Welcome! - How to Participate Online

• Use computer audio (versus telephone).
• All participants are muted upon entry. Please do not unmute yourself.
• Please do not turn on your camera unless you are speaking.
• Hover your cursor over the WebEx window to access the menu pictured below.
• To ask a question, type it into the Chat function.

• Raise your hand to request to be un-muted when we pause for questions and comments:
  • Open the Participants panel & click the hand icon next to your name
Airborne Threats:
Latest on Masks, HVAC, and COVID-19
Transmission in the Built Environment
Opening Remarks

William Raisch

Dr. Michael Horodniceanu, PE

Co-Directors, Project NEXT™
Informed by Ongoing Input from Diverse Group of Major Corporations & Others

- **Dozens of Major Corporations**
  Connected 24/7/365

- **Collaborating on Shared Risks**
  including COVID-19

- **Identified the Clear Need for More Coordination and Common Resources on COVID-19**
  including Sharing of Developing Practices & Lessons Learned

Security Operations Collaboration Network (SOC-NET)
The Need

- New Guidance for New Demands to Address COVID-19 / Infectious Disease in the Operations and the Built Environment
- Actionable Strategies Needed in Near Term & To Be Evolved with Experience
- Many Individual Efforts by Organizations Cobbling Together their Strategies
- Some Group Efforts but Often Siloed The Yet all Segments are Interdependent
- Result is Much Re-Invention with Potentially Disjointed Strategies
- Diverse Efforts Should Be Harmonized

- Multi-Disciplinary and Multi-Stakeholder Input Vital – with operations insights as well as key expertise disciplines
- Costs & Returns Must Be Considered to Assure Resources
- Economic Incentives Should Be Developed
- Neutral Convening Party Important
- Continuing Engagement Necessary to Evolve Guidance & Resources based on Experience as well as to Cross-Pollinate
- This Major Reset is also an Opportunity to Advance Additional Imperatives
The Response: Project NEXT™

**Mission:** To bring key stakeholders together to best adapt and re-imagine operations and operating environment for organizations in response to the current and emerging threats including infectious disease – *while also innovating for the better.*
Core Objectives

• Connect Diverse Stakeholders in Partnership with Leading Associations / Organizations
  • Subject Matter Experts (infectious disease / public health, architecture & engineering, performance improvement, sociologists, etc.)
  • Operators (of offices, retail, transportation, etc.)
  • Solution Providers (Technology, PPE, etc.)

• Enable Robust Cross-Pollination of Practices & Lessons Learned on an Ongoing Basis
  • Within Segments / Between Segments / Internationally

• Advance a Holistic Vision - Supporting Coordination Across Efforts
  • Landscape / Identify Current Guidance and Assemble into Resource Hub
  • Distill Common Principles and Framework from Authoritative Sources and Existing Efforts and Use Common Framework to Enable Comparative Analysis among Efforts
  • Give New Efforts an Initial Common Framework to Build From

• Build Back Better: Advancing Core Imperatives in creating our New Environment
  • Social including Racial Equality, Environmental and Governance.

• Integrate Incentives: Insurance, Legal Liability, Rating Agency, Operational Risk / Continuity
Targeted Environments for Implementation

- Office
- Retail
- Residential
- Hospitality
- Manufacturing / Factories
- Distribution (warehouses, fulfillment centers, trucking/freight, maritime)
- Education (primary, secondary, higher education)
- Entertainment / Tourist Attractions / Museums / Theaters

- Public Transport (aviation, rail, buses)
- Surface Transportation (individual autos, trucking, etc.)
- Food Service
- Utilities (water, power, telecom, gas)
- Government Facilities / Functions (public safety, courts, elections, etc.)
- Health Care Facilities
- Agriculture
Targeted Environments for Implementation

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- Health Care Facilities
- Agriculture
Key Strengths

Multi-disciplinary Approach & From Vetted Authoritative Sources

- Engaging diverse expertise from infectious disease, corporate operations, architecture, engineering, sociology, standards / codes, ergonomics, change management, organizational resilience and more.

- Embracing Diversity of Opinion but Assuring Credible Organizations & Experts

Robust Stakeholder Engagement:

- 15 year history of successful stakeholder engagement. Building upon an active network of dozens of multinational corporations who interact weekly and serve as a real-time source of insights on evolving practices and vetting.

Core Expertise in the Built Environment & Operational Risks / Resilience.

