Descriptive Epidemiology of the Severe Acute Respiratory Syndrome (SARS) Outbreak Ontario, Canada, 2003

Prepared by the Ministry of Health and Long-Term Care, in conjunction with the SARS Outbreak Analysis Committee

July 2006
FOREWORD

This report was prepared under the auspices of the SARS Outbreak Analysis Committee (SOAC). The SOAC was first formed as a Ministry of Health and Long-Term Care, Public Health Division initiative in September 2003. The committee was comprised of members from four Greater Toronto Area (GTA) Public Health Units (PHU) in collaboration with the Ontario Ministry of Health and Long-Term Care (MOHLTC). The committee included representation from the Public Health Division; Toronto Public Health; York Region Health Services Department; Durham Region Health Department and Peel Regional Health Department.

The mandate of the committee included the review and analysis of the data collected during the 2003 SARS outbreak to provide a complete and accurate account of all of the cases identified in Ontario. As data on SARS-specific infection control measures were not collected, this document does not evaluate the effectiveness of these measures. A review of SARS infection control practices among a group of Toronto healthcare workers has been published elsewhere (1). The purpose of this document was to summarize the descriptive epidemiology of cases reported during the 2003 SARS outbreak and to provide an epidemiological report that could be shared with public health unit staff, epidemiologists and other interested health professionals.
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Descriptive Epidemiology of the Severe Acute Respiratory Syndrome (SARS) Outbreak
Ontario, Canada, 2003
INTRODUCTION

In late February 2003, guests at a hotel in Hong Kong came in contact with an ill physician who had been treating patients with an atypical form of pneumonia in Guangdong, China. Days later, they developed similar symptoms and transmitted the disease via international travel to contacts in China, Singapore, Vietnam, and Canada (2). By March 15, 2003 (3), the World Health Organization (WHO) had received reports of more than 150 cases of this new atypical respiratory disease, later termed Severe Acute Respiratory Syndrome (SARS) (4). Globally, SARS affected 29 countries; 8,096 probable cases were identified of whom 774 died (5).

SARS is a viral respiratory illness caused by a coronavirus, called SARS-associated coronavirus (SARS-CoV). SARS presents with malaise, myalgia and fever, followed by respiratory symptoms including cough and shortness of breath; diarrhea may also occur. SARS is transmitted from person to person by close contact: caring for, living with, or direct contact with respiratory secretions or body fluids (e.g. stool or vomitus) of a suspect or probable case of SARS. While retrospective studies still continue, the spread of the virus is thought to be transmitted most readily through respiratory droplets produced when an infected individual coughs or sneezes and possibly through fomites (a surface or object contaminated with infectious droplets). The incubation period has been documented as between 3 to 10 days (6).

SARS was first introduced to Canada upon the return of one of the hotel guests to Toronto, Ontario in February 2003. A detailed timeline of the SARS outbreak in Ontario is presented in Appendix A. While SARS spread to other parts of Ontario, the majority of cases were in the Greater Toronto Area. Over 10,000 individuals in the Greater Toronto Area alone were placed in voluntary or supervised quarantine (7). Ongoing research on SARS continues to provide greater insight into the causative agent, the SARS coronavirus, as well as into the future direction for public health. A list of resources with more detailed information on the Ontario SARS outbreak can be found in Appendix B.

The objective of this report is to describe the epidemiology of the 2003 SARS outbreak in Ontario.

BACKGROUND: ONTARIO’S HEALTHCARE SYSTEM

The population of Ontario is 11.7 million with approximately 4.8 million (41.0%) living in the Greater Toronto Area (GTA) (8). Public health in Ontario including the protection against communicable diseases is delivered primarily through local health units as set out under the Health Protection and Promotion Act, 1990. Each health unit is governed by a board of health, which is an autonomous corporation under the Health Protection and Promotion Act, and is administered by the medical officer of health who reports to the local board of health. The board is largely made up of elected representatives from the local municipal councils. The Ministry of Health and Long-Term Care (MOHLTC) cost-shares the expenses with the municipalities (9). During the 2003 SARS outbreak there were 37 public health units with a large variance in population size among the catchment areas.

The Mandatory Health Programs and Services Guidelines, issued by the MOHLTC, set out minimum requirements for core programs and services targeted at disease prevention, health promotion and health protection. To ensure effective control of infectious diseases, health units have a responsibility in conducting surveillance, case-finding, contact tracing, immunization, infection control and risk assessment. Health units are also required to report all reportable diseases to the MOHLTC. During the SARS outbreak, Ontario made SARS a reportable, virulent, communicable disease under the Health Protection and Promotion Act. This allowed Ontario public health officers to issue orders to stop infected persons from engaging in activities that transmit SARS (9).
METHODS

The population described in this report includes individuals in Ontario (temporary or permanent residents) who met the case definition of either Suspect or Probable SARS during the 2003 outbreak. Residents of other provinces and countries who were exposed to SARS in Ontario were also included in the analysis. The majority of cases in the Ontario outbreak resided in four GTA health units (Toronto, York Region, Durham Region, and Peel Region).

The four GTA health units reviewed and reconciled their SARS case records to ensure consistency and comparability across jurisdictions. Reconciled case data were reported to the MOHLTC for verification and analysis. The resulting database was created through cooperation of all involved health units and the MOHLTC. Key variables used in the analyses are listed in Appendix C.

Case Definitions
The case definition for SARS evolved during the outbreak as more information became available. During the post-outbreak data reconciliation process, cases were reclassified based on the May 29, 2003 Health Canada revised SARS case definition (Appendix D) which required both clinical and epidemiological evidence.

A Suspect Case was defined as a person presenting with:
1. Fever over 38°C
2. Cough or difficulty breathing,
3. One or more of the following exposures during the 10 days prior to the onset of symptoms:
   a. Close contact with a person who is a suspect or probable case
   b. Recent travel to an area with recent local transmission of SARS outside of Canada,
   c. Or recent travel or visit to an identified setting in Canada where exposure to SARS may have occurred.

