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RISK ASSESSMENT OF A CORONAVIRUS INFECTION IN THE FIELD OF MUSIC

Second update from May 19, 2020

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Introduction

Since the first risk assessment published on April 25, 2020, additional questions have been raised due to the dynamically changing situation of the corona pandemic. With the gradual loosening of the lockdown (in Germany) beginning May 6, 2020—which also varies from state to state—increasingly urgent questions are coming from the field of professional and amateur music as to how and when musical activities could resume again. These questions relate to congregational singing in religious services, as well as organized forms of singing and playing music in amateur settings, as well as to the professional music making of orchestras, choirs, bands, and ensembles in theaters, concert halls, opera houses, and other venues.

The type of questions arising from various musical genres have something in common and are similar in scope. Especially relevant questions regarding singing and instrumental teaching at music colleges, music schools, and other educational institutions are particularly important.

As the number of people allowed to gather increases, depending on the basic regulations in some federal states, information about performance ensemble size in orchestras, concert bands and big bands becomes the focus of discussions. This expands the complexity of questions to be considered. Especially for professional musicians, there are questions of comparability with other work situations, for example: to what extent does the risk of infection when working in an open-plan office differ from that of a rehearsal workspace for an orchestra. The announced planned readmission of audiences, as permitted in individual states, also raises further questions.

Fundamentally, the national and state regulations in Germany regarding gatherings, contacts, minimum distancing, and mouth-nose protection, which are specified by government ministries and health authorities (as well as other jurisdictional authorities and the institution's statutory accident insurance), apply to all musicians. It is thus a

great challenge to develop appropriate recommendations of action for the specific instances and great variety found in areas of professional and amateur music, indeed, even more so for classical and popular music. In this context, specialized assessments, such as the present ones, are intended to provide information and guidance on decisions that would otherwise be made only at the political and institutional level.

The first scientific studies and discussions among experts have emerged in the past few weeks. There are also current risk assessments for musicians and singers from various sources in Germany (including Charité—Mürbe et al. and Willich, et al.), DGfMM (Firle et al.), Kähler & Hain, and the Health Working Group and Prophylaxis of the German Orchestra Association (DOV) with commentary by the Association of German Operators and Company Doctors VDBW AG Stages and Orchestra (Böckelmann et al.).

As authors, we are striving to include scientific results in our assessment that are as comprehensive and as up to date as possible. The aim is to continually adapt the risk assessments already made so that they are in line with the latest scientific knowledge, and thus to facilitate consensus.

In our risk assessment, we are including the results of a study of wind players and singers, which was initiated by the Bamberg Symphony Orchestra and took place on May 5, 2020, and in which the authors of FIM were involved. The company Tintschl BioEnergie- und Strömungstechnik AG was commissioned to do the technical measurements. All wind instruments common to the orchestra, as well as the recorder, saxophone, and singers (classical singing and popular singing styles), were included in the study. Both qualitative tests for flow visualization and quantitative measurements of air velocities at different distances were carried out. The presentation of the measurement data and resulting discussion will be published in a further update.

In those areas in which no scientific data is yet available, these comments will continue to represent informed professional assessments of the authors. The paper presented here

is therefore still a snapshot in time, which in the future—taking the latest status of existing governmental regulations into account—will be reviewed and adapted in light of new scientific evidence.

In order to increase the quality and reliability of the risk assessment at hand, we established an interdisciplinary working group at the University Medical Center Freiburg with colleagues Head Prof. Dr. med. H. Grundmann, Institute for Infection Prevention and Hospital Hygiene; Prof. Dr. med. Hartmut Hengel, Director of the Institute of Virology; and Prof. Dr. med. Hartmut Bürkle, Director of the Clinic for Anesthesiology and Intensive Care Medicine. The colleagues mentioned helped fashion and reviewed this paper from the perspective of their respective specialties.

Since the outbreak of the coronavirus pandemic, we have all gained an increased understanding of the epidemiologically important factors in the spread of SARS-CoV-2. From the start, the Robert Koch-Institute and politics in Germany have made it clear that the aim of the instituted protective measures is to slow and contain the spread of infection. The guiding principle of these measures is to reduce the risk of infection with SARS-CoV-2 as much as possible. In our view, a risk assessment focused on specific questions of music practice should therefore be based on the *added* risk that arises there from. This focus on existing general standards is important to us in that it enables political decision-makers to evolve appropriate recommendations for action in the field of music.

The risk assessment presented here pursues the concept of risk management with the aim of identifying specific risks in the field of music and at the same time offering risk-reducing measures. In this way risk management concepts and the related questions, adapted to meet specific musicians and musical situations, can be appropriately and flexibly integrated into the society as a whole.

In furthering a flexible risk adaptation, one could make a stronger differentiation in the future between infection risk and disease risk, and to take different precautionary measures depending on the susceptibility of the musicians (previous illnesses, age, etc.).

The local and time-dependent epidemiological situation (e.g., in a city or local community) could also be considered when devising strategies to prevent infections when making music together. For example, a COVID-19 tracing app, which is currently still under development, would allow for an even better assessment of the collective risk of a future choir rehearsal.

Even if there are currently insufficient comprehensive foundations and tools for such a differentiated risk adaptation for society as a whole and in the field of music, the authors of the present paper still wish to take a first step in that direction.

