Outbreak of severe acute respiratory syndrome in a tertiary hospital in Singapore, linked to an index patient with atypical presentation: epidemiological study

Khuang Yew Chow, Chien Earn Lee, Mui Lin Ling, Derrick Mok Kwee Heng, Soon Ghee Yap

Abstract

Objective To describe an outbreak of severe acute respiratory syndrome (SARS) in a tertiary hospital in Singapore, linked to an index patient with atypical presentation, and the lessons learnt from it.

Design Descriptive study.

Setting A tertiary hospital in Singapore.

Participants Patients, healthcare workers, and visitors who contracted SARS in Singapore General Hospital.

Main outcome measures Probable SARS as defined by the World Health Organization.

Results The index patient presented with gastrointestinal bleeding, initially without changes to his chest radiograph. Altogether 24 healthcare workers, 15 patients, and 12 family members and visitors were infected. The incubation period ranged from three to eight days. Only 13 patients were isolated on their dates of onset.

Conclusions Atypical presentation of SARS infection must be taken into consideration when managing patients with a history of contact with SARS patients. The main gap in the containment strategy in this outbreak was the failure to identify the index patient as someone who had been discharged from a ward in another hospital that managed probable SARS cases. Strict infection control measures, a good surveillance system, early introduction of isolation procedures, and vigilant healthcare professionals are essential for controlling outbreaks.

Introduction

On 6 March 2003 the Ministry of Health in Singapore issued a press release that three Singaporeans had developed atypical pneumonia after travelling to Hong Kong. Around the same time, the World Health Organization issued a global health alert on severe acute respiratory syndrome (SARS), an atypical pneumonia that has been associated aetiologically with a novel coronavirus, SARS-COV. We describe an outbreak in a tertiary hospital delivering acute care in Singapore that was linked to an index patient with atypical presentation and highlight the lessons learnt in managing the outbreak.

Methods

We used data from the period of 24 March to 15 April 2003. We describe the epidemiological link of 51 patients infected directly or indirectly by an index patient in Singapore General Hospital, a tertiary hospital delivering acute care.
The epidemiology and contact tracing team interviewed patients and their relatives; extracted information on patients’ movement from hospital databases; and reviewed the duty rosters of healthcare staff, patients’ case records, temperature charts, and discharge summaries to obtain information that supported the chain of transmission. An epidemiologist then analysed the information to identify the possible sources of infection and mapped the possible contacts.

At the time of the outbreak no reliable laboratory test for SARS was available; hence we used a case definition for a probable case that was based on the initial definition from the World Health Organization.

Results

On 4 April 2003 13 staff from two surgical wards in Singapore General Hospital were discovered to have developed fever over the past four days. In the next two days all patients and healthcare staff from the two wards were transferred to Tan Tock Seng Hospital, the national centre for managing SARS patients, for further assessment and to ringfence the source of infection.

A registrar was the first healthcare worker to develop symptoms, and initial investigations were focused on her as the potential source. However, we were not able to trace the source of infection based on the available information.

Attention was then focused on identifying the index patient, in particular among the patients who had been transferred from Tan Tock Seng Hospital, who could have infected the registrar and other healthcare staff.

A breakthrough came when SARS was diagnosed in the brother of a patient on 8 April in the affected wards who visited the patient on the ward. Detailed epidemiological investigations resulted in the conclusion that this patient, who was admitted on 24 March to Singapore General Hospital, was the index patient source of the SARS outbreak at that hospital.

Description of the index case

The index patient, an elderly Chinese man with chronic renal disease and diabetes mellitus, had previously been admitted to the ward at Tan Tock Seng Hospital, where the first SARS patient in Singapore was treated. Subsequently he was admitted to a surgical ward in Singapore General Hospital on 24 March for gastrointestinal bleeding and a diabetes related foot ulcer on his right heel.

To determine the source of gastrointestinal bleeding he underwent gastroscopy, colonoscopy, and barium studies on 26 and 28 March and 1 April, respectively. He was monitored for bloody stools daily and given laxatives in preparation for the procedures. From 26 March to 2 April he underwent desloughing and subsequently debridement of his foot ulcer.

