Changing the pattern to fight respiratory infections in the home Building ventilation needs much improvement

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Abstract: **By contrast, airborne pathogens and respiratory infections, whether seasonal influenza or COVID-19, are addressed fairly weakly, if at all, in terms of regulations, standards, and building design and operation, pertaining to the air we breathe. This could in part be based on the lack of perceived risk or on the assumption that there are more important ways to control infectious disease, despite ample evidence that healthy indoor environments with a substantially reduced pathogen count are essential for public health. Yet, before COVID-19, to the best of our knowledge, almost no engineering-based measures to limit community respiratory infection transmission had been employed in public buildings (excluding health care facilities) or transport infrastructure any- where in the world, despite the frequency of such infections and the large health bur- den and economic losses they cause (3). First, infection- focused ventilation rates must be risk-based rather than absolute, considering pathogen emission rates and the infectious dose [for which there exist data for a number of dis- eases, including influenza (6), severe acute respiratory syndrome coronavirus (SARS- CoV), Middle East respiratory syndrome, tuberculosis, SARS-CoV-2, and measles]. The only types of public buildings where airborne infection control exist are health care facilities, where requirements for ventilation rates are typically much higher than for other public buildings (9). Global WHO IAQ guidelines must be ex- tended to include airborne pathogens and to recognize the need to control the hazard of airborne transmission of respiratory infections.**

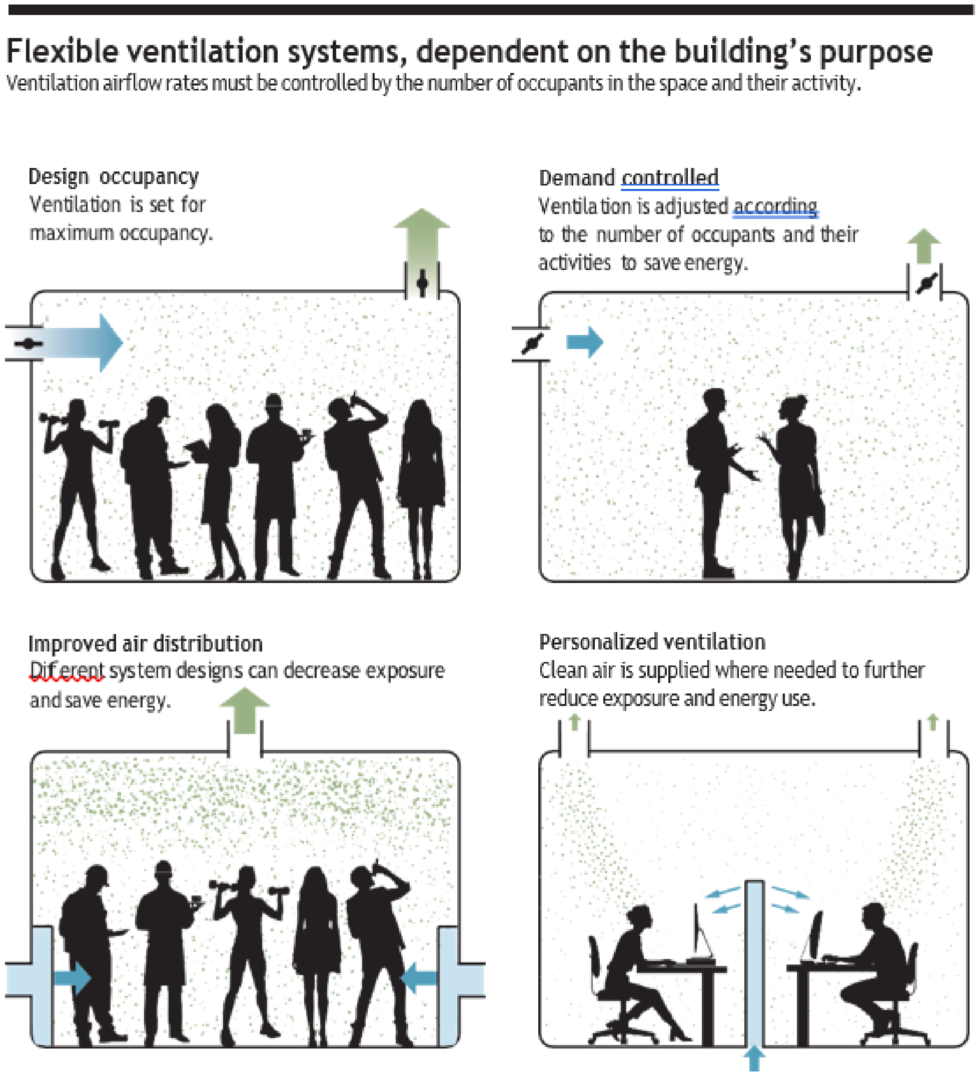
Keywords: **COVID-19, respiratory infections, improvement, protection.**

