

# COMMUNICABLE DISEASES AND VENTILATION SYSTEMS



## THE POTENTIAL SPREAD OF COMMUNICABLE DISEASES THROUGH THE VENTILATION SYSTEM

### TABLE OF CONTENTS

What are Communicable Diseases? _____	1
How are they spread? _____	1
Can communicable diseases spread through the ventilation system? _____	2
How to prevent the spread _____	3
The Issue of SARS _____	4
Conclusions _____	4
References _____	5

**WITH THE RECENT OUTBREAKS OF SEVERE ACUTE RESPIRATORY SYNDROME (SARS), COMMUNICABLE DISEASES HAVE CREATED COPIOUS PUBLIC CONCERN AND HAVE HELD THE SPOTLIGHT IN THE MEDIA.** How the diseases are spread is a common question, one that may create panic and anxiety when the answers are not known. How likely are we to contract a disease when we are at work, from a contagious coworker? What are the risks of an infectious diseases being transmitted through the ventilation system in an office building? Is there the potential for a worker on the 8th floor of a building to contract a disease from a worker on the 2nd floor?

The workplace has long been identified as an exposure point for common communicable diseases. This information package will address the potential risk of communicable diseases transmitting through a ventilation system in the workplace. It is based on existing research and will be updated as new information becomes available.

## WHAT ARE COMMUNICABLE DISEASES?

It is important to first distinguish between communicable and non-communicable diseases. A communicable, or contagious disease, is one that can be passed from one human to another, directly or indirectly. This is in contrast to non-communicable diseases which are mainly a result of the environment and cannot be transmitted in this manner.

When an individual becomes infected with a contagious disease, they have the potential to disperse particles into the air through the mechanisms of coughing or sneezing. The respiratory pathogens, any disease-causing organisms, can be divided into 3 major groups:

- Viruses
- Bacteria
- Fungi

Viruses and bacteria are the major microbial groups that are responsible for communicable diseases. The chart that follows outlines several of the more common airborne pathogens.

Airborne Pathogen	Microbial Group	Disease
Adenovirus	Virus	Colds
Togavirus	Virus	Rubella (German measles)
Influenza	Virus	Flu
Respiratory Syncytial Virus	Virus	Pneumonia
Mycobacterium tuberculosis	Bacteria	Tuberculosis
Clamylidia pneumonia	Bacteria	Pneumonia, bronchitis

## HOW ARE THEY SPREAD?

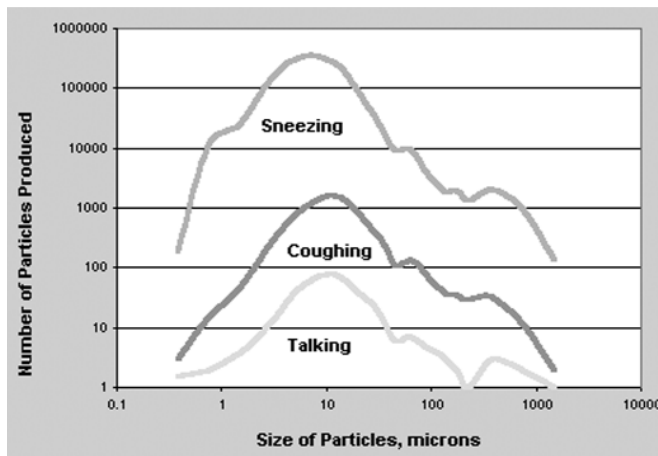
Communicable diseases are usually transmitted by the following methods:

- Airborne
- Vectors (*such as needle stick injuries*)
- Contact (*direct person to person contact through the exchange of infectious droplets or particles called fomites or blood*)

In order for a communicable disease to spread through the ventilation system of a workplace, the pathogens must be airborne. Coughing or sneezing by a contagious person disperses infectious droplets into the air which may then be inhaled by others. Examples of communicable diseases that are not airborne and are not able to pass through a ventilation system include Hepatitis A (*liver disease*), malaria (*mosquito-borne disease*), and impetigo (*skin infection*).

A single sneeze can generate a hundred thousand floating particles, and many may contain viable microorganisms. Figure 1 illustrates the amount and size of particles generated from sneezing, coughing or talking.

It is important to note that although sneezing produces a larger number of particles, coughing occurs approximately ten times more frequently.



