National Collaborating Centre for Environmental Health

Centre de collaboration nationale en santé environnementale

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COVID-19 Risks and Precautions for Choirs

NCCEH Evidence scan

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Choral Canada
August 19, 2020

Outline

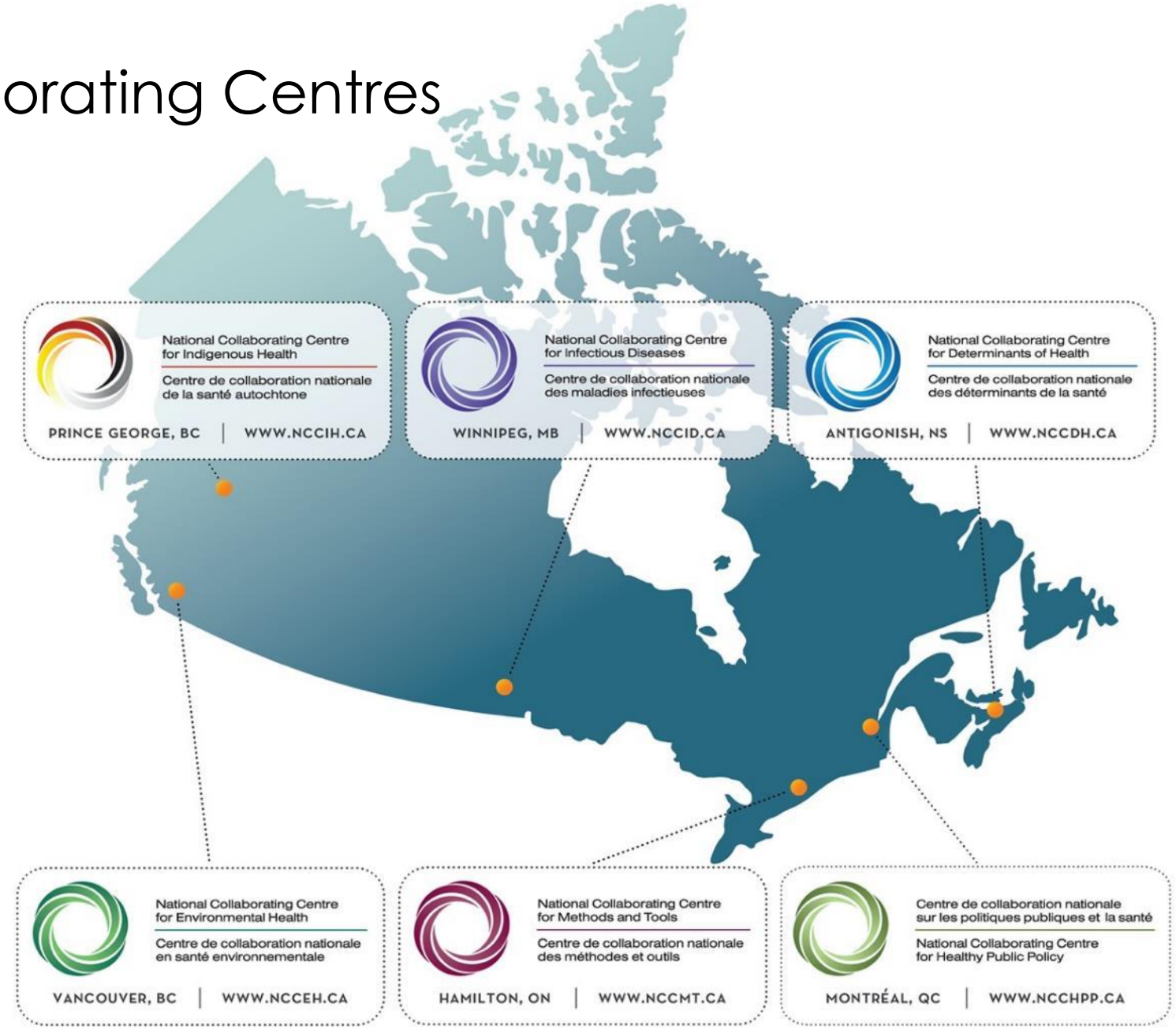
1. About NCCEH
2. Notable COVID-19 outbreaks related to choirs
3. Understanding transmission risks
4. Precautionary measures
5. Emerging research
6. Q&A

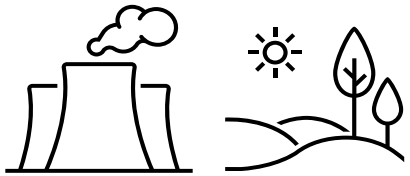
The National Collaborating Centres

Evidence-based knowledge synthesis and translation

Identify knowledge gaps

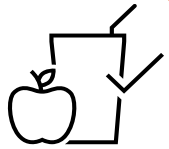
Foster networks, build capacity for Canada's public health system





Outdoor Air

Built Environment



Food

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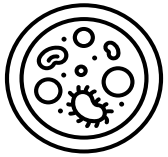
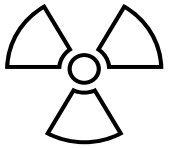
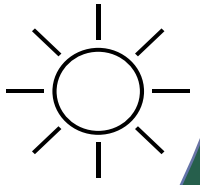
Water

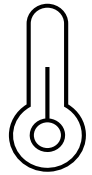
Contaminants and hazards





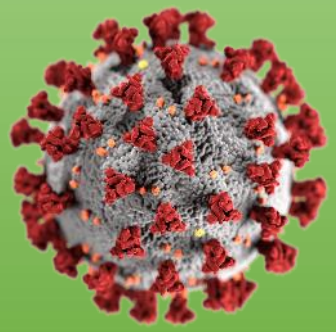
Climate





Emerging Public Health Issues

e.g. COVID-19



and hazards

COVID-19 resources for EH

Full report
available at NCCEH.CA
…and many other
COVID-19 resources

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Notable outbreaks

Skagit Valley Washington,

- 53 cases of 61 person choir, three hospitalizations, 2 deaths
- Low community spread, avoided physical contact, used hand sanitizer
- Long duration, minimal spacing (15-25 cm), limited ventilation

