National Collaborating Centre for Environmental Health

Centre de collaboration nationale en santé environnementale

www.ncceh.ca

COVID-19 Risks and Precautions for the performing arts

NCCEH Evidence scan

Juliette O'Keeffe MSc, PhD
Environment Health and Knowledge Translation Scientist
National Collaborating Centre for Environmental Health

Sept 30, 2020

COVID-19 resources for EH

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

Outline

1. Notable COVID-19 clusters and outbreaks
2. Understanding transmission risks
3. Precautionary measures
4. Q&A

Outline

1. Notable COVID-19 clusters and outbreaks
2. Understanding transmission risks
3. Precautionary measures
4. Q&A

Notable outbreaks in performing arts settings

Choirs: USA, France, Germany, Netherlands

- Feb-Mar 2020
- High attack rate among participants in rehearsals and performances (>80% in some cases)
- Hospitalizations and deaths

Theatre: Japan

- Jun-Jul 2020
- Small theatre (186 seats, running at 50% capacity)
- Following 5 days of performances, 30 cases among staff, cast and theatregoers

Dance: Russia ballet companies

- Apr 2020 – Bolshoi ballet, 34 cases identified following pre-performance screening
- Aug 2020 – Mariinsky ballet, over 50 cases including dancers and coaches; some hospitalizations

Bands/Instrumental

- Japan - 11% of 61 clusters in Japan were associated with music-related events including live concerts
- USA – High school band, Touring metal bands returning from Europe

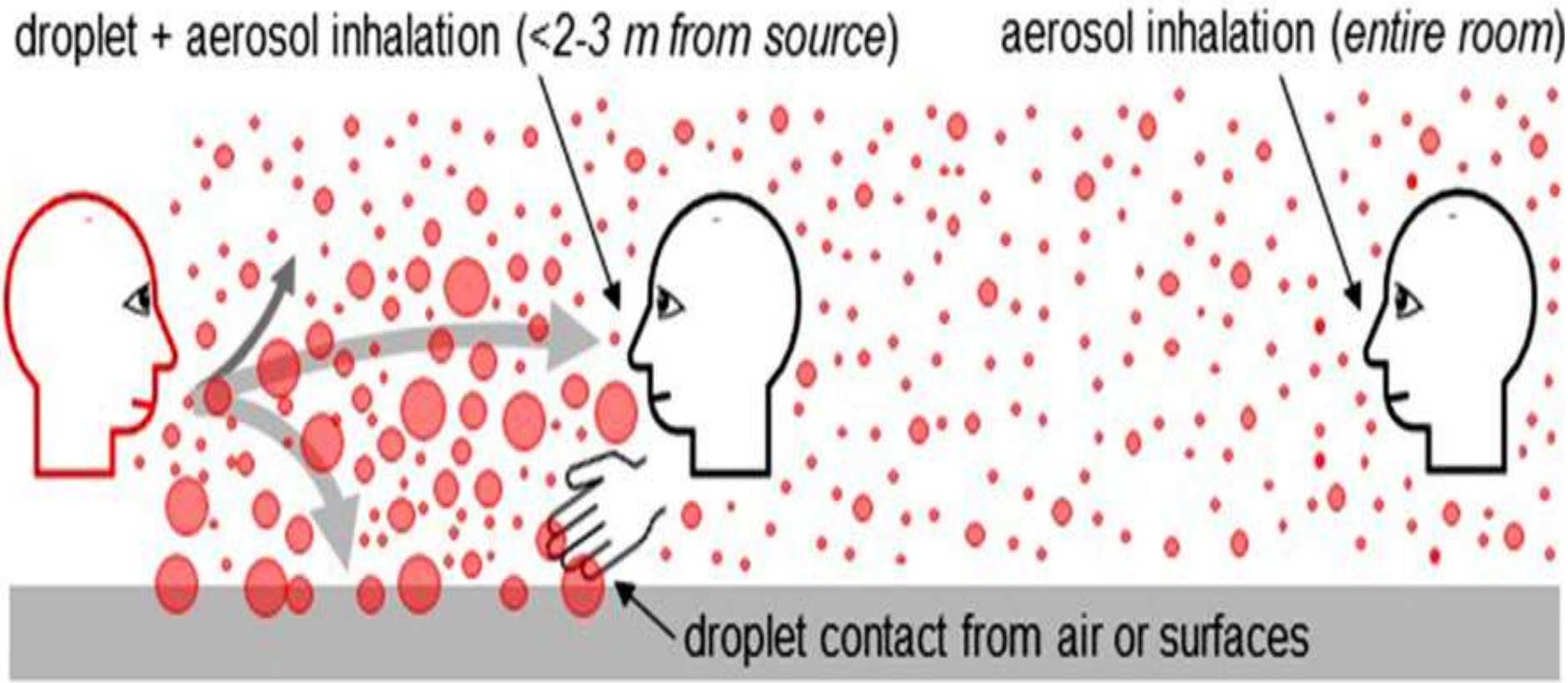
Outline

1. Notable COVID-19 clusters and outbreaks
2. Understanding transmission risks
3. Precautionary measures
4. Q&A

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)

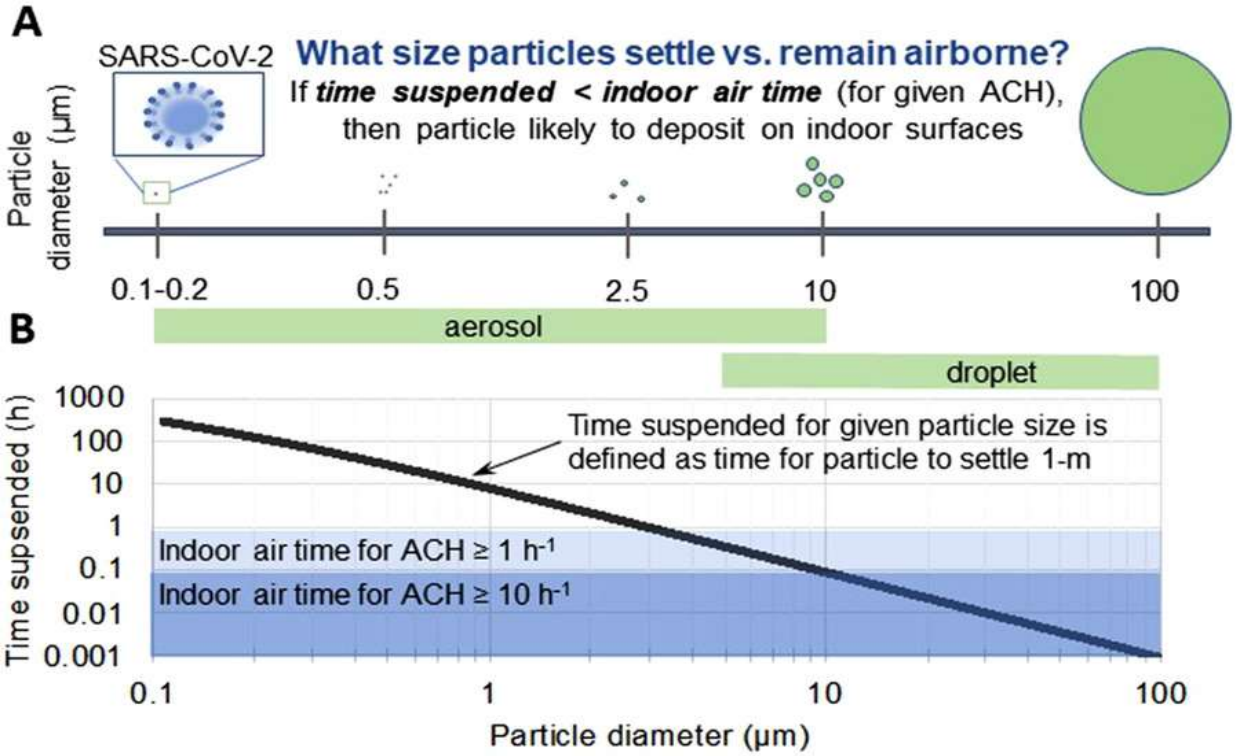
Contact with contaminated surfaces/fomites followed by contact with nose, mouth, or eyes



