Changes In Ventilation Of Schools when monitoring CO_2 — CIVOS

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Introduction

This research study investigates 'Changes In the Ventilation Of Schools' (CIVOS) when monitoring CO_2 and is a behavioural science informed pilot study to change ventilation behaviour and management. This research study was commissioned to better understand the extent to which ventilation training and the provision of environment indicator displays may result in classroom staff being able to better balance the needs for adequate ventilation, thermal comfort, and energy consumption.

Key Findings

- CIVOS has collected a year's worth of indoor air quality data thus far (March/2021 to March/2022). Seasonal analysis confirms large-scale differences in ventilation trends for cold and warm weather periods, as well as disparities between individual schools and classrooms.
- An increased likelihood of elevated CO_2 concentrations is predicted during the colder seasons. This is attributed to the need of school staff to balance indoor thermal comfort and energy consumption.
- There is scope for lower indoor CO_2 concentrations through a better management of ventilation openings. Better ventilation may result in positive health outcomes, such as reduced instances of infection from airborne pathogens and enhanced cognitive performance for students and education staff.
- The ongoing behavioural study that follows the training of school staff in ventilation practices has thus far produced inconclusive results. This is due to the currently limited available data for the post-intervention period and the difficulty in engaging with schools.

Results

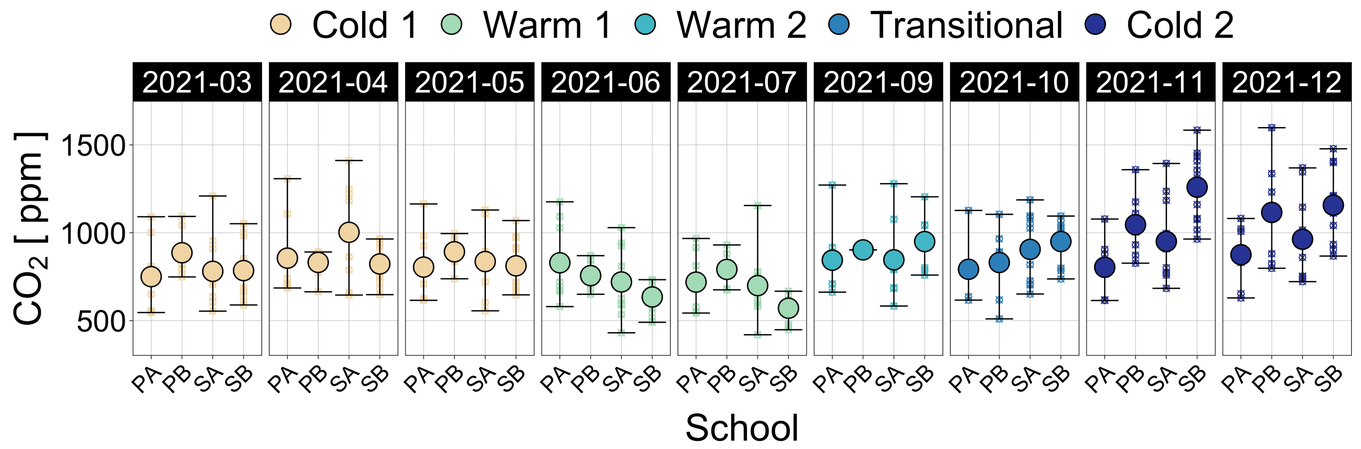

Figure 1: Monthly mean CO_2 variation across the four CIVOS schools during the pre-intervention period. The mean school CO_2 level during occupied hours is denoted with coloured markers(•), while the average CO_2 across the classrooms is designated with hollow markers (⊗) and interval ranges.

Figure 1 illustrates the variation of the mean monthly CO_2 for each individual school (data averaged across the classrooms at each site). Seasonal variations are apparent on this plot, which largely follow the groupings of the calendar year into different weather periods. Warmer seasons generally correspond to lower concentrations of CO_2 (< 1500 ppm) signifying more effective ventilation of the indoor space. The "Cold period 2" months on the other hand are accompanied by a decrease of the outdoor daily mean temperature by an average of 10.5℃ compared to the second "Warm" period, which brings about a significant increase of the CO_2 concentration to levels occasionally ≥1500 ppm.