Persons with unexplained acute respiratory illness resulting in death after November 1, 2002, but on whom no autopsy has been performed were also classified as a Suspect case. A Probable case was one that met the criteria for a Suspect case and had additional radiological evidence of infiltrates consistent with pneumonia or respiratory distress syndrome on chest x-ray or autopsy evidence of respiratory distress syndrome pathology.

All analyses presented in this report are based on cases that were classified as Suspect or Probable according to this case definition. As details on clinical history for the index case were not available, this case was excluded from this analysis as the individual did not meet the May 29, 2003 case definition.

Laboratory data
Infection with SARS coronavirus (CoV) is reportable in Ontario. All laboratories are required to send reports of positive SARS-CoV tests to the local public health authorities. While numerous specimens were collected during the outbreak by both hospital and private laboratories, only cases that had specimens collected and sent to the Ontario Public Health Laboratory and National Microbiology Laboratory in Winnipeg were included in the laboratory analysis. SARS laboratory results for this report were categorized using criteria in Appendix E, which are an adaptation of the World Health Organization’s May 1, 2003 recommendations and the Canadian Public Health Laboratory Network’s November 7, 2003 recommendations on the interpretation of SARS laboratory results (10). Results were categorized based on serology or virology methods used as sufficient or insufficient to determine a positive or negative laboratory classification.

Laboratory data presented in this report are intended as supplemental information only; case classifications were determined independently of laboratory results.
In this analysis, we used a single positive antibody test (enzyme-linked immunosorbent assay (ELISA) or immunofluorescent assay (IFA) as sufficient evidence for a positive SARS laboratory classification since the Ontario population was assumed to be immunologically naïve to the SARS coronavirus prior to the outbreak. The presence of SARS CoV-specific antibodies would therefore indicate recent infection.

We used the demonstration of SARS CoV antigens in at least two different clinical specimens (e.g., nasopharyngeal swab and stool) or more than one of the same clinical specimen (e.g., two or more nasopharyngeal swabs) collected on two or more different days during the course of illness for a positive SARS laboratory classification (see Appendix E).

Sufficiency of testing
SARS patients may take as long as 28 days after onset of illness to seroconvert, thus only a negative serological result in serum collected more than 28 days after onset of illness (i.e., negative convalescent serum) was considered sufficient evidence for a negative SARS laboratory classification. Additionally, lack of antigen detection in clinical specimens (using PCR) was not considered sufficient evidence for a negative SARS laboratory classification as the timing of the presence of virus in clinical specimens during the course of illness is not clearly understood.

Data analysis
All data were collected from the health units in Microsoft Excel format. Data were analyzed in SPSS 10.1.0 and EpiInfo v.3.3. Analyses were undertaken to describe the following characteristics of cases from the Ontario SARS outbreak: demographic, exposure, clinical and laboratory. Chi-square or Fisher's exact tests were used to conduct univariate analysis on categorical variables and T-tests for continuous variables. The incubation period was calculated for individuals with a single known exposure as the number of days between the exposure and the date of onset of the first symptom. The case-fatality rate was calculated by division of the total number of case deaths by the total number of probable and suspect cases.
1. **DESCRIPTIVE EPIDEMIOLOGY**

1.1. **SARS Epidemic Curve**

A total of 351 SARS cases (301 Probable and 50 Suspect) were reported to Ontario public health authorities. The onset date of the first case among this group was February 26, 2003 and the onset of the last case in June 12, 2003. The epidemic curve of the Ontario SARS outbreak is presented in Figure 1 (see page 29).

The epidemic curve demonstrates two phases of the Ontario SARS outbreak: the first peak (Phase 1) was in late March 2003 and the second (Phase 2) in late May 2003. Phase 1 started with a small number of cases in late February and early March, peaking sharply in mid to late March. It is of note that these cases were early in the global outbreak and before SARS transmission in Canada had been identified. After implementation of control measures that included strict infection control precautions, the levelling off of the first wave of infections is seen after March 27, 2003. With no new cases detected after April 20, 2003, the World Health Organization removed Toronto from the list of areas affected by SARS on May 14, followed by the lifting of the provincial emergency on May 17, 2003.

The second phase started as a result of unrecognized transmission of SARS among hospitalized patients. Retrospectively, it was determined that these cases had symptom onset in late April and early May. However, the second phase was not confirmed until the peak of Phase 2 in late May. Once identified, the second phase was controlled very quickly with a renewed emphasis on infection control measures and the number cases dropped dramatically by the beginning of June.

In both phases of the outbreak, the majority of cases were the result of healthcare-acquired transmission.

1.2. **Age and Sex of cases**

The breakdown of Probable and Suspect cases by age and sex is presented in Table 1.

Two-thirds (65.5%) of all Probable and Suspect SARS cases were female. This is likely a reflection of SARS as being primarily a healthcare-associated disease where the majority of healthcare workers are female.

SARS cases ranged in age from four months to 100 years old. The mean age of all cases at disease onset was 46.7 years (median 45.0 years). While the mean ages of female and male cases were similar (45.8 versus 48.5 years respectively), there were significantly more male cases over the age of 60 years compared to female cases (28.1% of males versus 17.8% of females; p=0.02).