- Institute for Design & Construction Innovation Hub
- International Center for Enterprise Preparedness (INTERCEP)
Key Strengths

Focus on Targeted Operating Environments
• Working directly with key stakeholders in these environments to identify the distinct challenges of office, retail, manufacturing, etc.

Bottom-Line Impacts
• Directly engaging insurance, legal liability, rating agencies as well as business risk management expertise. The objective will be to integrate financial incentives for organizations.

Actionable / Solution-Oriented Outcomes
• Evaluating current solutions, providing input on their improvement as needed, advancing innovation of new solutions when needed
Global Resource Hub & Stakeholder Outreach

- Actionable Insights
- Expert Briefings
- Best Practice Forums
- Solution Sourcing
Collaborating with Leading Associations to Engage & Support Key Sectors
Understanding the Challenge: Fundamentals of airborne transmission and what do we know and don’t know about transmission of COVID-19 – right now?

Mark Keim, MD

Former Associate Director for Science, US Centers for Disease Control and Prevention (CDC)

President & CEO, Disaster Doc
Principles related to airborne transmission of disease

By Mark Keim, MD, MBA
5 topics to inform our discussion...

Current transmission
Dose
Risk
Precautionary principle
Managing risk
Talking, sneezes and coughs create both droplets and aerosols

<table>
<thead>
<tr>
<th>Activity</th>
<th>Droplets produced</th>
<th>Small aerosols (1-2 microns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talking</td>
<td>Hundreds to thousands</td>
<td>Mostly</td>
</tr>
<tr>
<td>Cough</td>
<td>Hundreds to thousands</td>
<td>Mostly</td>
</tr>
<tr>
<td>Sneeze</td>
<td>Thousands to millions</td>
<td>Mostly</td>
</tr>
</tbody>
</table>

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*Morawska 2006*
1. Standard precautions
2. Transmission-based precautions
   • Contact precautions
   • Droplet precautions
   • Airborne precautions

• PPE for contact precautions
  • Gloves and gown

• PPE for droplet precautions
  • Glove and gown, plus
  • Eye protection, plus
  • Surgical mask

• PPE for airborne precautions
  • Glove and gown, plus
  • Eye protection, plus
  • NIOSH-approved N95 respirator
Airborne transmission occurs among viruses similar to SARS-COV-2.

CDC Recommendations for other coronaviruses (COV)

• SARS COV-1: 2003
• MERS COV: 2012-15
According to current evidence, COVID-19 virus is transmitted between people through respiratory droplets and contact routes.

WHO - March 29

“According to current evidence, COVID-19 virus is transmitted between people through respiratory droplets and contact routes.”

WHO - July 9

• “The role and extent of airborne transmission outside of health care facilities, and in particular in close settings with poor ventilation, also requires further study.”
The growing concern for airborne spread

February 2020

- Outbreak in China was reported to involve an air-conditioned restaurant in which, “Virus transmission in this outbreak cannot be explained by droplet transmission alone.”

- The Lancet reported asymptomatic cases in China. These implications were clear. It is possible to contract (and possibly spread) COVID19 without symptoms...without coughing or sneezing (i.e. without droplets).

March 2020

- JAMA reported that swabs taken from the air exhaust outlets tested positive, suggesting airborne virus.
- WHO recommended the use of N95 (i.e. FFP2 standard) respirators in clinical and community settings.

April 2020

- US Surgeon General demonstrated how to make a facemask from a t-shirt despite “only marginal protection” against COVID19.
July 2020
• 239 scientists wrote an open letter calling for airborne transmission to be reconsidered
The larger the dose, the more severe the disease
DOSE is dependent on concentration and time.
Risk is dependent upon probability and impact.
Low probability – High impact events are very challenging
Precautionary principle

• The burden of proof for potentially harmful actions rests on the assurance of safety (by industry or government)

In other words, it is better to err on the side of safety when the potential impact is high.
Hierarchy of controls
(in decreasing order of effectiveness)

1. Elimination
2. Substitution
3. Engineering (e.g. HVAC)
4. Administration (e.g. social distance)
5. Personal protection (PPE)
Source-path-receiver approach for risk control

**Source**
- Modify, Redesign, Substitute, Relocate, Enclose

**Path**
- Absorb
- Block
- Dilute
- Ventilate

**Receiver**
- Enclose, Protect, Relocate
Thank you

For more info see

http://disasterdoc.org
Understanding the Challenge: What are the physical & human considerations in the built environment?

