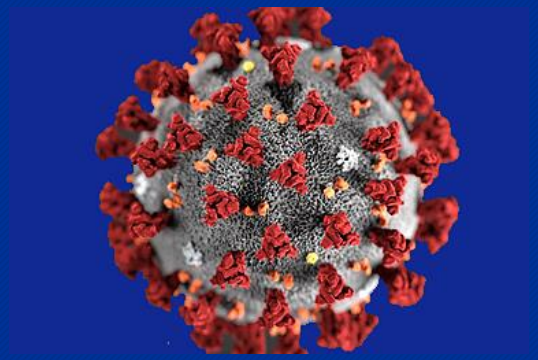

Using Ventilation to Minimize Exposure to SARS-CoV-2 in Workplaces

New Jersey Work Environment Council

September 29, 2020

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NEW JERSEY WORK ENVIRONMENT COUNCIL

An alliance of 70 labor, community, & environmental organizations

https://njwec.org/

What's wrong with this picture?

Definitions:

Harm

- physical injury or damage to health

Hazard

- a source of potential harm

Hazard Control

- a measure to protect workers from a workplace hazard

Risk

- the likelihood or probability that harm will occur

Risk Factor

- a circumstance or condition that causes risk

What is an "acceptable level of risk" to SARS-CoV-2?
Who defines "acceptable"?

Controlling COVID-19 in the Workplace

Apply the Hierarchy of Controls

Focus on the most effective methods first and then move on to the next level of control. **In all cases practice physical distancing, hand hygiene, and respiratory etiquette.**

Most effective

- ELIMINATION
- SUBSTITUTION
- ENGINEERING CONTROLS
- ADMINISTRATIVE CONTROLS
- PPE & NMM

Least effective

Elimination and Substitution

- Allow workers to work remotely where and if possible.
- Assess the need to report to the workplace in person on an individual or job role basis.
- People with immunocompromising health conditions (including chronic conditions such as diabetes, heart and lung issues, or cancer) or who live with immunocompromised individuals may need to continue to work remotely.
- Use technologies to facilitate working remotely, such as teleconferencing.

Engineering Controls

- Physical barriers.
- Increased ventilation and high efficiency filters.
- Sensors or no- or low-touch controls for water taps, doors, and garbage lids.

Administrative Controls

- Communicate risks and rules.
- Limit occupancy, stagger shifts/teams.
- Use electronic communications for sign-ins and administrative work.
- Screen workers and/or customers.
- Clean and sanitize frequently.
- Practice physical distancing, hand hygiene, and respiratory etiquette.
- Change work practices to encourage physical distancing.

Personal Protective Equipment

Respirators | Face Shields | Gowns

Non-Medical MASKS

- Non-medical masks are NOT personal protective equipment.
- Follow advice from your public health agency about when to use a non-medical mask.
- If your mask becomes damaged, wet or dirty, replace it with a fresh one.
- Wearing a non-medical mask or face covering is recommended when you cannot consistently keep 2 metres away from others, especially in crowded settings.
- Wearing a mask alone will not prevent the spread of COVID-19, but it can help. Continue to practice physical distancing and good hygiene.

CCOHS.ca
Canadian Centre for Occupational Health and Safety

Use all the tools in your toolbox

- Ventilation
  - mechanical, natural
- Physical distancing
- Source control
  - surgical masks, procedure masks, cloth face coverings
- Personal protective equipment (PPE)
  - respirators, protective clothing, eye protection
- Cleaning & disinfection
- Hand hygiene
- Symptom screening
- Exposure control plan
- Exposure incident assessment

- Contact tracing
- Isolation/quarantine
- Training
- Paid sick leave, medical insurance
- Other?

Basic Elements of Building Ventilation

- Ventilation rate — the amount of outdoor/outside air (OA) that is provided into the space, and the quality of the outdoor air
- Airflow direction — the overall airflow direction in a building, which should be from clean zones to dirty zones
- Air distribution or airflow pattern — outdoor air should be delivered to each part of the space in an efficient manner and the airborne pollutants generated in each part of the space should also be removed in an efficient manner.

Atkinson J. et. al. eds. Natural ventilation for infection control in health-care settings. *World Health Organization (WHO)*. 2009.
https://www.who.int/water_sanitation_health/publications/natural_ventilation/en/

Essential Principles: SARS-CoV-2 Ventilation

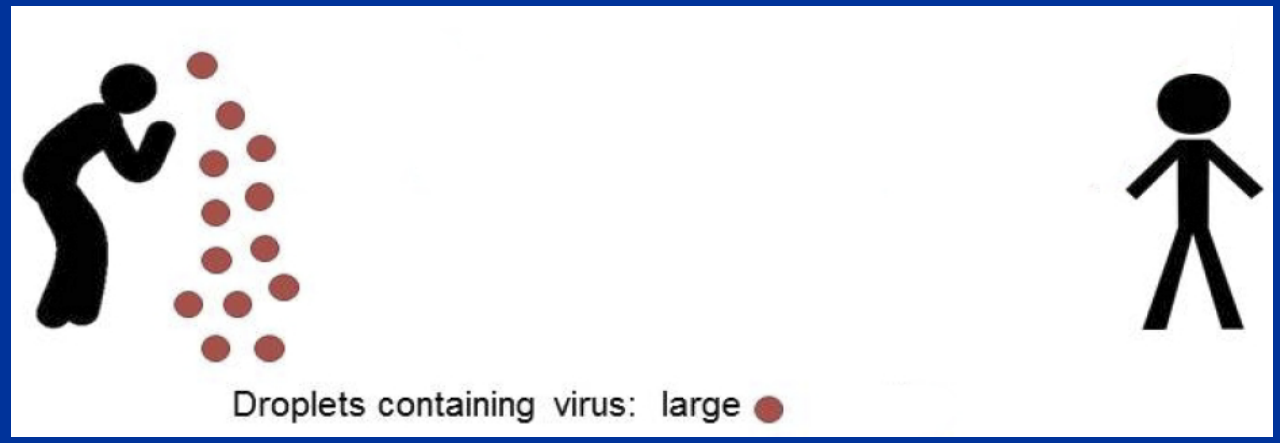
- Outside air (OA) is clean. Indoor air is potentially hazardous.
- Maximize provision of outside air (%OA).
- Maximize air exchange (air changes per hour, ACH).
- Eliminate or minimize recirculation of indoor air, within space or among spaces.
- Maximize filtration of recirculated or potentially contaminated air.
- Identify directional air flow. Prevent or minimize downstream exposure to potentially contaminated air.

