

Characterize the dynamic airflow pattern and heat/mass transfer in surgical site microenvironment control in operating rooms



Cohort Based Training 3
KTH Royal Institute of Technology, Sweden



DC 4 : Kunal Bairwa (NTNU)



HumanIC Project



WP1 : To create scientific knowledge on physical mechanism for airborne pathogen exposure and develop new engineering solutions and strategies for **controlling infection risk in transient indoor environment**.

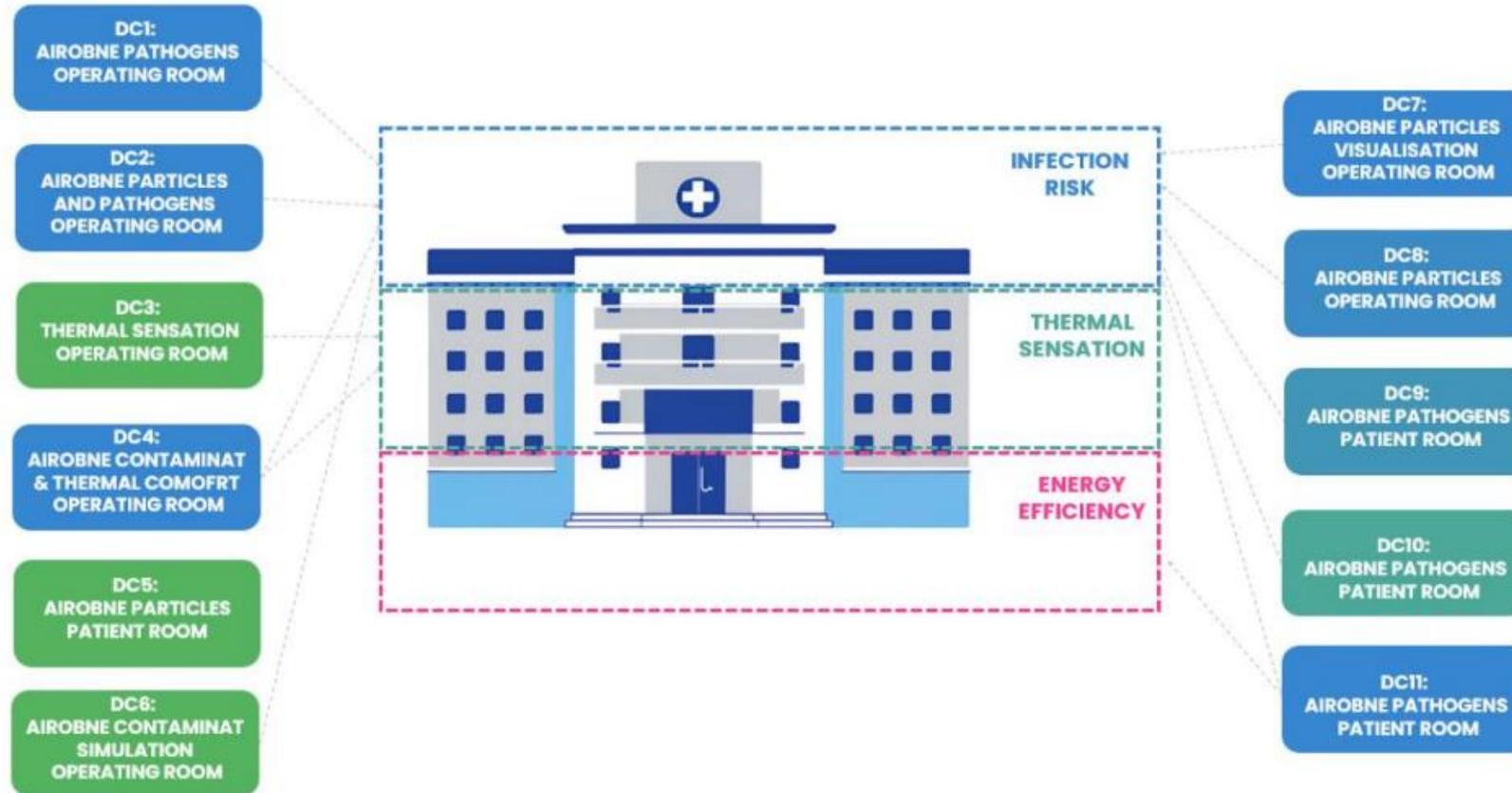


Fig.1. Scheme of contribution of individual projects to KPIs

What factors influence the airflow and air quality in an operating room?