Thirteen (3.7%) pediatric cases (less than 18 years of age) were reported; 9 (69.2%) were female. The mean age of these cases was 10.9 years (median 15.0 years, range four months-17 years). Ten (76.9%) pediatric cases were household contacts of SARS cases, one case was related to travel to a SARS affected region, one had acquired the disease in hospital and one case had been exposed to SARS at a community function. No pediatric cases required admission to the ICU and none died.
Table 1: Age and Sex of SARS cases

<table>
<thead>
<tr>
<th></th>
<th>Probable n(%)</th>
<th>Suspect n(%)</th>
<th>Total n(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>110 (36.5)</td>
<td>11 (22.0)</td>
<td>121 (34.5)</td>
</tr>
<tr>
<td>Female</td>
<td>191 (63.5)</td>
<td>39 (78.0)</td>
<td>230 (65.5)</td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 10</td>
<td>4 (1.3)</td>
<td>1 (2.0)</td>
<td>5 (1.4)</td>
</tr>
<tr>
<td>10-19</td>
<td>9 (3.0)</td>
<td>2 (4.0)</td>
<td>11 (3.1)</td>
</tr>
<tr>
<td>20-29</td>
<td>36 (12.0)</td>
<td>6 (12.0)</td>
<td>42 (12.0)</td>
</tr>
<tr>
<td>30-39</td>
<td>61 (20.3)</td>
<td>12 (24.0)</td>
<td>73 (20.8)</td>
</tr>
<tr>
<td>40-49</td>
<td>64 (21.3)</td>
<td>18 (36.0)</td>
<td>82 (23.4)</td>
</tr>
<tr>
<td>50-59</td>
<td>56 (18.6)</td>
<td>7 (14.0)</td>
<td>63 (17.9)</td>
</tr>
<tr>
<td>60-69</td>
<td>31 (10.3)</td>
<td>2 (4.0)</td>
<td>33 (9.4)</td>
</tr>
<tr>
<td>70-79</td>
<td>22 (7.3)</td>
<td>2 (4.0)</td>
<td>24 (6.8)</td>
</tr>
<tr>
<td>80-89</td>
<td>16 (5.3)</td>
<td>0 (0)</td>
<td>16 (4.6)</td>
</tr>
<tr>
<td>90-100</td>
<td>2 (0.7)</td>
<td>0 (0)</td>
<td>2 (0.6)</td>
</tr>
</tbody>
</table>

1.3. Geographic distribution of cases

Eight health units reported SARS cases meeting the case definition. Cases reported by Greater Toronto Area (GTA) health units accounted for 345 (98.3%) SARS cases; Toronto Public Health reported 213 or 60.7% of all cases. Among the eight health units, the incidence rate per 100,000 population ranged from 0.3 cases per 100,000 to 12.1 cases per 100,000. Total cases and incidence rates by health unit are shown in Figures 2 and 3.

Figure 2: Distribution of SARS cases by health unit of residence

Note: Other includes Haliburton-Kawartha-Pine Ridge (HKPR), Muskoka-Parry Sound and Simcoe County District

Descriptive Epidemiology of the Severe Acute Respiratory Syndrome (SARS) Outbreak Ontario, Canada, 2003
1.4. Cases by exposure setting

Exposure setting, or where the case was most likely exposed to SARS, was categorized into four groups:

1. Healthcare (e.g., hospital, physician’s office)
2. Household
3. Community (e.g., presence at religious or cultural events)
4. Travel

The distribution of SARS cases by exposure setting is presented in Figure 4. Most cases (n=263; 74.9%) developed SARS following exposure to a SARS case in a healthcare setting. Of these, 154 (58.8%) were healthcare workers, 61 (23.3%) were patients and 47 (17.9%) were visitors. Five SARS cases (1.4%) were travel-associated and imported into Ontario following exposure in a geographic area with documented SARS transmission. Of all SARS cases, 69 (19.7%) acquired SARS from exposure to a SARS case in a household setting and 14 (4.0%) acquired SARS following exposure in a community setting.

Of the non-healthcare associated cases, 78.4% acquired SARS through household transmission, 15.9% through community transmission and 5.7% through travel-related exposures.
Figure 4: Distribution of SARS cases by exposure setting

Figure 5 (see page 30) shows the epidemic curve for the outbreak by exposure setting. While the outbreak started as a result of household transmission, both phases of the SARS outbreak were primarily a result of healthcare-associated transmission. In Phase 1, the large increase in the number of cases occurred after a family member of the index case was admitted to hospital resulting in nosocomial transmission to several patients and staff who cared for this case (prior to identification of SARS). Once contact and droplet precautions had been initiated throughout the index hospital on March 25, 2003, there was a large decline in the number of nosocomial cases. Transmission in the latter half of Phase 1 shows a larger number of household and community cases which was a result of spread of infection from hospital cases to household and community contacts. Additional healthcare-related cases were predominantly due to unrecognized SARS cases being transferred from the index hospital to other healthcare settings resulting in transmission in these settings.

Phase 2 of the outbreak peaked on May 28-30, 2003 with almost all cases acquiring SARS in healthcare settings. Again, once new cases of SARS were recognized in Phase 2 and infection control measures were in place, there is an evident decline in the number of new SARS cases.

Statistical comparisons of exposure setting in Phase 1 and Phase 2 found a significant difference in how SARS was acquired ($\chi^2=19.3; p<0.001$). For the purposes of this analysis, Phase 1 included cases with an onset date prior to April 20, 2003; Phase Two included cases with an onset date on or after April 20, 2003. The proportion of healthcare-acquired SARS cases was significantly higher in Phase 2 than in Phase 1 (87.1% versus 68.9%; $p<0.0001$), while the proportion of cases acquired through household transmission was significantly higher in Phase 1 compared to Phase 2 (23.4% versus 12.1%; $p=0.01$). All cases arising from transmission at community events occurred during Phase 1 and four of the five travel-associated SARS cases were part of Phase 1.
The distribution of cases by exposure setting and age group is shown in Table 2. The largest proportion of healthcare associated cases was between ages 30-59 years (65.4%), which was expected as this age range represents that of the working population. Of the non-healthcare associated cases, 49 (55.7%) were between the ages of 20-49 years.

