

## ORIGINAL ARTICLE

## Cluster of Cases of Severe Acute Respiratory Syndrome Among Toronto Healthcare Workers After Implementation of Infection Control Precautions: A Case Series

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**OBJECTIVE.** To review the severe acute respiratory syndrome (SARS) infection control practices, the types of exposure to patients with SARS, and the activities associated with treatment of such patients among healthcare workers (HCWs) who developed SARS in Toronto, Canada, after SARS-specific infection control precautions had been implemented.

**METHODS.** A retrospective review of work logs and patient assignments, detailed review of medical records of patients with SARS, and comprehensive telephone-based interviews of HCWs who met the case definition for SARS after implementation of infection control precautions.

**RESULTS.** Seventeen HCWs from 6 hospitals developed disease that met the case definition for SARS after implementation of infection control precautions. These HCWs had a mean age ( $\pm$ SD) of  $39 \pm 2.3$  years. Two HCWs were not interviewed because of illness. Of the remaining 15, only 9 (60%) reported that they had received formal infection control training. Thirteen HCWs (87%) were unsure of proper order in which personal protective equipment should be donned and doffed. Six HCWs (40%) reused items (eg, stethoscopes, goggles, and cleaning equipment) elsewhere on the ward after initial use in a room in which a patient with SARS was staying. Use of masks, gowns, gloves, and eyewear was inconsistent among HCWs. Eight (54%) reported that they were aware of a breach in infection control precautions. HCWs reported fatigue due to an increase number and length of shifts; participants worked a median of 10 shifts during the 10 days before onset of symptoms. Seven HCWs were involved in the intubation of a patient with SARS. One HCW died, and the remaining 16 recovered.

**CONCLUSION.** Multiple factors were likely responsible for SARS in these HCWs, including the performance of high-risk patient care procedures, inconsistent use of personal protective equipment, fatigue, and lack of adequate infection control training.

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In November 2002, an atypical form of pneumonia—severe acute respiratory syndrome (SARS)—rapidly spread from its geographical origin in Guangdong Province, China, to distant regions, including Canada.<sup>1</sup> This syndrome, characterized by fever, headache, myalgia, cough, shortness of breath, and progressive infiltrates on chest radiographs, is caused by a novel coronavirus (SARS-CoV) that spreads predominantly by respiratory droplets.<sup>2,3</sup>

By the time the final probable case of SARS was reported on June 15, 2003, a total of 8,098 probable cases of SARS had been reported globally, primarily in mainland China, the Hong Kong Special Administrative Region, Taiwan, and Singapore,<sup>4</sup> and the illness had claimed 774 lives (mortality rate, 9.6%). Of these cases, 442 (251 probable and 191 suspected) were reported in Canada, the majority of which (247 probable

and 132 suspected) were in Ontario.<sup>5</sup> Almost half (109 [44%]) of the probable cases in Canada were in healthcare workers (HCWs).<sup>4</sup>

SARS-specific infection control directives from the scientific advisory committee of the Provincial Operating Centre (POC) in Ontario were implemented throughout Ontario, including all Toronto hospitals, on March 28, 2003, in an attempt to halt the spread of SARS-CoV among HCWs. Although SARS was not occurring outside of central Ontario, all hospitals in Ontario were following these directives. Routine infection control practices and contact precautions (ie, handwashing; use of gowns, gloves, masks, and eye protection; and airborne precautions, including use of National Institute for Occupational Safety and Health (NIOSH)-approved N95 masks and hospitalization of SARS-CoV-

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infected patients in single-bed rooms or negative-pressure airflow rooms) were recommended for all patients with known or suspected SARS. Similar practices and precautions were implemented for most other patients. HCWs, especially those in emergency departments, intensive care units, and dedicated SARS units, were expected to wear their personal protective equipment during their entire shift. Dedicated or disposable equipment was used, patient movement was limited, the number of visitors to the hospital was restricted, and staff were not permitted to work in other areas of the same hospital or in other hospitals. These SARS-specific infection control measures were effective in reducing transmission of SARS to other patients and HCWs.<sup>6</sup>

However, from March 28 through April 24, 2003, a total of 17 suspect or probable SARS cases were documented in HCWs at 6 different Toronto-area hospitals, even though, by this period, all of the above-mentioned SARS-specific infection control precautions had been implemented. An investigation was initiated to determine the factors that may have contributed to the acquisition of SARS by HCWs who reported that they used the recommended SARS-specific infection control precautions during the outbreak.

