



Overview of results  
Research project E3:  
Protective air solutions; excellence  
in pandemic response.

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# Consortium



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

- The E3, Excellence in Pandemic Response and Enterprise Solutions Co-Innovation project is one of the largest collaboration projects between companies and research institutes ever funded by Business Finland.
- 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.

22 companies

7 research  
organizations

Duration  
2,5 years

International  
cooperation

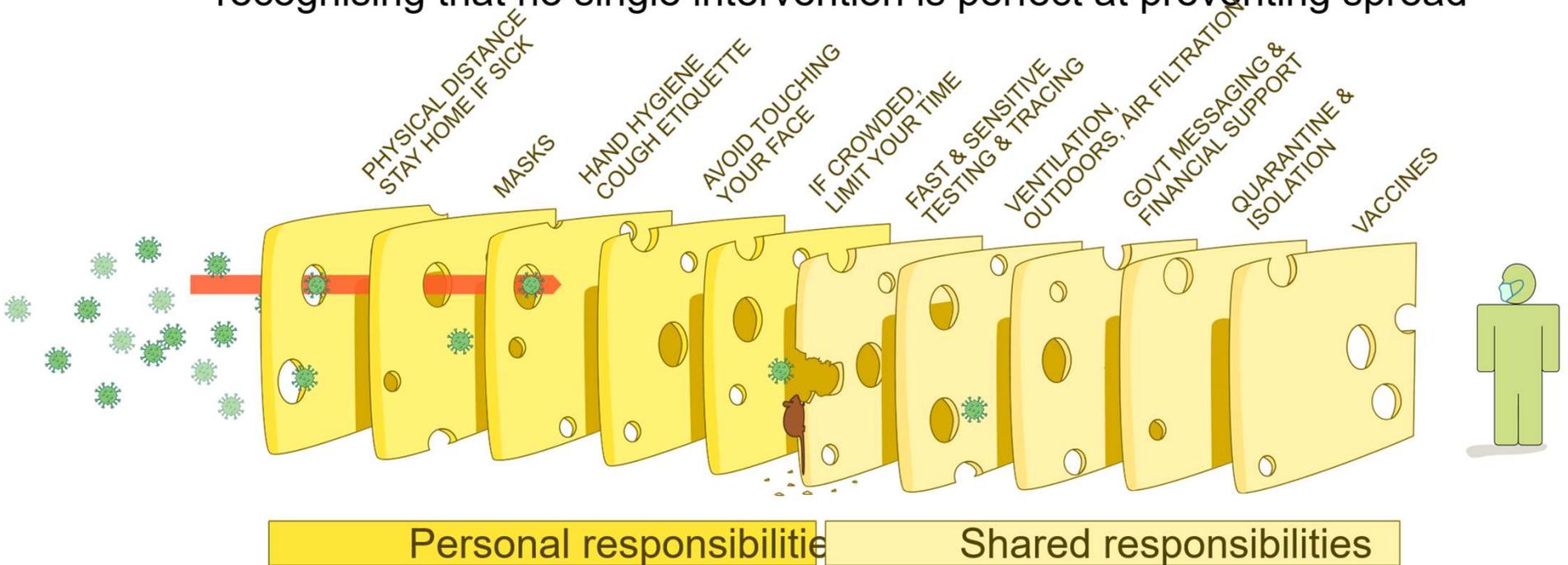


- The E3 project wants to harness modern science and technology to create effective countermeasures to prevent the spreading of novel infectious diseases.
- The diversity of countermeasures is key to fighting pandemics. Finding effective protection strategies towards pandemics, and infectious diseases in general, requires a multidisciplinary approach and close co-operation between different specialists, like medical doctors and engineers.
- The aim is to have technical solutions already in place during the current pandemic and before the next pandemic emerges, there would be technological solutions available and installed in indoor environments mitigating the transmission of pathogens in spaces where people meet.



# The Swiss Cheese Respiratory Virus Pandemic Defence

recognising that no single intervention is perfect at preventing spread

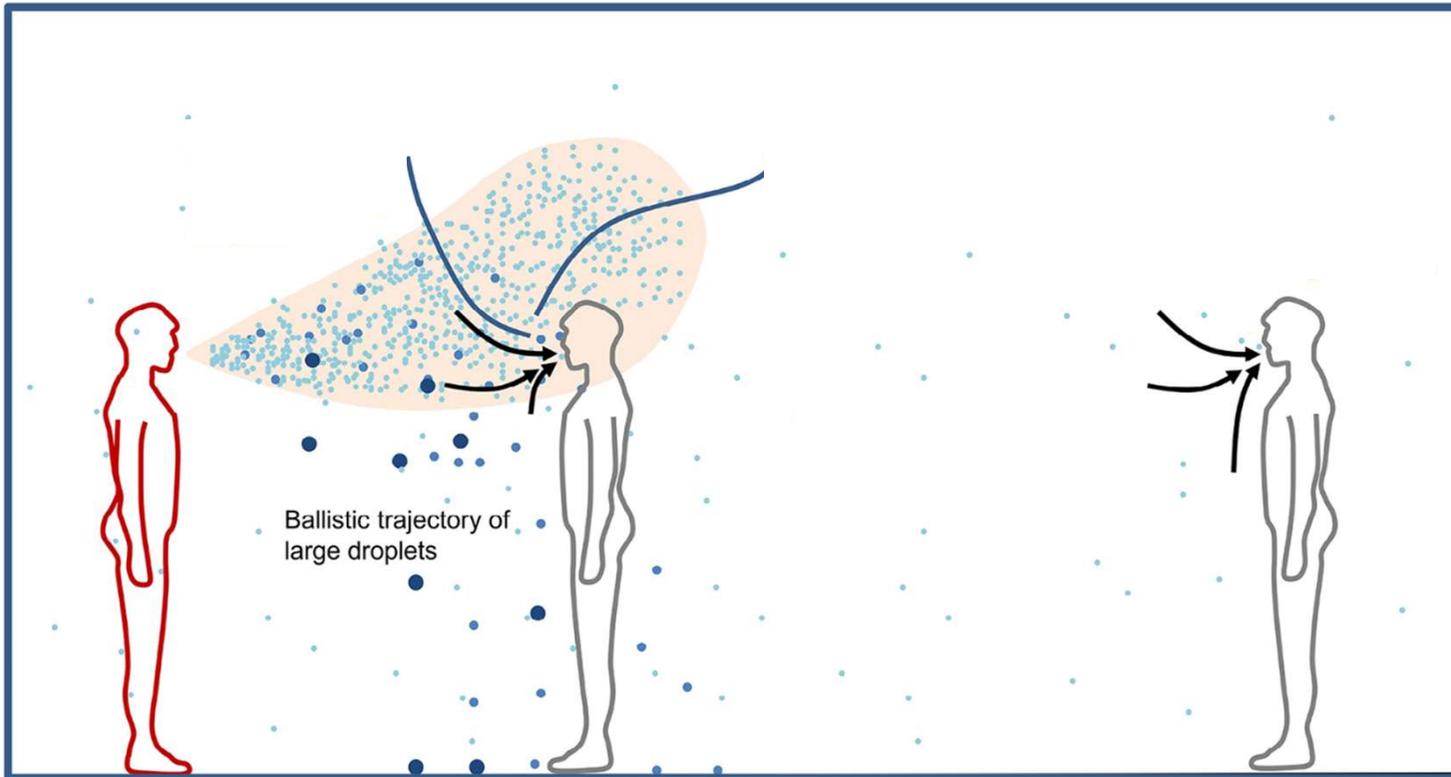


Each intervention (layer) has imperfections (holes).  
Multiple layers improve success.

