Chapter 4

Environmental Health Resilience: Monitoring CO_2 in Health and Longterm Care Facilities

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Chapter 4

Environmental Health Resilience: Monitoring CO_2 in Health and Long-term Care Facilities

1. Background

Ventilation is one of the crucial elements of the novel coronavirus disease (COVID-19) prevention. The Japanese government launched the 'Avoid the Three Cs (*Sanmitsu-Kaihi*)' (crowded places, close-contact settings, and confined and enclosed spaces) approach at the beginning of the pandemic in March 2020, which was further endorsed by the World Health Organization (WHO) in July 2020. Through this approach, it was recommended to open windows and doors for ventilation (Figure 4.1). With the growing awareness of the mode of transmission of COVID-19, in December 2021, the WHO acknowledged that COVID-19 spreads not only by droplet transmission but also by airborne transmission (WHO, 2021). In a closed place where many people stay, such as in classrooms, meeting rooms, buses, trains, airplanes, or restaurants, the virus, if present, would remain in the air and infect others who are in the same closed space. Ventilation to evacuate contaminated air eliminates COVID-19 and prevents infection.

Figure 4.1. Avoid the Three Cs

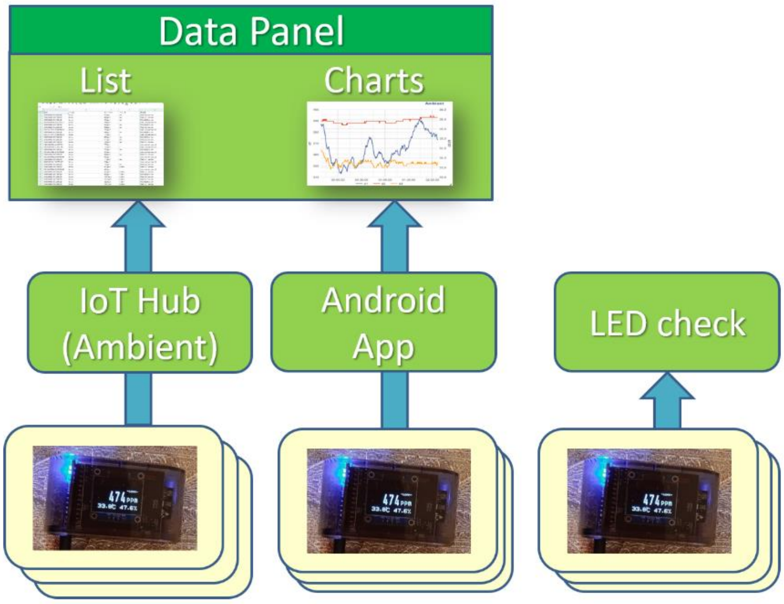
Source: WHO (2020).

In this research project, a system to monitor the carbon dioxide (CO_2) level as the proxy of air ventilation was implemented in health and long-term care facilities, and the system installation process was observed.

2. Methods and Findings

The CO_2 monitoring system comprises a CO_2 monitor, smartphone/PC, and an internet of things (IoT) service (Figure 4.2). A 'pocket CO_2 sensor'[1] was chosen because it is small and lightweight, has in-built Wi-Fi, is relatively affordable, and has multiple data handling systems in cloud storage, smartphones, and with an attached light-emitting diode (LED) panel. 'Ambient Free Cloud'[2] was used for data storage and visualisation if the sensor was successfully connected to Wi-Fi and the internet. If not, the sensor was connected to a smartphone, and the data are stored in the app together with location information obtained from the smartphone's global positioning system (GPS). If the sensor could not be connected to the internet or smartphone app, the CO_2 level was checked from the LED display on the sensor.

Figure 4.2. CO_2 Monitoring System



IoT = internet of things, LED = light emitting diode.
Source: Authors.

The CO_2 level of outside air is around 400 parts per million (ppm), and exhaled air from a person is around 45,000 ppm. Thus, when the number of people increases and the length of stay becomes longer, the CO_2 exhaled from persons in the space will increase the CO_2 level if there is no ventilation mechanism. The CO_2 level is recommended to be below 1,000 ppm by the Japanese Ministry of

1 The detailed explanation of the sensor is available at https://sites.google.com/view/pocket-co2/
2 The service is accessible from https://ambidata.io/

Health, Labour and Welfare (MHLW, 2022) and the United Kingdom's Health and Safety Executive (HSE, 2022).

