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COVID-19 Risks and precautions for the performing arts

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Introduction

The COVID-19 pandemic has caused major changes to how musicians and performers practise and rehearse and has brought many live performances to a halt. Restrictions have been put in place to reduce transmission risks for those who work or volunteer in the sector, and for audiences attending performances. This document synthesizes available evidence to date on transmission risks of SARS-CoV-2, the virus responsible for COVID-19, associated with performing arts activities. The document provides an overview of notable outbreaks that have occurred in performing arts settings and presents an overview of mitigation measures to reduce transmission risks from **live theatre, music** and **dance**. This is a companion document to *COVID-19 Risks and Precautions for Choirs*. The literature search method and search terms are provided in Appendix 1.

COVID-19 outbreaks and the performing arts

Public health measures implemented at the beginning of the COVID-19 pandemic restricted large gatherings, which included performances with a live audience in theatres, auditoriums, and other venues. Gathering in groups was identified as high-risk for SARS-CoV-2 transmission, and limits on the number of people gathering was an essential public health tool for reducing community transmission. In many jurisdictions, public health guidance expanded to include restrictions on activities where there was likely to be group singing, cheering, or other types of loud vocalization following notable outbreaks associated with singing in groups in Washington State,[1] Amsterdam,[2] Berlin, and France.[3] These events reported high COVID-19 attack rates[a] among attendees of choir rehearsals and performances. Other COVID-19 clusters and outbreaks associated with performing arts activities are presented in Table 1. Several of these share characteristics that can help to identify common risk factors. An analysis of COVID-19 clusters in Japan between January 15 and April 4, 2020, found that 11% of 61 clusters in the country were linked to music-related events (live concert, choral group rehearsal, karaoke party).[4] Common features included enclosed and crowded

[a] *The proportion of people that are infected following an exposure event*

indoor spaces with close-contact occurring between patrons.[5] Elsewhere, other outbreaks share common characteristics of crowding or gathering in large groups, enclosed spaces or poor ventilation, long duration of contact, person-to-person interactions such as greetings and social interactions, sharing of food, drinks or equipment, and shared transport. In addition, many of those affected participated in activities such as singing, shouting, or heavy breathing due to vigorous physical activity such as dance.

Table 1 Media and literature reports of COVID-19 clusters and outbreaks associated with performing arts activities including singing, dance, theatre and bands

Location	Date (2020)	Type of performing art	Settings/ Type of event	Outcome of outbreak	Ref
Amsterdam, Netherlands	Feb 28 – Mar 8	Choir Orchestra	Rehearsal Performance	102 of 130 choir participants fell ill with COVID-19 following multiple rehearsals and a performance. One member and three close contacts died.	[2]
France	Feb 28 – Mar 12	Choir	Rehearsal	Multiple choirs with outbreaks resulting in hospitalizations and deaths.	[3]
Berlin, Germany	Mar 9	Choir	Rehearsal	60 cases from 80 choir participants following one practice.	[3]
Skagit Valley, USA	Mar 10	Choir	Rehearsal	53 cases from 61 choir participants following one practice, resulting in two deaths.	[1,6]
Berrien Springs, USA	Mar 8	Solo vocal performance	Performance Backstage interaction	A singer tested positive for COVID-19 nine days after the event. Two attendees that had a backstage experience with the singer also tested positive.	[7]
Otaru, Japan	Jun 2020	Singing	Karaoke	Three clusters associated with karaoke establishments resulting in more than 30 cases, including customers and close contacts.	[8]
Quebec City, Canada	Aug 2020	Singing	Karaoke	63 cases plus 18 secondary cases including children linked to two index cases attended a karaoke night at a bar with a 100-person capacity limit while awaiting COVID-19 test results.	[9]
Cheonan, South Korea	Feb 15 – Mar 13	Dance	Group fitness and/or dance instruction at multiple facilities	Instructors who were asymptomatic or mildly symptomatic held classes resulting in subsequent infection of > 100 students, family members and other contacts across multiple facilities. These events involved intense physical exercise in densely populated facilities. Classes with fewer participants and less intense activity (e.g., yoga) had no cases.	[10,11]
Detroit, USA	Apr 2020	Dance	Social dance events	Several cases and deaths due to COVID-19 were reported among attendees of ballroom dance activities, but no event or venue was confirmed as an exposure site.	[12]
Moscow, Russia	Apr 2020	Dance	Rehearsals	34 cases identified following COVID-19 screening of the Bolshoi Ballet company two days prior to a performance, despite none being symptomatic.	[13,14]
Montreal, Canada	Jul 31 – Aug 15	Dance	Instruction	Three persons attending Latin dance events later tested positive for COVID-19, and exposures may have occurred in both indoor and outdoor venues.	[15]

