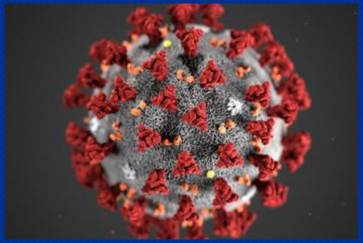

Using Ventilation to Minimize Exposure to SARS-CoV-2 in Schools

WEC Wednesdays

September 23, 2020

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An alliance of 70 labor, community, & environmental organizations
https://njwec.org/

NJEA NEW JERSEY EDUCATION ASSOCIATION

What’s wrong with this picture?

“The patient in the next bed is highly infectious. Thank God for these curtains.”

Essential Principles: SARS-CoV-2 Ventilation

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

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

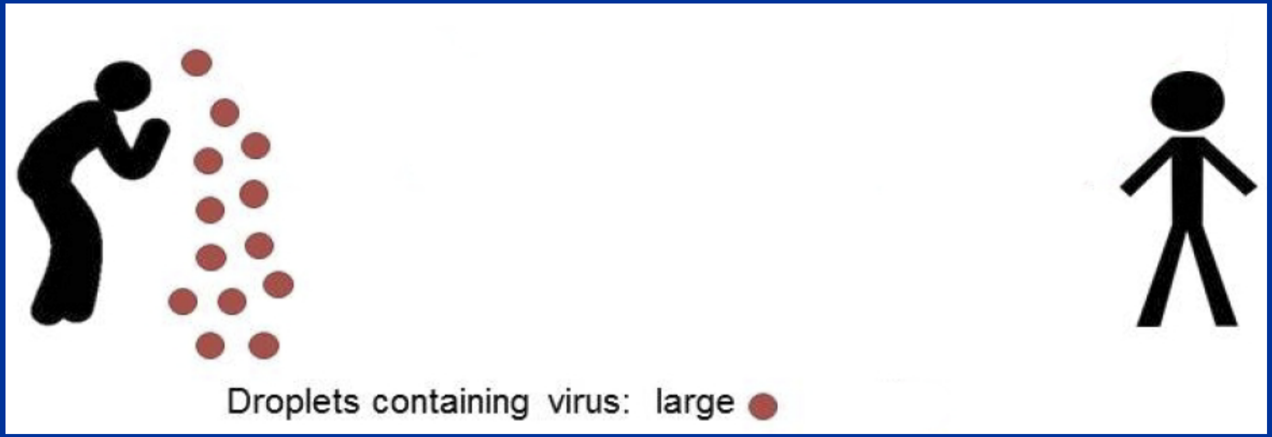
- a circumstance or condition that causes risk