Kohansky et al. 2020. Review of indoor aerosol generation, transport, and control in the context of COVID-19 **International Forum of Allergy & Rhinology, First published: 11 July 2020, DOI: (10.1002/alr.22661)**

Particle Size

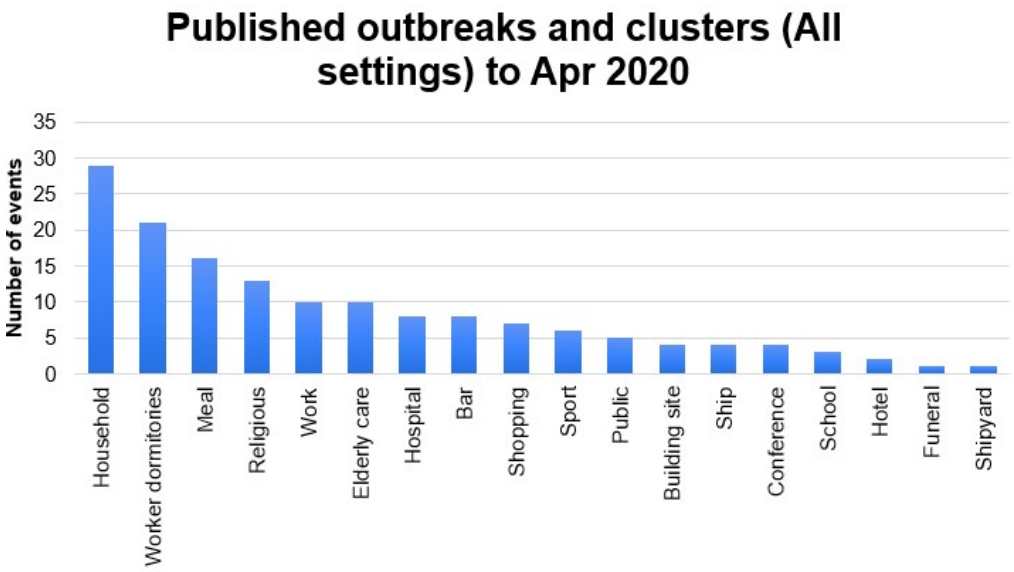
- Large droplets (< 5-10 µm)
  - Reduced settling time
  - Intense but less frequently release in coughs/sneezes
  - More likely released by symptomatic persons
- Aerosols (< 5-10 µm)
  - Increased settling time
  - May circulate and accumulate
  - Less intense release but could be generated continuously
  - Symptomatic AND asymptomatic persons
  - Potential to reach lower respiratory tract



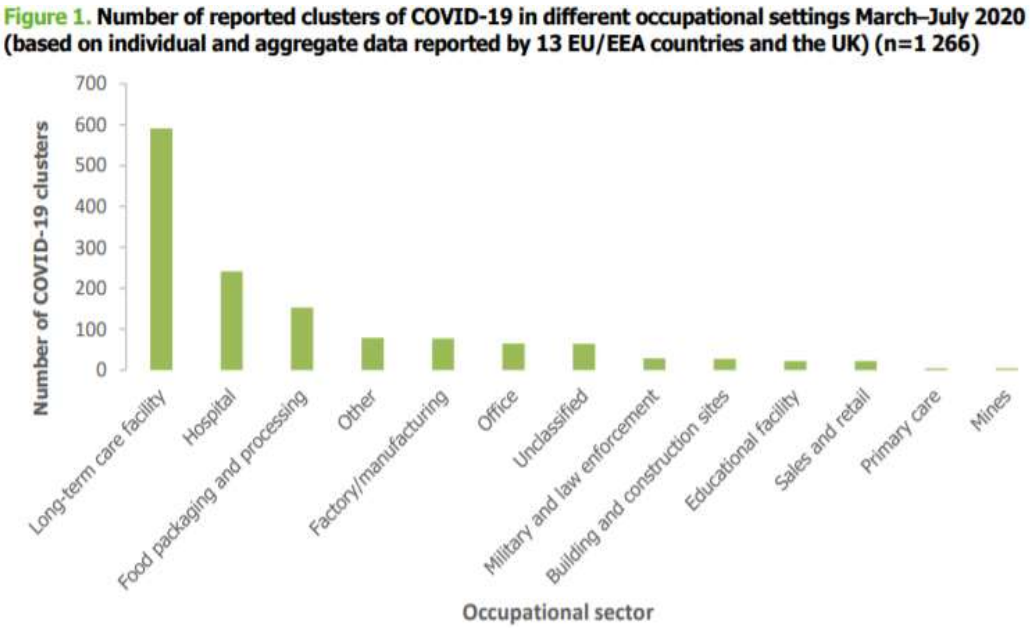
Kohansky, Lo and Waring. *Review of indoor aerosol generation, transport, and control in the context of COVID-19* International Forum of Allergy & Rhinology, First published: 11 July 2020, DOI: (10.1002/alr.22661)

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)



Leclerc et al. 2020



European Centre for Disease Control and Prevention (2020)

But…what are the transmission risks associated with performing arts?

Risks associated with **gathering in groups for rehearsals or performances**

Close contact

- Group or partnered performance segments
- Sharing of sheet music, props, stands, microphones, dressing rooms etc.