The CO_2 monitoring system was prepared by the research team to be implemented in health and long-term care facilities in Japan, Thailand, and Indonesia. Amongst the 19 locations contacted, two in Japan successfully implemented the IoT data cloud system, 10 in Indonesia stored the data in the smartphone app, and seven in Japan and Thailand used an LED display only. The example of the data obtained in the cloud or app is shown in Figure 4.3. In charts A and B, several different patterns are observed. It is because the sensors were carried from room to room to check the ventilation. Chart C only shows data in one location, but the CO_2 level fluctuates. When the number of people increases in the monitored room, or when the exhaled air hits the sensor, the CO_2 level increases. The CO_2 level fluctuates according to the situation. No location recorded a CO_2 level exceeding 1,000 ppm.

Figure 4.3. Examples of CO_2 Monitoring

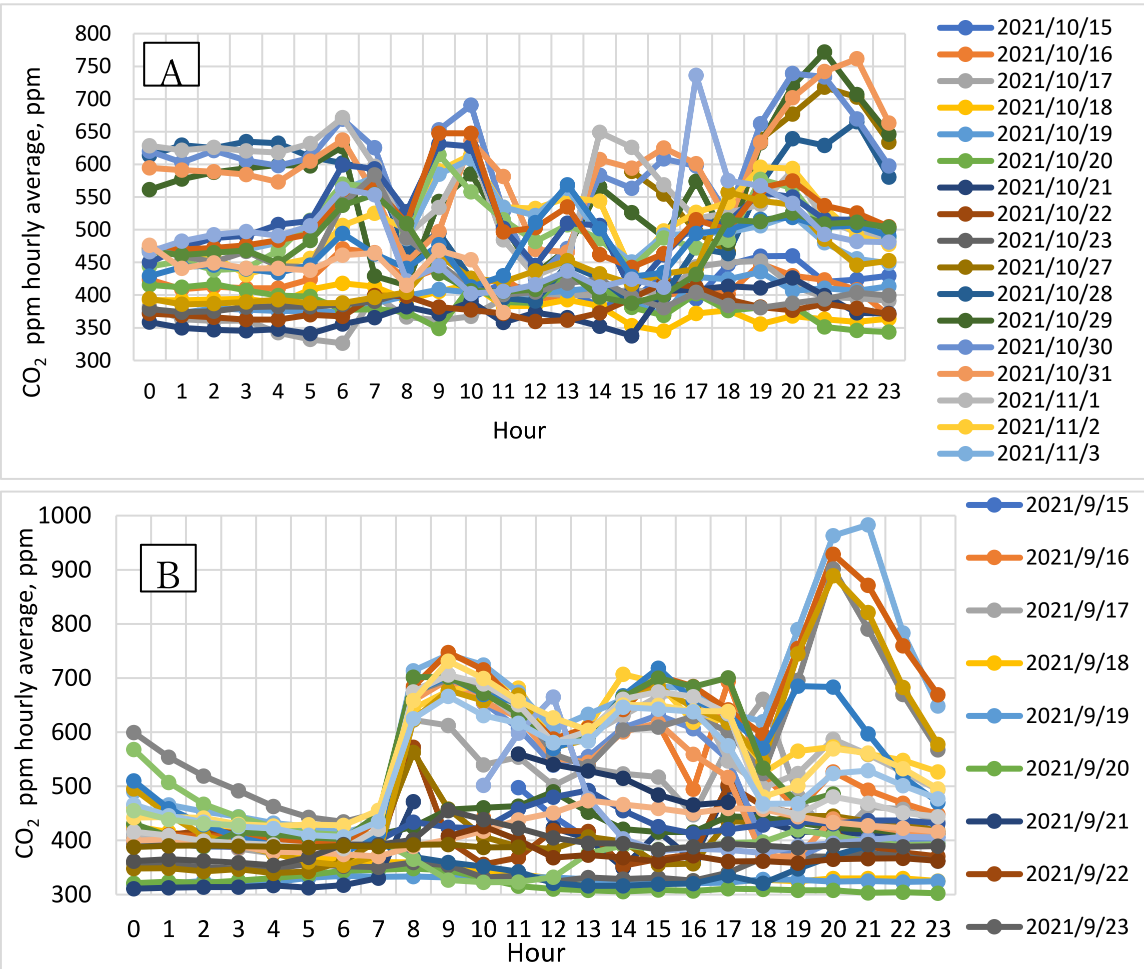


Figure 4.3. *Continued*

CO_2 = carbon dioxide, ppm = parts per million.

