Dynamics of Influenza Virus Bioaerosols in the Indoor Environment

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Despite remarkable advances in virology and medicine in recent decades, we know very little about the dynamics of the influenza virus in the environment during transmission between hosts. There is controversy over the relative importance of various transmission routes, and the seasonality of influenza remains unexplained. We measured airborne concentrations of influenza A viruses (IAVs) and size distributions of their carrier aerosols in a health center, a daycare center, and airplanes. Results indicate that the majority of viruses are associated with aerosols smaller than 2.5 μm and that concentrations are sufficient to induce infection. We further modeled the fate and transport of IAV-laden droplets expelled into a room by coughing, as a function of relative humidity (RH) and droplet size. The model shows that airborne concentrations of infectious IAV vary with RH through its influence on virus inactivation and droplet size, which shrinks due to evaporation. IAVs associated with large droplets are removed mostly by settling, while those associated with aerosols smaller than 5 μm are removed mainly by ventilation and inactivation. To investigate further the relationship between RH and influenza transmission, we measured the viability of IAV in droplets in media and in human mucus at varying RHs. Results suggest that there exist three regimes: physiological conditions (~100% RH) with high viability, concentrated conditions (~50% to ~99% RH) with lower viability, and dry conditions (<~50% RH) with high viability. A droplet's extent of evaporation, which is determined by RH, affects solute concentrations in the droplet, and these appear to influence viability. Increased influenza activity in winter in temperate regions could be due to greater potential for IAV carrier aerosols to remain airborne and higher viability of IAV in droplets at low RH. In tropical regions, transmission could be enhanced due to high viability of IAV at extremely high RH.