Deutschland und Finnland im Vergleich: Analyse der Raumlufthygiene in Patientenräumen

HEINZ TROX STIFTUNG

AACHENER TAG DER LUFTQUALITÄT
& NACHHALTIGER ZUKUNFTSRAUM PFLEGE

Aachen, 20. September 2022

HEINZ TROX STIFTUNG

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dECOnhealth

Demand Controlled Ventilation in Healthcare Settings

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Helsinki University Hospital

RWTH AACHEN UNIVERSITY

TURKU AMK
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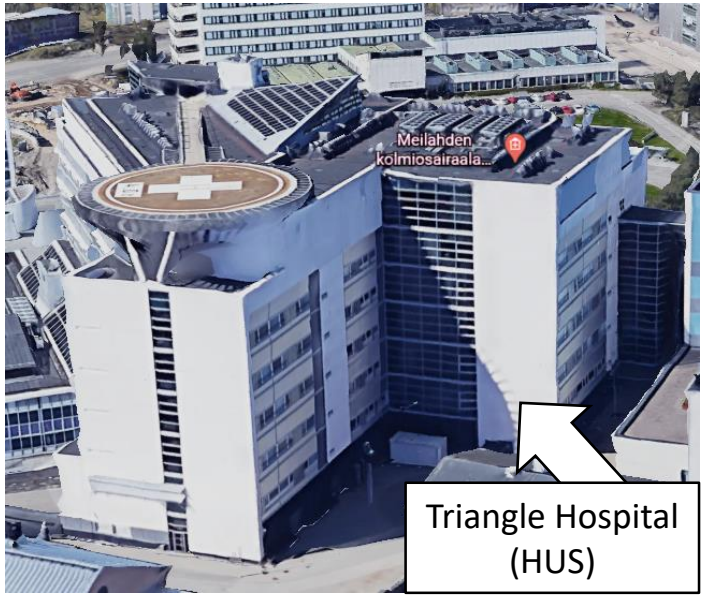
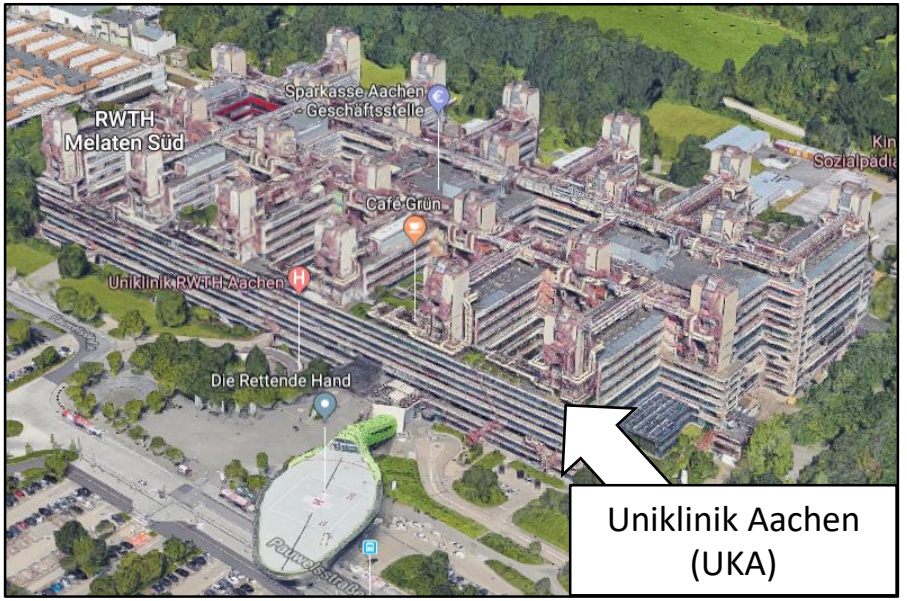
BUSINESS FINLAND

