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Indoor Airborne Pathogen Transmission and Mitigation, a Multidisciplinary Review, Remaining Gaps and Actionable Improvements

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Improving indoor air quality (IAQ) can result in a range of measurable health benefits, including reduction of infectious disease risks, and cognitive performance improvements. Using engineering controls to minimize the indoor transmission of airborne pathogens saves lives and improves health cost-effectively. Despite a strong evidence base, gaps remain in understanding disease transmission. To understand these gaps, the Johns Hopkins Center for Health Security (CHS) recently convened an interdisciplinary group of experts, including engineers, public health specialists, and policymakers.

We assessed pathogen transmission mechanisms across engineering and health sciences considering how pathogens are emitted from different parts of the respiratory tract and how many pathogens are emitted in this way; how pathogens are transmitted from one person to another in the air; how long pathogens may remain infectious in the air; the quantity of pathogens produced; and the relationship between exposure dose and the likelihood of infection. Addressing knowledge gaps and how they inform practices is important for future advances in IAQ engineering interventions to reduce disease transmission.

Our convening resulted in several key findings: (1) While increasing air changes per hour and improving filtration can reduce disease transmission, these interventions alone may be insufficient, particularly for close-proximity transmission; (2) Layered interventions combining multiple strategies show promise but require further study; (3) Current mathematical models of airborne disease transmission face limitations and could benefit from further integration of biological, physical, and epidemiological factors; (4) Far-UVC technology shows potential as a safe air disinfection method but requires additional research regarding ozone generation and other air quality impacts; (5) Personal air filtration devices demonstrate early promise in computational fluid dynamics studies.

This research highlights the critical need for breaking down disciplinary silos to advance our understanding of indoor airborne pathogen transmission. We identified specific knowledge gaps that require interdisciplinary collaboration, particularly in understanding the complex interactions between pathogen biology, physical transmission mechanisms, and building systems. Future research should focus on developing integrated approaches that combine expertise from multiple disciplines to create more effective, evidence-based interventions for improving indoor air quality and reducing disease transmission. This work provides a foundation for future collaborative research efforts and highlights the importance of considering both engineering and health perspectives in developing practical solutions for indoor air quality challenges.

We provide actionable insights for policymakers and building designers, offering a roadmap to implement cost-effective, evidence-based strategies that enhance indoor air quality, reduce disease transmission, and improve public health outcomes.

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