On admission he had an oral temperature of 37.4°C, but his temperature spiked on 26 March. He had no respiratory symptoms. On 28 March his blood culture yielded *Escherichia coli*, and he was treated accordingly. Ultrasound investigation of his kidneys showed a mass in his right kidney, reported as likely to be due to an abscess or tumour.

Onset date for inpatients takes the first date of fever but actual infection could be later as some patients may have a few bouts of fever.

Patient 1

**Description of the index case**

The index patient, an elderly Chinese man with chronic renal disease and diabetes mellitus, had previously been admitted to the ward at Tan Tock Seng Hospital, where the first SARS patient in Singapore was treated. Subsequently he was admitted to a surgical ward in Singapore General Hospital on 24 March for gastrointestinal bleeding and a diabetes related foot ulcer on his right heel.

To determine the source of gastrointestinal bleeding he underwent gastroscopy, colonoscopy, and barium studies on 26 and 28 March and 1 April, respectively. He was monitored for bloody stools daily and given laxatives in preparation for the procedures. From 26 March to 2 April he underwent desloughing and subsequently debridement of his foot ulcer.

On admission he had an oral temperature of 37.4°C, but his temperature spiked on 26 March. He had no respiratory symptoms. On 28 March his blood culture yielded *Escherichia coli*, and he was treated accordingly. Ultrasound investigation of his kidneys showed a mass in his right kidney, reported as likely to be due to an abscess or tumour.

Onset date for inpatients takes the first date of fever but actual infection could be later as some patients may have a few bouts of fever.

**Attention was then focused on identifying the index patient, in particular among the patients who had been transferred from Tan Tock Seng Hospital, who could have infected the registrar and other healthcare staff.**

A breakthrough came when SARS was diagnosed in the brother of a patient on 8 April in the affected wards who visited the patient on the ward. Detailed epidemiological investigations resulted in the conclusion that this patient, who was admitted on 24 March to Singapore General Hospital, was the index patient source of the SARS outbreak at that hospital.

**Description of the index case**

The index patient, an elderly Chinese man with chronic renal disease and diabetes mellitus, had previously been admitted to the ward at Tan Tock Seng Hospital, where the first SARS patient in Singapore was treated. Subsequently he was admitted to a surgical ward in Singapore General Hospital on 24 March for gastrointestinal bleeding and a diabetes related foot ulcer on his right heel.

To determine the source of gastrointestinal bleeding he underwent gastroscopy, colonoscopy, and barium studies on 26 and 28 March and 1 April, respectively. He was monitored for bloody stools daily and given laxatives in preparation for the procedures. From 26 March to 2 April he underwent desloughing and subsequently debridement of his foot ulcer.

On admission he had an oral temperature of 37.4°C, but his temperature spiked on 26 March. He had no respiratory symptoms. On 28 March his blood culture yielded *Escherichia coli*, and he was treated accordingly. Ultrasound investigation of his kidneys showed a mass in his right kidney, reported as likely to be due to an abscess or tumour.

Onset date for inpatients takes the first date of fever but actual infection could be later as some patients may have a few bouts of fever.
Multiple chest x-ray films from admission to 2 April did not show any focal lesion in his lungs. A chest x-ray film from 3 April showed ill-defined shadowing of the air space in the right lower zone and left peri hilar region. However, a chest x-ray film from 4 April showed no abnormalities.

The infectious disease doctor reviewed the patient on 2 April and thought that the kidney abscess had resulted in the secondary infection, *E coli* bacteraemia. Treatment with intravenous imipenem-cilastatin was started immediately. As SARS infection could not be excluded the patient was transferred directly to an isolation ward on the same day. His fever settled on 4 April.

On 4 April specimens obtained by throat swab were sent for virological studies, but they were negative for respiratory viruses. It was only on 9 April, when epidemiological evidence was finally supported by definitive changes to his chest x-ray film, that he was classed as a probable case of SARS.