Ian M Mackay  
virologydownunder.com  
with thanks to jody lanard, katherine arden & the Uni of Qld  
Based on the Swiss cheese model of accident causation, by James T Reason, 1990  
version 3.0  
update: 24oct2020

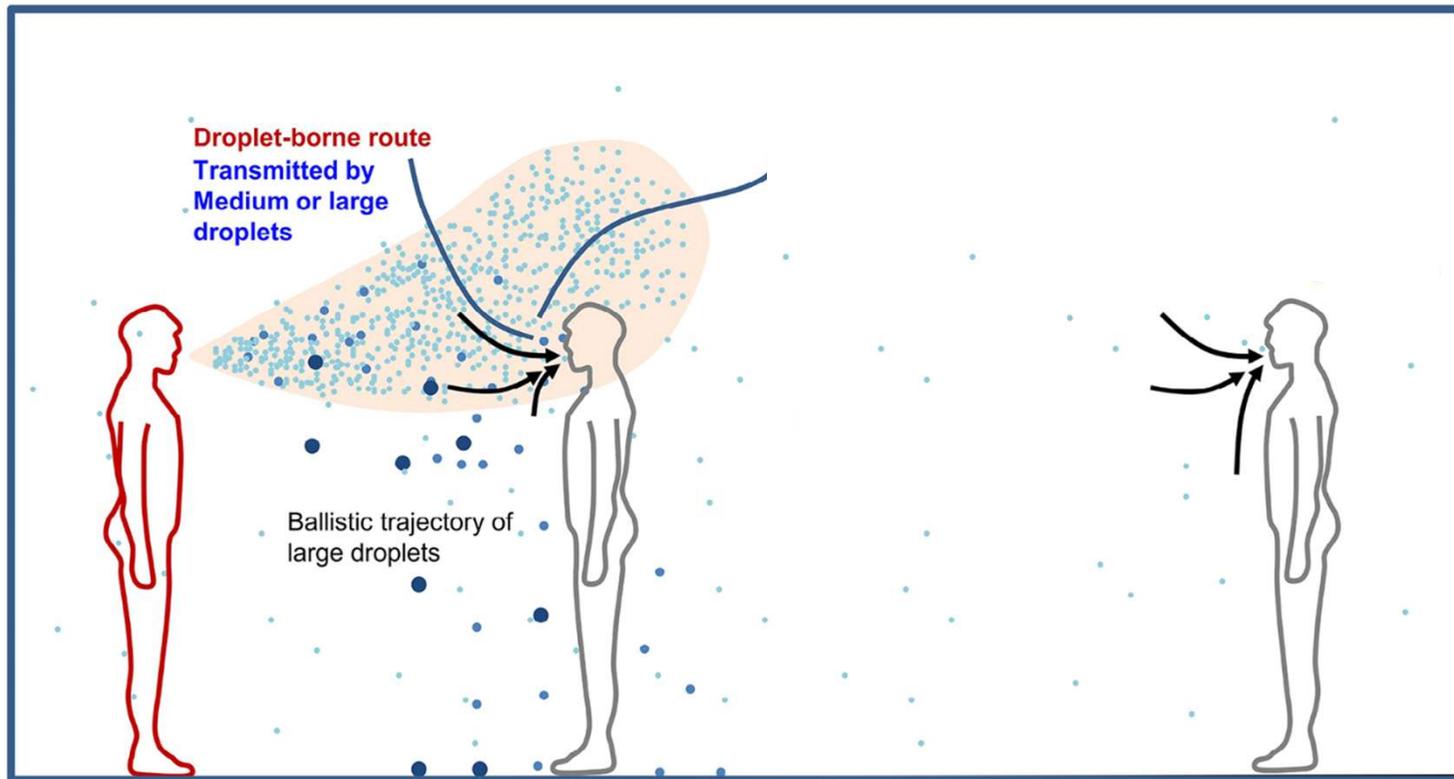


# Transmission Routes



Wei, Jianjian, and Yuguo Li.  
'Airborne Spread of Infectious  
Agents in the Indoor  
Environment'. *American Journal  
of Infection Control*, Indoor Air as  
a Vehicle for Human Pathogens,  
44, no. 9, Supplement (2  
September 2016): S102–8.

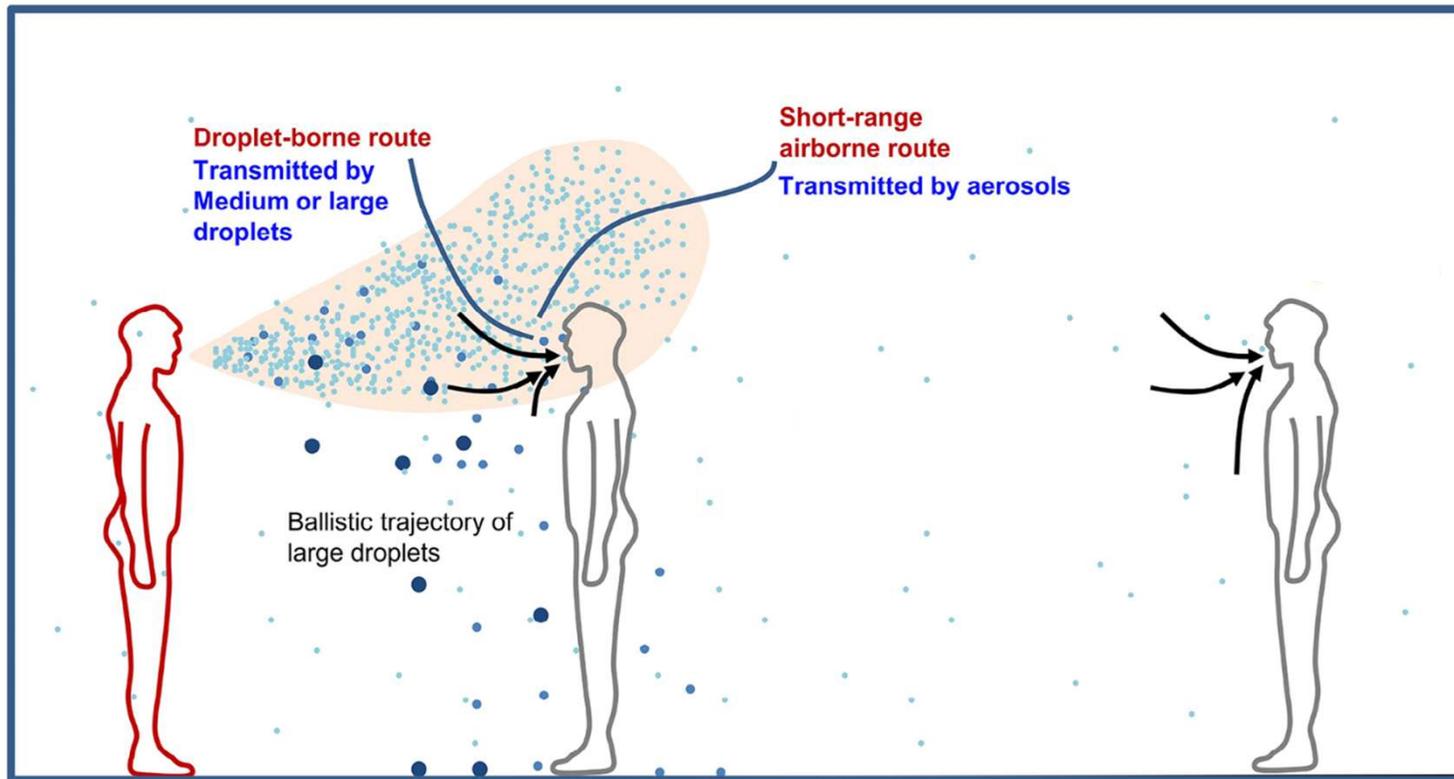
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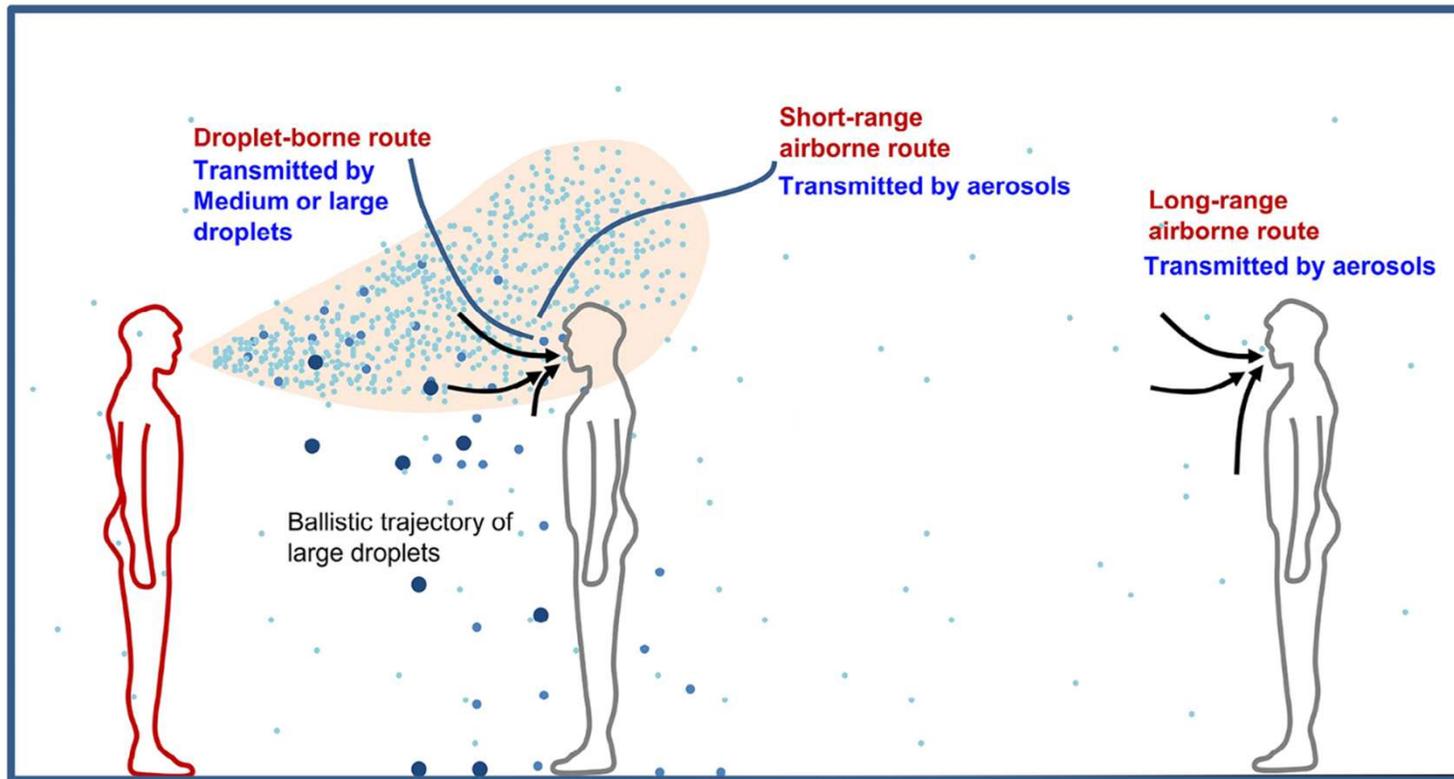