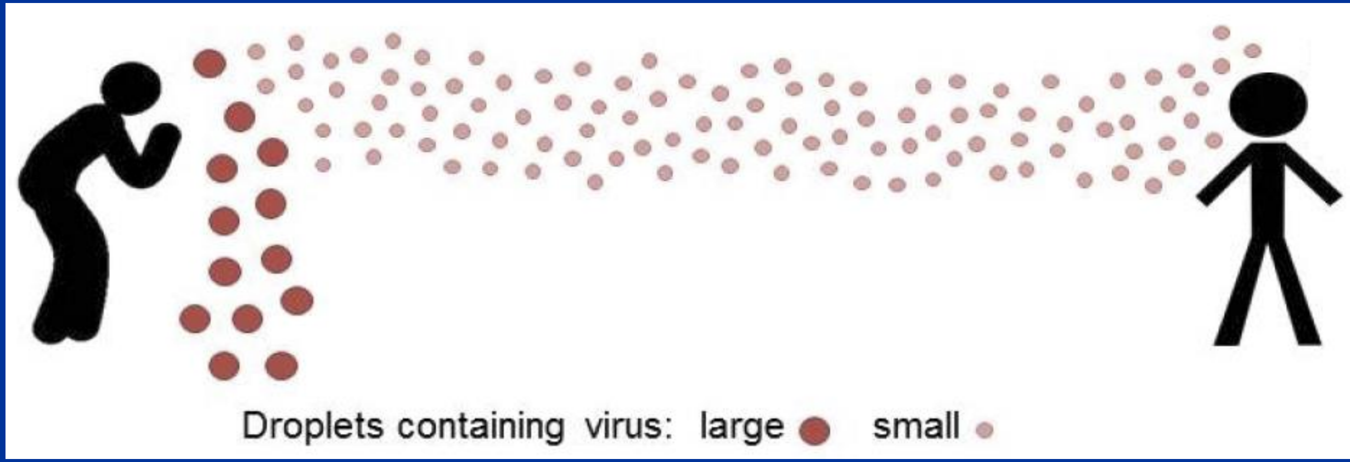
SARS-CoV-2 Modes of Transmission

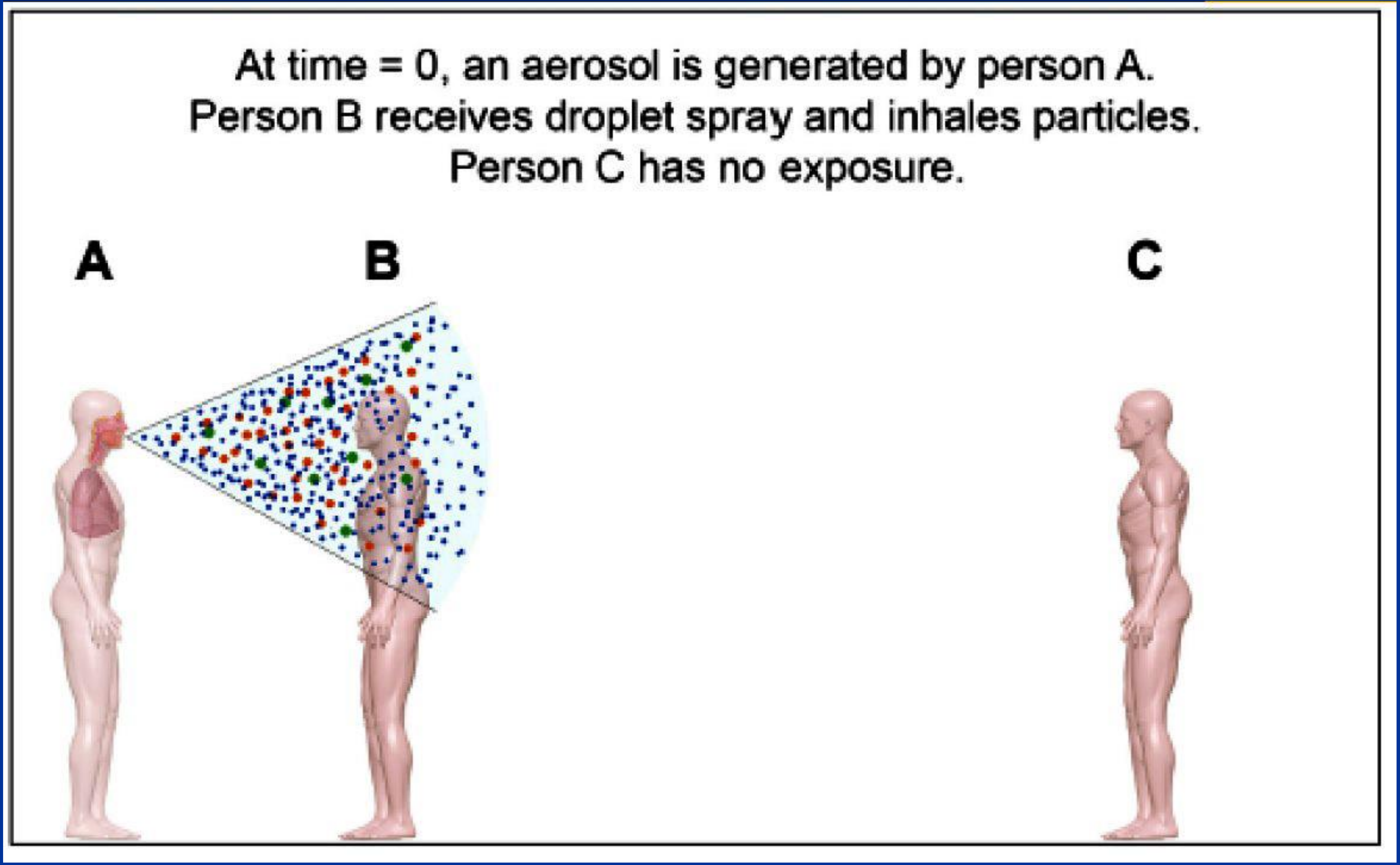
- **Mode** of **transmission:**
  the route or method of transfer by which the infectious microorganism moves or is carried from one place to another to reach the new host.

- **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

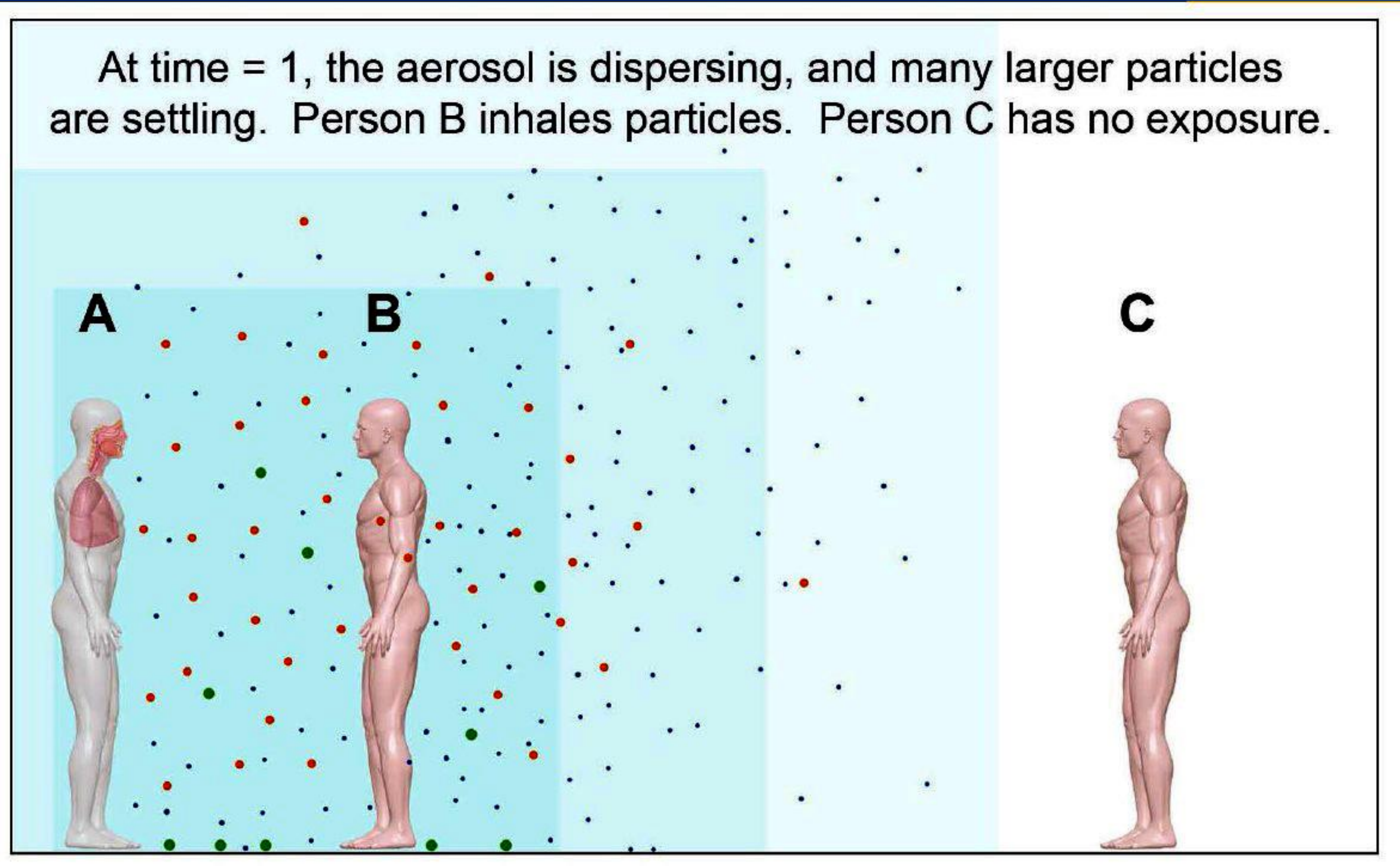
Evolution of understanding of Airborne Transmission