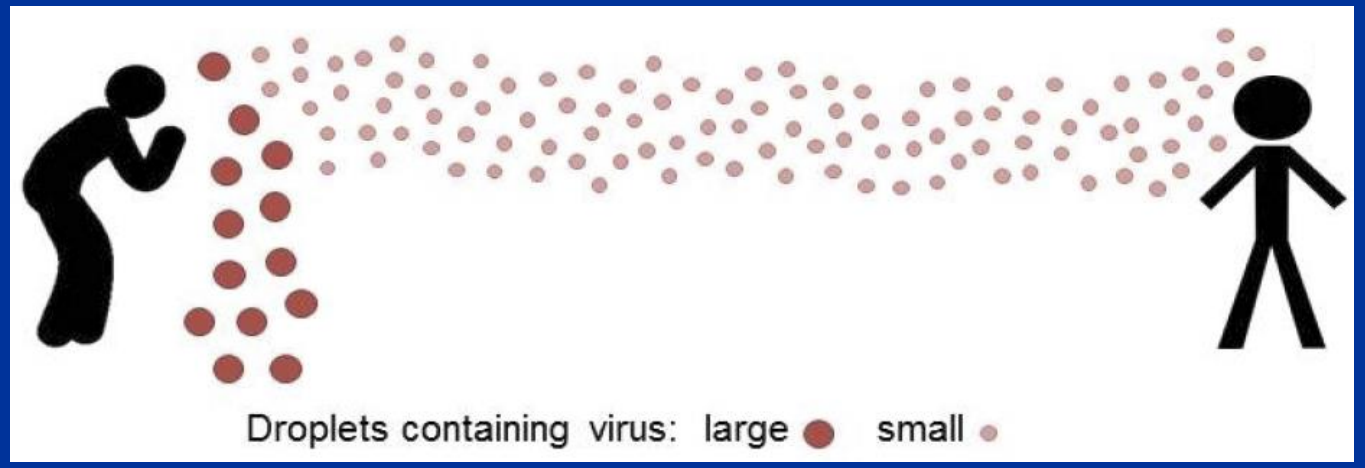
SARS-CoV-2 Modes of Transmission

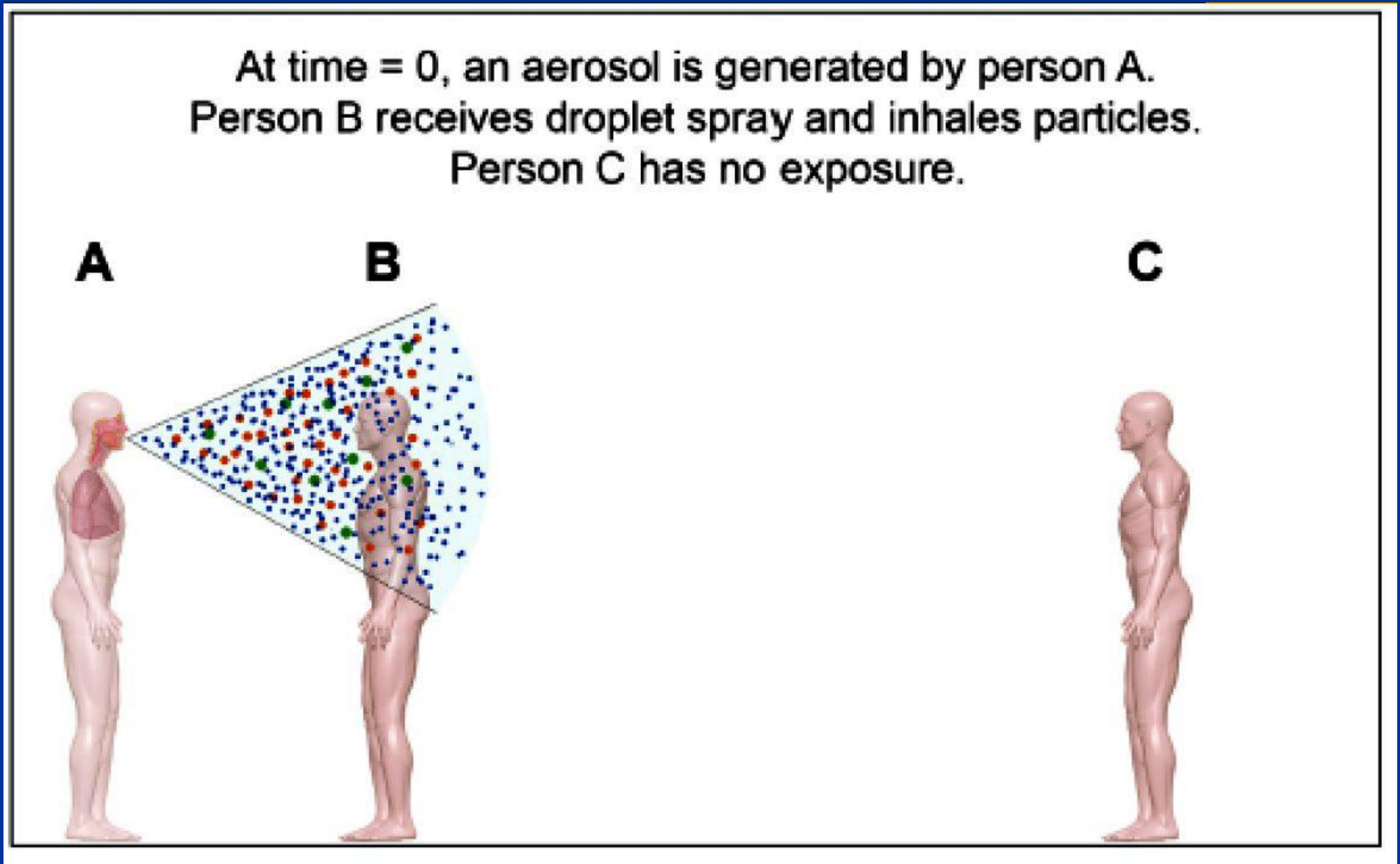
- **Mode** of **transmission:**
  the route or method of transfer by which the infectious microorganism moves or is carried from one place to another to reach the new host.