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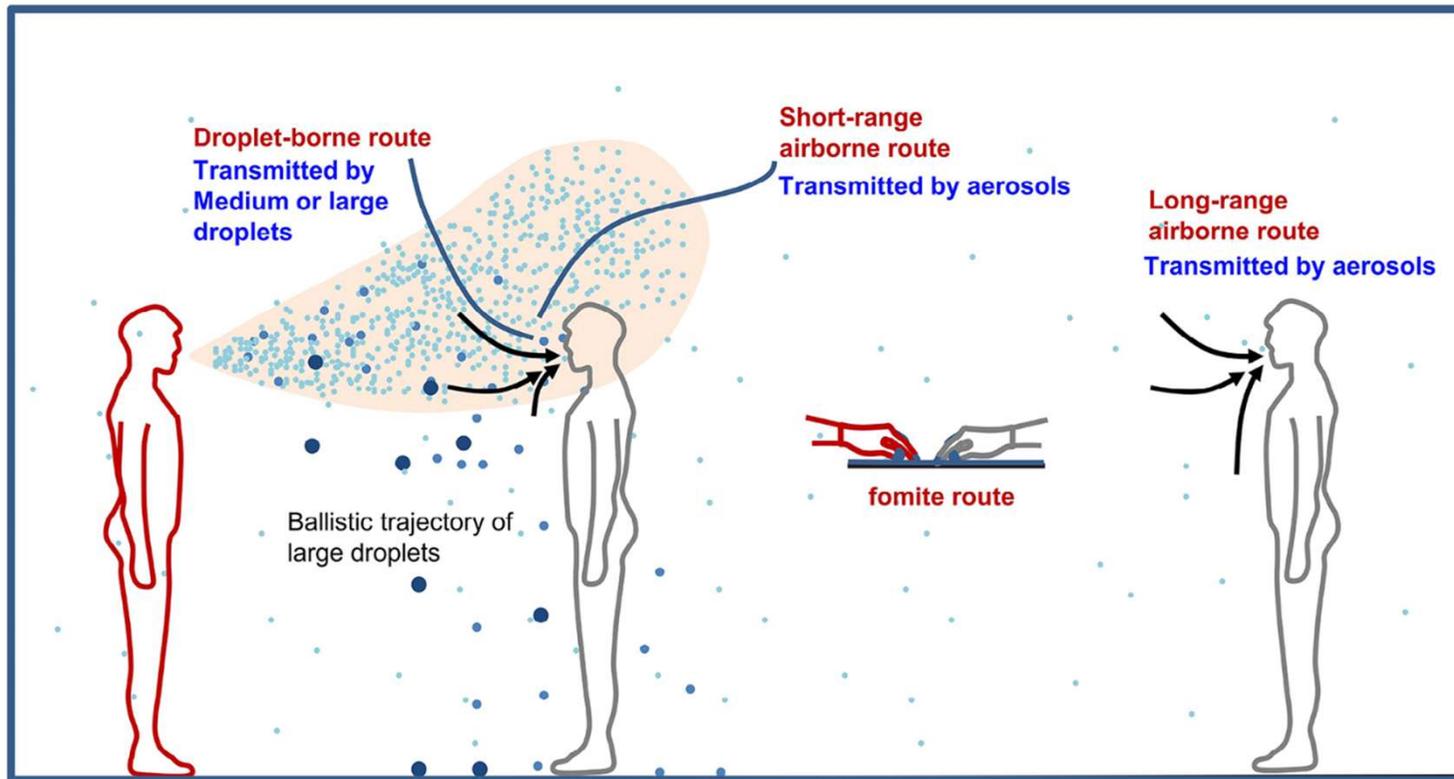
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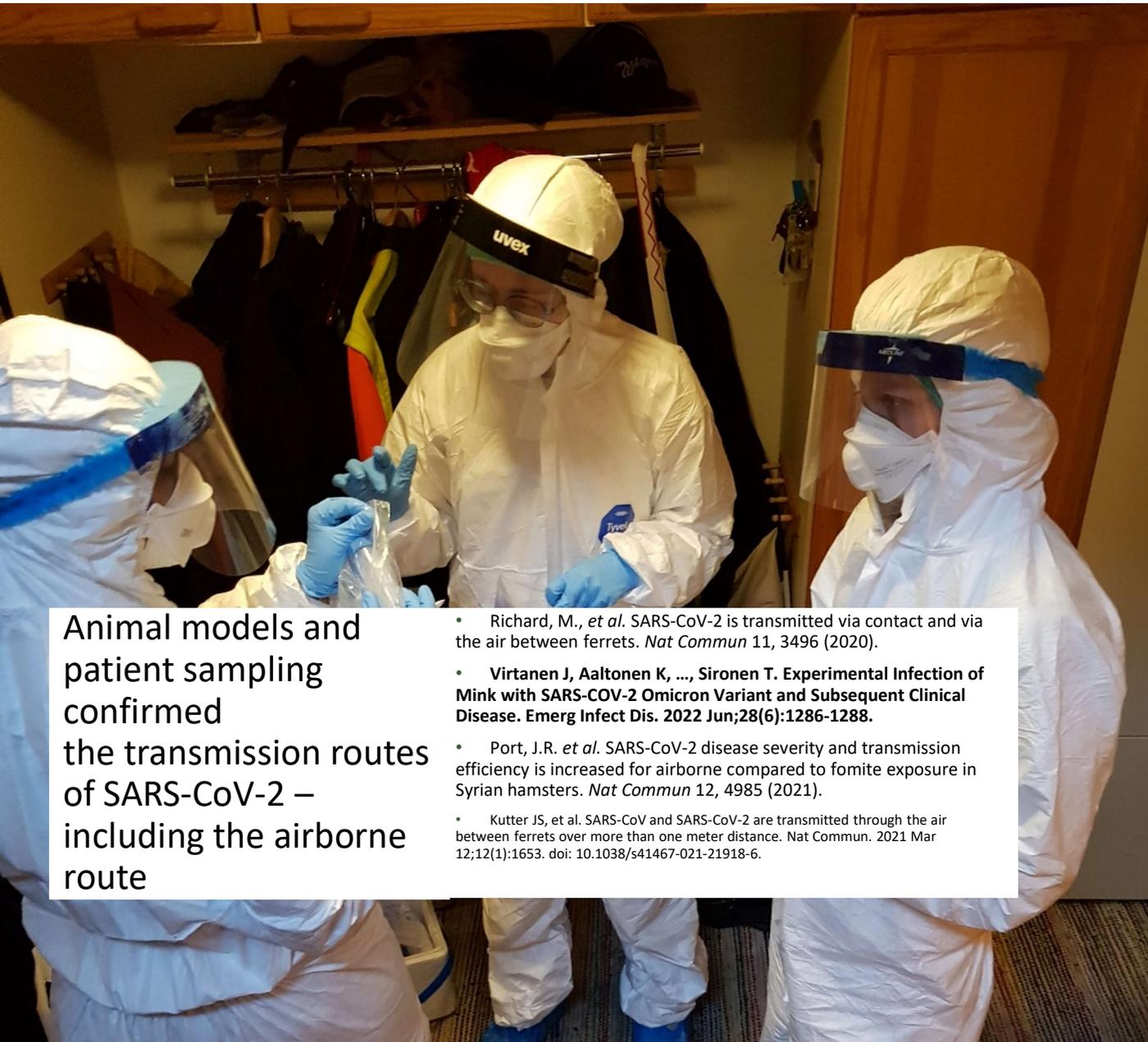


