Ventilation, Crowds And the Common Cold

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The influence of building characteristics including ventilation on the spread of viral respiratory infections has begun to receive increased attention from the public, government, media and scientists. However, few studies have examined ventilation and its possible association with airborne infection transmission. This column summarizes the paper by Sun, et al.,[1] that found a lower incidence of common cold infections to be associated with higher ventilation rates in college student dormitories located at Tianjin, China.

Methodology

As part of the "Dorm Environment and Occupants' Health" study at Tianjin, China, the authors analyzed common cold infection incidence of 3,712 students living in 1,569 dorm rooms in 13 buildings. Dorm buildings had three to 12 floors, with 26 to 43 dorm rooms per floor. Dorm rooms consisted of a simple bedroom. Each floor provided two washing rooms and restrooms. Six bachelor students, four master students or three Ph.D. students shared one dorm room with a volume of 50 m^3 to 70 m^3 (1,766 ft^3 to 2,472 ft^3). The average density was 5 m^2 (54 ft^2) per person. Ventilation for all dorm rooms consisted solely of opening doors and windows, plus uncontrolled infiltration.

In Phase I of the study, common cold infections were self-reported by students in a questionnaire. In Phase II, air temperature, relative humidity and CO_2 concentration in dorm rooms were measured for 24 hours. The ventilation rate at night was calculated from an analysis of the build-up period of metabolic CO_2 produced by sleeping occupants (1 a.m. until 8 a.m.).[2] Associations between varying rates of natural ventilation and common cold infections were analyzed by logistic regression models.

Results

In the questionnaire survey of Phase I, 249 out of 3,436 (7.3%) students reported six to 10 common colds in the previous 12 months, while 94 (2.8%) reported more than 10 common colds. Based on the questionnaire data from Phase I, 238 dorm rooms with 473 students were inspected and measured in Phase II. The studied dorm rooms represented different building structures, construction periods, locations and occupancy levels.

The ventilation rates for rooms measured in the heating season, during which door and windows were closed, had a median of 3 L/s (6.4 cfm) per person.[3] Ninety percent of the dorm rooms had a ventilation rate less than 8.3 L/s (17.6 cfm) per person.

Self-reported common cold incidence is compared for different occupancy levels in *Figure 1*.

Figure 2 shows the association between ventilation rates per person and common cold infection in six-person rooms. There appears to be a clear relationship between ventilation rate and common cold infections among college students in dorm rooms.

Figure 3 shows that the infection rate of common cold in buildings constructed after 1993, in winter, is dependent on the mean ventilation rate. There were seven buildings constructed after 1993 in this

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FIGURE 1 Comparison of common cold incidence for different occupancy levels over a 12 month time frame.

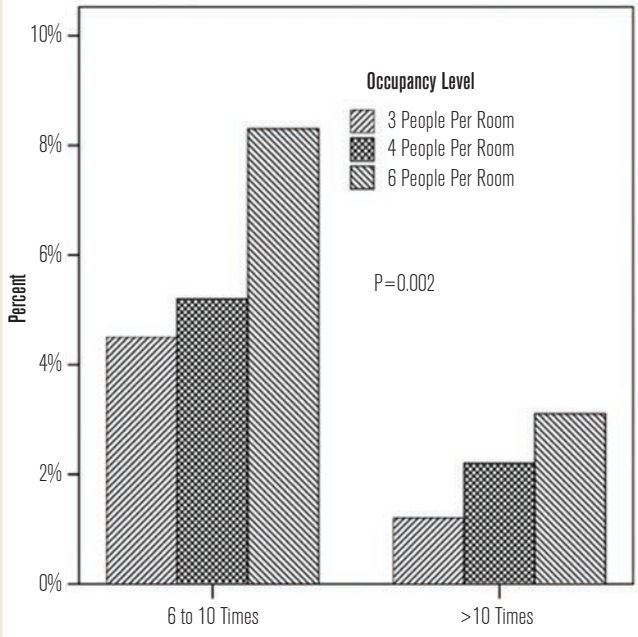
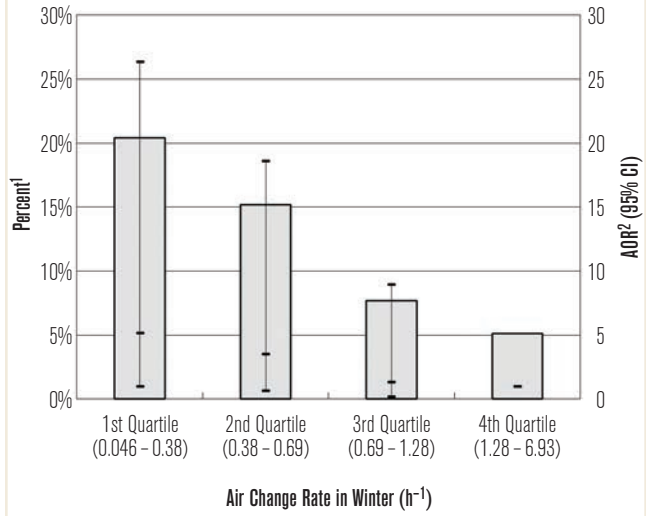