## METHODS

HCWs from hospitals in the greater Toronto area who had probable or suspected SARS were interviewed to determine their level and type of participation in the care of patients with SARS; their personal habits; their SARS-related medical conditions, symptoms, and exposures; and their compliance with infection control practices and infection control training. The interviews were conducted within the first several days after each HCW received their diagnosis, while they were still feeling well enough to comply. HCWs with SARS who were too ill to respond were not questioned. The study population consisted of all staff or employees who developed signs and symptoms consistent with the World Health Organization definition of probable or suspected SARS<sup>4</sup> after SARS-specific infection control practices were implemented in accordance with the Ontario POC directive. An HCW was eligible for inclusion in the study if they had probable or suspected SARS diagnosed within 10 days of working in a patient-care area with patients known to have SARS.

Data collection consisted of the following 2 components: detailed reviews of patient medical records and comprehensive interviews with HCWs. For each of the participating HCWs, medical record reviews were performed for all patients with SARS with whom they interacted during the 10 days before symptom onset. These patients were identified through a review of work logs and patient assignments and during preliminary interviews with the HCWs. For each interaction, the procedures and patient-care activities performed for patients with SARS were determined, along with the level of participation by the HCW, the infection control precautions used, the time spent performing the procedure

or activity, and the HCW proximity to the patient. Because of the intensive, time-consuming nature of the medical record reviews and HCW interviews, as well as personnel and resource limitations, these investigations were not extended to a control group of HCWs without SARS.

All interviews were performed by telephone. Interviewees were asked open-ended questions to determine underlying medical conditions and personal habits that could increase touching of the face with contaminated hands. In addition, the HCWs' overall knowledge, understanding, and compliance with routine and SARS-specific infection control precautions were assessed.

Information was manually recorded on data collection forms, and data were entered into Access 2000 (Microsoft). Descriptive analysis was performed using SAS software, version 8.1 (SAS Institute).

## RESULTS

### Case Chronology

Seventeen HCWs were included in this investigation. These HCWs were from 6 hospitals and developed SARS between March 28 and April 24, 2003, after the SARS-specific infection control guidelines had been implemented. Investigations were conducted within several days after they received their diagnosis. Serological tests of convalescent-phase serum specimens obtained from all 17 HCWs were positive for SARS-CoV antibody (testing was performed by the National Microbiology Laboratory, Winnipeg). One hospital (hospital C) accounted for 10 cases, another hospital (hospital B) accounted for 3 cases, and the 4 remaining hospitals each accounted for 1 case.

The index patient for the cluster of SARS cases in hospital C was a family physician. Between April 1 and 2, this physician examined 3 patients who were family members involved in a community cluster of SARS cases in Toronto. On April 4, the physician had fever, myalgia, headache, mild diarrhea, and cough. On April 8, a chest radiograph showed an infiltrate, and the physician was admitted to the SARS ward of hospital C. Between April 15 and April 21, nine HCWs who had cared for the index patient developed signs and symptoms that satisfied the World Health Organization case definition for probable or suspect SARS (Figure 1). This cluster of SARS cases has been described elsewhere.<sup>7</sup> The number of SARS patient-days in Ontario remained relatively constant until April 18, 2003, and then decreased by approximately 50% thereafter (Figure 2).

