years for males.

The advantage of DALYs is that they combine cases and deaths from many different diseases into one measure. They also allow comparability with other interventions, especially those done in collaboration with WHO, as DALYs are used extensively by WHO for the cost–effectiveness analysis of health interventions. Guidance and standards exist for determining the desirable and undesirable ranges for cost per DALY. Using DALYs would allow one to compare the value of surveillance and response with the value of other health interventions.

WHO has developed tools for carrying out cost–effectiveness analysis as part of the WHO-CHOICE (CHOosing Interventions that are Cost Effective) project, which is intended to provide regularly updated databases on the costs and effects of a full range of interventions to promote health and prevent disease, and to cure and rehabilitate (14). The availability of such tools and the increasing familiarity of health professionals with the use of cost–effectiveness analysis for other purposes are major advantages of DALYs.

There are several disadvantages of DALYs. The concept is not easily understood intuitively. The age weighting increases the data requirements and assumptions made, as it is necessary to estimate the age distribution of cases and deaths averted. The age-weighting and discounting of future years have been criticized on theoretical grounds. In particular, the fact that deaths in the future are discounted so heavily makes it more difficult to justify investments in health with large future pay-offs, compared with those with immediate pay-offs. For example, a life saved 50 years from now is worth only approximately 1/5 a life saved now (15). This has important consequences for surveillance and response systems, which have benefits over a relatively long period of time.

The fact that DALYs value the years lived by disabled persons less than the years lived by able persons has been criticized on ethical grounds.

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[5] There are a number of different quality-adjusted life year measures. It does not seem necessary to review other measures here, as WHO continues to use DALYs as the standard.

Other limitations are that DALYs consider only health outcomes, so that other economic and social benefits are not considered. Also cost–effectiveness analyses, which try to minimize DALYs lost with a fixed health budget, do not take into account the adequacy of the health budget itself as they do not allow evaluation of the trade-off between health benefits and other goods, and they do not count the value of greater health security gained by reducing the risk of large outbreaks.

5.3 Estimating the monetary value of cases and deaths averted

There are several methods of evaluating the monetary value of cases and deaths averted by surveillance and response in terms of lost productivity and health care costs saved.

5.3.1 Cost of illness

The cost of illness (COI) method estimates the economic costs associated with each case of morbidity and mortality. It considers cost avoided as an economic benefit using average costs per individual case or death averted. Typically included are costs attributable to lost productivity (mainly from days of work missed) and costs associated with health care. The opportunity costs to other household members caring for the sick individual or doing household work normally done by the sick person may also be considerable. Details of how to value such unpaid household work are beyond the scope of the current paper, but can be found elsewhere (*10*, *11*).

To calculate the COI avoided, a disease-tree is used with several levels of severity, from mild illness to death, together with the likelihood of a case belonging to each level. The average number of days of illness and the cost of health care typically received at each level are estimated. The cost to the individual in each level of severity is equal to the average cost for health care plus an estimate of lost income from the average number of days of work missed. Total projected lifetime earnings are used for those who die or do not return to work. Health care costs should include not only medical costs but also non-medical costs associated with treatment, such as cost of transport and opportunity costs of the care provided by family members – although, unfortunately, the opportunity costs of care provided by the generally female family members is rarely acknowledged or considered.

The advantages of this method are that it is easily understood intuitively and appropriate data are usually available. COI also provides an economic value that can be compared with costs. As not all costs are included in this measure, other economic costs attributable to loss of trade and tourism (see below) could be added; so, in theory, could intangible social and psychological costs such as pain, grief, psychological adjustments and changes in social functioning (though it is very difficult to place an economic value on these additional costs).

Before COI can be used for epidemic-prone infectious diseases, empirical work is required to construct disease-trees and estimate various economic costs.

5.3.2 Willingness to pay

Willingness to pay (WTP) is another way to measure the economic value of averting illness. The underlying idea is that the value of an item equals the amount of money that individuals are willing to pay for it.

It is not possible to estimate WTP using market prices for surveillance and response, partly because there are no functioning markets and partly because freedom from epidemics is a public good and not a private one. Economists, however, have estimated the monetary value of reduced risk of morbidity and mortality by valuing risk-averting behaviour by looking at wages of high and low risk occupations. The amount of extra wages needed to induce workers to accept riskier jobs is then considered to be the value of the risk premium (*16*). Viscusi reviewed the statistical literature on the value of a statistical life lost in the United States, and found that the most reasonable estimates of a life lost were between US$ 3 000 000 and US$ 7 000 000 (*17*).

There are major problems with the WTP approach. First, it requires estimates of value to be made on a country by country basis because occupational wages differ. Second, even within countries, estimates need to take into consideration such factors as firm size, union status, location, and the age and sex of the workers, because wages are known to vary by these characteristics. Other things being equal, wages are higher in industries and occupations that are unionized, in high cost areas, in large firms and in male-dominated occupations. The WTP approach also has the undesirable attribute that some lives are valued more than others. Third, freedom from risk of an epidemic is a public good and so it is subject to the free-rider problem when estimating its value.

