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Following the Science:

A systematic literature review of studies surrounding singing and brass, woodwind and bagpipe playing during the COVID-19 pandemic

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Overview

Introduction

The current COVID-19 situation has resulted in widespread concern and considerable uncertainty relating to the position of musical performance and in particular potential risks associated with singing and brass, woodwind and bagpipe playing. There is a wide range of advice and guidance available but it is important that any guidance given should be evidence-based and the sources of this evidence should be known.

The aim of the study was to carry out a systematic literature review in order to gather historical as well as the most current and relevant information which could provide evidence-based guidance for performance practice. This literature was analysed in order to determine the evidence of risk attached to singing and brass , woodwind and bagpipe playing, in relation to the spread of airborne pathogens such as COVID-19, through droplets and aerosol. It also informed the recommendations for best practice.

Research Questions:

Q - What is the evidence in the literature of risk attached to singing, brass, woodwind and bagpipe playing, in relation to the spread of airborne pathogens such as COVID-19, through droplets and aerosol?

Q - How do these music making activities relate to other everyday activities such as breathing, talking and exercise in relation to aerosol transmission?

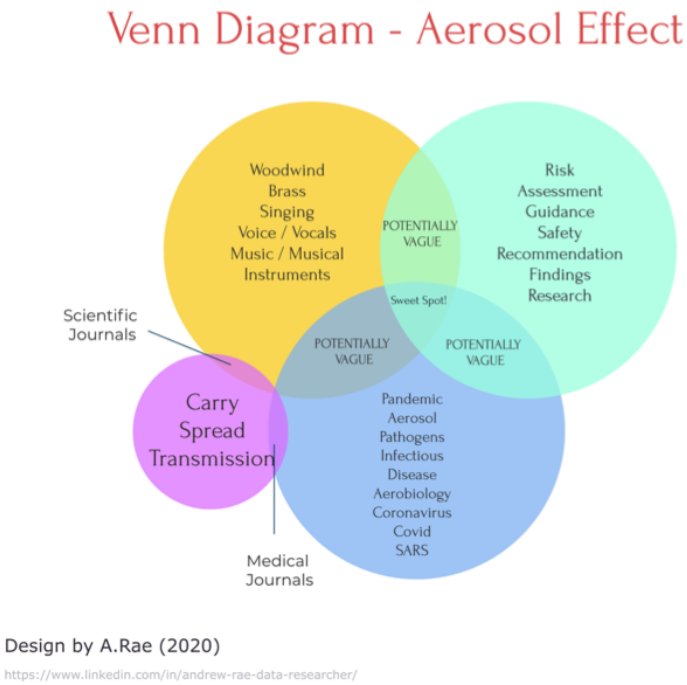
Q - What are the recommendations for best practice?

Research Method

Systematic Review

The approach adopted involved carrying out a systematic review of the literature in order to create a rigorous and transparent form of identifying a wide cross-section of risk-related literature to singing and brass, woodwind and bagpipe playing during the COVID-19 pandemic. A systematic review has been described as 'a replicable, scientific and transparent process that aims to minimise bias through exhaustive literature searches of published and unpublished studies and by providing an audit trail of the reviewer's decisions, procedures and conclusions' (Tranfield et al. 2003).

The review was designed to provide a complete and exhaustive summary of current evidence, published and unpublished up until the end of July 2020. These publications have been set out in the matrix of identified papers (**see Appendix**). Works published after this period will not necessarily appear in the literature matrix. However, there are some notable exceptions referenced in the discussion section (**page 6**) which are highlighted in this report as being notably recent and significant pieces of literature. Papers in the literature matrix include non-peer reviewed as well as peer-reviewed publications. This was on the basis that these unpublished and non-peer reviewed papers met the selection criteria..



Before conducting this process, a text-based matrix (see Venn Diagram above) of possible search terms which would maximise the likelihood of finding 'relevant' pieces of literature, pertaining to the research questions, was structured and implemented to allow the researchers to keep track of all the combinations and possible results.

These pre-determined 'search-strings' were then used alongside appropriate online databases and social sites, in order to trace all concurrent literature related to music activity guidelines on a global scale. A sample list of these search-strings has been provided below:

Search-Strings

(no.)	Keywords
1	music - airborne - pathogen - virus
2	music - instrument - covid - airborne - pathogen - virus
3	music - singing - covid - airborne - pathogen - virus
4	music - singing - spread - airborne - pathogen - virus
5	music - wind - instruments - vocal - singing - spread - pathogens - virus - airborne
...	...
26	brass - wind - instruments - vocal - singing - spread - pathogens - virus - airborne
27	brass - music - instrument - covid-19 - airborne - pathogen - virus
28	wind - music - instrument - covid-19 - airborne - pathogen - virus
29	performers - stage - covid-19 - airborne - pathogen - virus
30	performers - music - woodwind - brass - instrument - covid - airborne - pathogen - virus - guideline

Databases

PubMed	Web-of-Science	...	BIOSIS	Google Scholar
5	3	...	8	15
+ 2	+ 1	...	+ 3	+ 5
+ 1	+ 2	...	+ 1	+ 4
+ 3	+ 3	...	+ 4	+ 7
+ 1	+ 1	...	+ 1	+ 2
...	...	...	...	...
+ 10	+ 8		+ 6	+ 13
+ 4	+ 6	...	+ 5	+ 9
+ 2	+ 4	...	+ 1	+ 7
+ 1	+ 1	...	+ 1	+ 2
+ 4	+ 2	...	+ 2	+ 4

Rae, A. (2020)

For instance, taking string no.1 (music-airborne-pathogen-virus) and plugging it into a search engine, such as PubMed, may return '5' relevant results (**n=5**), then string no.2 may return the original 5, plus an additional '2' pieces of literary works (**n+2**). In this case, for the PubMed database, the running total at search-string no.2 is 7 pieces of 'candidate' literary works.

This systematic process known as 'scanning' helps properly assess and obtain all the relevant results available through each database. This process is then repeated, performing horizontal and vertical scans, across all search-strings (rows) and databases (columns).

Consistency Checklist

A total of **342** papers were then tested against a 'consistency checklist' made up of the following components: 'Relevance'; 'Keywords'; 'Reliability'; 'Discussion'; and 'References/Data'. An explanation of these terms is given below:

- **Relevance** - to the research questions - what are we trying to find out? This is always clearly pre-defined before carrying out the systematic review in the form of the 'Research Question' (RQ). Therefore, by reflecting on the RQ (wording and meaning) an individual literary work can then be scored on its overall relevance to this component.

- **Keywords** - every search is initiated by the use of 'search-strings'. This helps keep track of the results within the review but also helps in identifying strong potential candidate works based on 'exact' or 'partial' matches to these search-strings. Results which did not match the keywords would likely also score poorly in terms of 'relevance' (see above).

- **Reliability** - what is the source of the work? Was it peer-reviewed? Did it come from a reliable data source? By answering these questions a reliability metric can be created for each literary work under review. Works which were found through peer-reviewed databases (e.g. PubMed, Web-of-Science, and BIOSIS) tended to have higher reliability scores than those from more globally edited databases (e.g. Google, Bing or Yahoo).

- **Discussion** - is there an adequate amount of narrative or attempt to make a case for a literature's argument? Shorter works will not necessarily be penalised here (quantitative research tends to pack a lot of information into compact lines of text); however, in the case where there is considerably less presented evidence (e.g. qualitative articles with a small number of references) this will tend to reflect in a poorer discussion rating.

- **References/Data** - was there sufficient data or references in this literary work? The arguments proposed by each piece of literature can come in the form of quantitative or qualitative data. Not every relevant or reliable source will provide its own unique research or sourced data (e.g. online news articles, magazine and other related works), however, there should be some form of evidence, referenced or otherwise, that helps consolidate and drive the discussion relating to the work.

Articles with no data sources or appropriate references will tend to perform poorly in **all** categories related to the consistency checklist.

Each literary work was compared against this 'consistency checklist' (see above) which identified any particularly strong or weak candidates subject to further review, before concluding on the final list of selected literature. This literary archive was then further analysed under 'thematic categories' as a result of reviewing each individual work.

