



北海道大学

Comparison of indoor environment and energy consumption before and after the spread of Covid-19 in schools in Japanese cold climate region

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## Introduction

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- ❑ The spread of covid-19 has had a major impact on building operations in arctic area with cold climate.
- ❑ Classrooms where many active age students live in groups for long periods are particularly at risk for infection.
- ❑ ASHRAE recommends 4 to 6 ACH of ventilation, but many school classrooms do not meet this standard.
- ❑ Under the influence of covid-19, the only solution is to open windows, but it is difficult to open windows in arctic areas with severe winter weather.

How did school operations change before and after the spread of the infection?

- ❑ Operation for window ventilation
- ❑ Thermal sensation of Students
- ❑ CO<sub>2</sub> concentration in the classroom
- ❑ Energy

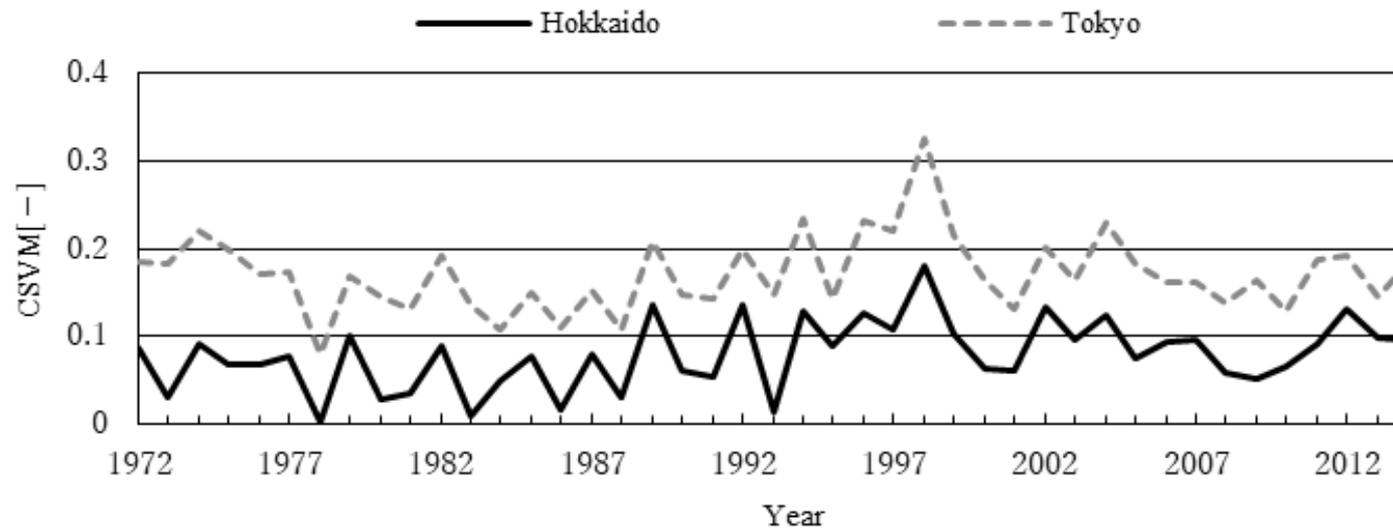
# Infection control in Japanese School

The spread of infectious diseases has occurred every year in Japanese schools .

Only 30% of schools are equipped with enthalpy exchange ventilation, even in cold regions.

The attendance of students with infectious diseases has been suspended.

When the number of absent students increases, class and school closures are implemented. **But not enough**



In arctic area with severe cold winter,  
Schools should be improved  
With

- ❑ Enthalpy exchanger with enough ventilation rate (30m<sup>3</sup>/h/person)
- ❑ Longer the operation time of ventilation system
- ❑ Energy efficiency with thick insulation
- ❑ Heating and cooling system with heat pump system (only in Sapporo?)



# Target Schools

We selected 5 schools with electric heater in Sapporo city. All school doesn't have any ventilation system in normal classroom.

