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Predictions and measurements of the stack effect on indoor airborne virus transmission in a high-rise hospital building

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ABSTRACT

As the viral diseases such as Severe Acute Respiratory Syndrome (SARS) and Influenza A (H1N1) occur in many countries recently, the epidemic of those influenza viruses causes many human casualties. Moreover, the second infection from infected patients particularly within general hospitals frequently takes places due to improperly hospitalized and/or quarantined patients. Accordingly, it becomes a great concern to accommodate safer ventilation system in general hospital wards against such airborne transmitted viruses. It is also a recent trend that many urban general hospitals are designed and constructed as high-rises. If a virus is transmitted through uncontrolled air movement within a hospital and then infected other patients or healthy visitors, it might be impossible to control the spread of the disease. Thus research has been preceded scrutinizing stack effect on the indoor airborne virus transmission in large hospitals by conducting both the field measurement and numerical analysis according to the outdoor temperature and the releasing vertical points of the tracer gas assumed as a viral contaminant. In the field measurement of a high-rise hospital, the indoor airflow was affected by the stack effect of vertical chute of the building. The numerical simulation was verified by comparing its prediction results and the field measurement data. In result, very high possibility has witnessed that the airborne contaminant emitted from the infected patients in the lower floors could be transported to the higher floors through the airflow driven by the stack effect.

1. Introduction

The spread of diseases from infected patients within hospitals causes many human casualties. If a virus were to be transmitted through uncontrolled air movement within a hospital and were then to infect other patients or healthy visitors, it would be impossible to contain the spread of the disease [1]. A pressure difference occurs in buildings due to different densities of outside and inside air that arise from temperature variation. Because the exterior of a building is cold and building interiors are warm during wintertime, the pressure above the ground surface is lower inside the building and airflows into the lower section of the building due to such pressure difference. The inflow air travels up the vertical shafts such as elevators to move to the higher section of the building and then flows outside. Until now, research on the stack effect has mainly focused on high-rise apartments that were built from around the year 2000. Many of the relevant studies have made significant progress, and solutions to various problems are steadily being published [2], even studies on concrete construction methods for strengthening the air-tightness of building interiors, such as using revolving doors and windbreak rooms. Although research on the stack effect has been generally limited to high-rise apartments, there is a high probability that such research will also be carried out on high-rise hospital buildings. Unlike in high-rise apartments, however, the changes in airflows due to the stack effect could cause serious problems in high-rise hospitals by allowing airborne viruses to spread. Because the traffic volume of residents in high-rise apartments is small, the stack effect can be reduced by installing features such as windbreak rooms or revolving doors. However, in hospitals where numerous outpatients and hospitalized patients, their families, doctors, nurses and students are constantly moving in and out, such measures do not render any significant results. In this environment, there is a high possibility that infectious airborne viruses could spread out to the entire hospital via vertical routes of elevators or staircases through the stack effect. Currently, however, only studies on the possibility of the stack effect in high-rise hospitals have been published and there have been no detailed reports based on field measurements. Only a few analyses of the

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