# War on SARS: a Singapore experience

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**ABSTRACT**

On Mar. 12, 2003, the World Health Organization issued a global alert regarding cases of a severe atypical pneumonia termed "severe acute respiratory syndrome" (or SARS). In Singapore alone, there have been 238 SARS cases and 33 deaths, including 5 health care workers. With modern global inter-connectivity, SARS rapidly spread to become a worldwide phenomenon. This article describes the Singapore "war on SARS" from an emergency physician's perspective, focusing on the "prevent, detect and isolate" strategy. Notable innovations include the use of home quarantine orders, mass temperature screening using thermal imaging, modular systems of hospital staffing, "virtual" hospital visits, and innovations in emergency department design. Most emergency departments, hospitals and health care systems appear to be psychologically and logistically unprepared for a massive infectious disease outbreak. In light of recent natural and terrorism-related threats, emergency care providers around the world must adopt a new paradigm. The current SARS outbreak may be merely a taste of things to come.

**Key words:** severe acute respiratory syndrome; SARS; emergency planning; quarantine; isolation; outbreak

**RÉSUMÉ**

Les urgences médicales pendant un vol sont des événements peu courants et généralement non fatals. Dans les cas fatals, la cause la plus courante de mortalité est l'arrêt cardiaque subit. Cet état de chose et la notion selon laquelle la défibrillation précoce est le facteur déterminant le plus important d'une réanimation cardiaque réussie ont mené à une disponibilité accrue des défibrillateurs externes automatisés (DEA) à bord des vols commerciaux. Les DEA sont des appareils perfectionnée et extrêmement fiables conçus pour être utilisés par des profanes formés à leur utilisation dans l'espoir de minimiser le délai crucial jusqu'à la défibrillation. Bien que les appareils soient conçus pour être infaillibles, des erreurs d'utilisation liées aux appareils eux-mêmes ainsi qu'à des opérateurs ont été relevées. Dans le cas à l'étude, nous présentons une erreur unique imputable à un opérateur impliquant la lecture erronée d'une fenêtre d'instruction d'un DEA. Nous passons brièvement en revue l'historique du recours aux DEA par l'industrie de l'aviation et nous insistons sur le besoin d'une bonne connaissance des soins de base en réanimation lors de l'utilisation de ces appareils. Nous concluons en faisant des recommandations pour éviter que des erreurs semblables ne se répètent dans le futur.

## Introduction

On Mar. 12, 2003, the World Health Organization (WHO) issued a global alert regarding a severe form of atypical pneumonia termed "severe acute respiratory syndrome" (SARS).[1,2] The clinical and laboratory features of this disease have been previously described,[3–7] and it has been linked to a novel coronavirus.[8–10]

Given the ease of modern travel, SARS rapidly spread and became a worldwide phenomenon.[11–14] Singapore's index pa-

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tient was admitted to hospital on Mar. 1, 2003, after a visit to Hong Kong[15] and triggered a cascade of outbreaks throughout our region. Singapore's experience with SARS suggests that emergency departments (EDs), hospitals and health care systems are psychologically and logistically unprepared for a massive infectious disease outbreak. In light of recent natural and terrorism-related threats, emergency care providers around the world must adopt a new paradigm in which defence against infectious disease threats is a daily operational necessity rather than an unfamiliar contingency plan activated only during recognized events. This paradigm shift would fundamentally change the way medicine is practised.

The objective of this article is to provide an emergency physician's perspective on the Singapore SARS experience and to describe the measures taken in our war on SARS. It is hoped this will help others who do not have first-hand experience with SARS prepare for future outbreaks.

## Outbreak

On Mar. 1, 2003, Singapore's index patient (Patient 1; referred to in Fig. 1 as "Superspreader 1") was admitted to Tan Tock Seng Hospital (TTSH). Patient 1, a 23-year-old Chinese woman, had been vacationing in Hong Kong from February 20 to 25. A guest from Guandong Province in southern China who stayed on the same floor in the Hong Kong hotel as did Patient 1 is thought to be the infection source for her and also for the index patients of outbreaks in Vietnam and Canada (Fig. 1).[15] Her two travelling companions were also admitted to hospital, one to TTSH and another to Singapore General Hospital (SGH).