Name	Floor area m <sup>2</sup>	Heating system
Sapporo Shinkawa High school	12,255	Electric heater
B High school	10,541	Electric heater
C Junior High school	10,202	Electric heater
D Elementary school	6,346	Electric heater
E Elementary school	5,813	Electric heater

# Development of CO2 sensor with warning display



Normal sensor is expensive

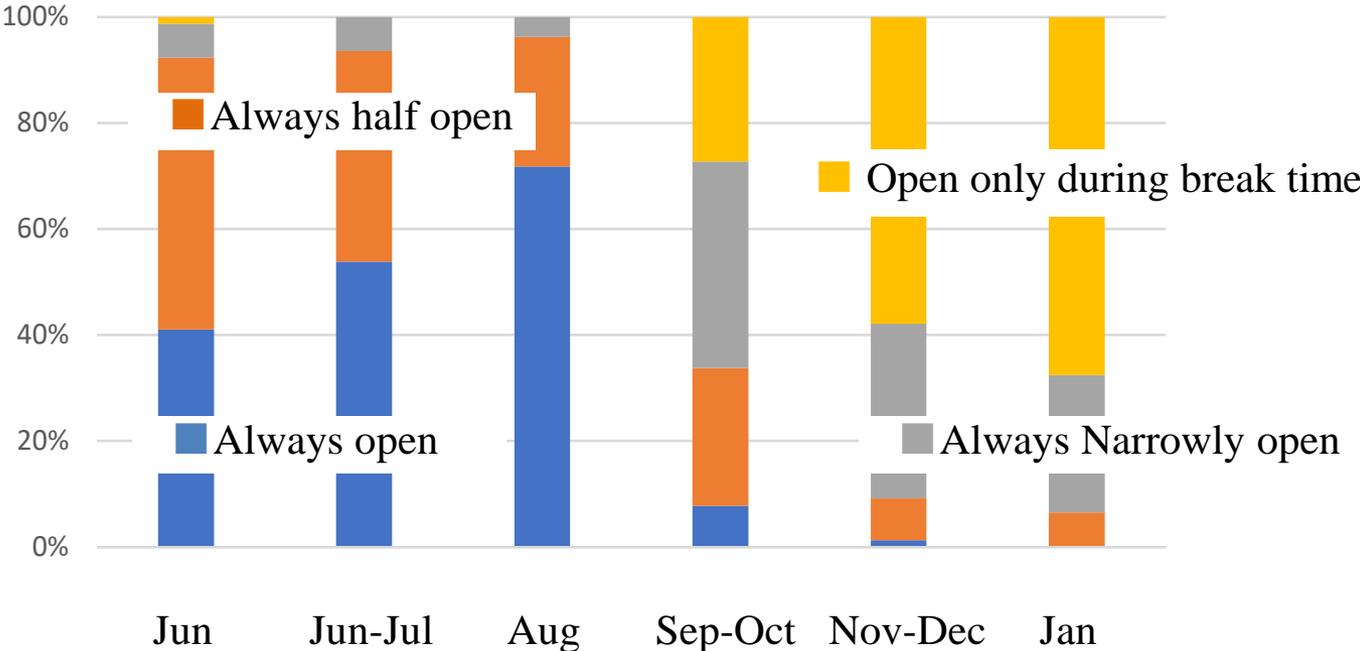
We developed the CO2 sensor with warning display using M5 series micro computer and sensirion's NIR sensor.

Over 800 ppm, the display changed to orange.

Over 1000 ppm, the display changed to red.