➢ **Increases risk of exposure to respiratory droplets and short-range aerosols**

Indoors over long duration

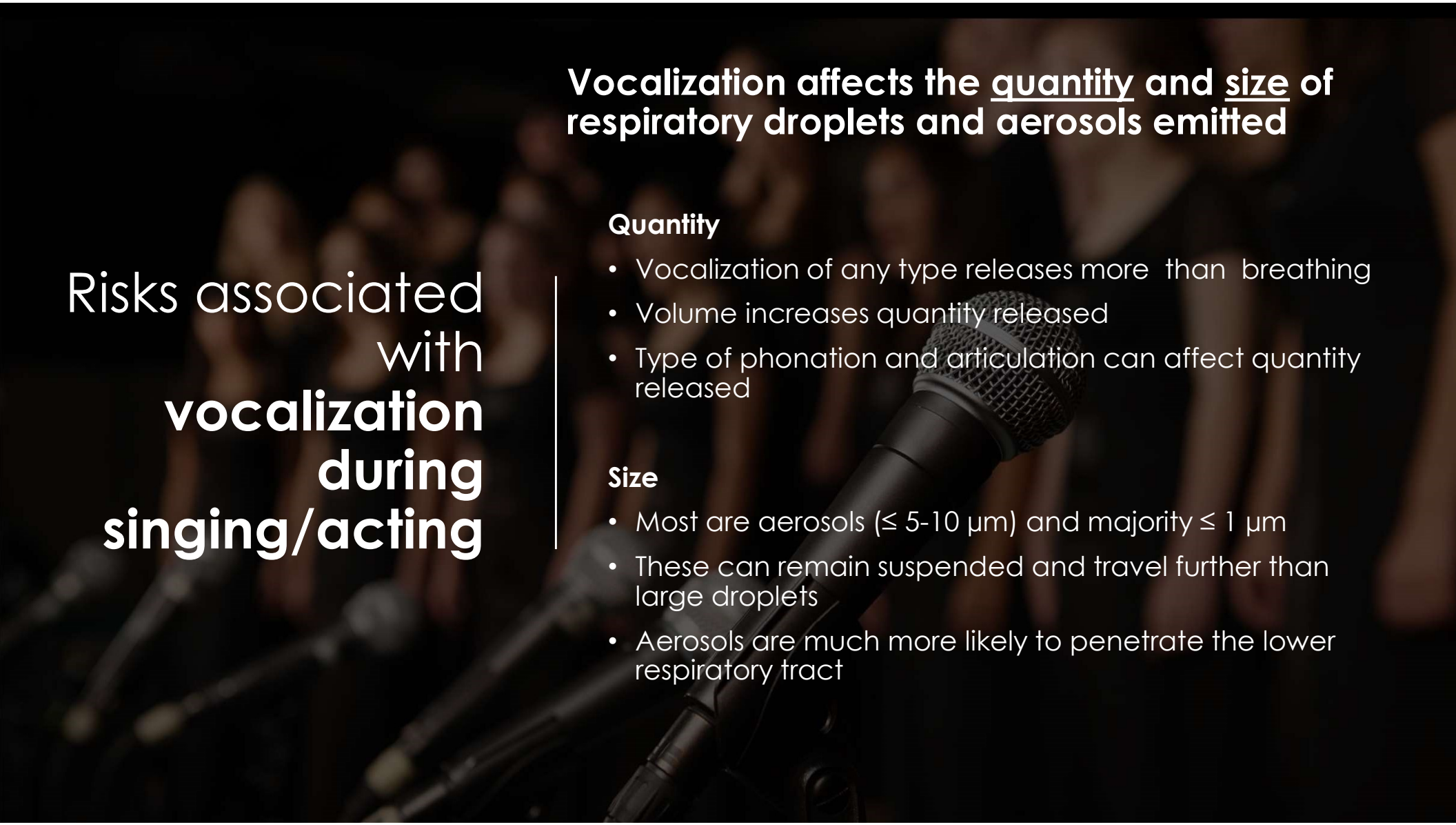
- Dressing rooms, backstage, orchestra pits, enclosed rooms
- Limited ventilation reduces the dilution and dispersion of aerosols

➢ **Increases risk of exposure to accumulated aerosols**

Sharing of surfaces or objects

- Musical stands, chairs, books, microphones, instruments, props, costumes, makeup and brushes, refreshments, etc.

➢ **Increased risk of exposure via fomites**



Risks associated with **vocalization during singing/acting**

Vocalization affects the quantity and size of respiratory droplets and aerosols emitted

Quantity

- Vocalization of any type releases more than breathing
- Volume increases quantity released
- Type of phonation and articulation can affect quantity released

Size

- Most are aerosols (≤ 5-10 µm) and majority ≤ 1 µm
- These can remain suspended and travel further than large droplets
- Aerosols are much more likely to penetrate the lower respiratory tract

Comparing singing and speaking to breathing

- 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 in this study

Also 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

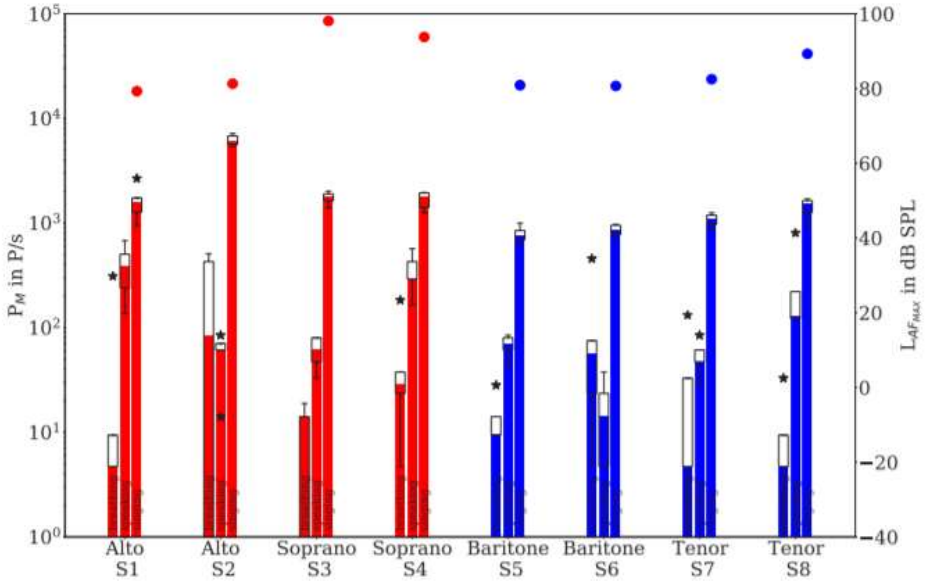
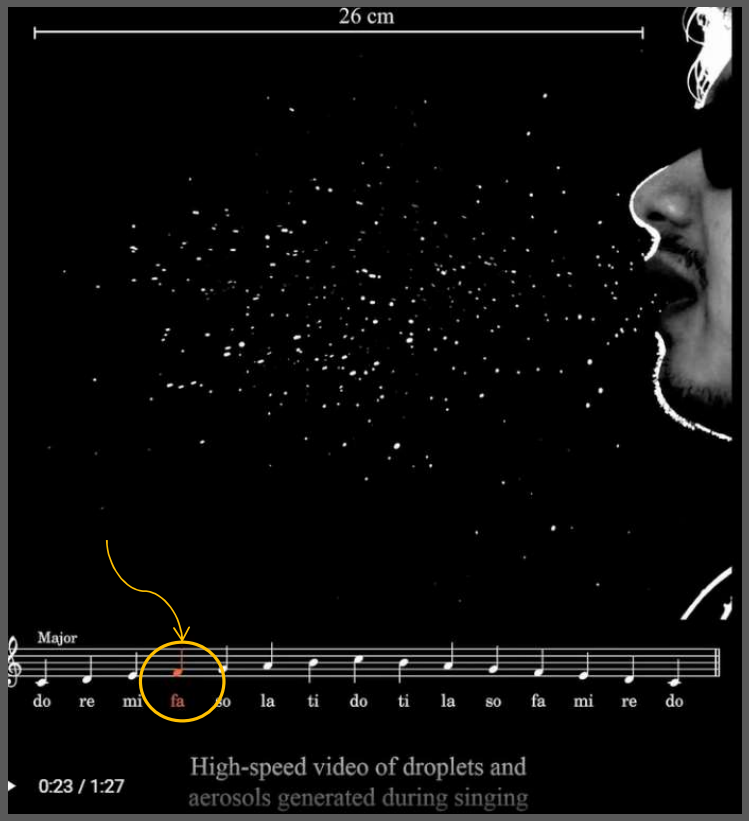
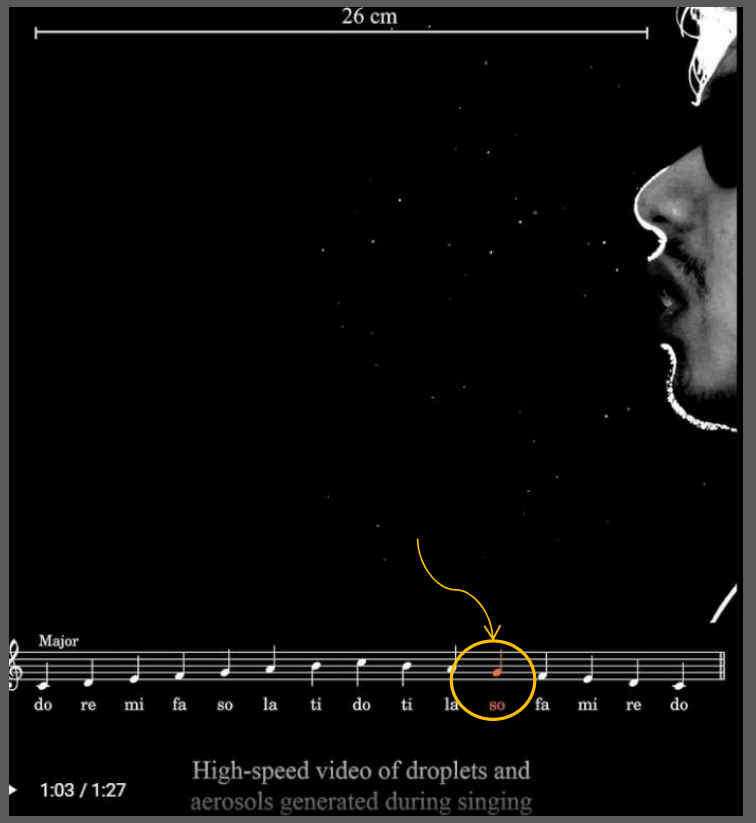