1. Transmission Pathways of SARS-CoV-2

Basic Information

The main avenue of transmission of viruses that cause respiratory infections generally takes place via **droplets** and **aerosols**. This occurs when exposure to coughing and sneezing leads to the inhalation of droplets by a person through the mucous membranes of the nose, mouth, and deep respiratory tract, and possibly through contact with the conjunctiva of the eye. In this context, droplets are to be understood as larger particles (diameter of more than 5 micrometers). In some cases, they can be so large that they are visible when a person coughs or sneezes and can be felt on the skin. An aerosol (an artificial word from ancient Greek *ἀήρ*, German *air* and Latin *solutio* “solution”) is a heterogeneous mixture of very small suspended particles in a gas (diameter of less than 5 micrometers) that are not visible without technical tools. A Finnish working group, centered around Ville Vuorinen from Aalto University in Helsinki, carried out a computer simulation of the spread of aerosols in a closed room/supermarket (Vuorinen et al. 2020). According to the simulation if an infected person sheds virus when coughing, the viruses can still be detected in the air after several minutes, even if the sick person has already left the room. Other people can then inhale the airborne viruses.

The viruses also land on surfaces from where they can be transmitted when others touch these contaminated surfaces with their hands and then touch their faces (before washing their hands); provided the virus particles still retain their ability to infect at this point (**contact transmission**).

The transmission pathways are shown schematically in Figure 1 below.

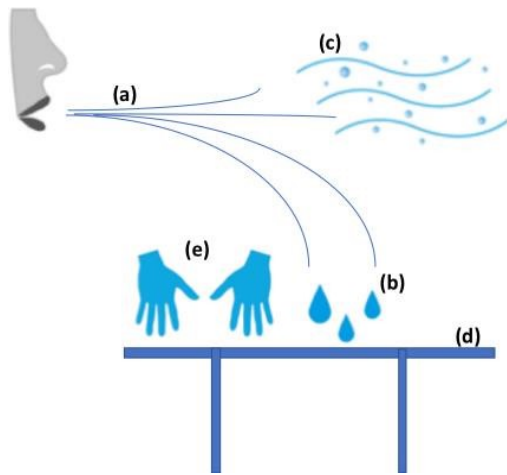


Fig. 1: Schematic representation of the possible transmission pathways. With exhaled air (a), droplets (b) and aerosols (c) are released into the environment. The droplets can land on surfaces, e.g., a table (d). From there they can be picked up by hands (e). If the hands then come into contact with the mouth, nose, or eye, a contact transmission (smear infection) can occur.

Specific Information about SARS-CoV-2

According to current knowledge, the spread of the coronavirus (scientific name: SARS-CoV-2) as a trigger for the COVID-19 disease can take place via the route of droplet infection or via aerosols (Meselson et al. 2020).

According to data in three studies from the Robert Koch-Institute from April 17, 2020, aerosols containing coronavirus RNA were detected in air samples of the exhaled breath of patients or in the room air inside patient rooms (Leung et al. 2020; Chia et al. 2020; Santarpia et al. 2020).

Contact transmission of the virus is also possible. Transmission through contaminated surfaces cannot be ruled out, especially in the immediate vicinity of the infected person (ECDC 2020), since reproductive SARS-CoV-2 pathogens can be detected in the environment under certain circumstances (van Doremalen et al. 2020). To what extent an infection via the eyes is likely here cannot yet be conclusively determined (Zhou et al. 2020).

In addition to the air we breathe, saliva and respiratory secretions should also be mentioned as other relevant infectious materials. In direct patient care, it was found that an above-average number of ear, nose, and throat doctors and anesthesiologists/intensive care physicians and nurses suffer from COVID19. This is

because they carry out endoscopic examinations and interventions in the mouth and throat area and may therefore have had intensive contact with all of these three forms of transmission (German ENT Society 2020; Ruthberg et al. 2020).

2. Specific Risk Aspects in the Field of Music

2.1 Systemic Possibilities for Risk Reduction in the Field of Music

Before a vocal, instrumental, and situational specific risk assessment can take place that can be used in the field of music, general systemic methods of risk reduction should first of all be established. From our point of view, these play an especially decisive role in ensembles with a larger number of people (choir, orchestra, concert band, big band).

The following Figure 2 gives an overview of possible risk reduction measures. We view these three useful areas for risk reduction measures:

- a.) Entrance screening
- b.) Air & Ventilation/ Room & Space / Duration parameters
- c.) Individual protective measures

The areas of a.) and c.) are related to behavioral prevention; area b.) is related to environmental prevention.

