Severe acute respiratory syndrome (SARS) is a viral disease that may be contracted by exposure to a newly recognized form of the coronavirus. It often manifests through a set of common respiratory symptoms that include fever and nonproductive cough. To date, SARS has no vaccine or definitive treatment. Approximately 20% of SARS patients develop respiratory failure, which requires mechanical ventilation and close cardio-pulmonary monitoring. Intensive care unit (ICU) nurses and other healthcare workers who care for SARS patients are at risk of contracting the disease. Thus, it is important that ICU nurses be familiar with the disease and its implications for critical care. This article provides critical care nurses with an update on the first SARS outbreak, its origin, case definition, clinical manifestations, diagnosis, relevant infection control practices, management, and recommendations for the role of ICU nurses in dealing with future outbreaks. (KEYWORDS: case definition, coronavirus, critical care nursing, infection control, severe acute respiratory syndrome)

Mr E. is a scientist who arrives at the emergency room (ER) of a rural hospital with flu-like symptoms that include a low-grade fever and dry cough. Upon admission, Mr E. becomes increasingly short of breath, stuporous, and he desaturates to 84%. The ER physician decides to intubate him. A portable chest X-ray shows right middle lobe and left upper lobe infiltrates. The patient is transferred to the intensive care unit (ICU) with a preliminary diagnosis of pneumonia of unknown origin. Once in the ICU, Mr E. is suctioned and given mouth care using standard infection control precautions. Two days later, the intubating physician and the nurse who admitted Mr E. to the ICU become febrile. The next day, their symptoms worsen and they experience generalized weakness, cough, and shortness of breath on exertion. History taking reveals that Mr E. had recently attended an international research conference in Singapore and that Mr
E.’s adult son had developed similar symptoms. Meanwhile, the nurse in charge of Mr E. receives an urgent call informing her that Mr E.’s lab results show a form of coronavirus (CoV) that could be the newly identified SARS virus. The laboratory report sparks an immediate state of shock, fear, and panic. Everyone in the unit is immediately concerned: Is this our first contact with SARS? Have we spread it to our families? What should we do? What do we know about this disease?

The preceding fictitious scenario may be encountered by ICU nurses in a healthcare facility that has not yet prepared staff to deal with potential future SARS outbreaks. Therefore, the purpose of this article is to provide critical care nurses with background information on the recent SARS outbreak and its implications for critical care nursing. The information presented in this article was current as of the date of submission for publication. However, knowledge of the SARS mystery is evolving as we learn more about the disease, its causative virus, and its effective management strategies. Therefore, some of the information presented in this article may be revised, updated, or changed in future publications as more knowledge of the disease evolves.

Historical Background: How Did SARS Reach North America?

It is believed that the first case of SARS occurred in November 2002 in a businessman from the southern Chinese province of Guangdong, an agricultural area known for its animal farming.1 Within 3 months, the disease had spread to 305 people in the province causing five deaths from what had been classified as atypical pneumonia.2 It was not until February of 2003 that this new illness received international attention. At that time, a physician from Guangdong Province, who had treated some of these pneumonia patients, became ill while staying in a hotel in Hong Kong. Twelve other hotel guests, seven of whom shared the same floor with the infected physician, also became ill. These hotel guests subsequently transported the disease to other parts of the world, such as Taiwan, Vietnam, Singapore, and Toronto, Canada. The rapid spread of the disease sparked an international investigation of the outbreak and an organized campaign led by the World Health Organization (WHO) to understand and contain the spread of the disease that was later identified as SARS.

On February 23, 2003, an elderly couple who had been among the guests at the Hong Kong hotel returned to their home in Toronto. Shortly thereafter, both became ill with symptoms of SARS, as did all three other adult members of the household; the only child in the home did not become ill. The woman who had been in Hong Kong and her 43-year-old son both succumbed to the illness. Subsequent contact tracing resulted in the identification of many additional patients with suspected or probable SARS.3 Additional cases of SARS were identified among other persons who had returned from areas outside of Canada where there had been documented transmission of SARS.

