LEARNING FROM SARS

Preparing for the Next Disease Outbreak

Workshop Summary

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of new cases within a certain number of days, but also an estimate of how to go about achieving that containment goal (i.e., how many staff, rooms, media campaigns, and other factors). Planning models that focus on critical resources in this manner can provide guidance for live exercises and may influence future investments in both infrastructure (e.g., installation of negative pressure isolation rooms) and disposable medical equipment (e.g., gowns and masks).

REPORTING, SURVEILLANCE, AND INFORMATION EXCHANGE: THE SARS IMPERATIVE FOR INNOVATION

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The emergence and widespread transmission of severe acute respiratory syndrome (SARS) in the winter of 2003 severely tested national, regional, and global reporting and surveillance systems for emergent infectious diseases. It presented a three-pronged challenge: (1) alerting responsible authorities; (2) rapidly describing the geographically diverse outbreaks in a consistent and useful fashion; and (3) providing guidance for prevention and control strategies based on experience in varied locations. Given the persistent emergence of new infections in recent years in the Asia Pacific—accompanied by the continued increase in population size and the greater range and volume of trade and travel in the region—this scenario must be considered a harbinger for the future. The gaps brought to light in this experience should be used to guide the rapid deployment of laboratory and communications systems in the region. In this article, the informatics components of the response to SARS are described and characterized. Prospective areas for applications of new technologies are discussed.

Hypothesis

The SARS experience represents a precursor to future scenario planning for the Asia Pacific. Descriptive data suggest both successes and gaps in timeliness,

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laboratory diagnostic tools, and useful, practical transparent communications among sectors within nations, and between nations partnered in trade and travel. This report will focus on gaps in the latter two areas: practical transparent communications among sectors and between nations.

Methods

We conducted a focused and systematic review of the 2003 SARS epidemic based on (1) our EINET experience operating an electronic, multisectoral communications network in the region, in collaboration with (2) a literature review for the identification of potential applications of informatics technology based on the 2003 experience (including response management, collaboration, capacity development, tabletops/training, and other factors).

Findings/Conclusions

SARS presented the confluence of three urgent requirements of the global public health informatics response: (1) expansion of knowledge about the disease in a rapid, systematic manner, particularly in microbiology and epidemiology through collaborative discovery; (2) communication of appropriate aspects of that knowledge base to guide implementation of isolation, quarantine, and prevention measures by public health workers and other policy makers; and (3) mitigation of adverse societal response through broader social communication. However, with concurrent outbreaks in numerous locations, each of these requirements rapidly increased in complexity. Working relationships in the Asia Pacific public health community have been formed in the course of the outbreak response that can be reinforced in the present "inter SARS" period. Specific computing and telecommunications tools can be expanded to assist more fully in the public health response. We propose the use of a virtual tabletop (scenario) tool to proactively implement improved communications and collaboration strategies in the region.

Background

The SARS outbreaks of 2003 have been described in numerous scientific reports (CDC, 2003a). In fact, the unprecedented volume and speed of scientific discovery and the dissemination of that knowledge has been the subject of a report (Drazen and Campion, 2003). This report focuses on (1) how informatics and telecommunications strategies assisted in the timeliness of this effort; and (2) what technologies or strategies could be tested and applied in the current "inter SARS" period to assure public health readiness for the future.

The factors related to the emergence of new infectious diseases have been described for more than a decade (IOM, 1992, 2003). The role of anthropogenic factors of emergence related to microbial pathogens in humans, while generally understood to be important, has become the object of systematic biomedical and interdisciplinary research. The overlay of globalization in manufacturing, commerce, travel, and trade on an uneven public health and sanitary infrastructure has put some populations at risk of new infections. These risks become reality in epidemics that increasingly challenge our ability to respond effectively.

