Investigation of the second wave (Phase 2) of severe acute respiratory syndrome (SARS) in Toronto, Canada. What happened?

M. Ofner-Agostini, PhD(1), T. Wallington, MD(2), B. Henry, MD(2), D. Low, MD(3), L.C. McDonald, MD(4), L. Berger, MD(2), B. Mederski, MD(5), the SARS Investigative Team and T. Wong, MD(1)

1. *Centre for Communicable Diseases and Infection Control, Public Health Agency of Canada, Ottawa, Ontario*
2. *Toronto Public Health, Toronto, Ontario*
3. *Mount Sinai Hospital, Toronto, Ontario*
4. *Centers for Disease Control and Prevention, Atlanta, Georgia*
5. *North York General Hospital, Toronto, Ontario*

Members of the SARS Investigative Team: S. Kormin, A. Saunders, R. Stuart, B. Yafee, Toronto Public Health, Toronto, Ontario; M. Christian, Mount Sinai Hospital, Toronto, Ontario; M. Loutfy, D. White, V. Nankoosing, North York General Hospital, Toronto, Ontario; L. Hansen, Health Canada, Ottawa, Ontario

Abstract

Background: Severe acute respiratory syndrome (SARS) was introduced to Toronto on 23 February, 2003. The outbreak was believed to be over in early May after two incubation periods had passed with no newly identified cases. However, on 20 May, 2003 a cluster of respiratory illnesses occurred in a rehabilitation facility in Toronto. These cases were later identified as SARS but not until a community hospital in which one of these cases was previously hospitalized (Hospital X) had already experienced nosocomial

transmission. This report describes the outbreak investigation of nosocomial transmission of SARS at Hospital X.

Methods: An investigation of 90 probable and suspect cases of SARS associated with a hospital outbreak was performed. The investigation included death record reviews, chart reviews, case finding and contact tracing. Nursing cohorts who worked on the specific ward in which nosocomial transmission occurred had work-shift and patient-assignment records reviewed to determine source of infection.

Results: The greatest number of cases occurred within hospital employees (42.5%) with an average age of 51 years and 69% being female. The mean incubation period for one time exposure patients was 6.3 days (range 4 to 10 days). Twelve (13.8%) of the cases died. Five of seven nurses who cared for a specific SARS patient during this period acquired SARS. Twelve of 17 (70.6%) nursing staff who developed SARS worked with another nursing staff who was symptomatic for SARS. Staff members who worked the evening shift or the morning shift and therefore likely attended a nursing appreciation breakfast were five times more likely to acquire SARS than those who did not attend.

Interpretation: What was believed to be the end of the Toronto SARS outbreak led the Provincial Operations Centre (POC) to issue a directive allowing a more relaxed use of infection-control precautions during the beginning of Phase 2 of the outbreak. These relaxations of precautions were temporally associated with the nosocomial transmission of SARS to hospital staff, other patients and visitors at Hospital X. As a result of this outbreak significant changes have been made with respect to infection-control practices within Canada.

Introduction

In early 2003 a new, virulent form of pneumonia now known as Severe Acute Respiratory Syndrome (SARS) spread from China to several countries around the world(1). This febrile respiratory illness caused by a novel coronavirus (SARS CoV) has now been well described(2,3). The largest outbreak outside of Asia was in Toronto,

Canada. Between February and June 2003, 228 people who lived in the City of Toronto were confirmed SARS cases and 38 people died from the disease. Over 26,000 contacts were identified, of whom more than 14,000 were quarantined(4). In all of Ontario, 351 cases were identified, with 44 deaths and an overall case fatality of 12.5%(5). The outbreak in Toronto had two distinct phases: Phase 1 from 23 February to 19 April and Phase 2 from 21 April to 12 June. The initial phase involved the introduction of the virus into Toronto in a returning traveller from Hong Kong. The virus was initially spread in their immediate family, and then subsequently in a Toronto community hospital in mid-March 2003.

On 26 March, SARS was declared a provincial public health emergency by the Premier of Ontario. The ministry, health care providers and local public health units took steps to contain the spread of SARS: isolating people who had been exposed, restricting hospital visits, and adopting enhanced infection-control procedures at all levels of the health care system. The outbreak subsided and the last reported case was diagnosed in mid-April. Two incubation periods after this case had been diagnosed and isolated, the POC determined that high level infection-control precautions could be safely reduced in hospitals (between 8 and 22 May).

On 20 May, a cluster of cases of respiratory infection at a rehabilitation hospital was recognized as SARS, and was subsequently linked to a larger outbreak at a Toronto community hospital (Hospital X) on 22 May. Hospitals in the greater Toronto area reinstituted the enhanced infection-control precautions adopted on 26 March. Control of transmission was achieved promptly. This paper describes the investigation into the second phase of the outbreak and provides a more detailed account of this phase than previous reported(6).

