Exposure Controls for SARS

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The emerging infectious disease called severe acute respiratory syndrome (SARS) has recently become a lingering global threat to public health, especially for people who work in health care settings. The origin of the virus that causes SARS is not yet certain to epidemiologists, in much the same way that the origin of HIV was not clear in the 1980s. The global outbreak of SARS has been epidemiologically linked to an epidemic that began during November of 2002 in Guangdong Province, People's Republic of China. SARS spread to other countries and regions, such as the Hong Kong Special Administrative Region of China, Vietnam, Singapore, Canada, and Taiwan. According to data compiled in August 2003, altogether 8422 cases occurred in 29 countries. According to the World Health Organization, the virus had spread to 32 countries including the United States and Canada by this time. In Toronto, the largest outbreak in North America occurred, and 23,000 people were quarantined. Health professionals investigated two thousand cases and 358 people were officially diagnosed with SARS, among which 38 died[1].

The current hypothesis is that SARS is a zoonosis that spread to humans in the live-animal marketplaces of Guangdong, China. The first cases appeared among people who commonly handle certain wild animals that are eaten as delicacies in parts of China. Tests of animals showed that the SARS strain of coronavirus is present in masked palm civets, Chinese ferret badgers, raccoon dogs, and Chinese horseshoe bats[2]. The official agent is a coronavirus (SARS-CoV), named appropriately for the crown-like spiky appearance of its surface (Figure 1). They have an RNA genome and are found in mammals and birds. The basic molecular biology research on this virus

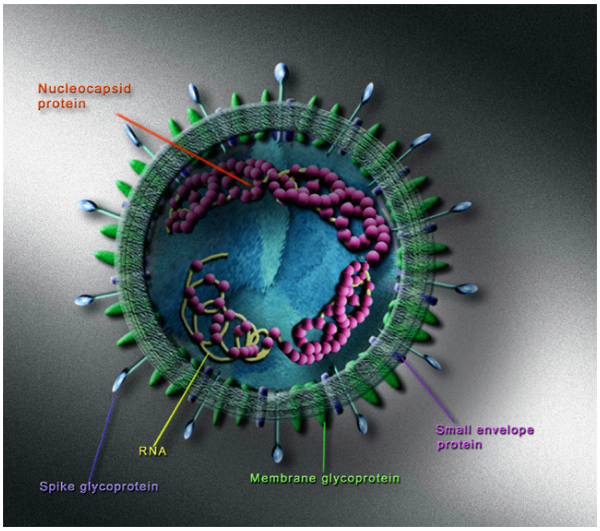


Figure 1. The SARS coronavirus virus is illustrated with envelope, RNA genome, and glycoprotein spikes.

has shown that it attains entry into cells by direct membrane fusion, and an alternative theory is that it uses pH-mediated endocytosis. The glycoprotein spikes shown above play a key role in this process, and in fact, the spikes are already constructed on the viral surface before the replicated viruses exit back out of the cell. The virus matures through utilizing the golgi apparatus of the host cell. There is some hope that targeting the "spike" as a strategy of vaccine development would be effective, as the spike's receptor binding domain as well as the receptor associated with the host have been characterized using X-ray crystallography. The N-protein, which is a phosphoprotein nucleocapsid has also been studied in great detail. This protein has been characterized to the extent that its most common antigenic site has been identified and may be exploited for diagnostic tests of the presence of the virus in the future.

This virus spreads by similar mechanisms to the common cold, through saliva and aerosols emitted from sneezing and coughing, which makes its particularly difficult to control. Once infection has occurred, it has symptoms similar to that of pneumonia, such as fever, headache, weakness, dry cough, difficulty breathing, and respiratory depression syndrome in a small proportion of cases. The tissue distribution of the virus is not limited to the lungs, as viral particles have been observed in urine and stool. There is histological evidence of its spread to the intestines, kidneys, liver, sweat glands, cerebrum, parathyroid, pituitary gland and pancreas. RNA from the virus has also been found in many places[1]. Some additional negative psychological effects include insomnia and depression, anxiety and the fear. In addition to SARS patients themselves, an estimated 50% of family members of SARS patients exhibit psychological problems such as feelings of depression or stigmatization. In the early period before more severe symptoms occur in a patient, their white blood cell count is normal to low, and X-ray tests indicate conditions mimicking those that characterize pneumonia. According the **CDC website**, the incubation period for SARs is 2-10 days, with a median of 4-6 days. Rarely, patients began exhibiting symptoms 14 days after exposure. Reports of respiratory illness occur 2-7 days after the first onset of fever, headache, and myalgias. Radiographic evidence of pneumonia usually develops within 7-10 days. Patients typically have low levels of circulating lymphocytes as well. Two of the biggest problems presented by this infection scenario are that people are still infectious during this incubation period before official diagnosis, and that this set of symptoms is also characteristic of other illnesses. This is why the molecular biology is so important to find a good diagnostic test for the disease. An excellent test would need to be rapid and sensitive, while at the same time requiring minimal technical expertise.