Indoor air quality measurement campaign – The Hospitals



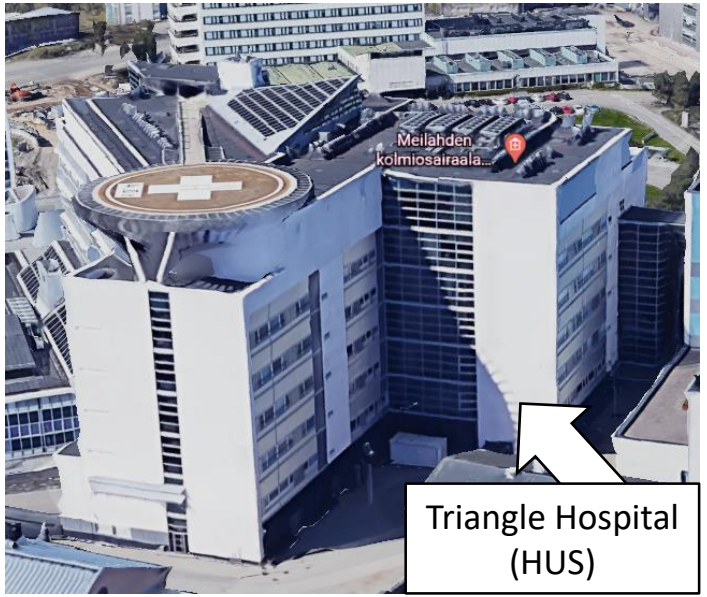
Triangle Hospital (HUS)



Uniklinik Aachen (UKA)

Indoor air quality measurement campaign – The HUS Triangle hospital

- **The Building is located in Meilahti (Helsinki), Finland**
- **The building was rather new, the construction was finished in 2010**
- **The building has 9 floors: 1 floor underground, and 8 floors above ground level**
- **The total floor area of the building was 21 600 m2 and it had almost 1000 rooms**
- **The building had mechanical ventilation with 34 air handling units serving the whole building**
- **Space heating was supplied with water-based radiators and cooling only through the supply air**
- **The air handling units were operating 24 hours per day and they had constant flow rate all the time**

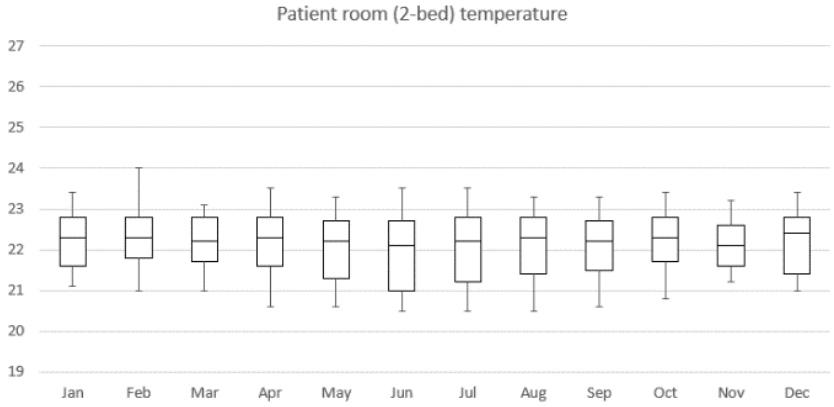


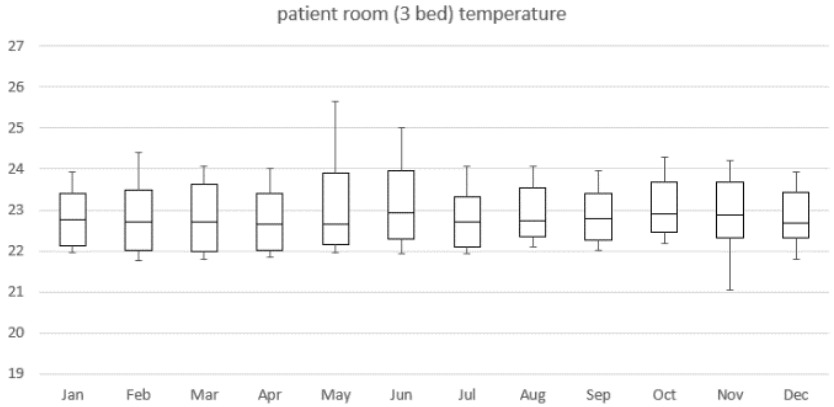
IAQ measurements at the HUS Triangle Hospital Building