When Patient 1 was admitted to TTSH, hospital staff did not recognize the highly infectious nature of SARS, and for the first 6 days she was treated in an open ward with no infection precautions. This resulted in an initial cluster of 25 cases, including 11 health care workers, 4 ward patients, and 10 visitors and relatives. A second cluster occurred at SGH after a patient discharged from TTSH was subsequently admitted there. Another patient who acquired SARS while visiting TTSH was admitted to a third public hospital, National University Hospital, spawning a new cluster of infections, and an additional patient discharged from TTSH to a nursing home caused an outbreak of infections there. Table 1 illustrates the sequence of events that followed.

It is important to note that there were no new in-hospital infections at any of the 6 major public hospitals after the implementation of infection control measures.

Almost all of the 238 suspected SARS patients were admitted through various EDs. In addition, all hospital EDs experienced a surge in patient volume due to the effective "closure" of TTSH when it was converted to SARS Central. In some cases ED volumes almost doubled. Besides taking on additional non-SARS-related patients, there were increased demands due to screening requirements for all febrile patients, although most were not SARS related. These factors produced severe strains on manpower, resources and beds. Fortunately, EDs were among the earliest adopters of full personal protective equipment (PPE) for staff and strict infection control measures. As a result, none of the ED staff were infected.

On May 30, 2003, Singapore was removed from WHO's list of SARS-affected countries, and on July 13, 2003, the last probable SARS patient recovered and was discharged. In total, there were 238 SARS cases and 33 deaths, including 5 health care workers. Singapore is still counting the social and economic costs, which were especially high in the tourism, trade and retail sectors. Although the first battle with SARS has ended, there are no illusions that the war is over.

## War on SARS

Singapore's strategy against SARS was based on the principles of "prevent, detect and isolate." Described here are the strategies at national/regional, hospital and emergency department levels (Box 1).

### *National/regional strategies*

Singapore is a small trading nation with an open economy; therefore, closing the borders was never a viable option. Our national strategy was based on detecting SARS and isolating SARS patients in one location — thus the decision to concentrate patients and resources at SARS Central. This allowed the 5 other public hospitals to continue providing emergency care for patients with non-SARS conditions. To protect community emergency medical services response and assure that all suspect or probable SARS patients were transported to SARS Central, a dedicated ambulance service was set up. In addition, EDs and primary care providers provided vigilant screening of all potential SARS patients. Rapid dissemination of case definitions, information updates and mandatory reporting of all suspected cases was part of this strategy.

Contact tracing was a key component of the plan, and one of the more important innovations was the use of contact logbooks, which were provided to all health care workers, restaurants and even taxi drivers. Command centres employed an army of contact tracers to track down and quarantine potential cases. In record time, the Singapore Parliament passed home quarantine legislation requiring people with possible SARS contact to quarantine them-