5.3.3 Contingency valuation

The contingency valuation method is another way to evaluate the willingness of people to pay for reduced health risk, and is based on surveys about people’s preferences. Surveys ask respondents how much they would be willing to pay for a particular good or service. It can be also used to estimate how much people value existing services by asking them how much money they would need to be compensated to be just as well off as they are currently, if the existing service were to be taken away. The method uses hypothetical questions about hypothetical scenarios, although the scenarios are realistic enough for respondents to understand what the scenario would mean for them.

Contingency valuation methods have been used in health since the 1970s. They have been used to estimate the value of risk reduction in areas such as airline safety and traffic safety, as well as exposure to hazardous wastes. A study that valued the risk of traffic deaths in the United Kingdom in 1982 found that a statistical life was approximately £1.5 million when the risk to own life was considered, and approximately £2 million when the risks to others were included as well (Jones-Lee et al., 1985, cited in *18*). There are also a handful of morbidity WTP studies that have evaluated the willingness of people to pay to avoid symptoms such as mild and severe cough, headache and shortness of breath (*19*). Theoretically, such methods could be used to derive WTP data that are applicable to the symptoms of epidemic-prone infectious diseases.

In practice, however, there is a long way to go before contingency valuation methods could be applied to morbidity caused by common epidemic-prone infectious diseases. In addition, few WTP studies apply to developing countries. In short, in the author’s opinion this is not a methodology that holds much value for our purposes at the current time – but one that is worth considering for future development.

5.3.4 Legal compensation payments

The judicial system regularly awards compensation to plaintiffs for illnesses and accidents caused by negligence. For example, legal settlements have been paid in cases related to the Bhopal disaster, asbestos-induced illness, food-borne illness, and automobile accidents. It might be useful to review these cases in order to see whether the amounts in such settlements would be useful for valuing disability or death. The advantage of using legal awards is that they are tangible payments made to compensate for illness and death, and they are monetary amounts which can be directly compared with costs of surveillance and response.

However, such legal valuations have to be treated with caution for a number of reasons. They are variable: different societies have different legal traditions and different ways of valuing lives and deaths. In the United States, for example, potential lifetime income weighs heavily in deciding the amount of compensation, which means that those with higher incomes are compensated more than those with lower incomes. The amount of the compensation may be related to the quality of the evidence, especially whether the illness or death was caused by the defendant in the case. Often cases are settled confidentially out of court. Furthermore, data may not exist for many of the diseases we would like to evaluate. Given their biases and variability, legal compensations are not of great value to us at present, although they might be useful as reality checks for comparison in the future.

5.4 Estimating the monetary value of other economic and social benefits

The economic and social benefits of surveillance and response systems considered here are the savings of economic losses that are sustained in terms of social and economic disruption during outbreaks, the value of health security, and additional benefits that are not directly related to the health system.

5.4.1 Avoidance of disruption during outbreaks

Social and economic disruption, including lost trade and tourism, lost investment, lost food exports and other economic losses, can be important costs of an epidemic that is not averted. There are also important losses from outbreaks of veterinary diseases among livestock; see Roth et al. for a framework that considers human health and productivity and animal husbandry (*20*). Estimates of the economic impact of recent outbreaks indicate how expensive outbreaks can be. Estimates of the 1994 outbreak of plague in Surat, India, are around US$ 2 billion; estimates of the 2003 SARS outbreak are in the range US$ 10–30 billion; and the likely economic cost to the United States of a possible future influenza pandemic are US$ 71.3–165.5 billion (*21*).

A surveillance and response system may also avoid economic and social disruptions that sometimes accompany unconfirmed rumours of outbreaks. In theory, credible and timely information can go a long way to dispel fears and limit inappropriate social and economic disruption. Although it would be useful to have a historical review of the extent to which false rumours have resulted in economic and social disruption it would not be feasible in the near future even to approximate a monetary value for this benefit of surveillance.

Estimating the economic savings from outbreaks averted requires several steps and assumptions. First of all, it is necessary to estimate losses to trade and tourism based on past experience and available estimates such as those for the SARS and plague outbreaks mentioned above. Because only a few estimates are available, a number of hypothetical scenarios need to be developed in order to produce a hypothetical percentage loss in tourism or trade. One would then need to account for how much of a loss in, say, tourism spills over to losses in other sectors, using multipliers that take account of forward and backward linkages to the economy.

A review of economic methods used for economic impact assessments of outbreaks is contained in Smith & Sommers (*22*).[6]

Whether an outbreak leads to large economic and social disruption depends on characteristics of the disease, characteristics of the economy (such as the share of the economy represented by exposed industries) and human behaviour. Therefore a determination of possible economic losses suffered during outbreaks will need to take account of these three factors. Examples of vulnerable sectors of the economy include such sectors as the food industry (subject to losses if there are food-borne outbreaks) and tourism (subject to losses if there is an outbreak of a serious new disease transmitted from person to person). Such an analysis could provide broad parameters (ball park figures) for estimating the benefits of averting the economic disruption that accompanies some epidemics.

WHO is bringing together epidemiologists and macroeconomists to develop an integrated model that will assess the economic impact of global disease outbreaks (Nick Dragger, WHO, personal communication, 2005). These assessments will be of considerable help in estimating the benefits of surveillance and response systems.