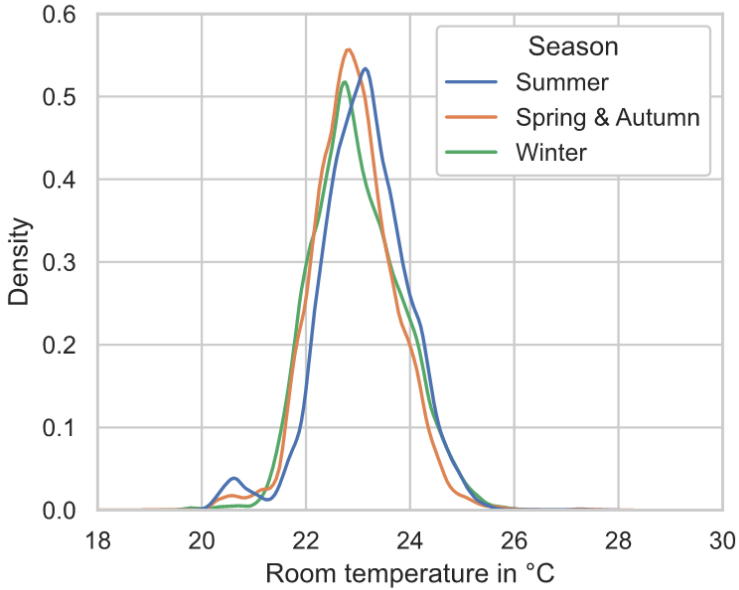
- **A wireless sensor network was installed into the hospital to monitor indoor conditions, i.e. temperature, CO2, relative humidity, TVOC, barometric pressure etc.**
- **In total data from 45 sensors (TUAS and HUS sensors) were analyzed in this study**
- **Data shown here was collected in 2020**

Space type	Number of Rooms
Isolation rooms	12
Patient rooms	13
Offices	5
Corridors	5
Consulting rooms	3
Treatment rooms	2
Break rooms	1
Supply air duct	4
In total	45

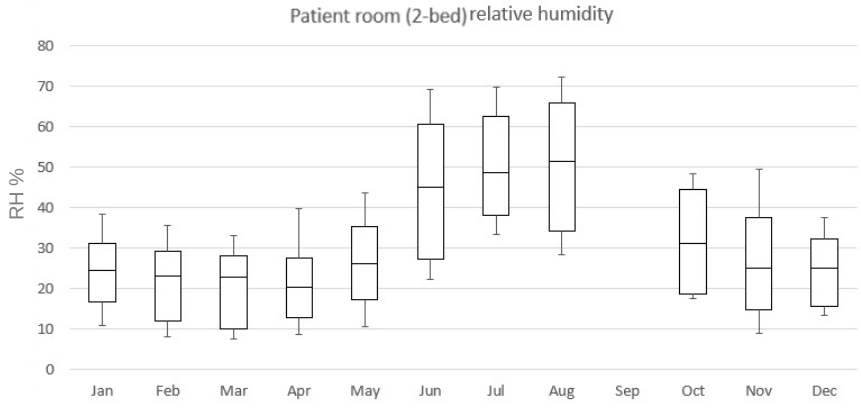
Temperature – Monthly and per season (HUS)

