
# Effect of ventilation systems for health safety in hospital environment

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# Reseach question?

Can the risk of airborne infection in hospital buildings be lowered using air purification units?

# Case studies

Naturally ventilated building

&

Mechanically ventilated buildings

Bucharest & Helsinki & Espoo


Matei Balș hospital Bucharest

# Objectives

- Measuring existing indoor air quality and ventilation status in the case study buildings.
- Developing proof of concepts (PoC) for decreasing viral infection risk in the selected risky spaces in each case study.
- Implementing proof of concepts (for example air purification units), in two case studies.
- Performing infection risk simulations

# Methods

## IAQ Measurements

Measure key parameters that correlate with good indoor air quality (IAQ).

## Air purifier intervention

Investigate the potential benefits of using portable air purifiers for improving IAQ.

## Simulation

Infection risk probability

# Measuring equipment and air quality parameters studied

## Air quality parameters studied

Particulate matter (PM)

The lung-deposited surface area (LDSA)

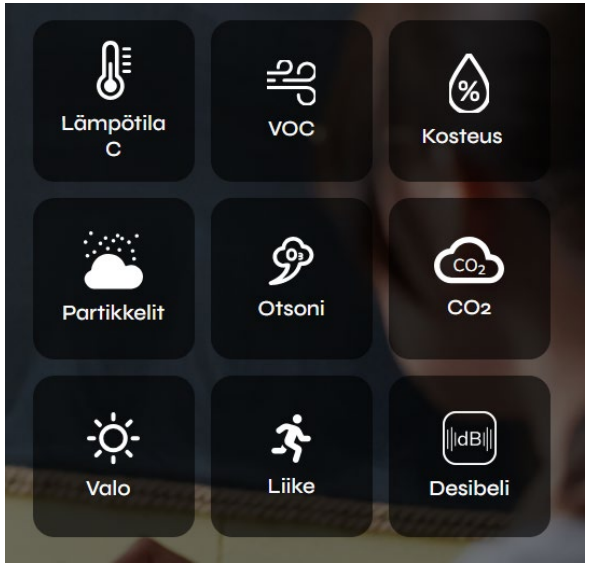
Total volatile organic compounds (TVOC)

$CO_2$ concentrations

Black carbon concentration (BC)

Temperature & Relative humidity (RH%)

Pressure differentials (PD) and air flow rate


Alphasense
PM1, $PM_{2.5}$ and $PM_{10}$


Observair
Blak Carbon (BC)


