Clean Air Production with Air Cleaners

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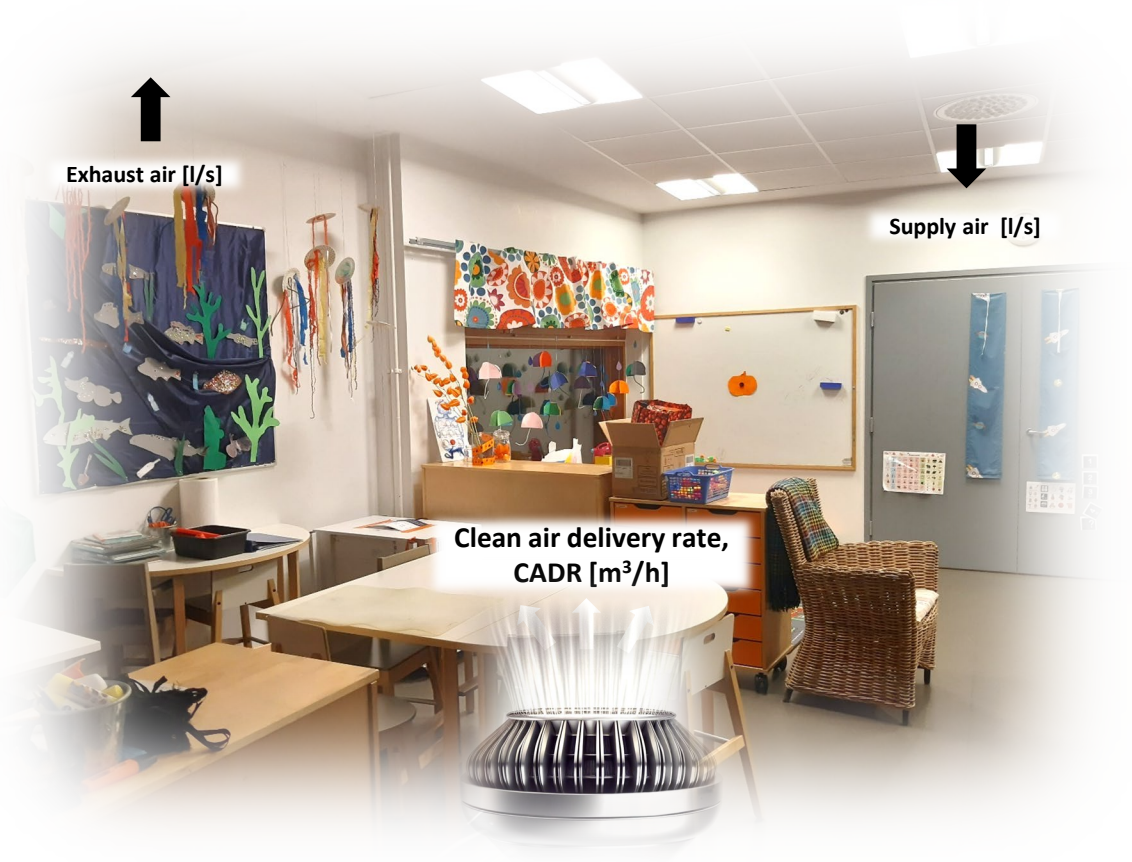
Daycare Intervention

The goal was to investigate whether the spread of diseases can be reduced with air purification.

Clean air can be provided to the spaces with

- a ventilation system
- the air cleaners.

The **sizing criterion** for the air cleaners is the **clean air delivery rate (CADR, m³/h)**, which is determined using a standard particle size, e.g., 0.1 – 1.0 µm.



Air Cleaner Sizing for Individual Spaces

Organization	Criterias and guidelines for room air cleaners
REHVA (The Federation of European Heating, Ventilation and Air Conditioning Associations)	**CADR** (measured for particle size of 0.3 - 0.5 µm) should be **2 times greater than the outdoor air flow by the ventilation system** in rooms with a ventilation rate more than one air change per hour (1 ACH). If the ventilation rate is lower than 1 ACH, the CADR should be **at least 2 ACH**.
The Swedish Asthma and Allergy Association	**CADR** value is recommended to be 4 times the ventilation rate (**4 ACH**).
AHAM (The Association of Home Appliance Manufacturers)	Recommends the 2/3 rule, meaning the **CADR** of the air purifier should be at **least two-thirds of the room's area** corresponding to an air change rate of **5 ACH** in a room of standard height.
CDC (Centers for Disease Control and Prevention)	Recommend an **air exchange rate of 5 ACH**. This can be achieved through any combination of central ventilation system, natural ventilation, or additional devices.
ASHRAE (The American Society of Heating, Refrigerating and Air-Conditioning Engineers)	Provide a calculation **method to determine the minimum equivalent clean airflow (l/s)** required for different spaces to reduce the risk of airborne infection (ASHRAE Standard 241-2023: Control of Infectious Aerosols). Recommendation **for example to educational facilities** is **20-25 l/s/person multiplied by number of people in the breathing zone**.
SFS-EN IEC 63086-2	**The room size as floor area (m^2)** can be calculated with equation: **$A = Q \cdot F_{room}$**, where Q is the CADR, expressed in m^3/h, and F_{room} is the effective room size constant, expressed in h/m. Using an average room ventilation rate of 1,0 /h, an average deposition rate of 0,2 /h and an average ceiling height of 2,50 m, an effective room size constant of Froom is 0,083 h/m.