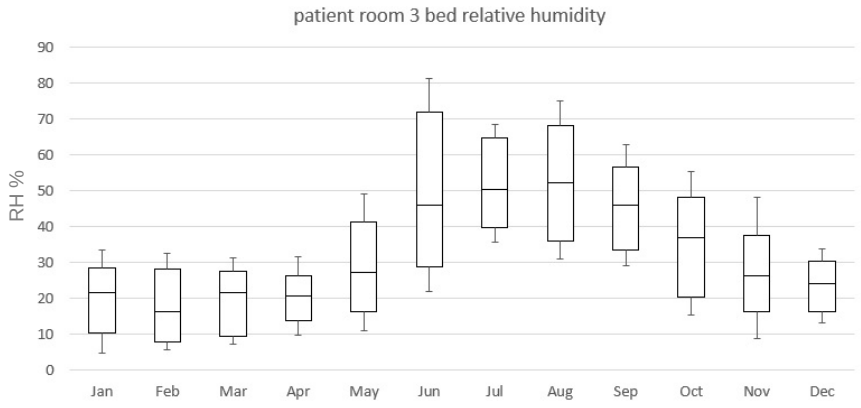


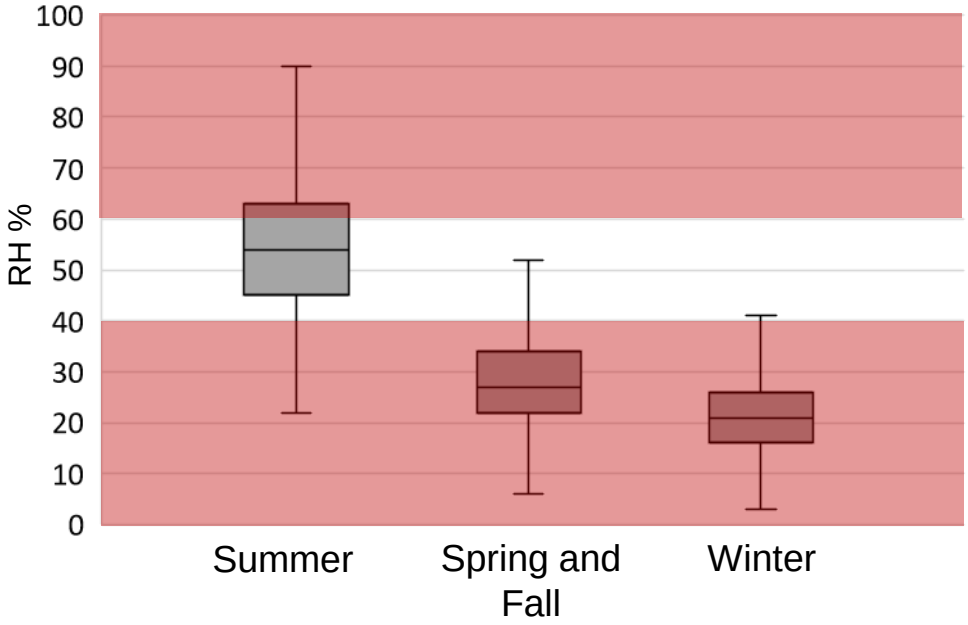




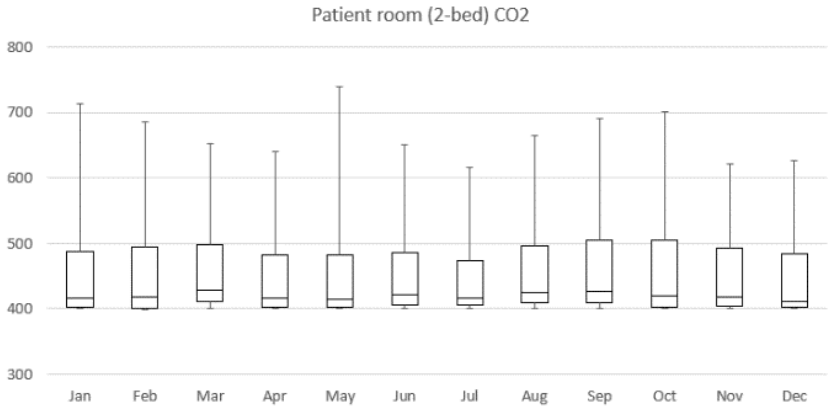
Humidity – Monthly and per season (HUS)

