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COVID-19 Risks and Precautions for Choirs

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Introduction

The COVID-19 pandemic has required a rethinking of how many of our daily tasks and routine activities influence risks of transmission of SARS-CoV-2, the virus responsible for the disease. Early in the response to the pandemic, gathering in groups was identified as high-risk and limits on the number of people gathering was an essential public health tool for reducing community transmission. As reopening progresses, groups that were previously prevented from gathering are seeking advice and guidance on when and how to resume activities safely. As more research and evidence on dominant transmission routes and risk factors for SARS-CoV-2 are identified, the public health guidance is also evolving. This includes better understanding of how the nature of specific activities and the characteristics of the settings in which they take place can influence risks of transmission.

This brief evidence review provides an overview of the key risks associated with singing in groups. Please see Appendix 1 for the literature search method and search terms. Beyond the risks and recommended precautions associated with gathering in groups, this review identifies the risks specific to singing in groups, and the suite of precautions that can be considered to minimize these risks. This document will be updated as further evidence emerges.

Notable outbreaks related to singing rehearsals or performances

Several examples of COVID-19 clusters or outbreaks, where singing or loud vocalization have featured in the venue or activity, have been reported in various media reports and academic journals.[1] These outbreaks have also included other risk factors such as crowding or gathering in large groups, enclosed spaces or poor ventilation, long duration of contact, and other types of interactions such as greetings and social interactions, sharing of food, drinks or equipment, and shared transport. Some examples of outbreaks where singing or loud vocalization have featured are listed below. There has been limited published literature detailing investigations of outbreaks related to singing in groups, with some reports providing only anecdotal accounts of these events.

As further research emerges, greater insight may be gained by investigating specific details of settings and the types of interactions that may have contributed to transmission.

Skagit Valley Washington: Choir rehearsal outbreak

The most widely cited outbreak associated with singing in a group was a choir in Skagit Valley, Washington where, following a 2.5-hour rehearsal on March 10, 2020 attended by 61 persons, 53 cases (33 confirmed, 20 presumed) were subsequently identified.[2] Three persons were hospitalized and two died. At the time of this event, there were no known cases of COVID-19 in the local community; however, the index case was experiencing cold-like symptoms for three days prior, and several members of the group also attended a rehearsal together the previous week. There is no evidence that more than one index case was present. Members of the choir avoided handshakes and hugging and used hand sanitizer but also spent time singing together spaced at 15 to 25 cm apart. Due to the widespread secondary attack rate, it is unlikely that fomite transmission and face-to-face contact with the index case were the primary routes of transmission, suggesting that inhalation of respiratory aerosols in shared air over a prolonged duration may have dominated.[3] Details on heating and ventilation in the setting were limited; however, no windows or doors were open, and the furnace that was operating used both outside make-up air and combustion air, although proportions were unknown. The furnace included a MERV 11 filter, with efficiency of up to 65% for particles 1 um or larger.[3]

Concertgebouw auditorium, Netherlands: Choir performance

A series of choir rehearsals between February 25 and March 7, 2020 and a performance by the Amsterdam Mixed Choir on March 8 resulted in 102 members of the 130 participant choir falling ill with COVID-19. Three partners of choir members and one choir member subsequently died. The choir held rehearsals on February 25, two days before the first official case of COVID-19 was announced in the Netherlands. Another rehearsal went ahead on March 3, with some members of the choir reporting symptoms and not attending the rehearsal. On March 7, the day before the concert, a dress rehearsal with the entire orchestra and six soloists was held in a large venue. Fifteen singers reported sick and did not attend the rehearsal. During the rehearsal, members reported being well-spaced while rehearsing but socialized and stood close in line for the coffee break. On the day of the concert, thirty members of the choir reported being ill, and in the weeks following, most of the choir members reported being ill. Of the thousand-member audience that watched the concert, subsequent follow-up inquiries with concert goers did not identify widespread transmission.

Berlin Cathedral, Germany: Choir practice

Five days after a Berlin Cathedral Choir practice on March 9, 2020, one of the 80 participants reported that she had tested positive for COVID-19. Within two weeks, 30 members had tested positive and another 30 were experiencing symptoms. Overall, 60 of the 80 participants that attended the March 9 practice became infected. Few details on the setting and types of interactions at the March 9 practice could be identified at the time of writing.