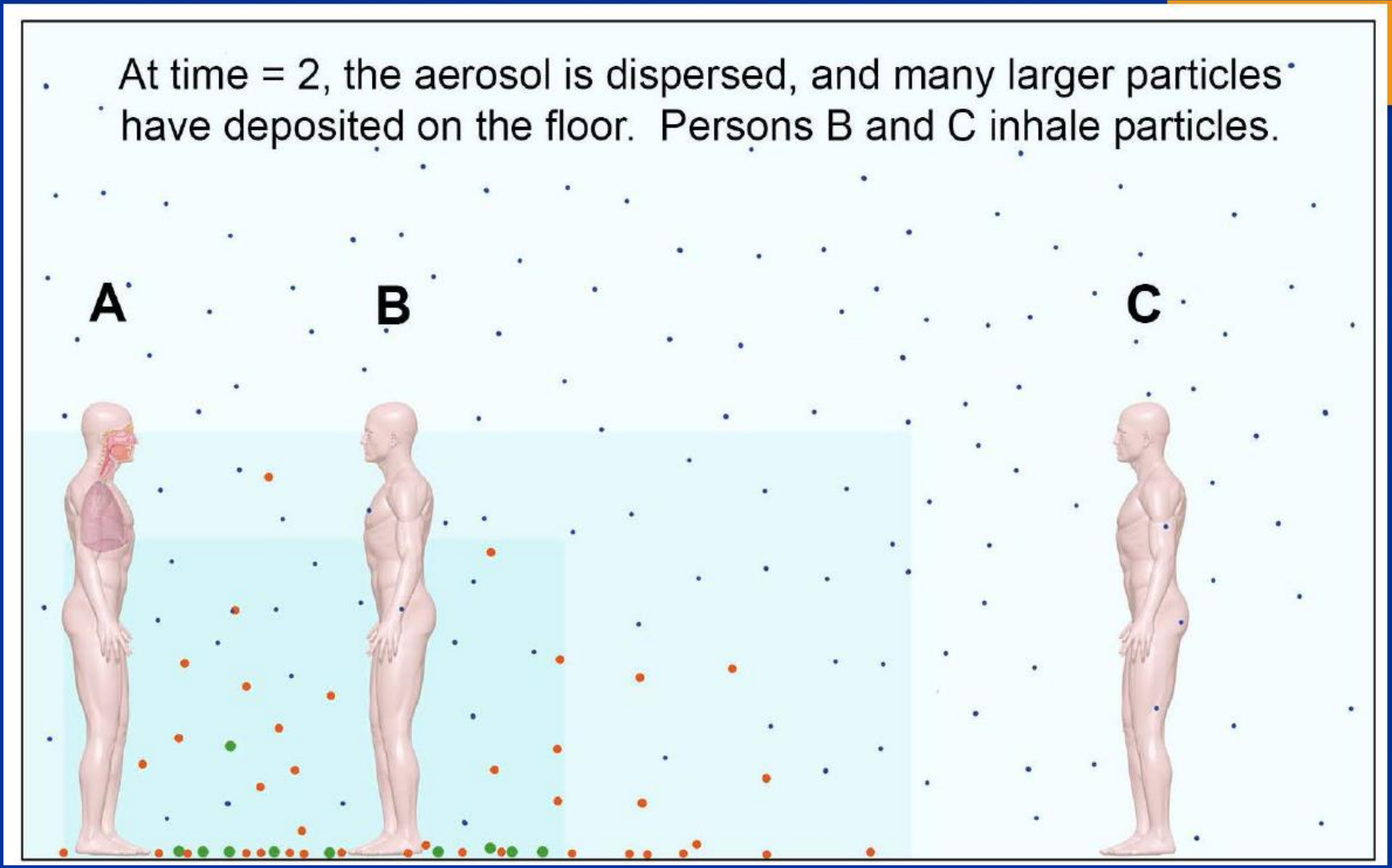




Credit Carlyn Iverson / CIDRAP



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."

