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The ventilation of multiple-bed hospital wards in the tropics: A review

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ABSTRACT

Hospital and healthcare facilities have diverse indoor environment due to the different comfort and health needs of its occupants. Currently, most ventilation studies revolve around specialised areas such as operating rooms and isolation rooms. This paper focuses on the ventilation of multiple-bed hospital wards in the tropical climate, taking into account the design, indoor conditions and engineering controls. General ward layouts are described briefly. The required indoor conditions such as temperature, humidity, air movements and indoor air quality in the ward spaces are summarized based on the current guidelines and practices. Also, recent studies and engineering practices in the hospital indoor environment are elaborated. Usage of computational fluid dynamics tools for the ventilation studies is discussed as well. As identified during the review, there is an apparent knowledge gap for ventilation studies in the tropics compared with temperate climates, as fact studies have only been published for hospital wards in countries with a temperate climate. Therefore, it is highlighted that specific tropical studies along with novel engineering controls are required in addressing the ventilation requirements for the tropics.

1. Introduction

Hospital and healthcare facilities have diverse indoor environments due to the varying needs of patients and healthcare workers. The indoor environments range from a simple general practitioners' room to an operating room. Furthermore, the recent pandemic of influenza creates the maximum likelihood for airborne transmission by congregating communicable and vulnerable individuals in healthcare facilities.

At this time, ventilation in healthcare facilities is important as it provides thermal comfort and protection from harmful emissions or airborne pathogenic materials to both patients and healthcare workers [1]. Typically, the ventilation requirements for spaces are governed by building codes, regulations and specific guidelines furnished by the local health authorities and others [2–5]. These requirements vary by country, depending on the geographic location, economic background and the country's specific needs.

The benefits of environmental control for isolation wards and operating room theatres have been recorded and analysed thoroughly. However, there is a lack of ventilation studies on open ward facilities, which is where most patients are placed, especially in the tropics. Recent outbreaks of pandemic diseases have heightened the risks associated with these facilities. Thus, in this paper, the current state of knowledge of the ventilation of multiple-bed hospital wards is reviewed.

2. Ventilation in healthcare facilities

By and large, the purpose of ventilation in any occupied space is to provide fresh air to the occupants and remove heat generated within a confined space. In healthcare facilities, the ventilation system should also help prevent diseases and treat patients.

Research has shown that the design characteristics of a healthcare facility, which include ventilation and layout improvements, can enhance the health outcome of the patients and provide a better working environment for employees [6]. Therefore, overall healthcare quality can be partly enhanced by improving the ventilation.

Many reports have shown that infectious diseases occur due to airborne transmission and surface contaminations by droplet nuclei. This topic is further elaborated in Section 6. Transmission of Severe Acute Respiratory Syndrome (SARS) has been documented in different circumstances and locations worldwide and is found to be highly communicable in healthcare settings [7,8]. Airborne transmissions are not only limited to the SARS episode but also extend to nosocomial infections, which are more prevalent in

Abbreviations: ACH, air changes per hour; ASHRAE, American society of heating, refrigerating and air-conditioning engineers; CDC, centers for disease control; CFD, computational fluid dynamic; HCW, healthcare workers; HEPA, high efficiency particulate air; HICPAC, healthcare infection control practices advisory committee; IAQ, indoor air quality; MRSA, methicillin-resistant *Staphylococcus aureus*; RANS, Reynolds averaged Navier–Stokes; RNG, re-normalisation group; SARS, severe acute respiratory syndrome; SBS, sick building syndrome; UV, ultraviolet; UVGI, ultraviolet germicidal irradiation; WHO, World Health Organization.

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