CLAIRE

Congres 2024

5 Juni

Finnish E3 – Pandemic Response

An introduction to the Finnish E3 project followed by a detailed overview of the daycare centre research conducted as part of the project.

Dit onderzoek is mede mogelijk gemaakt door
Health~Holland, Topsector Life Sciences & Health

NL Health~Holland

E3 Pandemic Response

The E3 project wants to harness modern science and technology to create effective countermeasures to prevent the spreading of novel infectious diseases.

Arto Säämänen, Principal Scientist

Clean Air Solutions

VTT Technical Research Centre of Finland Ltd.

www.pandemicresponse.fi

The E3, Excellence in Pandemic Response and Enterprise Solutions Co-Innovation project

- The project will primarily study the different pathways of pathogens and viruses, virus control and detection methods that can be used to find solutions to keep indoor air clean and safe in offices, public spaces, and vehicles.

- The main goal is to develop solutions that allow the various functions of society to continue uninterrupted and people to continue to move and live safely despite epidemics and pandemics.

22 companies

7 research organizations

Duration
3 years

International cooperation

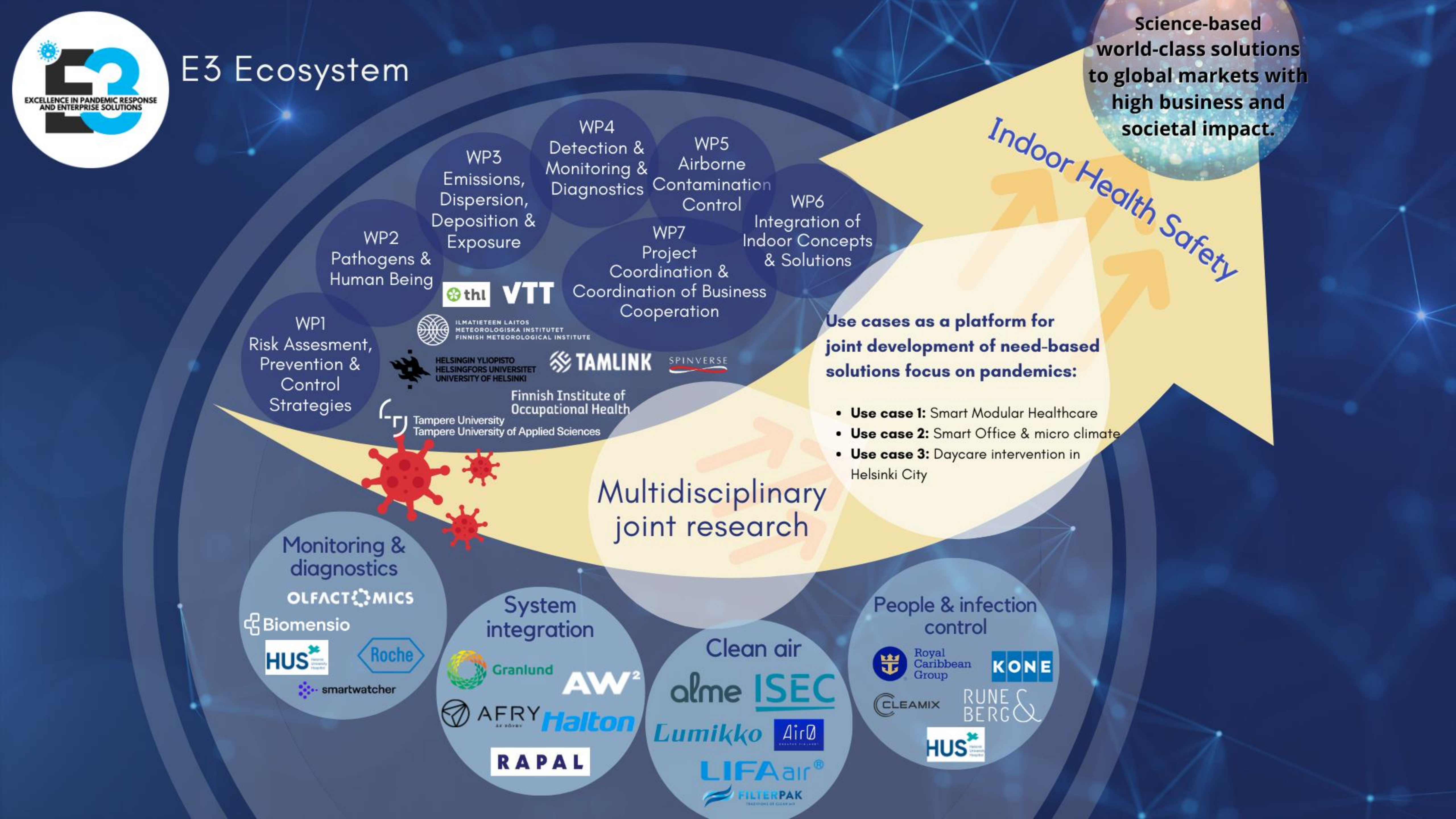
E3 use cases utilize the projects research results to find solutions for preventing virus contamination

Smart Modular Healthcare

- Hospital pilot in Romania & Helsinki

Smart Office & Micro climate

Daycare intervention



EXCELLENCE IN PANDEMIC RESPONSE AND ENTERPRISE SOLUTIONS
E3 Ecosystem
Science-based world-class solutions to global markets with high business and societal impact.
Indoor Health Safety
WP1 Risk Assesment, Prevention & Control Strategies
WP2 Pathogens & Human Being
WP3 Emissions, Dispersion, Deposition & Exposure
WP4 Detection & Monitoring & Diagnostics
WP5 Airborne Contamination Control
WP6 Integration of Indoor Concepts & Solutions
WP7 Project Coordination & Coordination of Business Cooperation
thl
VTT
ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE
HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI
TAMLINK
SPINVERSE
Finnish Institute of Occupational Health
Tampere University
Tampere University of Applied Sciences
Use cases as a platform for joint development of need-based solutions focus on pandemics:
Use case 1: Smart Modular Healthcare
Use case 2: Smart Office & micro climate
Use case 3: Daycare intervention in Helsinki City
Multidisciplinary joint research
Monitoring & diagnostics
OLFACTOMICS
Biomensio
HUS
Roche
smartwatcher
System integration
Granlund
AW2
AFRY
Halton
RAPAL
Clean air
alme
ISEC
Lumikko
AirØ
LIFAair
FILTERPAK
People & infection control
Royal Caribbean Group
KONE
CLEAMIX
RUNE BERG &
HUS

Research subjects

Risk Assessment, Prevention & Control Strategies

Emissions, Dispersion, Deposition & Exposure

Airborne Contamination Control

Pathogens & Human Being

Detection & Monitoring & Diagnostics

Integration of Indoor Concepts & Solutions

E3 Final Seminar:

Tackling Pandemics

Oct 30, 2024
Wednesday

9 AM – 4 PM
Helsinki, Finland

pandemicresponse.fi/finalseminar

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Use case 3: Daycare intervention

Daycare centres in Helsinki area

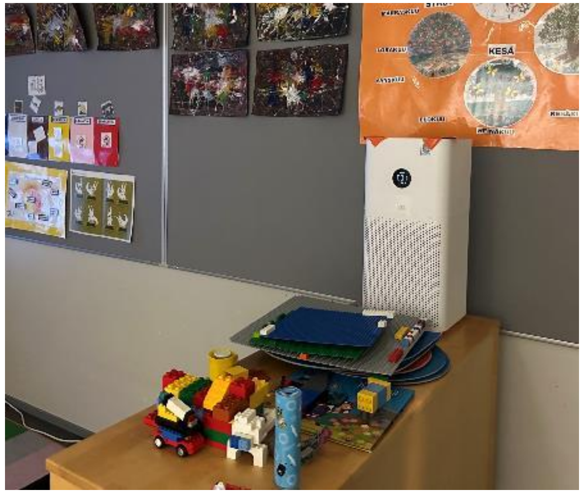
- 4 daycare centres: Building years 2001-2013
- Floor area 780 – 1185 m^2 (studied premisses 416 – 974 m^2)
- Occupancy: 105-123 persons
- **2-year crossover**: intervention – control; control - intervention
- Study periods from November to April 2022 - 2024
- **Control**: Normal ventilation in the building, 11.9 – 19.0 l/s/person
- **Intervention**: Normal ventilation with additional portable air cleaners, 27.5 – 42.3 l/s/person

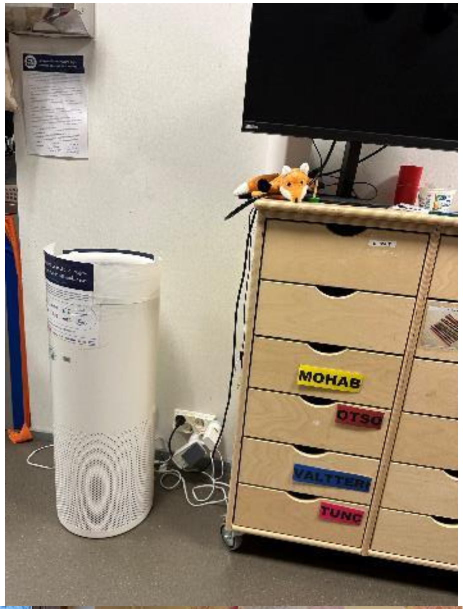
Collected data-sets and studies performed

- Relative infection probability and number of persons at risk of transmission in premises
- Occupancy and activity profiles of the premises
- Air flow rates of the rooms
- Intensive measurement campaigns 4 x 2 weeks: Outdoor air quality, Indoor UFP
- Sick leaves, parents' absence of work (statistics, diaries)
- User experience – abductive case study
- 12 IAQ sensors (T, RH, VOC, PM1, PM2.5, PM10): continuous time series
- 6 pressure difference monitors
- Energy consumption of the room air cleaners
- Deposited dust: microbes (e.g. SARS-CoV-2)
- Surface samples (Adeno, RSV, SARS)

Air cleaners

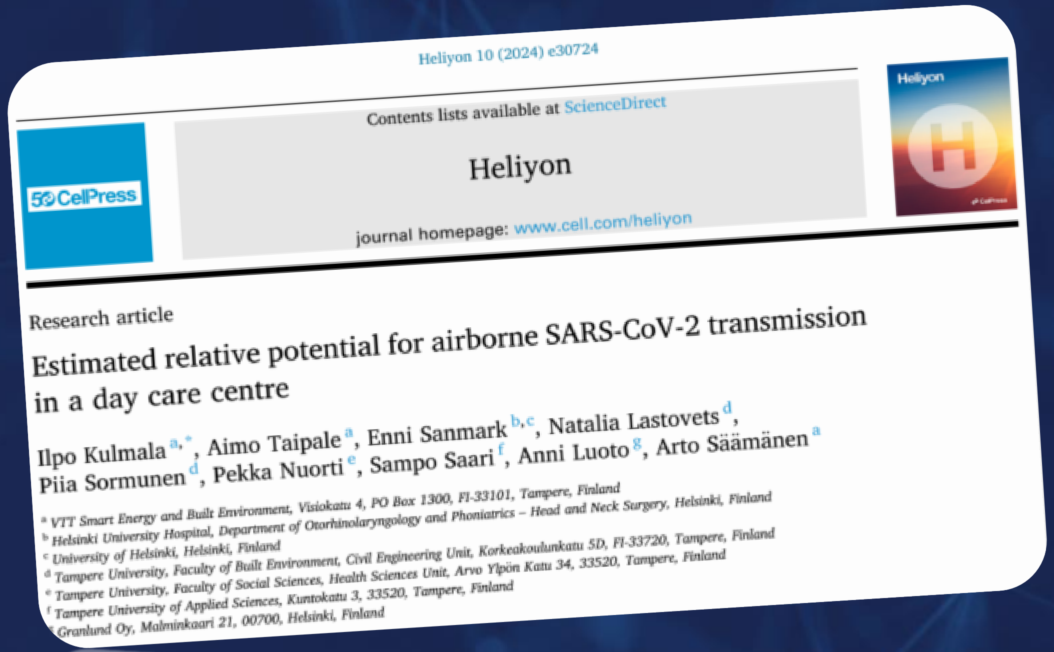
Model	CADR with fan speed setting used in this study m3/h
Air0 SmAIRt1200	1260
Air0 SmAIRt1200	1010
Air0 SmAIRt600	570
Air0 SmAIRt600	434
Alme Pure	372
Halton MobileAirCleaner VCR	1500*)
IQAir CleanZone SLS	650
IQAir Icleen Health Premium	240
ISEC Kuulas	125
ISEC Vinha	453
ISEC Vinha	302
Lifa Air LA502C	285
ISEC Type 1	195
ISEC Type 2	433





Estimated relative potential for airborne SARS-CoV-2 transmission in a daycare centre

Ilpo Kulmala, Aimo Taipale, Enni Sanmark, Natalia Lastovets, Piia Sormunen, Pekka Nuorti, Sampo Saari, Anni Luoto, Arto Säämänen


Heliyon 10 (2024) e30724
Contents lists available at ScienceDirect
Heliyon
journal homepage: www.cell.com/heliyon