HOBO
$CO_2$ / (T)/RH%

Partector
LDSA

# Air purification technologies

Air0
BREATHE FINLAND™

LIFAair®

SISÄILMA LÄHETTI

ISEC
Vaikuttavaa sisäilmaosaamista


# Main key findings

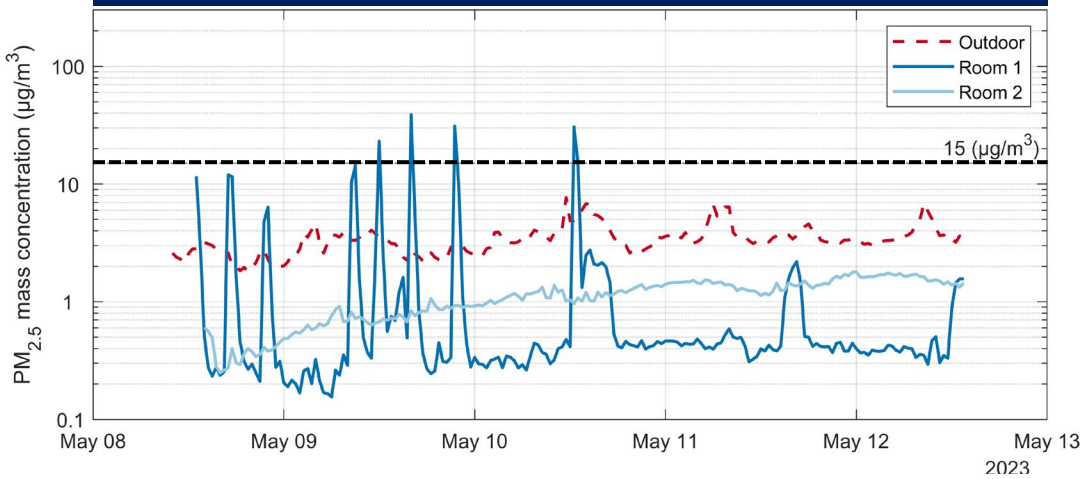
$PM_{2.5}$ Results

Air change per hour in isolation room

Calculated probability of airborne infection in Covid room

No intervention

## Mechanically ventilated - Helsinki

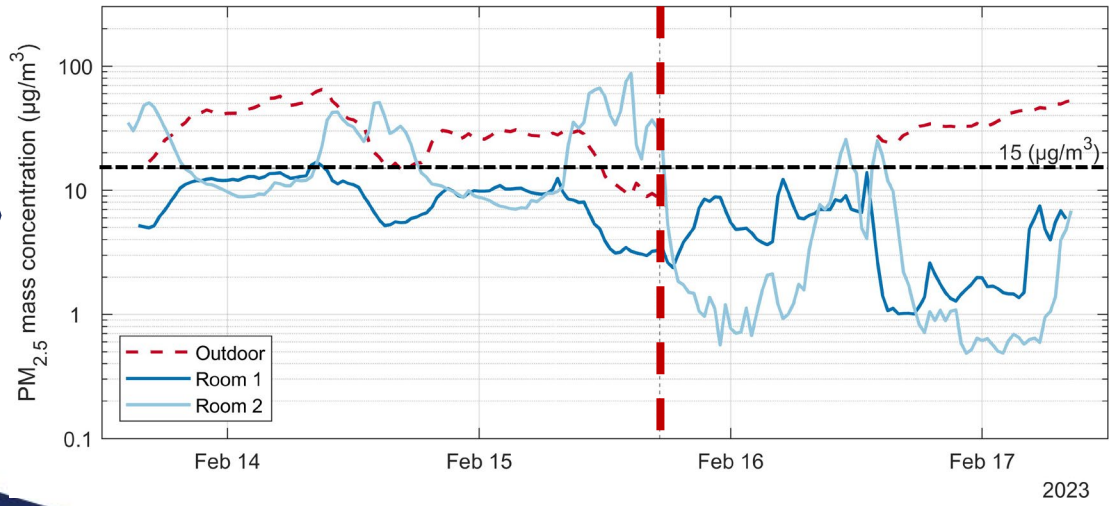



# $PM_{2.5}$ Results

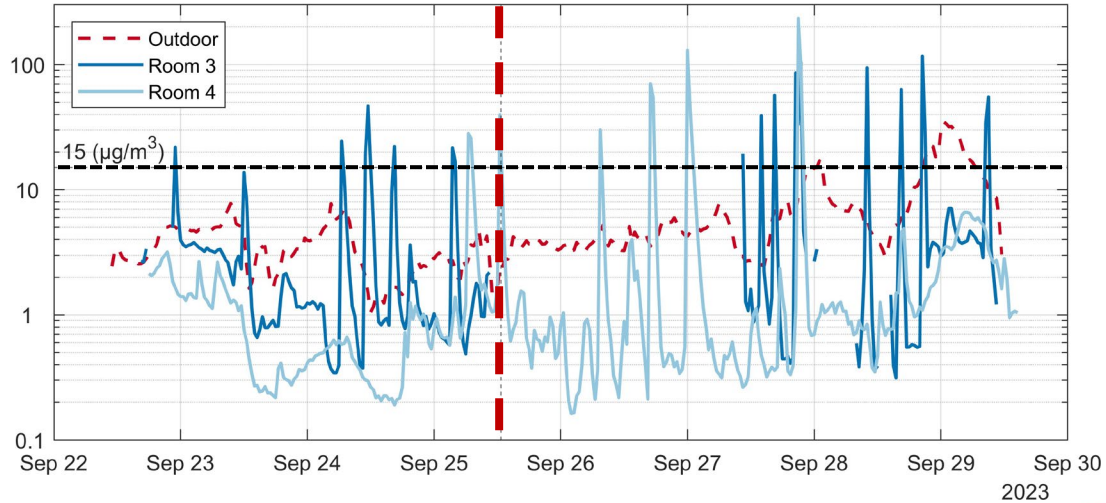
*$PM_{2.5}$ mass concentration (time series)*
*Room 1=isolation room*
*Room 2=patient room*