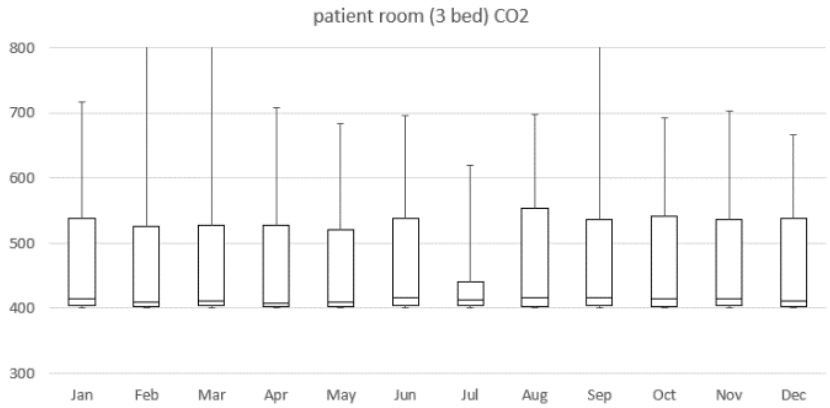




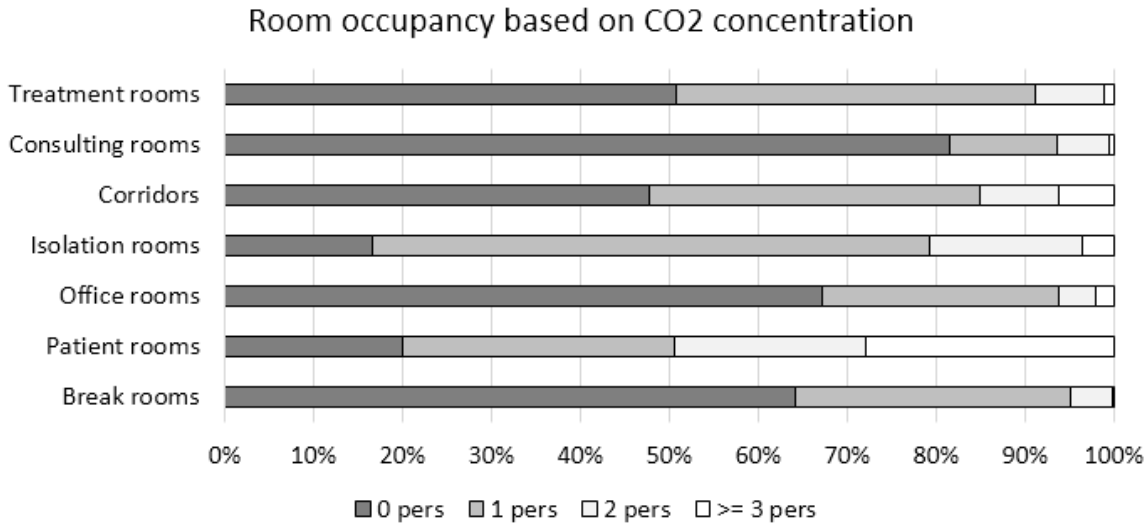


CO_2 – Monthly (HUS)





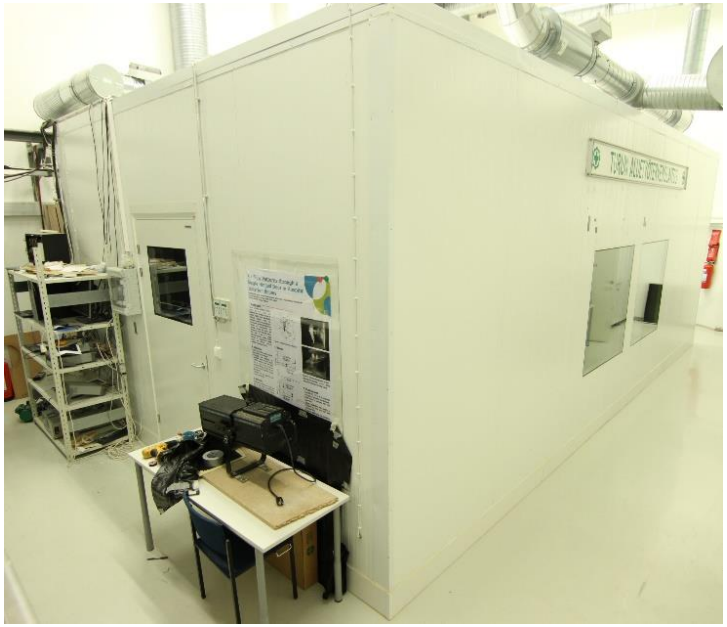
Occupancy (HUS)



Summary (IAQ measurement campaign at HUS)

- Room temperatures were on good level and did not fluctuate substantially between seasons
- RH varied greatly depending on season, low humidity during winter, spring and fall (no humidification in AHU)
- CO_2 concentrations were found to be on low level throughout the year
- In general, occupancy was high in the monitored hospital
    - Occupancy was especially high in isolation and patient rooms (used 24/7)
    - Occupancy in offices, treatment and consultation rooms were notably lower than in isolation and patient rooms (they are typically used during normal office hours)