**Figure 1.** Profile of sizes and number of particles produced by an infectious person. (Adapted from Kowalski, 1998)

The single most important physical characteristic by which to classify airborne pathogens is size, since it directly impacts filtration efficiency. Airborne transmission of pathogens occurs by propagation of airborne droplet nuclei (small residuals of droplets that are less than 5 micro-meters ( $\mu\text{m}$ ) and remain suspended in the air for sufficient periods of time) or dust particles containing the communicable agent both of which are dispersed by air currents.

Respiratory infections can be acquired from exposure to pathogens contained either in droplets or droplet nuclei. When droplets are produced during a sneeze or cough, a cloud of infectious particles greater than  $5\mu\text{m}$  in size is expelled, resulting in the potential exposure of susceptible persons within 3 feet of the source (resulting in direct contact transmission). The influenza virus can be spread in this manner.

Most large droplets will settle out of the air within a matter of minutes. Droplet nuclei particles can remain suspended for hours and spread by diffusion or air currents. These microorganisms can remain infective for hours and even days, depending on the environmental conditions. There is typically a rapid die-off of microbes due to dehydration in the first few seconds of dispersion. The remaining microbes may be influenced by the following factors:

- source strength (# people/# people infected)
- concentration of infectious agents
- spray factor
- route of infection (*inhalation, eyes, etc*)
- virulence of infectious agents
- influence of air volume
- ventilation rate
- host-specific factors (*i.e. immunological status*)
- relative humidity
- duration of exposure (*period that organism remains airborne*)

Additional environmental factors that destroy airborne microbes include direct sunlight, high temperatures, freezing, oxygen, pollution, and adsorption.

Many microbes that are endogenous to humans or environmentally common may cause opportunistic infections in those whose health has been compromised (*examples of these include nosocomial infections*).

## CAN COMMUNICABLE DISEASES SPREAD THROUGH THE VENTILATION SYSTEM?

As previously indicated, there are numerous factors that affect the viability and transport of infectious pathogens. It has not been clearly documented whether or not this mode of transmission is probable. Pennsylvania State University's Architectural Engineering Department has performed detailed studies evaluating the potential for transmission via the ventilation systems. It utilized a computer program to determine the risk of contracting a respiratory disease for an average person in an office building. In the computer model, a highly

infective Tuberculosis (TB) patient was placed on the first floor of a ten-story office building. The building was equipped with a ventilation system that supplied 20% outdoor air, in accordance with the American Society of Heating, Refrigeration, and Air conditioning Engineers (ASHRAE) guidelines. To err on the side of caution, no high efficiency particulate air (HEPA) filters were used or any other reduction methods. The results illustrated that after 8 hours of exposure, a person on the tenth floor of the building would have accumulated enough total exposure to have a 33% risk of contracting tuberculosis. It is important to note however that this happens extremely infrequently in workplaces that do not knowingly have TB patients, however it can be significant if it does occur. Most of the research available to date has focused on the spread of TB through ventilation systems and there has not been a lot of focus on more common communicable diseases from a general office environment.

In 2001, the National Institute of Occupational Safety and Health (NIOSH) published a review entitled, Health Hazard Evaluations: Tuberculosis (1990-1999). Numerous studies were performed at various workplaces, including hospitals, neighborhood health centres, TB clinics, homeless shelters, drug treatment centres, correctional facilities, social service facilities, laboratories, and medical waste treatment facilities. Several studies indicated that many occupational settings were at an increased risk for transmission of TB from infectious patients through the ventilation systems. The increased risk was reportedly due to inadequate isolation measures. Studies of parole office buildings also reported inadequate ventilation systems. The air handling units did not supply sufficient outdoor air to dilute the contaminated air. These social service workers are at an increased risk of exposure to TB. The parolees are at a greater risk of infection due to being previously incarcerated and possibly homeless (*high risk factors*). This is not the case in a general office building. There is limited research available for non-health care settings or those that have not been deemed high risk.