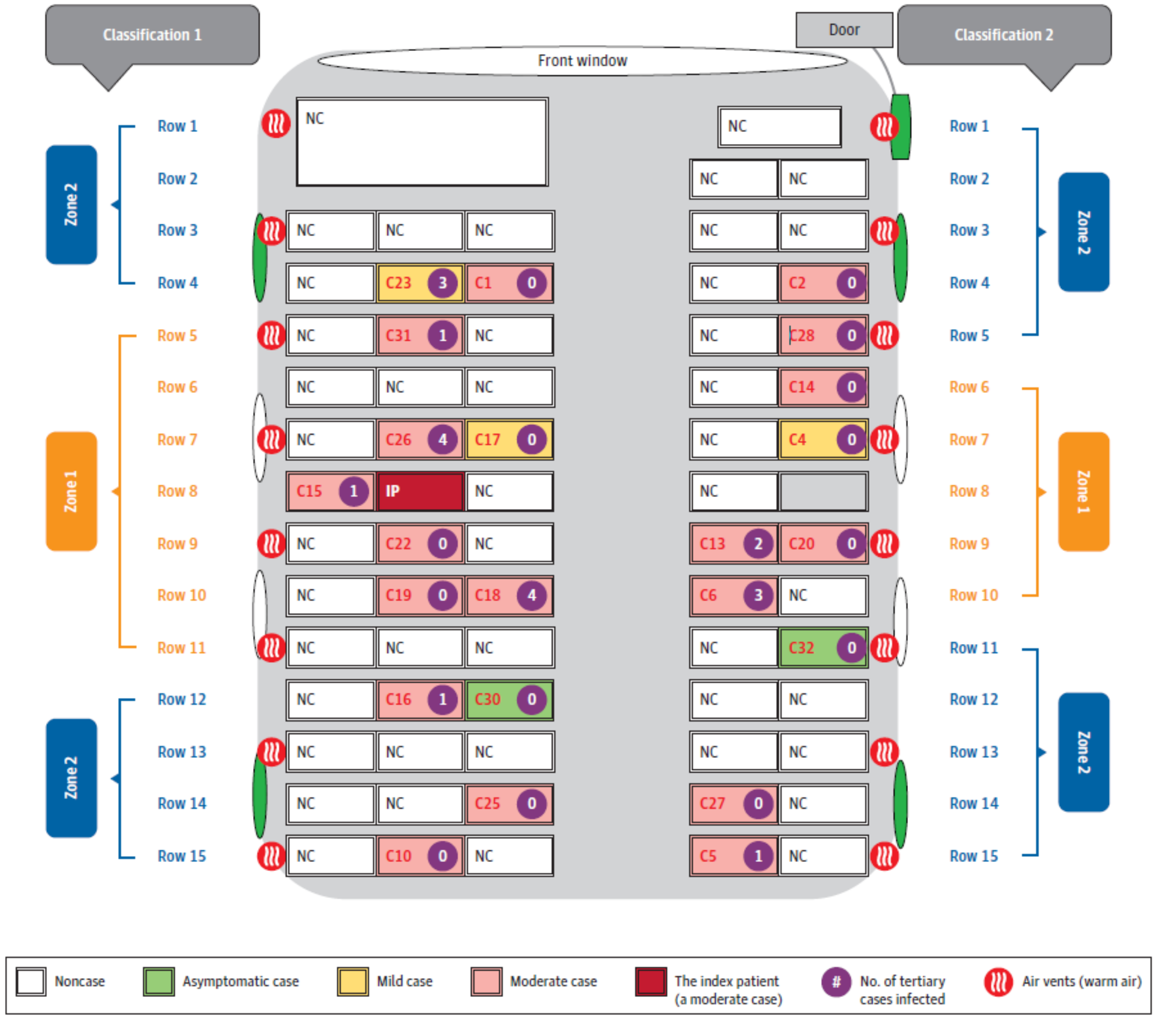
CDC Withdraws Recognition of Aerosol Transmission

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.