### HCW Characteristics

The mean age ( $\pm$ SD) of the HCWs with probable or suspected SARS was  $39.2 \pm 2.3$  years (range, 27-58 years). The ratio of men to women was 4:13. Ten HCWs (59%) were nurses, 3 (18%) were physicians, 2 (12%) were respiratory therapists, 1 (6%) was an orderly, and 1 (6%) was a radiology technician. In total, 11 (65%) received a diagnosis of probable

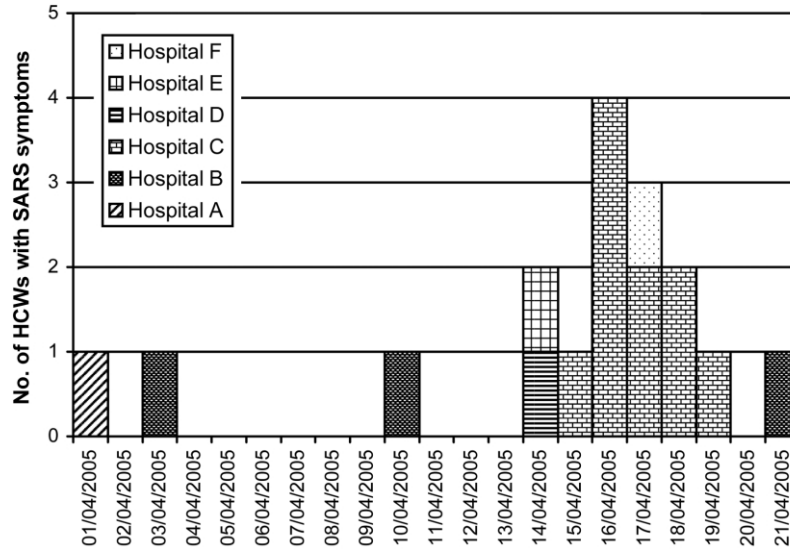


FIGURE 1. Dates of onset of severe acute respiratory syndrome (SARS) symptoms for 17 healthcare workers (HCWs) in Toronto who developed SARS after SARS-specific infection control guidelines had been implemented.

SARS, and the remaining 6 (35%) received a diagnosis of suspected SARS. Two HCWs were unable to participate in the interviews because of their illness. Of the remaining 15 HCWs, 9 (60%) reported 1-3 comorbidities, including asthma (4 HCWs [27%]), diabetes (2 [13%]), current smoking (2 [13%]), cardiac problems (1 [7%]), and immune-related problems (1 [7%]). Four (27%) reported unspecified comorbidities. One HCW died; the remaining 16 recovered from their illness, for a case-fatality rate of 6%.

Of the 15 HCWs interviewed, 7 (47%) indicated that they wore jewelry (primarily rings on fingers and chains around necks) at work (Table 1). Fourteen (93%) ate their meals at work, although only 4 (27%) ate on the same ward where they worked. Two (13%) had contact with patients with SARS outside of the hospital, although the type of contact was not de-

finied. Only 9 HCWs (60%) reported having received formal infection control training, which took the form of a demonstration for 6 (40%), written material for 4 (27%), a didactic session for 3 (20%), and/or a training video for 2 (13%).

#### Protection and Exposure

Each of the 15 HCWs who were interviewed reported at least 1 visit to a room with a patient who had SARS and was not wearing a protective mask. Masks, gowns, gloves, and eye protection were not always worn by HCWs in the rooms of patients with SARS or the units in which they were hospitalized (Tables 2 and 3). HCWs wore N95 masks or respirators (or their equivalents) approved by the NIOSH, although the equipment was not fit tested until near the end of the out-

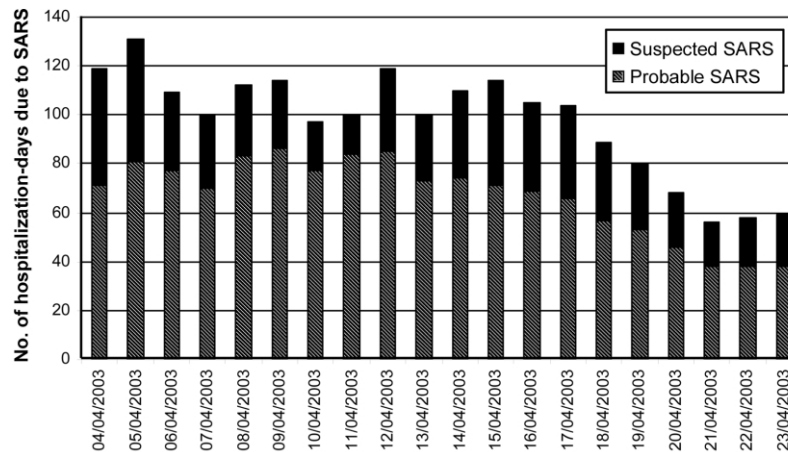


FIGURE 2. Total number of hospitalization-days due to severe acute respiratory syndrome (SARS) in Ontario, Canada, during April 2003.