Results

The result was 80 literary works (extracted from 342) which best fitted the criteria in terms of 'Relevance'; 'Keywords'; 'Reliability'; 'Discussion'; and 'References/Data'.

Thematic Categories

This review of the literature concerning the risks of spreading airborne pathogens such as COVID-19 through singing and playing brass, woodwind and bagpipes begins with an investigation of how sound is produced in these ways of making music. The following list of 80 papers, articles, and studies have been selected from a larger group of 342 gathered during this research exercise, and have been grouped in the matrix in the appendix under the headings: *Sound production; Hygiene; Airflow; Droplets and Micro-droplets (aerosols).*

The evidence arising from these sections can be broadly summarised as thus:

Sound production - there is a lack of information directly relevant to our research question in this area, so Alan Watson has provided an explanatory introduction on breathing and sound production in singing, brass, woodwinds and bagpipes on pages **8-11**.

Hygiene - this has general relevance to the question of ventilation, air quality, and environmental considerations such as relative humidity in the spaces, both indoor and outdoor, in which music making takes place. These are all factors in the transmission of viral infection. Specific subsections deal with general aspects of instrumental performance as well as a more focused presentation of brass, woodwind and bagpipe information.

Airflow - the evidence gathered so far seems to suggest that only the air in the immediate vicinity of the singer/player moves as a direct result of singing or playing. What the listener's ear perceives is a sound wave, which moves independently through the air. In addition some air movement occurs as a result of the performer's body heat.

Droplets and Micro-droplets (aerosols) - the earliest text dates from 1968 but the overwhelming weight of materials are from May - July 2020. Not included in our list are two important pieces of research from the UK, yet to be peer reviewed - the Brass Band England research carried out under sterile laboratory conditions, (Parker and Crookston 2020)[1] and research into singing led by Costello and Reid[2], and held in similarly controlled laboratory conditions.

[1] Parker, A.S., Crookston, K.(2020) Investigation into the release of respiratory aerosols by brass instruments and mitigation measures with respect to COVID-19. Preprint accessible from https://www.medrxiv.org/content/10.1101/2020.07.31.20165837v1

[2] Gregson et al. (2020). accessible from https://chemrxiv.org/articles/preprintComparing_the_Respirable_Aerosol_Concentrations_and_Particle_Size_Distributions_Generated_by_Singing_Speaking_and_Breathing/12789221).

Discussion

What does the evidence gathered in these groupings tell us substantively and in sufficient detail to influence current and future practice making music through singing, winds, brass, and bagpipes?

The way the sound is produced during singing, woodwind, brass, and bagpipe playing, and, how this relates to the flow of air and water vapour through the instrument, is fundamental to our understanding of the risks this poses for the transmission of airborne viruses. The vibration of the vocal cords, lips, or reed generates the sound which propagates as a wave through the air so that it may be heard at a considerable distance from the player. However, just as the spread of ripples in a pond travels through still water, the outward movement of sound is not dependent on the movement of air from the musician's instrument, which travels only a short distance. Expert singers and instrumentalists project sound into performance spaces mainly using the muscles of the abdominal wall and chest. During singing and wind playing, large droplets of mucus and saliva may be expelled from the mouth in addition to the micro-droplets that are suspended in the breath. These spread into the atmosphere of the teaching and performing spaces. The large droplets are relatively heavy and do not travel far beyond the musician but rapidly sink to the floor. It is to minimise the possibility of infection by these larger droplets that the two-metre rule has been implemented. The micro-droplets are smaller and lighter and form what are known as aerosols that travel further and can remain suspended in the air of the performance space for tens of minutes or longer. Whether the number of microscopic particles generated during wind playing is sufficient to pose a significant risk of infection, is not yet fully understood, though most of the research makes the reasonable assumption that this is true.

Though a considerable number of preliminary studies have been carried out with orchestral wind players, many were not carried out under sterile conditions, which undermines their conclusions and the advice derived from them. Furthermore most have not undergone the quality control process of peer review, which is essential if their findings are to be accepted. However, a few studies have been carried out under highly controlled conditions in rooms demonstrably free of aerosol at the beginning of the experiments, though they are still (as of November 2020) awaiting peer review. These suggest that micro-droplets are not produced in appreciably greater quantities during singing and brass playing than during normal breathing or speaking. What does seem to produce more particles to greater or lesser degree is moderate to strenuous exercise of any sort, shouting, loud speaking, singing and playing. Another important factor, for singers at least, is that some individuals produce many more large droplets than others though the reasons for this are not yet understood.

Interventions such as face-masks, Perspex separator screens, mouth shields in woodwinds and bell coverings in brass are variously effective in minimising the spread of large droplets and micro-droplets. Outdoor practice and performance is also less likely to see accumulation of small droplets as aerosols than indoor performance, although this is not possible year-round in either temperate or continental climates.

Basic hygiene is essential. Common sense measures, such as regular instrumental cleaning regimes always have been or should be a regular part of learning and teaching of brass and wind instrument technique. The discouragement of any build-up of debris that may harbour bacteria,[3] viruses,[4] and moulds,[5] through regular brushing out and rinsing of instruments and their detachable parts (especially in brass instruments) is an absolute, however some parts of the instrument will be more accessible than others. Instrument sharing should not be permitted. Infectious organisms have also been shown to be present in bagpipes.[6] They have been isolated from the bag, mouthpipe and other parts of the instrument.[7]

Hygiene extends to the venues, and their catering and toilet facilities. Overcrowding and lack of sufficient amenities add to the risk. Many venues, both outdoor and indoor, will need to be upgraded before they can reopen. Inadequate ventilation is a severe problem in many popular venues and rehearsal spaces. The same applies to many educational establishments, including some recently built schools, which because of soundproofing considerations, have no external windows. Though it has not been studied systematically, evidence of lung infections arising from the playing of brass, woodwind and bagpipes have all been recorded.[8]

Breathing

In singers and wind players, breathing must fulfil two functions. Its most fundamental role is to allow oxygen to be taken into the body and carbon dioxide to be expelled. In wind musicians and vocalists, (however), it is also used to control air pressure below the larynx or within the mouth, and to regulate how fast this flows through the larynx or into the instrument from the opening of the mouth. This is needed to maintain the vibration of the vocal cords, the lips or the reed. Singing and wind playing often require deep breathing to sustain long notes and phrases and this increases the risk both of developing respiratory diseases, because viruses and bacteria may be drawn deep into the lungs, and transmitting them if they are already present.

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[3] Glass RT, Conrad RS, Kohler GA, Bullard JW. 2011. Evaluation of the microbial flora found in woodwind and brass instruments and their potential to transmit diseases. Gen Dent 59(2):100-107

[4] Mobley J, Bridges C. 2015. Wind Ensemble Infectious Disease Risks: A Microbiological Examination of Water Key Liquids in Brass Instruments. Texas Public Health Association Journal 67(2):16-18.

[5] Davidson J, McErlane J, Aljboor K, Barratt SL, Jeyabalan A, Medford ARL, Borman AM, Adamali H. 2019. Musical instruments, fungal spores and hypersensitivity pneumonitis. QJM 112(4):287-289.

[6] King J, Richardson M, Quinn AM, Holme J, Chaudhuri N. 2017. Bagpipe lung; a new type of interstitial lung disease? Thorax 72(4):380-382.

[7] Ziegler K, Joest M, Turan N, Schmidt D, Rath PM, Steinmann J. 2019. Hypersensitivity pneumonitis of a bagpipe player: Fungal antigens as trigger? Med Mycol Case Rep 24:44-47.

[8] Mobley J, Bridges C. 2015. Wind Ensemble Infectious Disease Risks: A Microbiological Examination of Water Key Liquids in Brass Instruments,. Texas Public Health Association Journal 67(2):16-18.