Table 2: Distribution of SARS cases by exposure setting and age group

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Community n(%)</th>
<th>Healthcare n(%)</th>
<th>Household n(%)</th>
<th>Travel n(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 10</td>
<td>1 (7.1)</td>
<td>0 (0)</td>
<td>3 (4.3)</td>
<td>1 (20.0)</td>
</tr>
<tr>
<td>10-19</td>
<td>0 (0)</td>
<td>1 (0.4)</td>
<td>10 (14.5)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>20-29</td>
<td>1 (7.1)</td>
<td>28 (10.6)</td>
<td>12 (17.4)</td>
<td>1 (20.0)</td>
</tr>
<tr>
<td>30-39</td>
<td>3 (21.4)</td>
<td>58 (22.1)</td>
<td>11 (15.9)</td>
<td>1 (20.0)</td>
</tr>
<tr>
<td>40-49</td>
<td>9 (64.3)</td>
<td>62 (23.6)</td>
<td>11 (15.9)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>50-59</td>
<td>0 (0)</td>
<td>52 (19.8)</td>
<td>10 (14.5)</td>
<td>1 (20.0)</td>
</tr>
<tr>
<td>60-69</td>
<td>0 (0)</td>
<td>25 (9.5)</td>
<td>8 (11.6)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>70-79</td>
<td>0 (0)</td>
<td>19 (7.2)</td>
<td>4 (5.8)</td>
<td>1 (20.0)</td>
</tr>
<tr>
<td>80-89</td>
<td>0 (0)</td>
<td>16 (6.1)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>90-100</td>
<td>0 (0)</td>
<td>2 (0.8)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Total</td>
<td>14 (100)</td>
<td>263 (100)</td>
<td>69 (100)</td>
<td>5 (100)</td>
</tr>
</tbody>
</table>

The exposure setting to SARS varied by age group. A greater proportion of adults were infected following exposure in the healthcare setting while the majority of children were exposed to SARS in the home. As previously stated, 10 (76.9%) pediatric cases were exposed to SARS in the household setting. Of cases aged 60 years or older, 62 (82.7%) were exposed to SARS in a healthcare setting; 39 (62.9%) were patients, 16 (25.8%) were visitors, and 7 (11.3%) were employees. Of cases between the age of 30-59 years, 172 (78.9%) had exposure to SARS in a healthcare setting, however, the nature of exposure differed from that of the older cases. In this age group (30-59 years), only 20 cases (11.6%) were patients while 122 cases (70.9%) were employees and 30 (17.4%) were visitors.

Females accounted for 113 (73.4%) of all healthcare worker cases. A significantly higher proportion of female cases were healthcare workers compared to males (49.1% versus 33.9%; p=0.009). A significantly larger proportion of male cases were patients compared to female cases (24.0% versus 13.9%; p=0.03). There was no significant difference between genders in any of the other exposure categories.

2. CLINICAL CHARACTERISTICS OF SARS

2.1. Incubation period

Sixty-eight (19.4%) SARS cases had a single known exposure to a SARS case. Based on these point exposures, the mean incubation period was calculated as 4.9 days (range 1-11 days). Ninety-one percent of SARS cases had an incubation period in the commonly reported range of 3-10 days. Four SARS cases were reported as having an incubation period of 11 days and two cases were reported with a one day incubation period. Of the two cases that were reported as having an incubation period of one day, one was an elderly household contact of a SARS case and one was a healthcare worker who had a history of respiratory illness. It is possible that the onset of first symptoms was related to another illness or that SARS exposure occurred prior to that reported. While not impossible that the incubation period would fall outside of the 3-10 day period, it is necessary to understand that exposure and symptom onset dates were based on patient recall and thus may not be definitive.
2.2. Signs and Symptoms of SARS

The May 29, 2003 Health Canada case definition for SARS required that cases have fever (temperature >38°C) and respiratory symptoms (i.e., cough or difficulty breathing). By definition, all cases were reported as having fever. Presence of a cough was reported for 312 (88.9%) cases, and 254 (72.4%) cases had shortness of breath. For the purposes of this analysis, O\textsubscript{2} saturation of less than 94% was considered indicative of shortness of breath; this was reported for 160 (45.6%) cases. Data was also collected on other signs and symptoms including headache, myalgia, vomiting, diarrhea and nausea. Prevalence of these symptoms during the course of illness is presented in Figure 6. Gastrointestinal symptoms (vomiting and diarrhea) were reported in 43.9% of cases, however, this was not collected consistently throughout the investigation, based on the initial case definition provided by the WHO.
2.3. Medical history and severity of illness

During the course of SARS illness, radiological evidence of pulmonary infiltrates was present in 301 (85.8%) of cases. Of the 351 SARS cases, 110 (31.3%) had at least one underlying medical condition (kidney, heart, lung, or immunosuppressive disease, cancer or diabetes). A total of 145 (41.3%) cases had missing or unknown information regarding past medical history.

Most cases (n=332; 94.6%) were admitted to hospital during the course of their SARS illness, however, cases were often hospitalized during the outbreak to better monitor their status and to prevent household transmission. There were also 15 (4.3%) cases that were not admitted to hospital and four (1.1%) cases that were missing hospitalization data. Of those admitted to hospital, 301 (90.7%) were hospitalized as a result of their SARS illness while 31 (9.3%) cases were already inpatients for other medical reasons prior to SARS onset.

Cases admitted to hospital for illness prior to acquisition of SARS were significantly older than those admitted for SARS (mean 70.7 years versus 44.7 years respectively; p<0.001). As expected, these cases also had a higher proportion of comorbid conditions than those admitted as a result of SARS illness (74.2% versus 27.6% respectively; p<0.001). Seventy-six (21.7%) cases were admitted to the intensive care unit (ICU) for their SARS illness of which 54 (71.1%) were intubated. The cases admitted to the ICU ranged in age between 20 and 89 years; half (48.7%) of these were 60 years of age and older. Further comparison of severity of illness in cases admitted to hospitals for SARS and those cases already in hospital prior to acquiring SARS is presented in Table 3.
Table 3: Severity of illness in cases admitted to hospitals for SARS illness (N=301) versus cases already in hospital prior to SARS acquisition (N=31)