Berlin Cathedral Choir, Germany

- 60 cases of 80 persons who attended a March 9 practice
- One member reported a positive COVID-19 test March 14
- Within two weeks, 30 positive and 30 additional symptomatic

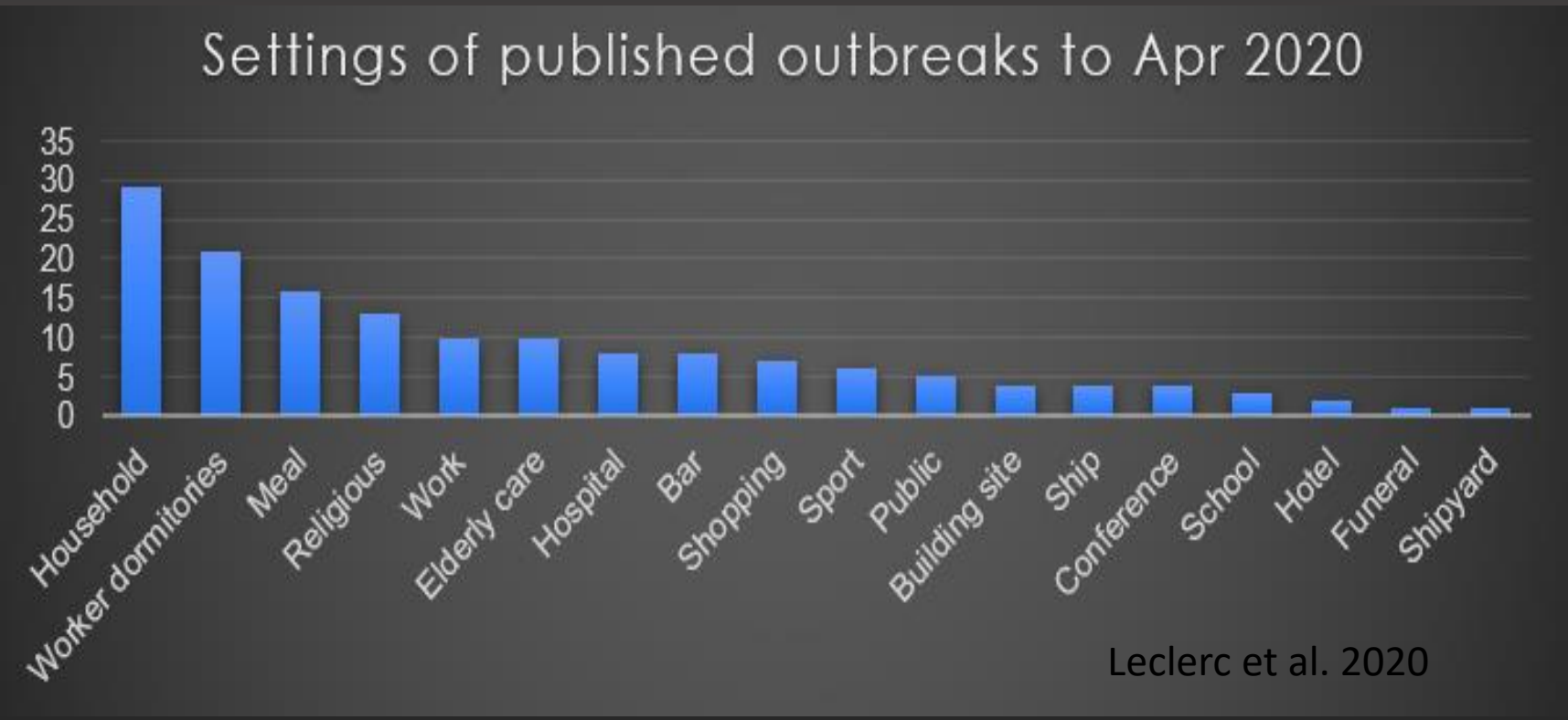
Amsterdam Mixed Choir, Netherlands

- 102 cases of 130 person choir, four deaths (1 member, 3 associated persons)
- Multiple rehearsals Feb 25-Mar 7
- Symptomatic persons reported on Mar 3, 7 rehearsals and March 8 performance

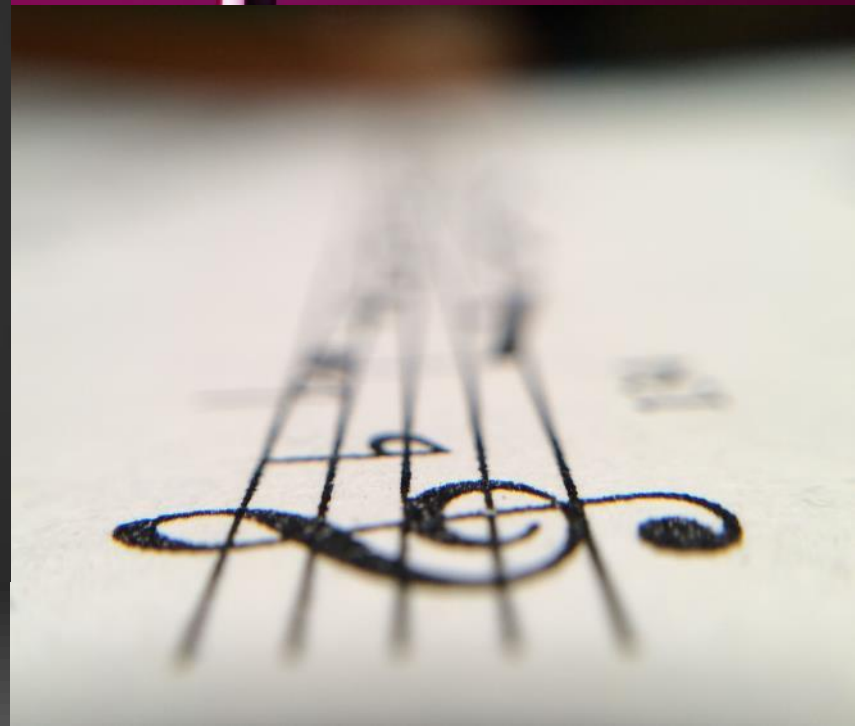
French choirs

- Feb 28 - Whir au Val (Haut-Rhin) 20 choristers and 69 secondary cases; 9 deaths
- Mar 12 - Men's choir practice, 19 cases of 27 participants, 7 hospitalizations, no deaths;
- Connected to another choir where several members reported symptoms

But outbreaks have occurred in other group settings where there was no singing – why are choirs special?