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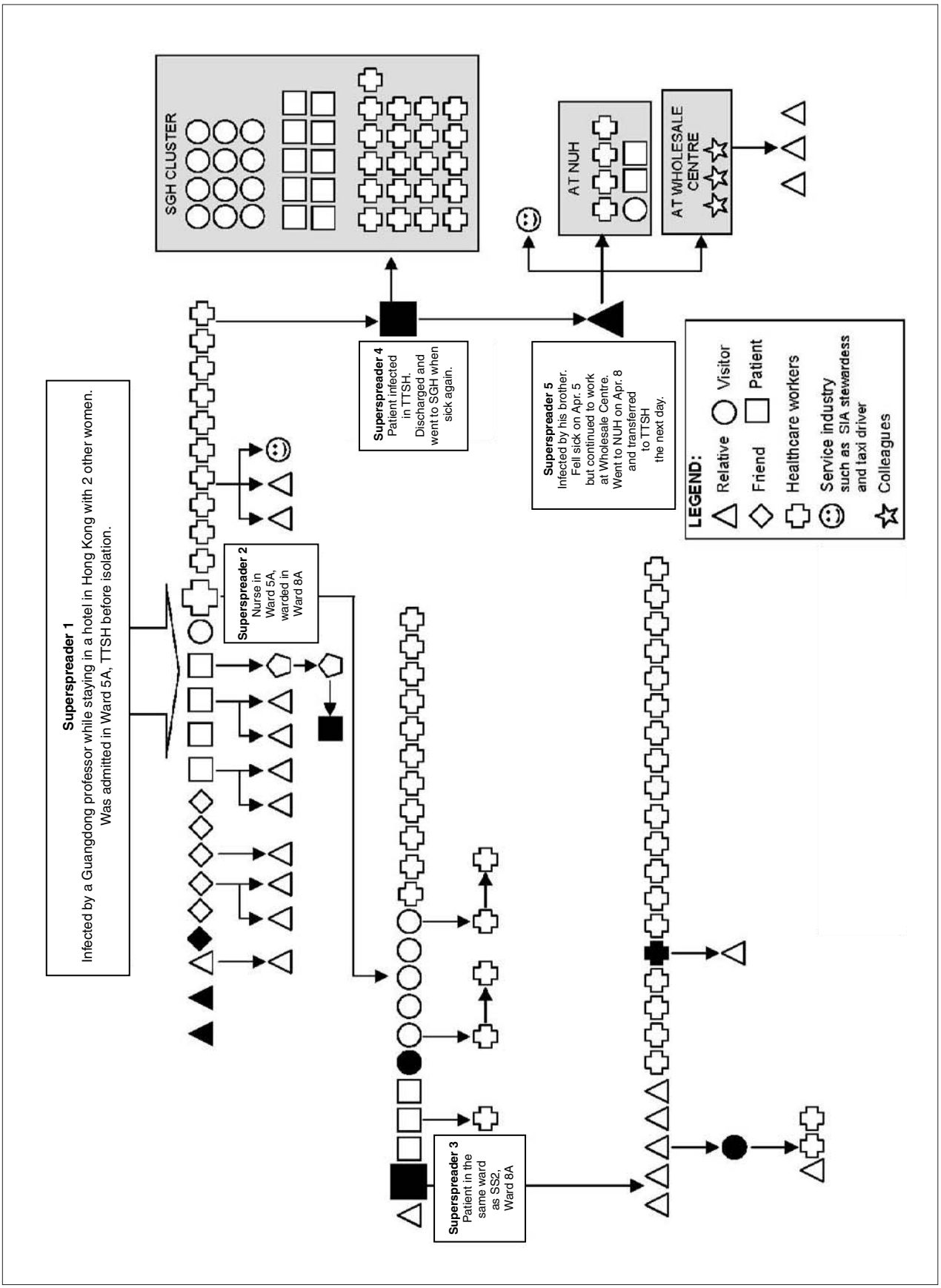


**Fig. 1: Index cases and initial chain of infection in the Singapore SARS outbreak. Symbols in black denote patients who died. TTSH = Tan Tock Seng Hospital; SS = Superspreaders (those patients known to have started a new cluster of infections); SGH = Singapore General Hospital; NUH = National University Hospital.**



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selves at home and monitor their temperatures. Home quarantine orders were enforced by daily phone monitoring and Web cam reporting. Grassroots organizations were employed to deliver food and financial support for those quarantined, and strict penalties, including fines or jail time, were imposed on those breaking quarantine. Recently, alternative accommodations were made available for people who prefer not to be quarantined at home.

After initial transient school closures, thermometers were issued to all students and military personnel for daily temperature monitoring. Mass temperature screening was implemented to prevent transmission in larger institutions. This principle was also used to restore public confidence in restaurants, taxis and public gathering places. Temperature screening and health declarations were also implemented at the international airport, as well as land and sea entry points.

Perhaps most important, a comprehensive communication strategy was developed in order to rapidly mobilize community resources. This strategy included daily press briefings, statistics updates by relevant authorities, and an aggressive information campaign using the press, radio, television and community organizations. Educational and hygiene packages were taught in schools and through the mass media.

On the scientific front, our scientists collaborated with international agencies to identify the virus and produce reliable rapid test kits, which are now becoming available. Research is continuing into specific therapies — for example, the development of a SARS vaccine.