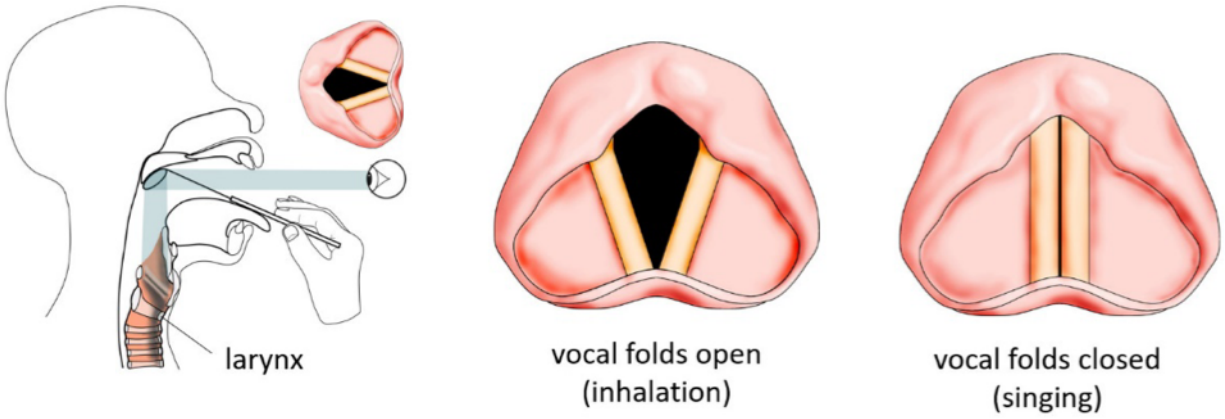
During inhalation, air enters through nose and mouth, into the throat and then down the windpipe to the lungs. As it passes through the nasal passages and the throat, it is warmed and made moist by layers of cells lining the airway that secrete a watery fluid that also contains mucus. The moisture saturates the air and prevents the lungs from drying out, while warming the air reduces the amount of cooling the body experiences during breathing.

The mucus traps dust, pollen and allergens and is later swallowed, preventing them from building up in the lungs. The air that is breathed out during singing or playing of wind instruments also contains a lot of moisture in the form of small water droplets of various sizes and larger drops of mucus that can carry infectious bacteria and viruses. In the case of singers, the number of these droplets increases with the loudness of the singing, but the levels appear roughly comparable to those generated by speaking at the same level of loudness. For reasons that are currently unclear, the number of droplets can vary greatly from one person to another. Some produce relatively few large and small droplets, but others singing in the same way, produce much more. This does not seem to be linked to the style of singing. In people carrying infections, the amount of virus expelled in the droplets also varies a great deal from person to person, but the reasons for this are also not understood.

Singing

The sound produced by the larynx is generated by two muscular flaps within it called the vocal folds (vocal cords). During inhalation, these are held open to allow the air to flow freely into the lungs. In order to generate the sounds of speech and singing, the vocal folds are held closed. The expiratory muscles contract, compressing the lungs and raising the air pressure below the folds. This forces them apart briefly, allowing the air to escape. They quickly close again because as the air flows ever more rapidly between the open folds, its pressure falls. This and the natural elasticity of the folds causes them to snap shut.

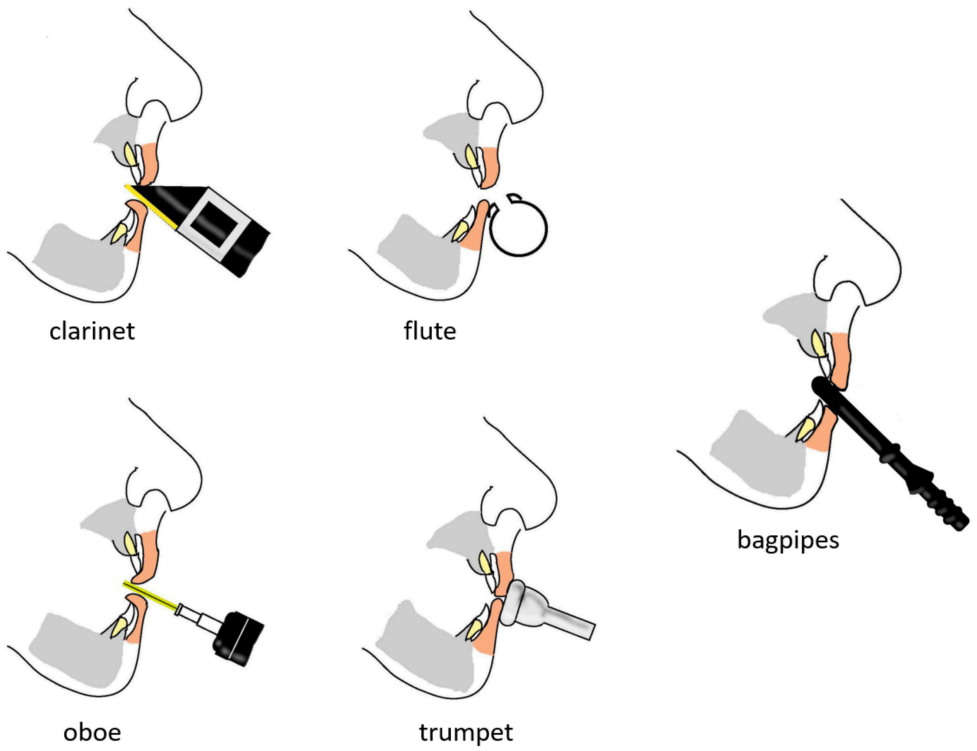
The cycle then repeats. The frequency of the sound produced matches the number of cycles of opening and closing in one second. For middle C, this is about 260 cycles per second (Hz), and for the C an octave above, it is just over 520Hz. The pitch of the note is controlled by altering the tension in the vocal folds.



The air coming from the lungs is moist, carrying many very fine droplets of water, and more water and mucus will be added from the puffs of air produced by each cycle of vocal fold opening and closing. More droplets (some very large) are produced from the mouth when consonants are formed by the lips and the tongue. These large droplets fall to the ground within a few tens of centimetres, but the small ones travel much further in the air currents produced by singing, and the smallest will remain suspended in the air for tens of minutes.

Brass Playing

As in singing, the sound created by brass instruments is also produced by a rapid series of puffs of air at the frequency matching the pitch of the note. In this case it is the movements of the lips within the mouthpiece that are responsible but they essentially behave in a similar way to the vocal folds of the larynx. The pitch is controlled mainly by altering tension in the muscles of the embouchure that lie in and around the lips, and by the speed of the air jet. Valves (or in the case of the trombone, the slide) are used to alter the length of the vibrating column of air within the instrument. The frequency of lip vibration must match the modes of vibration of the air column to produce a clear note. The expelled air is very moist but rapidly condenses when it enters the metal tubing of the instrument.



Only a small amount of water vapour escapes from the bell of the instrument. In the trombone, moving the slide upwards may also expel droplets from the bell. How much of the water remains inside depends mainly on the length of the tubing; the longer this is, the less water vapour escapes from the open end, therefore the trumpet retains less than the French horn.

The water that remains within the instrument has to be removed frequently as it will bubble during playing. In many instruments this is achieved by blowing out through a water key, which creates a spray. Sections of the tubing (crooks and slides) can also be removed to drain the water. Both methods will pose a significant risk if the player is infected.

Woodwind Playing

Orchestral and wind band instruments fall into three broad categories; single reed instruments (clarinet and saxophone), double reed instruments (oboe and bassoon) and flutes and piccolos, which lack any reed. The widely-played tin whistle and recorder are members of the flute family. In all cases, the sound arises from vibrations in the air column within the instrument. The pitch of the note is largely determined by using keys to open holes along the tube to change the length of the vibrating column of air, but it can also be modified by how the player blows. In the clarinet and saxophone, a broad single reed which is flat and thin, is attached to a plastic or metal mouthpiece, forming one side of a narrow slit-like opening.

When this in the player's mouth, the upper front teeth lie in contact with the top of the mouthpiece. The reed sits on the lower lip, which is wrapped over the front teeth. As the player blows, the reed vibrates up and down in the airstream opening and closing the thin opening at the frequency of the note and setting up vibrations within the instrument. In the oboe and bassoon, the air is blown in through a small opening between two narrow reeds. The reeds are held between the lips, which are wrapped over the upper and lower front teeth. The gap between the reeds opens and closes at the note frequency. For the flute and piccolo, the instrument is held against the outside of the lower lip, and air is blown across an open hole at the top end to set up vibrations in the air column within the instrument. In all woodwind instruments, moisture from the breath condenses inside and may drip from the open end or have to be drained though water keys.

