



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

Surveillance and control of infectious diseases at local, national and international levels

J. Weinberg

City University, London, UK

ABSTRACT

New emerging and re-emerging threats, the weight of public opinion and new technology for surveillance and treatment are likely to impact on how, and if, effective surveillance can be performed in the future. If surveillance fails to address the needs of practitioners and policy-makers, it is likely that there will be loss of confidence. Current surveillance systems are reasonably effective at detecting significant events that are localised in time and space. It is more difficult to detect diffuse and progressive events with a slow increase over time or sporadic and widespread events without obvious links to time, place or person. Detection of these events relies on good data collection, comparative background data and sophisticated analytical tools. To improve surveillance systems, we need methods with the appropriate sensitivity and specificity for the outputs desired. Targeted surveillance should enable better ascertainment of those cases which must be considered and those which can be dismissed. New methods, such as mathematical modelling and geographical information systems, support conventional surveillance in moving events into the known and predictable category. It is important to integrate surveillance across local, regional and international levels and to base surveillance on local public health structures. The purpose and value of data aggregation at each level and the amount of detail needed at each level must be carefully evaluated. The key to all these improvements is developing the workforce. Surveillance needs individuals with a broad range of skills: clinical, epidemiological, anthropological, and mathematical; in particular, people who can think laterally. These individuals must be encouraged through effective training courses, good mentorship, networking and clear career structures.

Keywords Infectious diseases, surveillance

Clin Microbiol Infect 2005; 11 (Suppl. 1): 12–14

INTRODUCTION

Surveillance is the cornerstone of an effective response to the threat of infection. Infections result from an interplay between a susceptible host, a virulent organism and the environment that brings them together. Failure to consider all of these elements and how they interact will result in a less than adequate response. Surveillance can provide information on the changing burden of infectious diseases, changes in the infecting agent (e.g., antimicrobial resistance), and changes in environmental factors (such as behaviour, e.g., condom usage),

and thereby allow the timely recognition of emerging threats and evaluation of interventions.

Effective surveillance should inform us about: the infections that are the most important causes of illness, disability and death, so that priorities can be determined for control and prevention activities; those populations most affected, or at risk, so that control and prevention efforts can be focused; outbreaks or epidemics, so that immediate action can be taken to identify and control the source; likely demands on healthcare services; and the effectiveness of control and prevention activities.

It should be clear from this that the data-capturing and analysis components of surveillance should be closely allied to control and prevention measures. Surveillance helps identify the appropriate measures and provides the means to assess their efficacy. Surveillance is a tool for improving the prevention, treatment and control

Corresponding author and reprint requests: J. Weinberg, Institute of Health Science, City University, Northampton Square, London EC1V, UK
E-mail: j.r.weinberg@city.ac.uk

of infectious disease—it is not an end in itself. Therefore, surveillance should be linked to outcomes, and should have clear objectives.

Indeed, a criticism of some surveillance systems is that the rationale for the data collection is not clear; the link between data collection and control activities has not been made, or has not been made explicitly. For many surveillance systems, the outputs, in terms of data, tables, newsletters, and websites, are often complex, inappropriate for the guidance of action, inadequate or not timely enough. If healthcare systems are to respond to future infectious disease threats, surveillance systems must provide those responsible for taking action with understandable, timely information.

Surveillance data come from a variety of sources, the main ones being: formal notification, by law—some diseases are ‘notifiable’, which means that a doctor should report them on the basis of the symptoms alone, rather than waiting for laboratory confirmation; laboratory reports; and clinician reporting. For some diseases that are of public health importance but not legally notifiable, key items of information are requested by public health authorities to ensure that appropriate action can be taken.

Surveillance data are commonly aggregated from local, through regional to national data sets. Recognition of international threats to health and increasing collaboration have driven the development of international data sets. Careful consideration must be given to the purpose and value of data aggregation at each level, and therefore the amount of detail that must be made available at each level. This is likely to be condition-specific. For many conditions, it is unlikely that individual specific data will be required above the local level; however, there may be some conditions or occasions when it is useful to collect individualised data at the international level.

Recent events have demonstrated the likelihood of continual threats of new infectious disease events. This is further complicated by the increasingly complex nature of the world, with expansion in international trade and travel. Surveillance must be appropriate for the population at risk. An outbreak related to an internationally traded foodstuff, or a conference of international travellers, raises complex issues of identifying the at-risk population, as well as issues of international collaboration, data exchange, ethics and law which

would not apply to an outbreak resulting from a problem in a village shop.