Location	Date (2020)	Type of performing art	Settings/ Type of event	Outcome of outbreak	Ref
Vancouver, Canada	Aug 2 – 11	Dance	Dance community party, Instruction	A dance instructor tested positive for COVID-19 on Aug 11, following a dance community party on August 2. A student returning from China also tested positive and may have been asymptomatic while attending the dance centre.	16
St. Petersburg, Russia	Aug 13	Dance	Rehearsals	Over 50 cases in the Mariinsky Ballet company, including many dancers, following the return to rehearsals and performances. Some hospitalizations were reported.	13
Japan	Jan 15 – Apr 4	Various large music venues	Performances	11% of 61 clusters in Japan were associated with music-related events including karaoke singing, live concerts, loud environments, in crowded and poorly ventilated venues.	4,5
Osaka, Japan	Feb 15 – 25	Live music		Eight "Live House" small concerts linked to four music clubs of 50-100 capacity resulting in 100 cases among patrons and their contacts.	17,18
Tokyo, Japan	Jun 30 – Jul 5	Theatre	Performance	Over 30 cases including staff, cast members and theatregoers, with up to 800 exposures following five days of theatre performances in a small 186 seat theatre operating at 50% capacity.	19
Kaysville Utah, USA	Jul 2020	Theatre	Rehearsals	Six cases identified among case and crew during rehearsals for a small theatre production, halting production.	20
Franklin County, Tenn, USA	Sept 2020	Band	Rehearsals	Several cases among high school band members, bringing a suspension of rehearsals and performances. Details on the number of individuals affected, or any outbreak investigation were unavailable.	21

Overview of transmission pathways for SARS-CoV-2

Coronavirus disease 2019 (COVID-19) is an illness caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Since the beginning of the pandemic, the scientific community has been gathering evidence from epidemiological investigations and experimental work to understand the drivers for infection. These include the transmission pathways, the dose needed to cause infection, and the susceptibility of the exposed persons to infection. This section provides an overview of the transmission pathways for SARS-CoV-2.

Respiratory droplets and aerosols

Currently, the primary mode of human-to-human transmission for SARS-CoV-2 is considered to be via prolonged close contact with an infected person and their respiratory emissions.[22] Respiratory emissions can range in size, with large droplets typically referring to those above 5-10 µm in diameter, and small droplets or aerosols referring to those below 5-10 µm diameter. Forceful respiratory actions such as coughing and sneezing can produce a burst of droplets that range in size and could include both large droplets and aerosols that can present an exposure risk in close proximity of an infected person. Evidence from animal studies has shown that transmission due to close contact is likely to be more efficient than indirect transmission over longer distances.[23-25] This may be due to large droplets only travelling a limited distance before falling to the ground and the concentration of aerosols released due to coughs, sneezes, or other respiratory action being higher in close proximity to the emitter.[26,27]

The majority of respiratory emissions produced by less forceful respiratory activities such as breathing, speaking, singing, shouting, or laughing produce smaller droplets or aerosols < 5 µm.[28] Aerosols can remain suspended in air for a longer duration and be transported over larger distances by ambient air currents.[29-31] Under experimental conditions, SARS-CoV-2 has been found to remain viable when airborne over short distances for several hours.[32,33] Viable virus has also been isolated from air samples at distances greater than 2 m from a COVID-19 patient, indicating that transmission may be possible over longer distances.[34] Increasingly, exposure to aerosols released by an infected person is considered to be an important route of transmission, with some experts calling for greater awareness of airborne precautions for some activities and in some settings.[6,27,29,35-38] This includes indoor environments where there is a high density of people and a long duration of contact.[5,39,40]

Contact transmission

Contact with contaminated surfaces (fomites) followed by touching of the eyes, mouth, or nose is another potential mode of SARS-CoV-2 transmission, although the relative importance of fomite transmission is not fully understood.