As a next step, one would need to make an educated guess on how many outbreaks with the potential to disrupt trade and tourism are or would be averted by the surveillance and response system. Estimates of the total cost of outbreaks averted over the reference time frame would then be made by combining steps one and two. For this, one would need to make a (subjective) judgement about the threshold of cases necessary to trigger major economic disruption. While a few cases of Ebola or a new disease may be sufficient, 50 cases of influenza may be insufficient. In addition, considerable work would be needed to develop a simple tool for countries to use to make these estimates.

As avoiding these costs is an important benefit of surveillance and response systems, there seems to be no choice but to estimate them in some way, even though it will be difficult to do well and the estimates will be guesstimates at best. In light of this, it would probably be best to estimate costs for a range of possible scenarios.

5.4.2 Health security

Surveillance and response systems have similarities to insurance. The amount people are willing to pay for insurance consists of two parts: the value of their expected risk plus an additional amount for risk avoidance and peace of mind regarding the possibility of unexpected large costs. In the same way, a surveillance and response system can be thought of as an insurance policy against uncontrolled outbreaks. There is the pooling of risk as well as the important psychological value of the peace of mind that comes from knowing that large outbreaks of epidemic-prone infectious diseases are unlikely. This value is over and above the expected value of costs of outbreaks averted. The added value should be considered as a benefit of surveillance even though it is intangible and is not usually measured quantitatively.

One way to value such costs might be to estimate the value paid for insurance in countries with well-developed insurance systems, over and above the expected value of payouts, for policies covering catastrophic disasters (such as catastrophic illness, floods or fires). There is a rich literature on this, too detailed for the current paper but worth serious consideration if this added value is to be measured quantitatively.

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[6] Smith & Sommers reviewed the literature on assessing the economic impact of communicable disease outbreaks and found that much of the work done was in respect of agricultural and veterinary problems such as foot and mouth disease.

5.4.3 Benefits not directly related to epidemics

As discussed in Section 1, surveillance and response systems have many objectives that are not directly related to the detection of and response to epidemics. Surveillance systems typically collect and analyse data that support diverse public health decisions from strategy development to resource allocation and research. For example, surveillance and response systems may have implications for industrial standards and norms, such as those for food production and food handling. The benefits of these additional uses of surveillance data go well beyond the health system itself, but they are difficult to measure quantitatively and difficult to attribute only to surveillance.

At present, we do not have enough knowledge about the benefits of these additional uses to make a comprehensive evaluation. It makes sense, therefore, to begin by identifying such benefits in different settings. This could be done first in country studies, using in-depth interviews with key informants and focus group discussions, followed by more in-depth analysis of how the surveillance and response system contributes to this particular benefit. Such studies would be possible in field settings, and the outcome would add considerably to our current understanding of the broader effects of surveillance and response on public health.

5.5 Sensitivity analysis and validation

Assumptions made in evaluating benefits should be subjected to sensitivity analysis, to see how dependent the results are on the assumptions made. In addition, validating the results of benefit studies with known benefits from other health interventions would be useful, in order to check the credibility of study results.

6. Example of how to evaluate the costs and benefits of surveillance and response for a specific disease: meningococcal meningitis in the African meningitis belt

This section provides a detailed example of how to evaluate the costs and the benefits of surveillance and response related to a specific epidemic-prone disease, namely, meningococcal meningitis in the African meningitis belt.

Meningococcal meningitis causes devastating epidemics in many African countries. It has a high case-fatality rate (approximately 10%, even with good case management) and leaves an estimated 10–15% of survivors with life-long neurological defects. The area of Africa particularly prone to such epidemics stretches from Senegal to Ethiopia and is known as the African meningitis belt.

The features of meningococcal meningitis that make it a good example for evaluating the benefits of surveillance and response for a specific epidemic-prone disease are as follows.

- There is clear strategy for response to meningitis epidemics linked to well-defined surveillance triggers.
- After an epidemic is detected and verified, response involves only two major activities: mass vaccination and effective case management.
- Mathematical models suitable for evaluating the value of surveillance and response strategies in terms of human mortality, morbidity and disability are well developed and available in the literature.

6.1 Epidemiology of meningitis

Neisseria meningitides (the causative agent for epidemics of meningococcal disease in the meningitis belt) lives in the nasal passages of individuals, where it is normally harmless. It is transmitted by respiratory droplets from infected individuals, and asymptomatic carriers are important for transmission. The mechanisms that cause N. meningitides to trigger disease are not well understood. The disease is both endemic and epidemic in the meningitis belt, meaning that, in addition to large number of cases that occur during epidemics, cases occur in smaller numbers during interepidemic periods as well. Thus a small number of meningitis cases do not necessarily signal an epidemic. Considerable work has been done to develop response triggers with optimal sensitivity and specificity so that, as far as possible, the response of mass vaccination takes place when an epidemic occurs but not otherwise.

A number of features of meningococcal meningitis epidemics are worth highlighting at this point, because they affect surveillance and the response strategy.

1. Currently available polysaccharide vaccines are not ideal because they:
    - provide only short-term protection against disease and therefore need to be repeated for every epidemic;
    - do not protect very young children;

- do not affect transmission, and therefore non-symptomatic carriers can spread infection to close contacts.