The Asia Pacific has witnessed the emergence of numerous new human pathogens, including Nipah virus, enterovirus 71, *E. coli* 0157H:7, and *Cyclospora Cayetanensis*. The reemergence of "old" pathogens such as cholera and multidrug-resistant tuberculosis has also affected the region. This may reflect the pace of change that countries bordering the Pacific Ocean have experienced in their demographics, migration, and rapid shifts in economic activity. In addition, these nations are among the most trade dependent in the world. The Asia Pacific dwarfs other regions of the globe in the volume and dollar value of trade and travel revenues.

Asia has had sustained growth of Internet connectivity over the past decade, despite economic crises in the region (Kimball et al., 1999). In a recent report, the International Telecommunications Union (ITU, 2003) noted that the number of broadband subscribers rose 72 percent in 2002, with Korea (21 subscribers per 100 inhabitants), Hong Kong (15 per 100), and Canada (11 per 100) showing the highest rates of broadband use. In Korea, "Disweb," an electronic surveillance system, has been in place since 1999 using web-based reporting over the Internet. Many other economies are increasingly integrating Internet-based reporting into their disease alert and surveillance systems.

While numerous electronic disease surveillance and alert networks are operating in the region, the Asia Pacific Emerging Infections Network (APEC-EINET) is unique in that it includes membership from trade and commerce (see Figure 5-3) as well as health. Now in its eighth year of operation, the network spans the entire Asia Pacific community. The network consists of a user group of more than 500 in 19 of the 21 APEC economies. Providing a biweekly bulletin and enriched website, the APEC-EINET is supported by APEC, the U.S. government, and the University of Washington.

Methods

Of the 1,150 articles entered into the Medline index with "SARS" in their text, 60 include the word "information" and 2 include "information technology" (Eysenbach, 2003). The 60 information-related articles were scanned for discussion on informatics or information technology employed during the outbreak by scientists or public health workers. In addition, informal discussions were held in person and through electronic communications with World Health Organization/Geneva (WHO/Geneva) and regional academic institutions and public health organizations to augment the information available for review in this report. Because the SARS experience is still being understood, the data obtained through personal communications may be incomplete.