**Description of the outbreak**

Twenty-four healthcare workers, 15 patients, and 12 visitors, who were in either direct or indirect contact with the index patient, developed probable SARS. The index patient created five main clusters of infections (figure).

The first cluster was that of healthcare workers in the two wards that he stayed before he was isolated.

The second cluster was a group of 12 patients from the two wards and seven visitors. Eight of these patients were directly infected by the index patient and the other four contracted secondary infections from two of the eight patients. Suspicion of an outbreak was not prompted at the early stage as most of the patients in the surrounding beds had multiple medical problems and were prone to infections. One of these patients was also suspected to have subsequently passed the infection to a surgeon who attended to him, although the surgeon was using full personal protective equipment.

The index patient also started a cluster of infection when he visited the diagnostic radiology department on 1 and 2 April. This included two healthcare assistants from the urology centre who were in the same waiting area as the index patient and two outpatients who attended the diagnostic radiology department for radiological procedures on 1 April. Similarly, a radiology healthcare assistant and a porter who had close contact with the index patient during the ultrasound procedure on 2 April were infected. Subsequently they infected a radiographer colleague.

The index patient also infected the husband of another patient, who was waiting for his wife to undergo barium meal examination in the diagnostic radiology department, who subsequently infected his wife.

The fourth cluster of infection was at the national cancer centre: a radiographer from the diagnostic radiology department of the national cancer centre who subsequently infected a porter from the same department.

The fifth cluster of infection was the family of the index patient.

The SARS infections in Singapore General Hospital had also affected others in the community, but we included only people infected in the hospital in our clusters. The index patient's brother and his sister in law infected two colleagues working in a wholesaler's, who subsequently infected their family members. As a result a total of 1825 people were placed on home quarantine. The porter working in the diagnostic radiology department at Singapore General Hospital infected eight of her friends through social contact.

The incubation period ranged from three to eight days. Two thirds of this group had short incubation periods of three to four days.

To determine the infectious period during which the infected patients and staff could have possibly transmitted their infection to others, we looked at the period between onset of symptoms to date of isolation for patients, healthcare staff, and infected visitors. Only 13 were isolated on or before their dates of onset of symptoms, the remaining 39 were isolated between one and 12 days from the onset of symptoms.

**Discussion**

The atypical presentation of SARS has been documented previously.\(^7\) In addition to fever and respiratory symptoms, other common clinical features include anorexia (45-55%) and diarrhoea (25-27%).\(^4\)\(^,\)\(^5\)

In the absence of respiratory symptoms the index patient was likely to have been shedding the SARS virus through his stool. His gastrointestinal bleed was probably a contributing factor as it required radiological and endoscopic examinations and daily monitoring of the stool colour. Associated procedures such as bowel preparation would also have increased viral shedding. Infection through contact with exudates

---

**Infection control measures**

- Early detection and prompt isolation of SARS cases in isolation rooms with negative pressure
- Hospital-wide implementation of the use of personal protective equipment in all areas where care for patients is undertaken—use of N95 mask (mask that is 95% efficient at filtering out particles of sizes 0.3 micron and above), gowns, gloves, goggles, head covers, and handwashing
- Completion of SARS screening questionnaire and temperature screen before entry to areas where care for patients is undertaken
- All hospital staff to monitor their temperature three times a day
- Mandatory attendance for hospital staff on infection control measures against SARS and N95 mask fit test for all staff
- Intense contact tracing and mapping of cases and exposed people
- 10 day home quarantine for staff, patients, and visitors exposed to SARS patients
- 21 day home quarantine for staff discharged from SARS hospital (Tan Tock Seng Hospital)