- The current response strategy is designed to overcome the limitations of the available vaccine; it requires mass vaccination of at least 80% of the population at risk whenever an epidemic occurs. This implies the need for timely epidemic detection, so that mass vaccinations can begin as soon as possible after the disease crosses the epidemic threshold.

2. Mass vaccination campaigns are relatively expensive, requiring considerable funds for vaccine and logistics. Many poor countries have difficulty finding resources for these campaigns. Meningitis therefore requires a good surveillance system, to confirm that there a high likelihood of an epidemic occurring before mass vaccination is begun.

3. Epidemics are seasonal, occurring primarily during the dry season between the end of November and the end of June, and waning quickly with the onset of the rainy season. This is helpful for modelling the disease, as the epidemics occur for only a defined period of time.

4. Epidemic cycles range from 8 to 15 years in most meningitis belt countries. This is useful for disease modelling.

5. A new strain of meningococcal meningitis, namely W135, has recently begun to cause epidemics in some meningitis belt countries, including a large outbreak in Burkina Faso in 2002. At the time, no affordable vaccine was available for the W135 strain, but one has subsequently been made available to countries in the meningitis belt.[7] This has increased the importance of surveillance to identify different meningococcal strains, since this information is now needed for vaccine choice.

6. Strains can be transported from country to country through travel, migration and pilgrimages. This has obvious important implications for disease surveillance and epidemic preparedness.

6.2 Current strategy for meningitis surveillance and response

The current disease control strategy entails “enhanced meningitis surveillance”, coupled with effective case management, and rapid mass vaccination if the epidemic threshold is crossed.

The strategy identifies four phases related to the epidemic cycle, which call for different types of action during each phase. These phases are based on the incidence of meningitis in the district (*23*).

Interepidemic phase. This is the period from the end of one epidemic season to the beginning of the next epidemic season. During this time, the number of meningitis cases is below the alert

[7] The only available vaccine protected against four strains of meningitis including W135 but was far too expensive for use in mass vaccination. After negotiations with pharmaceutical companies, an affordable vaccine was made available to developing countries that protects against three strains of meningitis including W135.

threshold. Laboratory confirmation of cases is needed for knowledge about circulating strains, which may be different from the circulating strains during the epidemic season.

Pre-epidemic phase. This phase consists of the time after an alert threshold has been crossed but before the epidemic threshold has been crossed. At this time, the collection of cerebrospinal fluid (CSF) specimens is stepped up – and it is recommended that at least 10 N. meningitides samples are confirmed during this period. Line listings of patients are recorded.

Epidemic phase. This phase begins as soon as the epidemic threshold has been crossed. At this time it is necessary for the exact strain(s) to be identified, and it is recommended that mass vaccination is begun as soon as possible. Sentinel districts for CSF sampling are established.

Post-epidemic phase. This typically lasts 4–6 weeks after the end of an epidemic. It begins when the attack rate in the district falls below the epidemic threshold, and continues until the attack rate in the last epidemic district remains below the alert threshold for two consecutive weeks.

6.3 Defining the scope of the evaluation

As discussed earlier, the first step in the evaluation of meningitis surveillance and response is to define its scope. This entails deciding on the perspective to use, defining the activities that make up the system to be evaluated, and selecting appropriate comparisons and the reference time period.

6.3.1 Perspective

There are considerable national and international inputs in surveillance and response to meningitis. Either perspective is acceptable to use. For the present example, the national perspective for society as a whole has been selected, because it is less complex. This means that international costs and benefits are not considered here. It also means that costs and benefits are considered for the whole society, and not just for the health sector.

6.3.2 Activities of the system

The surveillance and response system for meningitis typically includes the following:

1. Activities related to developing and monitoring the strategy for surveillance and response. This also includes the time of those who have responsibility at the national level for either the development or the implementation of the strategy.
2. Activities related to the uptake of the strategy for surveillance and response, including meetings, distribution of appropriate reporting forms, and ensuring that all the logistic tasks to get the system up and running are done.
3. Activities specifically related to training for surveillance and response. These may be single courses or continuous training, depending on the nature of the instruction.
4. Activities related to outbreak preparedness, such as those involved with procurement and storing of supplies, maintenance of epidemic preparedness committees, and similar tasks. They may be one time or continuing activities.
5. Activities related to detection – including reporting of meningitis – and the collation and analysis of the data. It is necessary to include everyone who is involved in reporting and recording, such as nurses and physicians, as well as

surveillance staff. Note that the amount of time people spend on surveillance and response may vary over the four phases of the meningitis surveillance and response strategy, both because of varying case loads over the period and because of different surveillance requirements for each phase.

6. Activities related to laboratory confirmation and verification and identification of strains. This includes all activities involved in investigation of probable and suspected cases, including extracting CSF specimens, transporting specimens to the laboratory, laboratory testing and transmission of results to the district. Consideration needs to be given to differing case loads and differing surveillance requirements during each strategic phase.