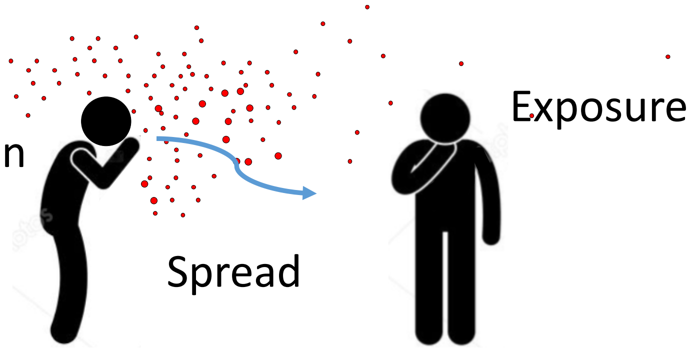
Research article

Estimated relative potential for airborne SARS-CoV-2 transmission in a day care centre

Ilpo Kulmala [a,*], Aimo Taipale [a], Enni Sanmark [b,c], Natalia Lastovets [d], Piia Sormunen [d], Pekka Nuorti [e], Sampo Saari [f], Anni Luoto [g], Arto Säämänen [a]

[a] VTT Smart Energy and Built Environment, Visiokatu 4, PO Box 1300, FI-33101, Tampere, Finland
[b] Helsinki University Hospital, Department of Otorhinolaryngology and Phoniatrics – Head and Neck Surgery, Helsinki, Finland
[c] University of Helsinki, Helsinki, Finland
[d] Tampere University, Faculty of Built Environment, Civil Engineering Unit, Korkeakoulunkatu 5D, FI-33720, Tampere, Finland
[e] Tampere University, Faculty of Social Sciences, Health Sciences Unit, Arvo Ylpön Katu 34, 33520, Tampere, Finland
[f] Tampere University of Applied Sciences, Kuntokatu 3, 33520, Tampere, Finland
[g] Granlund Oy, Malminkaari 21, 00700, Helsinki, Finland

Airborne transmission risk modelling



$$C = \frac{G}{(\lambda + \lambda_{IA} + \lambda_D)V + q_{AC}E}$$

$$D = C \cdot t \cdot Br \cdot fi$$

$$R = 1 - \exp(-0.693 \frac{D}{D_{50}})$$

Airborne concentration → **Inhalation dose** → **Infection risk**

Emission rate G
Inactivation rate λ_{IA}
Deposition rate λ_D
Ventilation rate λ
Room volume V
Air cleaner CADR $q_{AC}E$

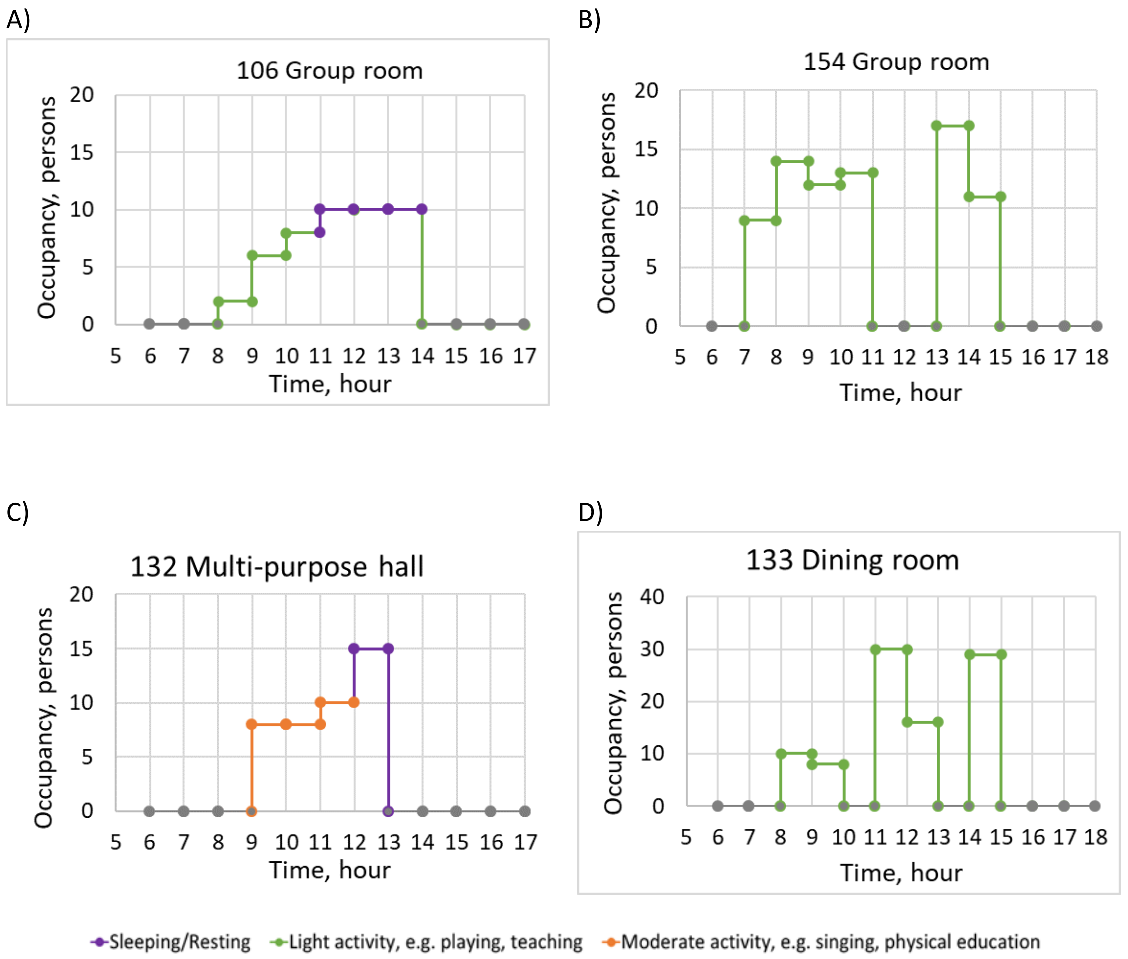
Airborne concentration
Exposure time t
Breathing rate Br
Deposited fraction f_i