Mary Beth Labate
President
Commission on Independent Colleges and Universities

Ali Vedavanz
Adjunct Professor, NYU Tandon School of Engineering
Director of Engineering, The City University of New York
Ali Vedavarz

Adjunct Professor, NYU Tandon
School of Engineering

Director of Engineering, The City
University of New York
Key Principles

• Most Indoor Air Quality problems can be prevented and resolved through simple, inexpensive measures.

• The cost and effort needed to prevent most IAQ problems is significantly less than the cost and effort required to resolve problems after they develop.

• To understand IAQ problems and solutions, it is important to know what factors affect IAQ. These include:
  • Sources of indoor air pollutants
  • Heating, ventilation, and air condition (HVAC) systems
  • Building occupants
  • Pollution pathways
Properly Designed HVAC Systems can:

- Control temperature and humidity to provide thermal comfort.
- Distribute adequate amount of outdoor air to meet ventilation needs of building occupants.
- Isolate and remove odors and pollutants through pressure control, filtration and exhaust fans.

Not all HVAC systems accomplish all of these functions depending on building needs and system design.

- The two most common HVAC designs are unit ventilators and central air handling systems. Both can perform the same HVAC functions, but a unit ventilator serves a single room while a central air-handling unit serves multiple rooms.
General short-term solutions for reopening schools, universities, hospitals, hotels, gyms, etc.

*Labs and hospitals:*

- There are many existing labs, hospital rooms, and other spaces that have 100% makeup air system which means:
  - The distribution air to maintain proper temperature, humidity, and adequate ventilation comes from outside.
  - And it is separately exhausted (no recirculation of air).
General short-term solutions for other than hospitals and similar

- Increasing the supply of outside air.
- Removing point sources of indoor pollutants (through exhausting fume hoods and local exhaust fans to the outside) before they disperse.
- Using 100% air side economizer if the AHUs have the capability.
- Utilize operable windows where possible.
- Replacing the AHU filters more frequently.
- Replace the filters with high efficient filters without reducing the air flow distribution.
- To enhance dilution and filtration, keep systems running longer hours (24/7 if possible).

- Add portable room air cleaners with HEPA or high-MERV filters.
- Bypass energy recovery ventilation systems that may leak contaminated exhaust back into the supply air.
- Teaching and training of building facility staff and occupants about IAQ issues. People in the buildings can reduce their exposure to many pollutants by understanding basic information about their environment and knowing how to prevent, remove, or control pollutants.
- Add upper room and/or portable UVGI devices in high-density spaces (waiting rooms, prisons, shelters).
- Installing UV filters or bipolar ionization system ($15K to $20k per AHU).
Identifying Potential Approaches / Solution Strategies: What are lessons from Engineering, Occupational Safety & Health and Infection Control?

Michael Connor
SVP & Head of Property & Buildings, WSP
Lead HVAC Instrumentation & Controls Engineer for CDC High Containment Continuity Lab

Richard L. Corsi, Ph.D., P.E.
H. Chik M. Erzurumlu Dean, Maseeh College of Engineering and Computer Science
Portland State University

Dr. Gurumurthy Ramachandran
Director, Education and Research Center for Occupational Safety and Health
Johns Hopkins University
Identifying Potential Approaches / Solution Strategies:
What are lessons from Engineering, Occupational Safety & Health and Infection Control?

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ASHRAE COVID-19 Task Force

— Several Sub-Committees feeding into the Taskforce
  — ASHRAE Environmental Health
  — National Institute for Occupational Safety and Health (NIOSH)
  — TC 2.10 Resilience and Safety
  — TC 9.6 Healthcare Facilities
  — SPC 170 Ventilation of Healthcare Facilities

— Serves as clearing house to review all technical questions

— Coordinates ASHRAE’s inhouse resources and public communications
I. Aerosol Size Range

Particle size is often determined by the process that generated the particle. Combustion particles usually start out in the 0.01-0.05 μm size range, but combine with each other (agglomerate) to form larger particles. Powder is broken down into smaller particles and released into the air; it is difficult to break down such particles smaller than ~0.5 μm. Biological particles usually become airborne from liquid or powder forms, so these particles are usually larger than ~0.5 μm.
Particle Settling in Still Air

Time to settle 5 feet by unit density spheres

- 0.5 μm: 41 hours
- 1 μm: 12 hours
- 3 μm: 1.5 hours
- 10 μm: 8.2 minutes
- 100 μm: 5.8 seconds

Aerodynamic diameter definition: diameter of a unit density sphere that settles at the same velocity as the particle in question.
Particle Settling in a Closed Room

Stagnant air

Particles of the same size will settle at the same speed in still or stagnant air.