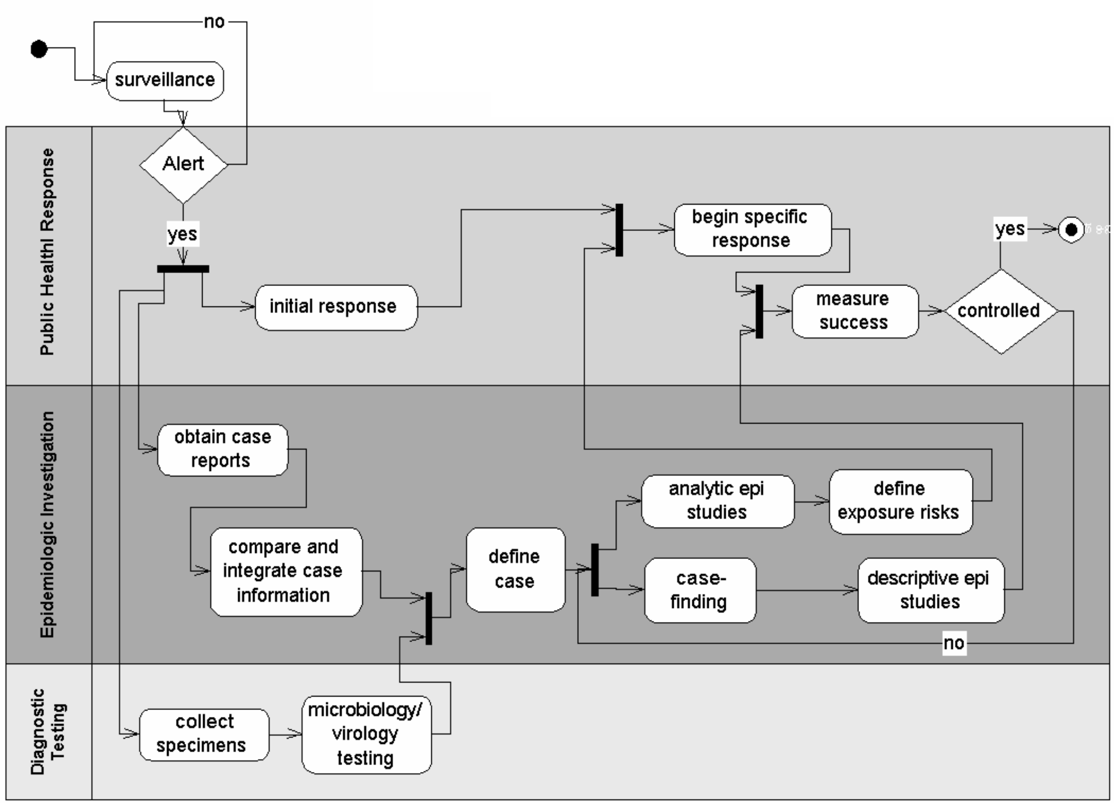

FIGURE 5-3 Integrated process for public health disease response.

After compiling this information, we segregated our conclusions into the informatics domains of (1) generation of new biomedical knowledge about the SARS agent; and (2) generation of new knowledge about the epidemiology of SARS disease prevention for purposes of predicting and monitoring success in control. We provide our assessment based on this analysis of the need for specific new communications and collaboration strategies.

Results

If the basic systems model of an outbreak alert, investigation, and response resembles the work model in Figure 5-4, then numerous frontiers for information technology application and evaluation exist. This diagram integrates business processes and the information flow that supports these processes in the course of work done to investigate and respond to an outbreak (Kitch and Yashoff, 2002). The focus of international information technology application during SARS centered on three aspects, which are shown in the figure: alert, diagnosis (biomedical discovery), and epidemiologic investigation.

Alert

According to WHO, the earliest alerts about an unknown pneumonia in Guandong were discovered by Global Public Health Information Network

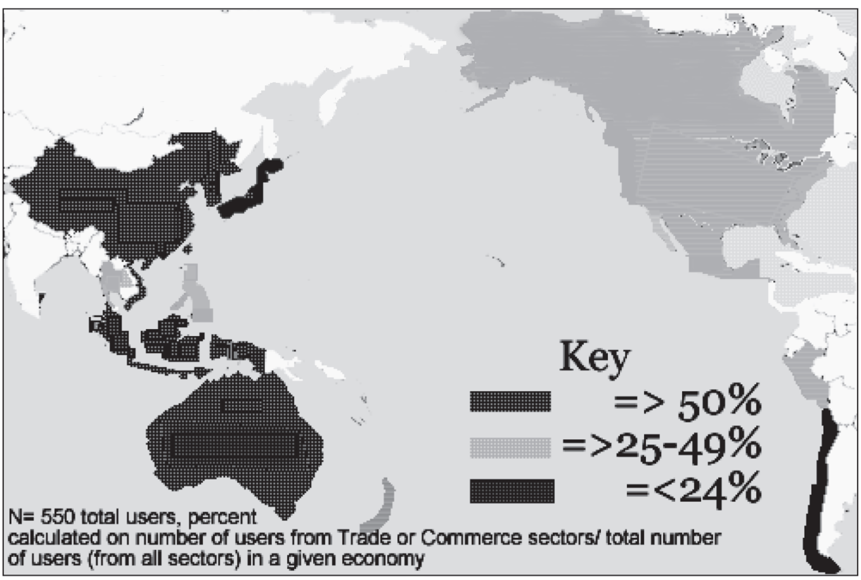

FIGURE 5-4 Percentage of APEC EINet users from trade and commerce by economy.

(GPHIN) (Heymann et al., 2001). Essentially a webcrawler, text-mining tool, this application was developed with Canadian government funding and implemented through an agreement with WHO in 2000. The "hits" generated daily are reviewed manually in Canada, and about 200 reports are forwarded to WHO per day. However, despite such alerts, all reports from GPHIN require independent verification from reliable sources on site (Grein et al., 2000; Hsueh et al., 2003).· In the absence of such confirmation, an international alert cannot be issued.