Japan: Clusters associated with large music venues

An analysis of 61 clusters of cases (five or more persons) in Japan between January 15 and April 4, 2020 found that 11 % were music-related events including large numbers of cases associated with large music venues. These events shared many risk factors common with other outbreaks including being enclosed indoor spaces with poor ventilation, crowded settings with large numbers of patrons and close contacts. Many of the settings were associated with activities that included loud vocalization including singing, cheering, and loud conversations and exercising; however, it is unclear the degree to which loud vocalization may have contributed to transmission.[4,5]

South Korea: The Shincheonji Church of Jesus

Religious venues have been at the centre of many outbreaks, with multiple examples of widespread community transmission among church congregations. Approximately 5000 cases were linked to the Shincheonji Church of Jesus, where characteristics such as large numbers of attendees, indoor confined spaces, and participation in singing and close physical contact could have led to transmission of SARS-CoV-2 via various transmission routes. The extent to which singing itself contributes to outbreaks among church congregations is unknown, but it may be one of many factors increasing overall risk in crowded indoor spaces.

Berrien Springs Michigan: Concert cluster

A small cluster of cases was identified following a performance by Christian singer Sandi Patty in Berrien Springs Michigan, in early March 2020. The singer was later found to be infected with the virus but had not displayed symptoms on the day of the concert. Two additional women who had participated in a backstage VIP experience with the singer also tested positive. No other concert goers were affected, indicating that transmission likely occurred during close contact during the backstage interaction and not during the singing performance.

Overview of transmission pathways for SARS-CoV-2

Large respiratory droplets

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 droplets generated during coughing, sneezing, and other respiratory actions that produce large droplets (> 5 µm diameter).[6] Large respiratory droplets can be contained by actions such as mask wearing, respiratory etiquette (covering one's mouth when coughing or sneezing) and via physical distancing measures that help to ensure there is sufficient distance for respiratory droplets emitted from an infected person to drop to the ground before reaching others.

Small respiratory droplets/respiratory aerosols

Increasingly, transmission via smaller droplets or respiratory aerosols (< 5 µm diameter) produced by speaking, singing, shouting, or breathing 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.[3,7–12] Small respiratory droplets can remain in the air longer than large droplets and could present both a risk of exposure in close contact with an infected individual, and potentially over longer distances in enclosed spaces.[11,13] Some preliminary evidence under experimental conditions suggests that SARS-CoV-2 may remain viable when airborne over short distances for several hours.[14,15] Transmission via respiratory aerosols could be occurring in settings where these particles accumulate in unventilated indoor environments where there is a high density of people and extended duration of contact.[4,16] Control measures for this type of transmission may rely heavily on reducing crowding, reducing the duration of interactions in indoor spaces, and ensuring good ventilation.

Contact transmission and fomites

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 still poorly understood. Surfaces can be contaminated by expelled droplets, or by direct contact with a contaminated hand. Surfaces that are frequently touched by many people, such as door handles or faucets, may be more important in fomite transmission compared to objects or surfaces that are only touched incidentally and less frequently. Control measures for fomite transmission include good hand hygiene practices and routine cleaning and disinfection of surfaces.

Pre-symptomatic and asymptomatic transmission

Understanding the dominant transmission pathways in the SARS-CoV-2 pandemic 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).[17] The precise incidence of pre-symptomatic and asymptomatic transmission is unknown, but it may be significant. A review of studies by Heneghan et al. (2020) found that between 5% and 80% of people infected with SARS-CoV-2 may be asymptomatic.[18] He et al. (2020) estimated that 44% of secondary cases became infected while the index case was pre-symptomatic.[19] This study estimated that infectiousness can begin two to three days before symptom onset and may peak 0.7 days before appearance of symptoms. This aligns with findings of investigations of outbreaks and clusters associated with pre-symptomatic and asymptomatic transmission, suggesting that infectiousness may peak on or before symptom onset in the index case.[20] Examples of pre-symptomatic and asymptomatic transmission throughout the COVID-19 pandemic have promoted the theory that, in the absence of symptoms such as sneezing and coughing, transmission routes other than via large respiratory droplets are significant, particularly in confined spaces.

Control measures to reduce pre-symptomatic and asymptomatic transmission include self-isolation for persons who have tested positive for COVID-19 or may have been exposed to known cases of COVID-19, limiting the number of social contacts and restricting group sizes, maintaining safe physical distancing, and mask wearing in public. The potential for transmission via pre-symptomatic and asymptomatic persons via multiple routes, including respiratory aerosols, has implications for activities such as singing in groups.