As many of the keys are open rings, the player's finger pads become moist. Water sometimes also collects under the keys or reeds and may have to be blotted or blown out periodically. Any moisture within the instrument when playing has finished will be wiped out with a cloth. In reed instruments, moisture from the breath is only released into the air by passing through the instrument, however in the flute, it is also blown directly into the air. All of these sources of moisture or water droplets may communicate infectious agents.

Bagpipes

In Western bagpipes, the chanter generally has a double reed like the oboe and the drones, a single reed. However, their vibration is driven by air from the bag rather than directly from the player's mouth. The bag is either filled through an open pipe which the player blows into (e.g. Highland bagpipes), or by a bellows operated by the arm (e.g. small pipes such as Northumbrian). In the bellows type, there is no risk of lung infection to the player or to the audience, but in pipes where the bag is inflated through a blowpipe, infectious agents (bacteria, viruses and fungi) carried by the moist air of the breath can build up in the bag and cases of respiratory illness among players are well documented. In such pipes, the bag, which is either made of leather or a synthetic material such as Goretex, must be disinfected regularly, particularly if the blowpipe does not have a non-return valve which prevents air from the bag re-entering the mouth. Air from the chanter and drones will release droplets and aerosols into the air.

The electronic chanter, which does not use air to create the sound, is now available as a practice and even performance instrument. This may be useful in situations where the risks of using the Highland pipes is deemed unacceptable.

Summary

We all inhale and exhale large volumes of air. At rest a person normally breathes 12 times a minute. When we are not physically active, the volume of each breath is about 500mls, so on average we are using 6 litres of air in that time. During vigorous exercise a person may breathe as many as 30 times a minute and each breath will be much deeper, with the result that we may use over 90 litres of air in that same minute. Over the course of a day, a person at rest, without additional exertion, will inhale and exhale upwards in the region of 11,000 litres. Because the exhaled air is warm, we generate an invisible 'thermal plume' which results in a current of air that rises upwards carrying aerosol droplets with it.

The lung capacity of healthy adult singers, wind and brass players averages 3.5-7.0 litres. This is best predicted by height but also depends on age, gender, body type (e.g. whether an individual is broad or narrow chested) and ethnicity. Musicians, both professional and amateur, are from an early age taught breath control. They are accustomed to breathe in quickly and exhale slowly, sometimes with as few breaths as 4-6 per minute, depending on the tempo and phrasing of the music. In singing, this slow exhalation goes straight into the atmosphere, whereas in wind and brass playing the air passes through the instrument. The exhaled air is warm when it enters the instrument but cools as it flows through it. As a result, the water vapour it contains condenses into liquid which collects in the tubing, and is expelled through water keys. Some water vapour does emerge from the bell of the instrument, but surprisingly little in the case of the longer instruments such as tuba, trombone and french horn, which trap most of the moisture inside. [9]

[9] He R, Gao L, Trifonov M, Hong J. 2020. Aerosol generation from different wind instruments. J Aerosol Sci:105669. https://doi.org/10.1016/j.jaerosci.2020.105669

Conclusions

Music in all its manifestations forms an important component of our societal, cultural, physical and mental health and well-being. Ways can and should be found of continuing the practice of music-making despite the global pandemic. Singing and playing musical instruments are normal and widespread human activities. Their suppression during the pandemic has aroused a great number of scientific investigations. The MEPG research paper *WeMakeMusicOnline* confirmed the utility of online resources whilst reaffirming from every respondent a unanimous desire for face-to-face, 'live' musical contact.

During the pandemic there has been a tendency, often through media exposure, to demonise certain musical activities such as singing, woodwind, brass and bagpipe playing as uniquely aerosol-producing human activities. That is simply wrong. We appear to have been led by subjective judgement rather than objective analysis of the data. Normal breathing and speaking also produce aerosols within the approximately 11,000 litres of air inhaled and exhaled by the average person each day. Moderate to strenuous exercise of any sort, loud speaking and shouting produce a greater number of aerosols.

There is no current available data showing that there is a statistically significant added risk of viral transmission from singing and the playing of brass and wind instruments on top of the already considerable risk in gathering socially in both domestic and public settings when suitable mitigations are in place. This is currently unquantified and more experimental data is needed. The research project PERFORM (**P**articulat**E** **R**espiratory Matter to In**F**orm Guidance for the Safe Distancing of Perf**OR**mers in a COVID-19 Pande**M**ic) being carried out currently at the University of Bristol with the support of Public Health England and the Department of Digital Media, Culture and Sport, under stringent laboratory conditions, should help to determine whether there is any added risk of transmission. Until such information is available we would recommend that music performance and education should be resumed within the stringent application of whichever current public health regulations are in place, and risk-assessed appropriately using the common measures below to mitigate risk.

Recommended measures to mitigate risk

Measures to mitigate risks in teaching and performance spaces should comply with risk assessments based on the national public health guidelines that are in place at any one given time for adults, children and young people. The following mitigations have been commonly put in place by arts institutions, teaching organisations and the management of performance venues. These measures relate to **generic**, **music-orientated** and **instrument-specific** guidance. This list is not exhaustive; but measures include:

Generic

- Self-examination for COVID-19 symptoms and consequent withdrawal and self-isolation if any symptoms present.
- Washing hands regularly with soap and water or sanitising fluid.
- Social distancing in ensembles (the preponderant advice currently is at least 2 metres).
- Ensuring that all performers at the venue wear face masks when not practicing or performing.
- Ensuring that the volume of the performance space is suitable for the numbers rehearsing, performing and listening when appropriate distancing measures are in place.
- Ensuring that adequate passive or active ventilation systems are used to ensure sufficient air changes in the room (recirculating air is not recommended).

Music-Oriented

- Disinfecting surfaces (stands and chairs) before and after use.
- Owning the personal hygiene of your own stand and chair as your own work-station and not sharing with anyone else during the same period of work.
- Using plastic containers and absorbent cloths to collect condensed water emptied from instruments, and disinfecting these after each use.
- No sharing of instruments.
- Reducing the size of ensembles, vocal and instrumental, and reconfiguring the way small ensembles (10 or fewer players/singers) are laid out.
- Handing out and taking in sheet music to be carried out by one person wearing gloves and a face mask.
- Printed music should be quarantined for 72 hours prior to re-use.

Instrument-Specific

- Ensuring that all audience and performers of strings, keyboard, and percussion in mixed ensembles wear face masks at all times.
- Cleaning instruments thoroughly and hygienically after daily use and where practicable sterilising mouthpieces.
- Clear Perspex Screen Separators (a good idea in ensemble or in the face to face teaching situation).
- Brass and Wind Instrument wind shields (as yet untested).
- Brass Bell Coverings (proven effective in the Brass Band England research).
- No buzzing of brass mouthpieces in performance venues as part of brass warm up.
- Humming instead of singing (effective for some rehearsal purposes but musically limited).

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Appendix - Matrix of identified papers

	Papers Peer-reviewed	Papers Non peer-reviewed	Dates - significance	Highlights	Risks	Guidance/recommended practice
Sound production						
- *instrumental (excl. brass & woodwind)*	Kemp & Smith		2012	Due to the requirement to measure the pressure and volume velocity accurately for waves striking the lips at all frequencies, it was a requirement that the lips of the player beheld in a fixed position by the player with zero DC flow. In measuring the reflectance when the lips are placed on the end of a truncated trumpet mouthpiece we use low amplitude exponential sine sweep excitation so that linear propagation holds good		
- *brass & woodwind*	Elliott & Bowsher		1982	This paper is concerned with the production of musical notes by the interaction between the lips of a player and a brass wind instrument. Experimental measurements of this mouthpiece pressure are presented, together with measurements of the steady and alternating components of the pressure in the mouth, and of the velocity in the mouthpiece for blown notes on a trombone and trumpet.		
Hygiene						
- *ventilation*		Cohen et al (book)	2016	Mass gatherings, such as music festivals and sports spectatorship an lead to outbreaks of respiratory infections such as influenza and gastro -intestinal illness due to overcrowding at venues, lack of amenities, problems with food handling and mixing of infectious and susceptible populations.		