**Organisational interventions**

- Formation of SARS task force to formulate guidelines and implement intervention to control the outbreak
- Restriction of visitors policy converted to a no visitor rule later
- Exposed patients and staff from affected wards transferred to Tan Tock Seng Hospital
- Modular team systems for doctors and nurses
- Suspension of elective services
- Surveillance system to review patients transferred to Tan Tock Seng Hospital, staff with fever, and “hot” wards (wards from which patients were transferred to Tan Tock Seng Hospital for respiratory illnesses pending investigation for SARS or wards with clusters of febrile patients pending investigation for SARS)
- Closure of ward (no admission, no discharge, no transfer) to prevent patients from being discharged till the source of infection is identified or patients in the ward cleared of SARS
- All sick staff must be treated and subsequently reviewed at staff clinic

**Infection control measures**

- Early detection and prompt isolation of SARS cases in isolation rooms with negative pressure
- Hospital-wide implementation of the use of personal protective equipment in all areas where care for patients is undertaken—use of N95 mask (mask that is 95% efficient at filtering out particles of sizes 0.3 micron and above), gowns, gloves, goggles, head covers, and handwashing
- Completion of SARS screening questionnaire and temperature screen before entry to areas where care for patients is undertaken
- All hospital staff to monitor their temperature three times a day
- Mandatory attendance for hospital staff on infection control measures against SARS and N95 mask fit test for all staff
- Intense contact tracing and mapping of cases and exposed people
- 10 day home quarantine for staff, patients, and visitors exposed to SARS patients
- 21 day home quarantine for staff discharged from SARS hospital (Tan Tock Seng Hospital)

**Organisational interventions**

- Formation of SARS task force to formulate guidelines and implement intervention to control the outbreak
- Restriction of visitors policy converted to a no visitor rule later
- Exposed patients and staff from affected wards transferred to Tan Tock Seng Hospital
- Modular team systems for doctors and nurses
- Suspension of elective services
- Surveillance system to review patients transferred to Tan Tock Seng Hospital, staff with fever, and “hot” wards (wards from which patients were transferred to Tan Tock Seng Hospital for respiratory illnesses pending investigation for SARS or wards with clusters of febrile patients pending investigation for SARS)
- Closure of ward (no admission, no discharge, no transfer) to prevent patients from being discharged till the source of infection is identified or patients in the ward cleared of SARS
- All sick staff must be treated and subsequently reviewed at staff clinic

---

**Infection control measures**

- Early detection and prompt isolation of SARS cases in isolation rooms with negative pressure
- Hospital-wide implementation of the use of personal protective equipment in all areas where care for patients is undertaken—use of N95 mask (mask that is 95% efficient at filtering out particles of sizes 0.3 micron and above), gowns, gloves, goggles, head covers, and handwashing
- Completion of SARS screening questionnaire and temperature screen before entry to areas where care for patients is undertaken
- All hospital staff to monitor their temperature three times a day
- Mandatory attendance for hospital staff on infection control measures against SARS and N95 mask fit test for all staff
- Intense contact tracing and mapping of cases and exposed people
- 10 day home quarantine for staff, patients, and visitors exposed to SARS patients
- 21 day home quarantine for staff discharged from SARS hospital (Tan Tock Seng Hospital)

**Organisational interventions**

- Formation of SARS task force to formulate guidelines and implement intervention to control the outbreak
- Restriction of visitors policy converted to a no visitor rule later
- Exposed patients and staff from affected wards transferred to Tan Tock Seng Hospital
- Modular team systems for doctors and nurses
- Suspension of elective services
- Surveillance system to review patients transferred to Tan Tock Seng Hospital, staff with fever, and “hot” wards (wards from which patients were transferred to Tan Tock Seng Hospital for respiratory illnesses pending investigation for SARS or wards with clusters of febrile patients pending investigation for SARS)
- Closure of ward (no admission, no discharge, no transfer) to prevent patients from being discharged till the source of infection is identified or patients in the ward cleared of SARS
- All sick staff must be treated and subsequently reviewed at staff clinic