Figure 2. Boxplots of the particle source strengths (bars represent the median) for different gender, voice classifications and tasks: mouth breathing, speaking and singing (left y-axis). Only particles ≤ 5 µm were considered. For singing, the maximum sound pressure levels LAF_{MAX} are also shown (full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

Mürbe et al. 2020

Visualization of droplets while singing





Bahl P, de Silva C, Bhattacharjee S, Stone H, Doolan C, Chughtai AA, et al. **Droplets and Aerosols generated by singing and the risk of COVID-19 for choirs**. Clin Infect Dis. 2020. Available from: https://doi.org/10.1093/cid/ciaa1241

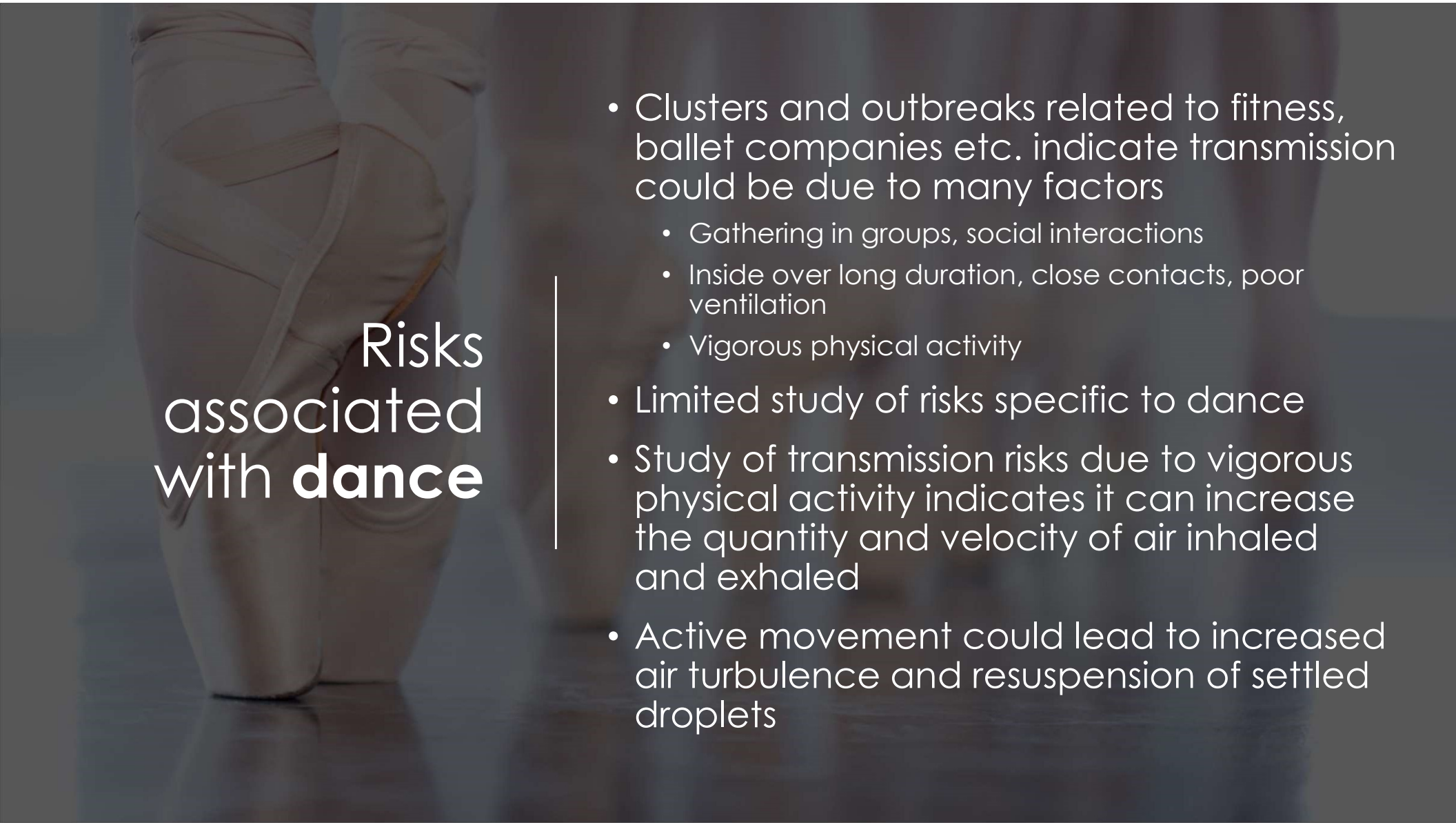
Risks associated with **playing of musical instruments**