FIGURE 2 Association between air change rate in winter and cold infection in six-people room.



[1]Proportion of occupants with ≥ 6 common colds in the previous 12 months.

[2]Odds ratios were adjusted for gender, age, family member allergy history, exposure to environmental tobacco smoke and building age.

AOR: Adjusted odds ratio; CI: Confidence interval.

study. However, one building was not included in the analysis because measurements were performed in only nine rooms. On average, there were 1,140 occupants in each dorm building. A mean ventilation rate of 5 L/s (11 cfm) per person was associated with ≥ six common colds per year in 5% of occupants, compared to 35% of occupants for 1 L/s (2 cfm) per person.

Discussion and Limitations

Although it is widely held that people in crowded spaces have more respiratory infections,[4] there are few studies on this topic. Our study is among the first published suggesting a relationship between occupancy levels, ventilation rates, and respiratory infections. With six occupants instead of three in a 20 m^2 (215 ft^2) dorm room, the proportion of occupants reporting more than six common colds in the previous 12 months doubled.

When the level of crowding is adjusted for, a lower ventilation rate is associated with an increased risk of the common cold. The suggested relationship between dorm ventilation rate and common cold infections among occupants could perhaps be extrapolated to other crowded public premises with lower ventilation rates, making this an important public health topic (e.g., for schools, daycare centers). A crucial question is whether the increased frequency of common cold in crowded places is due to direct contact (or via surfaces), rather than via droplets or droplet nuclei. The strong association with ventilation in this study indicates that airborne transmission is an important and perhaps the dominant route.

There were imperfections and limitations in our data collection. In some rooms, occupants may have had the window open during the night measurements in winter. Or perhaps the incidence of common cold was influenced by a pandemic of influenza. The common cold infections were self-reported without clinical confirmation. These sources of error, however, would shift our findings towards the null hypothesis, i.e., that there was no association between common cold infections and dorm crowdedness or ventilation rate. Thus, it is likely that more measurements and more accurate data on types of

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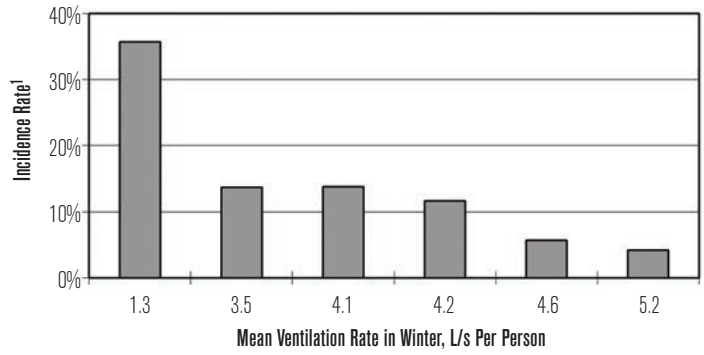
airways infections would show an even stronger association. This study needs to be repeated in other buildings and situations.

Practical Implications

Ventilation rate per person is important when considering the spread of airborne infectious diseases in rooms where people spend a lot of time. Minimum ventilation rates need to be carefully determined to control the transmission of airborne infections, especially in naturally ventilated buildings.

FIGURE 3 Associations between common cold infection rates and mean ventilation rate in winter in buildings constructed after 1993.



[1]Proportion of occupants with ≥ 6 common colds in the previous 12 months.

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