Leclerc et al. 2020



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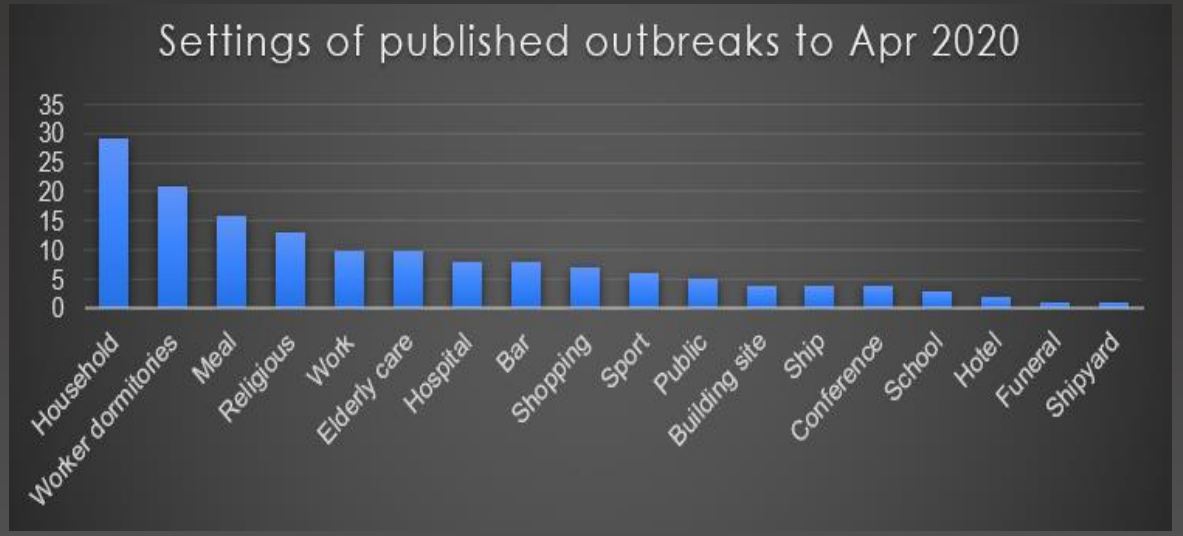
Common factors in many outbreaks

- Indoors
- Crowded spaces
- Close contacts
- Lots of interaction (greeting, talking, laughing, cheering, shouting, singing, sharing of food/objects)
- Long duration of interaction
- Poor ventilation
- Prevalence of community spread of the virus (symptomatic and asymptomatic)



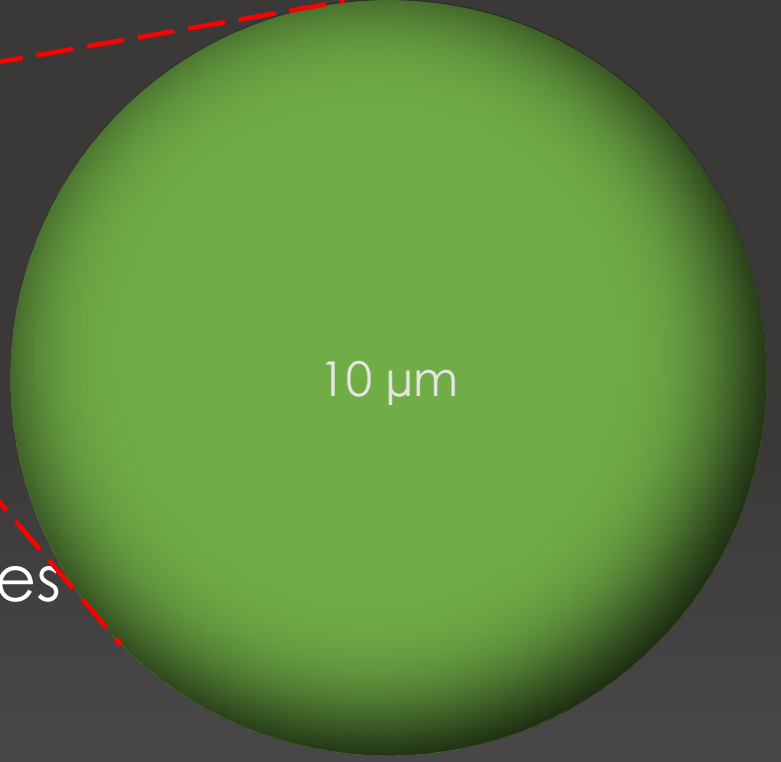
Large respiratory droplets – direct exposure when in close contact with an infected person who is sneezing, coughing (droplets > 5 µm)

Smaller respiratory droplets/aerosols – direct exposure from close contact or indirect exposure from accumulated aerosols

(droplets of < 5 µm)

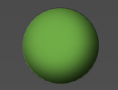
Contact with contaminated surfaces/fomites followed by contact with nose, mouth, or eyes