In mid-May, a respiratory outbreak at a rehabilitation hospital in Toronto was reported to Toronto Public Health in accordance with provincial protocols. Investigation revealed a cluster of three patients with febrile respiratory illness (FRI), including one who had recently been transferred to the rehabilitation facility from a nearby acute care community hospital (Hospital X). On 22 May, 2003 one of the patients

was found to have SARS-CoV by polymerase chain reaction in a bronchoalveolar lavage specimen. Trace back of the cases at the rehabilitation facility established the link to the Hospital X and a detailed investigation was initiated at the hospital on 23 May.

Methods

Case finding. Once the outbreak was recognized, medical staff and infection control practitioners at Hospital X conducted active surveillance for FRI among patients, visitors, and employees. Toronto Public Health and Health Canada established an on-site team of communicable disease investigators to work in collaboration with the hospital to investigate and manage the outbreak. Infection-control measures, building preparation, engineering, staffing and policies have been previously described(7).

Probable and suspect SARS cases were included in the analysis if they met the Health Canada case definition(8) and their exposure and subsequent infection with SARS could be epidemiologically linked to Hospital X on or after 17 April, 2003. Investigators conducted interviews and chart reviews on cases to collect demographic, clinical, and exposure information. Specific information included symptom onset, clinical findings (e.g., chest X-rays, laboratory work), underlying medical conditions, travel history, exposure settings, occupation (e.g., health care worker), other health care facility contacts or known SARS cases, activities while symptomatic, and attendance at community functions and events. Individuals were asked to recount their activities during the 10 days prior to onset of symptoms in order to assist in identifying possible exposures. When necessary, additional information was obtained from relatives and other close contacts. Progression of symptoms as well as case fatality rates, intensive care unit (ICU) admission, and intubation rates were determined for cases.

To identify and describe the extent of the outbreak, a review was conducted of ward-specific mortality rates for each ward in Hospital X from January 2003 to May 2003. A chart review was performed for all patients who had died at the facility between 1 March and 23 May 2003.

For one ward (Ward A), all patients' admission dates and room numbers were compared to nursing staff room assignments by patient and date. All nursing staff who worked on Ward A from 1 April to 24 May were included in an analysis to determine risk factors for nursing staff acquiring SARS. Working with an ill colleague was defined as: worked the same shift as, reported on or reported off to, gave medications for, or cared for one of their patients while they were on a break.

Chains of disease transmission were mapped based on identified exposure history, chart review and staff assignment lists. The incubation period for people with only one known exposure was calculated from the exposure to onset of first symptom.

Results

The outbreak hospital (Hospital X) in the second phase of the SARS outbreak in Toronto was a multi-site community teaching hospital with approximately 425 beds. A total of 90 people who met the case definition for SARS were associated with nosocomial transmission; the majority of cases were associated with one specific ward (Ward A). Sufficient data for analysis was obtained for 87 (85 probable and two suspect) SARS cases. Figure 1 shows the epidemic curve for Hospital X during Phase 2. The mean age of the cases was 51.0 years (median 49 years, range 11 years to 96 years); 60 (69%) were female (Table 1). The most common exposure type was hospital employee (42.5%). Seven of the 87 cases had a single exposure to a known SARS case. The mean incubation period in these cases was 6.3 days (median 5.3 days, range 4 to 10 days).

Figure 1: Number of probable and suspect SARS cases at Hospital X during Phase 2

Table 1: Characteristics of probable and suspect SARS cases associated wi

Characteristic	No. (%) of cases

Sex	
Male Female	
Age	
Mean (yrs) Median (yrs) Range (yrs)	51.0 49.0 11 to 96
Type of Exposure	
Healthcare employee Healthcare patient Healthcare visitor Household contact	37 (42.5) 28 (32.2) 14 (16.1) 8 (9.2)

Table 2: Signs and symptoms of probable and suspect SARS cases associated with Hospital X in of illness (*n* = 87)

Symptom	No. (%) at onset	No. (%) d
Fever	70 (80.4)	86 (93.8)
Cough	24 (27.6)	73 (83.9)
Shortness of Breath	10 (11.5)	59 (67.8)
Oxygen Saturation < 94%	4 (4.6)	46 (52.9)
Headache	32 (36.8)	43 (49.4)
Myalgia	29 (33.3)	43 (49.4)
Diarrhea	5 (5.7)	26 (29.9)
Nausea	2 (2.3)	19 (21.8)
Vomiting	1 (1.1)	8 (9.2)