		CondAir	Jan 2018 Blog	Viral infections such as influenza are directly influenced by the quality of an environment's air, which includes relative humidity levels and temperatures. If relative humidity levels are low – less than 40% RH – the space will effectively become a breeding ground for bacteria and viral infection potentialities.		
		DfE England	July 2020	*Guidance for schools and performing in all areas*		Social distancing measures, hygiene measures, ventilation.
- *instrumental*		Music Industry Association	March 2020 Webpage guidance	Musical instrument businesses across the country have questions in relation to the Coronavirus. The MIA has collated guidance from Public Health England, the Government and MIA Members and partners to help the industry deal with the outbreak…		*Don't share instruments.* *Maintain a good hygiene regime for instruments at all times.* *Clean brass instruments with warm, soapy water and an instrument brush (see Dennis Wick trumpet brush here). The brush MUST be used as it will dislodge any build-up of debris in the instrument. This will prevent any chance of re-infection or cross-contamination.*
- *brass & woodwind*	Marshall & Levi		2011	Walter and Chaffey (1959) found the combination of brushing and rinsing mouthpieces to be more effective than simple wiping or rinsing with plain water in lowering the numbers of residual organisms after playing. Nonetheless, recommendations for improving instrument hygiene and discouraging infection transmission (Bryan 1960; APMT 2010) have not been widely adopted.		
	Mobley & Bridges		2015	Most large brass instruments do not contain oral bacteria. French horns and trumpets may have oral bacterial flora in their accumulated liquid. Most instruments will have Alcaligenes faecalis. In general the liquid from water keys does not pose an environmental hazard to persons with normal immune systems. Bands are highly inclusive and diversified. There may be special situations in which players are prone to infection or have cancer or immune disorders, which would require attention for the prevention of infections.		Good health practices should be a regular part of musical instruction. Good health practice should include cleaning institution-owned instruments before reissuing them to another student.

	Queensland Govt		Sep 2019	Infection control Guidance		Mouthpieces of musical instruments. Instrumental Music Program. (e.g. class sets) - Clean inside with a brush, warm water and detergent. Air dry or use paper towels. Use alcohol wipes to disinfect.
	Walter & Chaffey		1959	In the past, improperly cleaned eating utensils have been shown to harbor pathogenic organisms (Cumming et al., 1920; Saelhof and Heine-kamp, 1920; and Lyons, 1936), but satisfactory procedures have been developed for cleaning and sanitizing such utensils for either institutional or domestic use. Various techniques common among musicians were tried in an effort to determine how effective they were in removing bacteria from a mouthpiece. The method finally employed utilized a stainless steel tank about 16 cm wide, 40 cm long, and 20 cm deep to which 12 L of tap water containing a commercial detergent-sanitizer of recommended strength was added.		Brushing and rinsing mouthpieces found to be more effective than simple wiping or rinsing with plain water in lowering the numbers of residual organisms after playing
		Wase	2008 Unpublished PhD thesis	Further research is needed to identify the complete bacterial flora of instruments, to identify possible viral and fungal flora that exist in brass instruments and to develop procedures and materials to quickly disinfect instruments.	Potential exists for cross contamination from the build-up of biofilm in the mouthpiece from secretions of the salivary glands and oropharyngeal/upper airway. In particular, there is a potential hazard for the transmission of the Gram-negative respiratory pathogens, Pseudomonas aeruginosa and Burkholderia cepacia complex.	
Airflow						
- vocal		Veith	May 2020 Blog	As for orchestral instruments, trumpets and trombones also affect the air only as far as half a meter. Woodwinds, interestingly, have a farther effect, moving the air in a range of one meter,		

				with flutes going beyond that. Similarly, singers use their diaphragms to create vibrations in the air, which eventually register on the listeners' eardrums. But what the listener hears is not the same air that comes out of the singer, infected or otherwise.		
- brass & woodwind		Kahler & Hain	May 2020 University YouTube video	A study from the University of the Bundeswehr Munich into the safety distance of musical activities, including singing, brass, and wind instruments. Explores air movement and droplet emission in different instruments and offers solutions including playing outdoors and use of pop-shields.		
-		Nashville Music Scoring	June 2020 Online video YouTube	This video intends solely to show that the commonly held belief that wind and brass instruments "project" air over great distances is not true. As a result, "droplets" are not spread a great distance as some assume. This video does not address any aerosol issues		
-		Smith	1999	The "wave," often a sign of audience boredom at stadia events, illustrates how the alternating part of the air travels through the instrument. Apart from this movement they are stationary, and their vibration is passed onto the next particle and so on down through the instrument. This is a longitudinal wave of energy that is travelling at the speed of sound (350 m/s or 780 miles per hour) – far faster than any air particles you can blow into the instrument!		
-				.		

Aerosols						
- *general*		Barber	June 2020 Online article		For the risks of singing, there are clues in the scientific literature, primarily from studies on breathing and talking that go back to the 1950s, when the primary interest was in stopping measles. One observation is that loud vocalizations mean more aerosols. But for instruments, researchers lack even that basic background to assess the risks and proper precautions.	
-		Barmann	March 2020 Online article	Marr also tells the LA Times that certain people simply have "super-spreader" abilities in their lungs — capable of exhaling 1,000 times more fine material than most people. While this case, which remains under investigation, should not scare people into hoarding N95 masks that will be key to saving healthcare workers from infection, it should give people pause about entering any enclosed space with strangers, whether they're coughing or not.		
-		Campbell	Feb 2020 You Tube video	video that shows the difference between droplets and aerosol. Because aerosol particles can hang in the air for so long, a person can walk through an aerosol cloud hours later and breathe in those particles. And because the particles are so small, they can travel into a person's lungs more easily than droplets		
-	Fernstrom & Goldblatt		2013	Aerobiology plays a fundamental role in the transmission of infectious diseases. As infectious disease and infection control practitioners continue employing contemporary techniques, the central variables affecting the airborne transmission of pathogens are becoming better known.		

-		Firle et al	May 2020 *Recommendations of the German Society for Music Physiology and Musicians Medicine*	From instrumental considerations it is very likely that fine droplets, which are contained in exhaled air blown into the instrument by the sounding vibrations of the reeds or lips (flute, brass instruments) in aerosols (<5 µm) to be "swirled". Aerosol formation and spreading, which appears to exist in several wind instrument, are possibly different.	It is also believed that due to deeper inhalation when playing wind instruments, potentially infectious aerosols can reach deeper lung sections	Hygiene measures, social distancing – detailed recommendations for particular instruments
-		Galton	April 2020 Online article	English National Opera is to stage socially-distanced drive through performances in the grounds of Alexandra Palace. The series includes a one-hour family-friendly adaptation of Mozart's The Magic Flute and a shortened version of Puccini's La Boheme - with singers and musicians spaced out in accordance with government guidelines.		
-		GMorch	May 2020 Webpage guidance	Written in Germany, collected recommendations for orchestras returning to work, including rehearsal guidelines, social distancing, protective equipment (e.g. covering bell with cloth cover, Perspex separators).		
-		Greenfield-boyce	April 2020 Blog	when a choral group in Washington state got together to sing, and ended up with dozens of cases of COVID-19 despite the fact that members of the group were careful not to touch each other or stand close. "The simplest explanation is that it was being transmitted through the air,"		People should ventilate buildings and that concentrations of particles are less likely to build up outdoors.
-		Harvard Medical School	July 2020 General Guidance			*The CDC provides general guidance on cleaning and disinfecting public facilities, including schools, that are exposed to someone ill with COVID-19. These guidelines should be adapted to specific circumstances.*
-		Kupfer-schmidt	June 2020 Online article	Individual patients' characteristics play a role as well. Some people shed far more virus, and for a longer period of time, than others, perhaps because of differences in their immune system or the distribution of virus receptors in their body.	A study in Japan found that the risk of infection indoors is almost 19 times higher than outdoors. (Japan, which was hit early but has kept the	