# Transmission Routes



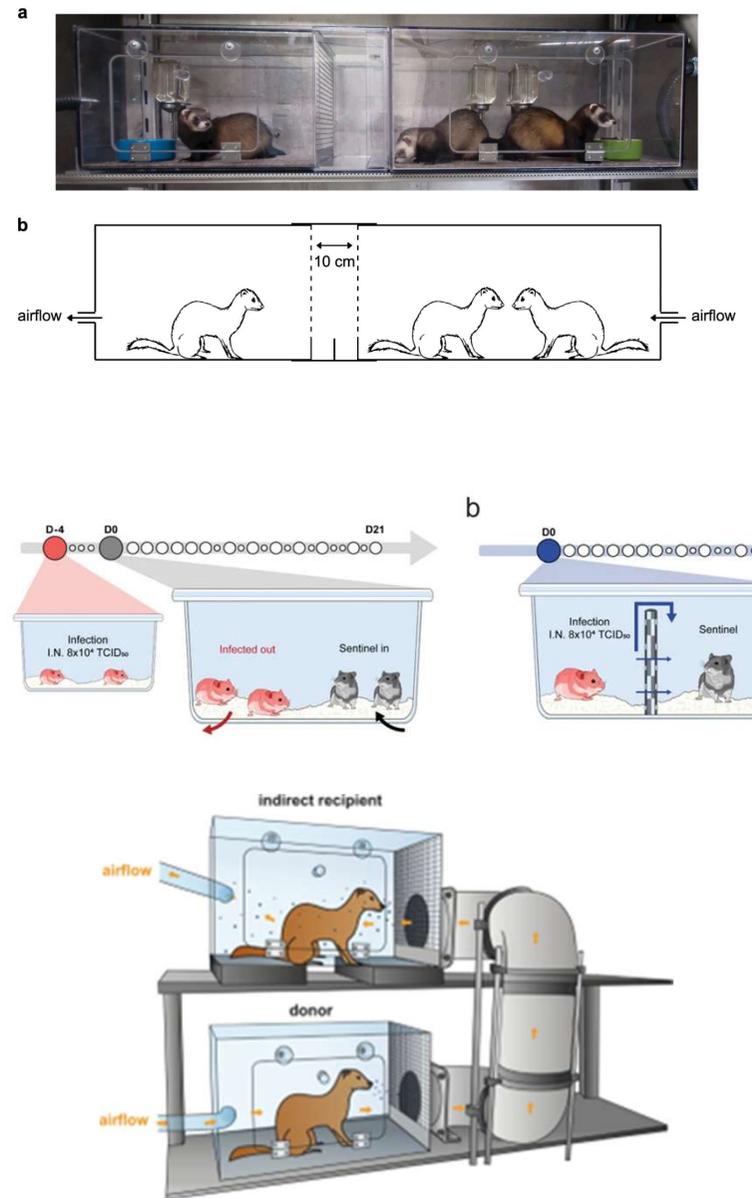
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Animal models and patient sampling confirmed the transmission routes of SARS-CoV-2 – including the airborne route

- Richard, M., *et al.* SARS-CoV-2 is transmitted via contact and via the air between ferrets. *Nat Commun* 11, 3496 (2020).
- Virtanen J, Aaltonen K, ..., Sironen T. Experimental Infection of Mink with SARS-CoV-2 Omicron Variant and Subsequent Clinical Disease. *Emerg Infect Dis.* 2022 Jun;28(6):1286-1288.
- Port, J.R. *et al.* SARS-CoV-2 disease severity and transmission efficiency is increased for airborne compared to fomite exposure in Syrian hamsters. *Nat Commun* 12, 4985 (2021).
- Kutter JS, *et al.* SARS-CoV and SARS-CoV-2 are transmitted through the air between ferrets over more than one meter distance. *Nat Commun.* 2021 Mar 12;12(1):1653. doi: 10.1038/s41467-021-21918-6.