Particle size



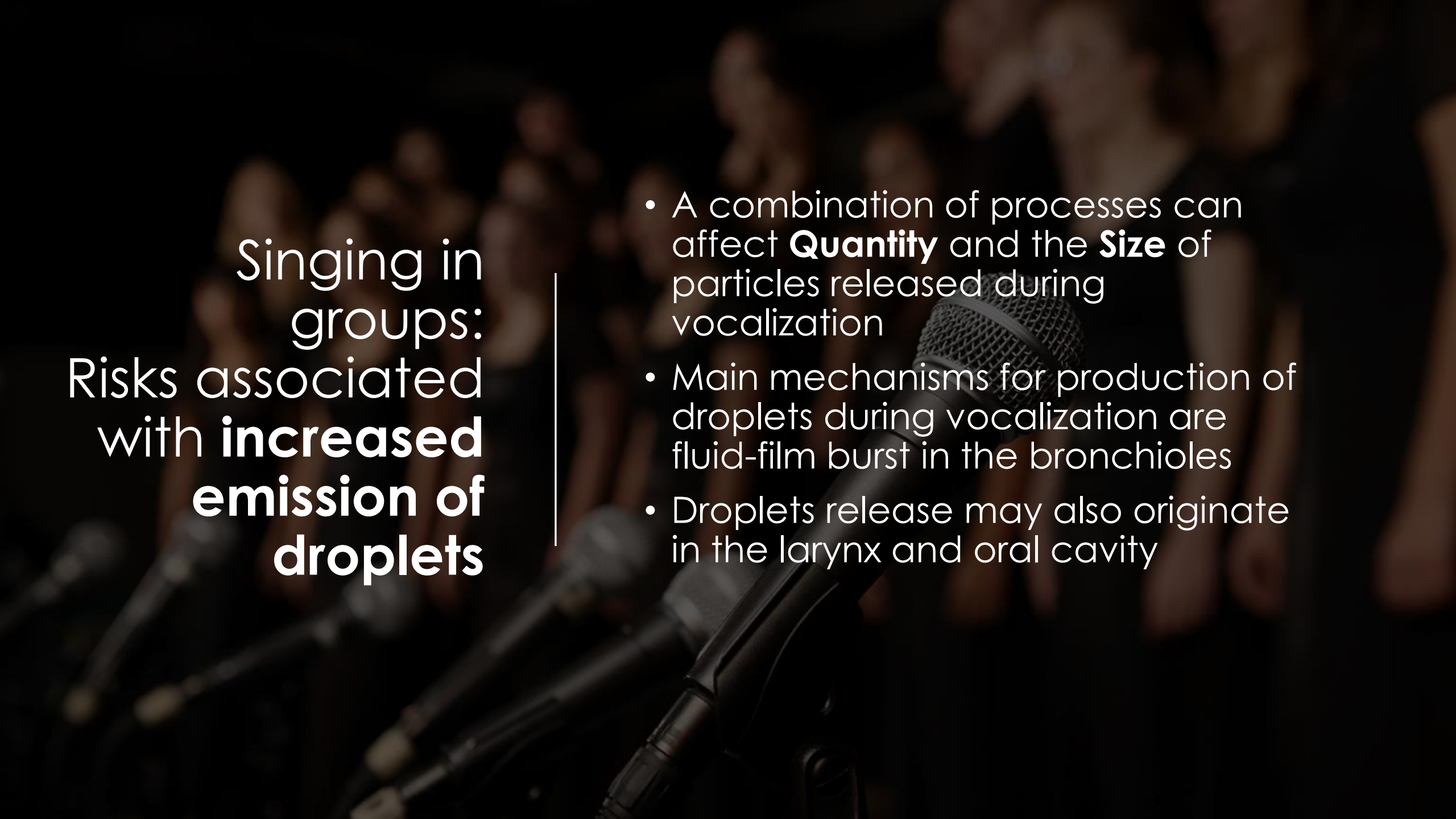
- Large droplets (≥ 5~10 µm)
  - More likely to fall to the ground at short distance
  - Intense but less frequently release in coughs/sneezes
  - More likely expelled by symptomatic persons
  - Upper airway

- Smaller droplets/aerosols (< 5 µm)
  - Less likely to fall to ground at short distance
  - May persist in the air for longer/accumulate
  - Less intense release but could be generated continuously
  - Generated by symptomatic AND asymptomatic/pre-symptomatic persons
  - Potential to reach lower respiratory tract



Singing in groups: Risks associated with **large gatherings**

- **Close contact** while greeting, talking, laughing, sharing of sheet music, stands, microphones
  - Increases risk of exposure to respiratory droplets and short-range aerosols
- Gathering in **large numbers for prolonged duration indoors**
  - Increases risk of exposure to accumulated aerosols
  - Limited ventilation reduces the dilution and dispersion of aerosols
- **Sharing of surfaces or objects** such as musical stands, chairs, books, microphones, instruments, food, dishes, drink dispensers
  - Increased risk of exposure via fomites



Singing in groups: Risks associated with **increased emission of droplets**

- A combination of processes can affect **Quantity** and the **Size** of particles released during vocalization
- Main mechanisms for production of droplets during vocalization are fluid-film burst in the bronchioles
- Droplets release may also originate in the larynx and oral cavity

Singing in groups: Risks associated with **increased emission of droplets**

Quantity

- Vocalization of any type releases a higher concentration of particles than breathing
- Singing releases more particles than speaking
- Particle release is affected by:
  - Volume (Louder = more aerosols)
  - Vocalization style/enunciation
  - Deep exhalation and rapid inhalation
  - Super-emitters

Singing in groups: Risks associated with **increased emission of droplets**

Particle size

- Studies have found that vocalization can produce a range of particle sizes
  - Smaller droplets dominate (≤ 5-10 µm)
  - Up to 80% are ≤ 1 µm
  - Smaller droplets can remain suspended and travel further than large droplets
  - Smaller droplets are much more likely to penetrate the lower respiratory tract