					epidemic under control, has built its COVID-19 strategy explicitly around avoiding clusters, advising citizens to avoid closed spaces and crowded conditions.)	
-		Mandavilli	July 2020 Online article	*In an open letter to the W.H.O., 239 scientists in 32 countries have outlined the evidence showing that smaller particles can infect people, and are calling for the agency to revise its recommendations. The researchers plan to publish their letter in a scientific journal next week.* *Aerosols are released even when a person without symptoms exhales, talks or sings, according to Dr. Marr and more than 200 other experts, who have outlined the evidence in an open letter to the World Health Organization.*	*Dr. Morawska and others pointed to several incidents that indicate airborne transmission of the virus, particularly in poorly ventilated and crowded indoor spaces.*	
-		Mixon	April 2020 Youtube video	a video demonstration of aerosol suspension from a person. The risk of infection from a person with micro droplets becomes even greater in a closed space with poor ventilation.		
-		Netherlands Govt	June 2020 (updated Sep 2020) Public guidance	It is not yet known whether sports activities increase the spread of the virus, for example because vigorous exercise produces more droplets. The same applies to musicians who play wind instruments, and to choral singers. Sports and singing certainly do release big droplets, similar to shouting and talking, but not as much as coughing or sneezing		*Social distancing, routine hygiene measures*
-	Pasnick et al.		June 2020	Our understanding of SARS-CoV-2 continues to evolve. Mounting evidence suggests the virus can be transmitted via contact, droplet, and possibly aerosol routes		

-		Rogers	May 2020	A vast number of the particles that come out of a person's mouth are much smaller, under 5 microns. They dry out quickly in the air and become so light they can float around for hours. Even the slightly warm layer of air constantly wafting upward from every person—our "thermal plume"—can carry these particles up, up, and away. Random air flow makes their spread turbulent, bounced around by currents like sand in a tide pool. And we emit them all the time	"If you look at what the CDC and WHO have been saying, they downplay the role of airborne transmission," says Joseph Allen, director of the Healthy Buildings Program at the Harvard School of Public Health. "I think that's a mistake."	
-		Saskat-chewan Health Authority	Dec 2017			**musical wind instruments** not permitted
-		Qureshi et al.	June 2020	The 2-metre social distancing rule assumes that the dominant routes of transmission of SARS-CoV-2 are via respiratory large droplets falling on others or surfaces. A one-size-fits-all 2-metre social distancing rule is not consistent with the underlying science of exhalations and indoor air. Such rules are based on an over-simplistic picture of viral transfer, which assume a clear dichotomy between large droplets and small airborne droplets emitted in isolation without accounting for the exhaled air. The reality involves a continuum of droplet sizes and an important role of the exhaled air that carries them		Other important factors to take account when considering safe social distancing (which were beyond the scope of this review to cover in depth) include host viral load, duration of exposure, number of infected individuals, indoor versus outdoor settings, air ventilation, wearing of PPE including facemasks, effectiveness and type of cleaning measures, individual susceptibility to infection, and activities that project airborne particles over greater distances in exhaled gas clouds, such as singing, coughing or heavy breathing.

-	Spahn & Richter		May 2020	Currently, there is no scientific data regarding the spreading of aerosols in closed rooms during rehearsals and concerts.	As long as this is the case, we believe that the greatest possible risk reduction should be carried out by using a combination of measures. This combination should be applied to orchestra or big band - as already described for chamber ensemble and choir - including regular room airing (see Section 2 above).	Regular airing of the room every 15 minutes or using rooms with an HVAC system are important measures for risk reduction.
-		Strain	July 2020 University webpage article	The debate largely comes down to size. Everyone agrees that the coronavirus can spread through large drops of liquid (think of the spray that flies out of your mouth when you sneeze). Where Jimenez and his colleagues and the WHO disagreed, at least until recently, came down to much smaller beads of moisture. These "microdroplets" are too tiny to see with the naked eye. But humans can expel them when they sing, talk or even just breathe—no sneezing required.		We need as much outside air as possible," Miller said. "If you have to recirculate air, then use the highest rated filter that you can."
-		UK Government	4 July 2020 Guidance	Written in England, this guidance provides advice on how places of worship can open, for limited permitted activities, in a manner that is safe and in line with social distancing guidelines.		**Singing, chanting and the use of musical instruments** People should avoid singing, shouting, raising voices and/or playing music at a volume that makes normal conversation difficult or that may encourage shouting. This is because of the potential for increased risk of transmission from aerosol and droplets.
-		UK Government	9 July 2020	This is the initial phase of the recommended guidance. Further guidance will be issued when there is sufficient scientific evidence to support a move.		Singing and playing wind and brass instruments, especially in groups, are considered higher risk activities because of the potential for aerosol production and the absence presently of developed scientific analysis to assess this specific risk.

-		University of Bristol	July 2020 University press release article	The research project, known as **PERFORM** (**P**articulat**E** **R**espiratory Matter to In**F**orm Guidance for the Safe Distancing of Perf**O**rmeRs in a COVID-19 Pande**M**ic), is supported by Public Health England… The researchers will carry out a number of scientific experiments to investigate airborne droplets produced during breathing, speaking, singing and the playing of brass and woodwind instruments		*The project aims to understand and find out: The amount of respiratory aerosol particles and droplets created by breathing, speaking, singing, coughing, and the playing of woodwind and brass instruments.* *The effect of distance on the mount of respiratory articles transmitted by breathing, peaking, singing, coughing, and the playing of woodwind and brass instrument.* *To explore how the length of the performance, volume, pitch and umber of performers relates to the amount of respiratory aerosol particles and droplets produced in venue.*
-	.	Volckens et al	June 2020 proposal	The project will develop two primary outputs. The first output is a robust and scientifically rigorous dataset on endogenous particle release rates (stratified by gender, age, and activity type). This dataset will be published in the open science literature and in a manner that is accessible and understandable by stakeholders in the performing arts community. The second output will be a guidelines document that outlines the efficacy of various strategies to control emissions and reduce exposures to infectious bioaerosols. This guidelines document is envisioned to provide the scientific basis for a "safe to perform" position statement to be developed in collaboration with national/international governance bodies in the performing arts	Only scant evidence exists to document the rate of aerosol release during performing arts activities [8, 9] and whether there are effective means to control such releases (and reduce the risk for human exposure). This proposal seeks to enact a rigorous, data-driven approach to inform a safe return to activities for the performing arts community.	
-		World Health Organisation	July 2020	Respiratory droplet transmission can occur when a person is in close contact (within 1 metre) with an infected person who has respiratory symptoms (e.g. coughing or sneezing) or who is **talking or singing**; in these circumstances, respiratory droplets that include virus can reach the mouth, nose or eyes of a susceptible person and can result in infection.		

- *vocal*		Alberta Health Services	May 22, 2020			No singing
	Ashley, M.		2020		Choral singing not higher risk	
		Asadi et al.	Feb 2019	results strongly suggest that more particles escape the respiratory tract if the vocalization is louder	Speech greater concern than breathing	
		Ashworth	June 2020 Newspaper article	The Munich study concludes: "Air is only set in motion in the immediate vicinity of the mouth when singing. In the case of the professional singer, the experiments showed that at a distance of around 0.5 m, almost no air movement can be detected, regardless of how loud the sound was and what pitch was sung. It is therefore unlikely that the virus could spread beyond this limit via the air flow created during singing." The researchers deemed this to be "not surprising, since singing does not expel a large volume of air in jerks like coughing or sneezing".		They concluded, with provisos: "If the findings and recommendations from our quantitative measurements are taken into account, then making music in a community should be relatively safe."
		Austin	May 2020 Online article	A few of us even appear to be "superemitters," spreading an order of magnitude more of these fine aerosol particles for an as yet unknown physiological reason, the UC Davis researchers found in a 2019 study in Nature's Scientific Reports. Because aerosols are so light, they may hang in the air for hours.		Eventually, choruses might meet in smaller groups, install UV-light air-disinfection systems, or hold rehearsals outside, where a gentle breeze may help waft away infectious aerosols.