Strings, Keys, Percussion

- Potential for fomite transmission via shared instruments
- Potential for increased release of aerosols if playing more energetically

Brass and Woodwinds

- Release of respiratory particles from instrument bell, or keys most of which are aerosols
- Current studies show contrary findings in comparison between different instrument types
- Quantity released can vary by tube length (brass), mouthpiece design (woodwinds), and playing style
- Breath condensate presents droplet, aerosol or fomite risk if not carefully collected and disposed



Risks associated with **dance**

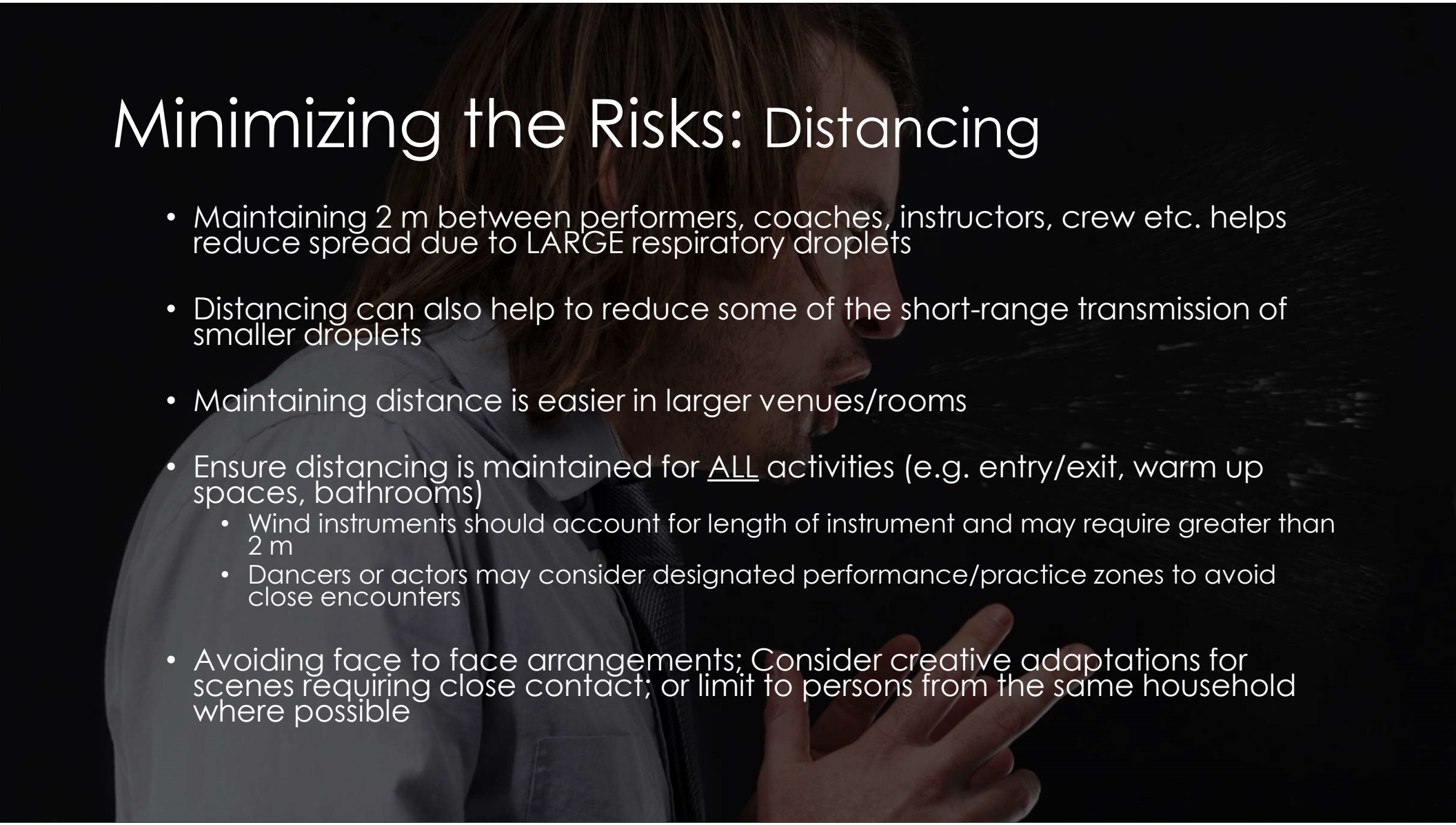
- Clusters and outbreaks related to fitness, ballet companies etc. indicate transmission could be due to many factors
  - Gathering in groups, social interactions
  - Inside over long duration, close contacts, poor ventilation
  - Vigorous physical activity
- Limited study of risks specific to dance
- Study of transmission risks due to vigorous physical activity indicates it can increase the quantity and velocity of air inhaled and exhaled
- Active movement could lead to increased air turbulence and resuspension of settled droplets

Outline

1. Notable COVID-19 clusters and outbreaks
2. Understanding transmission risks
3. Precautionary measures
4. Q&A

Minimizing the Risks: Personal measures

- Symptomatic or potentially exposed persons should stay home
- High risk/susceptible persons should stay home
- Limiting social contacts outside of performance or rehearsal cohorts where they are used
- Taking precautions outside of the group (distancing, face coverings, hand hygiene)
- Avoiding close contact, handshakes, sharing of objects/equipment and preparing offsite (makeup, costumes etc.)



Minimizing the Risks: Distancing

- Maintaining 2 m between performers, coaches, instructors, crew etc. 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 (e.g. entry/exit, warm up spaces, bathrooms)
  - Wind instruments should account for length of instrument and may require greater than 2 m
  - Dancers or actors may consider designated performance/practice zones to avoid close encounters
- Avoiding face to face arrangements; Consider creative adaptations for scenes requiring close contact; or limit to persons from the same household where possible

Minimizing the Risks: Reduce density and duration

- Larger spaces with fewer faces
  - Reduced loading of infectious particles; increased dilution and dispersion of accumulated aerosols
  - Solo performances, Cohorts/bubbles
- 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 or alternate between rooms/rehearsal spaces

Minimizing the Risks: Masks

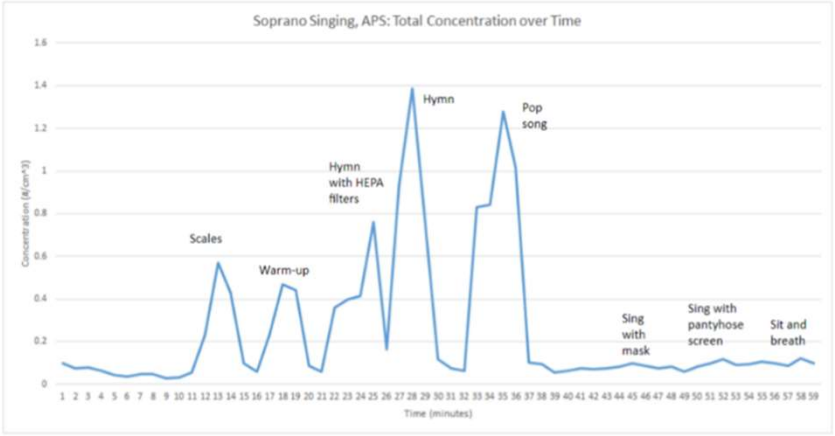
- Masks can block some emissions and reduce exposure to droplets and aerosols
- Effectiveness depends on
  - **Fit** - without gaps around the nose bridge, chin, and sides
  - **Filtration** - materials that effectively block the movement of both droplets and aerosols
- Most homemade masks and adaptations of traditional masks have not been assessed for their effectiveness
- Adaptations for various uses
  - Singers' masks for greater articulation and mouth movement
  - Brass and woodwind players
  - Instrument bell-covers
- Consider as an added layer of protection with other measures