Nurses, particularly ICU and ER nurses, were on the front lines in battling the first SARS epidemic and were, therefore, at risk of contracting the disease. As of September 3, 2003, a total of 438 cases were reported in Canada (251 probable and 187 suspected); more than 100 of the infected were healthcare workers (HCWs).4-6 An additional 167 cases were reported in the United States (8 confirmed, 19 probable, 137 suspected).7 Evidence suggests that most cases of SARS among HCWs in Canada were associated with: (a) caring for undiagnosed SARS patients who were not isolated, or (b) having contact with ill family members who had visited the hospital. Once isolation precautions were instituted in Toronto area hospitals, transmission to HCWs decreased substantially, but did not cease entirely. Transmission to 16 HCWs in three Toronto hospitals was attributed to difficult intubations in known and undiagnosed SARS patients.5 Transmission of SARS to approximately 10 HCWs also occurred in five low-risk units that were reported to be in compliance with appropriate standard infection control precautions,5 which indicated that standard infection control practices did not provide sufficient protection against transmission.
Etiology and Transmission

Laboratory investigations indicate that SARS is viral in origin and may be contracted by exposure to a novel coronavirus. The mechanism of transmission of this highly contagious disease is not fully understood. However, SARS is believed to be transmitted by droplet spread, surface contamination, and close contact with infected individuals. Persons who care for or have lived with SARS patients are considered to be at high risk. Transmission of SARS is believed to occur through contact with fluids from the nose, mouth, throat, or eyes. Kissing and sharing of food, beverages, and cigarettes are also believed to increase the risk of contracting the disease.

Prognosis

Although the initial SARS mortality rate was reported at 3%, recent surveillance data indicate that the mortality rate is much higher than first believed. According to the WHO, mortality was <1% in persons aged 24 years or younger; 6% in persons aged 25–40 years; 15% in persons aged 45–64 years; and >50% in persons aged 65 years and older. The rate of admission to intensive care was reported to range between 10% and 20% of all SARS admissions. Characteristics of patients who tend to be at higher risk for becoming critically ill with SARS include older age, diabetes, admission tachycardia, and elevated creatinine kinase and lactate dehydrogenase (LDH) levels. Predictors of mortality include hypertension, diabetes, advanced age, smokers, immunosuppression, and patients with other known respiratory infections.

Case Definition

Based on available clinical, epidemiological, and laboratory criteria, the Centers for Disease Control and Prevention (CDC) and the WHO have updated their surveillance case definition of SARS several times since the beginning of the initial outbreak. As of September 3, 2003, the CDC continues to classify SARS cases as either suspected or probable. However, as of August 14, 2003, the WHO ceased to differentiate between suspected and probable cases. Table 1 presents a description of the case definition criteria as presented by the CDC and WHO.

CDC SARS Exclusion Criteria

According to the CDC, a patient with SARS may be excluded as a suspect or probable case if:
- an alternative diagnosis can fully explain the illness,
- a convalescent-phase case for which a serum sample was collected >28 days after onset of symptoms was shown to be negative for SARS-CoV antibodies, or
- a case that has been reported on the basis of contact with a suspected/probable SARS patient who was subsequently excluded as a case of SARS.

Clinical Manifestations and Epidemiologic Investigations

SARS manifests itself as a vague set of signs and symptoms that can be confused with a wide range of respiratory diseases. However, fever >38 °C (100.4 °F), nonproductive cough, dyspnea, and signs of radiologic pulmonary infiltrates are the most common indications of SARS. A summary of clinical manifestations as reported in several epidemiologic investigations is presented in Tables 2 and 3.

Diagnostic Criteria

Laboratory testing for SARS-CoV is based on either the detection of the virus or the antibody response to viral infection. In the initial phases of the recent outbreak, a series of diagnostic tests such as chest X-ray, pulse oximetry, blood cultures, sputum for gram stain and culture, and testing for viral respiratory pathogens were recommended. Other more specific tests such as reverse transcription polymerase chain reaction (RT-PCR) assay for detection of viral RNA and seroconversion by Enzyme Linked Immuno Sorbent Assay (ELISA) or Indirect Fluorescent Antibody (IFA) for detection of antibod-
TABLE 1  Severe Acute Respiratory Syndrome Case Definition as Presented by the CDC and WHO