Infective dose D_{50}
infection risk of a single viral RNA copy p_{RNA}

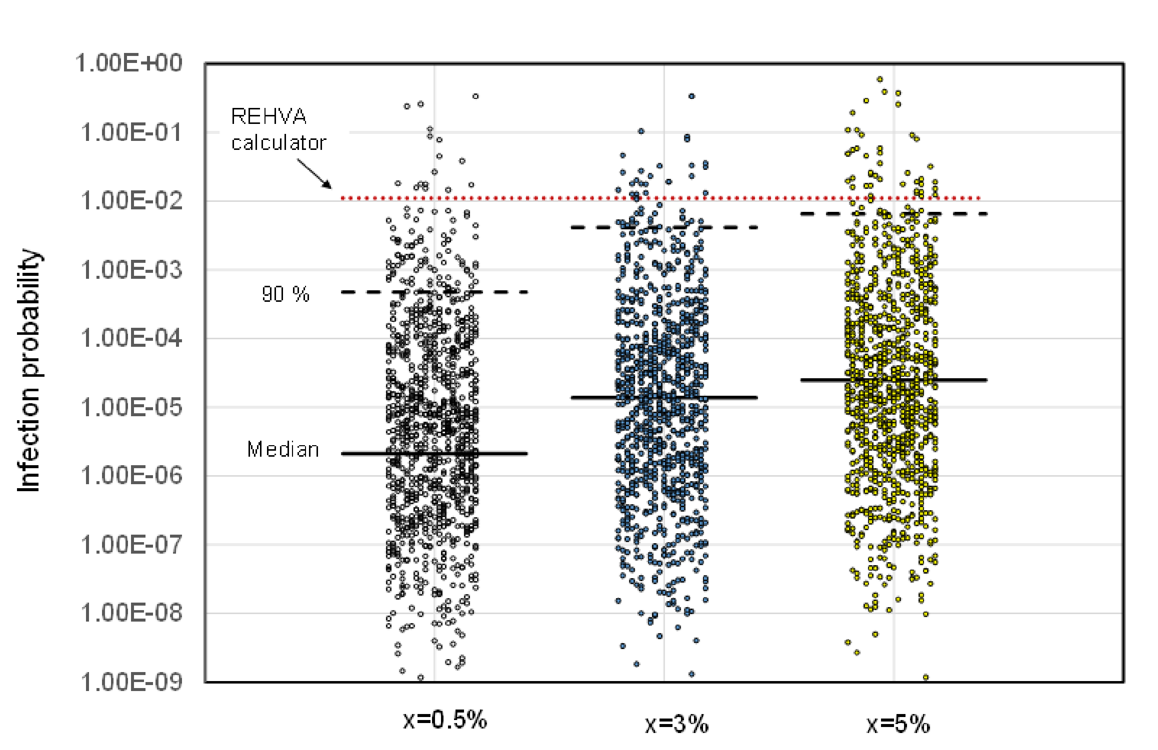
Case study: Kindergarten in Helsinki

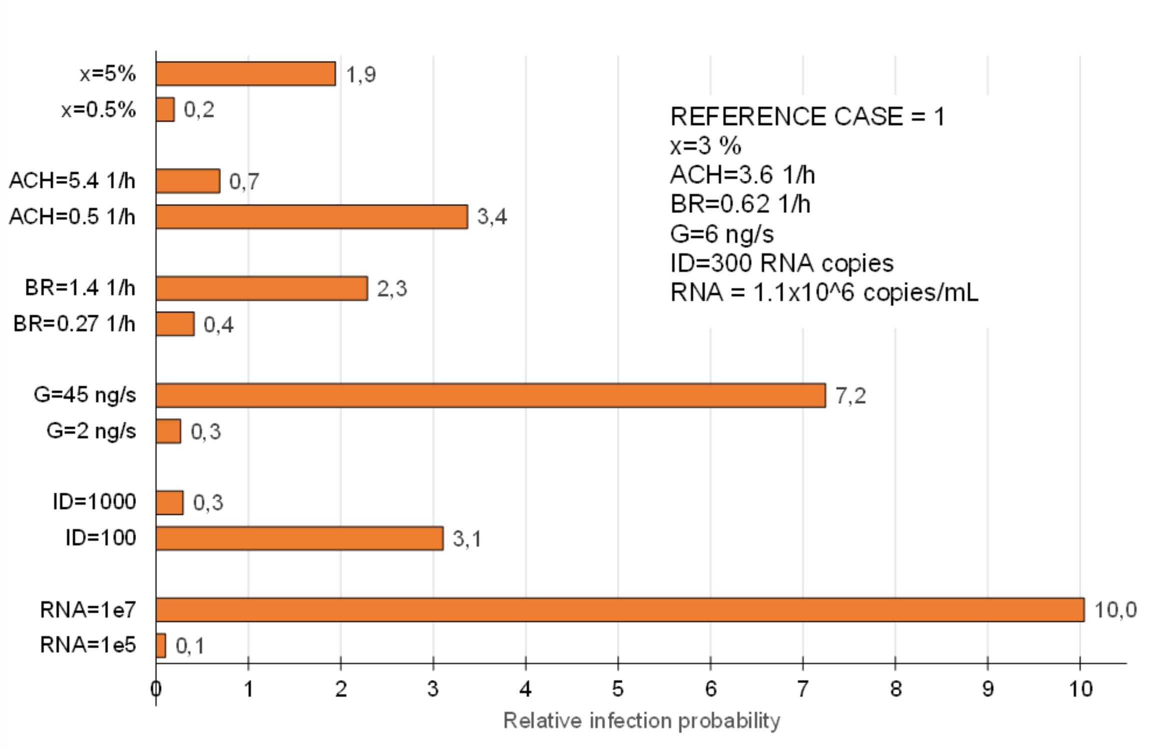
- Day care centre equipped with mechanical ventilation
- Constant air flow rate
- Air change rate in different rooms 0.9-3.8 1/h
- Daily occupation and activity was collected by a questionnaire
- Infection transmission risk was calculated for each room on hourly basis

Kulmala, I., Taipale, A., Sanmark, E., Lastovets, N., Sormunen, P., Nuorti, P., Saari, S., Luoto, A., & Säämänen, A. (2024). Estimated relative potential for airborne SARS-CoV-2 transmission in a day care centre. *Heliyon, 10(9), e30724. https://doi.org/10.1016/j.heliyon.2024.e30724*



Effect of initial values on calculated risk estimates





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Relative number of persons at risk

Red	Number of persons: High
Yellow	Number of persons: Medium
Green	Number of persons: Low

Conclusions

- The developed model is a simple and robust tool for calculating airborne infection transmission risk in indoor spaces
- Significant differences in infection probabilities and number of persons at risk between spaces and events were revealed.
- Most useful for finding hot spots where the infection transmission risk is at least temporarily increased due to favourable conditions or human behaviour
  - Ranking of high-risk rooms and activities
- Selection of mitigation methods, e.g. use of room air cleaners
  - enables an efficient focus on risk mitigation measures

EXCELLENCE IN PANDEMIC RESPONSE AND ENTERPRISE SOLUTIONS

The effect of room air cleaners on infection control in day care centres

Vartiainen, V. A., Hela, J., Luoto, A., Nikuri, P., Sanmark, E., Taipale, A., Ehder-Gahm, I., Lastovets, N., Sormunen, P., Kulmala, I., & Säämänen, A.