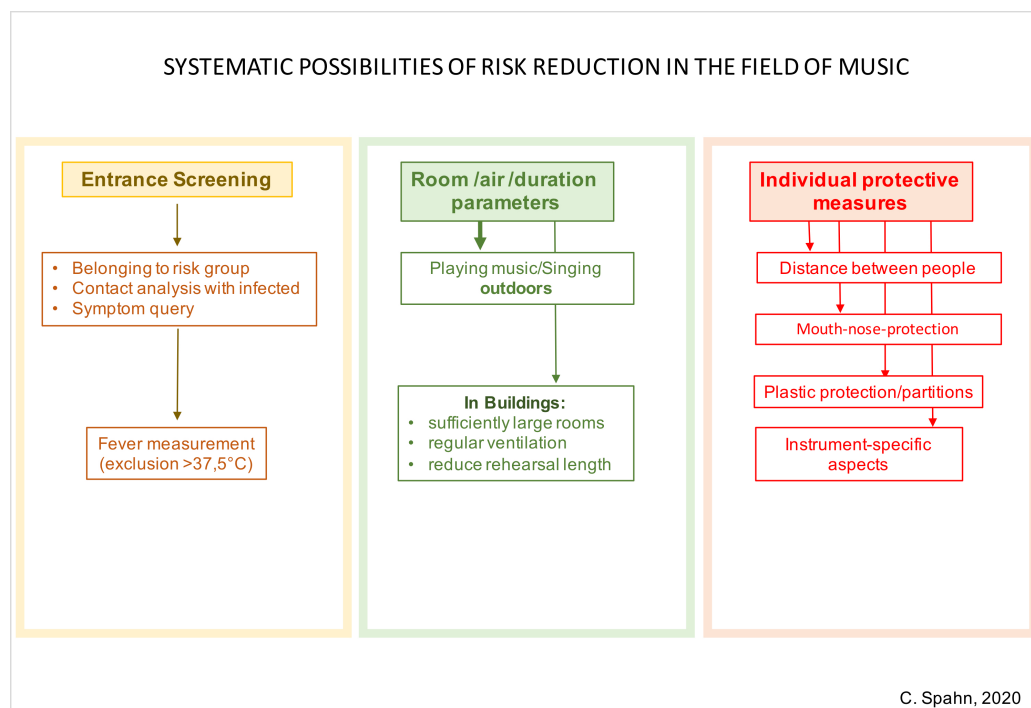


Fig. 2: Overview of systemic measures for risk reduction in the field of music

a.) Entrance Screening

An entrance screening can include a survey and a comprehensive assessment of several relevant characteristics for the disease:

- At-risk personnel can be identified utilizing the RKI list of pre-existing conditions (RKI list of risk groups for severe disease progression²).
- The assessment of carrier risk can be ascertained through a standardized survey (questionnaire or app³) of personal contact analysis of the previous 5–6 days and suspected COVID-19 symptoms. This standardized survey can serve to regulate eligibility for attendance at rehearsals / lessons / concerts and lead to better self-protection and the third-party protection in the future.
- Musicians in all areas of music should pay strict attention to general illness symptoms such as fever plus respiratory complaints (dry cough, catarrh) or, in the case of more typical COVID-19 symptoms such as the acute loss of smell and taste, by avoiding any contact with other musicians until the SARS-CoV-2 PCR nasopharyngeal smear result has ruled out infection.
- In the event of a confirmed infection, entry from another country, or contact with a person infected with the coronavirus, the most current quarantine rules must be observed. If symptoms occur, persons should definitely contact their family physician. In the case of music lessons for children and adolescents, legal guardians should also be given clear instructions to keep their child home at the first suspected sign of coronavirus or any mild symptoms. University students

² Older people (beginning at 50–60 years with an increasing risk of a severe progression), morbidly obese people, pre-existing conditions of cardiovascular disease, chronic lung disease, chronic liver disease, patients with diabetes mellitus, patients with cancer, patients with compromised immune systems

³ Questionnaires and app could be based on the survey instruments of the University Hospital Freiburg, in use since May 4, 2020

should also be made aware of this protocol. Of course, this applies to educators, who should not teach under these circumstances. Particularly strict precautions apply for older persons or persons at risk due to pre-existing conditions (see RKI risk list) when actively practicing and performing music.

- Another possible measure, which is relatively inexpensive and practical, is a system of temperature checks as an additional screening tool before making music with others. At the University Medical Center Freiburg, a majority of COVID-19 sufferers showed an elevated temperature in connection with acute respiratory complaints. The Robert Koch-Institute, on the other hand, no longer recommends using temperature measurement as a screening method for entry points, e.g. at airports, as only 42% of those infected in Germany had an elevated temperature ($>37.5^{\circ}$ Celsius) (Epidemiological Bulletin RKI 20/2020). Asymptomatic, fever-free virus carriers who are actively shedding virus cannot be identified using temperature checks.

Both a standardized survey and temperature check could improve the musicians' awareness of risks and increase the compliance of utilizing protective measures. The standardized survey is also part of the screening protocol for the elective outpatient procedures since the gradual opening of the clinics beginning May 4, 2020, currently in use at the University Medical Center Freiburg. These simple measures are practical, efficient, and very well received. In the professional music sector (operas, concerts, theater), detailed hygiene protocols could also be used, which depending on the facility would have to be developed and verified by the company doctors (Böckelmann et al. 2020). These protocols could call upon existing standards found in professional sports.

b.) Parameters of Room & Space / Air & Ventilation / Duration

The epidemiological findings from the course of the SARS-CoV-2 pandemic already show that room and air conditions, as well as the length of exposure to gatherings of

people, are likely to have a decisive influence on the risk of infection (Leung et al. 2020; Chia et al. 2020; Santarpia et al. 2020; Liu et al. 2020).

Singing and Playing Music Outdoors

Infections are especially likely to occur in people who spend a long time in closed rooms. In a study by Qian et al. in January and February 2020, in a total of 7,324 cases of infected people in China, the authors found that there was evidence in only one case of an infection being passed on outdoors (Qian et al. 2020). It can be assumed that aerosols dissipate faster outdoors, that deactivation of the pathogen is greatly accelerated (through UV, ozone, hydroxyl radicals, nitrogen oxides), and that the overall risk of infection is therefore much lower. If minimum distancing is observed, the risk of infection while singing and playing music outdoors can be considered to be very low.

Therefore, the first choice when making music with larger groups is the outdoor option. Especially in view of the fact that the coming weeks and months in which the gradual opening will take place are the summer months (in Germany), making music outdoors seems practical and even particularly attractive. There is a long cultural tradition here, just think of the ancient amphitheater. The term choir (ancient Greek χορός *choros*) originally referred to the dance floor of an amphitheater, in which people also sang. Brass music also has a tradition of taking place outdoors. Outdoor concerts are the predominant setting for Pop and Rock music. Audiences need to observe the prevailing protocols for groups and distancing or creative solutions (e.g., “concert promenades,” i.e., “Wander Concerts”) need to be found.

Singing and Playing Music in Closed Spaces

Airing-Ventilation. When singing and playing music takes place in closed rooms with natural ventilation, previous experience seems to show that regular and thorough ventilation seems to be an important factor in risk reduction. If the rooms are mechanically ventilated (ventilation and air conditioning systems, HVAC), a reduced risk of infection from aerosols can be assumed (Aerosols are removed by way of natural ventilation vis the exchange of air in the range of approx. 0.5–2/h even with closed

windows; for HVAC, e.g., in concert halls or performance halls, the air exchange rate is approx. 4-8/h).