Biomedical Discovery

Response depends on diagnosis of what an outbreak is or is not. In the case of SARS, new scientific discovery was probably the largest beneficiary of new information technology, and this was in line with its priority in enabling effective public health response. Bioinformatics software tools were used extensively to identify the genome of SARS (Li et al., 2003), calculate the likelihood of frequencies in the annotation process (Ruan et al., 2003), and model the virus for prospective drug design among other uses. These tools, employed by teams of scientists across international boundaries, allowed bench scientists to rapidly generate new information about the SARS agent.

Interlaboratory communication was a second area in which the Internet and communications technologies added value. Stohr and colleagues report on the multicenter collaboration convened by WHO to "identify the causal agent and to develop a diagnostic test" (WHO Multicentre Collaborative Network, 2003). The 11 laboratories were located in nine countries. Countries both affected and not affected by SARS figured among the nine.

The electronic tools implemented included: (1) a secure, password-protected website where primer sequences and other information were posted for researchers; (2) electronic mail communications using the Internet; and (3) the telephone for daily teleconferences. Probably as important, the ethical framework for collaboration was established through an agreed protocol for sharing results and information. This protocol protected the work of scientists involved and fostered information sharing for advancement of the mutual collaboration. This networked activity of distributive efforts was efficient, resulting in the discovery and initial description of the coronavirus of SARS over the period of one month.

Epidemiologic Knowledge

Disease investigation was carried out in earnest at each of the outbreak sites. Case counts and mortality counts were reported through PROMED, WHO, EINET, and the media. However, in our experience with EINET, the need for practical guidance for the Asia Pacific outstripped the available information in the first weeks of the epidemic. We received numerous queries about hospital isolation procedures, quarantine, airport measures, treatment, and other issues. While recommendations addressing these eventually were posted by international authorities, practitioners in closely linked but unaffected economies desired more specific and detailed information in a more timely manner.

WHO has convened the Global Outbreak Alert and Response Network partners over the past 8 years to begin to address exactly the kind of crisis presented by SARS. This activity proved to be a major asset to WHO in coping with SARS. However, the secure network and website approach that was implemented was less able to cope with the volume and diversity of information required. Specifically, the need for detailed information by public health authorities in unaffected areas was not optimally met (Kimball and Pautler, 2003).

The ability to monitor the impact of interventions is important to modulating the public health response. The key epidemiologic parameter to be followed is the reproductive rate of the epidemic in progress. If this rate is above 1.0, the epidemic will continue to expand as it infects new susceptibles at a greater rate than infected individuals recover (Lipsitch et al., 2003). This rate relies on modeling, and parameters that are difficult to collect through field investigation. In retrospect, only some of the affected localities were able to collect quality data in adequate amounts to enable such modeling to be reliably applied (Donnelly et al., 2003). As noted by one group, "Limited data and inconclusive epidemiologic information place severe restrictions on efforts to model the global spread of the SARS etiological agent" (Chowell et al., 2003).

Because our own user group includes trade and commerce officials from a number of APEC economies (Figure 5-4), our network was one of the few that provided updates on the epidemic situation in the region systematically to individuals not employed in the health sector. Although we have no quantitative information to document this, anecdotally we have been told this was useful in decision-making during the epidemic period.

Discussion: "Inter-SARS" Preparedness

SARS presented a challenge on both the research and response fronts. However, a similar challenge would be faced with any acute, severe viral respiratory infection for which diagnostic, treatment, and containment recommendations had not been well established. Influenza is an agent that could produce a similar picture and create similar chaos in the region. Thus, the overall concept of "preparedness" for such a natural disaster can serve to inform our actions in preparing for the "next wave." In fact, in the midst of SARS, this genre of concept surfaced in the literature (Augustine, 2003).