# Operation of window in 2020-2021

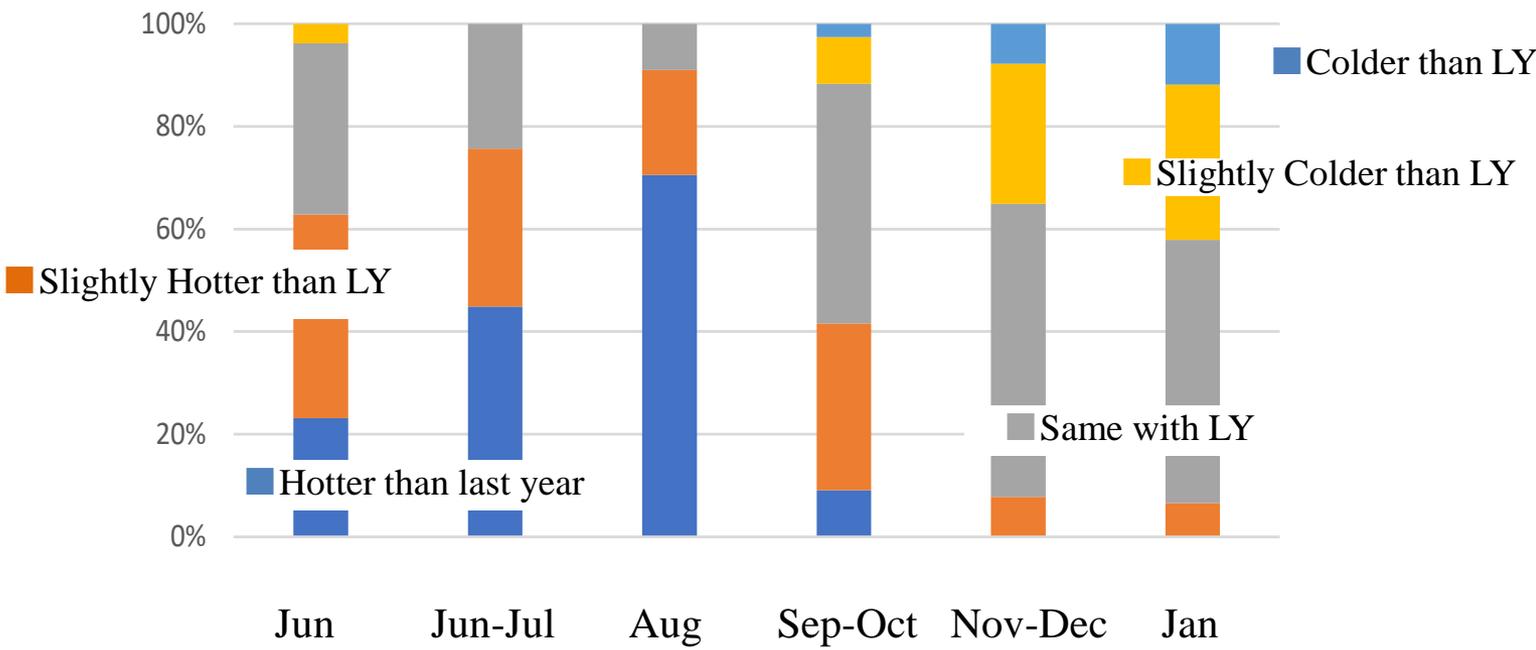
Windows in classroom were always open in summer season and gradually close in winter season because outdoor temp is very cold.



# Thermal sensation of students in 2020-2021

Over 90% of the thermal sensations were hotter and slightly hotter than that in last year in Aug. Because of wearing masks.

Over 40% of thermal sensations were colder and slightly colder than that in last year in Jan. even in keeping 18 °C because of the infiltration caused by window opening.