The remainder of this document will focus on efforts to control the spread of the virus with regard to recommended ventilation controls, quarantine measures, and PPE that may be utilized. Also, any applicable contemporary regulations shall be mentioned along with their shortcomings in mitigating an epidemic of SARS.

Regulations and Standards that Apply to SARS

Since the outbreak of SARS in 2003, there have been guidelines published by the Occupational Safety and Health Administration (OSHA) and the US Center for Disease Control (CDC). The guidelines are recommendations for health care works that may come in contact with SARS or treat patients that could be potentially affected. Workers must comply with all bloodborne pathogen (BBP) regulations (29 CFR 1910. 1030).

For SARS, areas of interested are:

- 1910.1030 (c): Exposure Control including a site specific exposure control plan that is regularly updated and exposure determination for all workers at the site.
- 1910.1030 (d): Methods of compliance including engineering and work practice controls, proper personal protective equipment (PPE), housekeeping and regulated waste.
- 1910.1030 (g): Communication of hazards to employees including labels and signs, information and annual training. Training may need to be conducted if changes occur, such as another outbreak of SARS or potential contact with a asymptomatic patient
- 1910.1030 (h): Recordkeeping of medical records along with training records and sharps injury log[4].

The following recommendations made by OSHA are not currently enforceable and hold no legal obligations.

1. **Early recognition**
    - Knowing the signs and symptoms (as outlined above)
    - Isolating potential affected individuals and health care workers
    - Seek medical attention if there is concern about contact

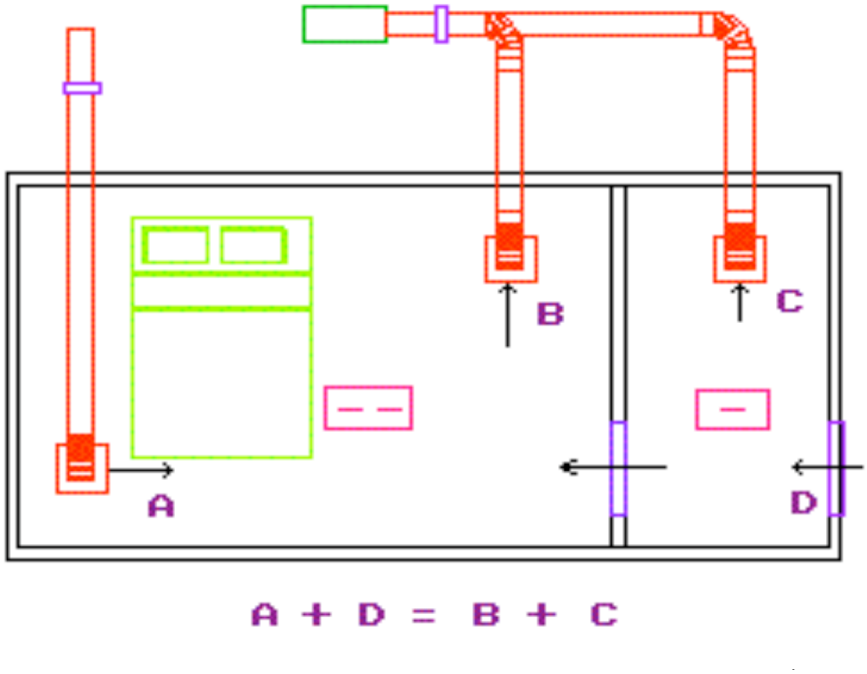
- Workers suspected of high exposure excluded from work for 10 days[5]

2. **Work procedures**:
   Proper hand washing and avoid contact with bodily fluids
   PPE:
   Gloves and gowns
   Closed toe shoes
   N-95 respirators: surgical masks are not adequate respiratory protection
   Eye protection
   EPA-approved disinfectant for viruses
   Laundering of linens: staff should avoid contact with potential SARS infected linens
3. **Engineering controls**:
   - Airborne isolation rooms
   - Negative pressure environments[6]
   - If not recirculation unavoidable, patients should be placed in an area where exhaust air immediately goes outside or through a HEPA filter
   - use of biological safety cabinets

Biological Safety Cabinets
Samples must be processed in a laboratory to determine whether an individual has contracted SARS. Any operations or procedures that may result in the aerosolization of the specimen should be performed in a biological safety cabinet. Any exposed surfaces should be cleaned with appropriate hospital disinfectant. At least a biological safety level two (BSL-2) cabinets should be used when dealing with specimens that may contain the virus such as sample preparation. If transporting the samples, the specimen should be sealed and decontaminated in the proper container. If working on cell culture or with viral agents from cultures, all work should be performed in a BSL-3 facility. The safety cabinets should be regularly monitored and maintenance performed to ensure proper airflow and check for leaks. Within all laboratory settings, proper PPE should be worn and care taken to ensure proper usage. Proper respiratory protection should be worn, at least a N-95 or higher. Fit tests should be performed regularly to ensure proper fit[7].