- **SARS-CoV-2 modes of transmission:**
  - Droplet (ballistic propulsion): 5→30μ (microns)
  - Airborne/Aerosol continuum: 0.1→5μ
  - Fomite (indirect contact via inanimate object)
  - Fecal-Oral

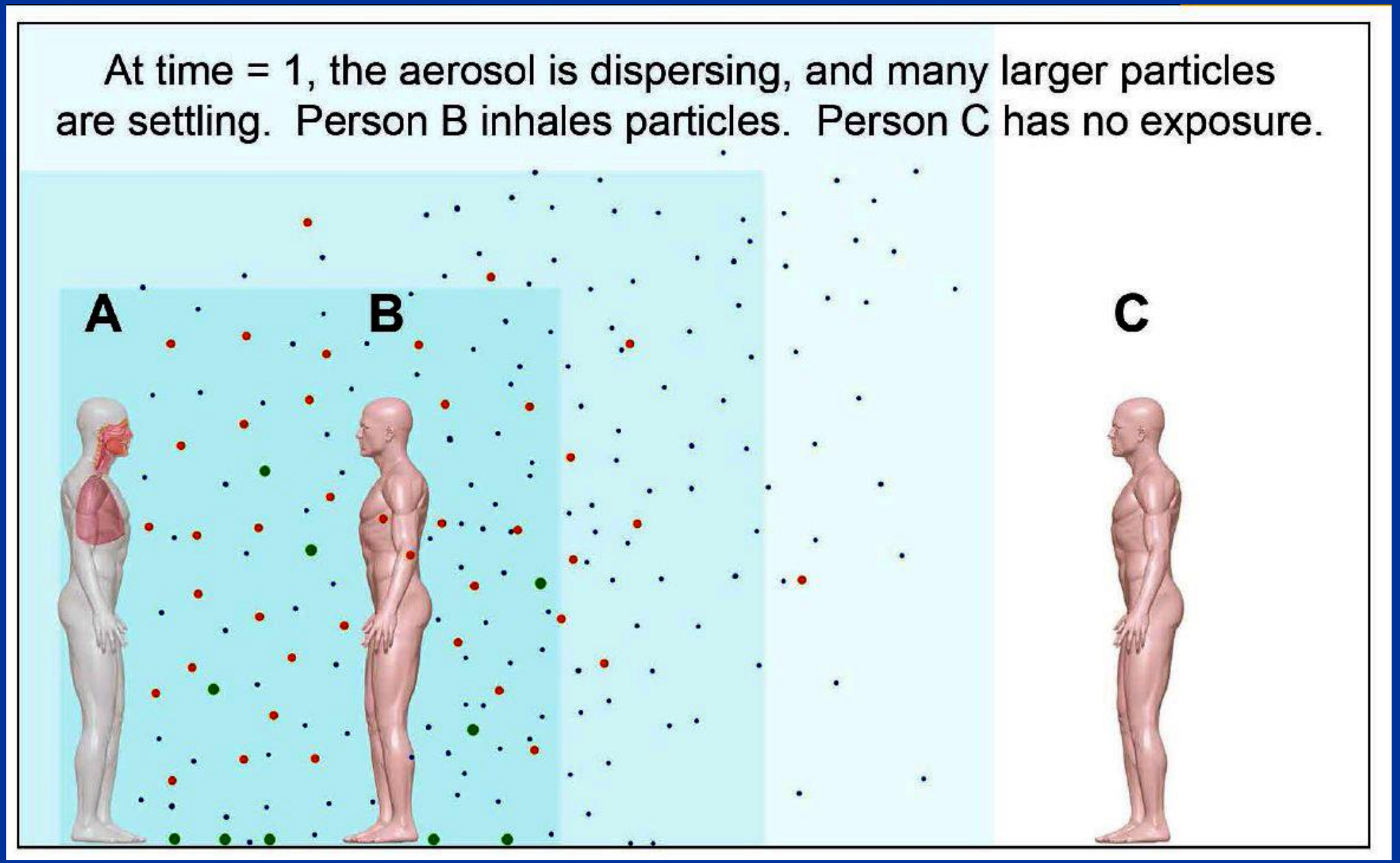
Evolution of Understanding of Airborne Transmission