Figure 2 presents plots of the CO_2 concentration against the classroom indoor temperature. The left-hand pane shows a week that corresponds to the first "warm" weather period, during which the indoor temperature remains above 20℃ at all times with values regularly crossing into the higher temperature range, while at the same time the CO_2 concentration remains below 1250 ppm. On the other hand, during the "cold" and "post-intervention" periods, the classroom experiences poorer ventilation with CO_2 concentrations in the range of 400-2500 ppm and the temperatures vary between 13 and 22 ℃.

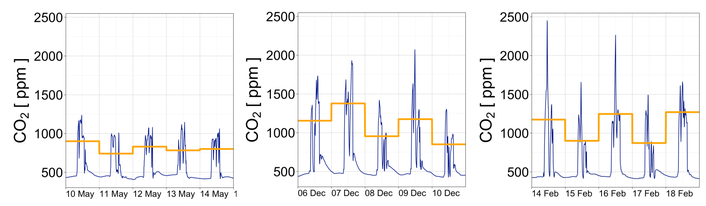

Figure 2: Temporal variation of the CO_2 concentration within a representative classroom (PA-4) with manual natural ventilation. Blue lines represent the raw timeseries and yellow horizontal lines mark the daily mean CO_2 concentration during classroom occupied hours.

The plots displayed in figure 3 convey that the presence of an infected person in an enclosed environment during the asymptomatic phase of their infection can have a cumulative temporal effect to the rolling likelihood of transmission. A comparison of the three plots in figure 3 shows that the infection risk can be approximately double during the period with poor ventilation provisions compared to the warm season.

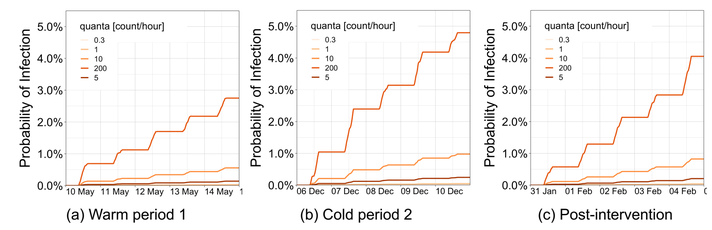

Figure 3: Probability of infection in classroom PA-4, inferred using numerical models that link the airborne infection risk with the temporal variation of CO_2. Parametric results based on different quanta generation rates, which reflect varying rates of emission of infectious doses.

Methodology

The study consists of unintrusive environmental data monitoring of CO_2, temperature and relative humidity in 36 classrooms across four schools. In addition, 'environment indicator' displays, which present occupants with instantaneous levels of the CO_2 and temperature were provided to all monitored classrooms. The use of environmental monitors was supported by a programme of enhanced information and training developed and delivered to classroom staff, school site managers and school leaders in two of the study schools (one primary school and one secondary), whilst in the other two study schools the guidance and training was not enhanced beyond that provided to all UK schools in support of the nationwide CO_2 monitor rollout. In addition to the training, an accompanying baseline survey was delivered to all study schools to identify existing knowledge, understanding, attitudes, and perceptions relating to ventilation behaviour.

★ Data from each monitor is securely accessible to the research team via a web-based portal.

★ All classrooms were naturally ventilated by classroom staff manually controlling the opening of windows and doors.

Conclusions

CIVOS has collected a year's worth of air quality data between March 2021 to March 2022 and is ongoing. Seasonal analysis confirms large-scale differences in ventilation trends for cold and warm weather periods, as well as disparities between individual schools and classrooms. Preliminary analysis of the difference in CO_2 levels between the intervention and control schools suggest that there was no effect of the training on CO_2 levels. Planned focus groups will enable detailed feedback from a subgroup of teachers, classroom assistants, school leaders and estates and facilities managers to aid understanding of these effects. This study has received additional funding and will continue collecting and analysing data until September 2022.

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