Room size. The size of the room, the number of people in a room, and the length of time they are in a closed room all seem to play an important role (Tellier 2006). A relatively large number of people who stayed in confined and poorly ventilated rooms for a long time seem to have contributed to the spread during the “well-known” outbreaks in Europe (e.g. Ischgl and Heinsberg). Pertinent to group music making, very large spaces such as church sanctuaries, concert halls, or city auditoriums could also be increasingly utilized as rehearsal rooms.

Rehearsal time. In addition to the sufficient room size, short rehearsal periods (e.g., 15 minutes, see also Robert Koch-Institute, as of April 16, 2020, Kontaktpersonennachverfolgung bei respiratorischen Erkrankungen durch das Coronavirus SARS-CoV-2) with breaks during rehearsal for ventilation, presumably reduces risk.

c.) Individual Protective Measures

Mouth-nose protection. From our point of view, wearing a mouth-nose-protection (surgical face mask) represents an important way of reducing risk, particularly in the music field. It is particularly important that the face masks be worn, even though they may be perceived as inconvenient or disruptive while singing or playing a string, plucked, or keyboard instrument. The medical differentiation between wearing filtering half-masks (N95) or wearing surgical face masks is whether the aim is to be protected from infection by droplets or aerosols from other people (own protection), or whether the aim is to reduce the spread of infectious material to other persons (protection of others).

The material of the medical face masks, type II (according to DIN EN 14683: 2019-6), that are currently readily available surgical face masks, absorbs $\geq 92\%$ of the particles $\geq 3 \mu\text{m}$ in diameter. Thus, they represent a sensible measure for protection of others, but also offer relevant own protection (according to IuK measurements, they retain e.g.

particles $\geq 0.5 \mu\text{m}$ to approx. 80–90% and particles $\geq 0.3 \mu\text{m}$ to approx. 70–80%). However, the correct mask fit also plays an important role here, as air particles can escape laterally past the masks, especially during forceful exhalation (Mittal et al. 2020). Current studies have shown that wearing such masks can effectively reduce the spread of droplets and aerosols (Leung et al. 2020).

Distance protocol. We continue to emphasize the importance of adhering to the distancing rules in protecting against droplet contamination, even in the music business. Since compliance with distancing protocols requires great attention—physical closeness and social connection are intuitive parts of music-making situations, and since singing and music-making do not take place from a rigid body position, but rather require a certain amount of freedom of movement—we believe that the distance between people should be 2 meters/6 ½ feet. An additional benefit can be simultaneously achieved by applying the radial distancing rule of 2 meters to a larger number of people in a closed room. Thus, by applying this rule, only a few musicians can fit into small rooms. With larger ensembles, a larger room size becomes necessary if this rule is to be observed. As a result, a minimum radial distance of 2 meters/6 ½ feet can help to reduce not only the risk of droplet transmission, but also the risk of increased indoor aerosol accumulation. However, compliance with distancing rules does not negate the need for regular ventilation and/or shortening rehearsal times.

Specific measures. Further specific considerations for individual instruments fall within the area of individual protective measures below (e.g., spit protection and partitions between singers and accompanists).

2.2 Vocal and Instrument-specific Risk Assessment

2.2.1 Vocal

General Risk Assessment pertinent to Singing

As previously described, a distinction must be made in the transmission pathways of SARS-CoV-2 between the risk of infection from droplets (containing viruses) and the infection from aerosols (containing viruses). In addition, it is important to note the other transmission paths via hand/nose/mouth contact and, potentially, hand/eye contact.

Droplets. Due to their size and weight, droplets sink quickly to the ground and travel a distance of maximum 1 meter (39 inches). This is the basis for the distance rule of 1.5 meters (5') in everyday situations (shops, offices, etc.).

Is there an increased risk of droplet infection when singing? In the field of voice physiology it has long been maintained that no significant additional air movement occurs in front of a singer's mouth during phonation (sound production when singing) since sound waves travel physically without significant flow: the flame of a burning candle does not move in front of a singer's mouth, even if one sings loudly.

This observation was recently confirmed by measurements made of three singers with the Bamberg Symphony Orchestra. The artificial fog channeled directly in front of the singers' mouths was not visibly redirected by singing even at different pitches, different volumes or different vocal styles. By forceful articulation, e.g. with consonants (plosives, fricatives), slight turbulences in the fog was observed in the close proximity to the singer's mouth. However, when measuring the air speed with sensors set at a distance of 2 meters/6 ½ feet from the singer, no air movement could be detected. This distance of 2 meters/6 ½ feet can therefore be viewed as a protective distance against droplet infection even with forceful articulation.

Aerosols. Reproductive pathogens are incorporated into aerosols in the airways, e.g., chickenpox virus, influenza viruses, measles virus, mycobacterium tuberculosis, and obviously, SARS-CoV-2 as well.

It has been shown that aerosol formation increases with increasing speech volume (Asadi et al. 2019). To date, there are no known scientific studies regarding aerosols while singing. When aerosols emerge from the mouth opening, it is to be expected that these will rise, due to their lower specific density (approx. 37° Celsius and >95% relative humidity), and then mix with the room air. Sedimentation of aerosols below a particle size of approximately 4 µm is, practically speaking, not a factor.

Is there an increased danger from aerosols when singing? Fundamentally, it must be assumed that singing can produce aerosols that can transmit viruses just as resting breathing or speaking can (Fabian et al. 2019). The measurement of aerosols, in general, are a challenge to quantitatively measure.

Inhalation. The extent to which deep inhalation while singing increases the risk of infection has not yet been scientifically investigated.