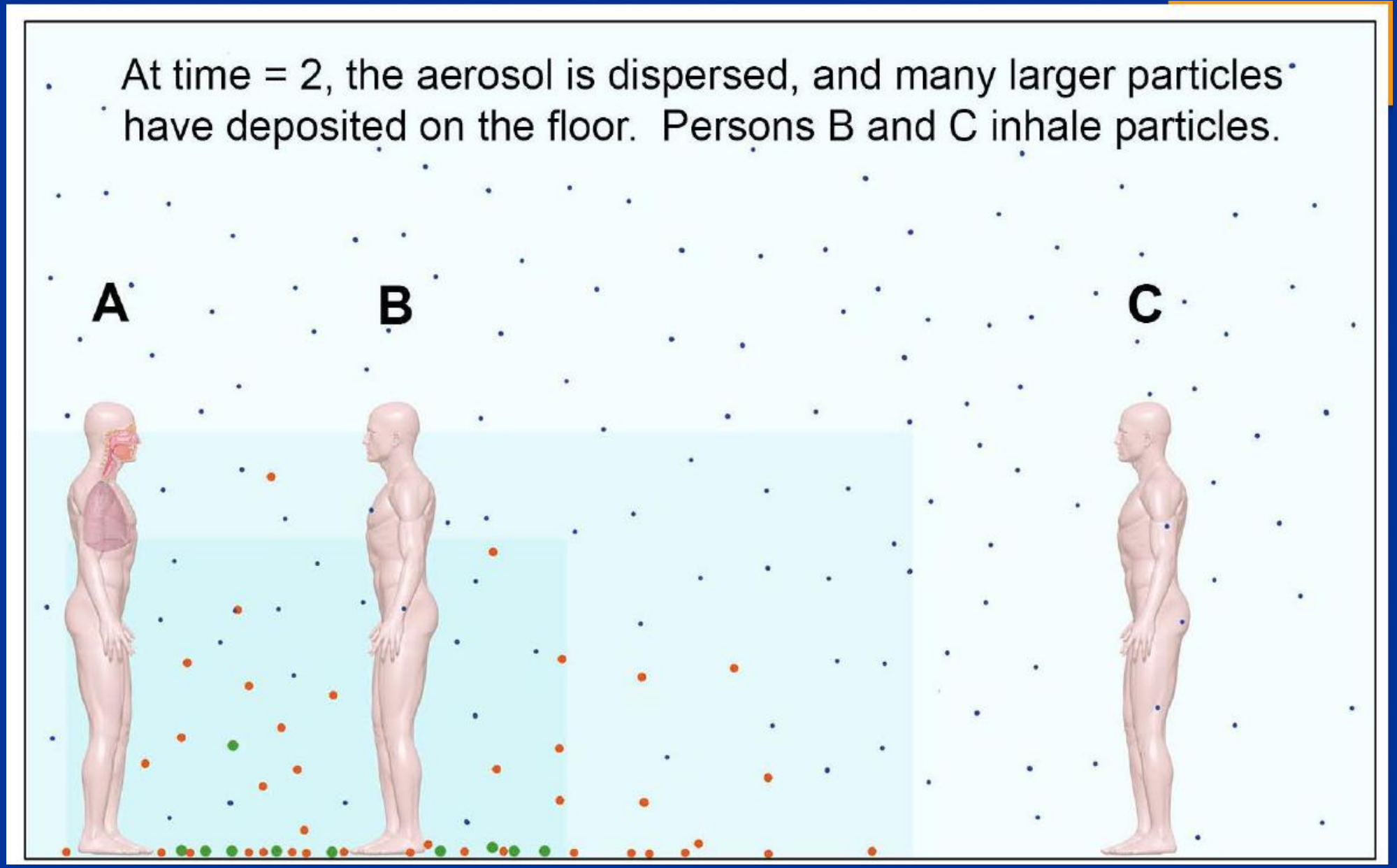




Credit Carlyn Iverson / CIDRAP



Credit: Carlyn Iverson, CIDRAP



Credit: Carlyn Iverson, CIDRAP

CDC Acknowledges Aerosol Transmission

https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html
September 18, 2020

- "COVID-19 [is] most commonly spread through respiratory droplets or small particles, such as those in aerosols… These particles can be inhaled into the nose, mouth, airways, and lungs and cause infection. *This is thought to be the main way the virus spreads…*

- There is growing evidence that droplets and airborne particles can remain suspended in the air and be breathed in by others, and travel distances beyond 6 feet… In general, indoor environments without good ventilation increase this risk."

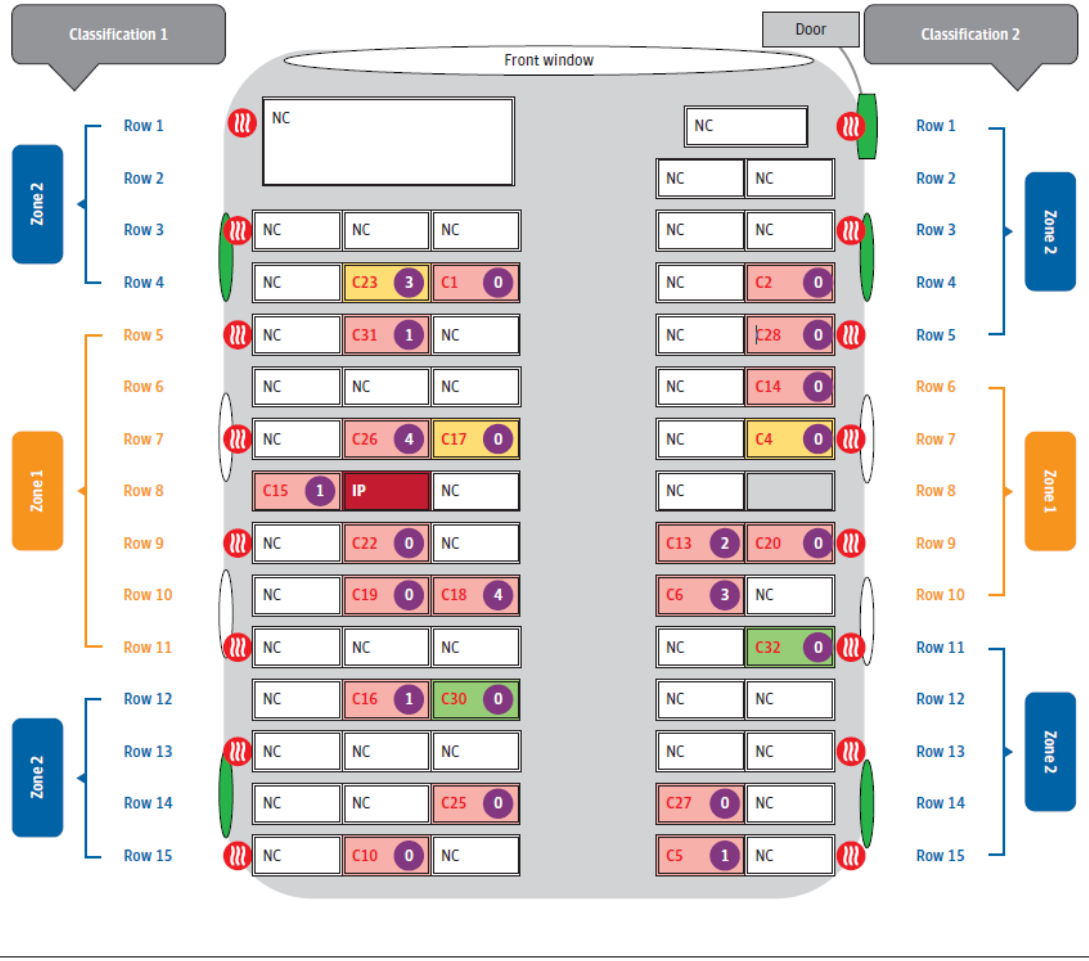
CDC Withdraws Recognition of Aerosol Transmission

September 21, 2020

"A draft version of proposed changes to these recommendations was posted in error to the agency's official website. CDC is currently updating its recommendations regarding airborne transmission of SARS-CoV-2 (the virus that causes COVID-19). Once this process has been completed, the updated language will be posted."

Airborne Transmission on Bus with Recirculated Air

Figure. Schematic Diagram of Bus 2, the Bus Carrying the Coronavirus Disease 2019 (COVID-19) Initial Patient (IP)



Classification 1[17] and 2.[18] Two different approaches to define high-risk and low-risk COVID-19 zones are indicated: zone 1 (high-risk zone) and zone 2 (low-risk zones). Severity levels of cases were indicated. Windows are indicated with ovals, and there are 4 green side windows and that could be opened for fresh air. C indicates case; NC, noncase.

