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Role of air changes per hour (ACH) in possible transmission of airborne infections

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Abstract

The cost of nosocomial infections in the United States is estimated to be $4 billion to $5 billion annually. Applying a scientifically based analysis to disease transmission and performing a site specific risk analysis to determine the design of the ventilation system can provide real and long term cost savings. Using a scientific approach and convincing data, this paper hypothetically illustrates how a ventilation system design can be optimized to potentially reduce infection risk to occupants in an isolation room based on a thorough risk assessment without necessarily increasing ventilation airflow rate. A computational fluid dynamics (CFD) analysis was performed to examine the transport mechanism, particle path and a suggested control strategy for reducing airborne infectious disease agents. Most studies on the transmission of infectious disease particles have concentrated primarily on air changes per hour (ACH) and how ACH provides a dilution factor for possible infectious agents. Although increasing ventilation airflow rate does dilute concentrations better when the contaminant source is constant, it does not increase ventilation effectiveness. Furthermore, an extensive literature review indicates that not every exposure to an infectious agent will necessarily cause a recipient infection. The results of this study suggest a hypothesis that in an enclosed and mechanically ventilated room (e.g., an isolation room), the dominant factor that affects the transmission and control of contaminants is the path between the contaminant source and exhaust. Contaminants are better controlled when this path is uninterrupted by an air stream. This study illustrates that the ventilation system design ,i .e., when it conforms with the hypothesized path principle, may be a more important factor than flow rate (i.e., ACH). A secondary factor includes the distance from the contaminant source. This study provides evidence and supports previous studies that moving away from the patient generally reduces the infection risk in a transient (coughing) situation, although the effect is more pronounced under higher flow rate. It is noted that future research is needed to determine the exact mode of transmission for most recently identified organisms.

Keywords

infection transmission and control,
risk assessment,
air change rate (ACH),
computational fluid dynamics (CFD),
patient room,
ventilation system design

Article History

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1 Introduction

The role that airborne transmission plays in nosocomial or hospital acquired infections (NI/HAI) has been highly debated for well over 40 years. Although transmission of nosocomial pathogens from people via an airborne route in the hospital setting is well established, it is a common misconception that most hospital acquired infections (HAI) are spread by aerosol transmission and that the number of air changes per hour (ACH) used to ventilate the occupied space directly impacts the transmission. Many studies on the transmission of infectious disease particles suggest that ventilation is one of the major methods for reduction and control of the spread of pathogens via the airborne route in hospitals (Streifel 1999; Kaushal et al. 2004; Beggs et al. 2008). ASHRAE 170 2008 and the CDC guidelines 2005 recommend ventilation rates of minimum 12 ACH for hospital insulation rooms. Although increasing ventilation airflow rate does dilute concentrations better when the contaminant source is constant, it does not increase ventilation effectiveness.

Li et al. (2005, 2007) discuss the role that ventilation systems play in cross infection between people. They conclude

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