## HOW TO PREVENT THE SPREAD

To date, most literature indicates that to reduce the transmission of communicable diseases throughout a workplace, a properly installed and maintained ventilation system should be utilized. This system can help to limit the concentration of airborne particulates in the environment. A heating, ventilation and air conditioning (HVAC) system is designed to: **1)** maintain the indoor air temperature and relative humidity at comfortable levels; **2)** control odors; **3)** remove contaminated air; **4)** facilitate air-handling requirements; and minimize the risk of transmission of airborne pathogens from infected people (*mainly in a hospital setting*). Essentially, the effect is to recirculate airborne contaminants and purge them over time. Most buildings bring in approximately 20-25% outside air which is mixed with recirculated air for dilution. In addition to environmental factors, the specifics of a ventilation system can affect the propagation of pathogens, as a result of the following:

- the range of temperature and humidity control
- the amount and distribution of outdoor air
- the efficiency of the filters
- the cleanliness of the facility

In addition to a standard ventilation system, other methods of control include:

- Outdoor air purge systems
- Filtration
- Ultraviolet germicidal irradiation
- Negative Pressurization

## OUTDOOR AIR PURGE SYSTEMS

Contagious viruses and bacteria come almost exclusively from humans and will appear only in the return air systems. Purging the system with outside air acts as a dilution mechanism. The rate of removal of airborne pathogens is dependent upon two factors, the air change rate (ACH) and the ventilation effectiveness (*or degree of air mixing*). This is not an appropriate method of controlling contagious pathogens if microbial growth has occurred in the air handling unit, as purging the unit with outside air may increase respiratory distress throughout the building.

## FILTRATION

The addition of a properly installed filter to a ventilation system, can assist in physically removing contagious bacteria and viruses. A HEPA filter is not commonly used in general office buildings, however they are frequently used in hospital environments, typically isolation rooms. Unfortunately, there is a lack of formal studies on the effectiveness of HEPA filters in real-world settings. Based on laboratory tests, bacteria and larger viruses can be completely filtered out of the air with the proper installation and maintenance of HEPA filters. However, in the real-world, perfection is rare.

## ULTRAVIOLET GERMICIDAL IRRADIATION

The use of ultraviolet germicidal irradiation (UVGI) for the sterilization of microorganisms has been proven to be highly effective in schools and hospitals, however is recommended only with the simultaneous use of HEPA filters and high rates of purge airflow. Many factors can alter the effectiveness of UVGI, including exposure time, room air mixing, power levels, the presence of moisture provide protection for microbes, and dust settling on light bulbs that can reduce exposures.

## NEGATIVE PRESSURIZATION

Utilizing negative pressure ventilation in hospitals or other health care facilities prevents the migration of microbes from one area to another. The most common application in the health industry today is for TB rooms. Full outside air systems are also used where outside air is drawn into a room or area, and then exhausted.

\*It is important to note that HVAC systems that are improperly operated or maintained can contribute to additional health problems. The U.S. Environmental Protection Agency (EPA) indicates that HVAC systems must be properly maintained to promote indoor air quality. If this is not done, ventilation systems can become a source of contamination or can become clogged and reduce or eliminate air flow. Humidification and dehumidification

systems must be kept clean to prevent the growth of harmful bacteria and fungi. Failure to properly treat the water in cooling towers may lead to growth of organisms in the HVAC supply ducts. Accumulation of water in the system may foster harmful biological growth that can be distributed throughout the building.

With all infectious illnesses, one of the most important and appropriate preventive practices is careful and frequent hand hygiene. Cleansing your hands often using either soap and water or waterless alcohol-based hand sanitizers removes potentially infectious materials from your skin and helps prevent disease transmission.

## THE ISSUE OF SARS

Severe acute respiratory syndrome or SARS is a respiratory infection similar to pneumonia. The main symptoms of SARS include both fever and respiratory problems, including chills, headache, muscular stiffness, loss of appetite, malaise, dry cough and shortness of breath, or breathing difficulties. The Centers for Disease Control and Prevention (CDC) indicates that SARS appears to spread primarily by, "close person-to-person contact." Examples of close contact include having cared for, lived with, or had direct contact with droplets from coughing or sneezing and body fluids of people with the disease. SARS is not thought to be airborne and therefore is not likely to transmit via a ventilation system.

## CONCLUSIONS

In summary, there are numerous environmental and physical factors that affect the potential for transmission of a communicable disease via the ventilation system in a workplace environment. Studies to date have focused on the transmission of diseases in hospital settings, affecting patients, visitors and hospital staff. The consensus is to isolate contagious patients in a negative pressured isolation room to prevent spreading to other areas of the hospital. With respect to general office buildings, there is limited research to date that specifically addresses the potential for the spread of contagious diseases through the ventilation system.