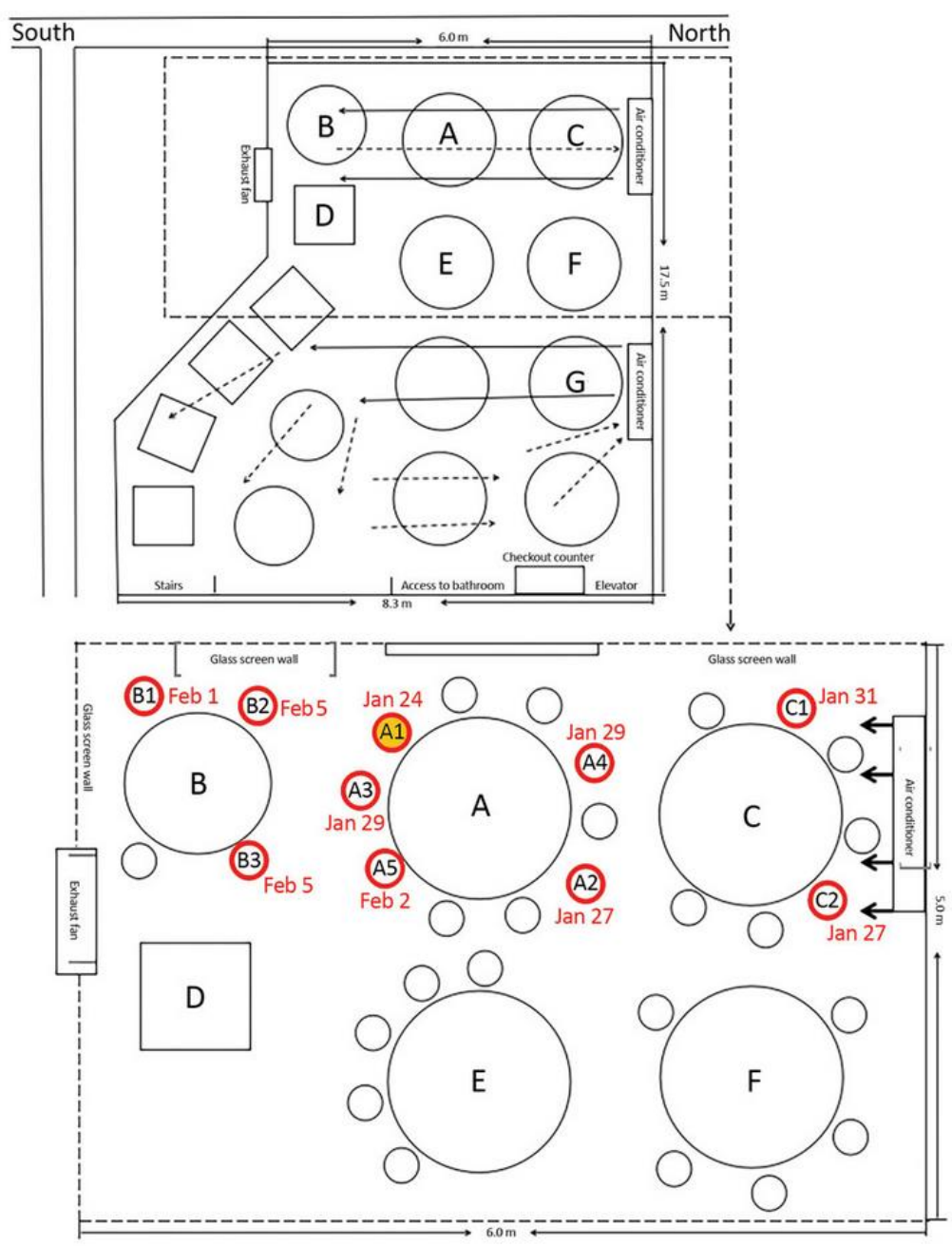
Key Points

Question Is airborne transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) a potential mean of spreading coronavirus disease 2019 (COVID-19)?

Findings In this cohort study of 128 individuals who rode 1 of 2 buses and attended a worship event in Eastern China, those who rode a bus with air recirculation and with a patient with COVID-19 had an increased risk of SARS-CoV-2 infection compared with those who rode a different bus. Airborne transmission may partially explain the increased risk of SARS-CoV-2 infection among these bus riders.

Meaning These results suggest that future efforts at prevention and control must consider the potential for airborne spread of SARS-CoV-2, which is a highly transmissible pathogen in closed environments with air recirculation.

Shen Y. et. al. Community Outbreak Investigation of SARS-CoV-2 Transmission Among Bus Riders in Eastern China. *JAMA Intern Med*. doi:10.1001/jamainternmed.2020.5225. Published online September 1, 2020.



Airborne Transmission via Air Current in Restaurant

Arrangement of restaurant tables and air conditioning airflow at site of outbreak of 2019 novel coronavirus disease.

Yellow-filled red circle indicates index case-patient.

Red circles indicate seating of future case-patients.

Jianyun Lu, Jieni Gu, Kuibiao Li, Conghui Xu, Wenzhe Su, Zhisheng Lai, Deqian Zhou, Chao Yu, Bin Xu, and Zhicong Yang. Covid-19 outbreak associated with air conditioning in restaurant, Guangzhou, China, 2020. Emerging Infectious Diseases, 26(7), 2020.