Pre-symptomatic and asymptomatic transmission

Understanding the dominant transmission pathways for SARS-CoV-2 has been complicated by the occurrence of pre-symptomatic transmission (during the incubation phase of an infected person) and asymptomatic transmission (transmission via an infected person who never displays symptoms).[41] The precise incidence of pre-symptomatic and asymptomatic transmission is unknown, but it may be significant.[41-43] Pre-symptomatic transmission may occur two to three days before symptom onset, peaking before appearance of symptoms.[44,45] Asymptomatic persons have been found to transmit the virus at a similar rate and duration to those displaying symptoms.[17,46] In the absence of symptoms such as sneezing and coughing, transmission routes other than via large respiratory droplets are likely more significant for pre-symptomatic and asymptomatic transmission.[29]

Infectious dose

The dose of SARS-CoV-2 required to cause an infection is still unknown. Initial evidence from animal studies suggests that the minimum infectious dose varies by species but may be slightly higher than SARS-CoV-1 and lower than Middle East Respiratory Syndrome (MERS), e.g., approximately a few hundred viral particles.[23-25,47-49] Animal studies have also indicated that infectious dose and subsequent distribution of the virus in the host may vary by the route of infection.[43,50]

The quantity of virus contained in droplets and aerosols expelled by an infected person will vary by the viral load in various parts of the respiratory tract and the stage of the disease. Viral load has been found to be highest in the early stages of the disease and to be higher in sputum than in the throat.[51] Median viral loads have been found to be between 10^4 and 10^6 copies per mL of respiratory fluid with an average emitter releasing about 10^6 copies per ml, but levels up to 10^{11} copies per mL have been detected in some cases.[51-54] Infected super-emitters who release a greater number of respiratory droplets could present a greater risk for transmitting the virus to others, particularly if they also carry a high viral load. Environmental conditions such as relative humidity and temperature can affect the movement of particles carrying the virus, virus survival, and susceptibility of exposed persons to infection.

Understanding the transmission risks associated with performing arts activities

Activities in the performing arts sector range from training and instruction in music, dance and acting, rehearsals and practice sessions, live performances, and interaction with event organizers, production and venue staff and audiences. The number and age of performers, the type and intensity of performance, the level of interaction between performers, dancers or actors, the size of the audience and the characteristics of the venue can vary widely. Each of these variables will influence transmission via the various pathways discussed above, with settings and activities that give rise to increased ***close contact***, increased exposure to ***respiratory droplets and aerosols*** and increased ***contact with contaminated surfaces***, leading to increased risk of transmission. This

includes settings where groups gather (rehearsals, performances, and audiences) and activities that increase the release of respiratory droplets and aerosols due to vocalization during singing, acting, playing of instruments, and vigorous physical activity such as dance.

Gathering in groups: Rehearsals, performances, and audiences

The vast majority of COVID-19 outbreaks have been linked to interactions in indoor environments, particularly large group gatherings with close interactions over long durations.[39,55,56] Activities that involve rehearsing or performing in groups can result in multiple close interactions in rehearsal venues, onstage, backstage, before and after rehearsals and performances, and during breaks. Risks of transmission are increased during various activities:

- Group or partnered dance or performance segments, the sharing of dressing rooms, sheet music, stands, or microphones or other similar activities make physical distancing difficult to maintain and increases the risk of transmission via respiratory droplets and short-range aerosols.
- Gathering in large numbers for long durations, in enclosed spaces with limited ventilation, such as dressing rooms, orchestra pits, and small rehearsal rooms increases the risk of accumulation of respiratory aerosols that do not drop to the ground or disperse with ventilation.
- Sharing of surfaces and objects such as music stands, chairs, books, microphones, instruments, props, hair and makeup supplies, food, dishes, cutlery, or drink dispensers increases the risks of fomite transmission.

Risks due to close contact may be present for audiences seated or standing close together. Audiences may also interact before and after the event, during intermissions, in refreshment queues, washrooms, or while entering and exiting the venue where there is potential for close contact and fomite transmission, due to contact with shared surfaces.