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

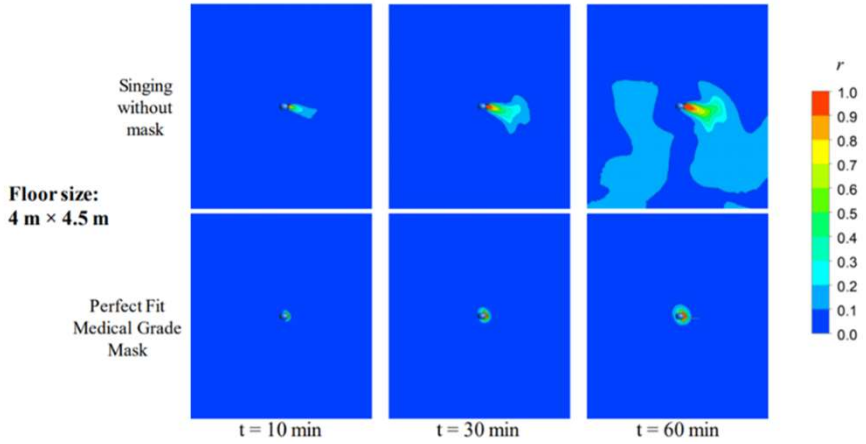
International Coalition of Performing Arts. **2020**

Singing APS (0.5-20 µm particles)

