What are the most appropriate methods of surveillance for monitoring an emerging respiratory infection such as SARS?

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Abstract

Effective surveillance is necessary for the successful management of emerging infection. It allows public health protection measures such as contact tracing and isolation to be put in place. This study aimed to find the most appropriate surveillance method for a disease like SARS. Existing surveillance methods were evaluated against a set of new criteria in a qualitative manner. Influenza and tuberculosis (TB) surveillance were used as models. A literature search was undertaken to find relevant evidence. The results show that TB surveillance is more appropriate than influenza surveillance as a model because it is more complete in its reporting. Clinician-based reporting is better than laboratory-based because it is more timely. The results suggest a clinician-based notification system would be the most appropriate form of surveillance for a disease like SARS for public health purposes.

Key words: SARS, respiratory infection, surveillance

Introduction

The SARS epidemic in 2003 demonstrated the threat of new respiratory infections. Effective surveillance systems are necessary for the management of epidemics in order to apply health protection measures. The impact of SARS worldwide was significant both in terms of human and economic cost. There were 8098 cases worldwide and 774 people died.¹ The total economic loss has been estimated as up to \$10 billion in Asia alone² with significant economic disruption of badly affected countries. Although the outbreak was eventually identified and brought under control, the possibility of further outbreaks must still be considered.³

SARS is not the only respiratory infection to emerge rapidly and have a significant global impact. The influenza pandemics of 1918, 1957 and 1968 caused large numbers of deaths.⁴ The latest outbreak of avian influenza in Asia has caused global public health concern. In this era of mass international travel and large population migration, the management of emerging infection becomes increasingly relevant to UK health systems. To deal with this issue successfully, we need effective surveillance systems.

The United Kingdom had no definite surveillance system for

SARS or other novel respiratory infection when the outbreak began. A voluntary reporting system was rapidly set up for all suspected, probable and confirmed cases of SARS in the United Kingdom,⁵ but questions were asked on what surveillance methods are necessary to deal with this condition, or any like it, in the future. The health spokesman for the Opposition suggested that SARS should be made a notifiable disease.⁶ The Chief Medical Officer considered this move,⁷ but decided to continue with the voluntary clinical reporting system. The HPA produced an option appraisal inviting comment on this issue.⁸

In order to be systematic in assessing surveillance methods, it would be useful to have a set of criteria to evaluate the choices. This paper describes a set of criteria that were constructed which we believe are important for the effective surveillance of a disease like SARS. We have evaluated existing surveillance methods against these criteria. The two diseases chosen to act as models for SARS were influenza and tuberculosis (TB), being respiratory infections of public health importance and occurring on a global scale.

Methods

A set of criteria was constructed with the surveillance of SARS in mind. The ideal surveillance system would be: (1) accurate, expressed as a high positive predictive value, so that a reported case was a true case; (2) complete, so that all or nearly all cases were reported; (3) timely, in that reports would be received by the relevant public health agency in time for control measures to be effective; (4) using agreed case definition(s); (5) continuous, running for long periods of time; (6) electronic to be fast and efficient; (7) able to detect local outbreaks or clusters of cases; (8) easily used to follow up cases and contacts.

The surveillance methods used in the United Kingdom for influenza and assessed in this study were sentinel general practices, laboratory data, mortality data, NHS direct data and the Medical Officers for Schools Association.⁹ Surveillance methods

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Table 1 Criteria for a SARS surveillance system and evaluation scheme