Singing and acting

Vocalization presents a risk of transmission via the production of respiratory droplets and aerosols during speaking and singing. Loud speech and singing, while less forceful than coughing or sneezing, can result in bursts of air releasing respiratory particles large enough to transport viruses, including some small enough to be transported on air currents and inhaled deep into the respiratory tract.[35,57,58] Respiratory particles released by vocalization are generated by a combination of mechanisms in the bronchioles, larynx, and oral cavity.[28,59,60] The **quantity** and the **size** of particles produced during vocalization enhances the risk of transmission compared to less intense respiratory activities.

Release of respiratory droplets and aerosols due to vocalization: Quantity

Vocalization, whether speaking or singing, even at low volumes, produces a ***higher concentration*** of aerosols than breathing, releasing hundreds to thousands of particles per second.[28,59,61-64] Vocalization produces fewer aerosols per event than coughing or sneezing, but the total produced

over time may be greater.[65] Studies that have compared the quantity of aerosols produced by singing and speaking at the same volume have reported contrary findings.[28,62,64] These studies, and others, do agree that the quantity of aerosols released increases with loudness, potentially due to the greater inhalation and exhalation required for louder vocalization.[28,59,62,64] The type of phonation and articulation of different vowel and consonant sound can also affect the quantity of particles released, with more exaggerated dictation potentially releasing more respiratory particles.[64-66]

Studies have shown that some people emit a much larger quantity of particles than others. These "super-emitters" have been found to release up to an order of magnitude more particles compared to normal emitters.[59,67] Asadi et al. (2020) estimated that a ten-minute conversation with an asymptomatic super-emitter at normal volume could release up to 6000 aerosol particles.[67] Multiple persons singing or speaking at once can release a greater source load of respiratory particles compared to solo singing, acting, or loud speech. This may be important where more than one infected person is present in a group.

Release of respiratory droplets and aerosols due to vocalization: Size

The majority of particles produced by vocalization, whether singing, shouting, cheering, or loud speaking are aerosols less than 5 µm in diameter, and most may be less than 1 µm in diameter.[28,68,69] Aerosols are more likely to remain suspended than large droplets that quickly settle to the ground due to the forces of gravity, although temperature, relative humidity, ventilation, and ambient air currents will influence settling or dispersion.[30] One study found that aerosols of around 5 µm in diameter can take up to nine minutes to settle to the ground.[69] They can be large enough to carry infectious virus and a modelling study estimated that one minute of loud speaking by an infected individual could produce up to 1000 virion containing particles.[38]

Playing musical instruments

The transmission risks associated with playing of musical instruments varies by the type of instrument. Playing of ***strings, keys or percussion*** typically does not present added risks due to respiratory droplets and aerosols but may present risks due to fomite transmission from shared instruments. Instrumentalist that play more energetically could be inhaling and exhaling more forcefully, which may increase the quantity of aerosols exhaled to the surrounding air.

Playing of ***brass and woodwinds*** may increase the release of respiratory particles by blowing air, sometimes forcefully, through a mouthpiece. Respiratory particles may exit through the instrument bell or keys, or across the surface for instruments such as the flute. Studies have visualized both the air disturbance and the release of respiratory particles from various instruments. Few studies have quantified the release of respiratory particles from brass and woodwind instruments. A study of blowing through a vuvuzela found that more particles were released, and at a higher velocity, than for loud shouting, with particles ranging in size from 0.5-5 µm.[68] More recent studies of aerosol releases from instruments are emerging in the literature, some of which are awaiting peer review.

- A study at the University of Denmark measured aerosols released from brass and woodwind instruments at distances of 0.5 to 4 m.[70] The total mass of particles below 10 µm was similar to background levels for brass instruments (tuba, trombone, trumpet, horn), and slightly higher for fagot, oboe, and flute; however, all instruments were significantly lower than coughing at a distance of 0.5 m
- At Colorado State University, Volkens et al. (2020) found that trumpet, saxophone and bassoon released more small aerosols than French horn, oboe and voice. Flute and piccolo released the least.[71]
- At University of Minnesota, He et al. (2020) found that released aerosol concentrations decreased with tube length, and mouthpiece design influenced aerosol concentration for woodwinds.[72] Tuba, bassoon, piccolo, flute, bass clarinet, French horn, and clarinet were found to produce lower or similar levels of aerosols compared to normal breathing and speaking. Trumpet, oboe, and bass trombone generated more aerosols than speaking. Playing style for individual musicians influenced aerosol concentration.