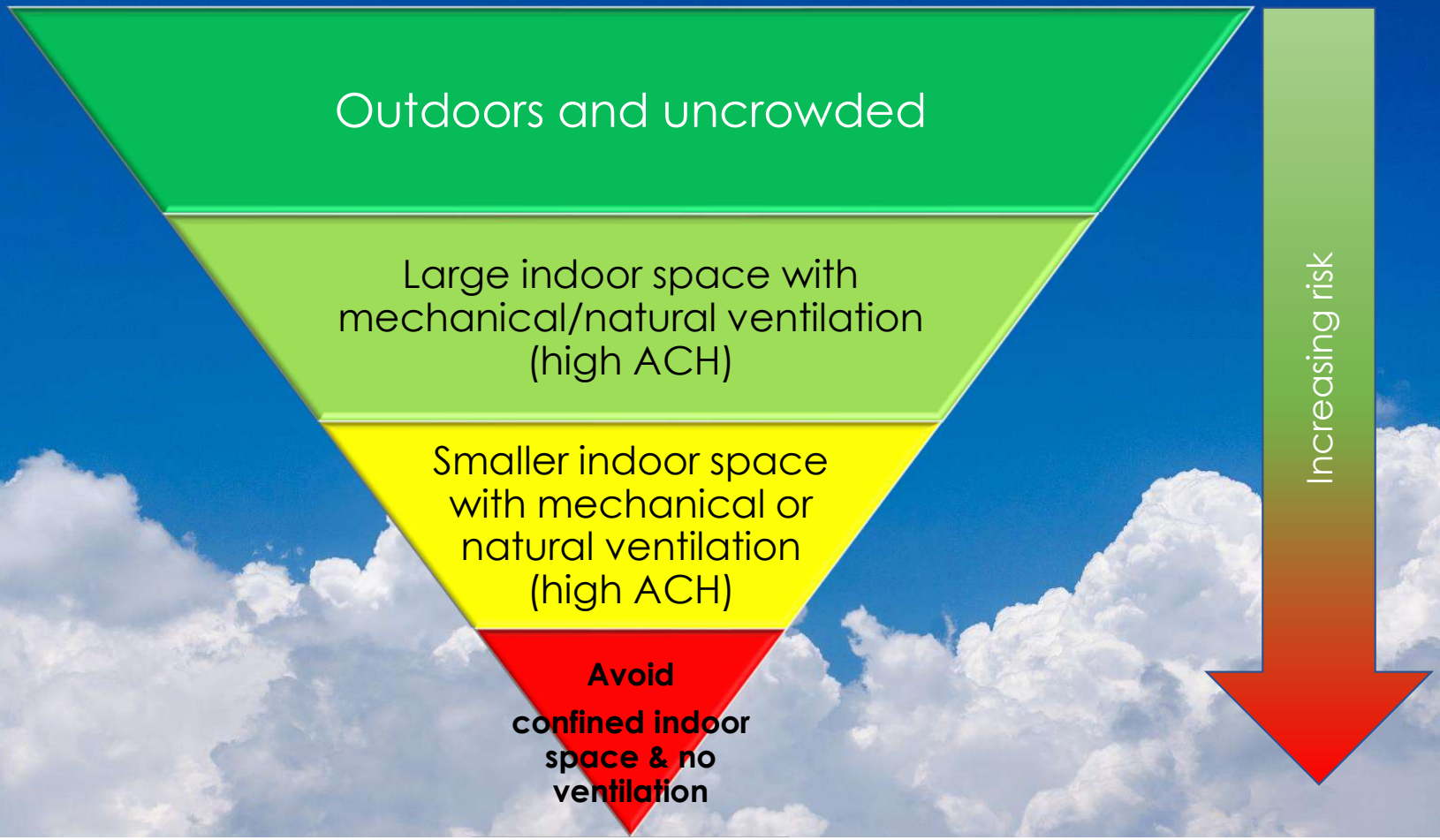


Indoor Case Study: Mask Impact on Infection Risk

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

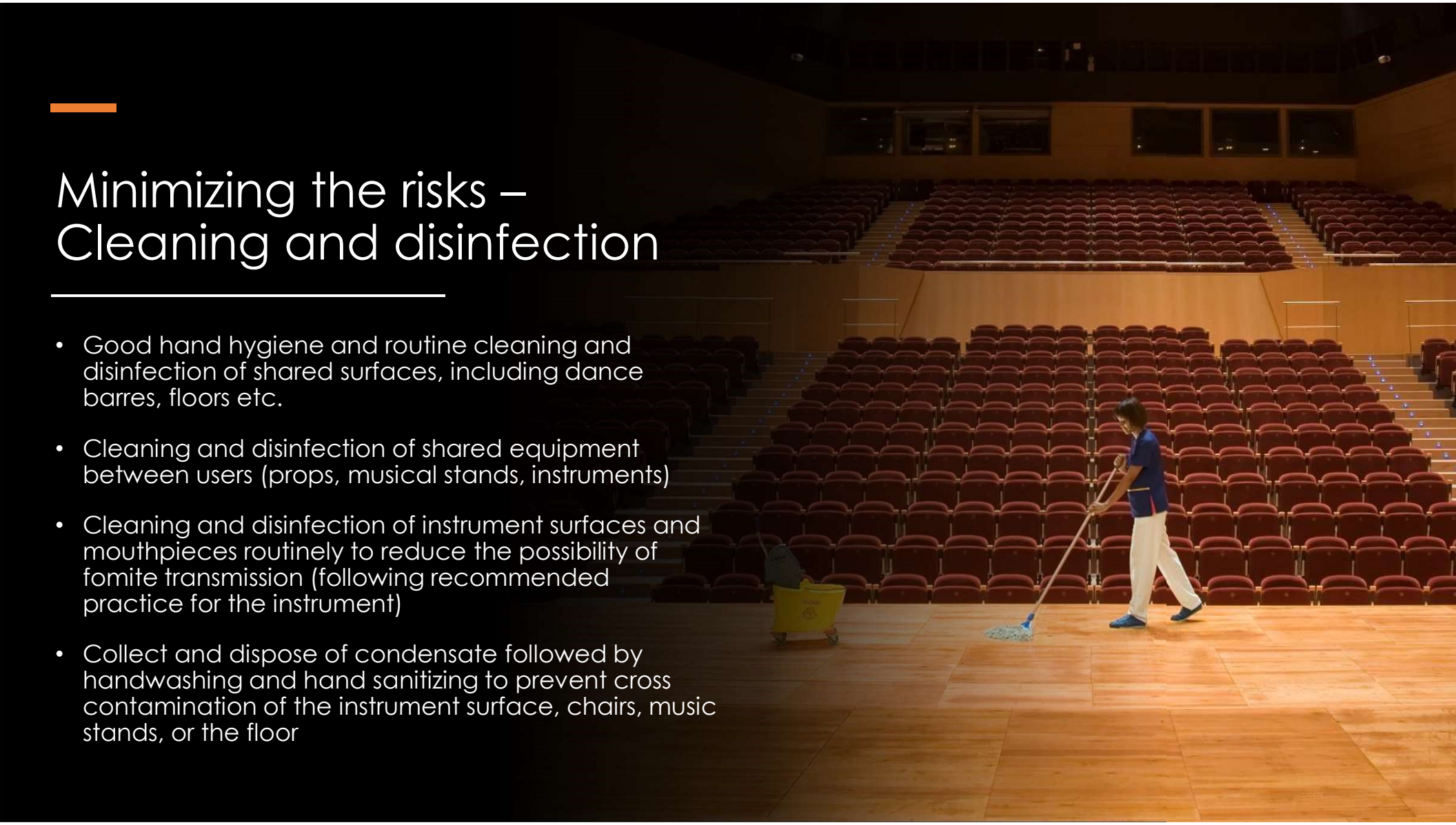


Minimizing the Risks: Ventilation



Minimizing the risks – Cleaning and disinfection

- Good hand hygiene and routine cleaning and disinfection of shared surfaces, including dance barres, floors etc.
- Cleaning and disinfection of shared equipment between users (props, musical stands, instruments)
- Cleaning and disinfection of instrument surfaces and mouthpieces routinely to reduce the possibility of fomite transmission (following recommended practice for the instrument)
- Collect and dispose of condensate followed by handwashing and hand sanitizing to prevent cross contamination of the instrument surface, chairs, music stands, or the floor



Minimizing the risks - audiences

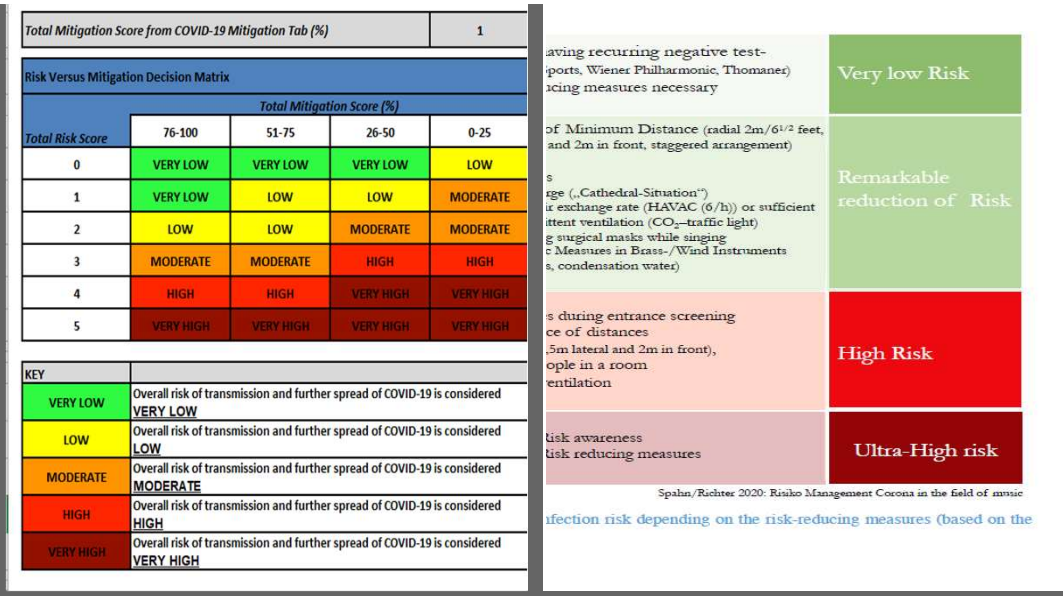
- Refer to occupancy limits and venues/workplace specific criteria for your jurisdiction
- Principles of encouraging distancing, mask wearing, good hand hygiene, and respiratory etiquette should be applied
- Communication with audiences prior to events can allow organizers to set out COVID-19 safety protocols, screening, and gather information for contact tracing
- Some guidance recommends discouraging audiences from singing, cheering, dancing, and laughing. Alternatives can be suggested for non-vocal participation, hand-held noisemakers, clapping etc.
- Innovations in audience layout and partitions, reducing crowding at entrances and exits, removing congregation points, using outside venues or improving ventilation inside can all add to layered approach to reducing risks

In summary

- Outbreaks and clusters in performing arts settings share common features of outbreaks related to **gathering in groups**
- Additional risk factors due to increased release of droplets and aerosols may also contribute to transmission in some settings due to
  - **Vocalization**
  - **Playing of wind instruments**
  - **Vigorous physical activity**
- Layering of precautions can reduce transmission risks

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
  - Layering of mitigation measures, following local PH advice
- Does mitigation eliminate or reduce risks sufficiently?
  - If not, what else can be done?