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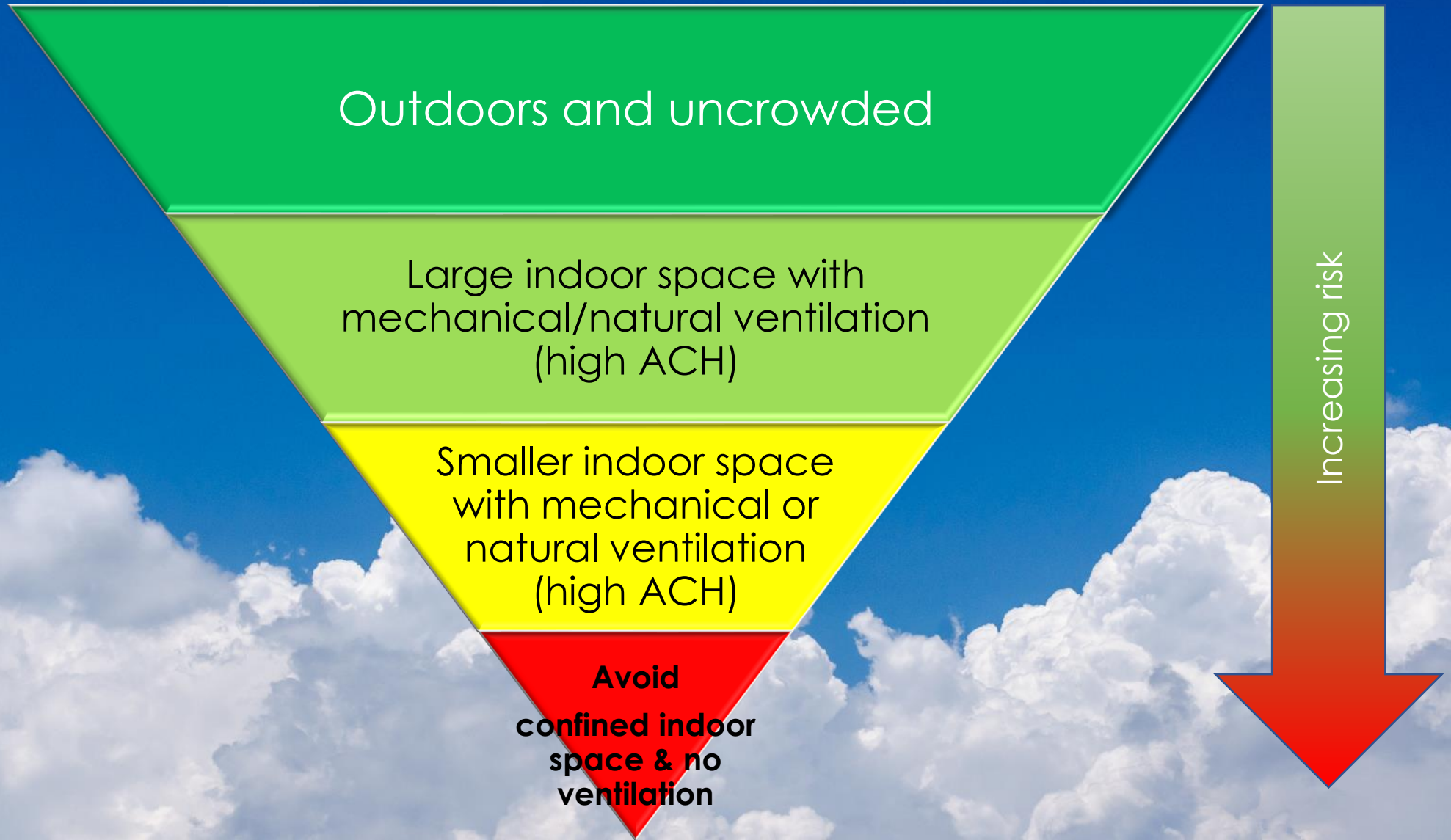
Minimizing the Risks: Distancing

- Maintaining 2 m between participants helps reduce spread due to LARGE respiratory droplets
- Distancing can also help to reduce some of the short-range transmission of smaller droplets
- Maintaining distance is easier in larger venues/rooms
- Ensure distancing is maintained for ALL activities, not just while singing (e.g. entry/exit, warm up spaces, bathrooms)
- Additional barriers or partitions could be considered where practical to do so and distancing is difficult to maintain

Minimizing the Risks: Reduce density and duration

- Larger spaces with fewer faces
  - Reduced loading of infectious particles; increased dilution and dispersion of accumulated aerosols
- Shorter duration (e.g. 30 minutes) and breaks between rehearsal or performance
  - Reduces accumulation of potentially infectious particles
  - Breaks should be in a different location, and not compromise distancing principles

Minimizing the Risks: Ventilation



Minimizing the Risks: Personal measures

- Symptomatic or potentially exposed persons should stay home
- High risk/susceptible persons should stay home
- Face coverings – if possible wear at all times, particularly where closer encounters are more likely (More on masks in the Q&A)
- Hand hygiene
- Avoid close contact, handshakes, sharing of objects/equipment

Risk Assessment

- Various approaches (WHO, Spahn and Richter 2020, PHAC, etc.)
- Consider the specific circumstance
  - Risk level of participants
  - Risk level of the venue
  - Risk level of the activity
  - Level of community transmission
- Consider mitigation potential
  - Hierarchy of controls/mitigation measures, local PH advice
- Does mitigation eliminate or reduce risks sufficiently?

Total Risk Assessment Score from COVID-19 Risk Evaluation Tab	2
Total Mitigation Score from COVID-19 Mitigation Tab (%)	1

Risk Versus Mitigation Decision Matrix				
	Total Mitigation Score (%)			
Total Risk Score	76-100	51-75	26-50	0-25
0	VERY LOW	VERY LOW	VERY LOW	LOW
1	VERY LOW	LOW	LOW	MODERATE
2	LOW	LOW	MODERATE	MODERATE
3	MODERATE	MODERATE	HIGH	HIGH
4	HIGH	HIGH	VERY HIGH	VERY HIGH
5	VERY HIGH	VERY HIGH	VERY HIGH	VERY HIGH

KEY	
VERY LOW	Overall risk of transmission and further spread of COVID-19 is considered VERY LOW
LOW	Overall risk of transmission and further spread of COVID-19 is considered LOW
MODERATE	Overall risk of transmission and further spread of COVID-19 is considered MODERATE
HIGH	Overall risk of transmission and further spread of COVID-19 is considered HIGH
VERY HIGH	Overall risk of transmission and further spread of COVID-19 is considered VERY HIGH

• Individuals having recurring negative test-results (see Sports, Wiener Philharmonic, Thomaner) • No Risk reducing measures necessary	Very low Risk
• Observance of Minimum Distance (radial 2m/6$^{1/2}$ feet, or 1,5m lateral and 2m in front, staggered arrangement) • Outdoors • Closed spaces – Very large („Cathedral-Situation") – High air exchange rate (HAVAC (6/h)) or sufficient intermittent ventilation (CO_2–traffic light) – Wearing surgical masks while singing – Specific Measures in Brass-/Wind Instruments (Shields, condensation water)	Remarkable reduction of Risk
• Abnormalities during entrance screening • No observance of distances (radial 2m, or 1,5m lateral and 2m in front), • Too many people in a room • Insufficient ventilation	High Risk
• Absence of Risk awareness • Absence of Risk reducing measures	Ultra-High risk

Spahn/Richter 2020: Risiko Management Corona in the field of music

assessment of the infection risk depending on the risk-reducing measures (based on the Nohl 2019)

