Impact of gender, mask usage, and speaking on aerosol number concentrations in a controlled chamber environment

Arya Toghraei[1] & Djordje Romanic[1]

1 Department of Atmospheric and Oceanic Sciences, Faculty of Science, McGill University, Montreal, Quebec, CANADA

Airborne transmission of respiratory aerosols is a key pathway for the spread of SARS-CoV-2, the virus causing COVID-19. Particles released during activities like breathing and speaking can carry viruses and remain airborne for extended periods, increasing infection risk. Respiratory emissions include both larger droplets that settle rapidly near the source and smaller aerosols that remain suspended, traveling farther by turbulent mixing. These small particles can be transported across a room as particle-laden flows, especially under conditions of poor ventilation. Consequently, the near-field region (close to the emitter) involves direct droplet exposure, whereas the far-field region highlights the longer-range transport of aerosols. While previous research has focused on directly measuring exhaled aerosols, the behaviour of these particles over longer indoor distances remains less explored. This study investigates how wearing masks, speaking versus normal breathing, gender, and time influence aerosol concentrations in a controlled indoor environment.

Experiments were conducted in a sealed measuring tent with a volume of 12 m^3 (3 m × 2 m × 2 m) to ensure a controlled setting. Six participants—three males and three females—performed four different 20-minute activities: breathing and speaking, both with and without surgical masks, while seated. All participants submitted consent forms approved by the McGill University Ethics Committee. Aerosol number concentrations, ranging from 0.253 μm to 35.15 μm in diameter, were measured at a 1-m distance at sitting height using a GRIMM 11D device at 6 s intervals. To reduce data noise, each 20-min task was divided into six 3.4-min intervals. Trend lines for each activity were calculated using weighted least squares. The results indicate that males emit more particles than females and that wearing masks effectively reduces aerosol concentrations.

To accurately compare the effects of different variables, a mixed-effects model was employed at the 5% significance level. The analysis shows that not wearing a mask increased aerosol concentrations by approximately 63% compared to wearing a mask (p-value < 0.001). Engaging in speaking activities increased aerosol levels by 26% compared to breathing (p-value < 0.001). Additionally, males produced 38% more aerosols than females, though this difference was not significant (p-value = 0.079) due to the small number of participants and high variability among them. The differences between males and females are likely due to variations in voice volume and exhaled air volume. These findings highlight the critical role of mask usage in influencing aerosol emissions, with pronounced effects observed in male participants.

Email address for correspondence: *arya.toghraei@mail.mcgill.ca*