Table 2 shows the initial and subsequent signs and symptoms of the cases of SARS. Comorbid conditions were present in 56.3% of cases; the most prevalent condition was cardiovascular disease (23.0%) (Table 3). Twenty-five (28.7%) patients were admitted to the ICU and 19 (76%) of these cases required intubation. The mean length of stay in ICU was 22.2 days (median 14 days, range 1 to 68 days). The case-fatality ratio (CFR) among those admitted to ICU was 36%. There were 12 deaths in the second phase of the outbreak (case-

fatality rate: 13.8%): mean age of 84.3 years (median 90 years, range 44 to 96); 7 (58.3%) were male (Table 4). Deaths occurred in eight hospital inpatients (66.7%), three hospital visitors (25.0%) and one nurse. The CFR among hospitalized patients who developed SARS was 28.6%, while the CFR among health care employees was 2.7% and visitors, 2.1%. There were no deaths in cases who were household contacts of a case. The CFR was highest in people > 65 years of age (42.1%), and 6.1% in those aged 18 to 64 years. No deaths occurred among cases who were < 18 years old. The mean duration from onset of symptoms to death was 24 days (median 20 days, range 3 to 76 days).

Table 3: Comorbid conditions of probable and suspect SARS cases associated

Comorbidities	**No.**
Cardiac disease (including hypertension)	20 (
Pulmonary disease	10 (
Diabetes	9 (1
Cancer	6 (6
Renal disease	4 (4

Table 4: Characteristics of SARS deaths at Hospital X durin

Characteristic	**No.**
Sex	
Male	7 (5
Female	5 (4
Age	
Mean (yrs)	84.3
Median (yrs)	90

Range (yrs)	44-9
Time from symptom onset to death	
Mean (days) Median (days) Range (days)	24 20 3-7(

Epidemiology. Our retrospective investigation at Hospital X identified two cases (Patient A, a suspect case, and Patient B, a confirmed case) of SARS who may have been the source of the second phase of the Toronto outbreak. Patient A was admitted in late March and transferred to Ward A in early April, 2003. He had multiple episodes of fever and radiographic findings of pneumonia throughout his hospital stay and initially responded to antimicrobial therapy. He developed Clostridium difficile diarrhea and died in early May. No samples were ever taken for SARS-CoV testing. After his death, several family members who were frequent visitors developed a FRI, which was later diagnosed as SARS by serology. Patient B was admitted in early April, to the same four-bed room as patient A, with fever, cellulitis and leg abscess. Patient B developed hospital-acquired pneumonia which was subsequently diagnosed as SARS by serology. These two patients had no travel to other SARS-affected countries, no known visit to another “SARS-affected” hospital or community site or prior close contact with known SARS patients other than each other.

A total of 41 nursing staff were identified to have worked on Ward A between 1 April and 24 May 2003, of whom 17 (41.5%) acquired SARS. Upon review of symptoms and their onset it became apparent that five nurses worked at least one shift while symptomatic with SARS. Of those who worked ill, the number of days each worked ranged from one to seven.

Nursing staff who worked with the first seven patients (during the enhanced precautions period) who were retrospectively identified to have SARS (based on date of onset of SARS symptoms) were compared to nursing staff who were assigned other “non-SARS” patients. There was no evidence of transmission of SARS to the

nurses who cared for the initial four cases (all of whom shared a four-bed room). However, five of seven nurses who cared for one patient who had onset of symptoms in mid-May became ill within 10 days of caring for this patient.

Working with another nursing staff member who was symptomatic for SARS was associated (RR 1.88, 95% CI 1.03 - 3.43; p = 0.04) with acquiring SARS. Twelve of the 17 (70.6%) staff who developed SARS worked with a symptomatic staff member and became ill within 10 days of that shift.

A staff appreciation breakfast was held on one morning in mid-May, 2003. Staff from both the evening and morning shifts were present. Staff members who worked the evening shift or the morning shift of the day of the breakfast were more likely to acquire SARS than those who did not work those two shifts (RR 5.63, 95% CI 1.10 - 31.37; p = 0.01). Two staff who in retrospect were ill at the time also worked one of these two shifts and attended the breakfast.

Discussion

Our analysis of the Ward A nursing staff cohort shows that no nursing staff became ill from exposure to the first cluster of cases on this ward (and, at the time, these patients were not thought to have SARS). This was likely due to the strict adherence to enhanced infection-control practices that were in place. This reinforces what has been found elsewhere that when infection-control measures are in place and adhered to, the likelihood of transmission of SARS is small(9-12). However, when the enhanced infection-control practices were reduced, the exposure to one SARS-affected patient, who required additional care including chest physiotherapy, feeding and all-hygiene care, likely led to transmission to five nursing staff and dramatic amplification of the outbreak. Unaware that they had SARS, several nurses who became ill continued to work after the onset of symptoms, and the virus was spread to other staff members. A further amplification event was likely the nursing appreciation breakfast.