Reminder
Essential Principles: SARS-CoV-2 Ventilation

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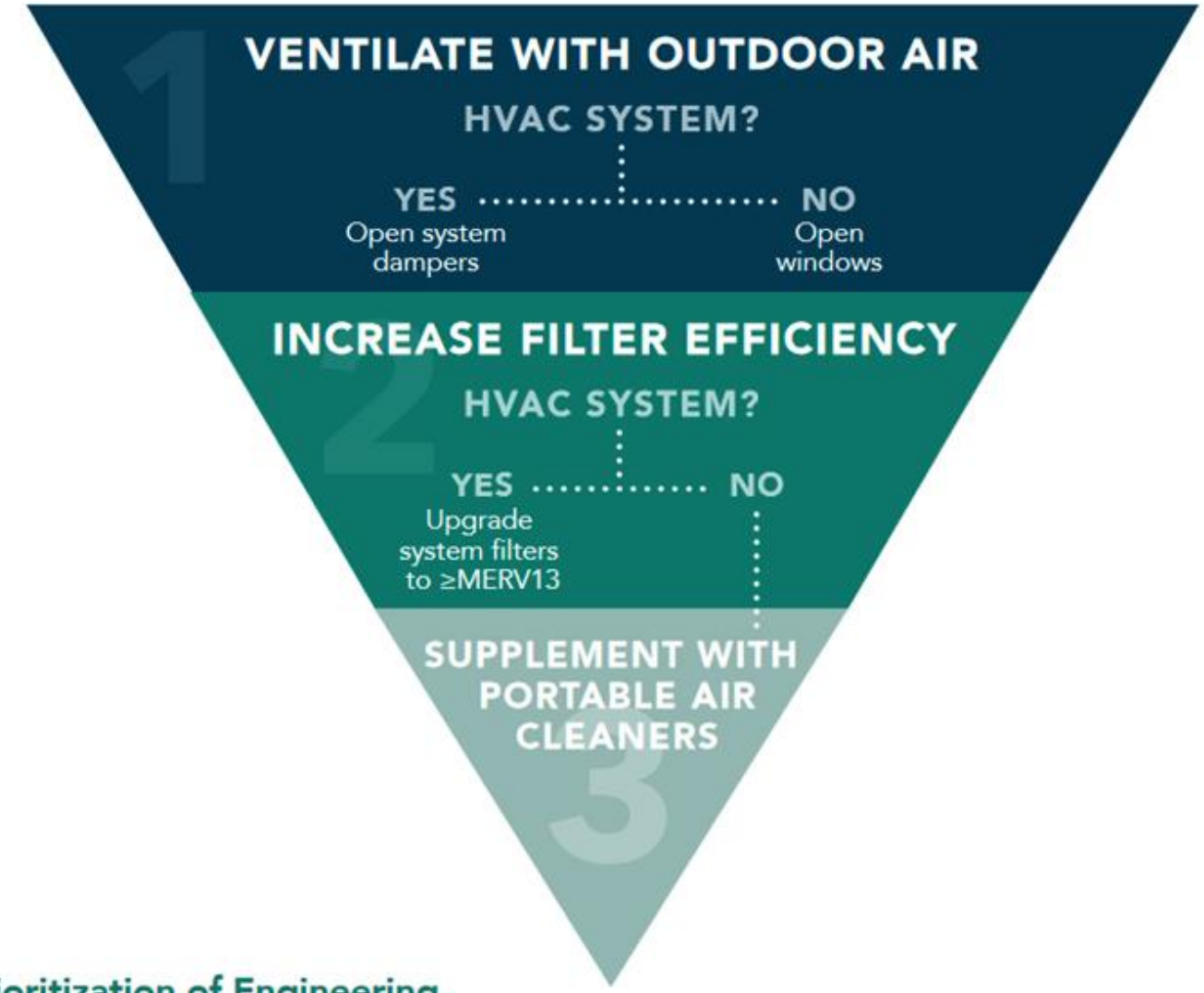
- Identify directional air flow. Prevent or minimize downstream exposure to potentially contaminated air.



Prioritization of Engineering Controls to Reduce Long-Range Airborne Transmission

HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH

Jones E, et. al. Healthy Schools: Risk Reduction Strategies for Reopening Schools. Harvard T.H. Chan School of Public Health Healthy Buildings program. June, 2020. https://schools.forhealth.org/wp-content/uploads/sites/19/2020/06/Harvard-Healthy-Buildings-Program-Schools-For-Health-Reopening-Covid19-June2020.pdf

Options for Ventilation in Workplaces During COVID

- ✓ Central HVAC System
- ✓ Dedicated HVAC System
- ✓ Local exhaust ventilation
- ✓ Windows, doors
- ✓ Filtration
- X Ductless (split) AC/heat unit
- X Ceiling fan
- X Pedestal fan
- X Table-top/personal fan
- ? Window fan
- ? Window-mounted AC