Phlegm production. Putting other factors in tone production aside, singing can produce a not inconsiderable amount of phlegm. For one, it is not uncommon to observe that extra phlegm is produced when warming up for playing or singing, which is then expelled from the respiratory system by coughing or clearing the throat. Likewise, prolonged instrumental playing can lead to increased formation of phlegm due to stress on the respiratory tract.

Conclusion: General risk assessment with regard to the activity of singing. Based on the interrelationships and results shown, we assume that singing does not increase the risk of droplet transmission if a distance of 2 meters/6 ½ feet is maintained. Based on the latest measurement results, it does not appear necessary to extend the distance to 3–5

meters/10–16 ½ feet, as we had initially formulated in the first risk assessment on April 25, 2020. The extent to which aerosol formation and diffusion are specifically changed by singing is still difficult to assess at present. It is also still unclear what influence deep inhalation during singing has on possible infection transmission. As a consequence of the existing knowledge, we believe that necessary protective measures need to be proposed. These are detailed below in their individual forms and settings, in which singing occurs.

Forms of Singing

Individual voice lessons

With solo singing, a deep inhalation and exhalation occurs during sound production. To the best of our knowledge, the extent to which this increases the risk of infection has not yet been scientifically investigated. Even if the direct air flow is not stronger in singing phonation, as our latest measurements have confirmed, it can be assumed that viruses are spread through aerosols during singing. In solo singing, spitting particles, i.e., droplets, are expelled when consonants are formed. The short range of these droplets has been described above.

Direct transmission by droplets can also be reduced by installing plastic partitions. Noise protection screens already available in some institutions could be used as makeshift protective barriers.

In addition, it makes sense to us that pedagogues wear additional face and nose protection during individual lessons when students are singing. If protective masks are available to the non-medical sector, wearing an FFP-2 (respirator type) mask for personal protection could further reduce the risk of infection.

In our view, if the safety measures are strictly observed, (according to the latest measurements, in particular a distance spacing of 2 meters/6 ½ feet, see above) and if the required room prerequisites are present (sufficient room size, ventilation breaks

every 15 minutes and between individual students) the risks in individual lessons can be reduced.

However, it cannot be inferred from this updated risk assessment that teachers or students can be obliged to teach or take part in individual face-to-face lessons. In our opinion, if the structural and organizational requirements are not met or the people involved belong to a risk group, then face-to-face teaching should not take place, but could be possible digitally.

Choir singing

Choral singing generally follows the characteristics of the singing process described above. Since it must be presumed that each and every singer creates aerosols, it is to be expected that aerosols containing viruses will accumulate in a higher concentration in an enclosed space when a large number of people gather (Liu et al. 2020). The quality of room ventilation also plays an important role here (Li et al., 2020). The question of the duration, i.e., how long a choir rehearsal lasts, also plays a role in the expected concentration of aerosol particles in a room. Over longer periods of time, particle concentration can rise to higher values than in shorter periods.

There have been repeated reports of the spread of SARS-CoV-2 infections among several different choirs after choir rehearsals and religious services. A scientific publication reported on one such outbreak in a choir in the United States on May 12th (Skagit County, Washington) (Hamner et al. 2020). A high infection rate was reported by the choir to the health authorities on March 17, 2020. The choir rehearsal, which presumably led to the high infection rate, took place on March 10, 2020. Of the 61 choir members who took part in the rehearsal on March 10th, 53 fell ill, three had to be treated in hospital, and two died. The median age of the singers was 69 years (range = 31–83), the three hospitalized patients had two or more known medical conditions. Infection via aerosols is discussed in the publication as a likely source. However, other influencing factors are also critically examined. The distance between individual singers was small,

6–10 inches (about 15–25 cm) between the chairs. The entire rehearsal lasted approximately 2 ½ hours. There was a 15-minute snack break. In addition, the presumed index person, who is suspected to be the primary source of viral spread at the rehearsal on March 10th, had already been symptomatic on March 7th. That person had also participated in the March 3rd rehearsal.

In order to reduce the risk of infection from aerosols in the choral setting, *mouth and nose protection* can be worn, as already explained above.

In addition, singing in very *large rooms*, such as concert halls or church sanctuaries, appears to be most favorable. A regular *airing out* of the room approximately every 15 minutes, or the use of rooms with an HVAC system are important risk-reducing measures. It appears that the most favorable way to minimize risk is to sing *outdoors* (see also Systemic Risk Reduction).

Furthermore, through better rehearsal scheduling, the *rehearsal periods* could be divided into short 15-minute sections—enabling *airing out* of the room—to help minimize risk.

To eliminate droplet transmission, choirs must observe the general *spacing rule* for social distancing, even in the choir breaks, where face masks should also be worn to protect against droplet transmission.

Above and beyond that, in our view, particular care must also be taken in break situations to ensure that there is no hand contact or contact with surfaces (e.g., by sharing music, etc.). Regular and thorough *hand washing* is very important. One should especially avoid touching the face and rubbing the eyes.

A further general risk reduction is the personal entrance screening (see above). Sneezing and coughing should be avoided, if possible, and caught in the crook of the elbow.

Singing in religious settings

Congregational singing appears possible if the distancing rule of 2 meters/6 ½ feet is observed and face masks are worn, since it can be assumed that there is no greater risk of being infected by singing than by speaking. In addition, services usually take place in large to very large spaces.

2.2.2 *Wind Instrument Playing*

Risk Assessment Regarding Playing Wind Instruments

With the exception of flute, experienced players of wind instruments do not let air escape at the contact point between the player's mouth and the mouthpiece (rim/cup, single and double reed). With some wind instruments, air escapes out of the keyholes for certain notes, but in general, wind instruments have a sound opening, e.g., in the form of a bell. The wind instruments will be considered individually because of their unique features.