7. Activities related to treatment.

8. Activities related to mass vaccination campaigns.

6.3.3 Selection of comparisons

It is useful to begin to think about appropriate comparisons for evaluating the cost and benefit of meningitis surveillance and response by asking “what would happen during an epidemic of meningitis if there were no surveillance and response system in place?” In most countries in the African meningitis belt, in the absence of meningitis surveillance and response either there would be no mass vaccination campaign during an epidemic, or the mass vaccination campaign would be launched relatively late in the epidemic, possibly after the epidemic peak. This is indeed what has happened all too often in the past. Therefore, studies of the costs and benefits of meningitis surveillance and response should allow for comparison with either or both of these possibilities. Of particular importance will be estimating the benefits of early intervention versus late intervention or no intervention at all. Estimates of the number of cases avoided each week are particularly useful, because they allow a flexible choice of comparisons.

6.3.4 Reference time period

The critical time frame for meningitis surveillance and response is the length of the epidemic cycle. The surveillance and response strategy places heavy emphasis on early detection and early response to epidemics, therefore the reference time frame should be long enough to include at least one complete epidemic cycle (8–15 years depending on the country).

6.4 Costing meningitis surveillance and response

The previous section listed the activities typically included in a surveillance and response system for meningitis. As discussed in Section 3, it will be necessary during the costing phase to price each activity according to standard accounting principles developed by WHO for costing health interventions.

Some apportionment principles will be needed for activities that are part of multidisease surveillance activities. For example, training, case detection, reporting, collation and data analysis are often done in a multidisease setting. One simple way of apportioning costs in this situation would be to divide the cost for multidisease activities by the number of diseases involved, though each situation will need to be approached in a pragmatic fashion. After experience is gained with apportionment from conducting field studies, it should be possible to provide specific examples to guide further studies.

Other key apportionment decisions for meningitis surveillance and response would be how to apportion the costs of laboratory services to the surveillance and response system. While surveillance and response activities are a major reason for such services, the benefits of laboratory diagnostic services go well beyond epidemic surveillance and response. It would not be reasonable to charge all the costs of laboratory services to surveillance and response. Further thought and experience is needed to develop reasonable apportionment principles for costing the surveillance and response components of public health laboratories.

Other costs associated with meningitis outbreaks, such as costs of treatment and costs to family members who take care of sick relatives, are important – but would require in-depth studies to estimate. Bovier et al. (*24*) have estimated the costs of meningitis treatment in the meningitis belt. In addition, it is difficult at the present time to estimate the costs of disruption to other health services during outbreaks, because the nature of the disruption differs with each outbreak and situation, and data on such disruptions are not easily available.

6.5 Evaluating the benefits of meningitis surveillance and response

As discussed in Section 5, benefits from averting epidemics of infectious diseases include:

- benefits derived from averting cases;
- benefits derived from averting deaths;
- benefits of avoiding social and economic disruptions;
- social and psychological benefits stemming from less apprehension and greater peace of mind regarding large outbreaks of serious infectious diseases.

This section focuses on the first two of the above benefits, which can be attributed to early epidemic detection followed by mass vaccination, namely, savings that accrue from fewer cases (which entail both less morbidity and less long-term disability) and fewer deaths attributable to meningitis. These benefits include benefits to the individual and to the family as well as to society. In order to calculate the savings, it is necessary first to estimate the number of cases and the number of deaths that would be averted with early warning and mass vaccination.

The second two benefits may be of considerable value, but they are more difficult to measure. For example, health services are often overwhelmed and disrupted during epidemics, but their value is rarely measured. Similarly, there is scant information on trade and tourism losses attributable to meningitis epidemics, nor is there a good methodology or good information for measuring psychological and social benefits from epidemics averted. The last two benefits listed above are therefore not considered further in this section.

6.5.1 Epidemiological model

The epidemiological model selected for this example of estimating the number of meningitis cases and deaths averted was first developed by Pinner et al. in 1992 (25).[8] The model is based on an epidemic of meningococcal disease in Nairobi between April and November 1989 and has been used with success to evaluate meningitis control strategies. Using this model, one can

[8] While there is a stochastic model available in the literature (24), the Pinner et al. model is easier to use as it requires fewer assumptions and uses an Excel spreadsheet.

estimate the number of cases that would have occurred in the absence of, or in the presence of, vaccination.

Model assumptions

Major assumptions of the Pinner model include:

- a one week interval between vaccination and protection;
- 85% vaccine efficacy;
- vaccination has no effect on carriage, and therefore does not alter the attack rate among the unvaccinated.

Model inputs

Required inputs into the model (taken either from historical records or from a hypothetical scenario) are as follows.

- Overall weekly attack rates.
- Weekly proportion vaccinated. Vaccination campaigns usually last one to two weeks.

  Therefore, the proportion vaccinated in a given week is usually either :

  - zero, before mass vaccination starts;
  - proportion vaccinated during the first week of the campaign;
  - proportion vaccinated after the second week of the campaign.

  These proportions will vary according to local conditions. Some allowances may need to be made for movement of people into and out of the district.

The data for the input can be hypothetical, or they can represent actual experience from a previous epidemic where good records were kept over the epidemic cycle. When hypothetical scenarios are used, it is common to present the results for several different scenarios to evaluate the cases and deaths averted in a variety of possible circumstances.