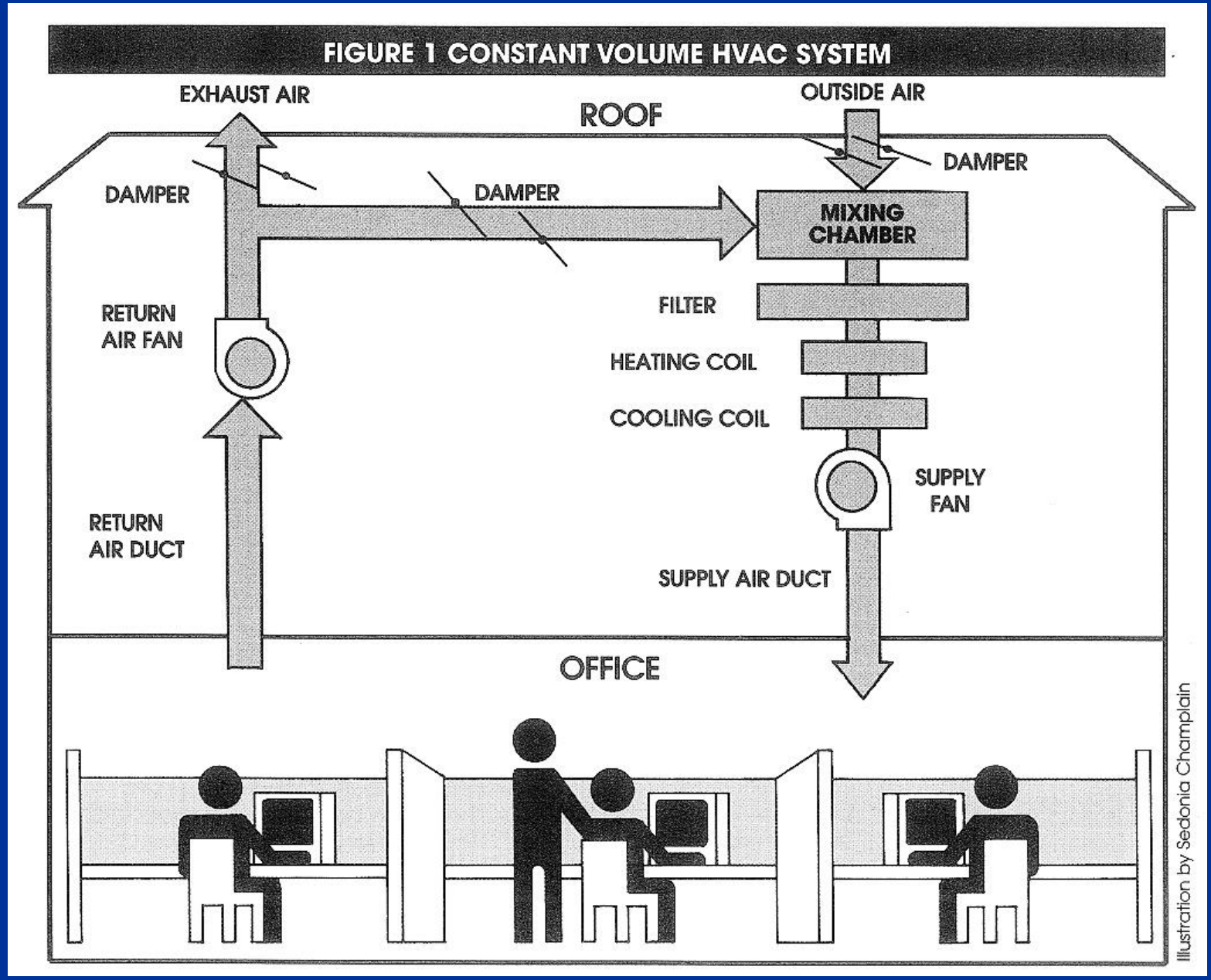


FIGURE 1 CONSTANT VOLUME HVAC SYSTEM
EXHAUST AIR
ROOF
OUTSIDE AIR
DAMPER
DAMPER
DAMPER
MIXING CHAMBER
FILTER
RETURN AIR FAN
HEATING COIL
COOLING COIL
SUPPLY FAN
RETURN AIR DUCT
SUPPLY AIR DUCT
OFFICE
Illustration by Sedonia Champlain

Table 2 shows the required time in minutes for removal efficiencies of 90 percent, 99 percent, and 99.9 percent for the given ACHs. However, the times reported in the table assume a mixing factor (K) of 1.0 (perfect mixing throughout the room that maximizes the dilution effect). In reality, we know that most ventilation systems are unable to provide such perfect mixing, and we must multiply the required time identified in the table by the actual mixing factor. (Mixing factors for dilution ventilation can vary from one, for ideal mixing, to over ten for poor mixing. As a rule of thumb, a mixing factor of three can be assumed for a room with 12 ACH and good air movement [ACGIH 2004, Francis] Curry National Tuberculosis Center 2004].)

Table 2. Air changes per hour (ACH) and elapsed time required to achieve a desired removal efficiency*

ACH	Minutes Required for the Desired Removal Efficiency		
	90%	99%	99.9%
2	69	138	207
6	23	46	69
12	12	23	35
16	9	17	26
24	6	12	17
48	3	6	9

Using the values from Table 2, we can see that for a patient room with 12 ACH, which we assume is designed with good air movement (K = 3), it will take 36 (3 × 12) minutes to remove 90 percent of the infectious aerosol and over an hour to remove 99 percent, assuming that the patient generates no additional airborne infectious aerosols during this decay period.

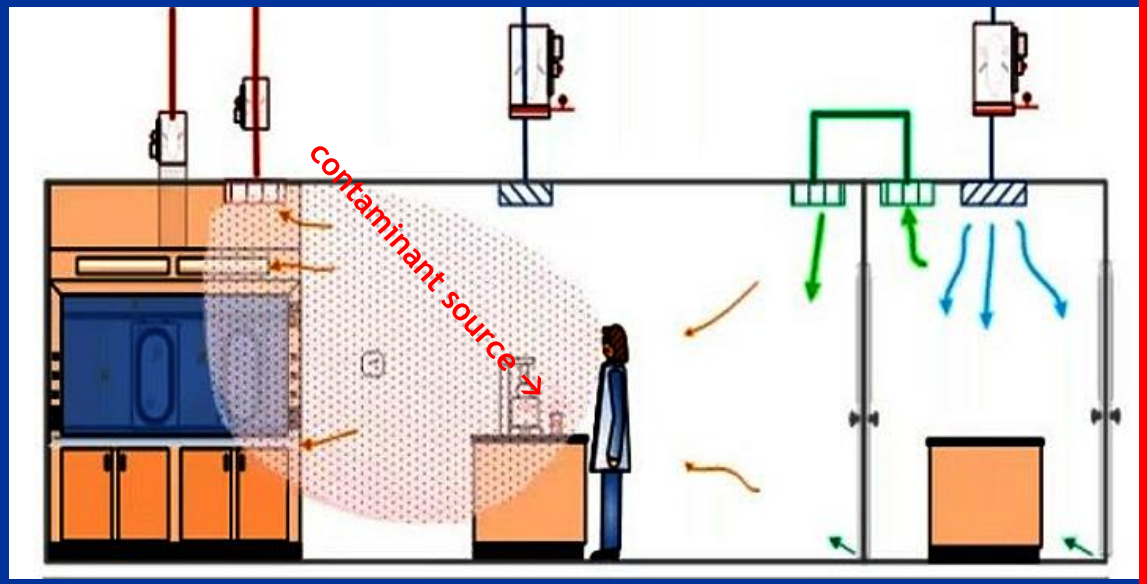
Air changes per hour (ACH):
rate of removal of airborne infectious particles necessary to achieve "steady state"

(with infectious source no longer present)

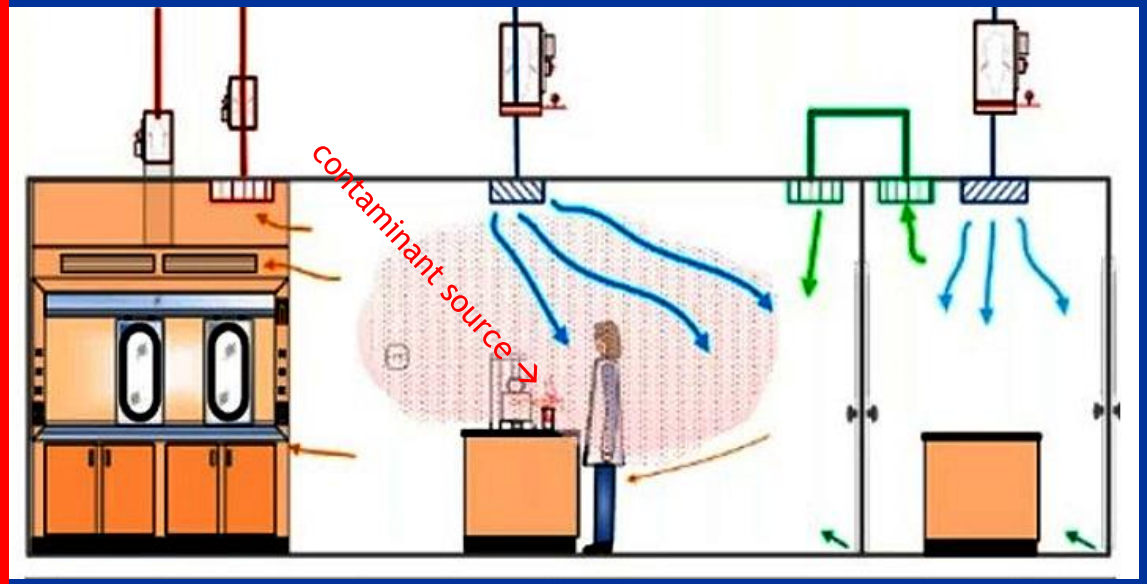
Mead KR. et. al. Expedient Methods for Airborne Isolation within Healthcare Settings during Response to a Natural or Manmade Epidemic. *CDC/NIOSH*. April 2002.
https://www.cdc.gov/niosh/surveyreports/pdfs/301-05f.pdf