Physical obstructions ([Cao et al. \(2018\)](#))

- Surgical light
- Medical equipment and tables

Human Factors ([Pokrywka & Byers \(2013\)](#), [Sadrizadeh et al. \(2021\)](#), [San José Alonso et al. \(2022\)](#))

- Staff movement and positioning
- Door opening

Thermal Plumes ([Cao et al. \(2018\)](#))

- Human, medical equipment and surgical lights

HVAC system design ([Krishnankutty et al. \(2026\)](#), [Agirman et al. \(2020\)](#), [Agirman et al. \(2021\)](#))

- Supply diffuser size
- Extract location

Current study



Characterization of airflow structures in the surgical microenvironment of operating rooms using Particle Image Velocimetry: Effects of ventilation strategy and extract position

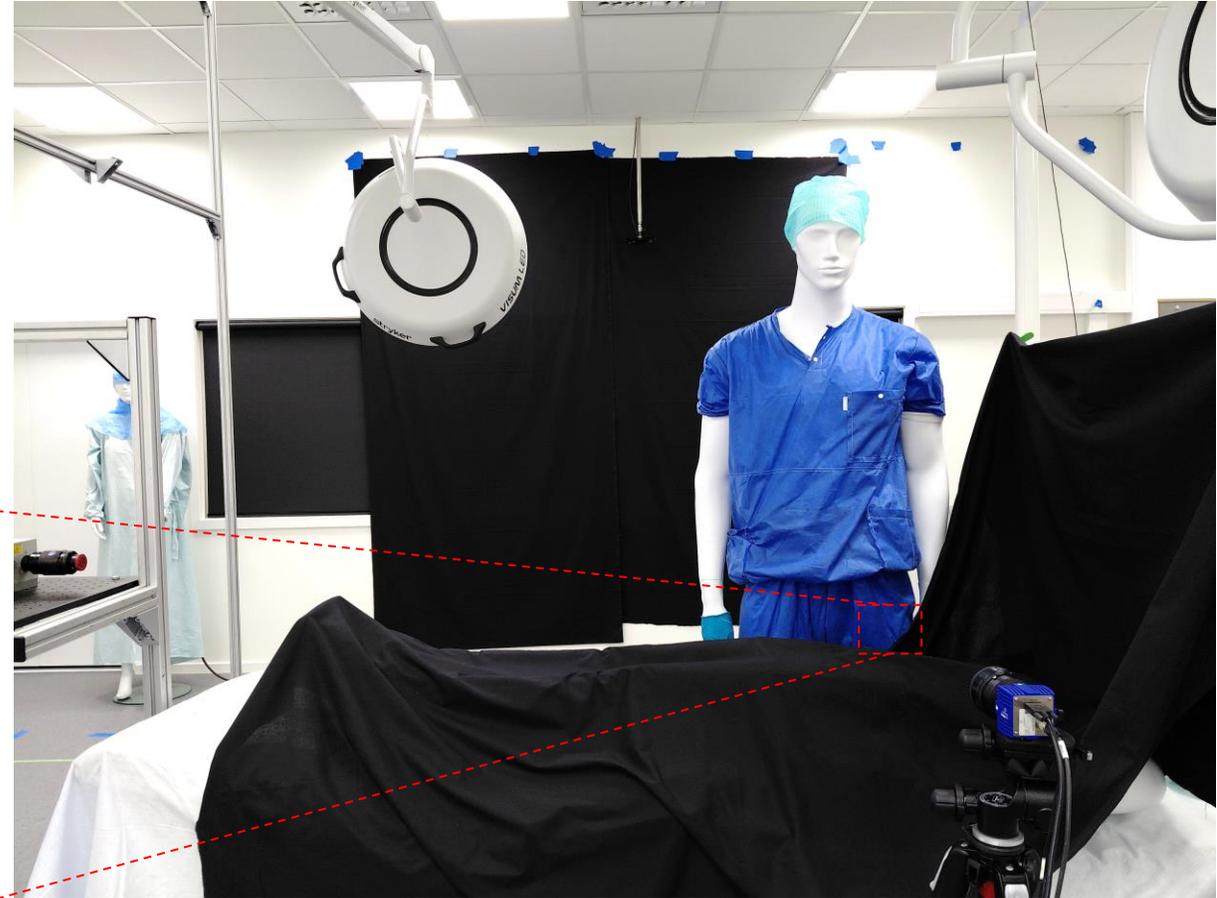
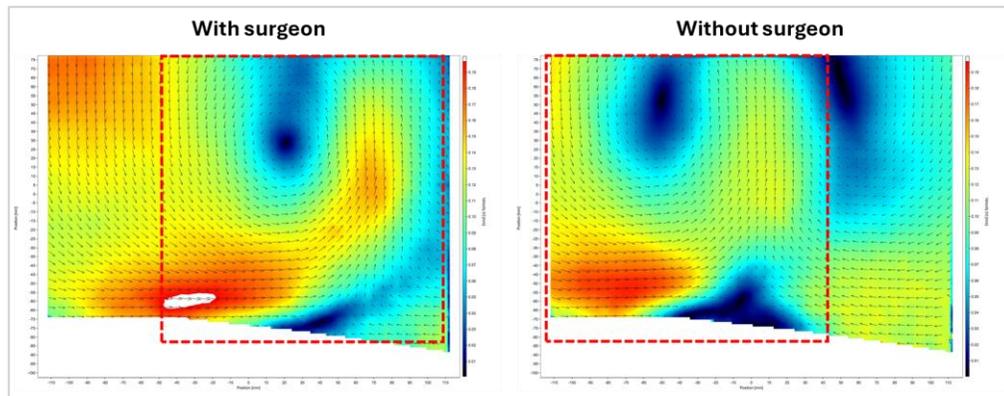
- ✓ **Why:** Relative to floor-only exhaust, combined outlets (floor + ceiling) *reduced particle deposition at the surgical table by ~64% for small particles (5 μm) and ~26% for larger particles (20 μm).* [Agirman et al. \(2020\)](#)
- ✓ **Reasoning:** As the particles are airborne, that means they should be transported via air. This implies that the airflow characteristics changes at the surgical site microenvironment.
- ✓ **Literature gap:** Previous studies on operating room ventilation mainly report mean airflow or bulk contaminant removal under laminar and mixing systems. High-resolution measurements of near-field airflow at the surgical site, particularly using Particle Image Velocimetry to assess the effect of exhaust configuration, are still scarce.



Objective and Expected results



- **Objective:** The objective of this study is to identify dominant flow features, vortex formations, and stability characteristics in the surgical microenvironment, and to assess how different extract configurations influence them under MV and LAF.
- **Expected results:** The resulting high-resolution PIV data, which are 2D velocity, Airflow pattern and planar turbulent kinetic energy, that offer detailed insight into the interaction between ventilation type and location of air extract openings, which may lead to optimization of ventilation design and provide robust experimental validation for simulation studies.