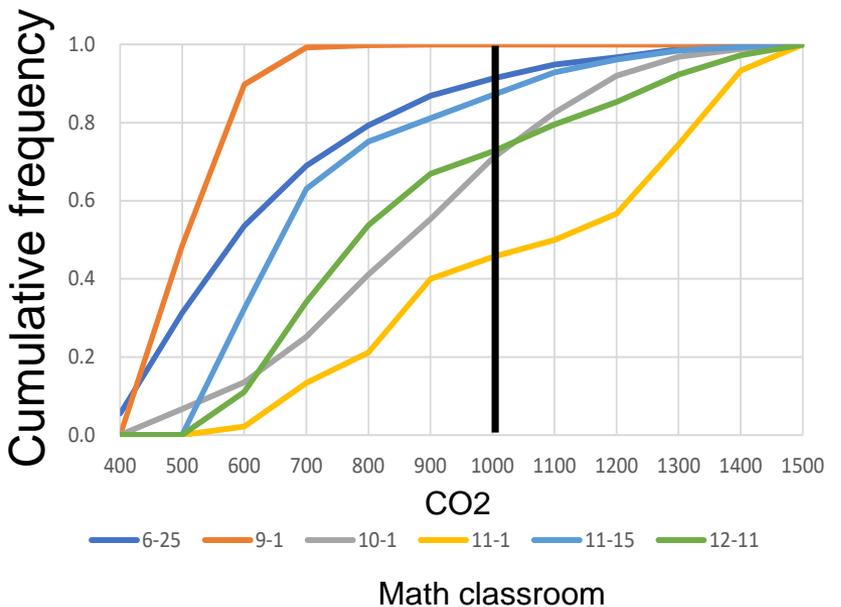
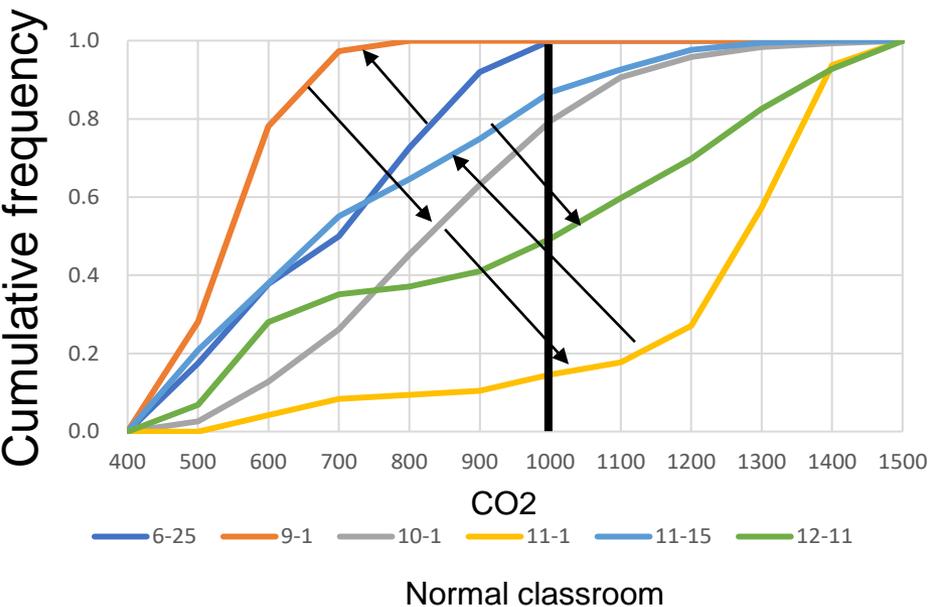


# Cumulative frequency distribution of CO2

First of Sep, the CO2 concentration (CO2) was always below 1000ppm during the use of the classroom,.

First of Nov, only 20% of CO2 was below 1000 ppm. We discussed the countermeasure for increasing ventilation rate at 15 Nov.

The CO2 was improved after the discussion, but in the middle of Dec, only 50% of CO2 was below 1000 ppm.