Indoor Environments 1 (2024) 100007

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Indoor Environments

journal homepage: www.sciencedirect.com/journal/indoor-environments

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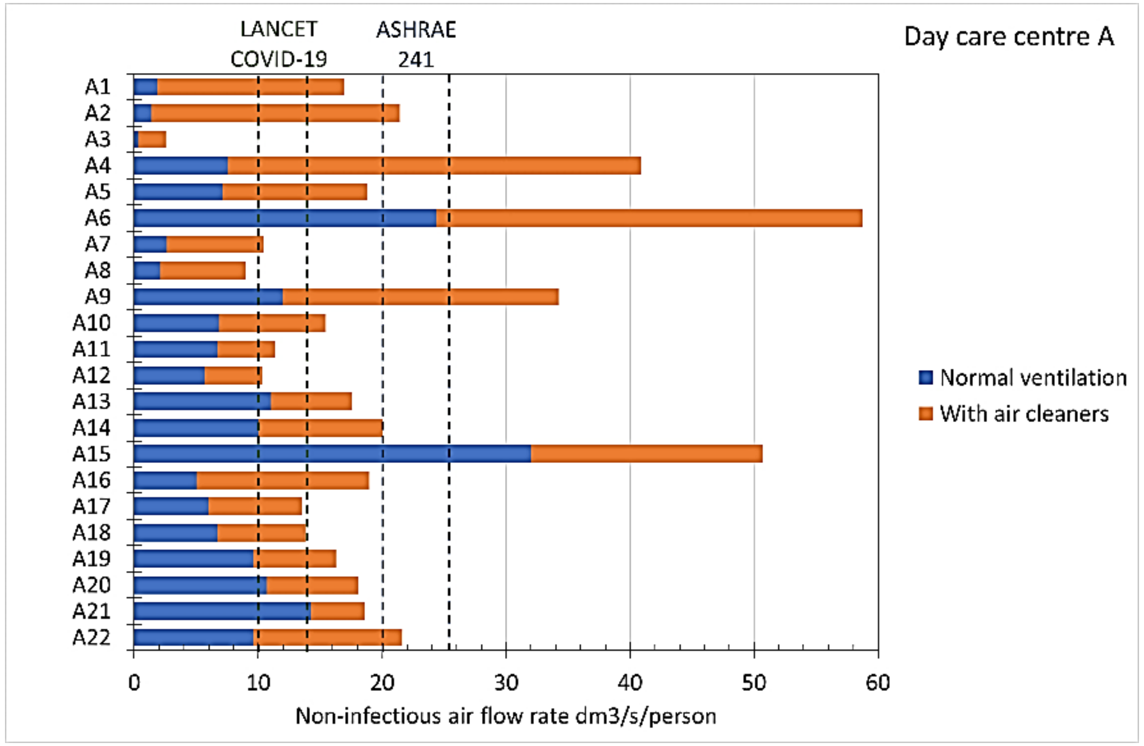
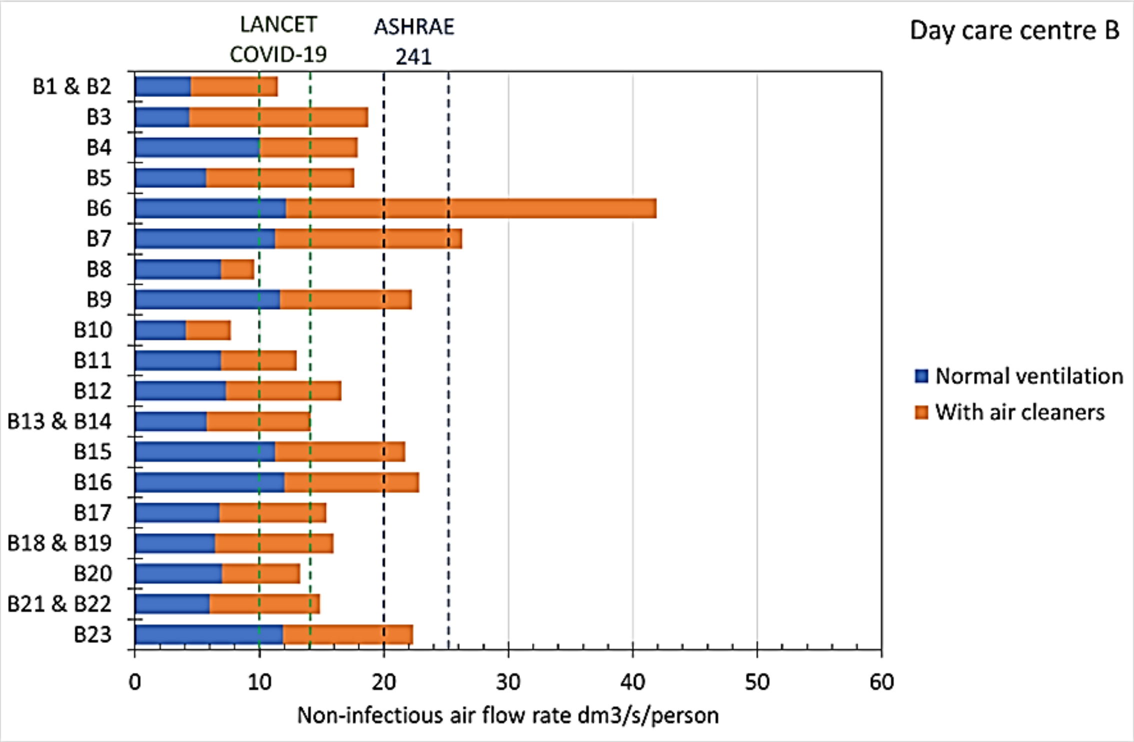
The effect of room air cleaners on infection control in day care centres

Ville A. Vartiainen[a,*], Johanna Hela[b], Anni Luoto[c], Petra Nikuri[a], Enni Sanmark[d], Aimo Taipale[e], Inga Ehder-Gahm[f], Natalia Lastovets[e], Piia Sormunen[c,e], Ilpo Kulmala[f], Arto Säämänen[f]

[a] Heart and Lung Center, Helsinki University Hospital, Finland and Faculty of Medicine, University of Helsinki, Biomedicum 2U, Tukholmankatu 8, PL 20, 00014, Finland
[b] Children and Adolecents, Helsinki University Hospital, Finland
[c] Construction and facility development, Granlund Ltd, Finland
[d] Department of Otorhinolaryngology and Phoniatrics - Head and Neck Surgery, Helsinki University Hospital, Helsinki, Finland
[e] Built environment, Civil engineering, Tampere University, Finland
[f] Clean Air Solutions, VTT Technical Research Centre of Finland, Finland

