Safety inside the Operating Room – Factors Influencing a Healthy Surgical Microenvironment

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HumanIC project has received funding from the European Union's Horizon Europe research and innovation program under the Marie Sklodowska-Curie (HORIZON-MSCA-2022-DN-01, project no 101119726

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Focus: surgical microenvironment

- Medical team as a boundary.

1986: Woods et al.

- Surgeons, patient, and surgical lights as a boundary.
- Cleanest zone in the OR

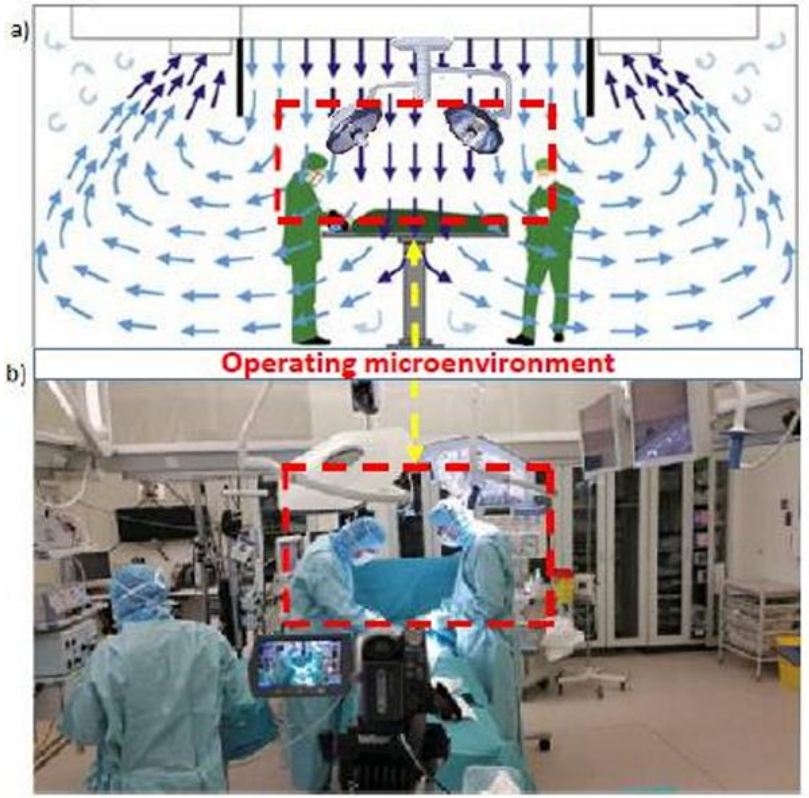
2018: Aganovic

- Consolidation of the definition

2021: Sadrizadeh et al.

Surgical microenvironment

- Critical zone immediately surrounding the surgical site and bounded by the patient, the surgical team, and the surgical lights. Air quality in this zone is critical for preventing SSIs caused by airborne microorganism contamination, while maintaining appropriate thermal conditions is essential to prevent intraoperative hypothermia, both of which are associated with adverse postoperative outcomes.



Aganovic, A., 2019. Airflow distribution for minimizing human exposure to airborne contaminants in healthcare facilities. NTNU: Trondheim, Norway.