With intervention

## Naturally ventilated - Bucharest




## Mechanically ventilated - Espoo

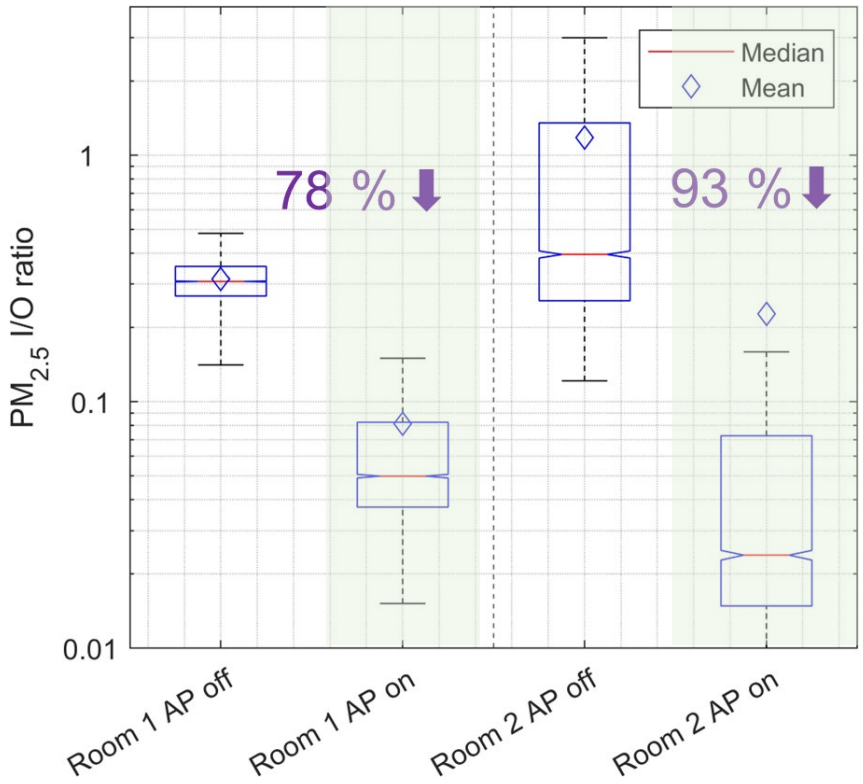



*$PM_{2.5}$ mass concentration (time series)* ***before*** *and* ***after*** *installing the – air purifier.*

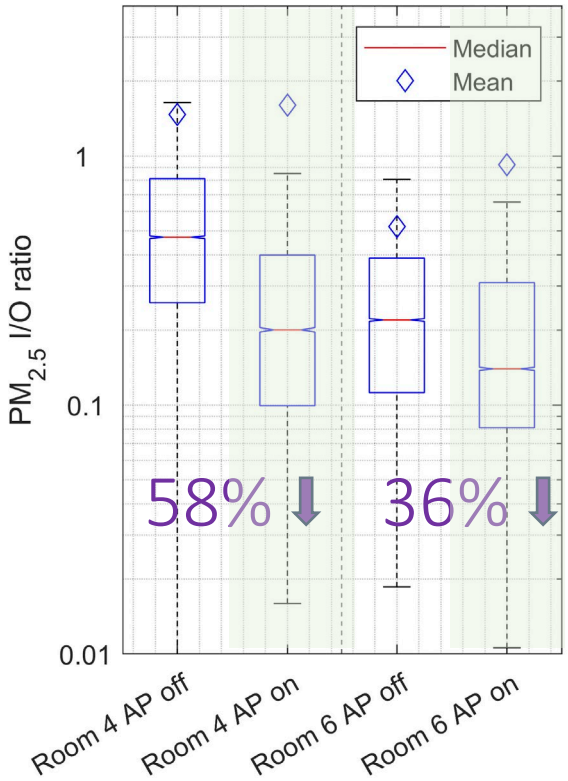
# $PM_{2.5}$ Results

Boxplots indicate the interquartile range of data with whiskers extending from the 1st and 3rd quartiles to 1.5 times the interquartile range. The red line and the blue diamond indicate the median and the mean value, respectively. The green areas indicate values when the intervention (air purifier) was in use.