TABLE 1. Personal Habits and Infection Control Training of Healthcare Workers (HCWs) From Toronto Who Developed Severe Acute Respiratory Syndrome (SARS).

Characteristic	No. (%) of HCWs ( <i>n</i> = 15) <sup>a</sup>
Personal habits at work	
Wore jewelry	7 (47)
Bit nails	2 (13)
Applied makeup	3 (20)
Wore eyewear	
Any	7 (47)
Glasses	6 (40)
Contact lenses	1 (7)
Ate meals at work	
Any location	14 (93)
In cafeteria	7 (47)
In staff lounge on ward	4 (27)
In other location	3 (20)
Contact with patient with SARS outside hospital	2 (13)
SARS-specific infection control training	
Received formal training	
Any	9 (60)
Demonstration	6 (40)
Written materials	4 (27)
Didactic sessions	3 (20)
Video	2 (13)
Instructor	
Infection control practitioner	4 (27)
Nurse	3 (20)
Other	2 (13)
Time of training	
Before first exposure to patient with SARS	5 (33)
After first exposure to patient with SARS	4 (27)

<sup>a</sup> Two HCWs could not be interviewed because of their illness.

break (ie, after the study period). Thirteen HCWs (86.7%) were unsure of the proper order of removal of personal protective equipment. Thirteen HCWs commented on a breach in precautions, and 7 (54%) recalled knowledge of at least 1 specific breach during patient care. Breaches ranged from 0-9 reports per HCW. During the interview, all 15 HCWs commented that they frequently failed to wash their hands between each removal of personal protective equipment, frequently touched their face to adjust the mask while wearing potentially contaminated gloves, and removed gown and/or gloves in such a manner that clothing could become contaminated. One HCW reported that they did not change gowns between patients. Six HCWs (40%) reused items (eg, stethoscopes, goggles, and cleaning equipment) elsewhere on the ward after use in a room in which a patient with SARS was hospitalized. Six of the 9 HCWs who developed SARS in hospital C and were available for an interview were directly involved in the endotracheal intubation of a patient with SARS in the intensive care unit.<sup>7</sup>

For each of the 17 HCWs investigated in the study, detailed review of medical records for all 68 patients with SARS with whom they interacted during the 10 days before symptom onset revealed at least 1 high-risk exposure per HCW (Table 4). Seven HCWs (41%) were involved in at least 1 intubation involving a patient with SARS. Three (18%) reported that their face was splashed with fluid from a patient with SARS, and 1 HCW reported that a patient with SARS repeatedly coughed in her face. Each HCW had direct (ie, physical) contact with at least 1 patient with SARS and worked a median of 10 shifts and a mean of 42.5 hours in the presence of patients with SARS during the 10 days before contracting the disease.

## DISCUSSION

All 15 HCWs who were interviewed reported direct contact with a patient with SARS, and it is likely that transmission occurred during these direct contacts rather than via widespread environmental contamination or transmission from other infected HCWs. This was especially apparent for the cluster at hospital C, where 9 of the 10 HCWs with SARS

TABLE 2. Self-Assessment of Personal Protective Equipment Use by 15 Healthcare Workers (HCWs) From Toronto Who Developed Severe Acute Respiratory Syndrome (SARS)

Personal protective equipment used	Value
Mask <sup>a</sup>	
Always worn in room of patient with SARS	14 (93)
Always worn on SARS unit	13 (87)
Always worn elsewhere in hospital	9 (60)
Duration of use per HCW, hours	0.5-4
No. used per HCW per shift	2-15
Mask use by patient with SARS while HCW was in room	
Always	1 (7)
Sometimes	12 (80)
Never	3 (20)
Gown	
Always worn in room of patient with SARS	14 (93)
Always worn on SARS unit	14 (93)
Gloves	
Always worn in room of patient with SARS	15 (100)
Always worn on SARS unit	13 (87)
Sometimes worn on SARS unit	1 (7)
Never worn on SARS unit	2 (13)
Eye protection	
Always worn in room of patient with SARS	13 (87)
Usually worn in room of patient with SARS	2 (13)
Never worn in room of patient with SARS	1 (7)

NOTE. Data are no. (%) of HCWs or range. Two HCWs could not be interviewed because of their illness.