### *Hospital strategies*

In addition to the usual ED patient flow, all hospitals, including those not designated as SARS hospitals, are responsible for screening potential cases and managing patients with fever of unknown origin. Early evidence suggested that the SARS coronavirus was present in sputum and feces[8] and could possibly remain viable in the external environment for several hours. Because of the high potential threat, infection control measures had to be introduced rapidly with an emphasis on the protection of health care workers. Standard personal protective equipment for frontline (i.e., ED, intensive care unit [ICU] and isolation ward staff) consisted of N95 respirator masks, gown,

**Table 1. Sequence of events in Singapore's war on SARS**

| | |
|---|---|
| 12 March | The World Health Organization (WHO) issues a global alert on cases of atypical pneumonia, particularly cases affecting hospital staff. |
| 14 March | Singapore issues a travel advisory. |
| 15 March | The Singapore doctor who treated Patient 1 is quarantined in Frankfurt after attending a conference in New York. He and 2 travelling companions, including his pregnant wife, are subsequently diagnosed as having SARS. |
| 17 March | SARS is made a notifiable infectious disease under the Infectious Disease Act. |
| 19 March | Health advisories are given to all schools, pre-schools and child care centres. |
| 22 March | TTSH is designated SARS Central, and all suspect and probable SARS cases are centralized there. New infection control measures are instituted for all staff, and the Tan Tock Seng Hospital Emergency Department is closed to all ambulance cases except suspected SARS cases. All elective admissions are stopped. |
| 24 March | Invoking the Infectious Disease Act, home quarantine orders (HQOs) are used to isolate contacts of SARS patients. Two children, aged 5 and 13 years, are found to have contracted the infection from their parents. |
| 27 March | All schools, pre-schools and child care centres are closed. (The precautionary closure lasted until April 6 .) |
| 31 March | Screening of passengers for all inbound flights from affected areas begins. |
| 7 April | All passengers from SARS affected countries required to complete a Health Declaration Card. (This requirement was later extended to all flights.) |
| 11 April | A 10-day quarantine imposed on work permit and employment pass holders entering Singapore from SARS-affected countries. The Courage Fund is established in honour of health care workers battling against SARS. |
| 15 April | Recovering SARS patients are issued HQOs for 14 days on discharge. Later, a 10-day HQO is applied for all patients discharged from affected hospitals. Inter-hospital transfer of in-patients is stopped. |
| 18 April | All public hospitals restrict visitors to one per patient per day. This was later upgraded to a "No visitors" rule. |
| 20 April | After a cluster of infections occurs in a 1000-tenent wholesale food centre, the centre is closed and 1798 HQOs are issued. |
| 22 April | All school children and military personnel are issued a personal thermometer to monitor their temperature daily. |
| 23 April | Thermal scanners are installed for rapid mass temperature screening of airport passengers, and at the 2 land border entry points. |
| 26 April | Regional health ministers meet to coordinate the war on SARS. Several joint measures and an action plan are announced. |



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**Box 1. Key strategies in the war on SARS**

**National and regional strategies**

- Concentrate patients and resources at specific SARS receiving hospitals
- Assign dedicated ambulances to transport all suspected SARS patients
- Implement vigilant screening of potential SARS patients by emergency departments (EDs) and primary care providers
- Rapidly disseminate case definitions and information to health care providers
- Introduce mandatory reporting of all suspect cases
- Establish command centres to track and quarantine potential cases
- Provide contact logbooks for health care and public service workers (e.g., restaurants, taxi drivers)
- Develop home quarantine orders and clarify self-quarantine policies for exposed people. Develop quarantine enforcement systems (e.g., daily phone monitoring and Web cam reporting)
- Issue thermometers to all students, military and hospital personnel
- Institute mass temperature screening and consider using thermal scanners at airports, borders, institutions and mass gatherings
- Develop an effective and comprehensive communication strategy through the mass media
- Teach hygiene essentials in schools and through the press, radio and television
- Develop reliable diagnostic kits and specific therapies
- Set up an easily accessible database of SARS contacts and hospital discharges