Table 3. Matrix for determining overall risk of contributing to COVID-19 community transmission and next steps

		Risk mitigation potential (from Table 2)		
		Stronger	**Moderate**	**Weaker**
Risk level (from Table 1)	**High**	**Moderate risk** of contributing to COVID-19 community transmission. Increase or strengthen mitigation strategies if possible.	**Higher risk** of contributing to COVID-19 community transmission. Consider delaying reopening. Increase or strengthen mitigation strategies.	**Highest risk** of contributing to COVID-19 community transmission. Consider delaying reopening. Increase or strengthen mitigation strategies.
	Medium	**Lower risk** of contributing to COVID-19 community transmission. Maintain mitigation strategies.	**Moderate risk** of contributing to COVID-19 community transmission. Increase or strengthen mitigation strategies if possible.	**Higher risk** of contributing to COVID-19 community transmission. Consider delaying reopening. Increase or strengthen mitigation strategies.
	Low	**Lowest risk** of contributing to COVID-19 community transmission. Maintain	**Lower risk** of contributing to COVID-19 community transmission. Maintain mitigation strategies.	**Moderate risk** of contributing to COVID-19 community transmission. Increase or strengthen

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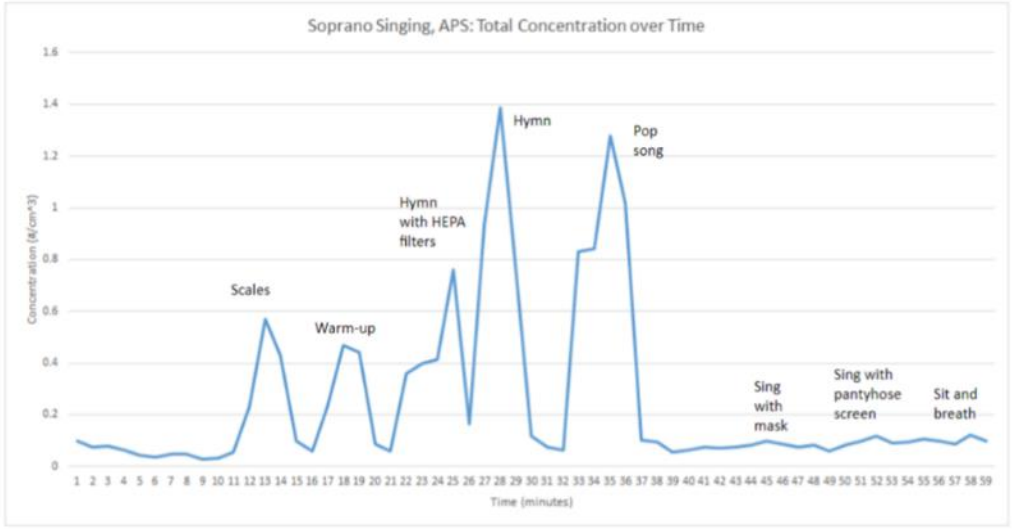
Emerging research (USA)

- International Coalition for the Performing Arts – preliminary results
  - Studies indicate that a higher concentration of respiratory particles are released during singing compared to breathing
  - Measurements indicate the effectiveness of masks and screens for reducing release of respiratory particles
  - Models of infection risk indicate risk increases over time; masks reduce risk overall

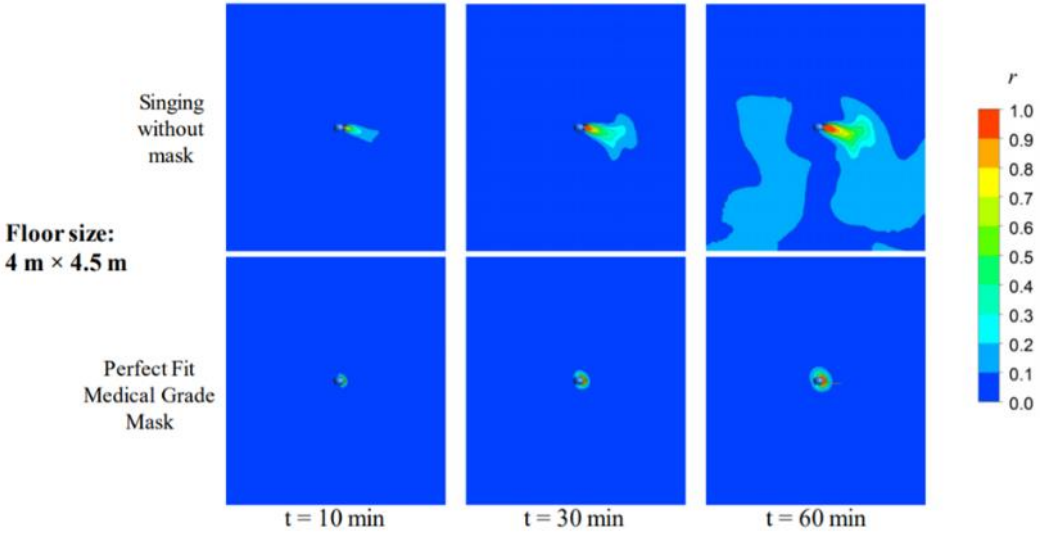
International Coalition of Performing Arts. **2020**

Singing APS (0.5-20 µm particles)



Indoor Case Study: Mask Impact on Infection Risk

Infection risk r by Wells-Riley equation at the height of mouth opening, with breathing rate of 8 L/min.



Emerging research (Germany)

- Mürbe et al. 2020
  - Laser particle counter study, 8 subjects during breathing, speaking and singing.
  - Significantly higher emission rates for singing compared to mouth breathing and speaking; Emissions increased with volume
  - Variation between singers; Higher emission rates for phonation by females vs. males
- Hartmann and Kriegel 2020
  - Relationship between CO_2 and aerosol concentration
- Hartmann et al. 2020
  - Risk assessment of rehearsal rooms for choirs with regard to virus-laden aerosols; Compared rehearsal rooms, concert Halls and office space
- Kriegel and Hartmann 2020
  - Indoor risk assessment of virus laden aerosols..

