Singing and Transmission: Literature Review as of October 8, 2020

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COVID-19 and Choir Practice

Overall, the most significant piece of evidence directly connected to the COVID-19 outbreak is the Skagit County outbreak in a church choir. This was first reported in newspapers and popular media, but the offical CDC investigation showed what they consider could be a superspreader event with the March 10 practice.[1] The report describes several opportunites for both droplet transmission within relatively close range as well as fomite tranmission, but does not rule out aerosols as a route of transmission. The attack rate was high (see Table 1 from document below). Age did play a role in severity.

TABLE 1. Number of choir members with and without COVID-19–compatible symptoms (N = 122)* and members' choir practice attendance† — Skagit County, Washington, March 3 and 10, 2020

	No. (row %)					
	March 3 practice			March 10 practice		
Attendance	Total	Symptomatic	Asymptomatic	Total	Symptomatic	Asymptomatic
Attended	78	51 (65.4)	27 (34.6)	61	53§ (86.9)	8 (13.1)
Did not attend	40	4 (10.0)	36 (90.0)	61	3 (4.9)	58 (95.1)
Attendance information missing	4	1 (25.0)	3 (75.0)	0	0 (—)	0 (—)
Attended only one practice	21	1 (4.8)	20 (95.2)	3	2 (66.7)	1 (33.3)

Abbreviation: COVID-19 = coronavirus disease 2019.
* No choir members were symptomatic at the March 3 practice.
† Thirty-seven choir members attended neither practice; two developed symptoms, and 35 remained asymptomatic.
§ Includes index patient; if the index patient excluded, 52 secondary cases occurred among the other 60 attendees (attack rate = 86.7%).

In a recent study published by several aerosol science experts, a mathematical model based on this choir event estimated a mean inferred emission rate of 970 (± 390) quanta per hour.[1] Based on their model, standard ventilation rates for spaces such as those used in the rehearsal would only allow 30 minutes of singing to keep risk below 10%. They suggest that current environmental interventions to decrease risk of infection include enhanced ventilation, mechanical filtration, and germicidal UV disinfection.

Choir and Tuberculosis Outbreaks

Other papers related directly to singing are connected to tuberculosis outbreaks, and there are several older papers that report this. In 1998, Mangura describes a "miniepidemic" in a church choir where 5 active cases of TB results in 23 others reacting positively, and this may have been connected to an air vent in the floor in front of the tenor section (4 of 5 index cases were tenors). A review paper also details community outbreaks of TB, with a specific section looking at singing. First, a boarding school outbreak showed much higher risk of TB conversion for those in choir (60%) versus those who shared classroom or dorm room which were described as poorly ventilated (12%). Secondly, the paper reports on a Dutch rockband who had 2 active TB infections within it. They played in small rooms and basements. They were responsible for hundreds of cases from the basements and 40 cases from the small rooms. Thirdly, in 1968, a Colorado choir of 30 individuals had a single TB case which spread to 8 other members whose

only exposure was a single choral practice. TB is obviously not the same microbe as SARS CoV-2, but these may help fill some gaps in choirs being connected to outbreaks of infections spread via airborne transmission.

Singing and Aerosol Emission

Other indirect evidence includes recent studies demonstrating an increase in human particle emission rate with loudness and noting there are "super emitters" for no known reason. Singing, which is usually much louder than speaking, therefore, would theoretically increase the amount of particles released. Also, two papers nearly a decade apart, suggest the dichotomy between droplet and aerosol transmission may be problematic in terms of discussing infection control measures, with work showing humans emit both droplets and aerosols simultaneously and one of these suggests that a sneeze or cough is more complicated than just a straight arc or line of dispersion, resembling a "turbulent cloud" which is dependent on many factors. Additionally, other studies suggest aerosols can play a significant role in transmission of SARS-COV-2, which, based upon these studies, may be dramatically increased during singing versus talking and pose a higher risk of transmission.

Airflow and Aerosol Analyses

Several European groups have investigated airflow and droplet/aerosol concentrations related to singing. The Austrian Choir Association requested MedUni Vienna conduct a measurement of aerosols while singing.[10] Additionally, two separate experiments were conducted by researchers from Munich and Berlin, Germany.[11,12] Though not yet published in peer reviewed journals, the studies consistently demonstrate that airflow from singers did not extend beyond the standard social distance of 6 feet, though the amount of particles emitted while singing is increased and the particle size tends to be in a range that could spread viruses and not immediately fall to the floor. From this, the use of masks, physical distancing of at least 1.5 meters, and good room ventilation are recommended by two of these groups.

National organizations in the United States are also addressing the aerosols question, with preliminary results released in July.[13] The study is examining airflow, aerosols, particle size, and concentration of particles using a Schlieren Test, condensation particle counts, and aerodynamic particle sizer spectrometer measurements, as well as computational fluid dynamics modeling of an unmasked singer. While preliminary results and recommendations focused on wind instruments, there is evidence presented that suggests the infection risk from singing increased markedly beyond 30 minutes of a single singer singing. Likewise, researchers at the University of Cincinnati have examined particle concentration and spread of singers, as presented in a webinar and uploaded to YouTube.[14] Singing statistically significantly increased the concentration of particles in the experiment room as compared to background. The researchers also show that using an appropriately sized air purifier placed at the performance point decreases this concentration of particles below background levels. This group's recommends more research on the topic before making recommendations.

More recently, two peer-reviewed studies have been published. In one study, particle velocities and angle of spread were measured from a subject who sang, spoke, and coughed. Results suggest particles

expelled from singing could stay suspended in the air for signficant periods of time.[15] Another study measured size and concentration of particles expelled during breathing, speaking, and singing. Their study included two participants who were confirmed to be positive with COVID-19. Their results are similar to other studies, with the amount of expelled particles increasing with singing versus speaking and also with loudness of singing. The use of a surgical mask significantly reduced the amount of expelled particles detected. Interestingly, no SARS-CoV-2 was detected from air samples collected at 0.8 meters from the two participants who were positive.[16]

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