<table>
<thead>
<tr>
<th>Definition Criteria</th>
<th>Description</th>
<th>CDC*</th>
<th>Suspected</th>
<th>WHO†</th>
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<tbody>
<tr>
<td>Clinical</td>
<td></td>
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<tr>
<td>Mild</td>
<td>Asymptomatic or mild respiratory illness</td>
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<tr>
<td>Moderate</td>
<td>Temperature of 100.4°F (≥38°C)</td>
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<tr>
<td>Severe</td>
<td>One or more clinical findings respiratory symptoms (cough, shortness of breath, dyspnea, hypoxia)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Temperature of 100.4°F (≥38°C)</td>
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<tr>
<td></td>
<td>One or more clinical findings respiratory symptoms (cough, shortness of breath, dyspnea, hypoxia)</td>
<td>✔</td>
<td>✔</td>
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<td>At least one of the following:</td>
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<td></td>
<td>• Radiographic evidence of pneumonia</td>
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<tr>
<td></td>
<td>• Respiratory distress syndrome</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• Autopsy findings consistent with pneumonia or respiratory distress syndrome without an identifiable cause</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Other</td>
<td>Absence of other alternative diagnosis that can explain the illness</td>
<td>✔</td>
<td></td>
<td></td>
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<tr>
<td>Epidemiologic</td>
<td></td>
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<tr>
<td>Travel</td>
<td>Including airport transit within 10 days of onset of symptoms to an area with current or previously documented or suspected community transmission of SARS</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
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<tr>
<td>Close contact</td>
<td>Within 10 days of onset of symptoms with a person known or suspected to have SARS</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Laboratory</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Confirmed</td>
<td>In the presence of one or more of the following:</td>
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<tr>
<td></td>
<td>• Detection of antibody to SARS-CoV in a serum sample</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>• Detection of SARS-CoV RNA by RT-PCR confirmed by a second PCR assay using a second aliquot of the specimen</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>• Isolation of SARS-CoV, or</td>
<td></td>
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<td></td>
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<tr>
<td>Undetermined</td>
<td>Laboratory test either not performed or incomplete</td>
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</table>

*The CDC case definition criteria were last updated on September 3, 2003; CDC continues to stratify cases as probable and suspected.
†The WHO definition criteria were last updated on August 14, 2003; it no longer stratifies SARS as being either probable or suspected.

RT-PCR, reverse transcription-polymerase chain reaction; CDC, Centers for Disease Control and Prevention; WHO, World Health Organization.
within 8 to 10 days, some patients do not test positive until >28 days after symptom onset. Therefore, it is recommended that for patients with a negative antibody test an additional serum specimen collected 28 days after onset of symptoms be tested to rule out SARS-CoV infection.\textsuperscript{24} Cell cultures and electron microscopy, which were widely used during the initial phases of the recent outbreak, are no longer recommended because they lack sensitivity.\textsuperscript{24}

\section*{Clinical Management}

\subsection*{Infection Control}

Early identification and isolation of patients with SARS is crucial to the prevention of widespread transmission of the disease. Because the route of transmission of the SARS-CoV is not yet fully understood, infection-control measures for suspected and probable cases include standard, airborne, droplet, and contact precautions.\textsuperscript{25} Nurses, who are often involved in the initial assessment of undiagnosed patients with SARS, are at higher risk of having unprotected exposures. To avoid contracting the disease, and to prevent its spread to others, nurses should be diligent in their adherence to infection control guidelines when dealing with patients with symptoms that are suggestive of SARS. Patients with a fever over 38°C (100.4°F) and one or more respiratory symptoms should be required to wear a mask until SARS has been ruled out. Nurses and other HCWs should wear respirator masks