What is the criteria being assessed?	Why is this question important?	What information is used to assess this property?	How is the criteria rated in this study?			
			A	B	C	U
Positive predictive value: what is the likelihood of a person having the condition (as defined by the gold standard test) if they are reported by the surveillance system?	(1) To make efficient use of resources, targeting them towards genuine cases; (2) high levels maintain public confidence; (3) high levels likely to improve reporting compliance	Data from text in article	High >90%	Moderate 90%-50%	Low <50%	Unknown/uncertain
Completeness: what fraction of the total number of cases of the disease does the surveillance system pick up?	All cases need to be detected for complete infection control	Data from text in article	High >90%	Moderate 90-50%	Low <50%	Unknown/uncertain
Timeliness: what is the length of time between initial diagnosis and reporting of the condition?	System needs to allow infection control measures to be taken as quickly as possible	Data from text in article	Fast < 24 h	Moderate 24 h to 1 week	Slow >1 week	Unknown/uncertain
Does the system make use of an appropriate case definition?	(1) To allow comparison between systems; (2) To improve consistency of reporting	From system description in article	Proven/operational	Potential/possible	Unlikely/impossible	Unknown/uncertain
Does the system provide continuous monitoring?	To allow detection of new epidemics whenever they occur	From system description in article	Proven/operational	Potential/possible	Unlikely/impossible	Unknown/uncertain
Does the system use an electronic or computer based reporting system?	To allow efficient transfer and handling of data	From system description in article	Proven/operational	Potential/possible	Unlikely/impossible	Unknown/uncertain
Would the system be able to pick up local outbreaks of a condition such as SARS?	To allow outbreaks to be identified and resources focused where needed	Evaluation of author based on completeness/ability to find links between cases	Almost every outbreak identified	Some but not all outbreaks identified	Very few outbreaks identified	Unknown/uncertain
Does the system allow rapid follow-up of known cases?	To implement public health protection methods (e.g. isolation, quarantine, contact tracing) as soon as possible	Evaluation of author based on timeliness/completeness/ quality of data received	Rapid follow-up likely	Rapid follow-up possible	Rapid follow-up impossible	Unknown/uncertain

for TB evaluated were statutory disease notification, enhanced surveillance, laboratory data and mortality data.¹⁰

Medline and Embase databases were searched for relevant articles describing these surveillance systems. The search was limited to articles published in English and written in the last 25 years. Only articles related to surveillance in North America, the United Kingdom, Europe or Australia were considered.

The search terms for influenza surveillance systems were 'influenza and surveillance' and one of the following: sentinel, spotter, laboratory, mortality, NHS direct, school, accuracy, sensitivity, specificity and effectiveness. The search terms for TB surveillance systems were 'TB and surveillance' and one of the following: notif, enhanced, laboratory, mortality, accuracy,

sensitivity, specificity and effectiveness. Relevant articles were selected from the abstracts and read.

The surveillance methods were rated against the criteria using information from this literature search (Table 1): surveillance methods were rated A if they met the criteria well, B if the method met the criteria imperfectly, C if the method was unsuitable for the criteria and U if the result was unknown.

If more than one paper reported a surveillance system with the same result, a recent reference is given. When evaluating the use of electronic recording, continuity and case definition the most favourable rating is recorded. In some circumstances there were no explicit data but the quality could be deduced from descriptions in the text. These deductions are displayed in brackets.

When there was no published evidence for a criterion, but it was possible to deduce from the method whether it would be effective, the author made a judgement as described in Table 1.

Table 2 Literature search results

	Number of articles from Medline and Embase	Number of articles after reviewing abstracts
<i>Influenza and surveillance and</i>		
Sentinel	132	55
Spotter	3	2
Laboratory	251	69
Mortality	328	80
NHS direct	2	2
School	146	16
Sensitivity	99	25
Specificity	70	12
Accuracy	31	10
Effectiveness	60	5
<i>Tuberculosis and surveillance and</i>		
Notif	212	41
Enhanced	43	13
Laboratory	231	27
Mortality	221	28
Specificity	62	6
Sensitivity	166	16
Accuracy	32	6
Effectiveness	88	10

Results

Very many references were found (Table 2). Many were simple descriptions of the operation of the surveillance system. Few attempted to assess the effectiveness of surveillance systems in action. We could find very little published evidence for two of our criteria, the ability to detect all local outbreaks and the feasibility of following up cases and their contacts through the surveillance method.

The results of our ratings are shown in Table 3.

Influenza surveillance systems tended to be less suited to observing a disease such as SARS because they had a lower positive predictive value and were far less complete in their reporting. Most of them (sentinel practice, NHS direct, school and laboratory reporting) were designed to sample a population and make predictions about the presence and character of an epidemic on the basis of this sample. TB surveillance methods, being designed to try and pick up each and every individual case, were much more favourably rated.