Non-infectious air flow rates





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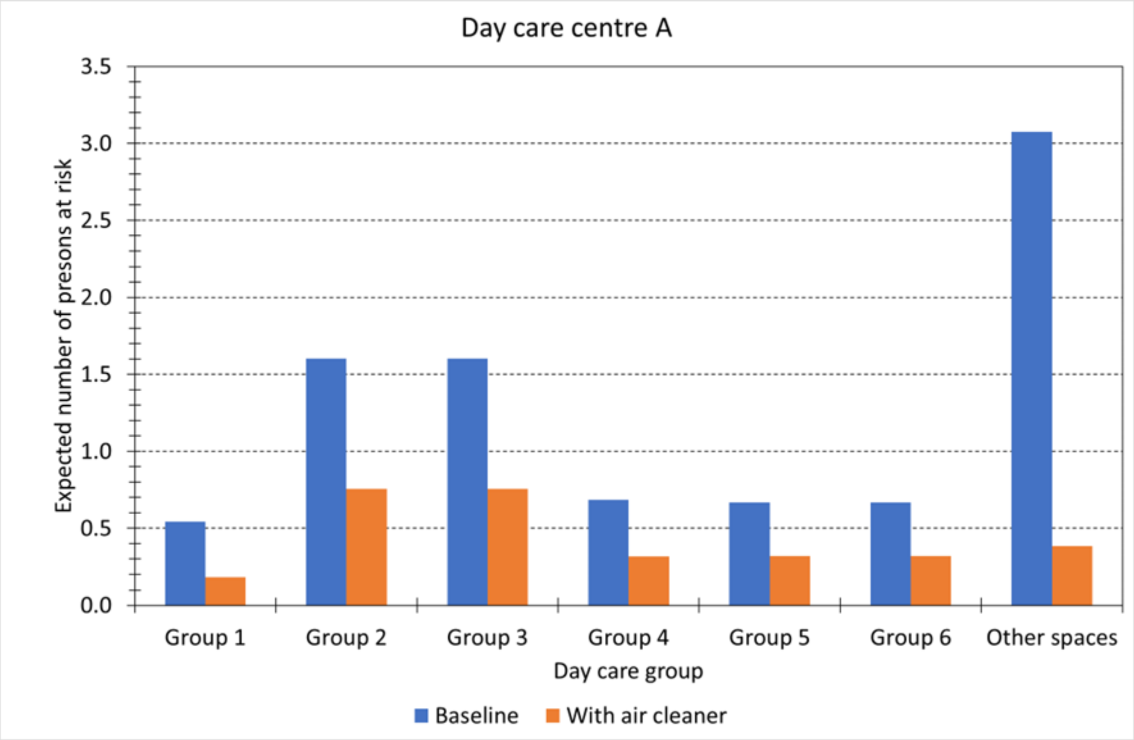
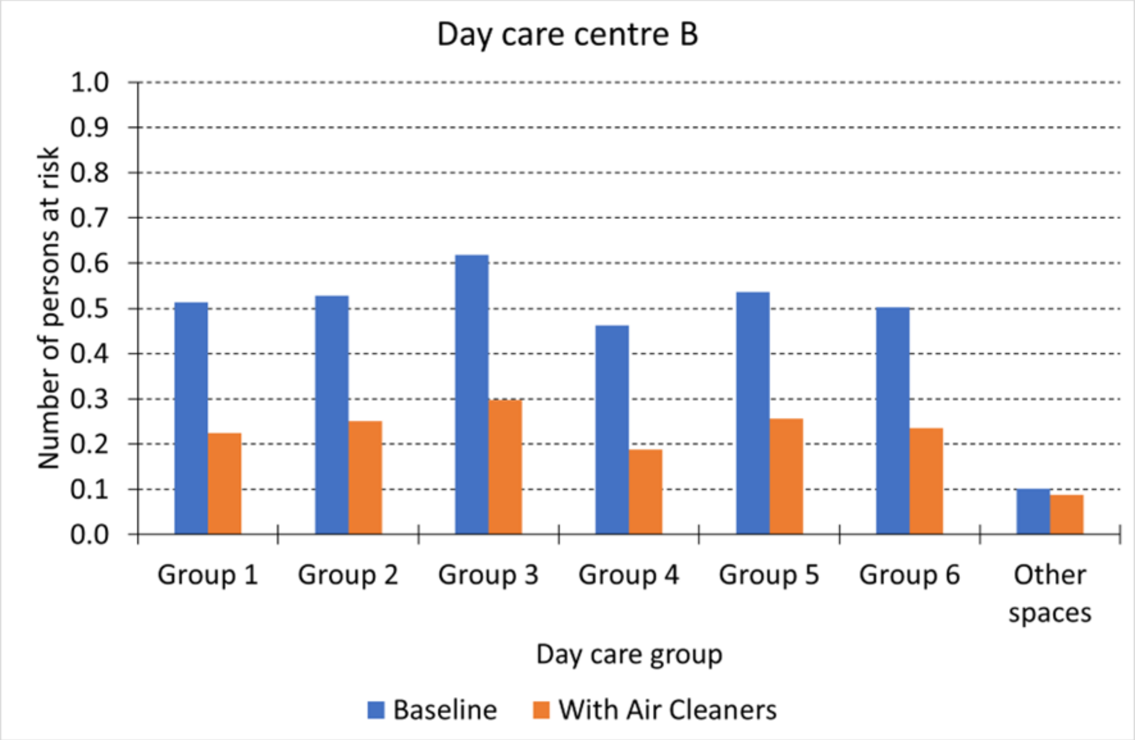
Air cleaners in kindergartens – calculated effect





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Conclusions

- Our study offers compelling evidence to support the implementation of air cleaners in daycare centres as an effective and cost-efficient strategy for mitigating the spread of respiratory infections among children.
- The use of portable air cleaners reduced the infections by 30% in intervention day centres compared to reference centres. (based on 1st year results – full crossover results to be published soon).
- The optimization parameter is the total number of persons at risk of being infected in the whole building, which should be minimized with the available number of air cleaners.
- The clinical results support the findings suggested by our theoretical model.
- The model provides a straightforward but valuable method for assessing the effects of ventilation and air cleaning on the transmission of airborne infections.
- When selecting and locating the air cleaners, the number of potentially exposed persons should also be considered to mitigate disease at the whole building level.

Air Flow measurements in Finnish daycare buildings

Antti Mäkinen, Sakari Uusitalo, Sampo Saari and Jussi-Pekka Juvela.

Tampere University of Applied Sciences, Finland.