\begin{table}[h]
\centering
\caption{Clinical Manifestations of Severe Acute Respiratory Syndrome (%) as Reported in the Literature}
\begin{tabular}{|l|c|c|c|c|}
\hline
\textbf{Signs and symptoms} & \textbf{Lee\textsuperscript{21}} (\textit{N = 138}) & \textbf{Peiris\textsuperscript{20}} (\textit{N = 50}) & \textbf{Poutanen\textsuperscript{3}} (\textit{N = 10}) & \textbf{Booth\textsuperscript{19}} (\textit{N = 144}) & \textbf{Lew\textsuperscript{15}} (\textit{N = 199}) \\
\hline
Fever & 100 & 100 & 100 & 99.3 & 89 \\
Chills & 73 & 74 & NA & 27.8 & NA \\
Cough & 57 & 62 & 100 & 74.3\textsuperscript{*} & 39 \\
Myalgia & 61 & 54 & 20 & 49.3 & 39 \\
Malaise & NA & 50 & 70 & 31.2 & NA \\
Runny nose & 23 & 24 & NA & 2.1 & NA \\
Sore throat & 23 & 20 & 30 & 12.5 & NA \\
Shortness of breath & NA & 20 & NA & 41.7 & 14.5 \\
Diarrhea & 20 & 10 & 50 & 23.6 & NA \\
Headache & 56 & 20 & 30 & 35.4 & NA \\
\hline
\end{tabular}
\end{table}

NA = no data available.

*Cough in Booth’s study was classified as 69.4% nonproductive cough, and 4.9% productive cough, with a total of 74.3%.

\begin{table}[h]
\centering
\caption{Severe Acute Respiratory Syndrome Investigational Results}
\begin{tabular}{|l|}
\hline
\textbf{Infiltrate on Chest Radiography} & \textbf{O\textsubscript{2} Saturation on Room Air <95%} \\
\textbf{Leukopenia} & \textbf{Lymphopenia} \\
\textbf{Thrombocytopenia} & \textbf{Elevated lactate dehydrogenase} \\
\textbf{Elevated aminotransferase} & \textbf{Elevated alanine aminotranferase} \\
\textbf{Elevated creatine kinase} & \textbf{Elevated lymphocyte count} \\
\hline
\end{tabular}
\end{table}
and eye protection when in contact with persons suspected of SARS.25 Once a patient meets the criteria for suspected or probable case, he or she should be moved to a room with negative pressure ventilation that is located in a designated isolation area whenever possible. If such rooms are unavailable, traditional single rooms with private bathroom facilities should be used as an alternative.25 When SARS patients require intensive care nursing, recommendations for infection control involve dedicating a single ICU to SARS patients whenever possible.12

Personal protective equipment, including gloves, long sleeve gowns, respirator masks, and eye protection, must be worn by all staff entering the isolated area. Gloves are used to provide added protection and must not be used as a substitute for hand washing, which is the most effective measure in preventing cross infection. Gloves should be put on before entering the patient's room and should be removed prior to leaving the room. Hands should be washed before and after patient contact and after removing gloves and/or other protective equipment. Alcohol-based skin disinfectants are effective and can be used if there is no visible soiling.

Appropriate eye protection is necessary during patient contact and during cough producing and aerosol-generating procedures. Goggles or full-face masks are recommended, but prescription glasses do not provide sufficient protection and should not be used as protective gear. To prevent unnecessary exposure and spread of the disease, patients' contact should be kept to an absolute minimum and visitors should be restricted.10,25,26 Some authorities suggest that attempts should be made to minimize the number of exposed HCWs by establishing a cohort of staff designated to provide care to these patients.1 To further limit unnecessary exposure, patients with SARS must be confined to their rooms. Whenever possible, all procedures should occur in the patient's room. When it is absolutely necessary to transport patients within the hospital, precautions should be taken to avoid unnecessary contact with other patients, the public, and HCWs. When transporting intubated patients, bag valve masks should not be used unless a filter is placed between the bag and the endotracheal tube.10 Health Canada27 suggests that nonintubated patients should be transported wearing surgical masks. However, we suggest that the use of N95 masks will provide greater protection.