The absence of travel or contact history along with the lack of rapid, validated, SARS diagnostic tests further contributed to delays in recognizing SARS cases at this hospital. This outbreak highlights the importance of FRI surveillance, infection control and close liaison with public health and occupational health concurrently in managing outbreaks. Once SARS was recognized, and during the early stages of the outbreak response, the implementation of an active surveillance protocol for FRI resulted in early identification of ill individuals. This combined with the reinstatement of enhanced infection-control protocols resulted in rapid control of the outbreak.

It is important to have in place a systematic approach to infection control when managing a nosocomial outbreak including engineering controls, administrative controls, and use of appropriate personal protective equipment by all staff. Close communication with public health provides a broader perspective and information as to what is happening in the community. Occupational health departments are vital in monitoring and reporting staff illness to public health and in educating staff. It is important that an environment be created in which staff do not feel either that they will be penalized for going home ill or that they are burdening their colleagues when they do so.

Limitations of our report include the focus only on nursing staff and not physicians, porters, cleaners and other hospital staff. While other hospital staff did become ill with SARS and may have contributed to spread of the outbreak, sufficient detailed and comprehensive records on movements in the hospital, shifts worked and patients cared for were only available for nursing staff. The analysis of nursing staff, however, does provide important insight into the outbreak on Ward A at Hospital X and we feel the findings, particularly with respect to behaviour and sick-time policies can be generalized to other hospital staff.

Although we were unable to identify with certainty the source of the SARS virus in Hospital X in the second phase of the Toronto outbreak, it became clear that an unrecognized source was present in the hospital when the outbreak was thought to be over in early May. Transmission likely occurred at a low level between patients who had other underlying illnesses that confused the picture, and was masked

by the continued use of enhanced infection-control measures by staff. Rapid amplification particularly among nursing staff occurred when these measures were withdrawn. This phase of the outbreak centered at Hospital X and its tragic consequences have led to a concerted government effort to augment resources in, and improve coordination and communication between, infection control, occupational health and public health so as to be better prepared for future threats from emerging infections.

References

1. Tsang K, Ho P, Ooi G et al. A cluster of cases of Severe Acute Respiratory Syndrome in Hong Kong. N Engl J Med 2003;348(20):1977-85.
2. Ksiazek T, Erdman D, Goldsmith C et al. A novel coronavirus associated with severe acute respiratory syndrome. N Engl J Med 2003;348(20):1953-66.
3. Drosten C, Gunther S, Preiser W et al. Identification of a novel coronavirus in patients with Severe Acute Respiratory Syndrome. N Engl J Med 2003;348(20):1967-76.
4. McKeown D. “Executive Summary”. *Communicable Diseases in Toronto 2003*. http://www.toronto.ca/health/ communicable_diseases/pdf/communicable_diseases2003. pdf. Accessed: June 18, 2007.
5. Ministry of Health and Long-Term Care, in conjunction with the SARS Outbreak Analysis Committee. *Descriptive Epidemiology of the Severe Acute Respiratory Syndrome (SARS) Outbreak Ontario, Canada, 2003*. July 2006. http://www.health.gov.on.ca/english/public/ pub/ministry_reports/sars_070106/sars_070106.pdf. Accessed: June 18, 2007.
6. Update: Severe Acute Respiratory Syndrome – Toronto, 2003. CCDR 2003;29(13):113-17.

7. Loutfy MR, Wallington T, Tutledge T et al. Hospital Preparedness and SARS. Emerg Infect Dis 2004;10(5):771-76.

8. Epidemiology, clinical presentation and laboratory investigation of Severe Acute Respiratory Syndrome (SARS) in Canada. CCDR 2003;29(8):71-75.

9. Seto WH, Tsang D, Yung RW et al. Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). Lancet 2003;361:1519-20.

10. Loeb M, McGeer A, Henry B et al. SARS among critical care nurses, Toronto. Emerg Infect Dis 2004;10(2):251-55.

11. Wong T, Wallington T, McDonald LC et al. Late recognition of SARS in nosocomial outbreak, Toronto. Emerg Infect Dis 2005;11(2):322-25.

12. Ofner-Agostini M, Gravel D, McDonald LC et al. Cluster of cases of Severe Acute Respiratory Syndrome among Toronto healthcare workers after implementation of infection control precautions: A case series. ICHE 2006;27:473-78.