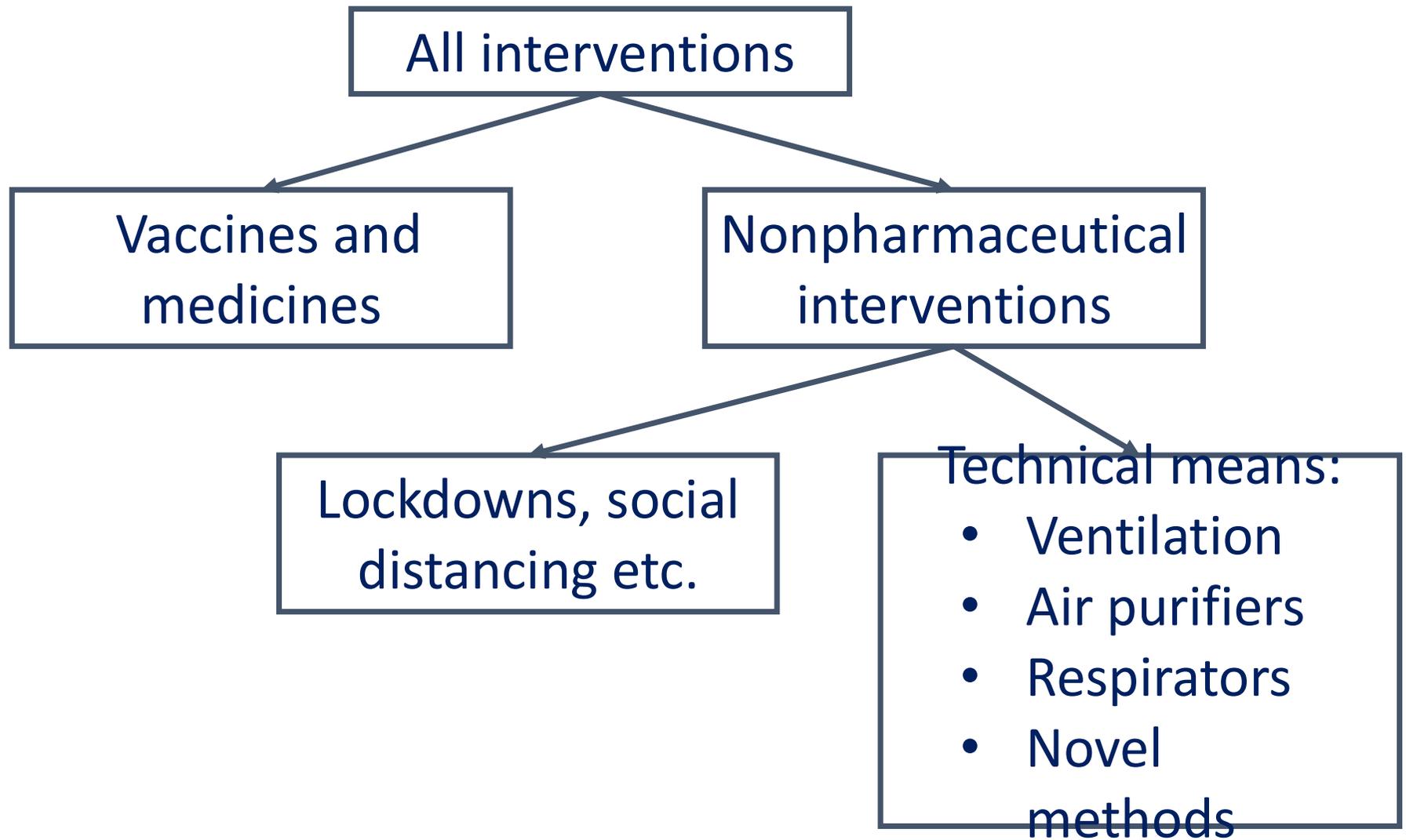


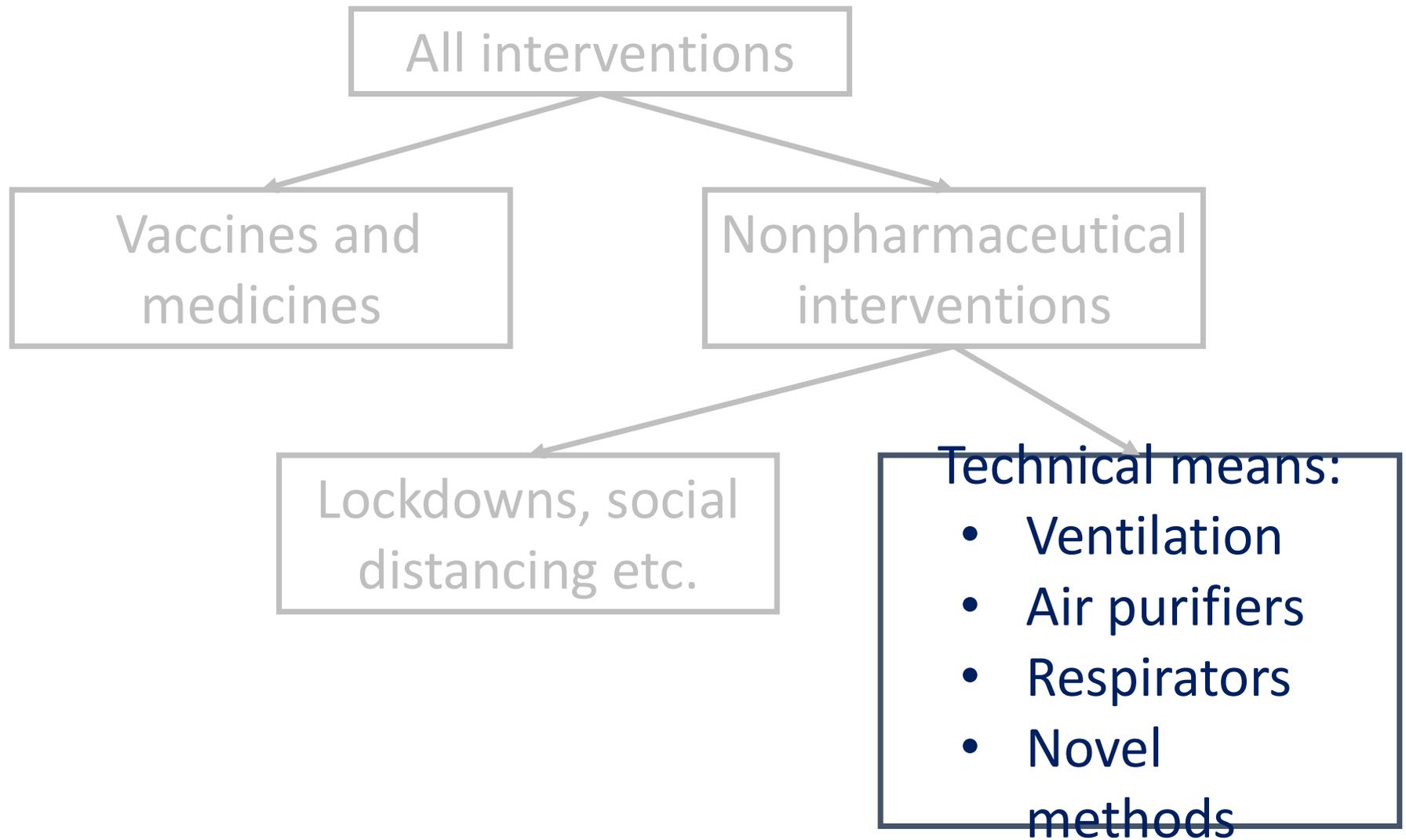
What can we  
do?



[www.pandemicresponse.fi](http://www.pandemicresponse.fi)







# Airborne contamination control

Technical means:

- Ventilation
- Air purifiers
- Respirators
- Novel  
methods

# What can we do?



Move Pathogens from Inside to Outside



Collect Pathogens

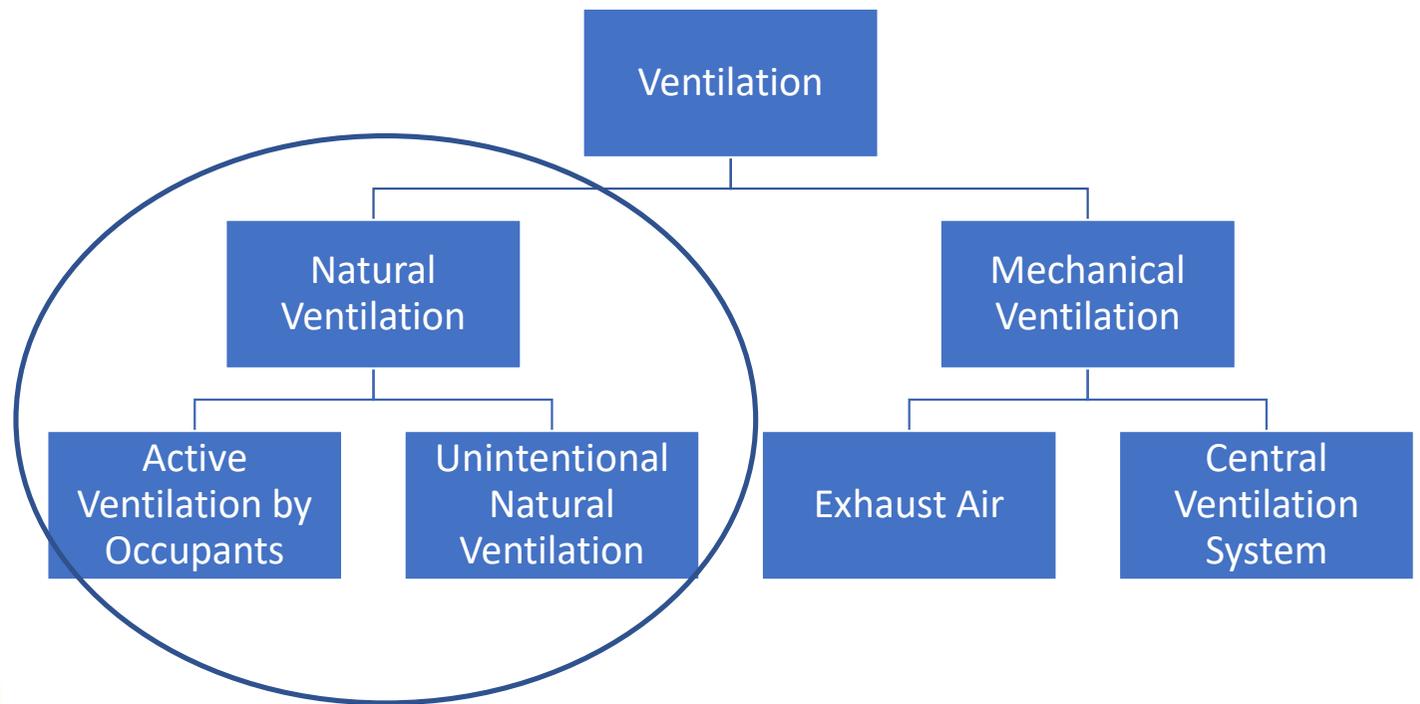


Inactivate Pathogens

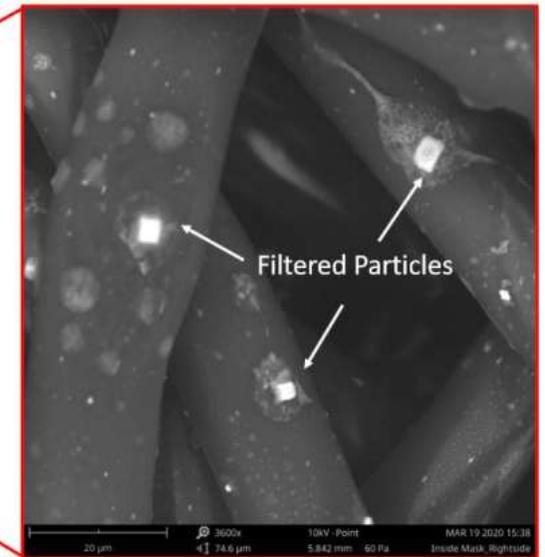
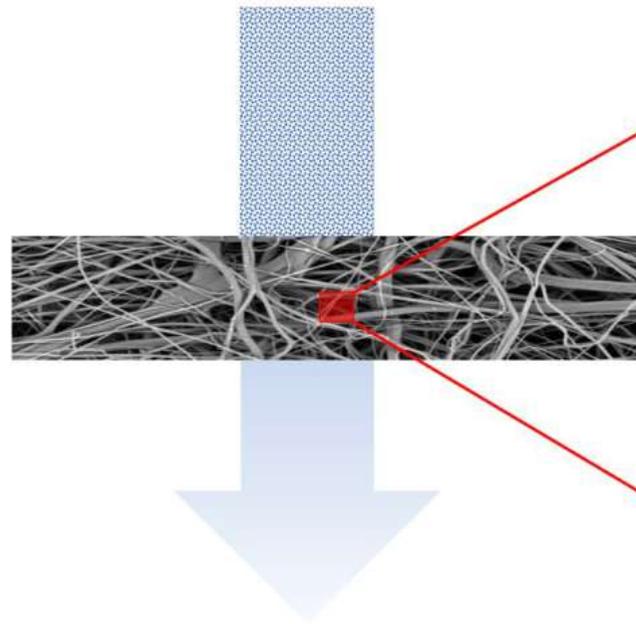


Redistribute Pathogens

# Ventilation



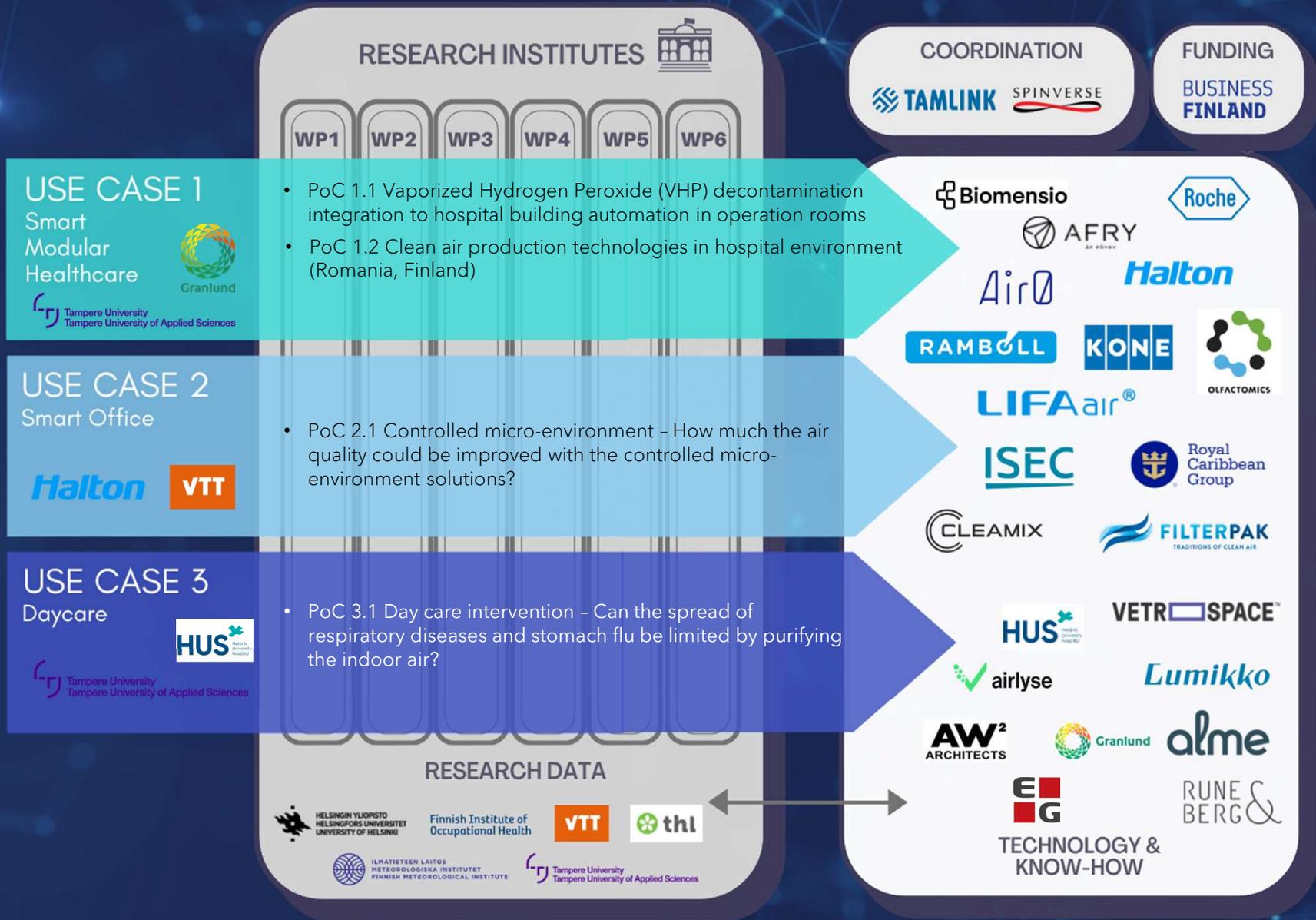
Generally inadequate →  
Other methods are needed



[Best indoor air purifiers - High filtration efficiency - Air0 Purifiers - Air0](https://www.nanoscience.com/applications/materials-science/effectiveness-of-masks-fast-answers-with-automated-sem-analysis/)

