

## SYNOPSIS

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# COVID-19 Transmission Risks from Singing and Playing Wind Instruments – What We Know So Far

## Introduction

PHO is actively monitoring, reviewing and assessing relevant information related to Coronavirus Disease 2019 (COVID-19). “What We Know So Far” documents are intended to provide a rapid review of the evidence related to a specific aspect or emerging issue related to COVID-19.

The development of these documents includes a systematic search of the published literature as well as scientific grey literature (e.g., [ProMED](#), [CIDRAP](#), [Johns Hopkins Situation Reports](#)) and media reports, where appropriate. Relevant results are reviewed and data extracted for synthesis. All “What We Know So Far” documents are reviewed by PHO subject-matter experts before posting.

As the COVID-19 outbreak continues to evolve and the scientific evidence rapidly expands, the information provided in these documents is only current as of the date of writing.

## Key Findings

- The evidence regarding the act of singing with respect to the risk of COVID-19 transmission (in group settings such as choirs) is limited to a few observational studies. In these reports, it is noted that multiple sources of transmission (e.g., prolonged close contact, touching common objects, or sharing food) may have contributed to disease spread.
- To date, there is no evidence that wind instruments increase the risk of COVID-19 transmission, either through the expulsion of infectious respiratory droplets or transfer of fomites from the wind instrument.
- There is evidence that the act of singing may generate droplets and/or aerosols, however, the degree to which this contributes to the risk of COVID-19 transmission is unclear.
- There is evidence that playing wind instruments may generate droplets and/or aerosols, and that instruments themselves could become contaminated with infectious pathogens. The degree to which this contributes to the risk of COVID-19 transmission is unclear.

## Background

Available evidence suggests COVID-19 is primarily transmitted via respiratory droplets during close, unprotected contact ([World Health Organization, WHO](#)). Transmission through fomites in the immediate environment may also occur, however the extent this contributes to community spread is not known. ([WHO](#)). Airborne transmission (over time and distance from source) has not been documented and is

unlikely to be contributing to community transmission. Small aerosol droplets may be generated during aerosol generating medical procedures, which may increase transmission risk ([PHO](#)).

COVID-19 transmission among choirs has been reported recently, prompting questions regarding the role of singing in transmitting the virus. Although transmission via wind instruments has not been reported to date, there is also a theoretical risk of transmission via respiratory droplets or aerosols produced during this activity.

The purpose of this document is to examine what is known so far about the risk of transmission of COVID-19 from singing and the use of wind instruments.

## Transmission Risk from Singing

Relevant studies on this topic are generally in two groups:

1. Studies that describe and/or measure the potential for generation of droplets or aerosols from the act of singing or playing a musical instrument.
2. Reports of transmission where singing has occurred.

Neither type of evidence is conclusive with regard to the risk of COVID-19 transmission. However, they suggest that a potential risk exists, though the magnitude remains unclear.

Below is a synopsis of the few identified studies documenting COVID-19 transmission through singing, such as in choirs. We additionally include research on other pathogens regarding singing and playing of wind instruments, to illustrate the general possibility of transmission in these contexts.

## Respiratory Droplet and Aerosol Dynamics

Current evidence suggests that the primary mode of transmission of COVID-19 is through direct contact and respiratory droplets that have the potential to be propelled varying distances ([Centers for Disease Control and Prevention \(CDC\)](#), [European Centre for Disease Prevention and Control \(ECDC\)](#), [Imai et al.](#)). Respiratory droplets have been measured up to 2 metres from the source, and as suggested in one study, the maximum transmission distance of SARS-CoV-2 aerosol might be up to 4 metres ([Guo et al.](#)). A systematic review of studies assessing the horizontal distance travelled by respiratory droplets found that = droplets can travel more than 2 metres and some studies found that they travelled up to 8 metres ([Bahl et al.](#)).

[Loudon and Roberts](#) demonstrated that singing produces fewer respiratory droplets (4,014) compared with talking (10,587) and coughing (41,857). However, the percentage of respiratory droplets that remained as droplet nuclei (aerosols) after 30 minutes was 35.7% for singing, 6.4% for talking and 48.9% for coughing. The results in this experiment need to be interpreted with caution, as the sample size was limited to three individuals, and the technology used for measurements at the time (published in 1967) is not the same as used today.