## Naturally ventilated - Bucharest




## Mechanically ventilated - Espoo




*$PM_{2.5}$ mass concentration indoor to outdoor ratios*

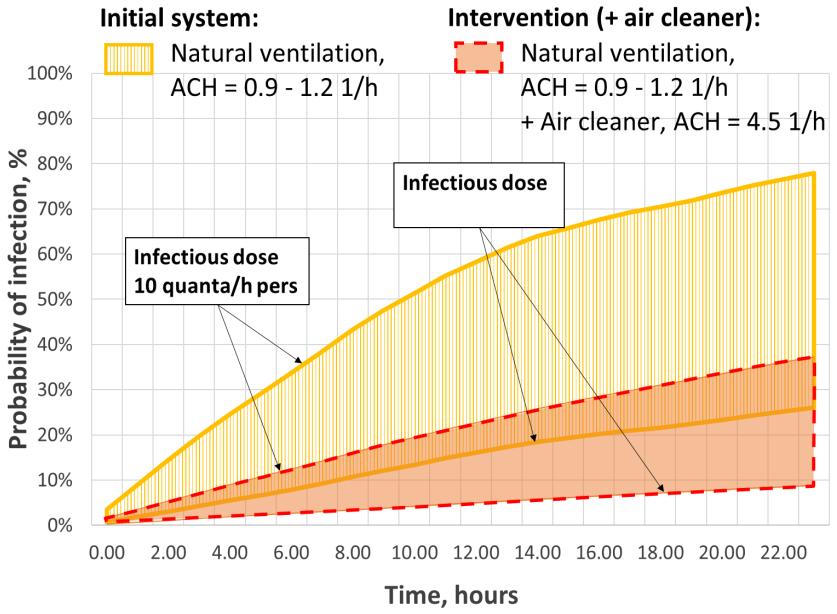
# Clean air production in isolation room

| Case studies<br><br>Isolation rooms | Ventilation type | Clean air production 1/h | | | | | |
|---|---|---|---|---|---|---|---|
| | | Initial situation | | | Intervention | Design requirements for isolation rooms, total ACH | |
| | | Design value<br>Mechanical ventilation<br>Air change per ACH [1/h] | Measured value<br>Air change per hour ACH [1/h] | Air purifier<br>Clean air delivery [1/h] | Total clean air production<br>Ventilation + Air purifier<br>[1/h] | The Lancet COVID-19 Commission (2022) | R3 Nordic Guideline for Hospital Ventilation (2023) |
| ***Hospital-Bucharest***<br>*(Built - beginning of the 20th century)* | Natural ventilation | N/A | 1.0* | 4.5 | 5.5 | 12 – 20 | 12 – 24 |
| ***Hospital-Espoo***<br>*(Built 1976)*<br>*Finland* | Mechanical ventilation + air lock | 4.2 | **1.7** | **9.1** | 10.8 | | |
| ***Hospital 2***<br>*(Built 2014)*<br>*Finland* | Modern mechanical ventilation +air lock | **9.3** | N/A | N/A | N/A | | |

