Association between Indoor Carbon Dioxide (Co_2) Concentration and Respiratory Symptoms among University Students: A case study from Rajarata University of Sri Lanka

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1. Introduction

Indoor Air Quality (IAQ) is widely acknowledged as essential for human health (UKIEG, 2017), particularly given that individuals spend the majority of their time indoors. (Tsantaki *et al*., 2020) The rising levels of indoor pollution have made poor IAQ a significant global health issue.

Carbon dioxide has emerged as one of the main indoor air pollutants (Satish et al., 2012), contributing to significant health concerns worldwide. Elevated indoor CO_2 levels have been linked to various respiratory and cognitive health problems (Alaa et al., 2022) (Erdmann et al., 2002), making it a growing global health issue. Numerous researchers have consistently highlighted the significance of indoor air quality (IAQ) for human health. (Orecchio *et al*., 2017) Many studies report a relationship between indoor CO_2 concentrations and health outcomes. (Seppanen, O.A., Fisk, W.J., and Mendell, 1999). Outdoor CO_2 levels typically range from 300 to 400 ppm, but in urban areas, this can rise to 600- 900 ppm. Indoor levels vary based on building location and ventilation. (OSHA, 2010). While a concentration of 350 ppm supports a healthy lifestyle (Bandaranayake *et al*., 2020), indoor CO_2 levels are projected to reach 700 ppm by 2050. (Bandaranayake *et al*., 2020). Though CO_2 is essential for physiological balance, elevated concentrations can lead to respiratory symptoms. (Bandaranayake *et al*., 2020) For instance, Huang *et al*. found increased childhood asthma risk due to higher indoor CO_2 levels. (Naydenov *et al*., 2008) Prolonged exposure to oxygen-depleted air caused by excessive CO_2 can result in suffocation. (OSHA, 2010) CO_2 concentrations have long been used as indicators of IAQ (Persily,2022) with rising levels directly linked to respiratory symptoms (Krismanuel, 2024).

Students often lack awareness of the connection between indoor CO_2 concentration and respiratory symptoms, a crucial factor influencing indoor air quality (IAQ). Elevated CO_2 levels, typically caused by poor ventilation, high occupancy and various indoor activities, can lead to respiratory issues, negatively impacting both health and academic performance. This study focuses on Rajarata University, located in Sri Lanka's dry zone, with a student population of 7,353 as of 2019. Given the increasing number of students and challenges in dormitory allocation, each dormitory room accommodates more than four students. Despite extensive global research on indoor CO_2 concentrations, there is a noticeable lack of studies focused on university dormitories in Sri Lanka. Previous research in the country has primarily addressed indoor CO_2 levels in environments such as lecture halls (Jayasooriya *et al*., 2020) and urban settings (Bandaranayake *et al*., 2020), leaving a significant gap in understanding CO_2 levels and their impact in residential settings like dormitories. This study aims to bridge this gap by exploring the relationship between indoor CO_2 concentrations and respiratory symptoms among university dormitory residents in Sri Lanka.

2. Materials and Methods

The study was conducted in the dormitories of Rajarata University of Sri Lanka and consisted of two phases: Phase I- a cross-sectional study and Phase II- case-control study.