Turbulent air

Particles passing close to a horizontal surface can settle, but the rest will continue to be stirred.

Concentration profiles using a direct measurement instrument.
Particle Dynamics

- Large particles/droplets fall near the source.
- Small particles/aerosols remain airborne.
- Aerosols follow the flow path of air.
- Density, size, and shape of particulates can affect the dynamics.
- Droplets can evaporate and become aerosol.
- External forces can affect the trajectory.
Spread of Contaminant - Cloud of 25 PPM

Time = 600 [s]

Two exhaust grilles

Three exhaust grilles
Identifying Potential Approaches / Solution Strategies:
What are lessons from Engineering, Occupational Safety & Health and Infection Control?

Richard L. Corsi, Ph.D., P.E.

H. Chik M. Erzurumlu Dean,
Maseeh College of Engineering and Computer Science

Portland State University
Motivation

79 / 69 / 54 / 26 / 6 / 4

[Graph showing percentage of respondents by location and time of day]
Airborne Transmission: Restaurant X

- Most detailed case for airborne transmission
- Infector from Restaurant X (Index X)
- Predict volume of Index X particles in respiratory system of others
- Move Index X to other indoor environments
- Define $\Omega$ as new metric for comparison

$$\Omega = \frac{\text{Volume}_{\text{dep}}}{\text{Volume}_{\text{dep, Restaurant X}}}$$

Want $\Omega << 1$ (can we get there, and how?)
Busy Restaurant

100 m² x 3.14 m; 69 patrons + Index X; 75 minute event
ASHRAE 62.1 yields 4.1 h⁻¹

- Greater ventilation
- Outdoors
- Masks
- Distancing
- Reduce density
- Reduce time in space

Additional concerns: close contact & fomites

Richard L. Corsi, Ph.D., PE.
Dean, Maseeh College of Engineering & Computer Science, Portland State University
School Classroom

- 700 ft²; 25 students for 75 min

**Infector = teacher**
- Occasional cough (Index X)
- Speaks 50% of time
- Lower amp than Index X

**Infector = student**
- No cough (10% speak)

- Masks decrease $\Omega$ even more!

Richard L. Corsi, Ph.D., PE.
Dean, Maseeh College of Engineering & Computer Science, Portland State University
Choir Practice

- 50 participants (+ Index X) in 100 m² x 2.8 m for 75 min
- 50% time singing (elevated speaking); Heavier breathing (emit & inhale)*
- ASHRAE 62.1 2019 yields 3.6 h⁻¹

* Based on literature, e.g., Salomoni et al., *PloS One*, 2016; 11(5): e0155084

Additional concerns: close contact & fomites

- Concern across board
- Outdoors w/ distancing
- Remote?
Gym w/ Aerobic Activity

- 40 patrons; Staff member = Index X; Heavy breathing receptor (aerobics)
- 100 m² x 4 m; ASHRAE 62.1 2019: yields 3.9 h⁻¹

Avoid indoor gyms
Outdoor workout
Masks
Physical distancing

Additional concerns: close contact & fomites
Ride Share

1 Patron + Index X as driver; 3 m$^3$ cab; 20 mph; 20 minutes across town

Air exchange rates reasonable based on a number of peer-reviewed papers

- Masks (passenger(s) + driver)
- Crack open windows
- Avoid long trips / busy commutes
- Can get $\Omega \approx 0.1$

Additional concerns: close contact & fomites
Elevator

Index X + 1; 1 min travel w/o door opening; Air changes = 60 h⁻¹ (1 min⁻¹)

- Elevator airborne negligible
- Short trip / well-ventilated
- Masks
- No speaking etiquette
- Reduce density
- Distance & face away

< 1/1,000<sup>th</sup> Restaurant X

Richard L. Corsi, Ph.D., PE.
Dean, Maseeh College of Engineering & Computer Science, Portland State University
Extra Slides
Indoor profile = fn (indoor sources)

* Resuspension significant

Ren, J. *et al.* *Building & Environment*, Accepted (pre-print available 7/7/20)

Can enough infectious viruses accumulate on flooring, accounting for rate of inactivation, for resuspension to be relevant?
Should schools remove carpet where it still exists before return? Also easier to clean/disinfect impermeable flooring.

Ren, J. et al. Building & Environment, Accepted (pre-print available 7/7/20)
Impacts on Particle Transport Time & Distance

Gravitational settling

Less important for small particles

Possibility of thermophoretic & electrostatic effects

How far Can Particles Travel?