Surveillance increasingly takes place in the full glare of the media and the scrutiny of public opinion. Any outbreak is seen as a failure, and public expectations of being protected from infection may be unrealistic. Just as surveillance must be linked to control, it should also inform public education and information.

SENSITIVITY OF SURVEILLANCE SYSTEMS

Surveillance systems, like any other detection system, can be examined from the point of view of their sensitivity and specificity, and the likelihood of false-positives and false-negatives being declared. A system can be made more sensitive, but with the concomitant problem that the false-positive rate is likely to rise. The appropriate sensitivity and specificity of a surveillance system depend upon its purpose.

An early-warning system for severe events might reasonably be designed to be sensitive, in which case systems must be put in place to manage the problem that will arise from identifying events that turn out to be false-positives. This means having access to rapid confirmatory tests or investigations, and the ability to manage the public and political anxieties that may be generated. The alternative model, which aims to avoid false-positives, runs the risk of missing real events, or delaying their identification.

A mature surveillance system, with specific laboratory tests, can be highly specific. It should also be remembered that the predictive power of a test (and a surveillance system can be considered a complex test) depends upon the prevalence of the condition in the population. Thus, when measles was common, clinical diagnosis of measles was useful as a surveillance tool. As measles has become less common, although the sensitivity and specificity of clinical diagnosis are unchanged, the false-positive rate has become unacceptable, and surveillance systems have been obliged to adopt more specific laboratory tools.

Surveillance systems should be developed with due consideration being paid to the population(s) at risk, their link to control/prevention measures, the appropriate sensitivity/specificity and the management of public expectations. Aids such as the ‘critical examination technique’

Table 1. Critical examination technique

Purpose	What is achieved?	Is it necessary and why ?	What else could be done?	What should be done?
Place	Where is it done?	Why there?	Where else could it be done?	Where should it be done?
Sequence	When is it done?	Why then?	When else could it be done?	When should it be done?
Person	Who does it?	Why that person?	Who else could do it?	Who should do it?
Means	How is it done?	Why that way?	How else could it be done?	How should it be done?

(Table 1) can be used to investigate a surveillance system and optimise its various components.

IMPROVING SURVEILLANCE

Improving surveillance systems involves ensuring the use of methods with the appropriate sensitivity and specificity for the outputs desired. It is not an improvement to increase the specificity for an early-warning system if this introduces unacceptable delays. There is no single model; the system must be fit for its purpose.

Infectious disease events can be considered graphically according to two axes, namely, predictable or unpredictable, known or unknown. Thus, there are the unpredictable and unknown, such as the outbreak of severe acute respiratory syndrome or vCJD, the predictable and known, such as measles outbreaks when vaccination rates drop, and the unpredictable and known, such as the possibility of food poisoning outbreaks related to large-scale catering events, without knowing where or when. Surveillance systems for a known and predictable event must be very different from those required for an unknown and unpredictable event. As knowledge matures and a condition moves from being unknown to known, the surveillance system must change with it. Indeed, one of the roles of surveillance is to help move understanding from the unknown and unpredictable to the known and predictable.

Better understanding of the epidemiology and basic mechanisms of infection enables surveillance to be better targeted to at-risk populations. Targeted surveillance (and targeting may be of whole populations) should enable better, more complete ascertainment of that which can be considered a case and that which should not. New methods such as the use of mathematical modelling and geographical information systems

support conventional surveillance in moving events into the known and predictable category.

Novel data sources may also be useful in improving ascertainment and understanding, and therefore providing better-quality data sets. Sales of over-the-counter remedies, perhaps tracked through customer loyalty cards, may be rich sources of information about 'coughs and colds' and could be used to provide early warning of upper respiratory tract infection. Calls to health advice lines can be used in a similar manner. Information about weather patterns and veterinary events can indicate the risk of human disease such as Rift Valley fever and West Nile fever.

Current surveillance systems are reliable in detecting significant events that are localised in time and space, e.g., point source food poisoning. However, it is much more difficult to detect diffuse and progressive events with a slow increase in incidence over time, or sporadic and widespread events where there may not be any obvious links among time, place or person. Detection of these events relies on good data collection, good background data for comparative purposes and sophisticated analytical tools that will provide alerts when meaningful changes from a baseline occur.

CONCLUSION

The key to all these improvements in surveillance is developing the workforce. Surveillance is dependent on access to individuals with a broad range of skills: clinical, epidemiological, anthropological, and mathematical. In particular, people who can think laterally and are not constrained to think merely within the known 'boxes' are needed. They must be encouraged through effective training courses, good mentorship and networking, and clear career structures.