[Anfinrud et al.](#) noted that during speaking, more droplets (including aerosols and larger respiratory droplets) may be generated (measured as “flashes”) as speaking becomes louder [Asadi et al.](#) demonstrated that the rate of particle emission [mean size was 1 µm in diameter] during speech increased as speaking becomes louder; however, they note that the rate is highly variable between individuals (e.g., more than an order of magnitude increase in so-called “speech superemitters”). [Kwon](#)

[et al.](#) described how air expelled through coughing had an initial velocity of 15.3 m/s (males) and 10.6 m/s (females), compared to the velocity of air while speaking which was 4.1 m/s (females) and 2.3 m/s (males). The generalizability of these findings to singing is unclear.

## COVID-19 Transmission

To date, there have been several studies describing COVID-19 transmission during singing. However, these studies could not rule out the possibility that transmission occurred from close unprotected contact or via contact with shared surfaces or food, rather than spread via respiratory droplets/aerosols produced through the act of singing. It is also uncertain if the size of the space and/or the quality of ventilation within an occupied space may have played a role in these transmission events.

- In Washington State, USA, [Hamner et al.](#) reported on an outbreak of COVID-19 among members of a church choir. Transmission in this report occurred during a 2.5 hour choir practice, in which there were 61 attendees. A symptomatic case led to 32 confirmed and 20 probable secondary cases, resulting in secondary attack rates of 53.3% (confirmed cases only) to 86.7% (confirmed and probable cases). The authors conclude that a number of factors could have contributed to transmission, including close proximity (6-10 inches for part of the time) for prolonged periods (2.5 hours), touching shared surfaces (e.g., stacking chairs, sharing snacks), and possibly facilitated by the act of singing.
- In Singapore, [Wei et al.](#) described seven clusters of COVID-19 cases in which presymptomatic transmission is believed to have occurred. In two of these clusters, a presymptomatic case infected another person during a singing class.
- In South Africa, [Jaja et al.](#) suggested that COVID-19 outbreaks were often associated with funeral and church services as social distancing guidelines are not routinely adhered to. Singing occurs at both funerals and church services. “During church services, congregant[s] sing and worship loudly, sit close to each other and often touch surface/fomite which may be contaminated.”
- In Hong Kong, [Cheng et al.](#) reported that 11 clusters involving 113 cases were associated with people not wearing masks in several setting, including “singing at karaoke.”
- In a study of a super-spreading event (carnival festivities) that occurred in Gangelt, Germany, [Streeck et al.](#) [not peer reviewed] note that “loud talking and singing in close proximity” are common behaviours at such events, but among the COVID-19 cases identified in the study, individuals who attended the festivities were significantly more symptomatic than those who did not, suggesting that loud voices and singing in close proximity may release more viruses in the air and lead to more severe infections.
- In Japan, [Furuse et al.](#) identified 61 clusters of COVID-19 (defined as  $\geq 5$  cases), of which 7 (11%) were events involving music (e.g., concerts, choir rehearsals, karaoke parties). No details were provided. The authors note that many of these clusters involved heavy breathing where people are in close proximity.
- Two other epidemiologic studies ([Pung et al.](#), [Yong et al.](#)) identified clusters of COVID-19 cases that occurred in the context of church service attendance; however, the role that singing had was not addressed.

## Non-COVID-19 Transmission

There are numerous examples in the literature where pathogen transmission has occurred during singing, such as in a choir. The generalizability of these examples to COVID-19 must be interpreted with caution, as the epidemiology and transmission of these pathogens is different (e.g., tuberculosis [TB] is an airborne infection).

- The most commonly reported pathogen transmitted during singing is *Mycobacterium tuberculosis* (causative agent of TB), and studies of TB transmission in this context date back at least to [Loudon et al.'s](#) 1967 review. Since then, several outbreaks have been documented among school and church choir members (e.g., [Mangura et al.](#), [Sacks et al.](#), [Washko et al.](#)). The percentage of choir members who demonstrated evidence of infection (positive skin test) after exposure ranged from 18% to 19%. Note that none of the studies demonstrated TB skin test conversion. Additionally, various factors aside from singing were considered as potentially contributing to transmission (e.g., ventilation, close contact, contact outside of choir activities, etc.).
- [Kar-Purkaystha et al.](#) reported on an early cluster of influenza A (H1N1) infections in 2009 in the United Kingdom (UK) involving 3 schools, a party and a choir. In this study the maximum attack rate for the choir setting was 4%, compared to attack rates between 1% (in one class) and 25% (at a party).
- In the UK, [Briscoe et al.](#) reported on an outbreak of streptococcal throat infections among students at a boys school, including some choir members. Over a period of three school terms, 37 out of 95 (39%) boys, including 13 (46%) out of 28 choir members, tested positive. The authors believed the infection likely spread by the classes, dormitories and choir, and there was no evidence that choir members were at higher risk of infection than other students.