The processes to address two major domain needs of the SARS response—laboratory research and epidemic investigation—were not truly ad hoc during the outbreak period. The basic structures of the two collaborative groups—the linked laboratories and the outbreak alert and response partners (including the implementation of GPHIN)—had been created over the years prior to the outbreak. However, the implementation of emergency response was ad hoc, as was the area of epidemiologic investigation. Response encountered obstacles in communications, which can be partially addressed through preparedness exercises.

Tabletop or scenario exercises have been a centerpiece in preparation for emergency response in the United States. In Japan and Korea, exercises of alert and syndromic surveillance systems have been conducted to prepare for events such as the World Cup (Suzuki et al., 2003). The scenario "Dark Winter" convened high-level policy makers to discuss smallpox preparedness planning in the United States, and the more recent "Global Mercury" exercise carried out by the Global Health Security Action Group demonstrated the utility of this approach internationally (U.S. Department of State, 2003).

The tabletop as envisioned will: (1) bring together research universities and their public health counterparts in a collaborative process to tailor a scenario for their location in response to the threat of a travel-related, highly infectious disease; (2) create automated access to pertinent information sources at multiple sites that will add value to actual response efforts should these be needed; (3) promote international communications and collaboration using newer communications strategies among partners, thus ensuring the availability of these new tools to the public health community; and (4) create a flexible scenario for use in preparedness domestically and potentially by multiple APEC economies in training efforts. We believe the use of access node communications (see Box 5-1) for collaborative conferencing will demonstrate added value in the collaborative design process and in the debriefing on generic lessons learned in the exercises.

Beyond the virtual tabletop exercise, systematic analysis of the integrated workflow diagram suggests many other potential application sites for new information technologies. One apparent area would be the development of a software tool that could allow individual outbreak sites to assess their own data and calculate their own rate of reproduction for the outbreak they are experiencing (Chowell et al., 2003; Donnelly et al., 2003; Lipsitch et al., 2003). Such a tool could enable local public health officials to step up or step down response as success is or is not achieved. However, such a tool would rely heavily on the generation of reliable field investigation data in a timely way. The generation, compilation, and analysis of these data during the course of an outbreak remain the cornerstone of successful outbreak curtailment. Innovations in information technology need to be evaluated for their ability to support the key function of effective public health outbreak response.

Electronic networking and promoting intersectoral collaboration figure among the five strategies adopted by APEC to respond to emergent infections (Asia-Pacific Economic Corporation, 2001). The virtual tabletop will begin

BOX 5-1
The Access Grid

"The Access Grid™ is one example of advanced communications resources now accessible within the Asia Pacific. An ensemble of resources including multimedia large-format displays, presentation and interactive environments, and interfaces to Grid middleware and to visualization environments, access grid nodes are used to support group-to-group interactions across the Grid. The Access Grid (AG) is used for large-scale distributed meetings, collaborative work sessions, seminars, lectures, tutorials, and training. The Access Grid thus differs from desktop-to-desktop tools that focus on individual communication.

The Access Grid is now used at over 150 institutions worldwide (including institutions in Japan, Taiwan, Korea, Singapore, Canada, US, China, Hong Kong, Thailand). Each institution has one or more AG nodes, or "designed spaces," that contain the high-end audio and visual technology needed to provide a high-quality compelling user experience. The nodes are also used as a research environment for the development of distributed data and visualization corridors and for the study of issues relating to collaborative work in distributed environments" (www.accessgrid.org).

to leverage the sophistication already in place in communications and computing in the Asia Pacific in the service of the public good. Specifically, (1) communications technologies and middleware capacities of Asia Pacific research and education telecommunication networks are in place to be tested and adapted within the EINET community to support reporting, surveillance, and information exchange, particularly through the use of the Access Grid; and (2) a network of Pacific Rim research universities are being brought into the effort to serve as primary points of access for these advanced networks and technologies and as hubs of a broader communications network with the capacity to engage public health as well as other professionals throughout the APEC community.

PUBLIC HEALTH LAW PREPAREDNESS

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The Central Intelligence Agency's (CIA's) unclassified report on severe acute respiratory syndrome (SARS) sets the tone for our current status on legal pre-

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