<table>
<thead>
<tr>
<th></th>
<th>Hospital inpatient prior to SARS acquisition n (%)</th>
<th>Admitted to hospital for SARS illness n (%)</th>
<th>95% CIdiff p-value***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probable cases</td>
<td>30 (96.8)</td>
<td>268 (89.0)</td>
<td>(-1.1-16.7; p=NS)</td>
</tr>
<tr>
<td>Age</td>
<td>Mean 70.7</td>
<td>44.7</td>
<td>(19.9-32.1; p&lt;0.001)</td>
</tr>
<tr>
<td></td>
<td>Median 75.0</td>
<td>44.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Range 29-96</td>
<td>0-100</td>
<td></td>
</tr>
<tr>
<td>Admitted to ICU</td>
<td>15 (48.4)</td>
<td>61 (20.3)</td>
<td>(8.2-48.1; p=0.001)</td>
</tr>
<tr>
<td></td>
<td>Intubated* 10 (66.7)</td>
<td>44 (72.1)</td>
<td>(-25.1-35.9; p=NS)</td>
</tr>
<tr>
<td>Presence of underlying</td>
<td>23 (74.2)</td>
<td>83 (27.6)</td>
<td>(28.6-64.6; p&lt;0.001)</td>
</tr>
<tr>
<td>medical conditions**=Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Died</td>
<td>13 (41.9)</td>
<td>31 (10.3)</td>
<td>(12.1-51.1; p&lt;0.001)</td>
</tr>
</tbody>
</table>

*Of those admitted to ICU  **at least one of: kidney, heart, lung, or immunosuppressive disease, cancer or diabetes  ***NS=not significant (p>0.05)

2.4. Mortality

There were 44 documented deaths among cases of SARS, resulting in an overall case-fatality rate of 12.5%. All were probable SARS cases. There were 23 (52.3%) males and 21 (47.7%) females who died. The mean age of death was 68.7 years (median 69.0 years; range 39–100 years).

Most (72.7%) of the deceased cases were 60 years of age or older. The case-fatality rate (CFR) was 4.3% among the 276 cases less than 60 years of age and 42.7% among the 75 cases that were 60 years or older. Similarly, among cases that were already hospital inpatients before their SARS exposure, the CFR was 22.2% among the nine cases less than 60 years of age and 50.0% among the 22 cases age 60 years and older. This is compared to cases that were not hospital inpatients at the time of SARS exposure where the CFR was 4.0% among the 249 cases less than 60 years of age and 40.4% among the 52 older cases.

All cases that died had been hospitalized. Thirty-four (77.3%) of these had been admitted to ICU. Among those who died, 32 (72.7%) had at least one underlying medical condition reported. The mean duration between the onset of symptoms and death was 35 days (median 24.5 days; range 2–210 days). Additional details on the Ontario SARS deaths, including available medical history, are reported in Table 4.
Table 4: Characteristics of Ontario SARS deaths (N=44)

<table>
<thead>
<tr>
<th></th>
<th>Number (%) of deaths*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>23 (52.3)</td>
</tr>
<tr>
<td>Female</td>
<td>21 (47.7)</td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>68.7</td>
</tr>
<tr>
<td>Median</td>
<td>69.0</td>
</tr>
<tr>
<td>Range</td>
<td>39-100</td>
</tr>
<tr>
<td><strong>Time from symptom onset to death (days)</strong></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>35.3</td>
</tr>
<tr>
<td>Median</td>
<td>24.5</td>
</tr>
<tr>
<td>Range</td>
<td>2-210</td>
</tr>
<tr>
<td><strong>Comorbid conditions</strong> (N=36)</td>
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</tr>
<tr>
<td>Heart</td>
<td>22 (61.1)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>16 (44.4)</td>
</tr>
<tr>
<td>Lung</td>
<td>9 (25.0)</td>
</tr>
<tr>
<td>Cancer</td>
<td>6 (16.7)</td>
</tr>
<tr>
<td>Kidney</td>
<td>2 (5.6)</td>
</tr>
<tr>
<td>Immunosuppressive illness</td>
<td>3 (8.3)</td>
</tr>
<tr>
<td>No known comorbid condition</td>
<td>3 (8.3)</td>
</tr>
</tbody>
</table>

*unless otherwise stated  **these categories are not mutually exclusive; missing values excluded

3. LABORATORY DATA

Of the 351 SARS cases, laboratory status data were available on 350 (99.7%) cases. Results are presented in Figure 7. More than half of the cases (55.1%; n=193) had positive laboratory results for SARS coronavirus (SARS-CoV) while laboratory results for 58 (16.6%) cases came back negative. Approximately one-third of cases (28.3%; n=99) did not have sufficient laboratory testing performed to determine a positive or negative laboratory classification.

Analysis by case type found that 179 (59.5%) probable cases had positive laboratory results, 44 (14.6%) had negative laboratory results and 78 (25.9%) had insufficient testing. Approximately one-third (28.6%; n=14) of suspect cases had a positive laboratory result, 14 (28.6%) had negative results and 21 (42.9%) suspect cases had insufficient testing completed.

Of the total 193 cases with positive laboratory results for SARS-CoV, results for 167 (86.5%) cases were based on at least one positive serology result, 20 (10.4%) were positive based on PCR testing, and six (3.1%) were positive based on both serology and PCR test results.
Figure 7: Laboratory Results for SARS Coronavirus in Ontario SARS cases (N=351)
DISCUSSION

The Ontario SARS outbreak began with spread of respiratory illness within a family setting during the respiratory illness season, which was not considered unusual. As a result, admission of a family member into the index hospital and unprotected contact with this case led to nosocomial spread (11). However, after the alert issued by the World Health Organization on March 12, 2003, SARS was recognized and contained through aggressive control measures including isolation, contact tracing and monitoring, infection control, and quarantine. Findings from our report on the descriptive epidemiology on the 2003 Ontario SARS outbreak provide insight into the morbidity and mortality associated with SARS.