## Transmission Risks from Wind Instruments

To our knowledge, there are no reports of COVID-19 transmission via wind instruments. In theory, transmission via wind instruments could occur from production of infectious droplets while playing, or touching or blowing into the instrument recently used by an infected individual, within a certain time period (i.e., the instrument serves as a fomite). Using other pathogens (e.g., bacteria) we can hypothesize that COVID-19 transmission via wind instrument contamination/use is possible.

## Respiratory Droplet Production by Wind Instruments

- [Lai et al.](#) investigated the quantity and size of aerosols emitted when playing the vuvuzela (plastic blowing horns used by sports fans) and compared this to shouting.
  - Aerosols exiting the instrument were measured and mean concentration of particles recorded from playing the vuvuzela and shouting were 658,000 and 3,700 per litre, respectively. The mean peak volume of air exiting the vuvuzela was 6.1 liters per second compared to 1.8 liters per second for shouting. The vast majority (97%) of particles captured from both the vuvuzela and shouting were between 0.5 and 5 microns in diameter.
  - Overall, the authors concluded that blowing the vuvuzela has the capacity to propel very large numbers of aerosols into the air of a size capable of penetrating the lower lung, potentially acting as a conduit for the spread of infectious particles if used by a person with a respiratory tract infection.
  - Note that the vuvuzela is essentially a straight, long, flared plastic tube with no keys. There are no equivalent instruments used in most organized musical settings (e.g., typical brass or woodwind band instruments) which all have bends and/or keys, which create turbulence and [impede direct airflow](#) (and particle dispersion). Therefore, one cannot generalize these findings to other wind instruments.
- The [Vienna Philharmonic](#) and [Spahn et al.](#) [both not peer-reviewed] conducted experiments measuring airflow and air movement while playing wind instruments.

- The [Vienna Philharmonic](#) observations:
  - The goal of this exercise was to document airflow from wind instruments and the musicians while playing, using photography.
  - The article does not provide sufficient details for replication. In brief, a steady flow of aerosolized salt solution was provided via nasal prongs to musicians' nostrils to create photographable, measurable clouds of their exhalations as they played.
  - While this study mentions "aerosols", the size of droplets was not measured and the sensitivity of the photographic method used to visualize the aerosols was not reported.
  - Normal breathing showed a cloud of fog of approximately 50 cm emitted from the nose and mouth. For string instruments, this observation remained unchanged while playing (versus while at rest). For winds, "aerosols" were not reported or were "hardly visible" from the opening at the end of the wind instrument, with the exception of the flute, for which a larger amount of "aerosol" escaped from the opening at the end of the instrument, leading to a cloud formation in the maximum range of approximately 75 cm. They conclude that a musician's exhaled air is not expected to expand by more than approximately 80 cm, and is therefore within the 2 m distance recommended for physical distancing.
- [Spahn et al.](#) conducted a risk assessment in the field of music, based in part on data from a study of wind players and singers with the Bamberg Symphony Orchestra.
  - In this study, air movement was measured while an instrument was being played using sensors in the vicinity of the musician. The authors concluded that a minimum of 2 metres (6.5 feet) distance between musicians (including winds) was sufficient as no additional movement of indoor air during playing was detected at this distance. Therefore the risk of droplet transmission, if this distance protocol is followed, was classified as very low. Similarly, the authors provided similar recommendations for singing (e.g., 2 metres apart is sufficient based on results from their experiment).
  - Of note, the authors proposed a number of preventive measures to mitigate the potential risk of COVID-19 transmission during musical activities, including reducing the duration of the activity to allow for regular airing out of the space and applying cloth protection to the bells of wind instruments where feasible. Similar suggestions on ensuring good ventilation in adequately sized spaces, and on the use of a thin tightly woven fabric at the bell to contain aerosols were made by [Kähler et al.](#)
  - Similar to the [Vienna Philharmonic](#) study, this work does not address aerosol production by wind instruments or musicians.
- Aside from the direct expulsion of aerosols from wind instruments, [Schwalje et al.](#) describe the possibility of aerosol generation through deep breathing and forceful exhalation while playing wind instruments. This risk of aerosolization may be more pronounced for people learning to play these instruments.

## Wind Instruments as Fomites

### POTENTIAL SURVIVABILITY OF COVID-19 ON INSTRUMENTS

SARS-CoV-2 (the virus which causes COVID-19) can survive on surfaces and may be transmitted via contact. Currently, there have been no studies on the survivability of COVID-19 on wind instruments. However, studies have been performed on metals such as stainless steel and copper. The literature demonstrates that wind instruments are commonly contaminated with bacterial pathogens.