Modify to get rid of gravitational settling

At air speed of 5 cm/s in free stream

<table>
<thead>
<tr>
<th>(d_a) (μm)</th>
<th>(V_{15}) (m/s)</th>
<th>(k_d) (1/hr)</th>
<th>(X_{1.5m}) (m) - GS</th>
<th>(X_{50%}) (m) - PF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>7.5E-06</td>
<td>0.05</td>
<td>10000</td>
<td>2500</td>
</tr>
<tr>
<td>1</td>
<td>3.0E-05</td>
<td>0.1</td>
<td>2500</td>
<td>1200</td>
</tr>
<tr>
<td>5</td>
<td>7.5E-04</td>
<td>1.5</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>10</td>
<td>3.0E-03</td>
<td>7</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>50</td>
<td>7.5E-02</td>
<td>100</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Particles ≤ 10 μm not substantially removed w/in 6 ft

Even 50 to 100 μm particles can travel > 20 ft

Buoyant jet effect

None of this is new
Emissions via Speaking

- Reasonable range = 300 to 3,000/min (some super-emitters to 12K /min)
- Super-emitter: 6 min of speaking loudly \( \approx \) mean emission of single cough
- Breathing \( \approx \) order of magnitude lower than speaking
Deposited Inhalation Dose (DID)

\[
\text{Dose}_{\text{inhal},i} = C_i \, (\#/L) \times B \, (L/min) \times t \, (min) \times f_{\text{dep},i}
\]

- Terms important
- Location of deposition likely important
- Particle deposition converted to volume
- Combine w/ viral load & infectious fraction
- Use w/ dose-response relationship
- Perfect world = fn (dp, location)

Fig. 1. Exponential dose-response model fitted to the pooled data sets for SARS-CoV.

Ref & review
Particles as Vehicles for Dose of SARS-CoV-2

Near Field (close contact)
Large Droplets + Aerosol

Far Field
Background Aerosol
Identifying Potential Approaches / Solution Strategies: What are lessons from Engineering, Occupational Safety & Health and Infection Control?

Dr. Gurumurthy Ramachandran

Director, Education and Research Center for Occupational Safety and Health

Johns Hopkins University
Applying the Hierarchy of Controls for COVID-19

- **Elimination**
  - Social Isolation

- **Substitution**
  - Not applicable

- **Engineering Controls**
  - Ventilation, physical barriers

- **Administrative Controls**
  - Work from home, stagger schedules, hand hygiene

- **PPE**
  - Masks, respirators, gloves

Adapted from NIOSH
STAY HOME if you are sick.

**Symptoms to watch for:**

- Cough
- Shortness of breath or difficulty breathing
- Fever
- Chills
- Muscle pain
- Sore throat
- New loss of taste or smell

**Avoid contact with others while you are sick**

- Stay in a specific room at home and away from other people, as much as possible
- Talk with a doctor and your supervisor about when you can return to work
Talk with a doctor and your supervisor about when you can return to work.

Stay at least 6 feet (about 2 adult arms’ length) from other people at work and in your community as much as possible

- Stay at least 6 feet apart during conversations, in locker rooms, hallways or corridors, and when entering or leaving your workplace
- Do not share drinks or food with coworkers
- Tools should be regularly cleaned and disinfected, especially when you change workstations or move to a new set of tools
- Do not carpool, if possible

Wear a cloth face covering over your mouth and nose while in the workplace and in public

- Fit your covering snugly, but comfortably, against the sides of your face
- When removing your face covering, try not to touch your eyes, nose, or mouth, and wash your hands immediately
- Wash or replace the face covering after use
- Replace the face covering when it is wet or dirty
- Continue to wear the personal protective equipment (PPE) required for your normal work tasks
FOOD AND AGRICULTURE WORKERS: Occupational Group that is Especially at Risk

• Need to safeguard the US food supply chain by protecting food and agricultural workers
• Even prior to the pandemic, workers in animal slaughtering and meat processing plants faced hazardous conditions and high rates of injury and illness
• COVID-19 cases have been reported at 115 meat and poultry processing facilities across 19 states, infecting nearly 5,000 workers and killing 20
• Operating procedures at processing facilities often make it difficult for workers to maintain a 6-foot distance from one another.

• Facilities have had difficulty adhering to worksite cleaning and disinfection protocols.

• The speed and physical demands of processing work can make it difficult for line workers to adhere to recommendations for using face masks, and wearing a single face mask for the duration of a work shift is not recommended if it becomes wet or soiled.