Airborne precautions require the use of respirator masks by all persons entering patients' rooms. The CDC28 and Health Canada25 recommend that these masks be capable of filtering particles that are one micron in size, and have a 95% filter efficiency, such as the N95 mask. The WHO26 recommends masks with 99.97% and 99% filter efficiency (eg, P100/FFP3 or P99/FFP2 filters), but suggests that the N95 is satisfactory and provides a high level of protection. To prevent leakage around the edges, masks should be closely fitted to the face and should be fit-checked with each use. Health Canada25 recommends that the wearer take a quick forceful breath to determine if the mask seals tightly to the face. To date, the CDC and Health Canada recommend that when respirator masks are unavailable, surgical masks may be used as a last resort and may provide limited protection.25,29 The reader is cautioned that use of surgical masks should only be used in extreme situations when N95, P100/FFP3, or P99/FFP2 masks are unavailable. All intubated patients should have a closed suction system to avoid air leakage and dissemination of the SARS-CoV.12

Although there is no evidence supporting the use of Powered Air Purifying Respirators (PAPRs) while intubating SARS patients,30 Lapinsky and Hawryluck10 recommend that PAPRs be used by all ICU personnel who are present during high-risk procedures such as intubation and bronchoscopy. It is also recommended that patients be sedated during intubation to minimize cough10 and the duration of intubation.30

**Healthcare Workers Caring for Patients With SARS**

In order to prevent the spread of the disease, nurses need to follow infection control procedures and monitor themselves for symptoms of SARS. The CDC28 has developed guidelines for HCWs who had protected and unprotected exposure to patients with SARS. According to these guidelines, healthcare facilities that treat SARS should place their
asymptomatic HCWs, who had protected exposure to SARS patients, under surveillance. Recommendations for surveillance include maintaining a record of all personnel entering the patient’s room and monitoring for increased employee absenteeism that may suggest emerging respiratory illness. HCWs who had protected exposure to SARS patients should be vigilant in self-monitoring for respiratory symptoms and fever twice daily for 10 days following the last exposure. HCWs who develop symptoms within 10 days of last exposure with SARS patients should not report for duty, and are required to stay in home quarantine and notify their local public health authority and Occupational Health Departments.28 If symptoms are developed while at work, HCWs should don a mask, leave the work place immediately, and report their symptoms to the appropriate authorities. HCWs who had unprotected high-risk exposure to SARS patients should be excluded from duty and be monitored for 10 days following the exposure. The CDC28 defines unprotected high-risk exposures as physical presence in a room with a probable SARS patient during a high-risk aerosol-generating procedure or event when recommended infection control precautions were absent or breached. Aerosol-generating procedures or events include aerosol medication treatments, diagnostic sputum induction, bronchoscopy, suctioning, positive pressure ventilation via face mask (eg, CPAP or BIPAP), high-frequency oscillatory ventilation, and close facial contact during coughing.

Medical Treatment

To date, there has not been a definitive therapeutic regimen for SARS, but therapy has included antibiotics, antivirals, corticosteroids, and supportive intensive care. Because SARS cannot be definitively diagnosed upon initial presentation, most physicians prescribe a course of broad-spectrum antibiotics for community-acquired pneumonia that is effective against both typical and atypical respiratory pathogens.1,31,32 Unfortunately, antibiotics were reported to be ineffective in treating SARS.32 The antiviral medication ribavirin was initially extensively used in the treatment of SARS. However, in light of its failure to demonstrate activity against SARS-CoV, and recent reports of serious and unexpected drug reactions, a panel of health experts and clinicians from Health Canada and the CDC recommended that ribavirin no longer be used for the treatment of SARS.31,32 Patients with severe cases of SARS were often given corticosteroids because changes in the lung tissue of SARS patients suggest that some of the alveolar damage that occurs may be due to the induction of cytokines by the SARS.1 It is now recommended that steroids be reserved for the most severe cases of SARS.

Critical care nurses will often provide care to patients with SARS who develop symptoms of respiratory distress and who require supplementary oxygen or mechanical ventilation. Because SARS patients who require mechanical ventilation generally meet the diagnostic criteria for ARDS, it is recommended that lower tidal volumes be used as a lung protective strategy to decrease mortality.12,33 While research regarding the management of SARS is well underway, critical care nurses need to use common sense in providing supportive management of patients with SARS until more evidence-based practice is disseminated.