**Hospital strategies**

- Provide standard personal protective equipment for all frontline staff; educate staff and perform mask fitting
- Implement strict infection control measures
- Provide adequate isolation beds and ICUs
- Screen at all hospital entry points
- Provide shower facilities so staff can change and shower before going home
- Implement central control for pooling and utilization of manpower and resources
- Institute modular staffing patterns to prevent cross infection on the wards
- Implement a "No visitor" rule (enable virtual hospital visits using videophones)

**Emergency department strategies**

- Create separate ED areas for febrile patients to be seen and treated
- Set up screening counters outside the ED
- Place security and screening at all entry points to the ED
- Limit ED and hospital access points
- Establish policies on procedures such as intubation and nebulization
- Provide psychological support for staff and patients
- Institute modular shift staffing

gloves, goggles, shower cap and shoe covers.

The ED served as the main triage and entry point to the hospital. Screening counters were set up outside the ED, outpatient clinics and wards. The initial plan was to separate admitted patients into "fever" (hot zone) and "non-fever" (cold zone) areas, but this plan failed because some patients did not make honest declarations, others had suppressed their fever with antipyretics, and many with co-morbid conditions or immune compromise did not arrive with fever. As a result, the whole hospital was considered a hot zone, and PPE was recommended during contact with all patients and even during contact with health care workers.

In this time of crisis, manpower and resources (e.g., ICU beds) were pooled. Elective operations and admissions were stopped, and a modular staffing system was introduced to prevent cross infection on the wards. Under the modular staffing model, designated teams of doctors, nurses and support staff were assigned to specific wards, no outside staff were allowed on the ward, ward personnel could not be re-deployed, and referrals were prohibited. Any outbreak among health care workers would then be confined, and contact tracing and isolation made easier. However, in the age of super-specialization, the modular system created another problem. For example, because of limited beds, a stroke patient might be admitted to a cardiology ward, and would have to be managed by a cardiologist for the duration of the admission!

Finally, provision was made for adequate isolation beds and ICUs. Single-bed wards were converted with ventilation modifications for this purpose. At SGH, a constructed "container city" helped provide single-bed cabins, which were used for nursing patients with a fever of unknown cause. There were also challenges in providing single-bed ICUs complete with anterooms and negative-flow ventilation.

### *ED strategies*

In the ED, patients were screened by filling out a declaration card that clarified travel, possible SARS exposure and symptoms (Fig. 2). Patients whose symptoms met the WHO case definition criteria (fever, cough/dyspnea, or a history of possible SARS exposure) were admitted to isolation beds. All ED patients had an initial triage and temperature screening and were given masks to wear. Later, a "No visitor" rule was imposed, as previously described.

At the SGH ED, a retrofitting and redesign were done in order to create separate areas for febrile patients to be seen and treated. This included ambulatory, trolley and resuscitation areas, each with separate ventilation systems installed. Redesign also included placing security and screening at all



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possible ED entry points. Dining and changing areas were moved out of the "hot zone," and showering facilities were provided so staff could change and shower before going home. Mandatory daily temperature checks and a modular team system incorporating all ED health care workers was implemented. In the ED, modular staffing meant that ED staff were grouped into fixed teams of doctors, nurses and support staff. The same team would always go on shift together, and no exchanging of shifts was allowed.

Gowning and ungowning (in addition to the use of other PPE) followed strict procedures. Mask fitting was compulsory, and hand washing was emphasized. Compliance to these measures was strict. Regular inspections and a system of fines were implemented.

In addition to the PPE described above, positive air purifying respirators were used for all endotracheal intubations. This followed a specified drill; both operator and assistant had to be using a positive air purifying respirator. Use of nebulizers was also discontinued where SARS could not be excluded. Metered-dose inhalers with spacer devices were used instead.