---

**Infection control measures**

- Early detection and prompt isolation of SARS cases in isolation rooms with negative pressure
- Hospital-wide implementation of the use of personal protective equipment in all areas where care for patients is undertaken—use of N95 mask (mask that is 95% efficient at filtering out particles of sizes 0.3 micron and above), gowns, gloves, goggles, head covers, and handwashing
- Completion of SARS screening questionnaire and temperature screen before entry to areas where care for patients is undertaken
- All hospital staff to monitor their temperature three times a day
- Mandatory attendance for hospital staff on infection control measures against SARS and N95 mask fit test for all staff
- Intense contact tracing and mapping of cases and exposed people
- 10 day home quarantine for staff, patients, and visitors exposed to SARS patients
- 21 day home quarantine for staff discharged from SARS hospital (Tan Tock Seng Hospital)

**Organisational interventions**

- Formation of SARS task force to formulate guidelines and implement intervention to control the outbreak
- Restriction of visitors policy converted to a no visitor rule later
- Exposed patients and staff from affected wards transferred to Tan Tock Seng Hospital
- Modular team systems for doctors and nurses
- Suspension of elective services
- Surveillance system to review patients transferred to Tan Tock Seng Hospital, staff with fever, and “hot” wards (wards from which patients were transferred to Tan Tock Seng Hospital for respiratory illnesses pending investigation for SARS or wards with clusters of febrile patients pending investigation for SARS)
- Closure of ward (no admission, no discharge, no transfer) to prevent patients from being discharged till the source of infection is identified or patients in the ward cleared of SARS
- All sick staff must be treated and subsequently reviewed at staff clinic
from the index patient's foot ulcer could not be excluded either. Healthcare workers were at increased risk of exposure to the virus through transmission during contact. The fact that transmission had been limited to close contacts of the index patient implies that droplet spread or direct contact was the main mode of transmission in this outbreak.

The index patient had already been isolated on 2 April, 9 days after admission, as a precautionary measure, even before an epidemiological link was established. By then at least 42 of the 50 healthcare workers, patients, and visitors who were infected in Singapore General Hospital would have already been infected.

With hindsight, draconian containment measures, such as quarantining all visitors to the affected wards as soon as the fever cluster was detected on 4 April, might have prevented the infection from spreading beyond Singapore General Hospital, as the visitor who started the cluster of infection at the wholesale centre showed symptoms only on the 5 April.

Personal protective equipment may not offer full protection if healthcare workers do not follow the recommended infection control precautions. In addition to personal protective equipment Singapore General Hospital also introduced stringent infection control measures and organisational interventions (box), to ringfence the source of infection and prevent further transmission of infection.

Conclusion

The key lesson from this incident is the need to identify potentially infected patients before they enter the hospital’s mainstream areas (wards etc) where patients, staff, and visitors mingle. Once our index patient had slipped through this gap, all other containment measures were catching-up exercises. The identification of the index patient was complicated by the atypical presentation and the presence of comorbidities. Constant vigilance is needed, especially when managing immunocompromised patients (such as patients with chronic renal failure) with multiple medical problems.

Contributors: See bmj.com

Funding: None.

Ethical approval: Professor Tay Boon Keng, chairman of the Medical Board and SARS Task Force Singapore General Hospital.

bmjlearning.com

Heart failure: an update on management

About 4% of men and 3% of women aged over 65 years have heart failure. The prevalence of asymptomatic left ventricular dysfunction is 5% in people of all ages. And the mortality from heart failure is high: studies report five year mortality ranging from 26% to 75%. So it is vital that doctors have a good grasp of how to treat patients with heart failure.

Most doctors have a good understanding of how to treat heart failure. In particular, the message about the benefits of angiotensin converting enzyme inhibitors has largely got through. However, many doctors want an update on the more recent advances in the management of heart failure. They want advice about the roles of echocardiography, echocardiography, and β-blockers and nitratriuretic peptides in the diagnosis of heart failure. They also want practical tips on when and how to start β blockers and spironolactone. Early intervention points to an increasing role for implantable cardiac defibrillators, so patients and doctors also need to know about these.

To get practical advice on the diagnosis and management of systolic heart failure, try our new module ‘Heart failure: an update on management’ on bmjlearning.com.

Kieran Walsh editorial registrar, BMJ Learning
(bmjlearning@bmjgroup.com)