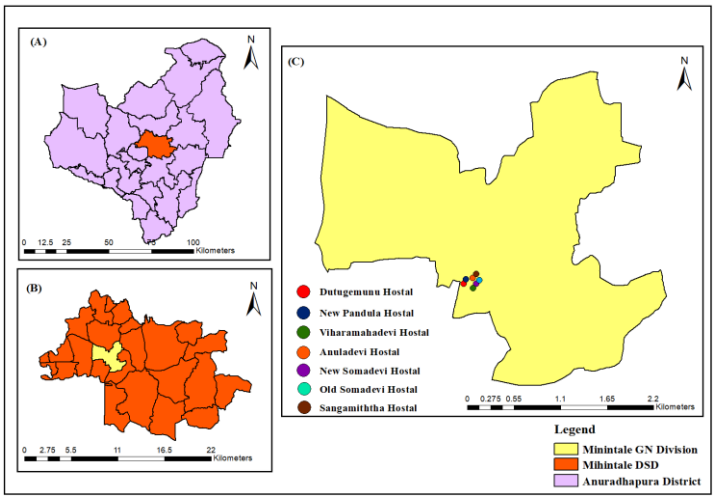

Figure 1: Study area-Dormitories in Rajarata University of Sri Lanka

In the first phase, multi stage cluster analysis was employed to gather data on the dormitory environment and respiratory conditions of students. Seven dormitory buildings were randomly selected from a total of 14, and 502 rooms were chosen from 698. A total of 2,956 students were surveyed with 2,234 completing the questionnaire, yielding a response rate of 76%. (Ayoma *et al*., 2024) Data collection took place in May 2020.

This study examined respiratory symptoms, including wheezing (ever and current), doctor-diagnosed asthma, rhinitis (ever and current), and doctor-diagnosed rhinitis. Phase II, a nested case-control study, recruited students from the cross-sectional study who reported at least two respiratory symptoms (doctor-diagnosed asthma, current wheezing, or current rhinitis) identified through phase I questionnaires. A total of 190 symptomatic students and 198 healthy controls (without asthma or allergic symptoms) were selected. These students occupied 245 rooms, where environmental measurements and observations were conducted.

Descriptive statistics were used to present basic information. Variances in frequencies and distributions were analyzed using the chi-square test, while CO_2 levels were assessed using the Mann-Whitney U test. Logistic regression was employed to calculate odds ratios with 95% confidence intervals. Data analysis was performed using STATA 16 and SPSS 21 software. Ethical clearance was obtained from the Faculty of Medicine and Allied Sciences at Rajarata University of Sri Lanka.

3. Result and Discussion

Sri Lanka's tropical climate is characterized by year-round warmth and significant precipitation. This study measured indoor environmental parameters, including CO_2 concentration, in the university dormitories of Rajarata University. The average CO_2 concentration recorded was 1160 ppm, which exceeds the recommended indoor air quality standards. Elevated CO_2 levels, especially at night, were linked to inadequate ventilation and high occupancy rates, factors contributing to poor indoor air quality. These findings underscore the need for improved ventilation in dormitory settings to reduce health risks associated with high CO_2 levels. In a similar study, CO_2 concentrations were observed to range from 1011 ppm in rooms with three occupants to 1483 ppm in rooms with six occupants during the hot season when windows and doors remained closed at night. (Sun *et al*., 2011) The elevated CO_2 levels were attributed to high occupancy rates, which likely contributed to insufficient ventilation in these enclosed spaces. (Marasinghe & Sun, 2021) These findings suggest that high indoor CO_2 concentrations are closely associated with the number of occupants and the lack of proper airflow.

Considering the indoor CO_2 levels in the rooms of students with and without allergies at the dormitories of Rajarata University, the study found significant associations between CO_2 concentrations and respiratory conditions such as asthma and rhinitis. Higher CO_2 levels were notably linked to an increased risk of asthma (AOR: 2.22) and rhinitis (AOR: 2.11) among the student population. This study observed a significant correlation between median CO_2 concentrations and asthma and rhinitis. Also, students with asthma and rhinitis had significantly higher CO_2 concentrations in the room than those without asthma and rhinitis symptoms. In a similar study, European countries conducted in the group of school children's exposure to CO_2 levels found that >1000 ppm showed a significant risk for rhinitis. (Simoni *et al*., 2010) These findings underscore the importance of controlling indoor CO_2 concentrations to mitigate respiratory health risks in similar environments.

4. Conclusion

In conclusion, this study revealed a significant association between elevated indoor CO_2 concentrations and increased risks of asthma and rhinitis among students in the dormitories of Rajarata University. Higher CO_2 levels, particularly during night-time, were identified as a key factor contributing to respiratory health issues. These findings emphasize the importance of improving ventilation systems and monitoring CO_2 levels in indoor environments to mitigate the risk of respiratory conditions, especially in densely occupied spaces such as university dormitories. Addressing these factors is crucial for promoting better indoor air quality and students' health.

5. Keywords

carbon dioxide, dormitories, indoor air quality, respiratory symptoms

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