Ventilation, air distribution and Healthcare worker exposure to exhaled breath of a patient (Airborne-project)



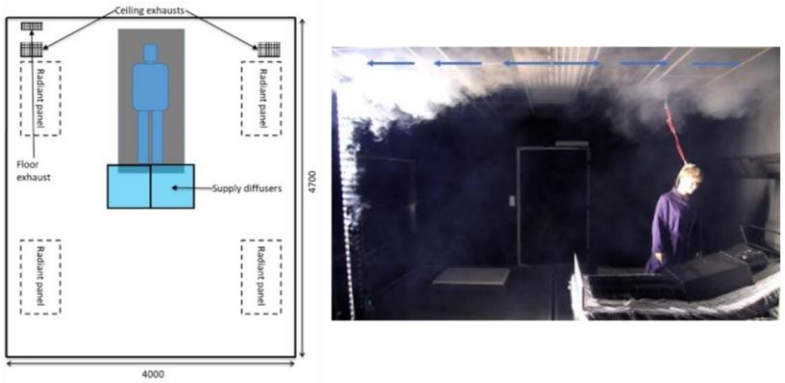
Methods

- **Isolation/patient room model**
  - A full-scale model of a patient/isolation room (LxWxH: 4 m x 4.7 m x 2.6 m)
  - Breathing thermal manikins with realistic exhalation, thermal plumes etc.
- **Smoke visualizations**
  - Theater smoke used to illustrate the dispersal of patient exhaled airborne pathogens and qualitatively assess the HCW exposure
- **Tracer gas experiments**
  - Tracer gas (SF6) was dosed into the exhalation of the patient and measured from the inhalation of the HCW manikin (and from the extracts) to assess the exposure
- **Air speed measurements**
  - Air speed was measured with hot sphere anemometers to assess the air movement above and around the patient bed
- **Thermal comfort measurements**
  - Thermal manikin was used to assess the patient thermal comfort when lying in the bed (using PMV scale)

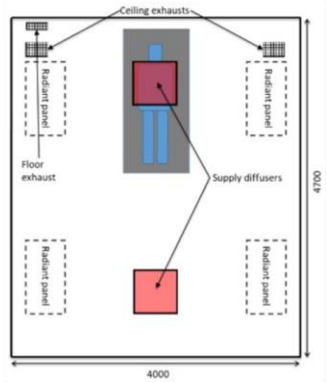
Methods

- **Examined supply air distributions**
  - Carried out with 4-12 ACH (85-170 L/s) ventilation rate
  - Supply air temperature 19 ˚C, room air temperature 22.5 ˚C
  - Total heat load of 750 W (HCW, patient, lighting, solar load, equipment)

Overhead mixing ventilation

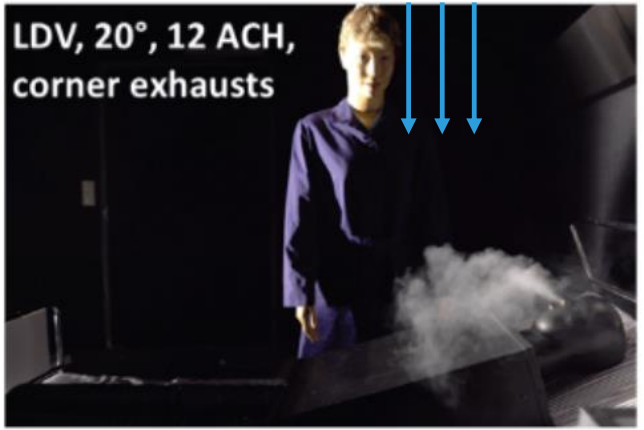


Local downward ventilation



Results (smoke visualizations)