In some situations, directional air flow may be more effective than amount of outside air (%OA or ACH)

credit: Tom Smith, 3 Flow



2 ACH but more protective due to directional air flow



8 ACH but less protective due to directional air flow

Employer Information for Office Buildings

https://www.cdc.gov/coronavirus/2019-ncov/community/office-buildings.html

- Increase % outside air (OA), potentially as high as 100%.
- Increase total airflow supply to occupied spaces.
- Disable demand-control ventilation that reduces air supply based on temperature or occupancy.
- Consider opening windows.
- Increase air filtration to as high as possible.
- Consider running HVAC at maximum OA for 2 hours before & after occupancy.
- Generate clean-to-less clean air movement.
- Consider using portable HEPA fan/filtration systems.
- Ensure restroom exhaust fans operate at full capacity when building is occupied.

COVID-19 Pandemic Ventilation for Industrial Settings

- Increase OA supply to 100% or as high as feasible.
- Operate HVAC system continuously during occupancy.
  - Operate long enough to complete several air changes after departure.
  - If HVAC is shut down or set back overnight, return to full operating conditions prior to occupant return.
- Utilize positive pressure to prevent entry of contaminants from adjoining spaces. Utilize negative pressure to limit escape of contaminants generated within a space.
- General airflow direction should be from cleaner air to less clean air.
  - Place workers on cleaner side of airflow pattern to reduce exposures.
  - Avoid having personal or pedestal fans blow from one person to another.
- Operate restroom fans continuously. Exhaust directly outdoors.
  - Provide disposable paper towels. Disable air dryers.

American Conference of Governmental Industrial Hygienists (ACGIH). White Paper on Ventilation for Industrial Settings during the COVID-19 Pandemic. August 2020.

ASHRAE 62.1 "Ventilation for Acceptable Indoor Air Quality" *not adequate* for SARS-CoV-2 exposure control

- **Class 1**: low contaminant concentration, low sensory-irritation intensity, inoffensive odor.
- **Class 2**: moderate contaminant concentration, mild sensory-irritation intensity, mildly offensive odors.
- **Class 3**: significant contaminant concentration, significant sensory-irritation intensity, offensive odor.
- **Class 4**: highly objectionable fumes or gases or potentially dangerous particles, bioaerosols, or gases, at high concentrations.

Table 6.2.2.1 Minimum Ventilation Rates in Breathing Zones (excerpts)

Occupational Category	*Outside Air Rate* ($ft.^3/min.$)	*Air Class*
Classroom (age 5 – 8)	15	1
Restaurant dining room	10	2
Hotel central laundry room	17	2
Office space	17	1
Supermarket	15	1
Gym	45	2
General manufacturing (excludes heavy industrial processes using chemicals)	36	3

Epidemic Task Force: Commercial August 17 2020

https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-commercial-c19-guidance.pdf

- This guidance has been formulated to… slow transmission of viruses via HVAC systems. The underlying effort… should be to increase outside air to the spaces, treat return air and/or supply air to spaces via mechanical filtration, and maintain indoor comfort…
- Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of heating, ventilating, and air-conditioning [HVAC] systems, can reduce airborne exposures. (https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-reopening-schools.pdf)

- Provide maximum outside air above code requirements, where possible.
- Provide maximum filter efficiency that the unit can handle, preferably MERV-13 or above filter.
- Consider opening windows, especially when system cannot accommodate MERV-13 filter or 100% OA.
- If room has insufficient OA and filtration is below MERV-13, consider portable air cleaner w/ HEPA filter.
- Operate HVAC system with maximum OA flow for 2 hours before and after occupied times, or, achieve 3 air changes of outside air in the space.
- Beware of horizontal air flow. Avoid prolonged air flow from the face of a person onto others.

Table 7.5-B Comparison of MERV Data, Filter Type, and Prior Designations

MERV Level	Dust Spot %	Typical Particulate Filter Type	% 0.3–1 µm	% 1–3 µm	% 3–10 µm
1	N/A	Low-efficiency fiberglass and synthetic media disposable panels, cleanable filters, and electrostatic charged media panels	Too low efficiency to be applicable to ASHRAE Standard 52.2 (ASHRAE 2007) determination		
2	N/A				
3	N/A				
4	N/A				
5	N/A	Pleated filters, cartridge/cube filters, and disposable multi-density synthetic link panels			20–35
6*	N/A				35–50
7	25%–30%				50–70
8	30%–35%				>70
9	35%–40%	Enhanced media pleated filters, bag filters of either fiberglass or synthetic media, rigid box filters using lofted or paper media		>50	>85
10	50%–55%			50–85	>85
11	60%–65%			65–85	>85
12	70%–75%			>80	>90
13	80%–85%	Bag filters, rigid box filters, minipleat cartridge filters	>75	>90	>90
14	90%–95%		75–85	>90	>90
15	>95%		85–95	>90	>90
16	98%		>95	>95	>95
The following classes are determined by a different methodology than that of ASHRAE Standard 52.2 (ASHRAE 2007).					
NA	N/A	HEPA/ULPA filters evaluated using IEST Recommended Practice CC001.3 (IEST 1993). Types A through D yield efficiencies at 0.3 mm and Type F at 0.1 mm	99.97% IEST Type A		
NA	N/A		99.99% IEST Type C		
NA	N/A		99.999% IEST Type D		
NA	N/A		>99.999% IEST Type F		

* MERV 6 is prescribed by ASHRAE Standard 62-2001 (ASHRAE 2001) for minimum protection of HVAC systems.

Final Reminder
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- Maximize filtration of recirculated or potentially contaminated air.
- Identify directional air flow. Prevent or minimize downstream exposure to potentially contaminated air.

THANK YOU!

EOHS ASSOCIATES LLC

WEC

JERSEY RENEWS

LABOR EDUCATION ACTION RESEARCH NETWORK

unions make work safer