Singing in groups: Risks associated with large gatherings

The vast majority of COVID-19 outbreaks have been linked to interactions in indoor environments, particularly large group gatherings over prolonged duration.[1,16,21] Gathering in large groups where individuals interact with each other, such as choirs, church congregations, or social gatherings with extended family or friend groups (e.g., weddings, funerals, birthday parties), presents risks of transmission via all three routes listed above:

- Close contact while greeting each other, as well as hugging, talking, and laughing increases the risk of transmission via respiratory droplets, fomites, and short-range aerosols. Close contact can also be associated with the sharing of sheet music, stands, or microphones that make physical distancing difficult to maintain.
- Gathering in large numbers for a prolonged duration, in enclosed spaces, with limited ventilation increases the risk of accumulation of smaller bioaerosols that do not drop to the ground or disperse in the ventilation. Bioaerosols that do not settle may also be transported beyond 2 m depending on air flow within a space.
- Sharing of surfaces and objects such as musical stands, chairs, books, microphones, instruments, food, dishes and cutlery, or drink dispensers increases the risks of fomite transmission.

Singing in groups: Risks associated with emission of droplets

No published studies have investigated singing and transmission of SARS-CoV-2 directly, although singing has been implicated as an important factor in some outbreaks. These studies propose that the act of singing, or loud vocalization, could contribute to the release of infectious respiratory droplets.

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.[8] Vocalization, whether whispering, loud speaking, or singing produces a higher concentration of particles than breathing.[22] Respiratory particles released by vocalization are generated by a combination of mechanisms in the bronchioles, larynx, and oral cavity. As air is exhaled from the bronchioles, the mucosal layer on the collapsed surfaces forms a continuous film. During inhalation, this continuous film is torn apart by incoming air, forming small particles (fluid-film burst) that are inhaled into the lungs, and subsequently exhaled. In the larynx, oscillation of the vocal folds occurs for voice production. As the vocal folds open and close during vocalization, fluid film between them can also rupture, releasing particles.[23] Aerosols can also be produced from the oral cavity during speech.[24]

A combination of processes thus occurs during speaking and singing as release of droplets due to fluid-film burst in the bronchioles varies with inhalation and exhalation, and release of droplets from the larynx may vary depending on vocalization style. Greater exhalation volume may be required for larger amplitude, and as the volume of speech increases, the number of respiratory particles released has also been found to increase, although the distribution of particle sizes remains similar.[23] The type of phonation can also affect particle production, with some vowel and consonant sounds producing more particles than others.[25,26]

There is some evidence that the type of singing and training of the singer may affect the release of droplets. Professional singers may be more skilled in adjusting their breathing mode to produce sound more efficiently, with less forceful inhalation and exhalation.[27] Deep exhalation can increase the concentration of exhaled particles by four to six fold, and rapid inhalation can also increase concentration of released particles by two to three fold.[28] In contrast, rapid exhalation has less impact on the aerosol concentration released. Choir singers have been found to have a higher average vital lung capacity than non-singers, and the inspiratory capacity of singers has also been found to be greater on average.[29] Children may release fewer respiratory particles due to smaller lungs with fewer terminal bronchioles where production of aerosols via fluid-film burst could occur. In a pre-print by Riediker and Morawska (2020), the authors propose that reduced formation of respiratory droplets may partially explain why children are poor transmitters of SARS-CoV-2 compared to adults; however, further study is needed to investigate this theory.[30]

Size of particles produced during vocalization

The size of particles produced by singing and loud vocalization may be important to identifying predominant transmission routes. A study of respiratory aerosols produced by various activities, including loud vocalization in the form of shouting or cheering, found that the majority of particles released were between 0.5 and 5 µm in diameter.[31] Another study examining droplet size distribution during speech found that both large and small droplets were released, with droplets in the range of 1 to 10 µm in diameter being more prevalent.[32]

While large droplets (e.g., ≥ 20 µm) will typically settle to the ground prior to losing moisture due to evaporation, moisture on smaller droplets may evaporate before they settle, causing droplet nuclei to remain suspended for some time.[33] Somsen et al. (2020) found that while large droplets emitted by coughing do not travel far, small droplets of around 5 µm in diameter, emitted by both speech and coughing, can take up to 9 minutes to settle to the ground.[32] In well ventilated rooms, the number of droplets produced by simulated coughing (average 5 µm in diameter) halved within 30 seconds, compared to 5 minutes in the unventilated rooms. 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.[12] Particles of 5 µm in diameter or less are much more likely to penetrate further into the respiratory tract, including the alveolar region, and particles of 5 to 10 µm can penetrate the tracheobronchial region.[34]