**DECLARATION FORM**

**Please answer the following questions:**

1. Have you treated or come into contact with any patient or person diagnosed with SARS in the last 14 days?
2. Have you been to Hong Kong, Taiwan, China, Vietnam or Toronto in the last 14 days? If Yes, please specify when and where you visited.
3. Is there anyone living in the same household or apartment as you who has been involved in the care of SARS patients?
4. Do you have cough, breathlessness or fever >38°C now?
5. Have you been recently discharged from hospital? / Did you accompany anyone to hospital for an appointment or visit? If Yes, please specify hospital and when.
6. For new or returning staff, have you been well for the last 10 days?

Name:

Signature:

Your temperature today:

**Fig 2: SARS screening tool. Adapted from the Singapore General Hospital ED screening tool. Please note: This is only a sample. The tool has been modified several times and has different versions for different situations. Future screening tools will differ depending on outbreak feature**

The psychological management of patients and staff should also be mentioned. Many staff and patients reported experiencing feelings of dread, dislocation and distancing. Dread included fears of becoming infected or infecting family members and loved ones. Dislocation was the result of drastic changes taking place in the daily situation and a sense of helplessness. Distancing was sometimes self-imposed, or was experienced by the person when he or she felt rejected by acquaintances and the public.

### *New technologies*

The war on SARS made use of many innovative technologies. Military-type thermal scanners were modified to screen large numbers of people at border checkpoints and to screen visitors to hospitals and clinics. Web cams and electronic wrist tags were used to monitor and enforce home quarantine orders. Virtual visitor centres were set up, using videophones to ease the pain of "No visitor" rules and even allowed ICU "visits." Rapid information access was available using "SARS Web," which included lists of all suspect or probable SARS patients and their known contacts. This system also tracked discharges from all public hospitals and those on home quarantine orders.

## A new paradigm

In the modern antibiotic era, infectious disease outbreaks were seldom part of the collective consciousness of the emergency community; however this has recently changed. In the light of humankind's extreme vulnerability to natural outbreaks and bioterrorism, a new paradigm is needed. The world is increasingly interconnected, and in this global village an infectious disease outbreak can quickly become international, as we have seen.

At the national level, emergency planning agencies must develop detailed responses to infectious disease scenarios. This may include enhancing public health surveillance, treatment and isolation capability. Inter-agency cooperation and coordination require a centralized command and familiar protocols. International cooperation and border surveillance and controls may also be important. Our experience has also shown the utility of quarantine legislation, especially against diseases with no definitive treatment.

Hospitals too need to have emergency planning for such scenarios. This may include provisions for pooling of resources and modular working systems. In the age of superspecialization, care should be taken that all staff are familiar with their emergency roles as well. Infection control training should be a routine part of continuing medical education.

We believe such provisions are now essential and no



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longer merely an option. Locally, we believe that use of PPE may become a standard precaution, especially if SARS becomes endemic in the region. We believe all hospitals and ED management need to re-examine the issue of whether their staff are adequately protected, even in current practice. For example:

- Are staff routinely using N95 masks when attending to patients with suspected meningitis, pneumonia, tuberculosis or fevers of unknown origin?
- Do we have effective measures in place to prevent patient-to-patient spread?
- Is our ED set-up adequate to cope with these problems and demands?
- Are we up to par on infection control practices?
- Do we have the capability to rapidly increase provision of isolation beds for nursing infectious patients?

Modular staffing systems may have merit for replacing current shift systems, especially during an outbreak. This would mean that at any one time only a portion of ED staff would be exposed to potential threats, thus creating a reserve of trained personnel that can function immediately when called upon. Psychological training and support is also needed in order for ED staff to cope with demands.

Most recently, in September 2003, a laboratory-related infection resulted in a postgraduate student acquiring SARS. Fortunately this was detected and isolated early, and the patient recovered without further transmission. However, this incident highlighted the importance of laboratory procedures and surveillance, especially as research continues on SARS.

### *Limitations*

Supporting evidence is not yet available for many of the solutions and strategies described above. More research is needed to determine what is truly effective. This is an important step in order to avoid wasting resources on ineffective interventions.

## Conclusion

In summary, it is proposed that emergency care providers and planners adopt a new paradigm that addresses current natural outbreaks and future terrorism-related threats. The recent SARS outbreak may only be a taste of things to come.

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We honor the memory of our fallen colleagues who gave their lives in the line of duty.

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