An added transmission risk for brass instruments is the breath condensate that must be regularly drained from the instrument. This concentrated fluid could potentially represent a risk of droplet, aerosol, or fomite transmission if not carefully collected and disposed.[73] Woodwind instruments with reeds can also present another route of transmission if there is the sharing or touching of other musicians reeds.[74]

Dance

There has been limited study of transmission risks specific to dance activities, with the risks associated with gathering in groups of key importance. Table 1 lists clusters and outbreaks associated with fitness classes, ballet companies, and ballroom/social dance instruction. The details of outbreak investigations are lacking but there may have been several contributing factors such as close personal contact with others, particularly for partnered dance, and enclosed and poorly ventilated indoor spaces.

The importance of vigorous physical activity during dance to the risk of SARS-CoV-2 transmission is not fully understood but physical activity can affect the quantity of air inhaled and exhaled and the air flow velocity.[75] Activities that result in deeper and faster inhalation and exhalation could increase the quantity of respiratory particles released and the distance they travel. If breathing zones of participants overlap, risk of inhaling particles released by others increases. A study of infection risks of influenza and tuberculosis during physical exercise in gyms found that infection risks increased with higher occupancy and poor ventilation.[75] There are relatively few studies examining transmission of SARS-CoV-2 during vigorous physical activity, with most of these linked to fitness centres and classes.[10,11,76] There many be similarities to dance in the types of fast movements and physical exertion that occurs. A study of five cases linked to a squash court in Slovenia found that the index case was a source of infection for his partner and other players using the same court after him, despite never having physical contact. Droplets and aerosols released by the index case during the squash match may have remained suspended due to poor ventilation and turbulent air flow or became resuspended due to disruption of droplets that had settled on

the floor. There is also potential that fomite transmission from touching of common surfaces within the court or changing rooms could have been a contributing factor.[77]

Risk modifiers in the performing arts

Transmission of COVID-19 is complex, and there are no single measures, other than self isolation from others, that can eliminate risk of infection entirely. In any setting, using multiple layers of protection can reduce risks of exposure significantly. The considerations for reducing transmission risks listed below are compiled from a wide range of Canadian public health and worldwide performing arts sector guidance and literature.[73,78-94] These do not supersede provincial health orders and local public health and occupational safety requirements. The Public Health Agency of Canada provides links to Provincial and Territorial resources for COVID-19 here. For most performing arts activities, the standard suite of precautions for reducing risks of transmission indoors apply, along with guidance specific to performing arts activities and venues.

Personal behaviours

Personal behaviours can affect the level of risk to an individual or others around them. Those who are immunocompromised or vulnerable to infection should consider staying home. Persons who are sick or have tested positive for COVID-19 or may have been exposed to known cases of COVID-19 should also self-isolate according to local public health advice. In the outbreaks in choirs in Washington State and Amsterdam, participants with symptoms attended the rehearsal(s) that resulted in transmission of SARS-CoV-2 to others. Communication with groups prior to rehearsals and events can include screening for symptomatic or highly susceptible persons, who should not attend.

The potential for transmission via pre-symptomatic and asymptomatic persons requires additional measures to reduce risks of transmission. Some groups may consider forming performance or rehearsal cohorts to limit the number of interactions within a larger company. Limiting the number of social contacts outside of a performance company or cohort can reduce the potential for members of the group to be exposed to infection from the wider community. Members of a group or company will rely on others practising safe personal behaviours outside of the group, such as physical distancing and mask wearing when in public and practising good hand hygiene.

Distancing measures

Maintaining physical distancing of at least 2 m is an important control measure for reducing transmission via large respiratory droplets and short-range transmission of aerosols. Physical distancing should be maintained between members or choirs, bands, dance companies, and theatre groups wherever possible, particularly during rehearsals and instruction. Face-to-face arrangement of performers should be avoided. Distancing should also be maintained between performers and the audience, technical staff, and venue staff, with mingling or socializing before or after rehearsals or performances discouraged. For performers playing wind instruments, distancing may need to be greater than 2 m to account for the length of the instrument.