Ventilation Engineering Controls for SARS and other Airborne Infectious Diseases
As the industrial hygienist advising the hospital administration about ventilation in relation to controlling aerosolized infectious agents like SARS you should recommend:

- Monitoring ventilation airflow rates at the inlet and outlets. Recommend that high flow rates be maintained for the general HVAC dilution ventilation system, with a minimum of 6 air changes per hour (ACH), and 12 ACH where feasible as advised by CDC.
- Install 4-way diffusers that provide better room mixing which dilutes airborne cough droplets more quickly.
- Avoid air recirculation to prevent spreading airborne infectious agents, use HEPA filters if the current building HVAC system requires air recirculation.
- Review and ensure that air-handling capacity of rooms is adequate for isolation and infection control needs of SARS patients.
- Negative pressure airborne infection isolation rooms (AIIR) should be monitored on a regular schedule to assure negative pressure is maintained at all times.
- 254 nm UV-C lamps (UVGI) are extremely effective at inactivating aerosolized infectious agents (including SARS) at low cost.
- Ideally exhaust air from airborne infection control rooms through UVGI lamp and HEPA filter and then outside.
- If updating the ventilation system is too costly, transportable UVGI HEPA filters with high powered fans can be used to sterilize, filter, and recirculate air in patient rooms or in staff areas to reduce concentrations of airborne infectious agents.



When ıould be measu ɣely. The measu e sum of the flc through the do increase the exhaust flow rate to maintain negative pressure. Negative pressure environments are essential to protecting health care workers and others outside patient rooms, especially those who are not equipped with respiratory PPE.

MANAGEMENT OF SEVERE RESPIRATORY FAILURE

To prevent the transmission of SARS in health care settings these are some control methods that are highly recommended.

Personal Protective Equipment

Contact precautions	Disposable gloves, gown, cap
Eye protection	Non-reusable goggles
Airborne precautions	N95 respirator (99% effective), powered air purification respirators (PAPR) for high-risk procedures

Staff education

- High risk procedures, alternatives, and precautions
- Limit opportunities for exposure: Limit aerosol generating procedures & limit number of HCWs present
- Effective use of time during patient contact
- How to ‘gown’ and ‘de-gown’ without contamination
- Emphasis on importance of vigilance and adherence to all infection control precautions
- Emphasis on importance of monitoring own health
- Dissemination of information on SARS and other prevailing infections as they evolve

Environment/Equipment

- Conform to CDC recommendations for environmental control of tuberculosis: Minimum 6 air change per hour (ACH). Where feasible, increase to 12 ACH or recirculate air through HEPA filter
- Preferred: Negative pressure isolation rooms with antechambers, with doors closed at all times
- Equipment should not be shared among patients
- Alcohol-based hand and equipment disinfectants
- Gloves, gowns, masks and disposal units should be readily available
- Careful and frequent cleaning of surfaces with disposable cloths and alcohol-based detergents
- Use of video camera equipment or windows to monitor patients

Transport

- Avoid patient transport where possible: Balance risks and benefits of investigations which necessitate patient transport

Special precautions for ICU

- Viral/bacterial filter placed in expiratory port of bag-valve mask
- Two filters per ventilator: Between expiratory port and the ventilator, and another on the exhalation outlet of the ventilator
- Closed-system in-line suctioning of endotracheal/tracheostomy tubes
- Heat and moisture exchanger (HME) preferred to heated humidifier: Careful handling of contaminated HME required
- Scavenger system for exhalation port of ventilator Optional if negative pressure with high air change (>12/h) is achieved
- Preoxygenate patient and temporarily switch off machine when ventilator circuit disconnection required (e.g. change of ventilator tubings, HME, etc.)

Administrative controls

- An infection control program identifying individuals likely infected
- Training of staff (main goal to limit opportunities of exposure)
- Medical surveillance of at-risk health care workers
- Respiratory protection for those in immediate contact with infected patients

The key objectives to prevent SARS in a health care setting are:

1. identify individuals who are likely infected
2. then isolate or contain infected patients in negative pressure isolation rooms
3. protect health care workers in limiting their opportunity for exposure by using appropriate PPE and conforming to CDC recommended ventilation rates
4. wear gloves when absolutely necessary and wash hands at every opportunity[8].

References

1. SATIJA, N., and S. K. LAL. 2007. "The Molecular Biology of SARS Coronavirus". *ANNALS- NEW YORK ACADEMY OF SCIENCES.* 1102: 26-38.