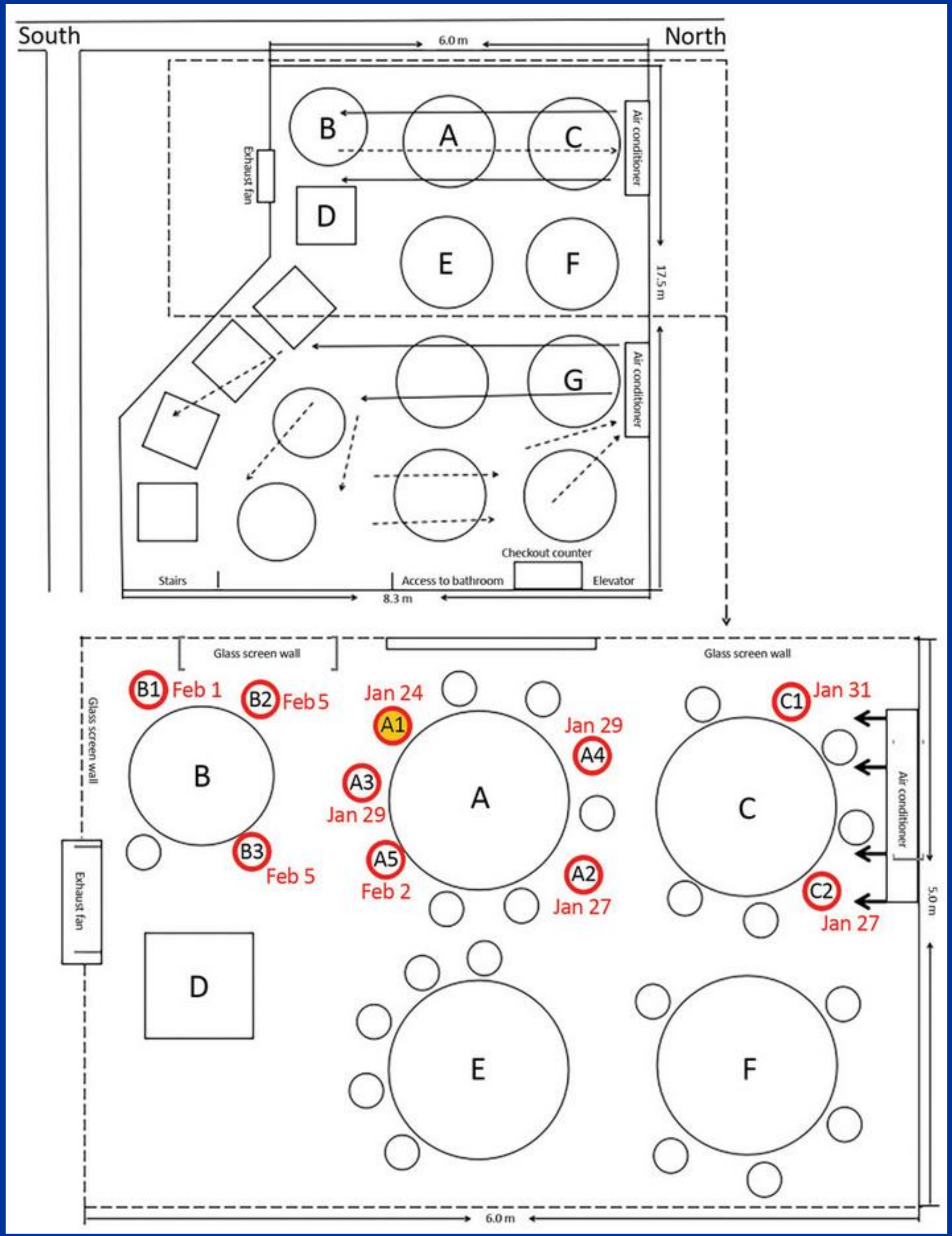
Key Points

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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- Maximize provision of outside air (%OA).
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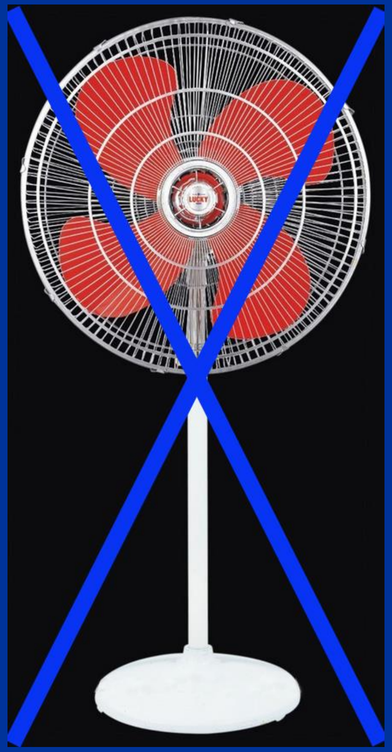
Basic Elements of Building Ventilation

- 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/

Options for Ventilation in Schools During COVID



- Central HVAC systems
  (Ex: offices, auditorium, gym, cafeteria)
- Individual HVAC systems
  (Ex: individual classrooms, chemical storage rooms, nurse suite)
- Local exhaust ventilation
  (Ex: chemistry lab fume hoods)
  (use dependent on directional air currents)
- Unit ventilators
  (only if provision for OA)
- Windows
- Window-mounted air conditioners
  (only if provision for OA)
- Ductless AC units (never)
- Fans – pedestal (never), table-top (never), window (maybe).