Model equations

Overall weekly attack rates (ARO) and attack rates among the vaccinated (ARV) and non-vaccinated (ARN) are related by the following equations:

1. ARO = ARV * % vaccinated more than 1 week ago + ARN * (1-% vaccinated more than 1 week ago)
2. ARV= .15 ARN

Notice that, in the absence of vaccination, the weekly attack rate for the non-vaccinated is equal to the attack rate for the population as a whole. The above two equations, together with the input data on number of cases per week, and proportion of population vaccinated, can be used in a simple Excel spreadsheet to calculate the number of cases averted by vaccination each week. Further assumptions about the proportions of cases with long-term disabilities and the proportion of cases that die can be used to indicate likely deaths and disability cases.

Model results

Using this model, studies have shown that prompt detection and mass vaccination, if begun within two weeks of crossing the epidemic threshold, have the potential to prevent over half the cases of meningitis: 65% of cases could have been saved in the 1997 outbreak in Togo (*8*) and 60% in Burkina Faso (*26*). In addition, using this model, it has been estimated that each week's delay in mass vaccination reduces the number of cases prevented by 3–8% (27, *28*).

Number of deaths averted

The number of deaths averted is derived from the number of cases averted by making an assumption about case-fatality rates. Whatever assumption is made should be carefully thought through and subjected to sensitivity testing. This is important because case-fatality rates from meningitis vary considerably (estimates range from 5–30% with treatment to 50% without treatment).

Extent of disability averted

Estimates of disability attributable to meningitis range from 10% to 20% of survivors. Such estimates can be used to estimate the extent of disability averted. As above, however, any assumptions used in this context should be subjected to sensitivity analysis.

6.5.2 Calculating total benefits from surveillance and response

The examples presented above and from the literature indicate that the model devised by Pinner et al. can be used for estimating the number of cases averted by a surveillance and response strategy during a meningitis epidemic (*8*, *26–30*). Benefits that can be attributed to cases, deaths and disability averted occur only during epidemics, which have somewhat irregular 8–15-year cycles in the meningitis belt. Therefore these benefits are for the entire cycle and not for a single year.

As discussed in Section 5, there are several ways in which the benefits from cases and deaths averted can be evaluated, including DALYs and monetary values. Disability weights for meningitis needed to calculate DALYs already exist,[9] so the additional assumptions needed concern only the age and sex distribution of cases and the distribution of disabilities among survivors.

6.6 Conclusions

In this example, the steps involved in evaluating the costs and benefits of surveillance and response systems for meningitis in the African meningitis belt have been discussed. An epidemiological model of meningitis outbreaks is available, and the research literature includes several evaluations of the meningitis surveillance and response strategy in terms of health benefits (decreasing morbidity, mortality and disability) using this model. These evaluations estimate the cases and lives saved by early detection and early response – but not the value of other benefits.

[9] The number of DALYs caused by meningitis was included in The World Health Report 2000, so the weights should be readily available in WHO.

7. Example of how to evaluate the costs and benefits of changes to an existing system: adding laboratory testing capacity for detecting *Neisseria meningitides* W135

To illustrate how to evaluate changes to an existing surveillance and response system, a hypothetical example is used: adding the laboratory capacity for detecting *Neisseria meningitidis* W135 for a country in the meningitis belt. *N. meningitidis* W135 is one of 12 serogroups of N. meningitides. It has been known to cause meningococcal disease for decades, but before 2002 the outbreaks had only been small. Outbreak control in meningitis belt countries had relied on vaccines that protected against serogroups A and C, but not W135. In 2002, a large-scale outbreak of meningitis in Burkina Faso was caused by *N. meningitidis* W135. WHO therefore worked with vaccine manufactures to make a vaccine that protects against *N. meningitidis* W135 available at affordable prices in the meningitis belt. At the same time, WHO worked with countries in the region to strengthen their capacity to detect and characterize the serogroups responsible for outbreaks. In the hypothetical example in this section, we discuss steps to evaluate the costs and benefits of strengthening the capacity of laboratories in the countries to be able to identify strains of *N. meningitidis* W135.

7.1 Defining the scope of the evaluation

7.1.1 Specifying the changes to be evaluated

This first step consists of clearly defining specific changes. Strengthening laboratory capacity to enable the identification of *N. meningitidis* W135 might involve the provision of reagents, improved training for laboratory technicians, better laboratory equipment, etc. These changes should be clearly listed in a straightforward fashion.

7.1.2 Reference comparisons

The comparisons will depend on the timing of the changes. If the changes have not been implemented, then the expected outcome of such changes should be compared with the current situation or with the recent past. If the changes have already been implemented, then the current situation should be compared with the situation before the changes were implemented. In the present example of a new capacity to distinguish *N. meningitidis* W135 from other strains, the pre-change comparison is the capacity to distinguish between serogroups A, B and C but not being able to identify W135.

7.1.3 Reference time period

Because changes in surveillance and response are being evaluated, two reference time periods will be needed: one for the pre-change period and one for the post-change period. Meningococcal meningitis is a cyclical disease, with a long epidemic cycle (typically 8–12 years). The ideal reference time period should therefore be at least 12 years for both the pre-change and post-change periods.