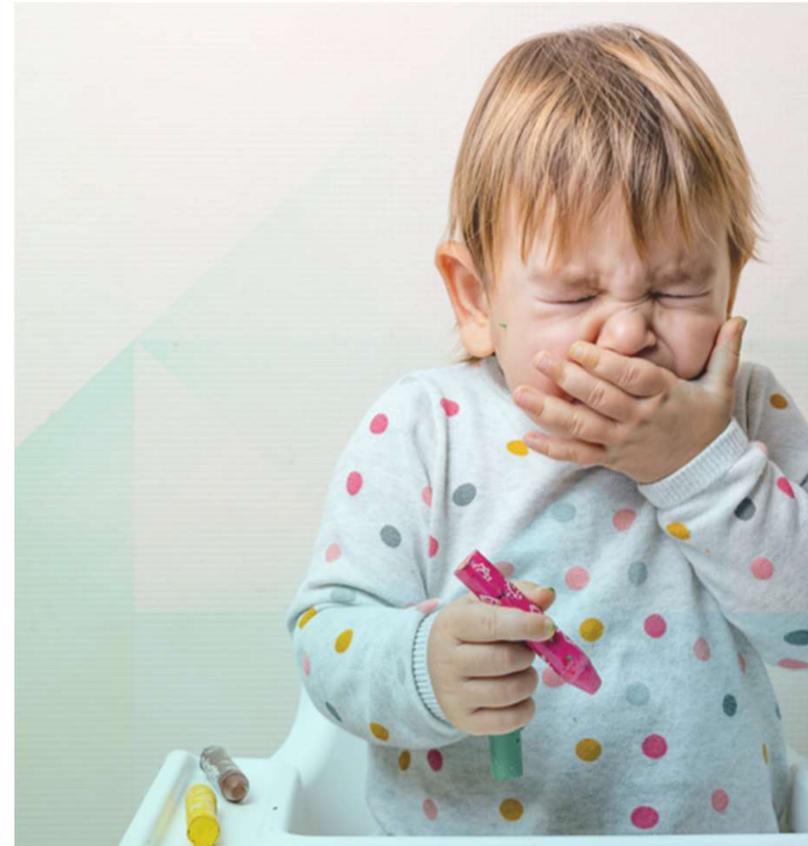
<https://www.nanoscience.com/applications/materials-science/effectiveness-of-masks-fast-answers-with-automated-sem-analysis/>

# USE CASES



# The incidence of illness among daycare children decreased by 18% by increasing the production of clean air

- In the E3 project, a study was conducted on the impact of producing clean air on reducing illness among daycare children.
- The study provided scientific evidence of the airborne transmission of respiratory infections.
- The results support the importance of ventilation and air purification in the airborne spread of infections.
- Several leading companies participated in the collaboration, contributing diagnostics, air purification, ventilation, and sensor technology to the research.



# Research question?

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

Smart Modular Health care

Case studies

Naturally ventilated building  
&  
Mechanically ventilated buildings

Bucharest & Helsinki & Espoo



Matei Balș hospital Bucharest



# Methods

## IAQ Measurements



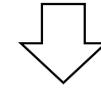
Measure key parameters that correlate with good indoor air quality (IAQ).

## Air purifier intervention



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

## Simulation



Infection risk probability



### Air quality parameters studied

Particulate matter (PM)

The lung-deposited surface area (LDSA)

Total volatile organic compounds (TVOC)

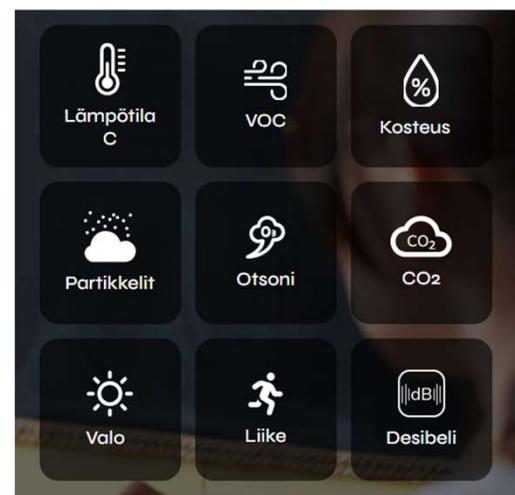
CO<sub>2</sub> concentrations

Black carbon concentration (BC)

Temperature & Relative humidity (RH%)

Pressure differentials (PD) and air flow rate

# Measuring equipment and air quality parameters studied



Alphasense  
PM<sub>1</sub>, PM<sub>2.5</sub> and PM<sub>10</sub>



Observair  
Blak Carbon (BC)



HOBO  
CO<sub>2</sub> / (T)/RH%



Partector  
LDSA





# Air purification technologies



# Main key findings

## PM<sub>2.5</sub> Results

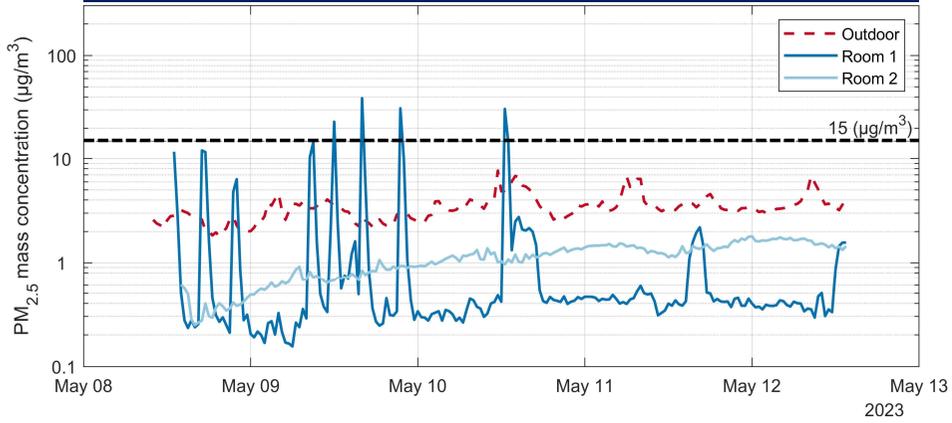
Air change per hour in isolation room

Calculated probability of airborne infection in Covid room



No intervention

### Mechanically ventilated - Helsinki

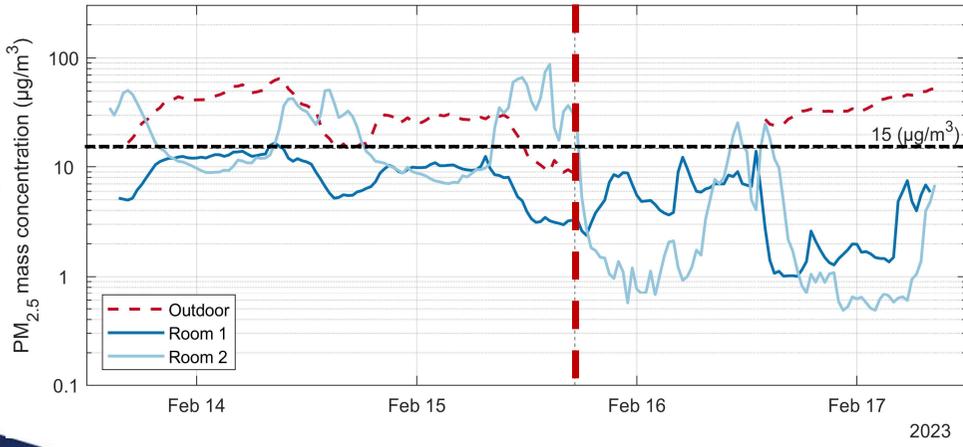


# PM<sub>2.5</sub> Results

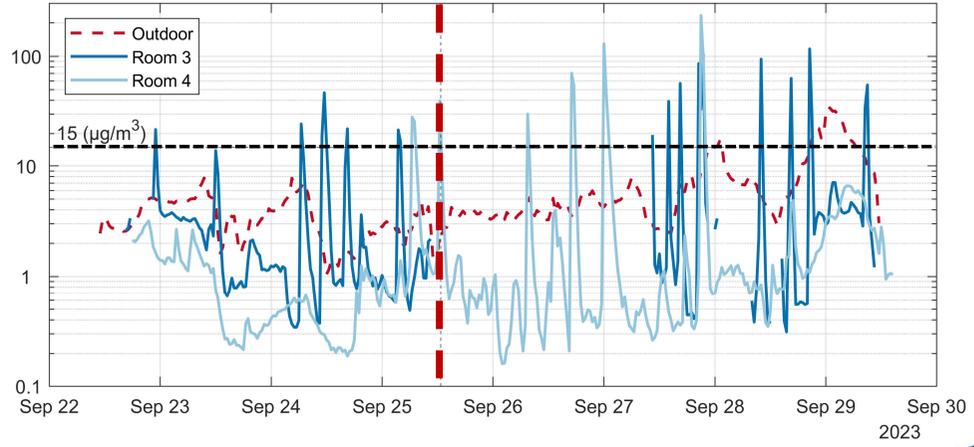
*PM<sub>2.5</sub> mass concentration (time series)*  
 Room 1=isolation room  
 Room 2=patient room