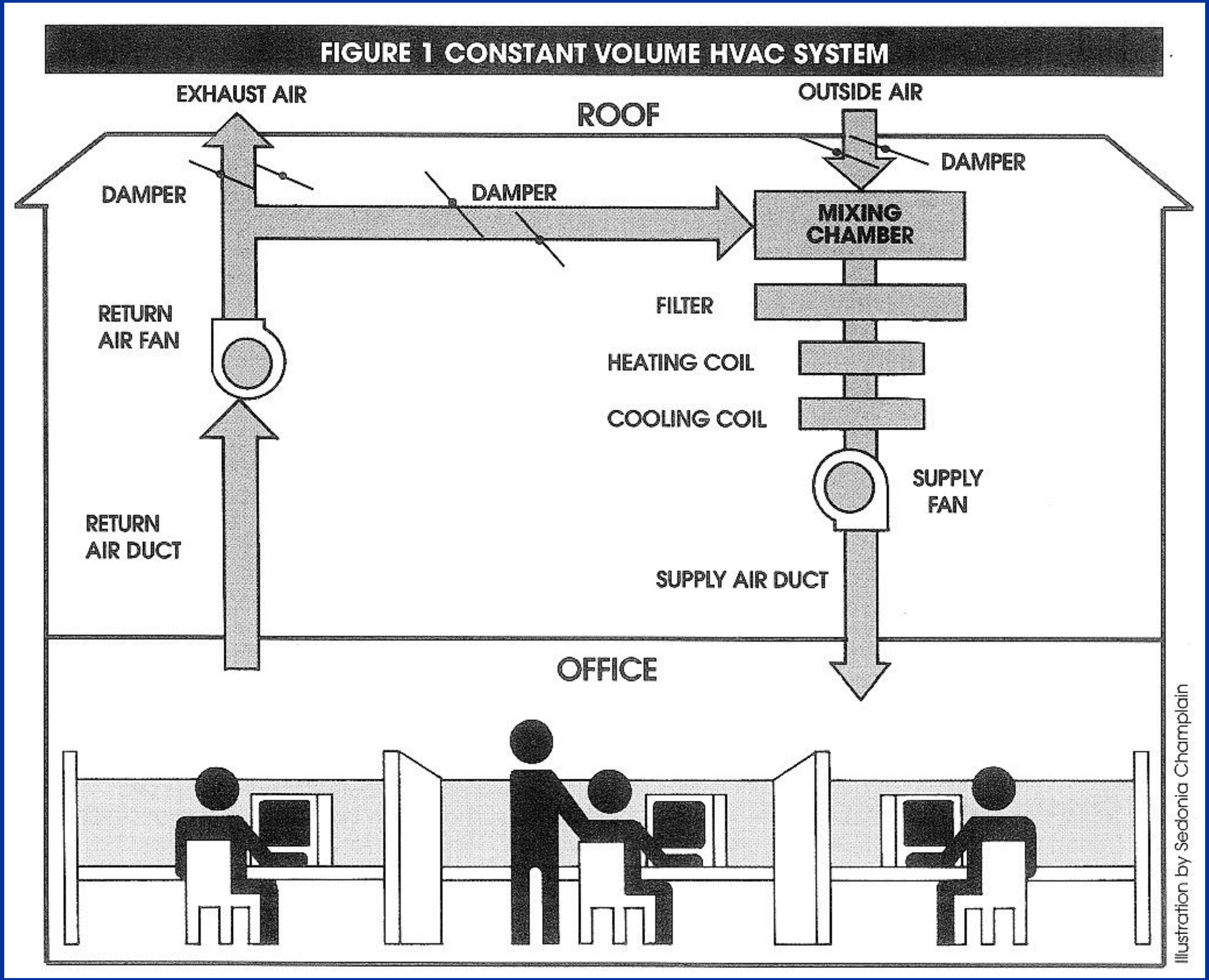


FIGURE 1 CONSTANT VOLUME HVAC SYSTEM
EXHAUST AIR
ROOF
OUTSIDE AIR
DAMPER
DAMPER
DAMPER
MIXING CHAMBER
FILTER
RETURN AIR FAN
HEATING COIL
COOLING COIL
SUPPLY FAN
RETURN AIR DUCT
SUPPLY AIR DUCT
OFFICE
Illustration by Sedonia Champlain

Air changes per hour (ACH): rate of removal of airborne infectious particles

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*

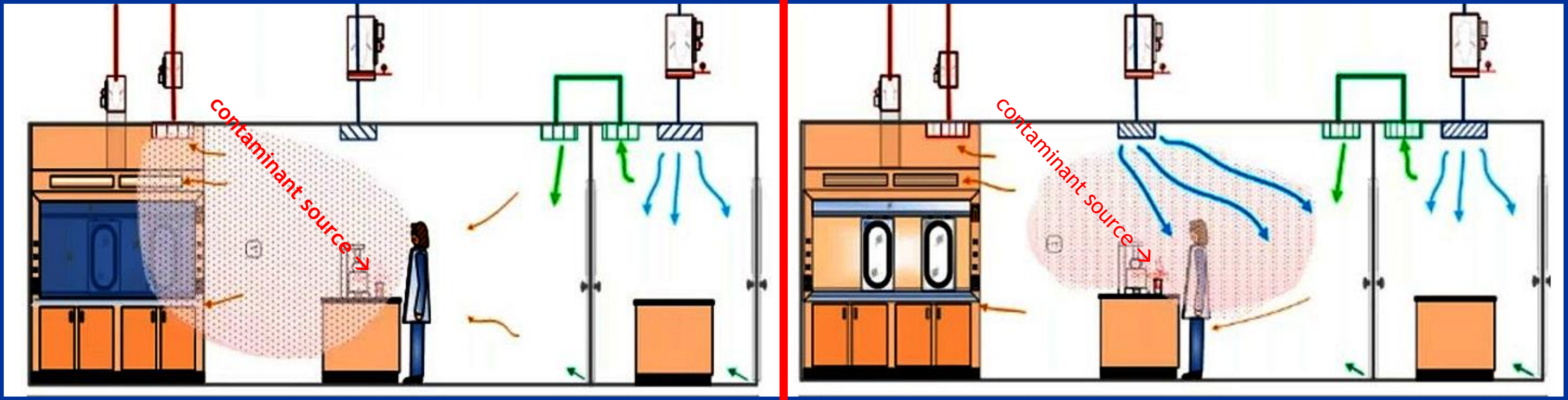
ACH	Minutes Required for the Desired Removal Efficiency		
	90%	99%	99.9%
2	69	138	207
6	23	46	69
12	12	23	35
16	9	17	26
24	6	12	17
48	3	6	9

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.