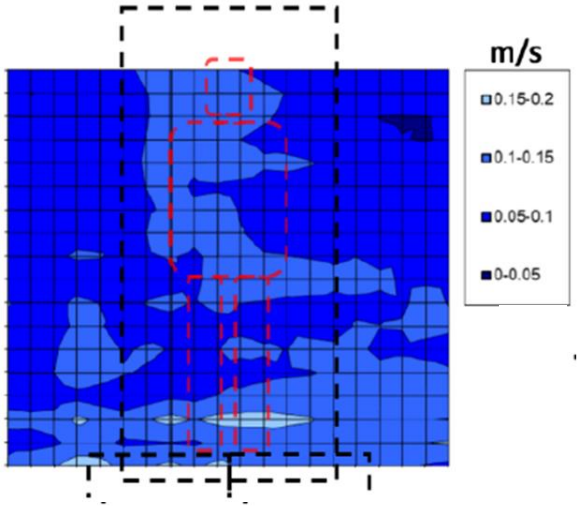
- **Smoke visualizations of the spreading of the exhaled air of the patient**
  - 12 ACH in both cases (170 L/s)
  - MV: all air supplied along the ceiling (170 L/s)
  - LDV: downward part 40 L/s, mixing part 130 L/s



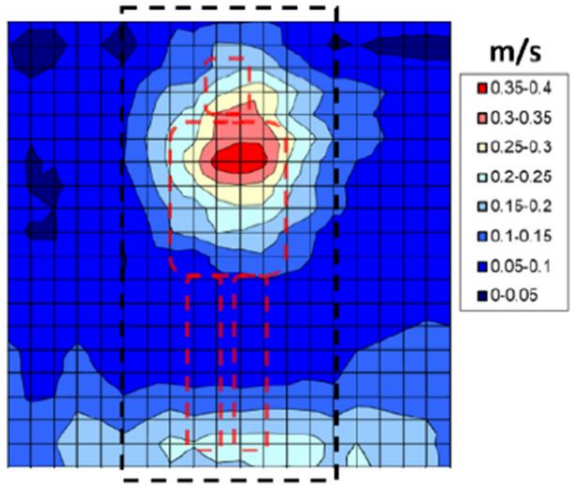
Results (air speed and thermal comfort)

- **Measured velocities and thermal comfort of the patient:**
  - 12 ACH, 22.5 °C room air temperature
  - MV: all air supplied along the ceiling (170 L/s)
  - LDV: downward part 40 L/s, mixing part 130 L/s

MV = Mixing ventilation



LDV = Local Downward Ventilation



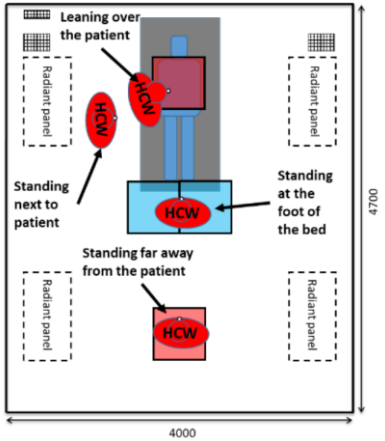
Thermal comfort

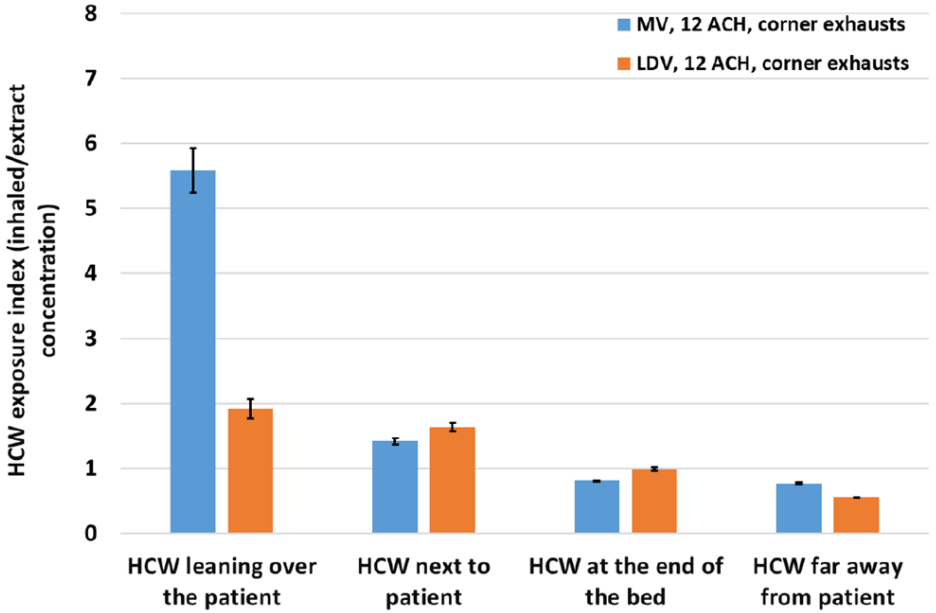
Case	Parameters				Results	
	clo	met	T_{eq} (°C)	RH (%)	PMV	PPD (%)
MV	1.5	0.9	22.6	50	0.1	5
LDV	1.5	0.9	20.8	50	-0.4	8