Quantity of particles produced during vocalization

A study that visualized bursts of speech droplets using laser light scattering found that speech can produce an average of 1000 particles per second, as well as a range of droplet sizes including larger droplets of 10 to 100 µm that remained airborne for at least 30 seconds.[35] Asadi et al. (2019) found a linear correlation between volume of speech and number of respiratory particles emitted.[23] Even quiet speech emits more particles than normal breathing and the quantity of emitted particles during all volume of speech are greater than during breathing. Respiratory events such as coughing and sneezing have a higher velocity and can release a high concentration of droplets of various sizes but these events have a low frequency compared to breathing, speaking, or extended periods of singing. Gupta et al (2010) found that the total volume of air exhaled during breathing and talking for two hours were an order of magnitude greater than 100 coughs. Over an extended period, the quantity of droplets produced by non-coughing or sneezing activities could be greater. 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.[23,36]

Release of infectious virus in respiratory particles

As presented above, singing, and loud vocalization could increase risks of transmission via respiratory droplets of all sizes. Large quantities of small respiratory particles can be produced, and they can remain in the air for an extended time frame. These small particles can reach deep into the respiratory tract where they can potentially cause infection. There is still no firm evidence as to the level of exposure to infectious SARS-CoV-2 virus that is required to cause an infection. It is speculated that approximately a few hundred SARS-CoV-2 viral particles is needed to cause infection.[37] Viral load in the respiratory tract can vary by location and stage of the disease, but measurements of viral load during the early stages of the COVID-19, when viral loads are highest, have found median viral loads between 10^4 to 10^6 copies per mL of respiratory fluid.[38–40] Viral loads of SARS-CoV-2 in sputum have been found to be higher than in the throat, and up to 10^{11} copies per mL have been detected in respiratory fluid.[38] Riedeker and Tsai (2020) estimated that an average emitter will release about 10^6 copies per ml.[41] 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 in the respiratory particles emitted. If infected persons are asymptomatic or pre-symptomatic, they may be unaware that they are emitting infectious particles and presenting a risk to others in the room. A modelling study found that being in the same room with a person (whether or not they are displaying symptoms) with a high viral load can lead to an increased concentration of infectious particles, and risk of infection in a relatively short time.[41]

Precautions for choirs to minimize transmission of SARS-CoV-2

The key risks associated with singing in groups have been identified as common risks associated with large gatherings, as well as the additional risks associated with vocalization (release of greater quantities of small respiratory particles). The number of singers, the room size, the level of ventilation, and duration of singing all contribute to determining risk as well as the prevalence of SARS-CoV-2 cases within the community. Some of the control measures that can be considered for reducing these risks are discussed below.

Distancing measures

Maintaining physical distancing of at least 2 metres is an important control measure for reducing transmission via large respiratory droplets and should be maintained between members of a choir and between singers and the audience. There is also evidence that maintaining 2 metres distance can help to reduce the short-range transmission of small droplets or bioaerosols.

Singing in groups also includes a risk of transmission via aerosols, but due to aerosols persisting in the air for a longer duration than large droplets, ambient air currents can cause them to be dispersed within a room. A minimum distance to prevent transmission via aerosols cannot be easily determined. The risks of exposure may vary depending on the size of the room, the number of singers, and environmental factors such as ventilation, temperature, relative humidity, etc. There may be no safe physical distance to reduce risks to a negligible level if one or more infected persons is present, or a super-emitter with a high viral load is present in an enclosed space. Groups should avoid singing in closed, unventilated rooms even with distancing measures in place.[42]

Reducing density and duration

Short of suspending the activity all together, an approach to maintaining good indoor air quality includes reducing indoor emissions by limiting the number of participants and the duration of participation.[3] It is more difficult to maintain safe physical distancing in crowded spaces, and occasional encounters less than 2 m are more likely to occur as crowding increases. Crowded spaces also allow for more rapid accumulation of exhaled air due to a greater number of persons emitting. Reducing the number of participants in the space at one time or moving rehearsals into larger rooms or performances into larger venues can reduce crowding. Reducing the duration of rehearsals or performances can also reduce accumulation of potentially infectious aerosols. Based on current standards of ventilation for many indoor environments, occupancy of 30 minutes is recommended for an infection risk level below 10% for high emission activities.[3]

Larger groups can also consider reducing the number or participants at any one time. Adjusting timings to allow for shorter rehearsals or performances, with fewer people, and more scheduled breaks outside of the rehearsal space can allow for aerosols to disperse or settle. It should be noted that scheduled breaks should not lead to participants gathering or socializing in other confined areas.