Daycare centers A & B

- Both buildings had a constant air volume (CAV) ventilation system

Daycare centre A
- Measured total supply airflow was about 30 % bigger than designed
- Measured total exhaust air flow was 12 % smaller than designed

Daycare centre B
- Measured total supply airflow was about 12 % smaller than designed
- Measured total exhaust air flow was 23 % smaller than designed

Room code	Room name	Measured airflow	Designed airflow	Difference	Difference
		[dm³/s]	[dm³/s]	[dm³/s]	[%]
021	Group room 3	65,5	47,5	18,0	38 %
		56,1	47,5	8,6	18 %
		-19,6	-31,6	-12,0	-38 %
		-25,9	-31,6	-5,7	-18 %
		-22,0	-31,6	-9,6	-30 %
022	Rest room 3	41,4	45,0	-3,6	-8 %
		47,8	45,0	2,8	6 %
		-23,5	-30,0	-6,5	-22 %
		-21,1	-30,0	-8,9	-30 %
		-21,5	-30,0	-8,5	-28 %
023	Hallway	65,7	46,6	19,1	41 %
		69,3	46,6	22,7	49 %
		65,7	46,6	19,1	41 %
024	Wet hallway	-31,3	-50	-18,7	-37 %
		-26,9	-50	-23,1	-46 %
025	Toilet / wash room	-18,3	-20	-1,7	-9 %
		-17,8	-20	-2,2	-11 %
026	Toilet / wash room	-21,0	-20	1,0	5 %
		-20,5	-20	0,5	2 %
027	Rest room 4	47,8	45,0	2,8	6 %
		53,4	45,0	8,4	19 %
		-21,1	-30,0	-8,9	-30 %
		-21,9	-30,0	-8,1	-27 %
		-23,4	-30,0	-6,7	-22 %
028	Group room 4	44,7	47,5	-2,8	-6 %
		56,1	47,5	8,6	18 %
		-20,9	-31,6	-10,7	-34 %
		-22,4	-31,6	-9,2	-29 %
		-24,3	-31,6	-7,3	-23 %

Table 1. Example: Group area airflows in daycare centre B

Daycare centers C & D

- Both buildings had a variable air volume (VAV) ventilation system, controled by CO_2 or temperature
- In both daycare centres VAV-system didn´t work and they behave like CAV –system.

Daycare centre C

- Measured total supply airflow was about 10 % smaller than designed
- Measured total exhaust air flow was about 15 % smaller than designed

Daycare centre D

- Measured total supply airflow was about 10 % smaller than designed
- Measured total exhaust air flow was about 6 % bigger than designed

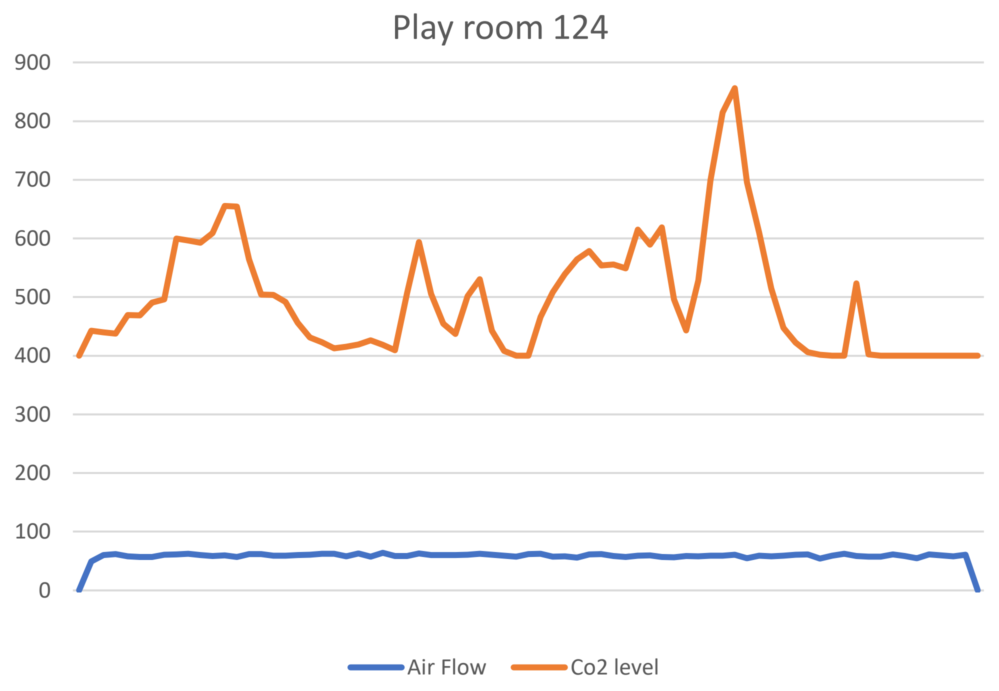


Diagram 1 One play room air flow and CO2 level in daycare centre D

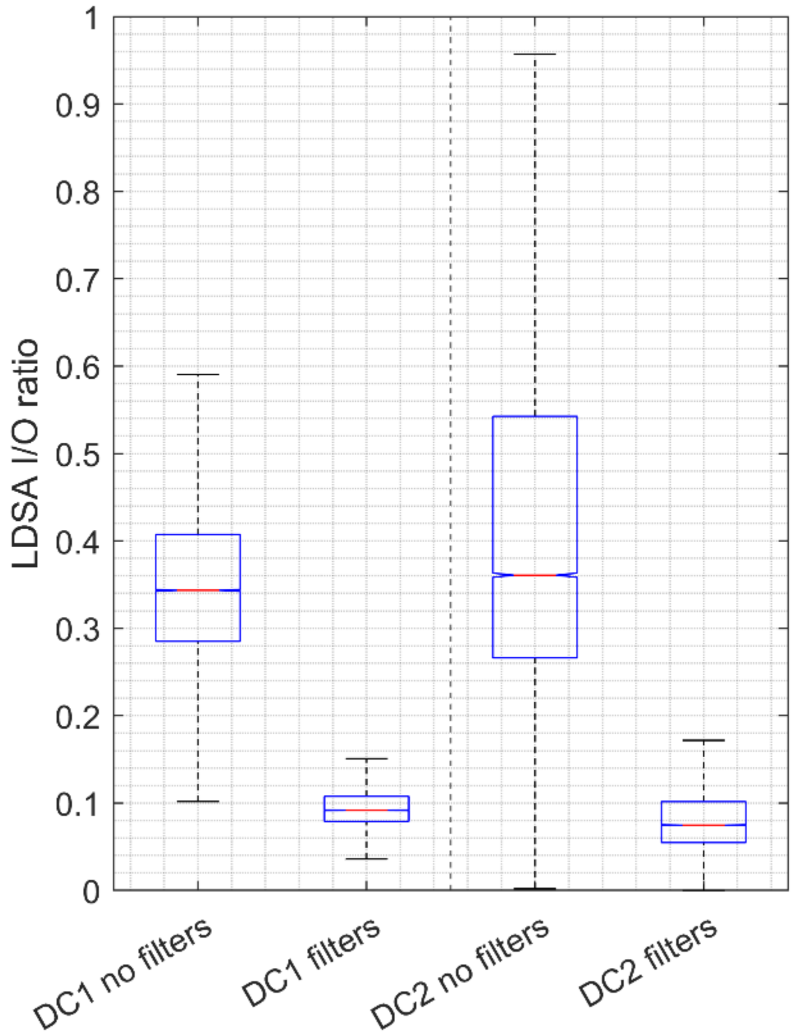
Indoor and outdoor particulate matter concentrations and the effect of portable air filtration units in urban day cares