As a commonality, apart from the flute-instruments, it can be stated that the sound is generated by vibrations of the lips of the mouth (brass instruments) or interrupted by a reed in the mouthpiece (reed instruments among the woodwind family). Comparable to singing, only small amounts of air flow out of the instrument's horn in wind instruments per unit of time. The latest measurements taken of the Bamberg Symphony Orchestra by Dipl. Ing. Schubert from the Tintschl company support these assumptions.

Due to the previously described transmission pathways of SARS-CoV-2, a distinction must be made between the potential risk of infection from virus-containing droplets and virus-containing aerosols when blowing air. In addition to these are the important transmission pathways via hand contact and hand/eye contact.

Droplets. Due to their size and weight, droplets sink quickly to the ground and reach a maximum distance of 1 meter (3'3"). This is the basis for the distance rule of 1.5 meters (4'1") in everyday situations (shops, offices, etc.).

Is there an increased risk of droplet infection when playing a wind instrument? Since no air escapes at the contact point between the player and his mouthpiece in those who control their instruments, no droplets are released directly into the environment from the musician's mouth when playing brass instruments, woodwind instruments with a single reed (clarinet and saxophone), and double reeds (oboe, bassoon). This is different with

flute instruments (flute, recorder). Especially with the flute, air is blown directly from the mouth of the player into the environment when blowing on the mouthpiece and droplets can be released. The measurements of the Bamberg Symphony Orchestra show, that with regard to the air speed parameter, no air movement could be detected at the sensors, which were placed 2 meters/6 ½ feet from the mouthpiece. Therefore, transmission by droplet infection is very unlikely at this distance. With the recorder, the lips surround the beak of the instrument, so that no droplets can get into the surroundings. On the other hand, droplets could form when the air flow is broken up at the labium of the head piece. In measurements taken with the Bamberg Symphony Orchestra, when the recorder was played air movements in the area of the labium were no longer measurable at a distance of 1.5 (4'1") meters. Therefore, transmission by droplet infection is very unlikely at this distance.

Condensation. Condensation is created when warm, moist, air inside the instrument—whose inner walls are markedly colder—condenses as drops of water. During this process, any aerosols contained in the exhaled air are greatly reduced (air purification principle [*Luftwäscher-Prinzip*]). If the breath is from a virus carrier, the question arises whether and to what extent this condensation, which Brass players need to release at the water key during breaks, contains viruses and is therefore potentially infectious. Measurements regarding the viral load in condensed water are still pending.

Aerosols. When aerosols escape from the mouth, they rise due to the low specific weight of the exhaled air. They spread out in space, with sedimentation no longer playing any practical role. A reduction can only occur as a result of dilution through the volume of air in the respective space and through the natural exchange of air.

Is there an increased risk of aerosols when playing wind instruments? Aerosols do not escape into the room air directly from the mouth when playing wind instruments, except for the flute. They get into the environment via the body of the instrument and through open keys and/or the bell. One needs to differentiate here between the possible exit

points among different wind instruments. In brass instruments, air exits through the bell. With woodwind instruments, only at the lowest note of the respective instrument are all side holes closed, so that only in this case the air escapes through the bell. Exceptions to this are the oboe and the English horn, in which air escapes through the last open side hole even when the instrument is at its lowest note. In addition, air that escapes through the first open side hole is subject to change depending on the pitch played in woodwind instruments.

Even when playing the flute and recorder, aerosol formation occurs exclusively in the airways. For the flute, the air flow can be compared to the flow of an exhalation. The air flow is diverted in accordance with the Coanda effect. With the recorder, the lips enclose the mouthpiece of the flute and the air flow is broken up at the labium of the headpiece.

It is a physical assumption, that inside every wind instrument it comes to surface contact with aerosol particles, which stick to the inner surfaces, i.e., that the instruments basically reduce the particle concentration of the given aerosol. The effect increases the longer the airway of the instrument, the smaller the diameter, and the more curved it is. The effect governs all particle sizes, but the effect is more pronounced for larger particles than for smaller particles, e.g., viruses. As described above, the question arises as to what extent the instrument also acts as a filter for aerosols (due to condensation of air humidity and due to surface contact). Measurements are still pending.

As long as no clear results are available, some authors (cf. Kähler & Hain; Willich et al.) recommend using some sort of transparent protective material or tightly woven silk cloths (aka drop protection) placed in front of the bell of the brass family instruments. Until further clarification of the question, this could help reduce potentially escaping aerosols. A covering over the bell of woodwind instruments seems less effective for reasons already mentioned.

To what extent inhaling deeply when playing wind instruments increases the risk of infection has not yet been scientifically investigated.

On the recipient side, the question arises to what extent virus loaded aerosols are absorbed in greater amounts due to the deep and often rapid inhalation when playing wind instruments, and to what extent higher concentrations of viruses thereby invade the respiratory system. To date, no scientific studies have been carried out on this topic.

For wind players, phlegm production can also occur as a byproduct of sound production. For example, it is not uncommon to observe additional phlegm being produced during inhalation, which is then removed from the respiratory system by coughing or clearing the throat. Likewise, prolonged wind playing can lead to increased phlegm formation due to overloading the respiratory tract.

Conclusion: General risk assessment of wind instruments. As far as we know, there are still no measurements of the viral concentration in the blown-out air of wind players. However, it is known that playing wind instruments requires an intensive exchange of air in the lungs and airways with, at times, high air pressures. The extent to which the viral load is reduced by the air's path through the instrument is currently unclear. Based on the latest measurement results, it does not appear necessary to extend the distance to 3–5 meters/10–16 ½ feet, as we had initially formulated in the first risk assessment on April 25, 2020. 2 meters/6 ½ feet seems sufficient as a minimum distance, because no additional movement of indoor air during playing was detected at this distance during the tests. Therefore, the risk of droplet infection, if the distancing protocol is being observed, can be classified as very low.