7.1.4 Perspective

The key decision here is whose perspective to take. The international perspective is a valid one to consider in this case as there has been a large international contribution over recent years, serving to improve the availability of vaccine supplies as well as surveillance and response capacities in countries. The national perspective of society as a whole is also a valid perspective from which to consider costs and benefits. Choosing which perspective to use would depend on the purpose of the evaluation.

7.2 Identifying and estimating costs

The detailed list of all specific changes to be made to the surveillance and response system needs to be priced. One of the key pricing decisions is whether to include only the marginal cost of the change, or to include overhead costs as well. For example, if the changes require only the acquisition of additional reagents, should one include part of the overhead cost of the laboratory facility or not? On one hand, overheads for the laboratory facility would be spent whether the reagents were acquired or not. On the other hand, by not including any overhead costs one is underestimating the total cost of the capacity of differentiating between W135 and other strains. The decision whether or not to include only marginal costs will depend on the purpose of the costing exercise.

Once these key accounting decisions are taken, the pricing exercise should be relatively straightforward, though it may be time consuming. WHO has done (and continues to do) considerable work on developing standard methodologies and assumptions to use in pricing health interventions; this work is readily available for use.

7.3 Estimating cases and deaths averted

There are two ways in which improving the capacity for laboratories to distinguish W135 from other meningitis serogroups will avert cases and deaths should an outbreak occur. First, outbreaks can be detected earlier because the transport of strains to a local laboratory should be faster than their transport to a laboratory outside the country. Second, strains might not be dispatched out of the country for testing as quickly as they would be sent inside the country. Normally strains would not be sent outside the country for testing unless there was an outbreak that was uncontrolled. In the absence of a local laboratory, therefore, W135 would not be detected until an outbreak was recognized and possibly not until response had been unsuccessful.

To estimate the savings in case of an epidemic, it is first necessary to ask programme managers for their expert opinion as to the amount of time that would typically be saved in responding to outbreaks if a local laboratory that could detect W135 was available. Information on the likelihood of an epidemic over the reference time period, and its likely size, would be needed to estimate the number of cases and deaths that would be averted by adding laboratory capacity. The result would be a range of estimates of cases, deaths and disabilities averted, rather than an exact number. For example, suppose there is good reason to assume that being able to identify W135 locally instead of internationally would allow response to be made one week earlier in the event of an epidemic. As discussed in Section 6, this would save 3–8% of cases according to the estimates made using epidemiological models (*27*, *28*).

8. Conclusions

This document is meant as a discussion paper and as a first step towards developing a framework for evaluating the costs and benefits of epidemiological surveillance and response systems. This is an area of great importance, yet so little research has been done on it that it is almost virgin territory. For this reason, this paper explores the potential of a number of methods of evaluating costs and benefits of surveillance and response systems and draws some suggestive conclusions.

Evaluating costs and benefits is new for surveillance and response systems, and there is very little published research literature on these topics. WHO has an active programme in cost–benefit analysis of specific health interventions, but this has not been applied to surveillance and response systems, presumably because they are very complex. In addition, in some instances the cost–benefit analyses that have been carried out for other health policies implicitly assume the presence of surveillance systems for identifying cases, but do not consider surveillance costs.

The conclusions reached include the following.

1. Surveillance and response systems should be evaluated together, as the costs and benefits of surveillance and response are closely linked with one another.

2. Before beginning an evaluation of costs or benefits it is necessary to specify the scope and design of the study, including the specific activities to be evaluated, the perspective to be used, a comparator baseline system, whether the study will be retrospective, prospective or use future scenarios, and the reference time period to be used.

3. Costs and benefits of surveillance and response systems are each important in their own right, and both are worth estimating even when it is not possible to set the costs against the benefits of specific aspects of surveillance and response (which will be common).

4. Measuring costs is relatively straightforward. There has already been considerable work by WHO in setting out the principles and operational guidelines on costing health interventions. These have not been applied to surveillance and response as yet, but could be adapted.

5. Criteria will be needed for apportioning costs for activities that are only partly done for surveillance and response purposes.

6. Evaluating benefits of surveillance and response systems is more difficult than measuring costs. Much less conceptual and empirical work has been done to lay the foundations for measuring benefits. Most evaluations to date have focused on the structure and functioning of surveillance and response systems rather than their impact.

7. Three major benefits of a surveillance and response system were identified and examined:

   – cases and deaths averted;

   – economic disruption averted;

– reduced apprehension of epidemics and greater health security.

8. Two methods of measuring cases and deaths averted were felt to have the best potential. The first uses epidemiological modelling techniques. The second uses expert opinion of public health professionals gathered through survey interviews. Despite a fair amount of imprecision, both methods would allow for a dialogue with countries about the real impact of a surveillance and response system – dialogue that would clearly be beneficial in gaining support for surveillance and response and for improving the system.

9. It is possible to combine cases and deaths into DALYs, though this would require additional work for some diseases.

10. A further step to calculating benefits would be to give a monetary value to cases and deaths averted. Given the difficulties inherent in assigning this value, however, it is the author's opinion that this exercise should not be attempted in the near future.