- [van Doremalen et al.](#) compared surface stability of SARS-CoV-2 and SARS-CoV-1. The results of this study were recently summarized in a [PHO Synopsis](#). An exponential decay in virus titre was seen for both viruses in all experimental conditions:
  - At 40% relative humidity and 21°C–23°C, both SARS-CoV-2 and SARS-CoV-1 were detectable for up to 24 hours on cardboard and up to two to three days on plastic and stainless steel. On copper, live SARS-CoV-2 and SARS-CoV-1 were not found after four hours and eight hours, respectively. The estimated median half-lives for SARS-CoV-2 on these surfaces were 0.8 hours for copper, 3.5 hours for cardboard, 5.6 hours for stainless steel, and 6.8 hours for plastic.
  - While the [van Doremalen et al.](#) study concluded that fomite transmission is possible, they did not demonstrate that it occurs.
- [Chin et al.](#) report on the stability of SARS-CoV-2 in different environmental conditions. At 22°C and a relative humidity of about 65%, viable virus was not detected after 7 days on stainless steel and plastic, after 1 day on treated wood and cloth, after 3 hours on printing and tissue papers, and after 4 days on glass. The authors noted that to recover the virus from the experimental surfaces, inoculated objects were immediately soaked in transport medium after the preset exposure time. As a result, the findings do not necessarily reflect the potential to acquire the virus from casual contact.
- [Pastorino et al.](#) tested the infectivity of SARS-CoV-2 on aluminum, glass and polystyrene plastic over 96 hours at 19°C–21°C and a relative humidity of 45%–55%, with and without 5% bovine serum albumin. The virus was not detected at 4 hours after inoculation on aluminum, at 48 hours on glass, but could still be detected at 96 hours on polystyrene plastic. In addition, infectivity of the virus was substantially preserved in the presence of proteins on all surface types, with a half-life of over 96 hours. The authors conclude that surfaces contaminated with the COVID-19 virus have a plausible role in transmitting the virus.

### POTENTIAL FOR INFECTIOUS DISEASE TRANSMISSION (NON-COVID-19) VIA MUSICAL INSTRUMENTS

- [Denton et al.](#) reported on a patient with cystic fibrosis who was recurrently infected with *Burkholderia cenocepacia* IIIB. The patient's trombone was implicated as the potential source of the infection on the basis of culturing the same pathogen from the instrument (spit valve, but not mouthpiece) as from his sputum. A similar study from [Corrao](#) identified *Mycobacterium kansasii* from sputum culture and in the trombone slide, which he argues may represent the source of infection. In both cases, the authors do not entertain that the pathogen was initially acquired elsewhere and deposited in the instrument from use.

- [Drover et al.](#) reported on the findings from 52 questionnaires completed by university orchestra members. Lung infection rates were higher in wind instrument players compared to the general public, attributed to poor instrument hygiene.
- [Glass et al.](#) noted that bacterial and fungal contamination of wind instruments was highest near the mouthpiece (unlike [Denton et al.](#), [Corrao](#)). The authors contend that shared instruments are a potential source of infection, especially among students.
- In a study examining bacterial and fungal contamination of wind instruments, [Marshall et al.](#) demonstrated that instruments played in the previous three days had the most mouth-associated microbial flora. In addition, reed instruments, compared to flutes and trumpets, had higher microbial loads. This study did not examine pathogen viability. A similar study from [Bridges](#) looked specifically at the microbial content of water key (“spit valve”) liquids (presumably contains saliva) from 30 samples taken from five types of brass instruments, and found evidence of environmental flora (*Alcaligenes faecalis*) in most, and a smaller proportion (5/30) demonstrating the presence of oral flora.

## Media

- There have been multiple media reports on COVID-19 acquisition in the context of singing. These have been summarized in [an Alberta Health Services review](#) on this topic. Such reports are informative but were not included in this scientific synopsis.

## Conclusion

The evidence for COVID-19 transmission from singing or playing instruments is limited to either experimental studies that demonstrate the potential for aerosol formation, or from observational studies where group singing preceded diagnosis in COVID-19 clusters. In the latter reports, multiple sources of transmission (e.g., prolonged close contact, touching common objects, or sharing food) may have contributed to disease spread. In summary, the extent to which group singing or playing of wind instruments increases the risk for COVID-19 transmission remains unclear, however organizing sessions to minimize duration of interactions and fomite contamination, maintain physical distancing and source control measures (e.g., face coverings and masks) and optimize ventilation may reduce the risk of transmission.

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