See Spahn and Richter 2020. Risk Assessment of a Coronavirus Infection in the Field of Music. Fourth update (2020 July 17). https://www.mh-freiburg.de/en/university/covid-19-corona/risk-assessment

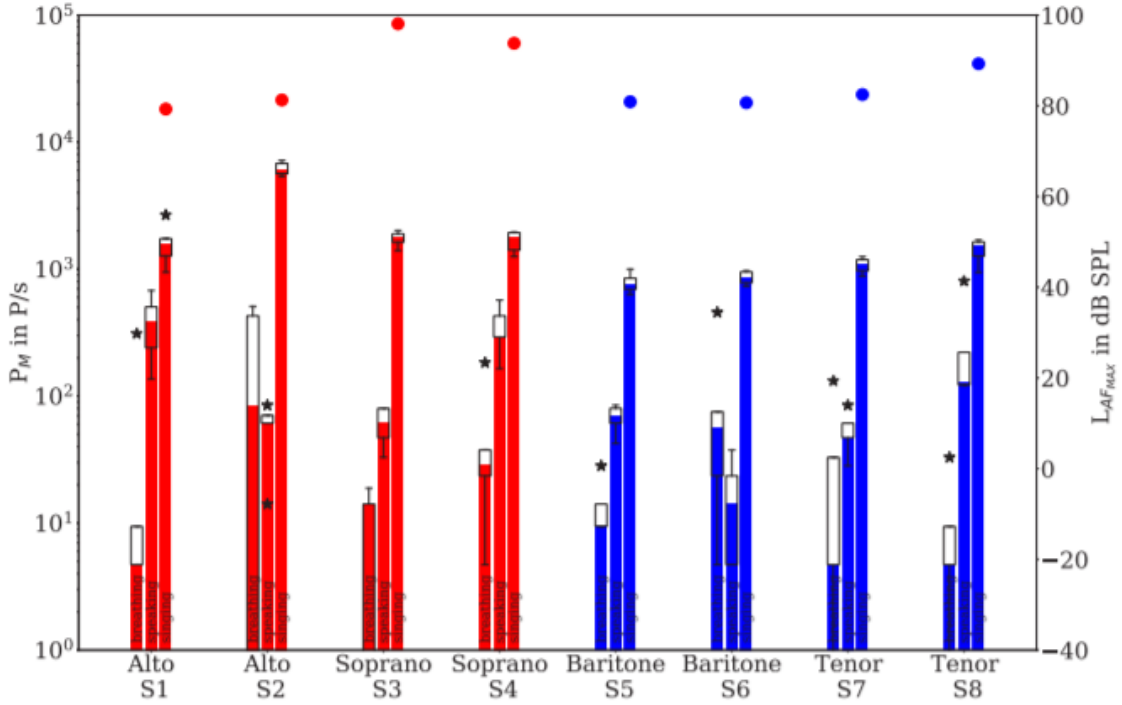
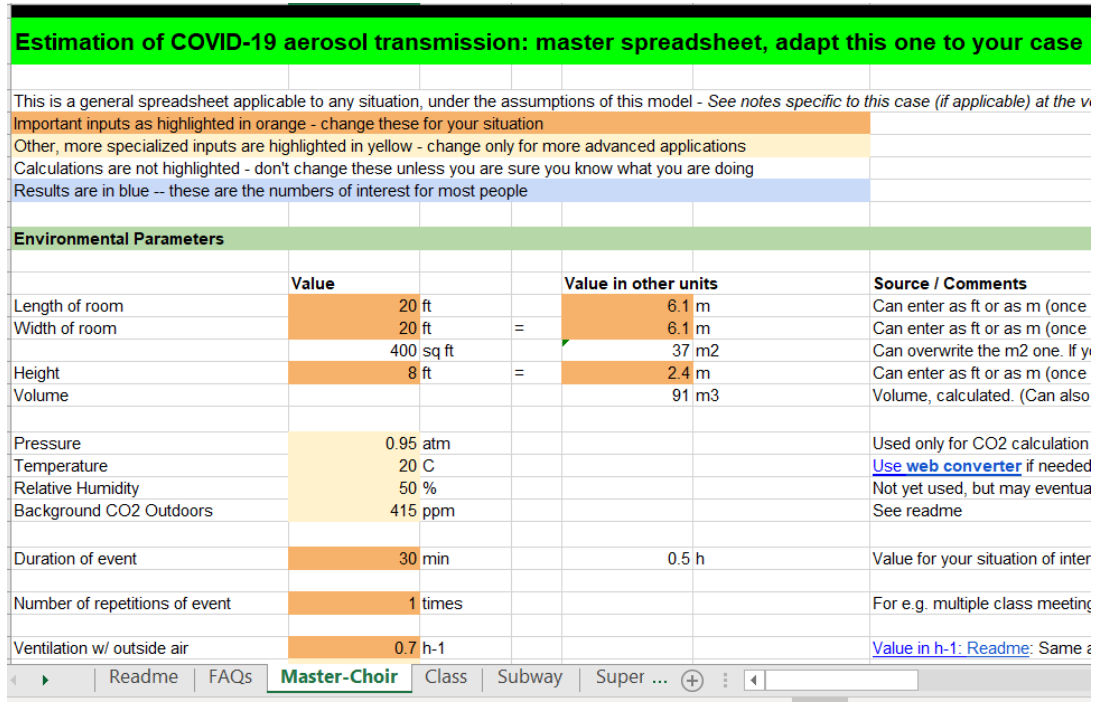


Figure 2. Boxplots of the particle source strengths (bars represent the median) for different gender, voice classifications and tasks: mouth breathing, speaking and singing (left y-axis). Only particles ≤ 5 µm were considered. For singing, the maximum sound pressure levels LAF_{MAX} are also shown (full circles, right y-axis).