<sup>a</sup> One HCW (7%) reported that patients with SARS were always equipped with a mask while the HCW was in the room, 12 (80%) reported that such patients were sometimes equipped with a mask, and 3 (20%) reported that such patients were never equipped with a mask.

TABLE 3. Characteristics of Eye Protection Used by the Healthcare Workers (HCWs) in Toronto Who Developed Severe Acute Respiratory Syndrome (SARS)

Characteristic	No. (%) of HCWs (n = 15) <sup>a</sup>
Frequency of washing reusable eyewear	
After each SARS exposure	13 (87)
Usually	2 (13)
Sometimes	1 (7)
Substance(s) used to wash reusable eyewear	
Soap and water	8 (53)
Accelerated hydrogen peroxide	4 (27)
Alcohol wipes	2 (13)
Towelettes	2 (13)
Location of washing	
Anteroom of SARS unit	2 (13)
Sink in SARS unit	7 (47)
Room outside SARS unit	2 (13)
Radiation department	1 (7)
Type of eye protection used	
Personal glasses	4 (27)
Safety glasses	6 (40)
Goggles	8 (53)
Face shield	5 (33)

<sup>a</sup> Two HCWs could not be interviewed because of their illness.

cared for and 6 were involved in endotracheal intubation of the index patient.

For all 17 HCWs, detailed reviews of the medical records for all patients with SARS with whom they interacted during the 10 days before symptom onset revealed exposure to at least 1 high-risk procedure, such as an endotracheal intubation, or 1 high-risk event, such as coughing by the patient within 1 m of the HCW. Attempts to reduce HCW risk during high-risk procedures might include intubation with preemptive rather than delayed intubation, limiting the number of people in the room, and promoting the use of sedatives or paralyzing agents to reduce patient combativeness. The importance of compliance to and proper training in infection control procedures during these situations should be emphasized.

Systematic breaches in infection control guidelines likely contributed to the transmission of SARS to these HCWs: 7 HCWs recalled a specific breach during care. As indicated in Table 2, self-reported adherence to appropriate use of personal protective equipment (including masks, gowns, gloves, and eye wear) was inconsistent, and most of the HCWs were unsure of the proper order of removal. There was a widespread practice of wearing gloves outside the rooms of patients on the SARS units (14 of 15 HCWs "always" or "sometimes" wore gloves on the SARS units). This also included reports of double gloving and double gowning. These practices, which were not included in the recommended precautions, may reflect an exaggerated sense of protection afforded by glove and gown use and may have promoted contami-

nation of the environment outside the rooms of patients on the SARS units if and/or when HCWs forgot to change gloves and/or gowns after patient contact. Furthermore, respirators worn by HCWs did not undergo fit testing, which is mandated in the United States.<sup>7</sup> In addition, some of the HCWs ate meals at nurse workstations, wore jewelry, applied make-up, and chewed their fingernails while at work. HCWs reported that it was difficult to keep from contaminating themselves or their environment and extremely time-consuming to implement the infection control precautions.

HCWs also reported fatigue due to increased numbers and lengths of shifts and due to the time required during repeated donning and doffing of personal protective equipment. The combination of fatigue, stress, and frequent changes in the infection control directives may have led to confusion about what to do. The procedure for donning and doffing personal protective equipment was complex, because of the number of items of protective equipment to don and doff and because of the need for frequent handwashing, particularly when removing personal protective equipment. The infection control precautions developed for SARS had never been used and consisted of a combination of standard, contact, and airborne transmission precautions. In addition, HCWs reported fa-

TABLE 4. Characteristics of Exposures to Severe Acute Respiratory Syndrome (SARS) Among 17 Healthcare Workers From Toronto During the 10 Days Before SARS Symptom Onset