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

Reminder
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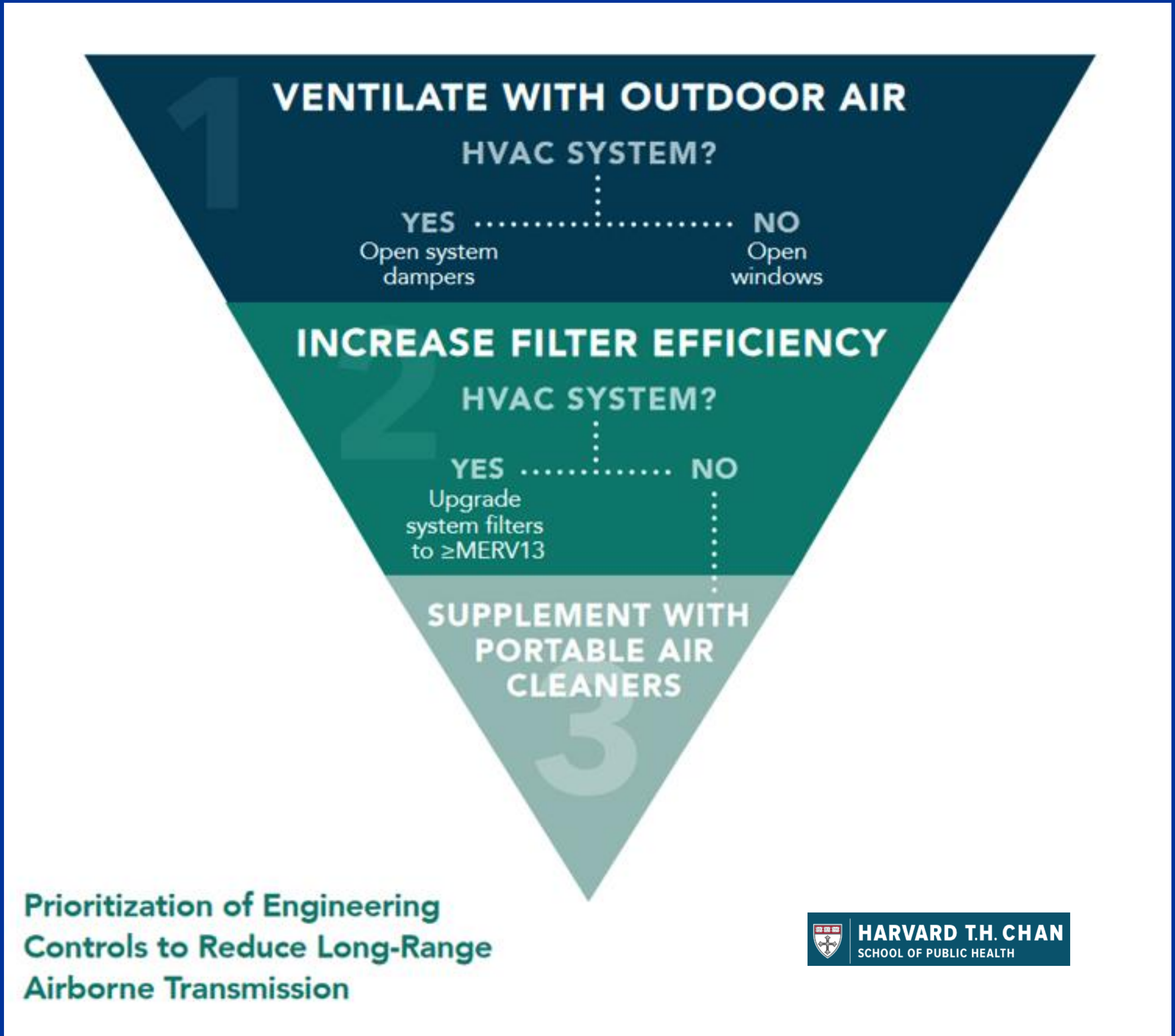
njea

WEC



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

Strategies for Protecting K-12 School Staff from COVID-19

https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/k-12-staff.html

- Increase total airflow supply to occupied spaces.
- Disable demand-controlled ventilation (DCV) controls that reduce air supply based on occupancy or temperature during occupied hours. (Note: Do not rely on CO_2 levels.)
- Further open minimum outdoor air dampers to reduce or eliminate HVAC air recirculation.
- Increase air filtration to as high as possible.
- Run HVAC system at maximum OA for 2 hours before & after occupied times.
- Operate restroom exhaust fans at full capacity while building is occupied.
- Maintain local exhaust ventilation in kitchens & cooking areas.
- Consider portable HEPA fan/filtration systems.
- Generate clean-to-less-clean air movement. Evaluate positioning of supply & exhaust air diffusers & dampers (especially in higher risk areas such as administrative reception areas & nurse's office).

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.

Risk Reduction Strategies for Reopening Schools

https://schools.forhealth.org/wp-content/uploads/sites/19/2020/06/Harvard-Healthy-Buildings-Program-Schools-For-Health-Reopening-Covid19-June2020.pdf

HARVARD T.H. CHAN
SCHOOL OF PUBLIC HEALTH

- Maximize outdoor air; eliminate or minimize recirculation.
- Ensure outdoor air inlet is not located close to exhaust air outlet to prevent re-entry of contaminated air.
- Increase natural ventilation via open windows and doors.
  - Consider using window fans or box fans positioned in open windows to supply outdoor air via one window and to exhaust indoor air via another window.
- Increase filtration on recirculated air to MERV 13 or higher.
- Supplement filtration with HEPA-equipped portable air cleaners.
  - Size devices carefully based on the size of the room.
- Measure carbon dioxide (CO_2) as a proxy for ventilation.← NO!

njea

WEC

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, and inoffensive odor.
- **Class 2**: moderate contaminant concentration, mild sensory-irritation intensity, or mildly offensive odors.
- **Class 3**: significant contaminant concentration, significant sensory-irritation intensity, or 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 Zone

(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values: Occupant Density (see Note 4)	Default Values: Combined Outdoor Air Rate (see Note 5)		Air Class
	cfm/person	L/s·person	cfm/ft^2	L/s·m^2		#/1000 ft^2 or #/100 m^2	cfm/person	L/s·person	
Correctional Facilities									
Cell	5	2.5	0.12	0.6		25	10	4.9	2
Dayroom	5	2.5	0.06	0.3		30	7	3.5	1
Guard stations	5	2.5	0.06	0.3		15	9	4.5	1
Booking/waiting	7.5	3.8	0.06	0.3		50	9	4.4	2
Educational Facilities									
Daycare (through age 4)	10	5	0.18	0.9		25	17	8.6	2
Daycare sickroom	10	5	0.18	0.9		25	17	8.6	3
Classrooms (ages 5–8)	10	5	0.12	0.6		25	15	7.4	1
Classrooms (age 9 plus)	10	5	0.12	0.6		35	13	6.7	1
Lecture classroom	7.5	3.8	0.06	0.3		65	8	4.3	1
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3		150	8	4.0	1
Art classroom	10	5	0.18	0.9		20	19	9.5	2
Science laboratories	10	5	0.18	0.9		25	17	8.6	2

Epidemic Task Force: Schools & Universities July 17 2020

https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-reopening-schools-and-universities-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.
- Operate all HVAC in occupied mode for a minimum of one week prior to occupancy.
- Verify proper separation between outdoor air intakes and exhaust discharge outlets to prevent/limit re-entrainment of potentially contaminated exhaust air.
- During the pandemic… introduce the maximum possible OA flow 24/7 until further notice.
- Apply the highest MERV [filtration] applicable… MERV 13 is recommended minimum if equipment can accommodate pressure drop and HEPA or MERV 14 are preferred.
- Check unit ventilators for proper amounts of OA and operation.
- Install portable humidifiers in each classroom for local humidity control.
- Adjust airflow patterns in classrooms to minimize occupant exposure to particles.