Total Mitigation Score from COVID-19 Mitigation Tab (%)	1

Risk Versus Mitigation Decision Matrix

Total Risk Score	*Total Mitigation 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

aving recurring negative test-
ports, Wiener Philharmonic, Thomaner)
cing measures necessary

Very low Risk

of Minimum Distance (radial 2m/$6^{1/2}$ feet,
and 2m in front, staggered arrangement)
s
rge („Cathedral-Situation")
ir exchange rate (HAVAC (6/h)) or sufficient
ittent ventilation (CO_2–traffic light)
g surgical masks while singing
Measures in Brass-/Wind Instruments
s, condensation water)

Remarkable reduction of Risk

s during entrance screening
ce of distances
,5m lateral and 2m in front),
ople in a room
entilation

High Risk

isk awareness
isk reducing measures

Ultra-High risk

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

fection risk depending on the risk-reducing measures (based on the

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

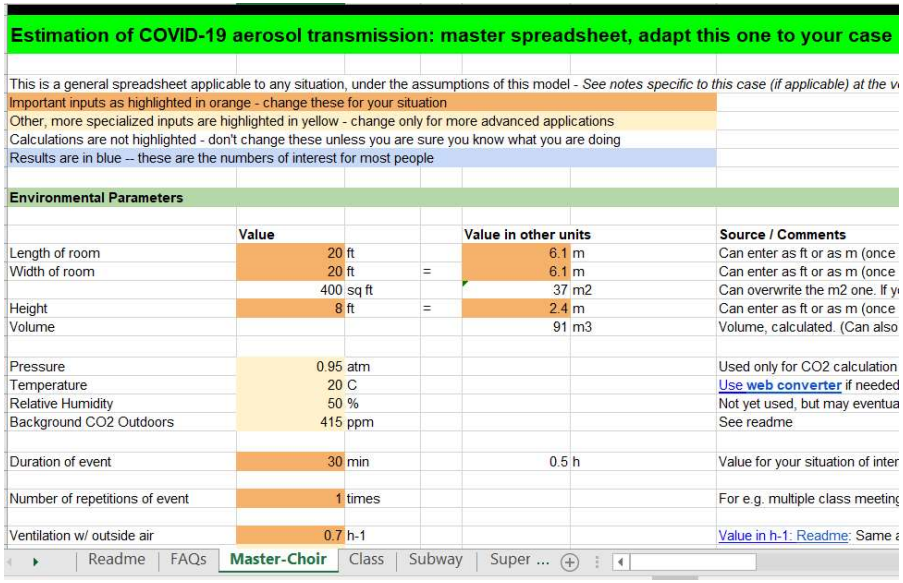
		Risk mitigation potential (from Table 2)		
		Stronger	**Moderate**	**Weaker**
Risk level (from Table 1)	**High**	**Moderate risk** of contributing to COVID-19 community transmission. Increase or strengthen mitigation strategies if possible.	**Higher risk** of contributing to COVID-19 community transmission.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

Risk of SARS-CoV-2 transmission from asymptomatic people in different settings and for different occupation times, venting, and crowding levels (ignoring variation in susceptibility and viral shedding rates).

Nicholas R Jones et al. BMJ 2020;370:bmj.m3223

Risk Calculators

- Based on models and estimates
- 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 etc.



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 — **AIRC**

Version 1.0

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

Outline

1. Notable COVID-19 clusters and outbreaks
2. Understanding transmission risks
3. Precautionary measures
4. Q&A

National Collaborating Centre for Environmental Health

Centre de collaboration nationale en santé environnementale

thank you!

www.ncceh.ca

Juliette.okeeffe@bccdc.ca

Production of this presentation has been made possible through a financial contribution from the **Public Health Agency of Canada**.

Selected Key References

Charlotte N. **High Rate of SARS-CoV-2 Transmission due to Choir Practice in France at the Beginning of the COVID-19 Pandemic**. medRxiv. 2020:2020.07.19.20145326. Available from: https://www.medrxiv.org/content/medrxiv/early/2020/08/05/2020.07.19.20145326.full.pdf.

Feng Y, Marchal T, Sperry T, Yi H. **Influence of wind and relative humidity on the social distancing effectiveness to prevent COVID-19 airborne transmission: A numerical study.** J Aerosol Sci. 2020;147:. Available from: https://www.sciencedirect.com/science/article/pii/S0021850220300744?via%3Dihub.

Fennelly KP. **Particle sizes of infectious aerosols: implications for infection control.** The Lancet. 2020 July. Available from https://doi.org/10.1016/S2213-2600(20)30323-4

International Coalition of Performing Arts. **International Coalition of Performing Arts Aerosol Study Round 2.** Indianapolis, IN: National Federation of State High School Associations; 2020 Aug. Available from: https://www.nfhs.org/media/4030003/aerosol-study-prelim-results-round-2-final.pdf.

Jimenez JL. **COVID-19 Airborne Transmission Estimator.** 2020. Available from https://tinyurl.com/covid-estimator

Kohansky et al. 2020.. **Review of indoor aerosol generation, transport, and control in the context of COVID-19.** International Forum of Allergy & Rhinology, First published: 11 July 2020, DOI: (10.1002/alr.22661)

Ledinicky JA et al. Viable SARS-CoV-2 in the air of a hospital room with COVID-19 patients. medRxiv. 2020:2020.08.03.20167395. Available from: https://doi.org/10.1101/2020.08.03.20167395

Mikszewski A et al. **Airborne Infection Risk Calculator (AIRC)**. 2020. Available from: https://www.unicas.it/media/4952018/AIRC%20Users%20Manual%201.0%20July%202020.pdf

Mürbe et al. 2020. Aerosol emission is increased in professional singing. Available from: https://depositonce.tu-berlin.de/bitstream/11303/11491/5/muerbe_etal_2020_aerosols-singing.pdf

National Collaborating Centre for Methods and Tools. COVID-19 Rapid Evidence Reviews. Available from: https://www.nccmt.ca/knowledge-repositories/covid-19-evidence-reviews

O'Keeffe, J. **COVID-19 Risks and precautions for the performing arts.** Vancouver, BC: National Collaborating Centre for Environmental Health. 2020 Sep. Available from: https://ncceh.ca/sites/default/files/COVID-19%20Risks%20and%20precautions%20for%20the%20performing%20arts.pdf

Public Health Agency of Canada. **Community-based measures to mitigate the spread of coronavirus disease (COVID-19) in Canada.** 2020. Available from https://www.canada.ca/en/public-health/services/diseases/2019-novel-coronavirus-infection/health-professionals/public-health-measures-mitigate-covid-19.html#_Community_gathering_spaces

Public Health Ontario. **What We Know So Far About… Coronavirus Disease 2019 (COVID-19).** 2020.Available from: https://www.publichealthontario.ca/en/diseases-and-conditions/infectious-diseases/respiratory-diseases/novel-coronavirus/what-we-know

Santarpia JL, Aerosol and surface contamination of SARS-CoV-2 observed in quarantine and isolation care. Scientific Reports. 2020;10(1):12732. Available from: https://doi.org/10.1038/s41598-020-69286-3.

Spahn C, Richter B. **Risk Assessment of a Coronavirus Infection in the Field of Music. Fourth update.** 2020 July 17. Available from https://www.mh-freiburg.de/en/university/covid-19-corona/risk-assessment

Tang, Y. Mao, R.M. Jones, Q. Tan, J.S. Ji, N. Li, J. Shen, Y. Lv, L. Pan, P. Ding, X.Wang, Y. Wang, C. Raina MacIntyre, X. Shi, Aerosol Transmission of SARS-CoV-2? Evidence, Prevention and Control, Environment International (2020), doi: https://doi.org/10.1016/j.envint.2020.106039.

World Health Organization. **WHO mass gathering COVID-19 risk assessment tool – Generic events.** 2020 Jul. Available from: https://www.who.int/publications/i/item/10665-333185