V. Silvonen[1], M. Jäppi[1], H. Lintusaari[1], J. Hoivala[1], T. Lepistö[1], J. Widenius[1], L. Salo[1], K. Kylämäki[1], L. Savolainen[1], L. Markkula[1], T. Rönkkö[1]

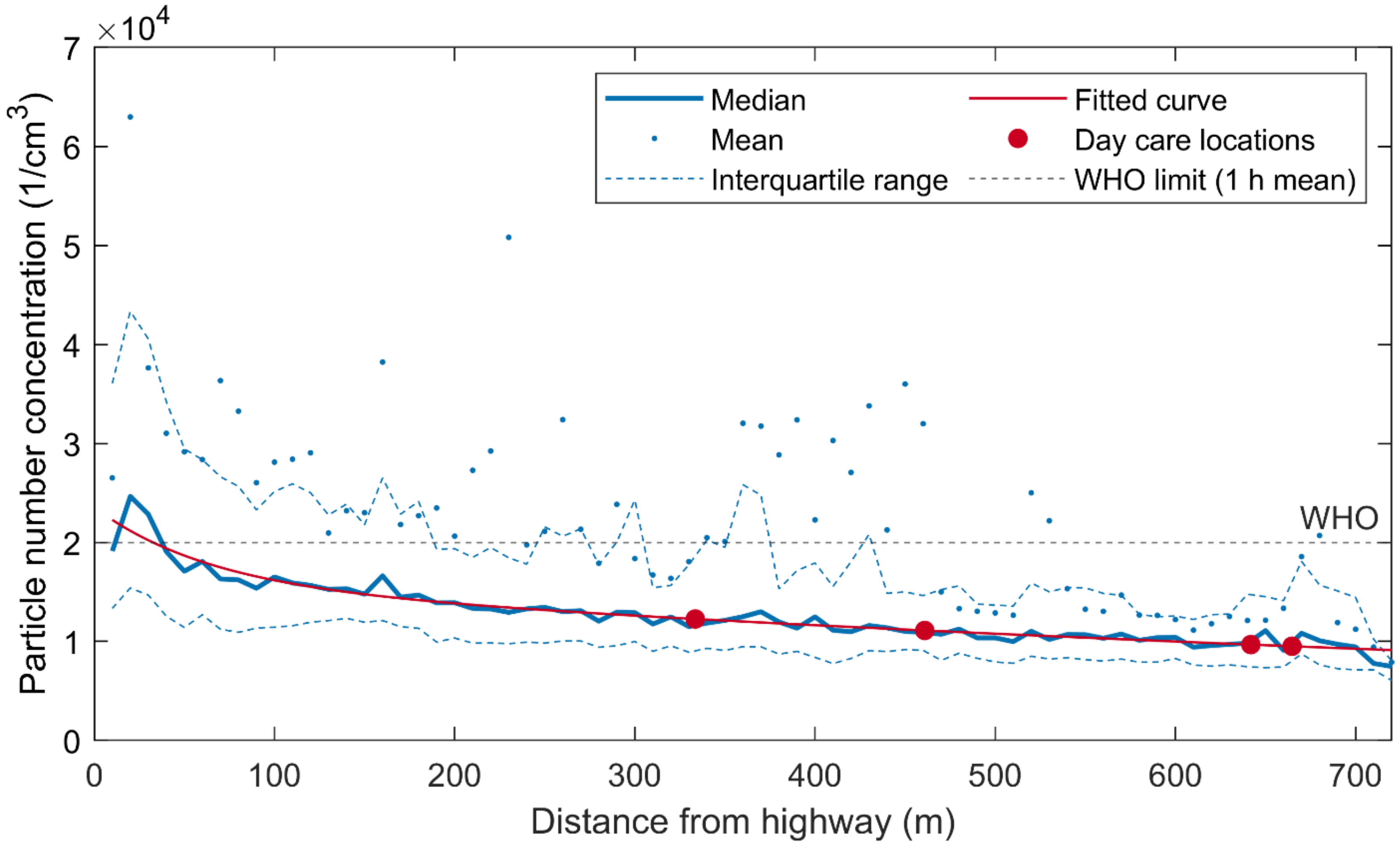
[1]Aerosol Physics Laboratory, Tampere University

EXCELLENCE IN PANDEMIC RESPONSE AND ENTERPRISE SOLUTIONS

Indoor particle LDSA concentration and the effect of air filtration units



Outdoor particle number concentration in the area



What can we learn?

- Air quality measurements can provide important context
- Portable air filtration units can reduce indoor particle concentrations
- Air quality may play an important role in transmission
  - Exposure to particles can impair human immune functions
- Urban planning / city level design can help reduce exposure

Human factors

M. Nuutinen, J. Paasi & J. Rökman

VTT Technical Research Centre of Finland Ltd.

Aim

- The human factors research of E3 project aims to give design principles related to human and organizational behaviour, user experience, and acceptance for the development of solutions mitigating the spread of pandemic/epidemic in indoor spaces
- The design principles arise from the understanding of the use of target spaces, and they are given as User Experience (UX) Goals together with context-dependent specifications

Methods

- Research strategy – abductive case study
- Background
  - Literature, internet search
  - Material from different E3 project discussions
- Empirical case studies: day care centres and hospital
- Phased analysis

Results: E3 UX Goals guiding the design of solutions mitigating the spread of pathogens

The solution should aim to provide users with an experience that:

- Supports essentials in work
- Promotes being together safely
- Respect personal health and safety needs discreetly
- Justifies feelings of safety
- Ensures user acceptance as a part of the whole

Viewpoints for the use of UX Goals in the context of daycare centres

Aim to provide users with an experience that

- Supports essential in work
  - Position and select the devices by considering the need to maximise floor area for the use of children and the need to have clear visibility in the room
  - Adjust the noise to an acceptable level. When adjusting, remember to communicate that decreasing the noise may weaken the performance.
- Promotes being together safely
  - Allowing health-safe small group activities
- Respect personal health and safety needs discreetly
  - Joint design with end-users (including the look of devices) and start-up situation
  - Consider highly sensitive persons (sounds, smell, outlook etc.)
- Justifies feelings of safety
  - Give research-based information on the benefits of solution in a form that can be understood by the end-users
- Ensures user acceptance as a part of whole
  - Give understanding & argumentation for the personnel on the impact of solution for the improvement in conditions and health safety

EXCELLENCE IN PANDEMIC RESPONSE AND ENTERPRISE SOLUTIONS

Thank you for your attention

Arto Säämänen

VTT Technical Research Centre of Finland Ltd.

https://cris.vtt.fi/en/persons/arto-säämänen