Clinician reported data (sentinel GPs and notifications) based

Table 3 An evaluation of existing surveillance methods against our SARS-specific criteria

Disease	Surveillance method	PPV	Completeness	Timeliness	Case definition	Continuous	Electronic	Can it pick up outbreaks?	Is follow up possible?
Influenza	GP sentinel	B ¹² /C ¹³	C ¹⁴	B ¹⁵ /C ¹⁴	A ¹⁶	A ¹⁷	A ¹⁵	B	B
	NHS direct	U	(C)	A/B ¹⁸	C ¹⁸	B ¹⁸	A ¹⁸	B	B
	School reporting	U	(C)	B ¹⁹	C ¹⁹	A ¹⁷	U	B	B
	Laboratory	A/B ²⁰	C ¹⁴	A/B/C ²⁰	A ¹⁴	A ¹⁷	A ¹⁴	B	B
	Mortality	U	B ²¹	B ¹⁷	(C)	A ¹⁷	U	B	U
Tuberculosis	Notification	(A)	A ²² /B ²³	B/C ²⁴	A ²⁴	A ²⁵	A ²⁶	A	A
	Enhanced surveillance	(A)	(A)	U	(A)	A ²⁷	U	A	U
	Laboratory	A ²²	A ²²	C ²⁸	A ²⁹	A ³⁰	A ³⁰	A	C
	Mortality	B ³¹	C ³¹	U	(C)	A ³¹	U	B	U

on rapidly assessed history, examination and early investigation gave more timely reporting than most laboratory methods. Laboratory-based reporting had the advantage of accuracy but also the disadvantage of being slower than a clinical diagnosis.

Mortality reporting provided interesting figures that are useful for retrospective analysis of epidemics, but were too slow for the immediate need.

NHS direct, the only other means of surveillance likely to provide genuinely timely data, had a great deal of scope as a future surveillance tool, but problems of completeness and accuracy reduced its rating in our assessment.

Discussion

The results show some striking patterns and demonstrate that a qualitative analysis using a set of criteria and a literature search can be undertaken to compare the basic properties of surveillance systems. Although in some areas there is a lack of definite information, these results allow some conclusions to be drawn about the sort of surveillance systems that might be appropriate for a disease like SARS.

The conclusions must be cautious because of the limitations of the study. We used an arbitrary set of criteria and a qualitative rating, and restricted the study to evidence found from Medline and Embase, which might have missed information not formally published in medical journals.

There are limitations in applying information from TB and influenza models to SARS. For certain criteria the evaluation of a surveillance system is dependent on the disease being monitored. For instance, the timeliness of TB and SARS laboratory reporting will not be the same but will depend on the specific laboratory process in each case. The general theme remains however that laboratory testing is likely to be slower, regardless of the disease. Developments such as the availability of a sensitive RT-PCR test for SARS corona virus which can produce results quickly¹¹ would change the rating for laboratory-based reporting. However, there may not be rapid laboratory tests available in the early stages of a new respiratory epidemic.

Given these limitations, we conclude that the best system of surveillance for a disease like SARS would be clinician-based reporting using TB notification as an example. The clinician-based reporting of influenza is less suitable as a model because it is sample based, whereas SARS requires every case of the disease to be reported.

Even using good case-definitions, clinician-based reporting of all suspected cases will yield false cases, which will add to the costs of the time of health care staff in running the system and to the burden placed on the people subjected to the control measures. The cost of running a clinician-based surveillance might be an argument for having surveillance for a condition like SARS held in a latent state until the first signs of an epidemic, instead of continuous monitoring. This runs a risk that the process of making a disease reportable or formally notifiable

would take too long in the event of a new outbreak. The costs of starting, or re-starting, a surveillance system would need to be considered with plans to distribute information to front line medical services as soon as the threat of disease is imminent.

A surveillance method used for SARS should gather more information than is currently collected by formal notification forms, and should follow the example of the extra data in the enhanced TB surveillance scheme to improve possibilities of identifying outbreaks and following up people at risk.

This study does not answer the question of whether a clinician-based reporting system should have the statutory basis of notifications. We could find no evidence to compare effectiveness of notification systems that have a statutory basis with those that do not. The question on whether to make SARS formally notifiable may be more a question of whether the control measures for SARS require a legal foundation that includes a statutory notification than deciding on the best surveillance method.

We recommend the establishment of a clinician-based reporting system for SARS, similar to current notifiable disease reporting, which collects as much information as possible about individual cases. If the system is not continuous, it should be held 'in waiting' ready to be put into action as quickly as possible.

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