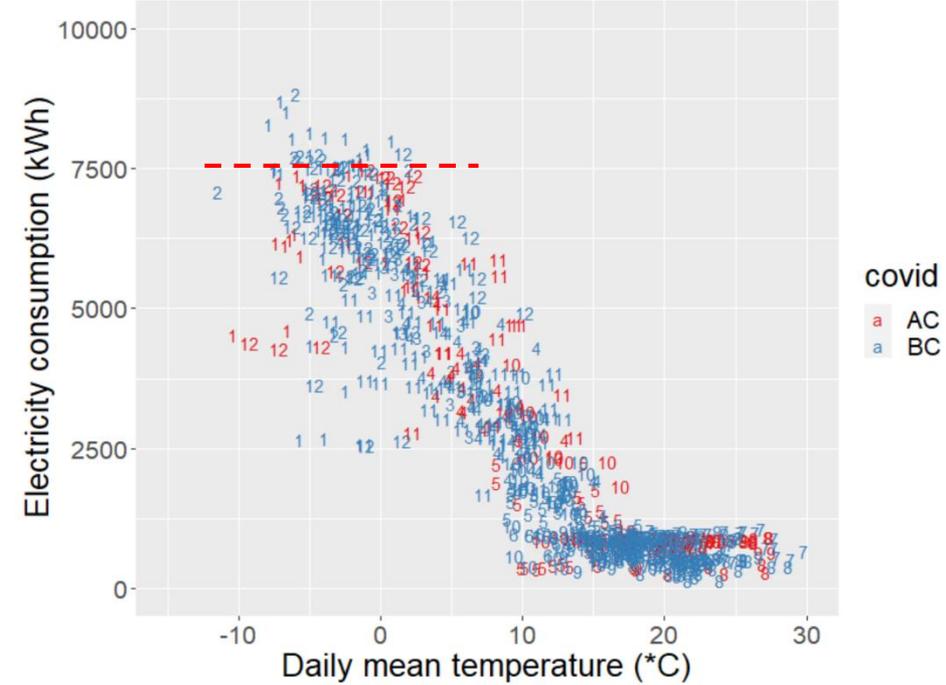
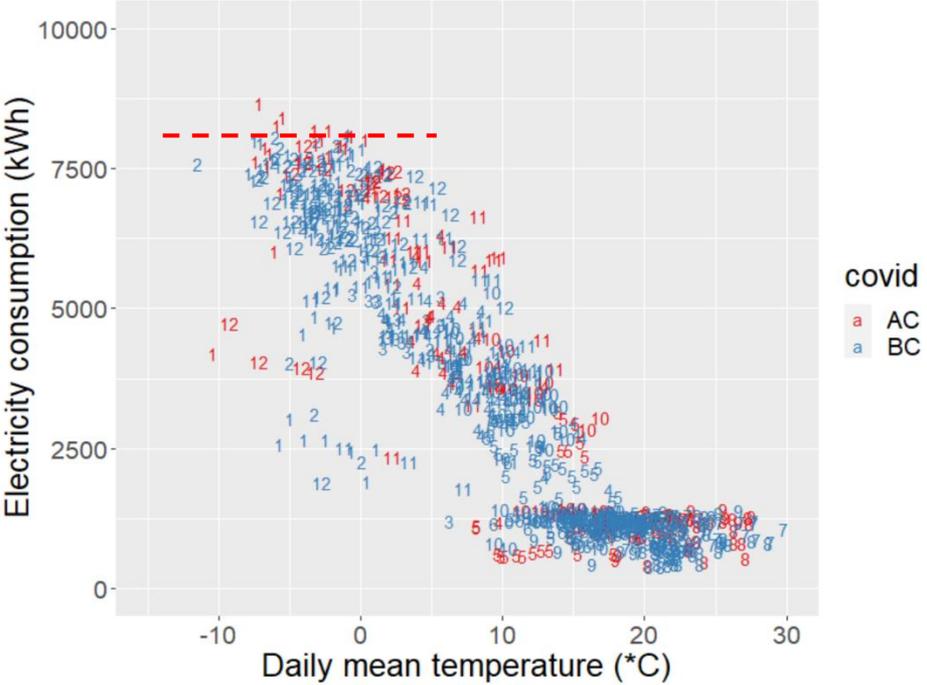


The electric energy consumption per day (EC) after covid-19 (AC) was higher than that before covid-19 (BC)

EC was negatively proportional to the outdoor temperature. But EC did not increase below 0° C in AC.

The outside temperature is too low, so the opportunity to open the windows has decreased.

Extracurricular activities had been restricted in the pandemic.