		Ballard	May 2020 Online article	Studies commissioned by the Vienna Philharmonic and the Bamberg Symphony Orchestra reached the same conclusion for orchestral players. All the studies stress the importance of social distancing. But the singing, or playing, itself was not the problem. Professional choirs in Europe have been quick to adapt.		
		Bollinger	June 2020 Online article	When Germany locked down in mid-March, religious services were banned. As restrictions began to ease in late April, Angela Merkel met with leaders of the country's 16 states to coordinate a nationwide set of rules, including rules to govern worship services.		In the end, the German federal government did not impose a nationwide ban but stated that singing should be avoided "because of the increased production of potentially infectious droplets, which can be spread over greater distances". Several German states have banned all singing from services.
	Borak, J.		June 2020	This remarkable example of interpersonal 'super spreading' best explained by enhanced aerosolized transmission resulted from enthusiastic singing	Singing and air turbulence	
	Buonanno et al		June 2020	outbreaks are not caused by the rare presence of a superspreader, but can be likely explained by co-existence of conditions, incl. emission and exposure parameters, leading to a highly probable event, which can be defined as a superspreading event		to guarantee an acceptable individual risk for exposed subjects in naturally ventilated indoor environments, exposure time should be shorter than 20 min
		Christensen, G.	May 2020	While it is certain that COVID-19 can be spread by exhaled "droplets", there is a growing amount of evidence to support the hypothesis that COVID-19 can also be spread by exhaled aerosols. The dangers from these aerosols are believed to be mitigated by the widespread use of appropriate PPE and masks, but, that is not always practical, especially when singing is involved.	Singing in confined or 'sealed' spaces	Importance of ventilation
		Cockburn	June 2020 Online article	Analysis of the US choir outbreaks does suggest ventilation is an issue, and in those cases ventilation was poor and the duration of practice was high (around 2-2.5 hours).		Other actions associated with playing a wind instrument can pose additional risks, like when players blow out spit valves. For this reason, plexiglass between wind instrumentalists has been recommended.

				How much the viral load is reduced by travelling through an instrument is still unclear.		
		Delaware Government	June 2020	Strong evidence exists showing that large droplets, such as those in a cough or sneeze, as well as very small droplets in the air, such as those produced when singing or speaking (especially when speaking loudly or yelling as in coaches giving directions to athletes or camp staff giving directions to other staff or children), spread the disease. In fact, these very small airborne particles can travel up to 13 feet away from the infected person.		Social distancing measures and hygiene procdures
	Evans		June 2020	Droplets produced while speaking, for instance, depend on speech loudness; speaking loudly, yelling or singing can produce an order of magnitude more saliva than speaking normally.		Ventilation and use of masks
		Feder	April 2020 Online article	The World Health Organization has taken pains to emphasize that the coronavirus is primarily spread through respiratory droplets, unlike, for example, measles, which is transmitted in aerosols and can linger for hours in the air. Projecting your voice could send droplets further — but it's unclear how infectious they are at the end of their journey.		
	Feng et al.		May 2020	Based on the observation from this study, microdroplets can either suspend and transport in the air farther than 1.83 m (6 feet) or deposit on human bodies. Thus, only keeping the social distancing guidelines as of May 2020 is not sufficient, and the guidelines should be scrutinized further.		Six-feet social distancing policy for COVID-19 may not be sufficient with ambient wind. Wearing PPEs, avoiding handshakes, and washing hands frequently are necessary

		Fairchild et al.	May 2020 University recommendations	Where teaching involves enhanced modes of vocal projection (e.g., lecturing to a large room, demonstrating a wind instrument, demonstrating pronunciation in a language class), the instructor may choose to wear a face shield. In most of these cases, it is recommended that where practical instructors also wear face masks unless it is absolutely necessary to do otherwise (e.g., meet the needs of students with disabilities such as hearing impairment).		There is currently little current evidence to guide performance-based activities. Because of this, we are recommending a balanced risk approach be taken when considering the risk of virus transmission and the activities required for certain performance-based majors
		Hamblin	June 2020 Online article	A cheaper option is using nature to take services and rehearsals **fully outdoors**. This will be only a **temporary fix** in most places, because winter will bring its own challenges. And singing in the open air will fundamentally alter the effect: it's not a zero-risk scenario, but we have every reason to believe it is safer than the old way.		the safest thing would be to never gather in groups for the foreseeable future. Short of that, the more preventive work that can be done, the better.
	Hamner et al		March 2020	Choir practice attendees had multiple opportunities for droplet transmission from close contact or fomite transmission (9), and the act of singing itself might have contributed to SARS-CoV-2 transmission		Current CDC recommendations: maintaining physical distancing of at least 6 feet wearing cloth face coverings, washing hands often, covering coughs and sneezes, staying home when ill, cleaning and disinfecting high-touch surfaces
	Louden & Roberts		1968	Factors described as favouring such point-source outbreaks include tuberculin-negative status in a large proportion of those exposed, overcrowding and **lack of ventilation**, and the presence of a patient with positive sputum and disseminating characteristics.		

		McKie	May 2017 Newspaper article	But not all scientists agree with the idea that our musical appetites pose a health risk. In particular, fluid mechanics expert Professor Christian Kähler of the Military University, Munich was highly doubtful about the dangers posed by concerts and decided to conduct experiments in the wake of the Amsterdam outbreak to find out how far singers and musicians expel air and droplets. Kähler said the virus was probably spread among chorus members because of **their close proximity** to each other before and after rehearsals and performances		
		Moss	July 2020 Blog	This assessment applies the concept of risk management with the aim of identifying specific risks related to COVID-19 in the field of music and theatre and offering risk-reducing measures.[1] Two core beliefs underlie this work: (1) a belief that the greater the number of risk-reducing measures, the more the risk of infection can be reduced; and (2) a belief that until we have more refereed research on the spread of airborne infection specific to music making and theatre productions, we must over- rather than underestimate the possible risks in case of doubt. In this way, by combining risk-reducing measures, we can lower the overall risk of infection as much as possible. Residual unquantifiable risk, however, will always remain according to the ALARP (as low as reasonably practicable) principle.	In combination, these risk reducing measures may lower the risk of infection from Music & Theatre activities, a risk made greater by the increased number of aerosols emitted through loud speech, singing, and, potentially, through playing wind instruments..	Individually, everyone must have the right to decide for themselves the level of personal risk they will take, yet do so without increasing the risk for others and while preserving unity within their department and educational community

	Naunheim et al.		June 2020	Scientific research has not examined safe singing practices in relation to the risk of SARS-CoV2 transmission. The evidence that exists is based on prior viral outbreaks and situations that may or may not translate to various singing environments. Each individual community of singers and performers must do what it can to mitigate as much risk as possible and then decide if that risk mitigation of SARS-CoV-2 transmission is sufficient to resume each singing activity considered, taking into account all of the factors discussed above.		It is likely the risk can be mitigated with certain practices, but risks cannot yet be eliminated.
		Nelson	April 2020 Blog	Researchers are still not fully in consensus on whether the SARS-CoV-2 can be transmitted as a live virus in aerosol. It takes time to thoroughly study a topic. Good science just takes time. For now, results are conflicting, and there's not enough of a body of data yet to get a good lay of the land. However, the most recent research from the New England Journal of Medicine relays data that the virus can remain viable in aerosol transmission for up to three hours.		It may be more likely that an outdoor space, still with appropriate physical distancing, could be a safer way to meet
		Neustaeter	May 2020 Online news article	"The act of singing, itself, might have contributed to transmission through emission of aerosols, which is affected by loudness of vocalization," the report said. The CDC report also said that some people, known as superspreaders, release more of these particles during speech than others.		If I had to sing in a group, I would do it outside, and I would pay attention to wind direction to avoid being downwind of people in the group,". Furness added that group members could also be widely dispersed in a large room, however he recognized that that can pose challenges for ensemble work and staying in tune. For now, he said singers should stay home and skip in-person rehearsals
		Read	June 2020 Online news article	The researchers say that the coronavirus can spread in respiratory aerosols, which may linger in the air for an hour or more, floating farther than the six feet commonly prescribed for social distancing..	They say that choir members are particularly vulnerable to infection from airborne particles, because they exhale and inhale deeply to sing, often at close quarters in poorly ventilated rooms	