Ontario SARS cases
A total of 351 cases were included in this review of the SARS outbreak. As all cases were reviewed retrospectively, the case counts presented here may differ from those reported during the outbreak. The outbreak was primarily healthcare-associated with 75% of cases acquiring SARS in a healthcare setting and only 4% acquiring SARS through a community (non-household) setting. While cases were from all age groups, the majority of the 44 cases who died were older (aged 60 years or more) or had comorbid conditions. The case-fatality rates among cases less than 60 years of age (4.3%) and among those 60 years or older (42.7%) were comparable to those reported in other reports on the Ontario outbreak (2.9% and 53.8% respectively) as well as comparable to other countries such as Hong Kong (6.8% and 55.0% respectively) (12,13). The overall case-fatality rate was higher than that reported by other countries (12.5% v. 2.0%–6.5%); however, this is likely due to the use of different methods for calculating the CFR and longer follow-up time on cases (13, 14). As age appears to be a significant factor, it is also necessary to realize that the overall CFR may be misleading if different age groups were affected in other countries. This report did not examine the role of SARS as the cause of death, as a contributing cause of death or unrelated to the individual’s death. Thus, we are only able to report that 44 people died among people who had SARS. Of note, there were no pediatric deaths from SARS in the Ontario outbreak, and no record of transmission from a child with SARS.

Clinical data were limited by the elements of the data collection form, when data was collected, as well as by characteristics of the case (e.g., age, severity of illness). For example, information on onset date of symptoms or exposure dates asked later in the course of illness may have been difficult to recall, resulting in slight variations in the incubation periods.

For analytical purposes and to facilitate comparison of data with other countries, only cases that were found to meet the May 29, 2003 Health Canada case definitions for Suspect and Probable SARS were included in this analysis. There were additional individuals that were designated and managed as SARS cases by health units even though they did not meet this case definition. As a result, these individuals were not included in the analysis. This includes cases that had radiological evidence and positive serology for SARS but may not have had either fever or respiratory symptoms recorded. This also includes the Ontario index case who died without clinical data being captured. One of the decision rules in the analysis used oxygen saturation less than 94% as an indicator of respiratory conditions. This enabled the inclusion of cases that were unable to report cough, difficulty breathing or shortness of breath (e.g., rapidly intubated patients without a documented history of respiratory symptoms). Although an oxygen saturation of less than 94% does not necessarily manifest in difficulty breathing or shortness of breath, given the other components of the case definition (i.e., minimum of epidemiological link and fever) the SOAC agreed that a diagnosis of SARS was highly likely.

As a result of only including cases meeting the Health Canada definition, it is not possible to know the range of the clinical spectrum of SARS illness; this report would likely represent cases at the more severe end of the clinical spectrum for SARS. For example, there were children who were part of family clusters of SARS and had either fever or mild respiratory symptoms, but did not meet the clinical criteria of the case definition and were not included in the case count. Some of these children
had serological testing and were positive for antibodies to SARS-CoV, therefore it is possible that SARS is a milder illness in children than in adults.

Data were not collected on severity of SARS illness other than what can be inferred from ICU admission, oxygen saturation and mortality fields. Hospitalization was not considered a useful indicator of severity as cases were often hospitalized during the outbreak to better monitor their status and to prevent household transmission. Only 4.3% of the 351 cases were not hospitalized for SARS illness while 8.8% were already in hospital prior to SARS acquisition. Duration of hospitalization was not analyzed since policies on discharging SARS cases changed throughout the outbreak and may have been facility-specific.

Laboratory data
On March 24, 2003, international collaboration among laboratories isolated a new coronavirus from a SARS patient. Between April 8–10, researchers found positive antibody titers to SARS CoV in a high percentage of SARS patients and no titer in control patients. On April 16, the WHO announced that this coronavirus, previously never seen in humans, was the cause of SARS based on results of a study that found that monkeys infected with the pathogen exhibited symptoms similar to those of human SARS cases (15). While the speed with which the causative agent of SARS was identified was made possible by excellent collaborations in 10 countries (including Canada), the identification occurred more than one month after the start of the Ontario outbreak.

At the onset of the outbreak, laboratory testing was not conducted consistently as optimum timing of collection and specimen type were not known. As a result, analysis and interpretation of results of laboratory confirmed cases as identified here should be used with caution. Two assays were most often used to diagnose SARS-CoV infection: PCR for detection of the virus and serological testing for antibodies to the SARS coronavirus. The SARS laboratory tests algorithm (Appendix E) defines a positive case as demonstration of SARS CoV antigens using molecular detection tests (e.g., PCR) in at least two different specimens or the same clinical specimen collected on two or more different days. While data on the total number of cases tested by PCR methods was not available for this analysis, our data showed that only 13.5% of Ontario SARS cases had positive PCR results. This could be due to timing of the sample collection or the nature of the specimen. It has been stated that while PCR tests are sensitive and highly specific for SARS-CoV, the ability of the test to detect SARS-CoV infection can be limited by the low concentration of virus in clinical specimens (16). In addition to this, the prevalence of SARS infection worldwide is low, reducing the positive predictive value of the diagnostic tests even further.

The SARS laboratory tests algorithm also defines a positive case as one with a single positive antibody test (ELISA or IFA) to SARS-CoV. Data published by Tang et al. demonstrate that serology may be the best marker for true SARS-CoV infection (17) as SARS is a new illness with no background seroprevalence against SARS-CoV in control populations screened. Therefore, a positive antibody test indicates previous infection with SARS CoV. While 90% of the laboratory-confirmed cases were based on positive serology, this only represented 49% of all Ontario SARS cases.

It is acknowledged that those without confirmation by the SARS laboratory tests algorithm (i.e., negative or insufficient testing) may have had SARS and that confirmation is limited by the test, timing of specimen collection and specimen source. Many blood samples were drawn earlier than 28 days after symptom onset, and no later samples were obtainable. Information about the optimal time of specimen collection was not available at that time. The fact that laboratories were refining the PCR techniques during the outbreak to improve reliability and validity is also not reflected in our analysis. Further, test outcomes may have been associated with case classification. For example, fewer Suspect cases had positive laboratory results. This may be due to testing of specimens taken at an early point in the course of infection, or reduced sensitivity of the tests in milder cases. It is possible that those with more severe disease, requiring on-going connection with health care facilities (e.g., hospitalized...
patients) were more likely to be tested repeatedly. The lack of additional results from hospital laboratories that may have done PCR testing for SARS-CoV during the SARS outbreak is a limitation of the data in this report.