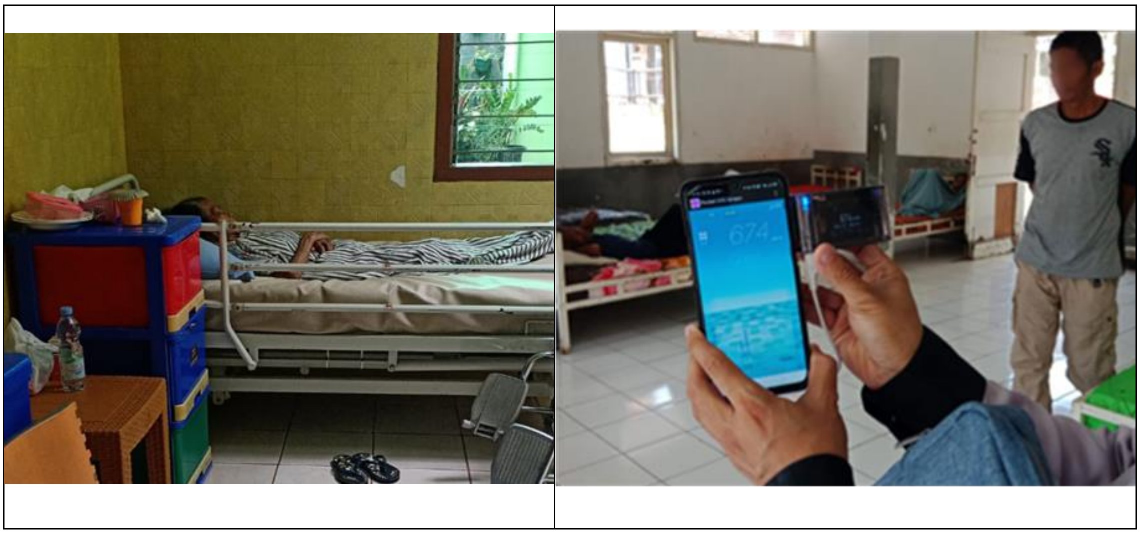
Source: Authors.

3. Lessons Learnt

Monitoring the CO_2 level continuously and automatically via IoT is the optimal way. However, it is not easy to implement without a specialised technician. Under the high alert of COVID-19, many facilities restricted the entrance of non-residents, and it became difficult to install and configure the sensors to be connected by Wi-Fi to IoT. The android app was easier to implement and adds geographical location information but will be used only when the smartphone is available. The LED display is a simple but quick way to check the CO_2 level, but it does not record cumulative data. For the dissemination of CO_2 monitoring, easy-to-install devices, such as built-in monitors attached to the air-conditioning switches, would be helpful.

In this experiment, no locations recorded CO_2 levels of more than 1,000 ppm. There are biases, such that those who participated in this experiment were well aware of the importance of ventilation and might have responded quickly to a rising CO_2 level. Also, in Indonesian long-term care facilities, the rooms are not equipped with air-conditioning; thus, they keep windows and doors open (Figure 4.4). It must have reduced cluster infection in long-term care facilities in Indonesia.

Figure 4.4. Well-ventilated Long-term Care Facilities in Indonesia



Source: Authors.

4. Recommendation to Policymakers and Long-term Care Professionals

Before COVID-19, the importance of ventilation was somewhat neglected. With COVID-19, ventilation has become a crucial component for infection control, and CO_2 monitoring has become an effective tool. This time, we conducted a trial experiment on how the CO_2 monitoring system would be accepted and used in health and long-term care facilities in Asian countries. Like temperature and humidity, the level of CO_2 should be monitored regularly in a space where humans live, especially in health and long-term care facilities. The system needs to be simple so that it would be utilized widely. The small sensor that is easy to carry could detect the CO_2 in different rooms in different locations instantly, raising awareness of air quality and ventilation.

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