Implications for Critical Care Nursing

On January 1, 1967, the WHO launched a global program that led to the eradication of the smallpox epidemic in 1977. The eradication of smallpox, coupled with highly successful vaccination programs and promising new antibiotics, led many in the public health arena to believe that the battle against infectious diseases was being won. Sir MacFarlane Burnet, immunologist and Nobel Prize Laureate, wrote that “at times one feels that to write about infectious disease is almost to write of something that has passed into history.”34 However, the proliferation of emerging and reemerging infectious diseases such as HIV/AIDS, Ebola, West Nile Virus, and most recently, SARS, have dimmed these hopes.

In today’s open and mobile global population, the Chinese outbreak of SARS is thought to have sparked the recent global
SARS epidemic. However, the success of global efforts in containing the recent outbreak and preventing it from spiraling and spreading out of control signals a new area of effective collaboration and scientific advances in the fight against emerging infectious diseases. The ability of scientists across the globe to coordinate efforts and identify the SARS-CoV, unveil the complete sequencing of its RNA, and reveal preliminary but significant information regarding the survival time of the virus on various environmental surfaces and in various body fluids in such a short time was remarkable. These achievements are expected to have significant impact on preventive and management strategies of future outbreaks. The WHO maintains that “SARS can and must be contained and pushed back out of its new human host.” However, until a vaccine is developed, the threat of the disease is not totally eradicated and can resurface at any time in the future. Thus, HCWs in general, and emergency personnel in particular, need to be vigilant for any out-of-the-ordinary reports of acute respiratory illnesses.

The threat of future SARS outbreaks carries devastating health, economic, social, and political global repercussions. Unlike most other emerging infectious diseases, SARS seems to be airborne, has no geographical or ethnic boundaries, and does not need a transmission vector. Thus, it poses a greater threat than other recent emerging infectious disease such as West Nile Virus and Ebola. To date, there is no vaccine or definitive treatment for SARS. The disease can present on a continuum that ranges from a relatively minor illness to severe respiratory distress and failure, requiring mechanical ventilation and close cardiopulmonary monitoring. Thus, critical care nurses play an important role in the battle against SARS and need to be familiar with the disease and its implications for clinical practice, research, and policy. ICU nurses need not panic when working with potential SARS patients as panic can be detrimental to containment efforts. Such emotions were justifiable during the initial stages of the recent outbreak when many of those who contracted the disease were HCWs. At that time, very little was known about the disease. As a result, there were many misdiagnosed patients and unprotected exposures. However, the mystery of SARS is slowly being solved and many of its secrets have been revealed. Implementation of infection control guidelines has drastically reduced the incidence of SARS among HCWs. Thus, ICU nurses who work or may be working with SARS patients need to be aware that stringent implementation of infection control strategies is important for protection against the disease.

Given that SARS is a diagnosis of exclusion, patients presenting with respiratory symptoms during an outbreak need to be treated with full infection-control precautions until definitive diagnostic procedures prove it to be otherwise. Had SARS cases been treated with such a precautionary attitude, the outbreak might have not spread as widely as it did, nor be as costly. The small number of isolated cases in countries known for their high travel volume, such as the United States, demonstrates the importance of preparedness and a high level of awareness of SARS containment measures. The ability of the Canadian health authority to contain the disease within the affected healthcare facilities is another example that preparedness and good management are essential in SARS control. Because intensive care nurses are on the front lines treating critically ill patients with SARS, it is important that they are involved in collaborative policy and research efforts that aim at understanding the disease and providing tools for evidence-based practice.

Dr H. Mahler, former WHO director-general, described the successful smallpox eradication program as “a triumph of management, not of medicine.” Today, as we witness the outstanding cooperation among all globally involved organizations, particularly the WHO, the CDC, and Health Canada, we commend their success in containing the disease and praise their impressive management of the crisis. We also commend nurses, particularly ICU nurses, for their courage, dedication, and professional commitment in confronting this potentially deadly disease.

**Summary**

SARS is a viral disease that may be contracted by exposure to a new form of the no-
turous coronavirus. It often is manifest through a set of vague respiratory symptoms that include fever and nonproductive cough. The mechanism of transmission of this highly contagious disease is not fully understood. To date, the disease does not have a vaccine or definitive treatment. Therefore, adherence to infection control guidelines is key to the prevention and control of SARS. Despite the fact that the SARS outbreak has been contained and efforts to disclose all mysteries of the disease continue, many unresolved questions remain to be answered.

References