In addition, there is the formation of condensation from the exhaled air in the instrument, which can be regarded as another potentially virus-spreading material. We recommend avoiding the draining of condensation onto the floor and recommend instead disposing of it in a collection container or absorbent blotting paper. Furthermore, wind players should not blow through the instruments to clean them. Wind instruments should, if possible, be cleaned in separate rooms away from the teaching or rehearsal setting. In the event of contact with condensation or with the interior of the instrument (e.g., horn),

great care must be taken to ensure a thorough hand hygiene protocol is followed (at least 30 seconds of hand cleaning, i.e., very thorough hand washing with soap or, if necessary, the use of a hand sanitizer).

Forms of Wind Instrument Playing

Individual lessons with wind players

In our opinion, the risk seems basically comparable to that of singers in individual lessons (see above). It also makes sense to us that educators and pupils wear mouth-nose protection in individual lessons, when they are not playing. We emphasize the correct handling of the masks based on the current hygiene rules. If protective masks are available to the non-medical sector, wearing an FFP-2 (respirator type) mask for personal protection could further reduce the risk of infection.

Wind ensembles

Wind ensembles can have different numbers of players depending on their instrumentation. The number of players must always correspond to the currently applicable regulations on group sizes. Even with smaller ensembles, a minimum distance of 2 meters/6 ½ feet should be maintained according to the latest data, since at this distance no additional room air movement could be detected when playing. Rehearsal rooms should be as large as possible and should be thoroughly and regularly aired out every 15 minutes.

Since compliance with the distancing rule is a very important measure, see section 2 c.), making music in large rooms—in addition to concert halls, church sanctuaries should also be considered in this case—can further reduce the risk. In the summer season, we see an important opportunity to play outdoors. There is a great tradition of playing outdoors in the field of wind music.

It can be assumed that aerosols dissipate faster outdoors, that the deactivation process of the pathogens is greatly accelerated (UV, ozone, hydroxyl radicals, nitrogen oxides), and the cumulative effect thereof is a much lower risk of infection. If the minimum distancing rule for wind ensembles is observed, then the risk can be deemed very low.

2.2.3 Other Instruments

Keyboard, Bowed and Plucked String Instruments, Percussion

From our point of view, there is no increased risk to other instrumentalists *through music making* when compared to other social situations with regard to the question of droplet infection or increased aerosol formation, provided that the applicable rules are strictly observed. The known risks apply. If several musicians are gathered in one room, the risk of a possible infection via aerosols has to be considered. In our view, the measures listed above (see Paragraph 2 b.) should therefore apply; in particular, ventilating (after 15 minutes of rehearsal/lesson *shock ventilation* [*Stoßlüftung*]), having sufficient room size and observing distancing. Thorough hand cleaning is of particular importance.

Keyboard instruments

With pianists, the risk of contact transfer plays a role if different pianists play the same instrument in succession. Before playing begins, all players must wash their hands for at least 30 seconds (i.e., very thorough hand washing with soap or, if necessary, use a hand sanitizer). In addition, from our point of view, the keys themselves should be disinfected with cleaning cloths before and after being played.

In our opinion, during collaborative/accompanied rehearsals care should be taken to ensure that there is a distance of 2 meters/6 ½ feet between pianist and fellow musicians, including during the coaching/rehearsals of wind players or singers, as it is not uncommon for spontaneous movements to occur when making music, such as turning towards the accompanist. According to our measurements, there is no danger of droplets being transmitted through the air from a wind instrument and a singer's mouth at this distance.

However, a possible infection from aerosols in the room cannot be ruled out. In the sense of the risk reduction measures described above, we see the wearing of face masks in the context of mutual protection of third parties and self-protection of the players as an

important option for the accompanist and the instrumentalists/singers with whom they make music. For wind players, the risk reduction measures described above (wearing face masks) are problematic.

String bowed, plucked, and percussion instruments

The transfer or sharing of instruments should be avoided, if at all possible. As with pianists, the risk of contact transmission can be reduced by washing hands and avoiding touching the face, mouth, nose, and eyes.

Chamber Music Ensemble / Wind Ensemble

Even for smaller ensemble configurations of chamber music or wind groups, the options for risk reduction through the *entrance screening*, the optimization of the parameters of *room-space / air-ventilation / duration*, as well as the *individual protective measures* detailed in Section 2 above should be observed. Here too, it is very important to observe the distancing protocols so as to protect against droplet contamination. For complying with the distance protocols requires great attention, and because physical closeness and social connection are an intuitive part of music-making situations, and since music is accompanied by movements around the body axis in space, we feel a distance of 2 meters/6 ½ feet between people should be observed. In addition, when several people play music in a closed room, the risk-reducing protective factors for infection by aerosols apply. These are: rooms as large as possible (enforced by a radial distance of 2 meters/6 ½ feet around each musician), regular room airing (after 15 minutes of rehearsal/instruction *shock ventilation* [*Stoßlüftung*] in closed rooms with natural ventilation) and a reduction in the total rehearsal time.

In addition, musicians who do not play a wind instrument in chamber music ensembles and wind chamber groups should wear mouth-nose protection (face masks), as described several times above, in order to reduce the risk of an aerosol-borne infection. Above and beyond that particular care must also be taken to ensure that there is no hand contact or touching of surfaces (e.g., by sharing music, etc.) during breaks. Regular and thorough

hand washing is very important and especially avoid touching the face and rubbing the eyes. Sneezing and coughing should be avoided as much as possible and caught in the crook of the elbow.