Expected Results



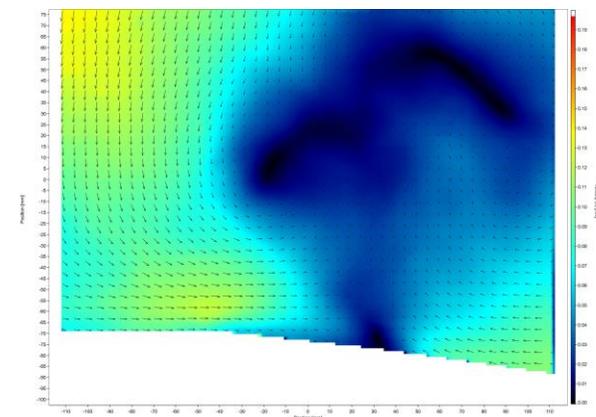
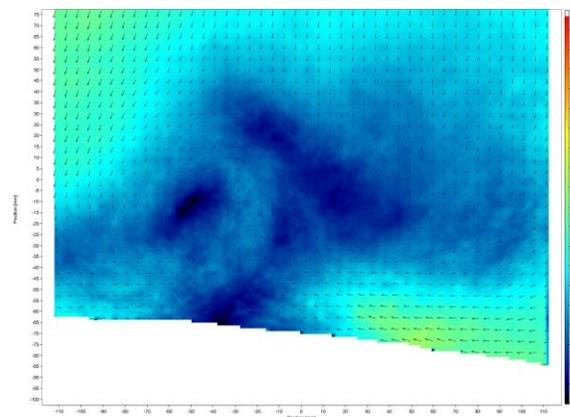
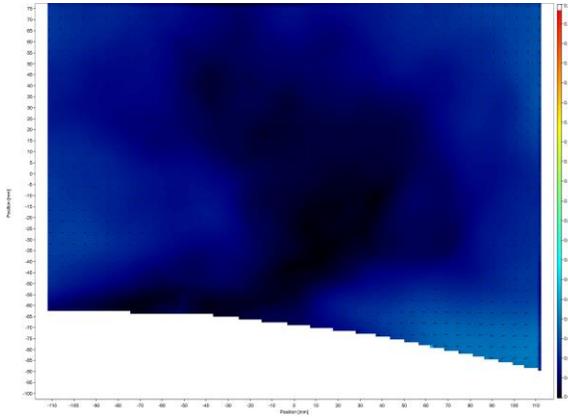
Example from test cases: With surgeon

Mix

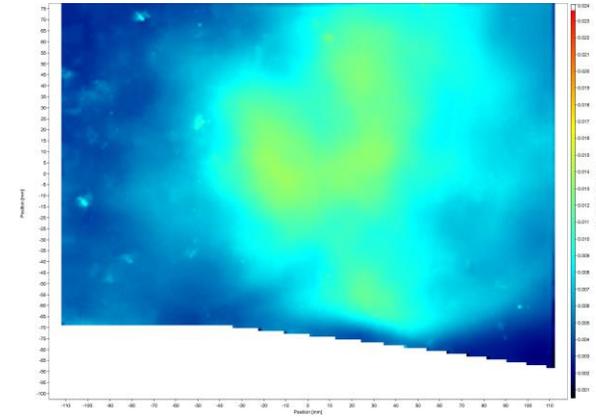
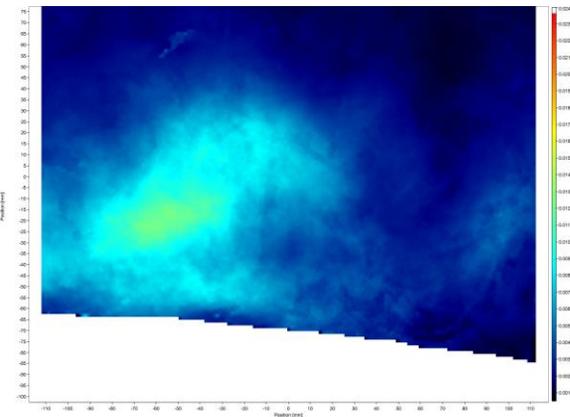
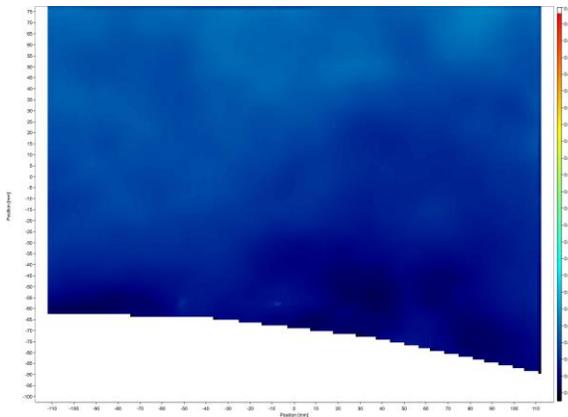
LAF Low