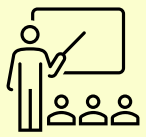
Clean Air Delivery Rate

$$N(t) = N_0 \cdot e^{-kt} \Rightarrow \mathbf{CADR} = (k_{AC} - k_{nat}) \cdot V_{chamber}$$

- N_0: Initial particle consentration
- k_{AC}: decay rate with air cleaner
- k_{nat}: natural decay rate
- $V_{chamber}$: chamber volume

Air Change per Hour

$$\mathbf{ACH} = \frac{\text{Airflow } [\frac{m^3}{h}]}{\text{Area } [m^2] \cdot \text{Height } [m]}$$

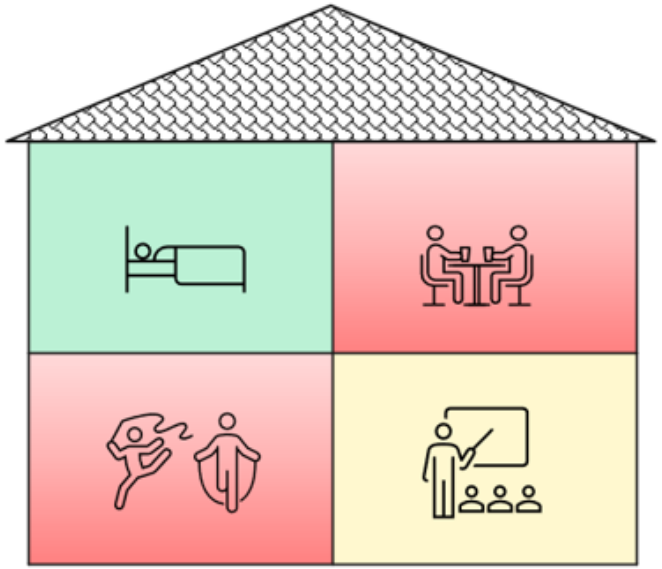


Air Cleaner Sizing for Daycare Premises

In the intervention of the daycare centers, the focus was not on sizing air cleaners for individual rooms, but rather on considering the sizing comprehensively for all the spaces where the daycare staff and children spend their days.

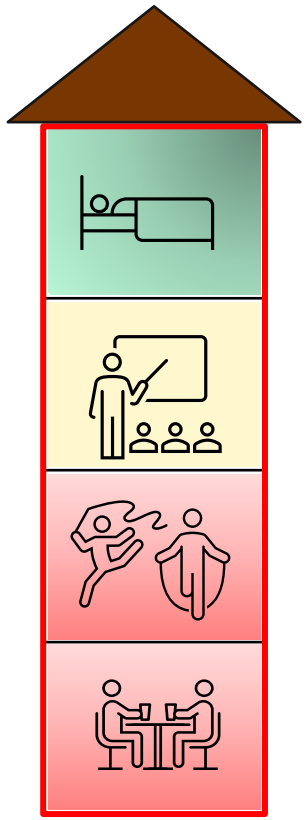
The goal was to reduce the amount of airborne pathogen exposure received during the day in a specific set of spaces.

- The aim was **to double the amount of clean, infection-free air** in daycare premises compared to the original levels,
- and to **distribute** the needed amount of **clean air** to the right places in the building **with risk-based sizing**.



Risk-Based Sizing of Air Cleaners

- **The increase in clean air** produced by air cleaners **was targeted to areas based on the airborne transmission risk**, taking into account the following factors in the risk assessment process:
  - **Existing ventilation**, i.e., the planned supply air values.
    - The functionality of the ventilation was verified through measurements.
    - The premises had mixing ventilation system.
  - **Usage profile of the spaces** at different times of the day.
    - The number of people
    - Occupancy times
    - Nature of activities (three categories: light activities (such as crafts), heavy activities (such as singing and physical exercise), and sleeping).
    - ➢ Usage profiles were determined through **a survey** conducted with daycare staff.
  - Using this data, the **weighting factors** were calculated **for each space** to indicate where in the building is the highest airborne transmission risk.
  - ➢ Based on the ventilation rates and the usage profiles, the air cleaners were ideally placed to distribute the needed amount of clean air to the right places in the daycare centers.

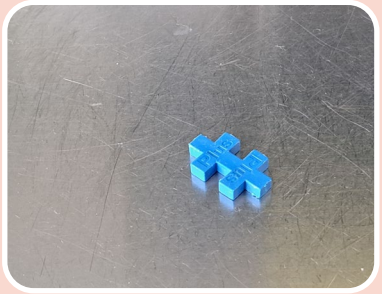


The use of the devices was controlled with smart plugs to ensure they remained on as desired.

The placement of air cleaners took into account the locations of supply and exhaust air vents, as well as other spatial constraints.

Summary:
Key Steps for Producing Clean Air

Check the operation of **the ventilation** and improve it as much as possible.



Find the hot spots of the premises using the information of each space (the amount of supply air, the stay time, the amount of people, the quality of the activities).

Place **the air cleaners** using **risk-based sizing** optimally and energy-efficiently to the hot spots.

Make sure the air cleaners **stay ON** when the facilities are in use.

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