11. Economic disruptions associated with outbreaks can be very costly, especially for new diseases or diseases that engender panic. There is a growing literature on this topic. In the author's opinion, reviewing evidence of economic costs of previous outbreaks and estimating the potential costs of future outbreaks should be encouraged. This is an important economic benefit of surveillance and response systems that countries need to take into account. It will be difficult to estimate the potential costs of future outbreaks, in part because they are country specific, and estimates will only be hypothetical ball park figures. However, even a partial analysis that identifies economic vulnerabilities would be useful for advocacy purposes and to raise awareness.

12. The benefit of health security, including reduced apprehension about epidemics, is very important. Because it is confounded with the other benefits of surveillance and response systems, measuring it will be difficult; in the author's opinion analysis should not be pursued at the present time, given how much else needs to be done for cost and benefit evaluations to be put on a firm basis.

13. Although this paper focused on benefits resulting from either averting or controlling outbreaks, there are many other objectives of surveillance and response systems. Benefits relating to these other objectives have not been fully identified and documented. In-depth interviews and focus group discussions with surveillance and response officers in the field would be a useful first step in developing a more comprehensive understanding of the benefits of surveillance and response systems in different settings.

The step by step approach suggested in this paper would mean that the research would begin with a number of small pilot studies and would proceed cautiously, based on the results, thus permitting the costs and benefits of the research programme to be evaluated periodically. Only after there is some experience with empirical country studies would it make sense to embark on a more complete research agenda. The next steps should include, in the author's opinion:

a) Pilot studies of the costs of surveillance and response in two or three countries in different regions. There should also be pilot studies of benefits (in terms of cases and deaths) in two or three countries in different regions, using combinations of epidemiological modelling and expert judgement to value benefits. These studies would also indicate the costs and the feasibility of carrying out such studies.

b) After completion of country pilot studies, and based on this experience and improved knowledge, a meeting should bring together epidemiologists, economists and national policy-makers to draw conclusions about research priorities and plans for the future.

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Annex. International Health Regulations (2005)

Annex 1: Core capacity requirements for surveillance and response[10]

1. States Parties shall utilize existing national structures and resources to meet their core capacity requirements under these Regulations, including with regard to:

(a) their surveillance, reporting, notification, verification, response and collaboration activities; and

(b) their activities concerning designated airports, ports and ground crossings.

2. Each State Party shall assess, within two years following the entry into force of these Regulations for that State Party, the ability of existing national structures and resources to meet the minimum requirements described in this Annex. As a result of such assessment, States Parties shall develop and implement plans of action to ensure that these core capacities are present and functioning throughout their territories as set out in paragraph 1 of Article 5 and paragraph 1 of Article 13.

3. States Parties and WHO shall support assessments, planning and implementation processes under this Annex.

4. At the local community level and/or primary public health response level

The capacities:

(a) to detect events involving disease or death above expected levels for the particular time and place in all areas within the territory of the State Party; and

(b) to report all available essential information immediately to the appropriate level of health-care response. At the community level, reporting shall be to local community health-care institutions or the appropriate health personnel. At the primary public health response level, reporting shall be to the intermediate or national response level, depending on organizational structures. For the purposes of this Annex, essential information includes the following: clinical descriptions, laboratory results, sources and type of risk, numbers of human cases and deaths, conditions affecting the spread of the disease and the health measures employed; and

(c) to implement primary control measures immediately.

5. At the intermediate public health response levels

[10] Extracted from World Health Assembly resolution WHA58.3 Annex 1, pp. 42–43. Geneva, World Health Organization, 2005.

The capacities:

(a) to confirm the status of reported events and to support or implement additional control measures; and

(b) to assess reported events immediately, and if found urgent, to report all essential information to the national level. For the purposes of this Annex, the criteria for urgent events include serious public health impact and/or unusual or unexpected nature with high potential for spread.

6. At the national level

Assessment and notification. The capacities:

(a) to assess all reports of urgent events within 48 hours; and

(b) to notify WHO immediately through the National IHR Focal Point when the assessment indicates the event is notifiable pursuant to paragraph 1 of Article 6 and Annex 2 and to inform WHO as required pursuant to Article 7 and paragraph 2 of Article 9.

Public health response. The capacities:

(a) to determine rapidly the control measures required to prevent domestic and international spread;

(b) to provide support through specialized staff, laboratory analysis of samples (domestically or through collaborating centres) and logistical assistance (e.g. equipment, supplies and transport);

(c) to provide on-site assistance as required to supplement local investigations;

(d) to provide a direct operational link with senior health and other officials to approve rapidly and implement containment and control measures;

(e) to provide direct liaison with other relevant government ministries;

(f) to provide, by the most efficient means of communications available, links with hospitals, clinics, airports, ports, ground crossings, laboratories and other key operational areas for the dissemination of information and recommendations received from WHO regarding events in the State Party's own territory and in the territories of other States Parties;

(g) to establish, operate and maintain a national public health emergency response plan, including the creation of multidisciplinary/multisectoral teams to respond to events that may constitute a public health emergency of international concern; and

(h) to provide the foregoing on a 24-hour basis.