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Commentary

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Bio aerosols Exhaled by Humans are spread via Airborne Transmission by Ventilation

Michael Grabner*

Department of Precision Medicine, University of Campania Luigi Vanvitelli, Naples, Italy

***Corresponding author**: Michael Grabner, Department of Precision Medicine, University of Campania Luigi Vanvitelli, Naples, Italy, E-mail: michaelgrabner@gmail.com

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Introduction

The 2003 worldwide Severe Acute Respiratory Syndrome (SARS) epidemic, the growing potential threat of bio-terrorist attack through deliberately releasing agents such as anthrax or smallpox, the H1N1 influenza epidemic in 2011, and MERS in 2013 have all highlighted the serious threat of airborne infection in buildings to human health. Growing urbanisation, deteriorating overcrowding in modern mega cities, and quickly expanding global transportation networks may hasten the spread of infectious diseases carried by the air. Indoor areas, where most individuals spend over 90% of their time, were the most common sites of airborne transmission. The importance of ventilation in regulating the spread of airborne infections has long been known. The importance of ventilation was further reemphasized in 2003 by the worldwide SARS outbreak, particularly a hyper spreading episode at a Hong Kong hospital. Li et al. (2005) and Tomlinson and Cockram (2003) investigated the greatest nosocomial SARS outbreak in Hong Kong at the Prince of Wales Hospital and concluded that an ineffective ventilation system was extremely likely to blame for the virus's propagation in Ward 8A. Using the big urban contact networks computation, Gao determined that boosting ventilation rates in classrooms, offices, and houses is a relatively successful technique for managing airborne infections in a large metropolis. By eliminating or diluting virus-laden aerosols breathed by infected patients, ventilation is one of the most essential strategies of preventing cross infection. The supply/distribution or removal of air from space by mechanical or natural means is referred to as ventilation. To meet health and comfort standards, ventilation provides external air while also removing excess heat, humidity, and toxins from inhabited spaces. In addition, hospital ventilation is expected to efficiently remove the nuclei of droplets that may carry germs, reducing the danger of cross infection and providing pathogen-free fresh air for breathing. In a hospital, several ventilation methods may be required for patients with various conditions.

The optimal ventilation system for a general ward and a negative pressure isolation ward is thought to be one that efficiently exhausts or dilutes impurities and supplies pathogen-free fresh air to Healthcare Workers (HCWs) and inpatients. The airflow direction from clean to filthy zones should be adequately managed to prevent the transfer of virus-laden aerosols between rooms. Since the SARS outbreak, the function of ventilation in limiting airborne illnesses has received a lot of attention. Previous studies have looked at the process of airborne droplet/droplet nuclei dispersion in space, the risk estimation of airborne infection, the role of airflow rate, the impact of airflow pattern, and so on. This work aims to provide a basic understanding of the transmission mechanism of airborne infection, risk calculation of airborne infection, and three major ventilation elements impacting airborne infection.

Impact of airborne infection

By eliminating or diluting pathogen-laden airborne droplet nuclei, increasing ventilation rate is thought to prevent cross infection of airborne transmitted diseases. A faster rate of ventilation can dilute the infected air inside the area and reduce the danger of cross infection. Menzies et al. looked at the link between HCW tuberculin conversion and the rate of ventilation in patient care environments. They discovered that tuberculin conversion in HCWs was substantially linked to insufficient ventilation in general patient rooms and job length. During the 2003 SARS outbreak in Guangdong, Jiang et al. evaluated the infection risk of HCWs in different wards with varying window sizes in two hospitals and discovered that larger ventilation windows exhibited a lower infection risk. Despite the fact that a higher ventilation rate can provide a greater diluting capacity to decrease cross infection, higher ventilation rates also indicate a higher energy cost for mechanical ventilation. According to systemic.'s review, there was a lack of sufficient scientific evidence in proposing a minimum ventilation flow rate for infection management. It is necessary to strike a balance between lowering the risk of cross infection and lowering energy use. Most guidelines recommend a minimum ventilation rate of 12 Air Changes Per Hour (ACH) for airborne infection isolation rooms, up from 6 ACH in the Centers for Disease Control and Prevention (CDC) guideline and then doubled after the 2003 SARS outbreak, whereas it is only 1 ACH for commercial buildings. The Wells-Riley Equation can be used to describe the effect of ventilation rate on cross infection of airborne transmitted diseases. Wells coined the term "quantal infection" to characterise the amount of pathogens required to infect a new susceptible. Riley derived the infection possibility, which is known as the Wells-Riley equation, based on this assumption and Poisson distribution, to forecast the probability of airborne infection: where P is the risk of cross infection, C is the number of cases that will become infected, S is the number of susceptibles, I is the number of infectors, p is the pulmonary ventilation rate of each susceptible (m3/h), Q is the room airflow rate (m3/h), q is the quanta produced by one infector (quanta/h), and t is the exposure time (h). A measles outbreak in a suburban school in the United States was effectively predicted using the Wells-Riley equation. The equation, as well as its refinements, have been frequently utilised to anticipate airborne infection outbreaks and even to investigate the relationship between sick leave and ventilation systems. According to the equation, increasing the ventilation rate can greatly minimise the risk of infection.

Natural ventilation can provide high ventilation rates while using little energy. Natural ventilation can provide substantially higher ventilation rates than mechanical ventilation. Escombe et al. were the first to suggest that natural ventilation may be used to control infection. According to the calculation results of the Wells-Riley equation, they studied different wards in eight hospitals ventilated in Lima and Peru, and discovered that natural ventilation could provide much higher ventilation rates than mechanical ventilation, which helped reduce airborne contagion, especially with the high ceiling and large windows. In Hong Kong, Qian et al. measured ventilation rates in two hospitals with naturally ventilated wards. In the downtown and green areas, there are two hospitals. When the windows were fully open, natural ventilation delivered a ventilation rate of up to 69 ACH for cross ventilation and 18 ACH for single-side ventilation. The hospital in the green has a far higher natural ventilation potential. In resource-constrained areas, maximising natural ventilation has long been suggested for infection management. Natural ventilation was proposed as a guideline by the WHO for infection management in hospital settings. The guideline described six typical naturally-ventilated hospital wards for reference, including single-side corridors, central corridors, courtyards, wind towers, atriums and chimneys, and hybrid (mixed-mode) ventilationZhou et al. used numerical simulation to evaluate the performance of different natural ventilation types in hospital wards, finding that central corridor ventilation, which is widely used in China, has the potential to cause cross infections between wards, indicating that it may not be recommended. According to prior research, raising the ventilation rate lowers the likelihood of cross transmission for long-distance airborne illnesses. The effect of ventilation rate on the risk of long-term airborne infection has been well investigated. The effect of ventilation on droplet-borne transmitted diseases, on the other hand, does not appear to be as clear. Gravity and exhalation velocity have a greater influence on the fate of droplets. The rate of evaporation can be influenced by air velocity and relative humidity in ventilation. Further research into the effect of ventilation rate on the danger of short-range airborne diseases is still needed.