I. INTRODUCTION

In food safety, sanitation, and drinking water for public health purposes. By contrast, airborne pathogens and respiratory infections, whether seasonal influenza or COVID-19, are addressed fairly weakly, if at all, in terms of regulations, standards, and building design and operation, pertaining to the air we breathe. It starts with a recognition that preventing respiratory infection, like reducing waterborne or foodborne dis- ease, is a tractable problem. Two factors in particular may contribute to our relatively weak approach to fighting airborne transmission of infectious diseases compared to waterborne and foodborne transmission. Second, a long-standing misunderstand- ing and lack of research into airborne trans- mission of pathogens has negatively affected recognition of the importance of this route (1). Most modern building construction has occurred subsequent to a decline in the belief that airborne pathogens are important. Therefore, the design and construction of modern buildings make few if any modifications for this airborne risk (other than for specialized medical, research, or manufacturing facilities, for example). For decades, the focus of architects and building engineers was on thermal comfort, odor control, perceived air quality, initial investment cost, energy use, and other performance issues, whereas infection control was neglected. This could in part be based on the lack of perceived risk or on the assumption that there are more important ways to control infectious disease, despite ample evidence that healthy indoor environments with a substantially reduced pathogen count are essential for public health. Although the highest exposure for an individual is when they are in close proximity, community outbreaks for COVID-19 infection in particular most frequently oc- cur at larger distances through inhalation of airborne virus–laden particles in indoor spaces shared with infected individuals (2). Such airborne transmission is potentially the dominant mode of transmission of numerous respiratory infections. There is also strong evidence on disease transmission— for example, in restaurants, ships, and schools—suggesting that the way buildings are designed, operated, and maintained influences transmission. Yet, before COVID-19, to the best of our knowledge, almost no engineering-based measures to limit community respiratory infection transmission had been employed in public buildings (eXcluding health care facilities) or transport infrastructure any- where in the world, despite the frequency of such infections and the large health bur- den and economic losses they cause (3). The key engineering measure is ventilation, supported by air filtration and air disinfection (4).

II. VENTILATION OF THE FUTURE

Their objectives are to address the issues of odor, and occupant-generated bio effluents [indicated by the concentrations of occupant-generated carbon dioxide (CO)], by specifying minimum ventilation rates and other measures to provide an accept- able indoor air quality (IAQ) for most occupants. To achieve this, the amount of outdoor air delivered to indoor spaces is recommended or mandated in terms of set values of air change rate per hour, or liters of air per person per second. There are, however, no ventilation guidelines or standards to specifically control the concentration of these pollutants indoors. Therefore, it is necessary to reconsider the objective of ventilation to also address air pollutants linked to health effects and airborne pathogens. First, infection- focused ventilation rates must be risk-based rather than absolute, considering pathogen emission rates and the infectious dose [for which there exist data for a number of dis- eases, including influenza (6), severe acute respiratory syndrome coronavirus (SARS- CoV), Middle East respiratory syndrome, tuberculosis, SARS-CoV-2, and measles]. There is often limited knowledge of viral emission rates, and rates differ depending on the physiology of the respiratory tract (which varies with age, for example), the stage of the disease, and the type of respiratory activity (e. , speaking, singing, or heavy breathing during exercise).Second, future ventilation systems with higher airflow rates and that distribute clean, disinfected air so that it reaches the breathing zone of occupants must be demand controlled and thus flexible (see the figure). There are already models enabling assessments of ventilation Demand control and flexibility are necessary not only to control risk but also to address other requirements, including the control of indoor air pollution originating from inside and outside sources and, especially, to control energy use: Ventilation should be made adequate on demand but not unreasonably high. Therefore, although building designs should optimize indoor environment quality in terms of health and comfort, they should do so in an energy- efficient way in the context of local climate and outdoor air pollution. Management of the event reproduction number is important for the control of an epidemic, especially for indoor spaces with a high density of people, high emission rate (vocalization or exercising), and long periods of shared time. It means that a building should be designed and operated according to its purpose and the activities conducted there, so that air- borne infection risk is maintained below an acceptable level. The only types of public buildings where airborne infection control exist are health care facilities, where requirements for ventilation rates are typically much higher than for other public buildings (9). Comparing health care ventilation requirements with those for non–health care venues suggests that non–health care rates should be higher for effective infection control or that more recirculation with better filtration should be used.It is not known exactly what fraction of infections could be prevented if all building and transport ventilation systems on the planet were ideal (in terms of control- ling airborne infections), or the cost of de- sign and retrofitting to make them ideal. Estimates suggest that necessary investments in building systems to address airborne infections would likely result in less than a 1% increase in the construction cost of a typical building (14). For the vast inventory of existing buildings, although economic estimations are more compleX, there are numerous cost effective, performance-enhancing solutions to minimize the risk of infection transmission. Although detailed economic analyses remain to be done, the existing evidence suggests that controlling airborne infections can cost society less than it would to bear them. The costs of infections are paid from different pockets than building and operating costs or health care costs, and there is often resistance to higher initial expenditure. An improvement in indoor air quality may reduce absenteeism in the workplace from other, noninfectious causes, such as sick building syndrome and allergic reactions, to the extent that the reduction in productivity losses may cover the cost of any ventilation changes.



III. A PATH FORWARD

First and foremost, the continuous global hazard of airborne respiratory infection must be recognized so the risk can be controlled. Global WHO IAQ guidelines must be ex- tended to include airborne pathogens and to recognize the need to control the hazard of airborne transmission of respiratory infections. The recently published WHO Ventilation Roadmap (15) is an important step but falls short of recognizing the hazard of airborne respiratory infection transmission and, in turn, the necessity of risk control. National comprehensive IAQ standards must be developed, promulgated, and enforced by all countries. Some countries have IAQ standards, but none are comprehensive enough to include airborne pathogens. Comprehensive ventilation standards must be developed by professional engineering bodies. Organizations such as the American Society of Heating, Refrigerating and Air-Conditioning Engineers and the Federation of European Heating, Ventilation and Air Conditioning Associations have ventilation standards, and during the COVID-19 pandemic, they have proposed building and system-related control actions and design improvements to mitigate risk of infection. However, standards must be improved to explicitly consider infection control in their statements of purpose and definitions. Existing IAQ sensor technologies have limitations, and more research is needed to develop alternative indicator systems.

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SUPPLEMENTARY MATERIALS

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