**Public health information system**

As SARS was a new and emerging disease, the changing of case definitions and data requirements affected data collection. The reclassification of cases based on new definitions and changing data needs made transmission of data between hospitals, health units and the Ministry difficult.

Data needs during the outbreak and the creation of this report revealed the need for a provincial software platform to track cases, contacts, and disease courses for new and emerging infectious diseases. Issues with respect to the data quality, which resulted in delays in producing this Report, would also be obviated if clear definitions of data elements were provided and if consistent, valid and reliable tools were centrally available. These issues have also been addressed in external provincial and federal reviews of the 2003 outbreak (18-20).

Information technology infrastructure, capacity for data analysis and interpretation, and communication between healthcare services and public health authorities are essential for effective case and outbreak management.

**Other limitations**

Outside of areas already addressed in this report, key limitations of this report were due to data collection. Progression of the outbreak and advancements in the knowledge about SARS led to changes in the case definition and data needs. As a result, this review included searching charts for references to information that was unclear in its original interpretation or was not initially required (e.g., diarrhea in the symptom list was not initially required and was not collected consistently). Even with the review, data for these analyses were incomplete. For example, almost half of all SARS cases (41.3%) had missing or unknown information regarding underlying medical conditions.

At the time of the outbreak, the lack of a common database with clearly defined fields and built-in quality/edit checks also limited the ability to have consistent interpretation and data entry of required fields. For example, fields listing “chest X-ray” were interpreted by some to require a “yes” or “no” response, while others provided findings of the chest x-ray. During the chart review, while the data fields were now clearly defined, the reliance on existing medical charts limited the ability to extract the level of detail now required. For example, exposure information (dates, duration and settings) was difficult to determine. Where multiple exposures (dates and/or settings) occurred, the most likely exposure was selected by the health unit reviewer. This may have biased the exposure data to areas for which the reviewer knew more details (e.g., hospital exposures) and could impact the calculation of the incubation period.

Although the data presented in this report support the conclusion that most cases were the result of healthcare-acquired transmission, it is acknowledged that a case detection bias could exist since healthcare workers were more likely to be screened and, therefore, identified as SARS cases. It is likely, however, that detection bias would be minimal since contact follow-up for non-healthcare workers was extensive.

SARS transmission in both phases of the outbreak was controlled by aggressive infection control and public health measures including active case finding, contact tracing and monitoring, quarantine and other containment strategies. These measures involved intense, sustained collaboration among institutions and individuals beyond the traditional public health infrastructure. This provincial report provides data that will permit comparability of cases with other countries affected by SARS and provides health authorities with a summary of the limitations and needs for improving data management and communication in the event of future outbreaks.
References:


Appendix A
Chronology of Key SARS Events in Ontario

2003/3/12
The World Health Organization issues global alert about atypical pneumonia
(later clinically referred to as SARS) for Singapore, Vietnam, Hong Kong, and Guangdong province in China

2003/3/13
Toronto Public Health (TPH) notifies Ministry’s Public Health Branch (PHB)
That a patient (son of index case) has died of atypical pneumonia

2003/2/23
Index case returns to Toronto From Hong Kong

2003/3/25
SARS becomes a reportable, communicable and virulent disease, Under the Health Protection and Promotion Act (HPPA)

2003/3/26
SARS declared a provincial health Emergency under the Emergency Management Act

2003/4/23
WHO issues a travel Advisory for Toronto

2003/5/14 – 2003/5/29
2003/05/14 — WHO removes Toronto from list of areas affected by SARS
2003/05/17 — Ontario Premier lifts Provincial Emergency
2003/05/26 — WHO adds Toronto to list of areas with recent local transmission of SARS
2003/05/29 — Canada adopts WHO’s SARS case definition

2003/5/22
A new cluster of cases was reported at a Toronto hospital

2003/6/12
Onset date of last Ontario SARS case

2003/7/2
WHO removes Toronto from List of SARS affected cities

February 23, 2003
March
April
May
June
July
July 2, 2003
Appendix B

Resources on the Ontario SARS Outbreak


SARS Quarantine Evaluation and Community Transmission Study: a report to the Ministry of Health and Long Term Care. Publications are pending.

SARS Quarantine Evaluation and Community Transmission Study: a report to the Ministry of Health and Long Term Care. Publications are pending

Household transmission of SARS in Ontario, 2003. Publications are pending
### Appendix C

**Key Variables in Analyses**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Response Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Female, Male</td>
</tr>
<tr>
<td>Date of Birth</td>
<td>Household, Non-household Close Contact, Healthcare Worker, Healthcare Patient, Healthcare Visitor, Travel, Community</td>
</tr>
<tr>
<td>Type of Contact</td>
<td>Cultural, religious, Education, Other Community, Household, Acute hospital, Long-Term Care Home, Other Healthcare, Non-healthcare Institutional, Travel</td>
</tr>
<tr>
<td>Exposure setting</td>
<td>Date, Cultural, religious, Education, Other Community, Household, Acute hospital, Long-Term Care Home, Other Healthcare, Non-healthcare Institutional, Travel</td>
</tr>
<tr>
<td>Exposure date</td>
<td>Date, Positive, Negative, Insufficient</td>
</tr>
<tr>
<td>Laboratory information</td>
<td>Yes/No for the following: Heart Disease, Lung Disease, Kidney Disease, Diabetes, Cancer, Immunosuppressive Disease</td>
</tr>
<tr>
<td>Underlying medical conditions</td>
<td>Deceased</td>
</tr>
<tr>
<td>Signs &amp; symptoms</td>
<td>Fever, Cough, Shortness of breath, O₂ Sat. &lt;94%, Headache, Myalgia, Vomiting, Diarrhea, Nausea</td>
</tr>
<tr>
<td></td>
<td>Yes/No for all</td>
</tr>
<tr>
<td>Date of onset</td>
<td>Date</td>
</tr>
<tr>
<td>Hospitalization</td>
<td>Yes/No</td>
</tr>
<tr>
<td>ICU</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Intubation</td>
<td>Yes/No</td>
</tr>
</tbody>
</table>
Appendix D
Health Canada Revised Case Definition