Ventilation

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. When inside, moving activities to very large rooms with good air exchange is recommended to reduce risks.[43] 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 consideration of 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.[42]

While recirculating systems are discouraged, where unavoidable, control measures to improve conditions such as increased percentage of outside air in ventilation, high quality filters (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.[44,45] Small and poorly ventilated areas may require ventilation cycles between usage, increased airflow or adding filtration where possible.[44]

Additional measures

As noted in the outbreaks in Skagit Valley, and Amsterdam, participants with symptoms attended the rehearsal(s) that resulted in additional transmission of SARS-CoV-2. Although these events occurred early in the global pandemic, they demonstrate the importance of symptomatic persons, even if only mildly symptomatic, excluding themselves from group activities. Communication with groups prior to rehearsals and events can include screening for symptomatic or highly susceptible persons, who should not attend.

Members who do attend can consider avoiding face to face singing, and the use of face coverings when not singing to reduce the release of aerosols due to breathing. Face coverings can also be considered during breaks or when speaking to each other or entering/exiting the venue. Other types of barriers may be considered in some situations to limit the spread of aerosols and droplets directly in front of a singer, such as pop shields on microphone stands.[46] Other measures that have been suggested include a staggered arrangement of singers in rows, and practices such as tilting the head downwards when singing to limit projection of respiratory particles.[46] Further study is needed to identify the impact of these measures on reducing risks of transmission

General precautions associated with close-contact and fomite transmission can also be applied to singing groups. Control measures for fomite transmission include good hand hygiene practices and routine cleaning and disinfection of surfaces, as well as avoiding sharing of equipment, musical stands, and microphones, and socializing over food and drink during breaks.

Further guidance

A number of organizations have developed guidance and recommendations for various levels of choir singing, from school choirs to community choirs. The American Choral Directors Association committee report from June 15, 2020 includes detailed recommendations for instruction, rehearsals and performances.[47] Choir Alberta, Choral Canada, and Government of Manitoba have also produced resources, and many individual groups and choirs are now developing their own guidance and plans for safe singing.[48-50] Quick response evidence reviews from Alberta Health Services on *Singing as a risk for transmission of SARS-CoV-2 virus,*[51] Newfoundland & Labrador Centre for Applied Health Research on *Choirs and COVID-19*,[52] and Public Health Ontario on *COVID-19 Transmission Risks from Singing and Playing Wind Instruments*[53] have also been produced, summarizing recent literature and media reports on COVID-19 and choirs. Additional resources will be added to this document as they emerge.

Several organizations are currently conducting research to further understand how singing contributes to release of respiratory aerosols and implications for transmission of SARS-CoV-2. Examples of upcoming research yet to be published include study of droplet and aerosol emission of choristers by Public Health England,[54] and by MU University Hospital Munich and the Universitätsklinikum Erlangen (FAU)[55] in Germany. Outcomes of a study on the rate and size of bioaerosols emitted by different singers, and the impact of active and passive control measures by University of Colorado[56] is also expected. This document will be updated as new evidence emerges.

Conclusions

This brief review has outlined the key risks associated with singing in choirs, including the risks associated with gathering in large groups, and the additional risks related to production of small respiratory droplets via vocalization. While singing may have contributed to transmission in notable outbreaks associated with choirs, the degree to which singing impacted transmission is uncertain. In each of the outbreaks listed, multiple transmission routes may have contributed to overall infection levels. General features such as gathering indoors in large groups for prolonged duration, and with close personal interactions, have also featured in other outbreaks. Further research is needed to better understand the concentration, survival, and transport distance of SARS-CoV-2 in aerosols, and the dose/response relationship for SARS-CoV-2.[7] Greater understanding of the risk of different activities indoors and outdoors is also needed. Further research is needed to investigate appropriate distancing measures between the choir and the audience, the impact of choir configurations, and precautions specific to children's choirs.

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Appendix 1: Rapid review method and search 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 group singing were scanned for details of outbreak investigations. A limitation of the review was the paucity of research specific to SARS-CoV-2 and transmission via singing, as well as the rapid turnaround time for examining all relevant evidence.

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”)

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