## REFERENCES

- Aerobiological Engineering: *Airborne Pathogen Database*. Pennsylvania State University, Aerobiological Engineering Department, 1998.
- Aerobiological Engineering: *Filtration of microorganisms*. Pennsylvania State University, Aerobiological Engineering Department, 1998.
- Aerobiological Engineering: *Fungi and Bacteria in Ventilation Systems*. Pennsylvania State University, Aerobiological Engineering Department, 1998.
- Aerobiological Engineering: *Isolation rooms and pressurization control*. Pennsylvania State University, Aerobiological Engineering Department, 1998.
- Aerobiological Engineering: *The spread of respiratory disease in Office Buildings*. Pennsylvania State University, Aerobiological Engineering Department, 1998.
- Canada Communicable Disease Report. *Infection Control Guidelines: Prevention and Control of Occupational Infections in Health Care*. Health Canada; 28S1, 2002.
- Centers for Disease Control and Prevention. *SARS information*. [www.cdc.gov](http://www.cdc.gov), 2003.
- Canadian Centre for Occupational Health and Safety Resources (CCOHS). [www.ccohs.ca](http://www.ccohs.ca), 2003.
- Centers for Disease Control and Prevention. *Draft guideline for environmental infection control in healthcare facilities*. Healthcare Infection Control Practices Advisory Committee (HICPCA), 2001.
- Kowalski WJ. *Airborne respiratory diseases and mechanical systems for control of microbes. Heating, Piping, Air Conditioning*, 1998.
- Nardell EA, Keegan J, Cheney SA, and Etkind SC. *Airborne Infection: Theoretical limits of protection achievable by building ventilation*. American Review of Respiratory Diseases, 1991; 144:302-306.
- National Institute for Occupational Safety and Health. *Health Hazard Evaluations: Tuberculosis (1990-1999)*. Centre for Disease Control, 2001.
- New York State Department of Health. *Communicable Disease Database*. [www.health.state.ny.us](http://www.health.state.ny.us), 2003.
- U.S. Environmental Protection Agency. *Fact Sheet: Ventilation and Air Quality in Offices. Office of Air and Radiation*, 1990.
- Wilson AG. Institute for Research in Construction. *Canadian Building Digest*. National Research Council Canada, 1969.

## OHCOW OFFICES

If you need further assistance, call the Occupational Health Clinic for Ontario Workers Inc. Closest to you.

### HAMILTON

848 Main Street East  
Hamilton, ON  
L8M 1L9  
(905)-549-2552  
Toll Free: 1-800-263-2129  
Fax: (905)-549-7993  
E-mail: hamilton@ohcow.on.ca

### SARNIA-LAMBTON CLINIC

171 Kendall Street  
Point Edward, ON  
N7V 4G6  
(519)-337-4627  
Fax: (519)-337-9442  
E-mail: sarnia@ohcow.on.ca

### SUDBURY

1300 Paris St.  
Suite 4  
Sudbury, ON  
P3E 3A3  
(705)-523-2330  
Toll Free: 1-800-461-7120  
Fax: (705)-523-2606  
E-mail: sudbury@ohcow.on.ca

### TORONTO

970 Lawrence Ave. West  
Main Floor  
Toronto, ON  
M6A 3B6  
(416)-449-0009  
Toll Free: 1-888-596-3800  
Fax: (416) 449-7772  
E-mail: toronto@ohcow.on.ca

### WINDSOR

3129 Marentette Avenue  
Unit #1  
Windsor, ON  
N9A 4N1  
(519)-973-4800  
Toll Free: 1-800-565-3185  
Fax: (519)-973-1906  
E-mail: windsor@ohcow.on.ca

### PROVINCIAL OFFICE

15 Gervais Drive  
Suite 601  
Don Mills, ON  
M3C 1Y8  
(416)-443-6320  
Fax: (416)-443-6323  
Toll Free : 1-877-817-0336  
E-mail: info@ohcow.on.ca

Every effort has been made to ensure the accuracy of the information in this workbook.  
OHCOW assumes no responsibility for how this information is used.

March 2004