Maintaining physical distancing may be more challenging in dance and theatre settings. Creative adaptations to performances may be needed to reduce the potential for close encounters and to avoid performers crossing through the breathing space of others. Assigning performers with designated areas on a stage/floor can prevent overlap of performance areas. Partnered dance or performance segments that require close contact could be adapted or limited to persons from the same household where possible.

The use of partitions is not practical in all settings but may be considered where it is safe to do so, either between stationary performers, or between performers and audiences. Maintaining distancing should not be limited to performance areas, and consideration for reducing close encounters in dressing rooms, washrooms, and backstage should be made such as floor markings, one-way flow of traffic, and occupancy limits for small spaces.

Box 1: Innovations for Keeping Audiences Distant:

The use of bigger venues makes separating audiences easier by allowing multiple entrances and exits and distancing between groups. Live concerts at a Cologne Germany arena have proceeded with reduced capacity of 1000 to 2400 by implementing distancing and hygiene rules and using plexiglass cubes to separate the audience into small groups of up to eight people. In Leipzig Germany, an experimental indoor live concert provided 1500 volunteers with fluorescent hand gel and electronic contact trackers to trace the contact rates and distances for three scenarios. The outcomes of the study will inform how various measures can reduce transmission risks.

Image credit: GettyImages

Reducing density and duration

Crowding makes it difficult to maintain physical distancing and allows for rapid accumulation of exhaled aerosols, which can be transported on air currents. There may be no safe physical distance to reduce risks to a negligible level if one or more infected persons, or a super-emitter with a high viral load, is present in an enclosed space.[54] Reducing the density of participants and the duration they spend in a space can reduce the potential exposure dose. Large groups should avoid activities in closed, unventilated rooms even with distancing measures in place. Maximum occupancy limits or moving activities to larger spaces can reduce the concentration of exhaled air in a space.

Duration limits vary by jurisdiction, ranging from 15 minutes to no specified limit. Based on current standards of ventilation for many indoor environments, one study estimated that occupancy of 30 minutes is recommended for an infection risk level below 10% for high-emission activities.[6] The 30-minute limit followed by a break outside of the room, or moving to an alternative space, to allow the room air to clear is a commonly recommended duration for activities such as choir singing.

Masks

The use of face coverings whenever possible while around others can block emissions of droplets and reduce the spread of aerosols, but masks do not remove transmission risks entirely.[71,95-97] To reduce reliance on masks while performing, some theatre companies are adapting performances to reduced speaking or using voice-over narration as an alternative.[98] Where masks are used, the most effective are those that fit well, without gaps around the nose bridge, chin, and sides, and those made of materials that effectively block the movement of both droplets and aerosols. Many homemade masks and adaptations of traditional masks have not been assessed for their effectiveness. Masks such as singers' masks, adapted for use during rehearsal and performance, have not been widely assessed (Box 2).

Box 2: Innovation in Masking for the Performing Arts

Several versions of performers' or singers' masks (pictured) have been designed that allow for greater articulation and mouth movement.

Similarly singers face shields adapt the concept of conventional face shields by adding a cloth covering around the edges of the shield to prevent the outward movement of droplets and aerosol. The effectiveness of these for reducing transmission risks has not been assessed in the literature.

Image credit: Broadway Relief Project

Standard masks have also been adapted for playing of some wind instruments by cutting a straight opening in the centre of the mask for the mouthpiece to allow the instrument to be played while the performer wears a mask. These masks should be replaced with unaltered masks when not performing. Masks, or bell covers, for instruments are also recommended to prevent the release of aerosols during playing. An alternative for flutes is a pop screen in front of the mouthpiece that can reduce forward projection of droplets and aerosols.

Ventilation

Ventilation can affect the distribution and persistence of potentially infectious aerosols in a room. One study found that in well-ventilated rooms, the number of droplets produced by simulated

coughing (average 5 µm in diameter) halved within 30 seconds, compared to five minutes in the unventilated rooms.[69] Stadnytskyi et al. (2020) similarly found that airborne particles released by vocalization in a stagnant air environment were detected 8 to 14 minutes after speaking.[38]

Moving activities outside wherever possible is recommended. Outside air can help to dilute infectious particles to low levels and air flow can help to disperse particles (Box 3).