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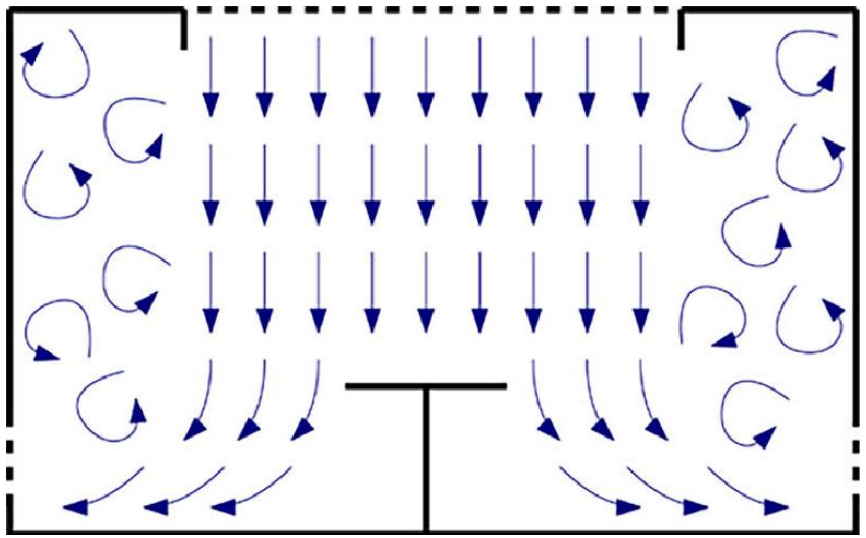
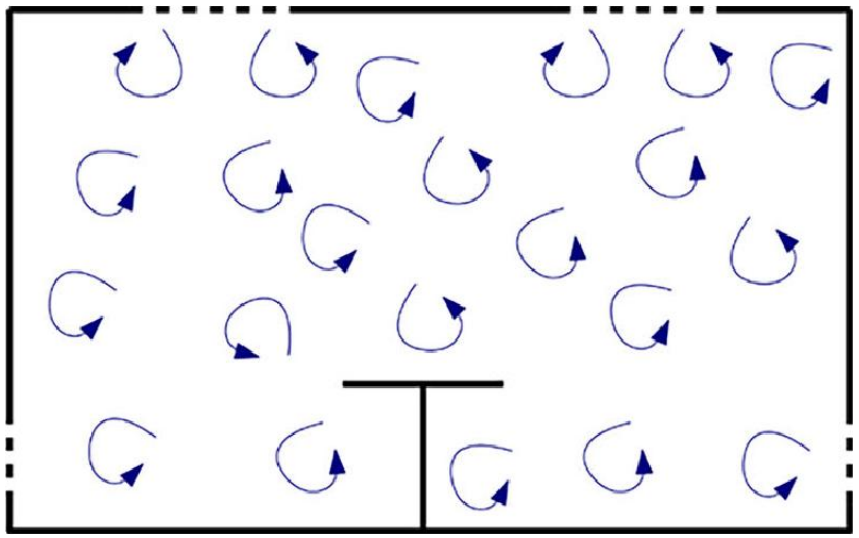
Ventilation system

LAF - Laminar Airflow



TAF - Turbulent Airflow



Hofer, V., Hartmann, A., Rotheudt, H., Zielke, B. and Kriegel, M., 2022. Disturbance of a laminar air flow caused by differently shaped surgical lights. International Journal of Ventilation, 21(3), pp.213-228.

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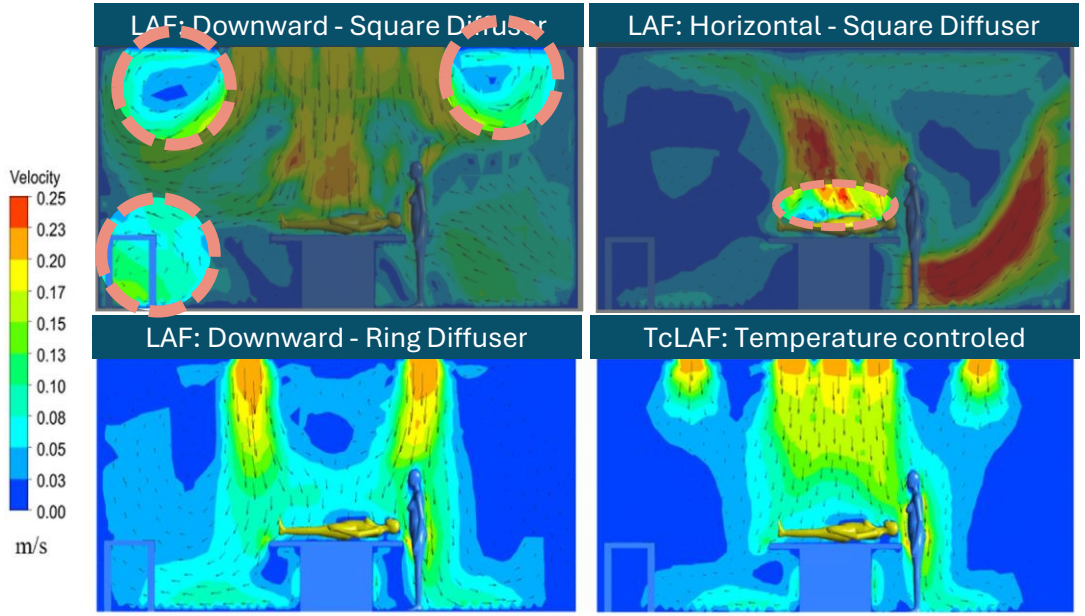
Supply and exhaust: characteristics + location