Health Canada Revised Case Definition (May 29, 2003)

Suspect Case
A person presenting with:
- Fever (over 38°C)
AND
- Cough or difficulty breathing
AND
One or more of the following exposures during the 10 days prior to the onset of symptoms:
- Close contact with a person who is a suspect or probable case
- Recent travel to an “Area with recent local transmission” of SARS outside of Canada
- Recent travel or visit to an identified setting in Canada where exposure to SARS may have occurred (e.g., hospital [including any hospital with an occupied SARS unit], household, workplace, school, etc.). ***This includes inpatients, employees or visitors to an institution if the exposure setting is an institution.
OR
A person with unexplained acute respiratory illness resulting in death after November 1, 2002, but on whom no autopsy has been performed
AND
One or more of the following exposures during the 10 days prior to the onset of symptoms:
- Close contact with a person who is a suspect or probable case
- Recent travel to an “Area with recent local transmission” of SARS outside of Canada
- Recent travel or visit to an identified setting in Canada where exposure to SARS may have occurred (e.g., hospital [including any hospital with an occupied SARS unit], household, workplace, school, etc.). ***This includes inpatients, employees or visitors to an institution if the exposure setting is an institution.

Probable Case
A Suspect case with radiological evidence of infiltrates consistent with pneumonia or respiratory distress syndrome (RDS) on chest x-ray (CXR)
OR
A Suspect case with autopsy findings consistent with the pathology of RDS without an identifiable cause

Exclusion criteria: A Suspect or Probable case should be excluded if an alternate diagnosis fully explains his/her illness.

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1 Public Health Agency of Canada
Appendix E
SARS Laboratory Tests Algorithm

Patient has Laboratory results?

- Yes
  - Virology: Patient has results on 2 or more different dates, or from 2 or more different sites?
    - Yes
      - Negative virology on 2 or more different dates or from 2 or more different sites
        - Insufficient Evidence
      - Positive virology on 2 or more different dates or from 2 or more different sites
        - Sufficient Evidence: Positive by Virology
    - No
      - Insufficient Evidence
  - Serology: Patient has positive serological results? (Acute or Convalescent sera)
    - Yes
      - Negative acute serum (collected <28 days post-onset)
        - Insufficient Evidence
      - Negative convalescent serum (collected >28 days post-onset)
        - Sufficient Evidence: Negative by Serology
    - No
      - Insufficient Evidence

- No
  - Insufficient Evidence
<table>
<thead>
<tr>
<th>Laboratory results</th>
<th>Sufficiency</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any reactive serology</td>
<td>Sufficient testing</td>
<td>POS- testing sufficient and results positive</td>
</tr>
<tr>
<td>Nonreactive serology on a specimen collected fewer than 28 days after disease onset</td>
<td>Insufficient testing</td>
<td>N/A- not applicable, insufficient tests completed</td>
</tr>
<tr>
<td>Nonreactive serology on a specimen collected greater than 28 days after disease onset</td>
<td>Sufficient testing</td>
<td>NEG- testing sufficient and results negative</td>
</tr>
<tr>
<td>2 PCR tests on specimens collected from the same site on 2 different dates; both positive</td>
<td>Sufficient testing</td>
<td>POS- testing sufficient and results positive</td>
</tr>
<tr>
<td>2 PCR tests on specimens collected from 2 different sites; both positive</td>
<td>Sufficient testing</td>
<td>POS- testing sufficient and results positive</td>
</tr>
<tr>
<td>2 PCR tests on specimens collected on 2 different dates or from 2 different sites; 1 positive, 1 negative</td>
<td>Insufficient testing</td>
<td>N/A- not applicable, insufficient tests completed</td>
</tr>
<tr>
<td>2 PCR tests on specimens collected on 2 different dates or from 2 different sites; both negative</td>
<td>Insufficient testing</td>
<td>N/A- not applicable, insufficient tests completed</td>
</tr>
<tr>
<td>1 PCR test; positive or negative</td>
<td>Insufficient testing</td>
<td>N/A- not applicable, insufficient tests completed</td>
</tr>
</tbody>
</table>
### Appendix F
Decision Rules for Classification of SARS Cases

<table>
<thead>
<tr>
<th>Conditions Present</th>
<th>Decision Rule</th>
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</thead>
<tbody>
<tr>
<td>Fever &gt;38°C AND Cough or Shortness of Breath AND Epi-Link</td>
<td>Suspect Case</td>
</tr>
<tr>
<td>Fever AND Cough or Shortness of Breath AND Epi-link AND Radiological evidence of pneumonia or infiltrates indicative of respiratory distress syndrome (RDS)</td>
<td>Probable Case</td>
</tr>
<tr>
<td>O2 Sat &lt;94% decision rule</td>
<td>Respiratory symptoms=Yes</td>
</tr>
</tbody>
</table>
Figure 1: Epidemic Curve of 2003 Ontario SARS Outbreak, by Case Type

1. SARS made a reportable disease (Mar 25, 2003)
2. Ontario declares a state of emergency (Mar 26, 2003)
3. Hospital infection control directives implemented (Mar 29, 2003)
5. WHO removes Toronto from list of SARS affected areas (May 14, 2003)
6. Premier lifts provincial state of emergency (May 17, 2003)
Figure 5: Epidemic Curve of 2003 Ontario SARS Outbreak, by Exposure Setting

- Healthcare
- Household
- Community
- Travel
- Index Case (Travel)