Box 3: Moving Performances Outside

Image credit: 604now.com

Until audiences can safely attend performances in sufficient numbers to be financially sustainable, some groups may not return to indoor venues. Innovations for outdoor venues have been observed in many countries the form of drive-in concerts (left) and the use of hundreds of socially distanced pods keeping small groups distanced from each other.

When inside, moving activities to larger rooms with good air exchange is recommended.[99] Larger room sizes allow for greater dilution of respiratory particles, but without proper ventilation, particles can accumulate and disperse within the room over time. Opening windows or exterior doors can be effective where mechanical ventilation systems are not available, but how air is flowing within a space should also be considered. Portable fans should be used with caution to ensure they are not simply dispersing contaminated air around a room. Mechanical ventilation, or well-planned natural ventilation can help remove particles with upward air flow exhausted to the outside, and can dilute indoor air with clean outdoor air.[73]

While recirculating systems are discouraged, where unavoidable, control measures to improve conditions such as increased percentage of outside air in ventilation, high-quality filters (e.g., MERV-12), or integrated disinfection systems (e.g., UV germicidal irradiation, either in ducts or in an upper room configuration) can be used to minimize recirculating virus.[100,101] Small and poorly ventilated areas may require breaks or alternative between two rooms to reduce the build-up of aerosols and allow room air to clear between uses. The use of portable air cleaners could be considered where other ventilation strategies are not possible.[100] Using portable air cleaners with high-efficiency particulate air (HEPA) filters can remove virus-laden aerosols from the air.[102] The effectiveness is influenced by the clean air delivery rate (CADR) of the air purifier (e.g., the volume of air that can be processed over a given time) as well as proper operation and maintenance of the system, such as changing and safe handling of filters at specified intervals.

Cleaning and disinfection to reduce fomite transmission

Control measures for fomite transmission include good hand hygiene practices and routine cleaning and disinfection of surfaces, as well as avoiding sharing of equipment, props, musical stands, instruments, costumes, microphones, and food and drinks. Where use of shared microphones is unavoidable, the use of disposable foam screens could be considered, which should be changed between performers followed by disinfection of surfaces where appropriate. Performers are also encouraged to keep their costumes apart from others and wash and clean them after each use or performance. Similarly, performers should consider doing preparation offsite, such as hair and makeup. Precautions should be taken for hair and makeup done onsite, such as avoiding the use of communal brushes and makeup supplies.

Although sharing of musical instruments is discouraged, cleaning and disinfection of instrument surfaces and mouthpieces should still be done routinely to reduce the possibility of fomite transmission. Guidance on cleaning and disinfection procedures and materials should be reviewed to ensure a thorough process is followed, while avoiding damage to the instrument.[103] For brass instrument players that empty condensate through spit valves, care should be taken to safely collect and dispose of condensate into a cloth or closed container followed by handwashing and hand sanitizing to prevent cross contamination of the instrument surface, chairs, music stands, or the floor.

Considerations for audiences

While jurisdictions will set the occupancy limits and detailed criteria specific to venues for allowing audiences to return to live performances, the 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 clearly set out COVID-19 safety protocols, to provide screening questionnaires regarding symptoms and exposures, request ill persons to stay at home, and to gather information for contact tracing following the event if needed. Some guidance recommends discouraging audiences from singing, cheering, dancing, and laughing. This can be a difficult request, but providing audiences with alternative ways to join in such as humming, clapping, or providing handheld noisemakers, can allow audiences to engage and to express their appreciation for the performance without vocalizing it.

Conclusions

Several factors may have contributed to COVID-19 clusters and outbreaks in performing arts settings, which include characteristics of the settings (indoors, crowded, poor ventilation), the activity (close interactions, loud vocalization, heavy breathing or exertion) and the prevalence of community transmission. Current evidence suggests that activities such as loud vocalization (speaking, singing, cheering, laughing) and physical exertion increase the quantity of small respiratory particles that can accumulate and remain suspended in air and could contribute to transmission risks. While the local epidemiological situation is the key driver of when and how activities will resume or scale up in various jurisdictions, there are precautions and control

measures that can be used to create several layers of protection for reducing transmission via respiratory droplets and aerosols and via fomites.