• The environment in slaughterhouses may further compound the risk of transmission; experts have posited that low temperatures (designed to keep meat from spoiling) may help the virus survive.
SHIELD · TEST · TRACE · TREAT

• **SHIELD**: Protect workers using mitigation strategies based on the hierarchy of controls including in-plant COVID-19 mitigation strategies enhanced with personal protective equipment (PPE).

• **TEST**: Prioritize workers for regular COVID-19 testing.

• **TRACE**: COVID-19 cases must be subject to contact tracing by state and local health departments.

• **TREAT**: Provide workers affected by COVID-19 with access to healthcare, isolation and quarantine pay and other support to stop outbreaks.
Classroom Modeling: At Johns Hopkins University
We considered a range of conditions

Table 1: Parameter assumptions for evaluating the impact of mask efficiency. Additional assumptions: Volume of room = 150 m³; Breathing rate for all analysis = 0.8 m³/hr;

<table>
<thead>
<tr>
<th>Case</th>
<th>Ventilation (Air changes per hour)</th>
<th>Viral Decay Rate (hr⁻¹)</th>
<th>Emission Rate (quanta/hr)</th>
<th>Duration of class (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Risk Case</td>
<td>1.9</td>
<td>0</td>
<td>500</td>
<td>2</td>
</tr>
<tr>
<td>Medium Risk Case</td>
<td>9</td>
<td>0.32</td>
<td>135</td>
<td>1</td>
</tr>
<tr>
<td>Low Risk Case</td>
<td>17</td>
<td>0.63</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>High Risk Case</td>
<td>Ventilation (Air changes per hour)</td>
<td>Viral Decay Rate (hr⁻¹)</td>
<td>Emission Rate (quanta/hr)</td>
<td>Duration of class (hr)</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------------------------</td>
<td>-------------------------</td>
<td>--------------------------</td>
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<td>1.9</td>
<td>0</td>
<td>500</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

The maximum probability of infection was 84% for no mask wearing by instructors or students (mask efficiency =0).

Expected number of cases:
Number of uninfected people * Probability of infection
<table>
<thead>
<tr>
<th>Medium Risk Case</th>
<th>Ventilation (Air changes per hour)</th>
<th>Viral Decay Rate (hr⁻¹)</th>
<th>Emission Rate (quanta/hr)</th>
<th>Duration of class (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>0.32</td>
<td>135</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

The maximum probability of infection was 6% for no mask wearing by instructors or students (mask efficiency = 0).
<table>
<thead>
<tr>
<th>Low Risk Case</th>
<th>Ventilation (Air changes per hour)</th>
<th>Viral Decay Rate (hr⁻¹)</th>
<th>Emission Rate (quanta/hr)</th>
<th>Duration of class (hr)</th>
</tr>
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<tr>
<td></td>
<td>17</td>
<td>0.63</td>
<td>21</td>
<td>1</td>
</tr>
</tbody>
</table>

The maximum probability of infection was 6% for no mask wearing by instructors or students (mask efficiency = 0).
How Long to Wait Between Classes?

- Concentrations will be reduced to below 10% of their average levels within 1 hour for air change rates exceeding 2.5 hr\(^{-1}\). This process can be accelerated by opening classroom windows (if they exist) to substantially increase ACH.
What type of Face Coverings Should be Recommended?
Recommendations

To minimize risk of infection from classroom instruction we provide the following recommendations for the near future term:

• Only offer instruction for courses where at least 6 ft separation can be maintained between students and the instructor.

• Maximize fresh air ventilation to the extent possible on an HVAC unit with older buildings often not capable of 100% outdoor air in the classroom areas.

• Use the highest efficiency filters possible in air handling systems (MERV 14 or higher whenever possible). For some situations, portable HEPA air filtration systems may be a cost-effective approach to improve ventilation.

• Maintain temperatures between 72-80F and 40-65% RH. Cool, dry conditions are favorable for viral survival.

• Everyone should wear at least a fabric facial coverings (e.g. mask, bandana, gaitor) but, if possible, higher rated masks such as N95 are preferable. Face shields are not a substitute for masks.

• Classrooms should remain empty for one hour between sessions.
Evaluating Options:
What is Actionable in the Near Term &
What Needs Further Work /
Collaboration?
Join us in Advancing Project NEXT™

- **Allied Associations** – Jointly serving members

- **Leading Public & Private Organizations** – Share Best Practices and Lessons Learned

- **Corporate Partners** – Expertise & Support

Email us at: INTERCEP@nyu.edu or JLC27@nyu.edu