Ventilation system		Supply diffuser characteristics		Exhaust grille characteristics	
		Quantity	Area, [m^2/diffuser]	Quantity	Area, [m^2/grille]
TAF	No. of mentions	8	5	9	4
	% of mentions	42.11	26.32	47.37	21.05
	mean	**9.75 ± 8.91**	**0.26 ± 0.13**	**4.89 ± 2.32**	**0.17 ± 0.18**
LAF	No. of mentions	18	16	15	10
	% of mentions	90.00	80.00	75.00	50.00
	mean	**1.28 ± 0.96**	**6.86 ± 2.63**	**5.49 ± 2.95**	**0.26 ± 0.24**



Liu, Z., Yin, D., Hu, L., He, J. and Cao, G., 2022. Bacteria-carrying particles diffusion in the operating room due to the interaction between human thermal plume and ventilation systems: An experimental-numerical simulation study. Energy and Buildings, 270, p.112277.

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Supply parameters: according to standards

Standard/design guideline	Supply characteristics					
	Kinematic properties				Hygrometric properties	
	Volumetric Airflow Rate, $V_{total}\|_{in}$ [$m^3/(h)$]	Air Change Rate, ACH [h^{-1}]	Mean Air Velocity, $v\|_{in}$ [m/s]	Turbulence Intensity, $TI\|_{in}$ [%]	Mean Air Dry Bulb Temperature, $T_{db,ha}\|_{in}$ [°C]	Relative Humidity, $\phi_{ha}\|_{in}$[%]
Technical specification/guideline - Portugal: Technical Specifications for HVAC Installations in Hospital Buildings – ET 06/2008	≥ 600 Or 100 [$m^3/(h \cdot person)$] **Notes:** ▪The values refer only to fresh air.	≥ 25 **Notes:** ▪At least 5 ACH of fresh air.	n.r.	n.r.	$\|T_{db,ha}\|_{out} - T_{db,ha}\|_{in}\|$ should not exceed 8 °C	n.r.
Technical memorandum/guideline - United Kingdom: Health Technical Memorandum 03-01: Specialised ventilation for healthcare premises	10 [$L/(s \cdot person)$] **Notes:** ▪At least 20% of fresh air when recirculated air exists. However, it's advised that air extracted from OTs should not be recirculated.	≥ 22	n.r.	n.r.	$\|T_{db,ha}\|_{out} - T_{db,ha}\|_{in}\|$ should not exceed: ▪10 K for winter heating; ▪7 K for summer cooling.	< 70
Guideline - Nordic: R^3 Nordic Guideline for Hospital Ventilation	≥ 990	n.r.	n.r.	n.r.	n.r.	n.r.
Standard - Germany: DIN 1946-4: Ventilation and air conditioning – Part 4: Ventilation in buildings and rooms of health care	For TAF: ≥ 60 $m^3/(h \cdot m^2\|_{operating\ area})$ For LAF: ≥ 900 $m^3/(h \cdot m^2\|_{supply\ diffuser\ area})$ **Notes:** ▪At least 1200 m^3/h of fresh air.	For TAF: ≥ 20 For LAF: n.r.	n.r.	For TAF: n.r. For LAF: ≤ 20	n.r.	n.r.
Standard - Spain: UNE 100713	≥ 2400 m^3/h **Notes:** ▪At least 1200 m^3/h of fresh air when recirculated air exists.	≥ 20	n.r.	n.r.	n.r.	n.r.
Standard - United States: ASHRAE 170-2021: Ventilation of Health Care Facilities	n.r.	≥ 20 **Notes:** ▪At least 4 ACH of fresh air	For LAF: [127 ; 178] $L/(s \cdot m^2\|_{supply\ diffuser\ area})$	n.r.	n.r.	n.r.