LAF Med.

Velocity



Turbulent kinetic energy



Future work



Physical obstructions ([Cao et al. \(2018\)](#))

- Surgical light
- Medical equipment and tables

Human Factors and movements ([Pokrywka & Byers \(2013\)](#), [Sadrizadeh et al. \(2021\)](#), [San José Alonso et al. \(2022\)](#))

- Staff movement and positioning
- Door opening

Thermal Plumes ([Cao et al. \(2018\)](#))

- Human, medical equipment and surgical lights

HVAC system design ([Krishnankutty et al. \(2026\)](#), [Agirman et al. \(2020\)](#), [Agirman et al. \(2021\)](#))

- Supply diffuser size
- Extract location



References



1. Valsala Krishnankutty, V., Muraleedharan, C., & Palatel, A. (2026). Numerical Analysis of Airflow and Temperature Distribution in Surgical Operating Rooms. *Buildings*, 16(1), 171. <https://doi.org/10.3390/buildings16010171>
2. Pokrywka, M., & Byers, K. (2013). Traffic in the operating room: a review of factors influencing air flow and surgical wound contamination. *Infectious disorders drug targets*, 13(3), 156–161. <https://doi.org/10.2174/1871526511313030002Rooms>. *Fluids*, 10(9), 225. <https://doi.org/10.3390/fluids10090225>
3. Sasan Sadrizadeh, Amar Aganovic, Anna Bogdan, Cong Wang, Alireza Afshari, Anne Hartmann, Cristiana Croitoru, Amirul Khan, Martin Kriegel, Merethe Lind, Zhijian Liu, Arsen Melikov, Jinhan Mo, Hansjörg Rotheudt, Runming Yao, Yixian Zhang, Omid Abouali, Håkon Langvatn, Olof Sköldenberg, Guangyu Cao, A systematic review of operating room ventilation, *Journal of Building Engineering*, Volume 40, 2021, 102693, ISSN 2352-7102, <https://doi.org/10.1016/j.jobe.2021.102693>
4. Cao, G., Storås, M. C. A., Aganovic, A., Stenstad, L. I., & Skogås, J. G. (2018). Do surgeons and surgical facilities disturb the clean air distribution close to a surgical patient in an orthopedic operating room with laminar airflow?. *American journal of infection control*, 46(10), 1115–1122. <https://doi.org/10.1016/j.ajic.2018.03.019>
5. J.F. San José Alonso, M.A. Sanz-Tejedor, Y. Arroyo, M.R. San José-Gallego, Analysis and assessment of factors affecting air inflow from areas adjacent to operating rooms due to door opening and closing, *Journal of Building Engineering*, Volume 49, 2022, 104109, ISSN 2352-7102, <https://doi.org/10.1016/j.jobe.2022.104109>.
6. Agirman, A., Cetin, Y.E., Avci, M. *et al.* Effect of air exhaust location on surgical site particle distribution in an operating room. *Build. Simul.* **13**, 979–988 (2020). <https://doi.org/10.1007/s12273-020-0642-1>
7. Agirman, A., Cetin, Y. E., Avci, M., & Aydin, O. (2021). Effect of laminar airflow unit diffuser size on pathogen particle distribution in an operating room. *Science and Technology for the Built Environment*, 27(4), 402–413. <https://doi.org/10.1080/23744731.2020.1816405>

Thank You

