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What role do acidic and alkaline pH levels in exhaled aerosol particles play in Influenza A Virus infectivity?

Using thermodynamic and kinetic data for respiratory fluids as input to the biophysical respiratory aerosol model ResAM (Luo et al., 2023; 2025), we show that exhaled particles rapidly desorb H_2O and CO_2, becoming alkaline, and then absorb gaseous nitric acid (HNO_3) and other acidic substances from the ambient air, becoming acidic. The rate of these processes depends primarily on particle size. Large droplets (> 50 μm) remain alkaline for days due to the loss of bicarbonate, whereas submicron particles turn acidic in less than 1 minute at typical concentrations of gaseous acids and bases in indoor air (Nazaroff and Weschler, 2020), with alkaline ammonia playing only a secondary role. Subsequently, we use virus inactivation measurements in bulk solutions of synthetic lung fluid acidified to different pH values (from acidic pH2 to alkaline pH11) to calculate the inactivation times of Influenza A Virus (IAV) in exhaled particles of different sizes (Klein et al., 2022). The results compare well with IAV inactivation measurements in an aerosol chamber (Motos et al., 2024; 2025) at different relative humidities (RH) and HNO_3 concentrations, provided that certain assumptions are made about the diffusivities of molecules and ions in the liquid phase. By weighting the results with size distributions characteristic of aerosol in exhaled breath (Pöhlker et al., 2023), changes in relative transmission risk as a function of RH and pH can be estimated and applied to typical indoor conditions in single-family homes and public spaces, such as schools, libraries, and museums, where acidic gases could be partially removed by air filtration. In doing so, the distribution of viruses in particles of different sizes with a preference for small particles (< 5 μm) must be factored in (Milton et al., 2013; Yan et al., 2018). Our results suggest that achieving indoor concentrations of gaseous acids at levels found outdoors leads to rapid inactivation of IAV. Conversely, indoor concentrations, as we typically encounter them in winter, delay inactivation. This effect is enhanced by the seasonality in RH, which can slow or even inhibit the uptake of acidic gases under dry winter conditions. Therefore, indoor air acidity and humidity are important factors in understanding seasonal influenza. We discuss the implications of these results for risk assessment of airborne transmission and possible public health measures.

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