Kalliomäki, P., Koskela, H., Waris, M. and Tang, J. W-T. (2020). https://iosh.com/media/8432/aerosol-infection-risk-hospital-patient-care-full-report.pdf.

Results (tracer gas measurements)

- **HCW exposure in different locations inside the isolation room model**
- Steady state conditions (except for breathing)
- Bars represent one hour averages (HCW exposure relative to the extract concentration)
- Whiskers represent the standard error of the average





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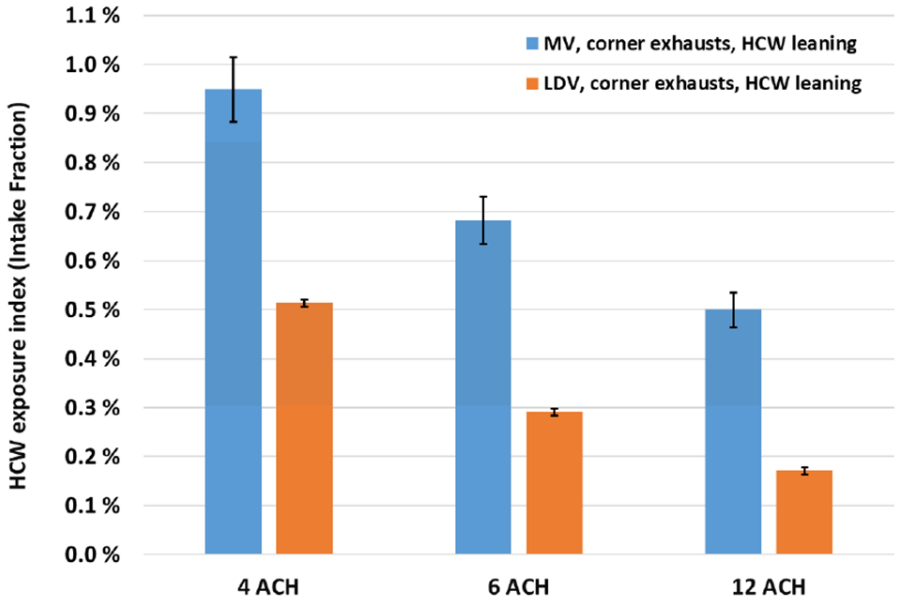
Results (tracer gas measurements)

- **HCW exposure with different ventilation rates**
- HCW leaning over the patient
- Steady state conditions (except for breathing)
- Bars represents one hour averages (how much HCW is inhaling the patient exhaled contaminant)
- Black whiskers represents the standard error of the average



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Summary (Ventilation, air distribution and exposure)

- **Air distribution affects notably the HCW exposure, especially close to the patient**
- **HCW exposure close to the patient was found to be substantially higher than further away from the patient, especially with mixing ventilation**
- **Increasing ventilation rate can reduce the HCW exposure to patient exhaled breath, even close to the patient**
- **Local downward ventilation was able to flush the HCW breathing zone more effectively, hence reducing the HCW exposure compared to the mixing ventilation case**
- **Thermal comfort was found to be adequate with both examined supply air distribution modes**

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  - Turku University of Applied Sciences: **Mr. Hannu Koskela, Dr. Henna Maula**
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  - University of Turku: **Dr. Matti Waris**
  - University Hospitals of Leicester NHS, UK: **Dr. Julian Tang**
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Thank you for your attention!

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