- *brass & woodwind*		Brandt	2020	Emission of aerosol measured from brass and w/w instruments very low, and almost at same level as background concentrations. Other experiments have shown very little airflow and very small aerosol concentrations at short distances from brass and w/w		
-	Eiche		June 2020	Less aerosols are released when playing wind instruments than when speaking. no or practically no additional aerosols are produced in the instrument which would aggravate the problem. On the contrary, it seems that the aerosols get stuck in the instrument and that the instrument works like a filter.	The louder and more expressive the speech, the more aerosols are excreted. Singing loudly or softly makes only a small difference and for many singers the emission was even lower when singing loudly than when singing softly.	Social distancing and hygiene measures Wind players can be treated in the same way as all other members of the orchestra, i.e. keep the same distance. It should be noted that for the winds the "emission point" is the instrument and not the person's mouth. - The same applies to the singers.
-		Kahler & Hain	May 2020	Our quantitative measurement results show that the dispersion of droplets when singing and making music with wind instruments is in general relatively small. A safety distance of 12 m is therefore completely exaggerated.		However, when singing, the safety distance should in any case be greater than 1.5 m, in order to be largely safe even when people in the vicinity are coughing without observing the rules of hygiene (cough into the crook of your arm and turn away from other people).
-		Kazushi	June 2020 Online article	**'The wind instrument tests showed that players make less spray during a concert than they do in daily conversations before and after the concerts and in daily life'** '[The results] showed much less strength and speed in the aerosol from the wind instruments compared with the results from the European orchestras' When Professor Okuda measured the aerosol of the wind instrument players, there was a strong result when the measuring instrument was close to their mouths, but it was less than that of the male singer. The wind instrument tests showed that players make less spray during a concert than they do in daily conversations before and after the concerts and in daily life. After this test the brass instruments played the Fanfare from Dukas's La Péri with the 1.5m distance, and a very big gap between the fourth horn on the left side		Dr Kunishima was surprised by the tests, because they showed much less strength and speed in the aerosol from the wind instruments compared with the results from the European orchestras. He suggested that this might relate to the difference in humidity of the air in Japan – the air in Europe is much drier than in Japan.

				and tuba on the right side – almost 8m from right to left. They couldn't see each other well and were not able to play together, even though they knew the piece well and the first trumpet gave clear signs. We positioned them slightly closer, which was clearly better, but it was still difficult to blend the sound and be exactly together. Finally, they were positioned at 1m and adjusted themselves superbly		
-	Lai et all		2011	Aerosols play an important role in the spread of communicable diseases [1], [2]. Aerosol transmission can be airborne, where contaminated droplet nuclei exhaled by an infected individual are inhaled by a susceptible individual. As far as we are aware this is the first report in the scientific press regarding the issue of aerosol dissemination by the vuvuzela and no epidemiological data regarding impact of the instrument on disease transmission have been reported. Similarly there have been no reports of disease transmission from sharing vuvuzelas, or from transfer of non-aerosolized respiratory secretions that collect inside the instruments.		
-		Lebrecht	June 2020 Online article	University of Iowa Hospitals and Clinics, has been working on a full assessment of the risk of spreading COVID-19 by playing brass and woodwind instruments. Together with his colleague Dr Henry T Hoffman, Dr Schwalje, who is himself a wind player, has written this paper for publication in medical journals.	The risk of aerosol production posed by wind instrument performance is not known, though there are several indications that it might exceed background risk of COVID-19 transmission. Studies on this risk, and the effectiveness of risk mitigation strategies, have not yet been completed.	Acknowledging the risks and attempting to mitigate them is important – but should not lull musicians into a false sense of security. Unfortunately, the available scientific evidence is too scant to reliably inform decisions about risk mitigation strategies for wind musicians. Musicians should be empowered to make their own decisions based on their individual risk tolerance. Leaders should be cautious in their representations of risk and clear about uncertainty regarding the efficacy of risk mitigation strategies.

-	Miller et al.		May 2020 Proposal for study	The risk of COVID-19 infection from droplets and aerosols generated by playing band instruments could be significant. This study is needed to better understand potential risk and how to mitigate the risk so that musicians can return to playing and music students will be able to continue playing in school bands, practicing and performing.		
-		Public Health Ontario	July 2020	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.		
-		Raybaud	March 2020 Blog			For **wind instruments**, a fine felt at the mouth would only slightly affect the sound quality and, on the other hand, would allow the expired air to be filtered. Partitioning with these musicians would be necessary. Sterilization by UV C and OZONE lamps at the end of the show will be very useful.
-		Roberts	May 2020 Online article	Article on PPE coverings for brass and woodwind musicians, in preparation for concerts to return post- lockdown. For trumpeters, the team have designed a face mask with an opening in the middle for the musician to make contact with the mouthpiece, as well as a closed covering for the bell to reduce the risk of transmitting of droplets while playing.		

-		Roseburg Chamber	June 2020 Guidance doc.			Activities that include brass or woodwind instruments should increase physical distance as these instruments may disperse respiratory droplets farther than 6 feet.
-		Santa	2020 Product project webpage	*The current COVID19 crisis is bringing into question the safety of musical rehearsal and performance. Current governmental suggestions for containing viral transmissions do not specify precautions for environments such as wind sections of orchestras or bands which have humans emitting air at high velocities.*		*A current product on the market, the Win-D-Fender ™, is a flute accessory developed to allow a flutist to perform outdoors by blocking the disturbance of outside air (wind) which easily disrupts the flutist's airstream thus impairing sound quality.*
-		Sixto	2020 Online article	There are many forthcoming studies in the near future to gather stronger evidence. Although, it is encouraging that these preliminary results reported from Bamberg regarding aerosols presume that some wind instruments are not as contagious as we originally thought. However, social distancing will not go away anytime soon. It is still strongly recommended.		
-		Schwalje & Hoffman	June 2020	It is more important than ever to read studies and guidelines with a critical eye and keep in mind the basics of scientific inquiry. A scientific study would cite sources, would be peer reviewed, in the case of COVID-19 would have the input of a physician or infectious disease specialist, and would be clear about who is producing the study and any conflicts of interest. The ability to replicate results is crucial, though this aspect of scientific inquiry can take time. Musicians who do rely on the conclusions of non-reproducible studies might underestimate either the risks of their activities or the uncertainty involved in assessment of these risks. Unfortunately, there are several recent, widely-circulated, pseudoscientific assessments of risk and risk mitigation strategies for wind musicians. The good news is that there are several scientific studies on these questions also, most of which are still ongoing.	The risks of wind playing in the COVID-19 era are unknown. There is a possibility, currently being studied, that the risks of wind playing and associated behaviors are greater than baseline risk of spread of COVID-19. This has wide ramifications as programs are attempting to re-open. Acknowledging the risks and attempting to mitigate them is important – but should not lull musicians into a false sense of security.	If we assume there's no risk, or if we assert that unstudied risk mitigation procedures work, then people can't make an informed decision about whether to put themselves in those potentially risky situations. Also, if there is at least an acknowledgement of risk, then those who are at greater personal risk from COVID-19 (the elderly, those with comorbidities, etc.) may be able to seek accommodations for risk mitigation from their local governments. In the US, for example, this might be accomplished through the Americans with Disabilities Act (EEOC).

-		Toronto Public Health Plan	March 2007 Guidance			During an influenza pandemic, schools should **consider suspending the use of shared wind instruments** due to the possibility of indirect transmission of the virus. Schools that continue the use of wind instruments during a pandemic must ensure mouthpieces and sections of the instrument that may contain/retain saliva are **properly cleaned and sanitized** in accordance with school protocols. Hand hygiene should be practiced following the use of wind instruments.

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