One of the limitations of this review is the lack of published details of epidemiological investigations of clusters and outbreaks. Further research is needed to better understand the concentration, infectiousness, and transport distance of SARS-CoV-2 in aerosols, and the dose-response relationship for SARS-CoV-2. Research and examples of what has worked or not worked in other jurisdictions will also be valuable in guiding and informing implementation of measures to reduce COVID-19 risk for performers, audiences, and production and support staff.

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Appendix 1: Rapid review method and search and terms

A rapid literature search was performed by the NCCEH information specialist using Ebscohost databases (includes Medline, Cinahl, Academic Search Complete, ERIC, etc.), and Google Scholar, with no date or jurisdictional limit, for English language documents. Further examination of bibliographies of key articles were scanned to retrieve more extensive information, and key authors in the subject area were searched to identify additional relevant citations. Forward chaining of key papers added to the search results and news reports identifying localized outbreaks associated with performing arts were scanned for details of outbreak investigations.

Search Terms: Variants and Boolean operator combinations, e.g.,:
(choir OR choral OR chorale OR singers OR chorister OR band OR opera OR ensemble OR "musical group" OR "music group" OR accompanist OR musician OR instrumentalist)
AND
(singing OR sing OR vocal OR vocalization OR rehearsal OR audition OR voice OR "forceful exhalation" OR exhale OR "lung capacity" OR speaking OR "speaking loudly" OR eject OR "forced Expiratory Volume" OR yelling OR screaming OR sharing)
(aerosol OR aerosolization OR aerosolization OR droplet OR crowding OR ventilation OR expel)
(predisposition OR vulnerability OR laryngeal OR illness)
AND
(transmission OR transmit OR infect OR infectious OR infectiousness OR infectivity OR illness OR virus OR viral OR influenza OR airborne OR expelled OR propel OR "Upper respiratory tract infections" OR respiratory OR sick OR sickness OR epidemiology OR outbreak OR "case report")
("seating arrangement" OR practice OR "wind instrument" OR woodwind OR brass OR oboe OR flute OR clarinet OR saxophone OR bassoon OR recorder OR trumpet OR trombone OR euphonium OR tuba)
("social connection" OR "connectedness" OR bonding OR socialization)
(coronavirus OR ncov OR "novel cov" OR COVID-19 OR SARSCOV-2 OR Sars-Cov-19 OR SarsCov-19 OR SARSCOV2019 OR "severe acute respiratory syndrome cov 2" OR "2019 ncov" OR "2019ncov")

(dance OR ballet OR play OR theatre OR theater OR hall OR audience OR workout OR karaoke)
(class OR classes OR studio OR show OR performance OR audition OR practice OR practise OR rehearse OR rehearsal OR "performing arts")
("live music" OR orchestra OR opera OR operetta OR festival OR "stage show" OR musical OR venue OR "art group" OR concert)
(dancer OR performer OR cast OR crew OR ballerina OR actor OR musician)
(Mariinsky OR Petersburg OR Boshoi OR Moscow)
(fitness OR exercise OR zumba OR aerobics OR workout OR disco OR jazzercise OR danceworks)
("fitness center" OR "fitness centre" OR "fitness facility" OR "fitness facilities" OR OR gymnasium OR gym)
("dance event" OR nightclub OR "night club" OR nightlife OR "night life" OR lounge OR hookah OR bar OR karaoke OR "after hours" OR partiers OR bar OR pub OR legion OR tavern OR festival)
AND
(cardiovascular OR volume OR lung)
(aerosol OR aerosolization OR aerosolization OR droplet OR crowding OR ventilation OR expel)
(predisposition OR vulnerability OR laryngeal OR illness)
AND

(transmission OR transmit OR infect OR infectious OR infectiousness OR infectivity OR illness OR virus OR viral OR influenza OR airborne OR expelled OR propel OR "Upper respiratory tract infections" OR respiratory OR sick OR sickness OR epidemiology OR outbreak OR case OR report OR study)

(coronavirus OR ncov OR "novel cov" OR COVID-19 OR SARSCOV-2 OR Sars-Cov-19 OR SarsCov-19 OR SARSCOV2019 OR "severe acute respiratory syndrome cov 2" OR "2019 ncov" OR "2019ncov")

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