2. Svoboda, T. 2004. "Public Health Measures to Control the Spread of the Severe Acute

Respiratory Syndrome during the Outbreak in Toronto". *NEW ENGLAND JOURNAL OF MEDICINE.* 350: 2352-2361.

3. Hampton, Tracy. 2005. "Bats May Be SARS Reservoir". *JAMA : the Journal of the American Medical Association.* 294 (18): 2291.

4. Bloodborne pathogens.-1910.1030. *US Dept. of Labor and Industry: Occupational Safety & Health Administration.*12-06-1991.
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10051
Accessed 3/6/08

5. Information Regarding Severe Acute Respiratory Syndrome (SARS). *US Dept. of Labor: Occupational Health & Safety Administration.* 30 May 03. http://www.osha.gov/dep/sars/
Accessed 3/6/08

6. HOSPITAL INVESTIGATIONS: HEALTH HAZARDS. *US Dept. of Labor: Occupational Safety & Health Administration.*
http://www.osha.gov/dts/osta/otm/otm_vi/otm_vi_1.html#43/6/08
Accessed 3/6/08

7. Appendix F5— Laboratory Biosafety Guidelines for Handling and Processing Specimens Associated with SARS-CoV. *Severe Acute Respiratory Syndorme (SARS)*. Dept. of Health and Human Services: Center for Disease Control and Prevention. 5/3/05.
http://www.cdc.gov/ncidod/sars/guidance/f/app5.htm.
Accessed 3/6/08

8. *Recommended Resources supporting the use of these Exposure Controls*

Guidelines for Environmental Infection Control in Health-Care Facilities, Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC)

Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings 2007

Isolation Rooms & Pressurization Control (figure)
http://www.engr.psu.edu/ae/iec/abe/control/isolation.asp
Date accessed: Mar 7, 2008

Jiang, S., Huang, L., Chen, X., Wang, J., Wu, W., et al. (2003). Ventilation of wards and nosocomial outbreak of severe acute respiratory syndrome among healthcare workers. *Chinese Medical Journal, 116*(9), 1293-1297.

Li, Y., Leung, G. M., Tang, J. W., Yang, X., Chao, C. Y., Lin, J. Z., et al. (2007). Role of ventilation in airborne transmission of infectious agents in the built environment - a multidisciplinary systematic review. *Indoor Air, 17*(1), 2-18. doi:10.1111/j.1600-0668.2006.00445.x

Liao, C. M., Chen, S. C., & Chang, C. F. (2008). Modelling respiratory infection control measure effects. *Epidemiology and Infection, 136*(3), 299-308. doi:10.1017/S0950268807008631

Siegel JD, Rhinehart E, Jackson M, Chiarello L. *The Healthcare Infection Control Practices Advisory Committee*

Loutfy, M. R., Wallington, T., Rutledge, T., Mederski, B., Rose, K., Kwolek, S., et al. (2004). Hospital preparedness and SARS. *Emerging Infectious Diseases, 10*(5), 771-776.

Moore DM, Gilbert M. *Occupatioanl Health and Infection Control Practices Related to*

Severe Acute Respiratory Syndrome.

Public Health Guidance for Community-Level Preparedness and Response to Severe Acute Respiratory Syndrome (SARS) Version 2, CDC, Janurary 8, 2004

Tjiu, C. S., Chan, W. C., & Leong, H. T. (2004). Infection control measures against severe acute respiratory syndrome (SARS) in minimally invasive surgical procedures. *The Medical Journal of Malaysia., 58*, 192. ArticleFirst database.

Walker, C. M., & Ko, G. (2007). Effect of ultraviolet germicidal irradiation on viral aerosols. *Environmental Science & Technology, 41*(15), 5460-5465.

World health organization executive board 113th session aganda item 8.3, 23 January 2004

Severe Acute Respiratory Syndrome (SARS) An overview of worker protection issues: http://www.osha.gov/OshDoc/data_General_Facts/osha-factsheet-sars.pdf
Date accessed: Mar 5, 2008

Severe Acute Respiratory Syndrome (SARS): **http://www.cdc.gov/ncidod/sars**
Date accessed: Mar 6, 2008

SARS: Can a mask protect you? Wendy Mesley; Producer: Ines Colabrese; Researchers: Marlene McArdle, Colman Jones, Louisa Jaslow. http://www.cbc.ca/consumers/market/files/health/sars_masks/, April 8, 2003.
Date accessed: Mar 5, 2008

SARS: ventilatory and intensive care. Loretta YC YAM, Rong Chang CHEN AND Nan Shan ZHONG. http://web.ebscohost.com/ehost/pdf?vid=2&hid=15&sid=85f4955a-3871-40d7-bf70-a7a68aace66b%40sessionmgr7
Date accessed: Mar 6, 2008