Characteristic	No. (%) of HCWs	Median no. per HCW (range)
Shifts worked with patients with SARS	...	10 (6-14)
Patients with SARS cared for per shift <sup>a</sup>	...	6.5 (0-33)
Type of SARS exposure		
Direct contact, by patient characteristic		
Overall	17 (100)	...
Receiving supplemental oxygen	8 (47)	7 (1-21)
Receiving mechanical ventilation	5 (29)	1 (1-2)
Died because of SARS	3 (18)	1 (1-3)
High-risk procedure		
Overall	14 (82)	...
Intubation	7 (41)	1 (1-3)
Use of BiPAP <sub>H</sub>	6 (35)	2 (1-4)
Manual ventilation	6 (35)	1 (1-2)
High-flow mechanical ventilation	5 (29)	2 (1-11)
Chest physiotherapy	4 (24)	2 (1-4)
Suctioning	3 (18)	1 (1-1)
Nebulizer therapy	2 (12)	1 (1-1)
High-risk event		
Overall	17 (100)	...
Coughing	14 (82)	3 (1-17)
Diarrhea	6 (35)	1 (1-11)
Vomiting	4 (24)	1.5 (1-2)

NOTE. BiPAP<sub>H</sub> = bilevel positive airway pressure.

<sup>a</sup> HCWs worked 8-h or 12-h shifts.

tigue from working with personal protective equipment (especially N95 respirators) for several hours. Many HCWs reported dizziness, nausea, and shortness of breath while using the respirators. Some HCWs did not return home after their shifts, to avoid potentially exposing family members to SARS, further contributing to their emotional and physical fatigue. The SARS outbreak clearly added challenges to the workload of HCWs. Despite this increase in workload, the ratio of HCWs to patients initially remained the same (although it decreased later during the outbreak); this is important, because it has been shown that reduced levels of HCW staffing may be associated with an increase in the spread of nosocomial infection.<sup>8</sup>

HCWs were interviewed while they were ill. However, they were interviewed early in the course of the illness, often within the first few days after onset of symptoms. Most HCWs with SARS were able to answer questions regarding patient care. Medical records would be brought into the HCW to help with the recall of patient-care activities and their own notes. This was done to decrease recall bias.

HCWs reported that communication of infection control precautions posed a further challenge. New public health and infection control directives were issued frequently, and some HCWs claimed that they could not determine which infection control precautions were current. Many HCWs lacked formal infection control training before the outbreak, and some received training only after working several shifts with patients who had SARS. Training was often provided by one HCW to another, so there was some possibility of error in training. The physicians who developed probable or suspected SARS indicated during their interview that they had not receive formal infection control training on the appropriate use of personal protective equipment. Physicians generally reported that their infection control training, which usually only consisted of the presence of informational posters throughout the wards, was inadequate.

Inclusion of a control group of HCWs who did not acquire SARS but worked with patients with SARS would have been helpful for revealing potential risk factors for SARS acquisition. Unfortunately, because of the nature of the outbreak and the urgency of addressing all SARS-related matters, there were no people available to conduct that investigation.

This cluster of SARS cases was likely due to multiple factors, including patient-care procedures that put HCWs at high risk for infection, an especially difficult endotracheal intubation for the index patient, inconsistent use of personal protective equipment, and lack of adequate infection control training. Other contributing factors included HCW difficulty in maintaining compliance with SARS-specific infection control pre-

cautions over a long period and a high level of HCW fatigue and stress associated with treatment of the critical mass of patients with SARS who presented a high risk of SARS transmission. A major limitation of this investigation was the lack of a control group of HCWs who cared for patients with SARS but did not themselves develop SARS. Had a control group been included, the relative importance of these various factors might have been determined. Nonetheless, the results of this investigation do at least suggest that, because of the potentially increased workload, it may not be possible to safely care for a relatively large number of patients with SARS: an increase in the ratio of nurses to patients during SARS outbreaks may be necessary. Further study is warranted to determine the level and complexity of personal protective equipment that are required to reduce or eliminate the potential transmission of SARS to HCWs.

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