Mürbe et al. 2020

Emerging research
Risk Calculators

- COVID-19 Airborne Transmission Estimator (Jimenez 2020)
- Airborne Infection Risk Calculator (AIRC) (Mikszewski et al. 2020)
- Risk Analysis of the transmission of CARS-CoV-2 by aerosols (*in German,* Trukenmüller 2020)
- Essential inputs
  - Room dimensions
  - Air exchange
  - Number of persons
  - Duration of exposure



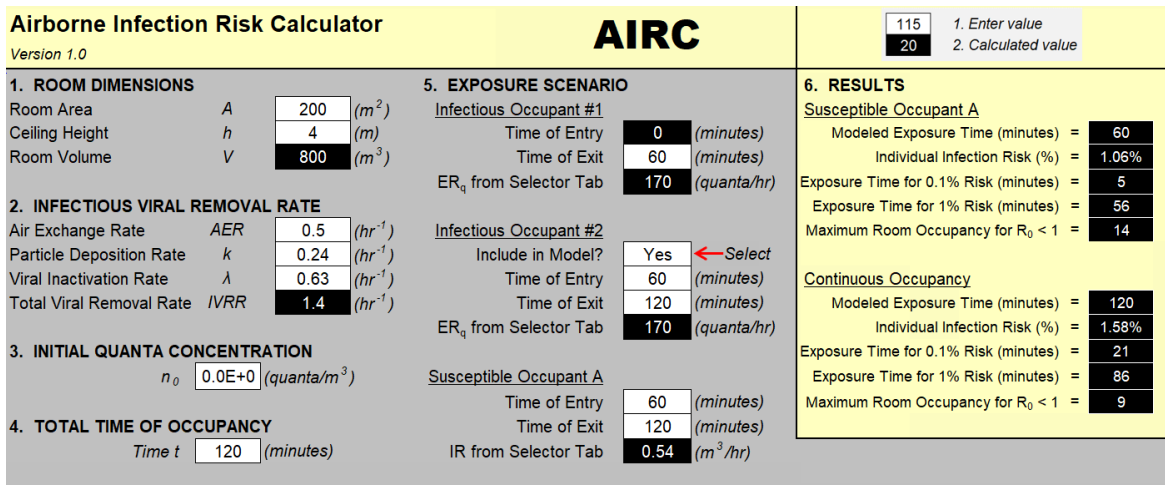
Estimation of COVID-19 aerosol transmission: master spreadsheet, adapt this one to your case

This is a general spreadsheet applicable to any situation, under the assumptions of this model - *See notes specific to this case (if applicable) at the v*
Important inputs as highlighted in orange - change these for your situation
Other, more specialized inputs are highlighted in yellow - change only for more advanced applications
Calculations are not highlighted - don't change these unless you are sure you know what you are doing
Results are in blue -- these are the numbers of interest for most people

Environmental Parameters

	Value			Value in other units		Source / Comments
Length of room	20	ft		6.1	m	Can enter as ft or as m (once
Width of room	20	ft	=	6.1	m	Can enter as ft or as m (once
	400	sq ft		37	m2	Can overwrite the m2 one. If y
Height	8	ft	=	2.4	m	Can enter as ft or as m (once
Volume				91	m3	Volume, calculated. (Can also
Pressure	0.95	atm				Used only for CO2 calculation
Temperature	20	C				Use web converter if needed
Relative Humidity	50	%				Not yet used, but may eventua
Background CO2 Outdoors	415	ppm				See readme
Duration of event	30	min		0.5	h	Value for your situation of inter
Number of repetitions of event	1	times				For e.g. multiple class meeting
Ventilation w/ outside air	0.7	h-1				Value in h-1: Readme: Same a

Readme | FAQs | Master-Choir | Class | Subway | Super ...



Airborne Infection Risk Calculator — *Version 1.0* — **AIRC**

115 *1. Enter value*
20 *2. Calculated value*

1. ROOM DIMENSIONS

Room Area	*A*	200	(m^2)
Ceiling Height	*h*	4	(*m*)
Room Volume	*V*	800	(m^3)

2. INFECTIOUS VIRAL REMOVAL RATE

Air Exchange Rate	*AER*	0.5	(hr^{-1})
Particle Deposition Rate	*k*	0.24	(hr^{-1})
Viral Inactivation Rate	*λ*	0.63	(hr^{-1})
Total Viral Removal Rate	*IVRR*	1.4	(hr^{-1})

3. INITIAL QUANTA CONCENTRATION

n_0 0.0E+0 (*quanta/m^3*)

4. TOTAL TIME OF OCCUPANCY

Time t 120 (*minutes*)

5. EXPOSURE SCENARIO

Infectious Occupant #1

Time of Entry	0	(*minutes*)
Time of Exit	60	(*minutes*)
ER_q from Selector Tab	170	(*quanta/hr*)

Infectious Occupant #2

Include in Model?	Yes	← *Select*
Time of Entry	60	(*minutes*)
Time of Exit	120	(*minutes*)
ER_q from Selector Tab	170	(*quanta/hr*)

Susceptible Occupant A

Time of Entry	60	(*minutes*)
Time of Exit	120	(*minutes*)
IR from Selector Tab	0.54	(m^3/*hr*)

6. RESULTS

Susceptible Occupant A

Modeled Exposure Time (minutes)	=	60
Individual Infection Risk (%)	=	1.06%
Exposure Time for 0.1% Risk (minutes)	=	5
Exposure Time for 1% Risk (minutes)	=	56
Maximum Room Occupancy for $R_0 < 1$	=	14

Continuous Occupancy

Modeled Exposure Time (minutes)	=	120
Individual Infection Risk (%)	=	1.58%
Exposure Time for 0.1% Risk (minutes)	=	21
Exposure Time for 1% Risk (minutes)	=	86
Maximum Room Occupancy for $R_0 < 1$	=	9

Emerging research
Aerosols transmission

- Further understanding of transmission via aerosols
    - Additional evidence of viral RNA detected in the room air of COVID-19 patients. Improved understanding of how virus moves around the room – particles found deposited on window sills, under the bed (Santarpia et al. 2020);
    - Isolation of culturable virus from air sample of patient rooms > 2 m distance (Lednicky et al. 2020, *pre-print*)

Viral particles can be dispersed due to ambient air currents

These particles may be infectious

What remains unknown?

Many questions remain…

- Movement and accumulation of aerosols in different indoor environments?
- How long do viral particles remain infectious and what is the infectious dose?
- Transmission by children, severity of disease, longer term effects
- Effectiveness of emerging technologies
  - Disinfection technologies
  - New types of coatings/surfaces
- Results of further outbreak investigations
  - Improve understanding of transmission for different settings, activities, groups etc.
- And more…

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