With intervention

### Naturally ventilated - Bucharest



### Mechanically ventilated - Espoo



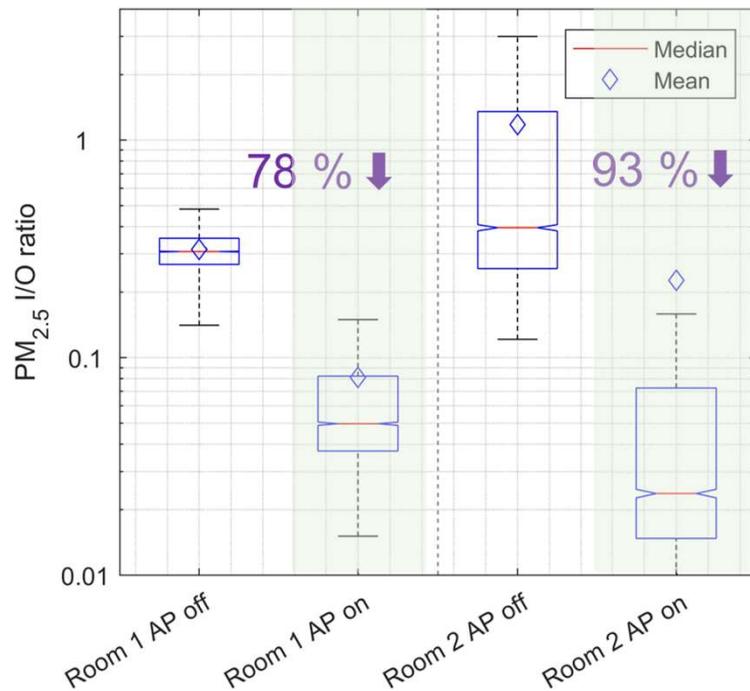
*PM<sub>2.5</sub> mass concentration (time series) before and after installing the – air purifier.*



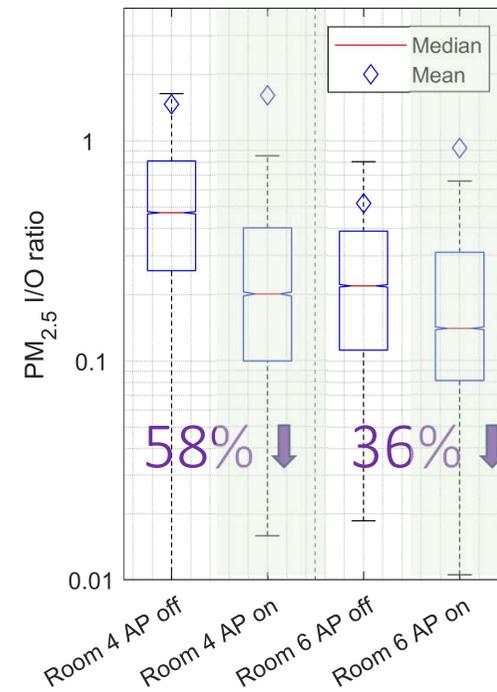
# PM<sub>2.5</sub> Results

Boxplots indicate the interquartile range of data with whiskers extending from the 1<sup>st</sup> and 3<sup>rd</sup> 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<sub>2.5</sub> mass concentration indoor to outdoor ratios*



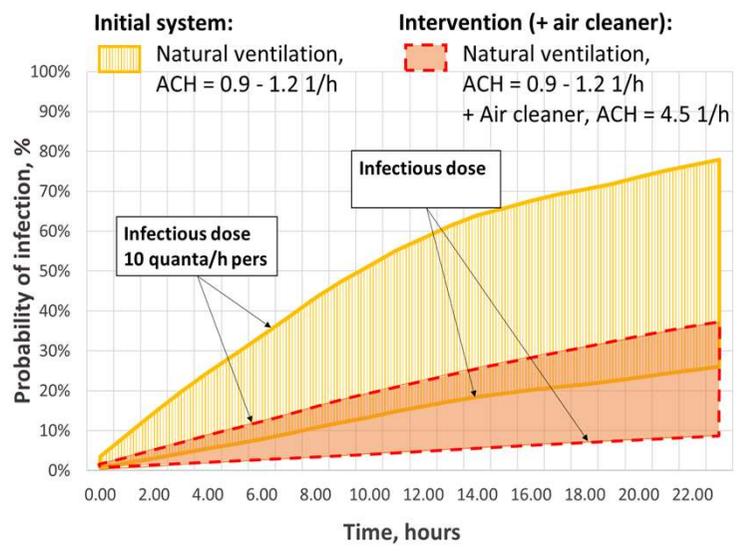


# Clean air production in isolation room

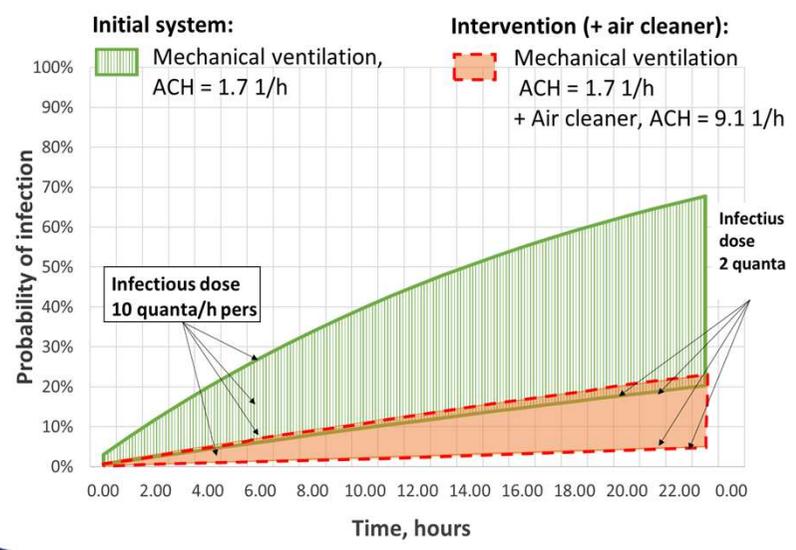
Case studies Isolation rooms	Ventilation type	Clean air production 1/h					
		Initial situation			Intervention	Design requirements for isolation rooms, total ACH	
		Design value Mechanical ventilation Air change per ACH [1/h]	Measured value Air change per hour ACH [1/h]	Air purifier Clean air delivery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

\* Simulated ACH with Ida-Ice program

Naturally ventilated - Bucharest



Mechanically ventilated - Espoo



# Calculated probability of airborne infection in covid room

52-65%

74-66%

Calculated infection risk reduction by air purifier

## Initial data

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



# Conclusions

- Solid scientific evidence shows that SARS-CoV-2 spreads mostly by airborne transmission. Other modes include droplet, fomite, and zoonotic transmission.
- Spaces can be made healthier and safer with technical solutions
- **A scientific estimate of infection risk can be calculated**



# 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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