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%			50–65	>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		

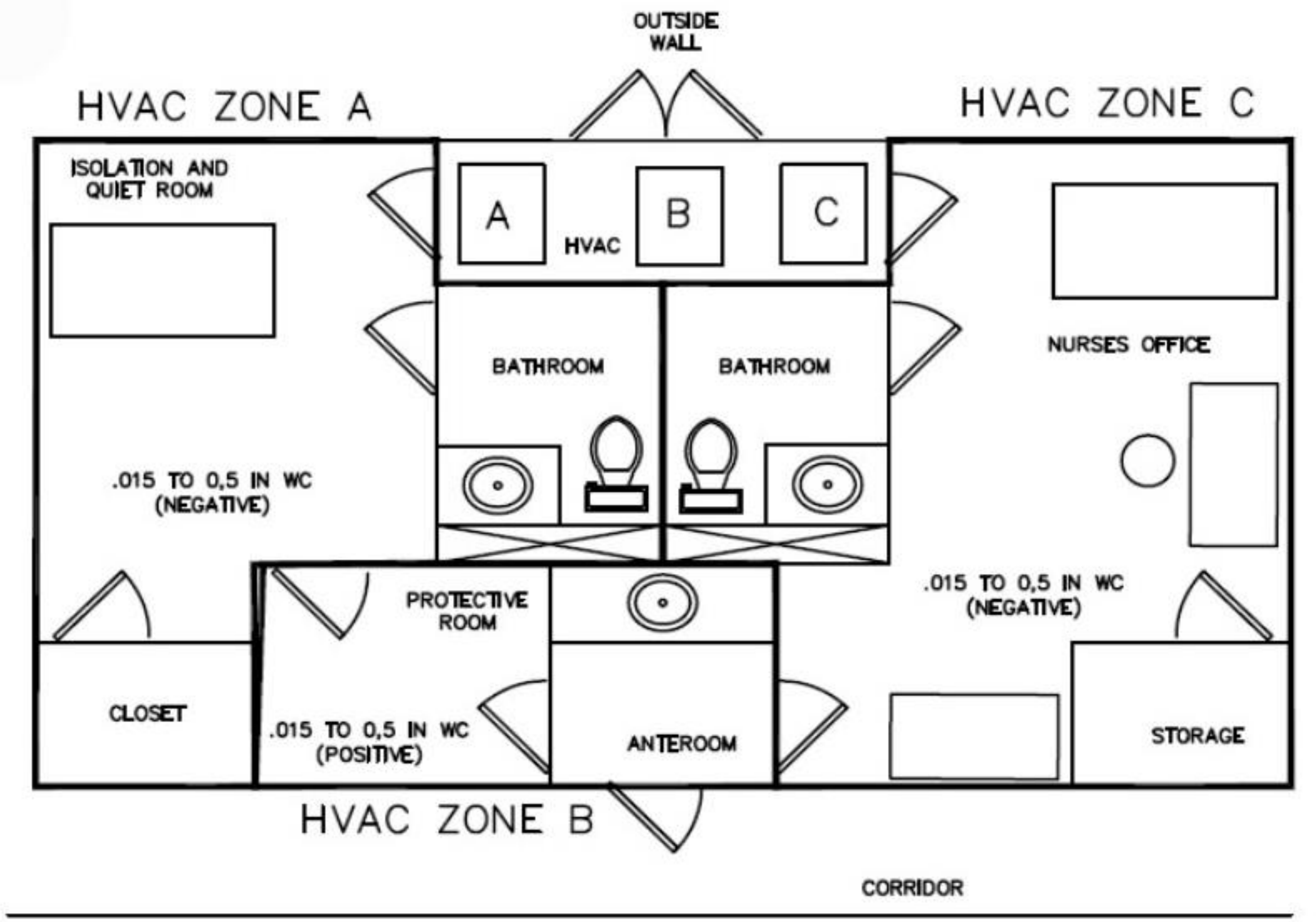
* MERV 6 is prescribed by ASHRAE Standard 62-2001 (ASHRAE 2001) for minimum protection of HVAC systems.

Nurses' Office/Suite: General Requirements

https://www.ashrae.org/technical-resources/reopening-of-schools-and-universities

Isolation Mode:

- Dedicated system; 100% OA; 10 ACH, 6 ACH minimum
- Exhaust directly to exterior; no re-circulation
- 2 filter banks, MERV 7 & HEPA (or MERV 7 & 14 if HVAC cannot support HEPA)
- Negative pressure
- Run supply & exhaust ventilation during occupancy & 2 hours before & after.



Note:
Systems A, B, and C are the Dedicated "Isolation Mode" systems, each system is individually operated and controlled.
The Supplementary HVAC systems for "Normal mode" are not shown.

Final Reminder
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NJEA Health & Safety: technical assistance request process

1. Local EA contacts Uniserv Field Rep
2. Uniserv Field Rep submits request to Mike Rollins
3. NJEA contacts NJ WEC
4. NJ WEC industrial hygiene consultant contacts Uniserv Field Rep and local EA

Don't let this be you!

NEW JERSEY
EDUCATION ASSOCIATION

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