Orchestra / Concert Band / Big Band

In large groupings of musicians, such as orchestra, concert band, or big band, the measures described above for risk reduction are to be applied in accordance with the respective ensemble's situation. When the risks from droplet transfer and/or aerosols are summarized, the risk-reducing measures must be combined in such a way that the greatest possible risk minimization can be achieved. With regard to the transmission of droplets between the individual musicians, according to the data from the Bamberg Symphony Orchestra and other working groups, it can be assumed that at a distance of 2 meters/6 ½ feet (radial) between the musicians—including the wind instrumentalists and the flute—no droplet transmission is to be expected.

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. In terms of risk minimization, it seems most favorable if musical groups can play outdoors (see also Systemic Risk Reduction). In addition, a face mask should be worn for own protection and protection of others. For wind instruments, as long as the filter effect of the instruments has not been proven, appropriate cloth protection can be attached to the bells. The question of the length of time, i.e., how long a rehearsal or concert lasts, also plays a role for the expected particle concentration of aerosol in a room: during longer time periods the particle concentration can increase to higher values than in shorter time periods. This should be considered

when planning rehearsals or concert productions. Sneezing and coughing should be avoided, as much as possible, and caught in the crook of the elbow.

Especially with larger numbers of people, situations outside of orchestral/band music activity plays an important role for a possible infection. It is particularly important to ensure that there is no hand contact or contact via surfaces (e.g., by sharing music, etc.) during breaks. Regular and thorough hand washing is very important, and especially avoid touching the face and rubbing the eyes.

The entrance screening mentioned under the measures above could represent an effective additional step if used consistently.

3. Risk Management

Effective risk management usually requires a precise risk analysis with an associated likelihood of occurrence and knowledge of the effectiveness of certain risk-reducing measures. At the moment, however, we do not yet know much about the transmission of SARS-CoV-2, so that risk management currently means an equation with many unknowns. These unknowns leave room for different goal perspectives (disease rate vs. preservation of the music culture) and different personal attitudes (risk-willing or risk-averse) to lead to different recommendations for action. Individually, everyone must have the right to decide for themselves what level of personal risk they are willing to carry.

As scientists, we want to help convert as many of these unknown variables of the equation into known variables as possible.

In practice, from our point of view, an optimal risk management would currently look something like each institution developing its own risk management protocols for its own specific musical setting. It is to be expected that the higher the number of risk-reducing measures, the greater the reduction of infection risk. This action should be guided by the advice of company doctors, health departments, etc.

As long as we do not have a sufficiently scientifically verified understanding, we must err on the side of over- rather than underestimating the possible risks. In this way, the overall risk of infection can be reduced as much as possible by combining risk-reducing measures. However, it must be clearly pointed out that according to the ALARP principle (As Low as Reasonably Practicable) there will be residual risk that is currently not quantifiable.

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Author's Information

The authors, *Claudia Spahn* and *Bernhard Richter*, are two medical doctors who also hold educated musician backgrounds. They are both Professors of Musicians' Medicine and direct the Freiburg Institute for Musicians' Medicine (FIM), a joint institution of the Freiburg University of Music and the Albert-Ludwig-University of Freiburg (Germany), represented by the Medical Faculty. For the purpose of health care, there is cooperation with the University Medical Center Freiburg. Claudia Spahn specializes in psychotherapeutic medicine and Bernhard Richter is an ENT and phoniatic/pediatric audiologist. Both have received university recognition for outstanding teaching. They collaborated with three additional colleagues at their university; each are medical directors of divisions, respectively for the Institute for Infection Prevention and Hospital Hygiene, Institute of Virology, and Department of Anesthesiology and Critical Care.

Translator's Notes

Kirk D. Moss, Ph.D. is Professor and Chair, Department of Music & Theatre at University of Northwestern – St. Paul and former National President, American String Teacher's Association

My primary interest in the work of our colleagues at the university in Freiburg, Germany, is their May 19, 2020, university risk assessment of a coronavirus infection in the field of music. With the aid of multiple online translation tools and the assistance of *Susanna Klein*, a native German speaker from Stuttgart, Germany—and an artist-teacher/ASTA member/Associate Professor of Violin at Virginia Commonwealth University—we offer this English translation. I am grateful for Professor Klein's role in helping to make the German sentence structure/syntax clearer and more reader friendly for us, as well as in helping check for accuracy. That said, neither of us translates for a living, so please be kind. We did our best.

Throughout this pandemic, music educators have encouraged one another with expressions of, “*You* are not alone.” My motive for this translation shares that sentiment. I am comforted to know that music educators worldwide wrestle with similar problems and work to find solutions in order to one day make music with students face-to-face again safely. *We* are not alone.

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Through my many old friends and contacts in the voice teacher's community, both in Europe and USA, I have been witnessing and sharing the difficulties and challenges that the Corona Virus pandemic has visited upon us all. As we all cope with suddenly teaching online, getting up to speed with unfamiliar digital tools, and trying to learn as singers what is safe to do and not, Drs. Richter and Spahn offer musicians professional, thoughtful and long needed practical advice on how to navigate the pandemic as with minimal risk.

When I read their 1st Risk Assessment in German from April 25 of this year, I immediately felt this vital information needed to be made available to a wider audience. What better way than to translate it into English! Although not a professional translator, my long career in Germany and Europe allowed me a more nuanced viewpoint from which to make an English translation than Google Translate alone could offer. Dr. Richters and Spahn have graciously allowed me to translate both their first (April 25) and second (May 6) Risk Assessments into English.

This translation of their Risk Assessment Update from May 19th is an “open-source” endeavor. In the main, it is a combined work of Dr. Moss, myself and Google Translate. The mistakes are ours, as are the interpretations necessary for a translation. Please send any corrections or suggestions for improvement to Drs Richter and Spahn. My thanks to *Prof. Marilyn Schmiede*, Pres. of BDG, for her eagle eyes in redacting the previous translations. We all hope that this translation will help you find answers to your many questions about being a musician in the time of Corona Virus.