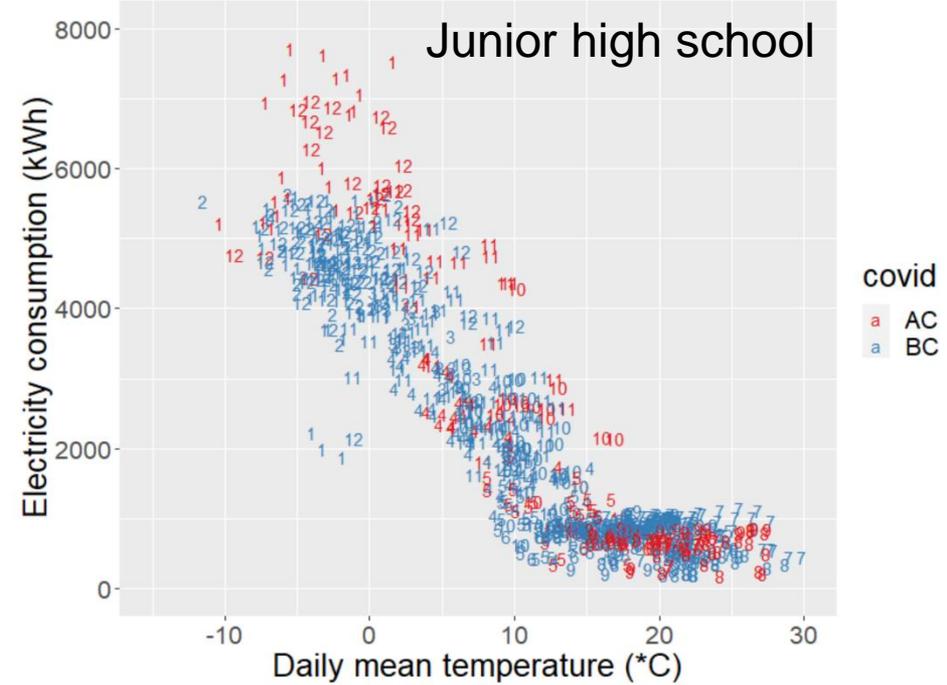
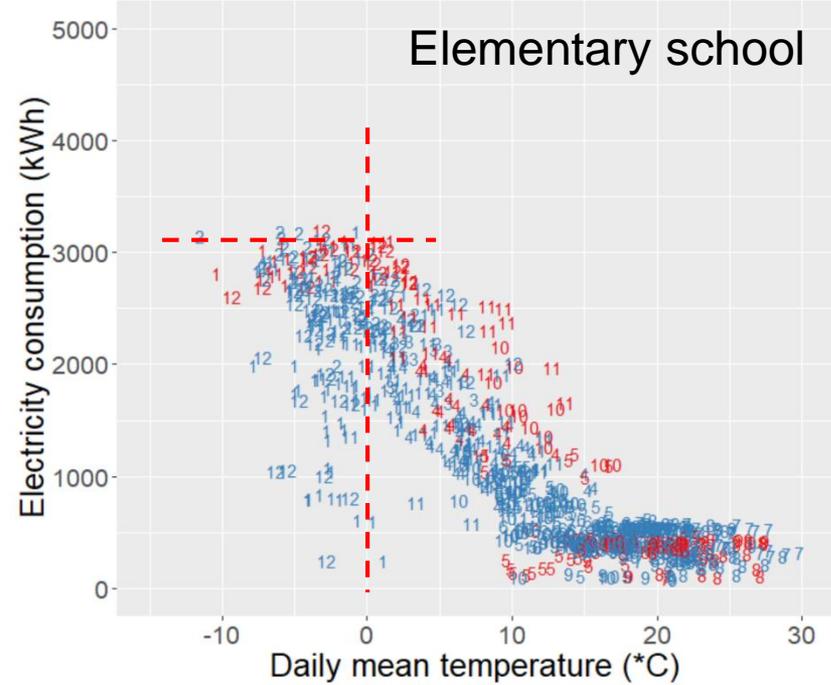


# Cumulative frequency distribution of CO2 in elementary school and Junior high school

The situation of E Elementary school was same with two high schools. The EC of C Junior high school increased even when the temperature was below 0° C.

School administrators are under pressure to reduce energy use as a way to cut costs.

Under these circumstances, reducing energy use puts the health of students at risk.



## Summary

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We developed the CO<sub>2</sub> sensor with warning display.

We investigated the window operation for ventilation.

We compared the thermal sensation of students before and after covid-19.

There are many school facilities in the Arctic region that are vulnerable to infectious diseases, as are schools in Sapporo.

We should aim for safer schools by renovating school facilities and updating equipment.

Enthalpy heat exchanger for ventilation and cooling system should be installed.