* Simulated ACH with Ida-Ice program

# Calculated probability of airborne infection in covid room

Naturally ventilated - Bucharest

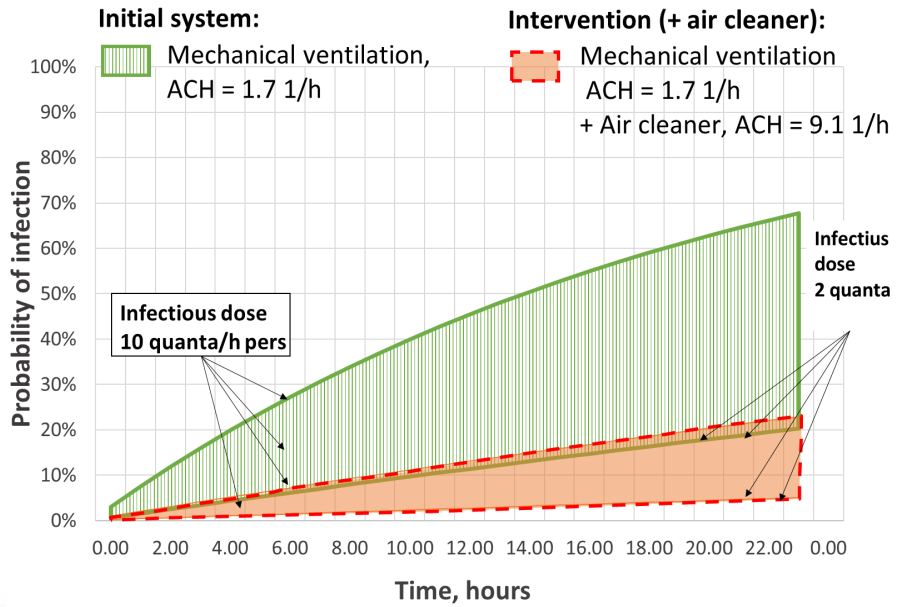



52-65%

Calculated infection risk reduction by air purifier

74-66%

Mechanically ventilated - Espoo




## Initial data

- One patient has covid infection
- One patient has no infection
- The infection risk is calculated with Wells-Riley model

# Conclusions

- Air purifiers were efficient in reducing airborne particulate matter in the studied case studies (36-93%).
- The air quality and health safety in natural ventilated hospital building can be significantly improved using air purifiers.
- In Finland in older hospital building air purifiers produced clean air in hospital rooms, achieving nearly the same standardized limits as newly built isolation rooms.
- Measurements play a key role in our search for methods to tackle pandemics.
- Ventilation system commissioning is crucial for ensuring optimal system performance, energy efficiency, and indoor air quality by verifying that all components operate as designed.
- While it is challenging to measure air pathologies directly, measuring and controlling particulate matter (PM) is an indirect way to monitor and improve air quality and health safety.

# Publications related to the study

Transient zonal model for predicting indoor airflows in naturally ventilated buildings: A case study of hospital patient rooms
Natalia Lastovets, Anni Luoto, Mohamed Elsayed, Piia Sormunen
E3S Web of Conf. 562 09004 (2024)
DOI: 10.1051/e3sconf/202456209004

Particle concentration and indoor air quality in mechanically ventilated isolation patient rooms-A field study in a hospital building in Espoo, Finland.
Elsayed, Mohamed; Silvonen, Ville; Lintusaari, Henna et al.
2024. 667-674 Abstract from Indoor Air, Honolulu, United States.

Indoor air modelling and infection risk assessment in a naturally ventilated patient room
Lastovets, N., Elsayed, M., Silvonen, V., Luoto, A. & Sormunen, P., Oct 2023, Ventilation, IEQ and health in sustainable buildings: Proceedings of 43rd AIVC Conference, 11th TightVent Conference, 9th venticool Conference. p. 826-835

Particle concentration and indoor air quality in naturally ventilated patient rooms: A field study in a hospital building in Bucharest, Romania
Elsayed, M., Lastovets, N., Silvonen, V., Luoto, A., Rönkkö, T. & Sormunen, P., 9 Oct 2024, Retrofitting the Building Stock: Challenges and Opportunities for Indoor Environmental Quality. Wouters, P., Janssens, A. & Kapsalaki, M. (eds.). Vol. 44 th AIVC Conference . p. 93-102 10 p.

Evaluating the impact of air purifiers and the influence of ventilation and location to PM2.5, BC and LDSA in the indoor air of European hospitals: Case Studies from Finland and Romania
Planned journal article

# Thank You!

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