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Exhaust parameters: according to standards

Standard/design guideline	Exhaust characteristics			Differential Pressure, ΔP [Pa]
	Kinematic properties	Hygrometric properties		
	Volumetric Airflow Rate, V_{out} [$m^3/(h)$]	Mean Air Dry Bulb Temperature, $T_{db,ha}\|_{out}$ [°C]	Relative Humidity, $\phi_{ha}\|_{out}$ [%]	
Technical specification/guideline - Portugal: Technical Specifications for HVAC Installations in Hospital Buildings – ET 06/2008	n.r. **Notes:** ▪70% floor-level and 30% ceiling-level	[17 ; 27]	[30 ; 60]	+ 20
Technical memorandum/guideline - United Kingdom: Health Technical Memorandum 03-01: Specialised ventilation for healthcare premises	n.r.	n.r.	n.r.	+25
Guideline - Nordic: R^3 Nordic Guideline for Hospital Ventilation	n.r.	[18 ; 26]	< 60 (at 21 °C) **Notes:** ▪Air humidification is not required	≥ +10
Standard - Germany: DIN 1946-4: Ventilation and air conditioning – Part 4: Ventilation in buildings and rooms of health care	n.r.	n.r.	[30 ; 65] **Notes:** ▪≤ $W_{ha}\|_{out}$ = 13 g_w/kg_{da}	Positive
Standard - Spain: UNE 100713	n.r. **Notes:** ▪1200 m^3/h at floor-level and remaining at ceiling-level	[22 ; 26]	[45 ; 55]	n.r.
Standard - United States: ASHRAE 170-2021: Ventilation of Health Care Facilities	n.r.	n.r.	[20 ; 60]	≥ +2.5

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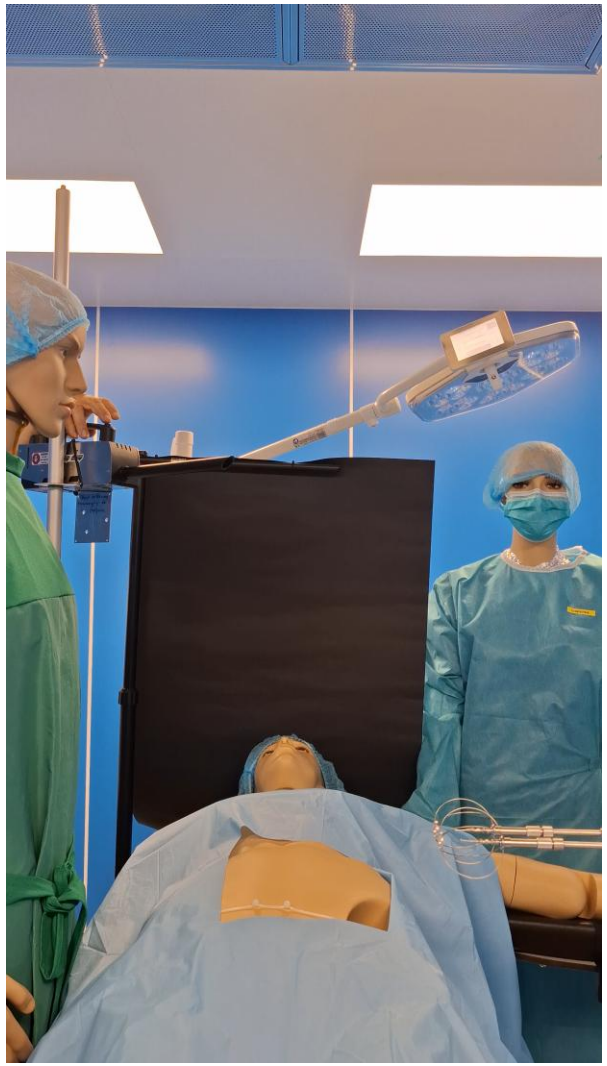
Surgical lamps



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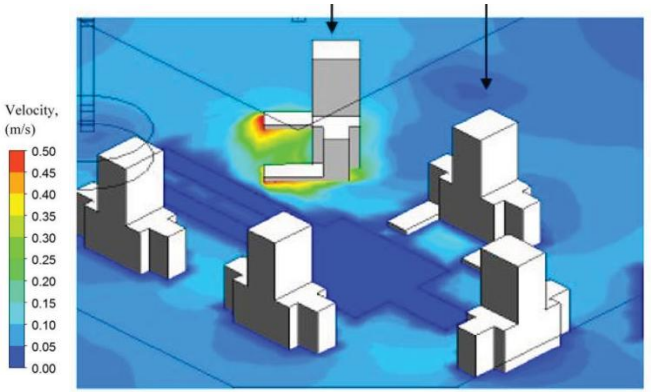
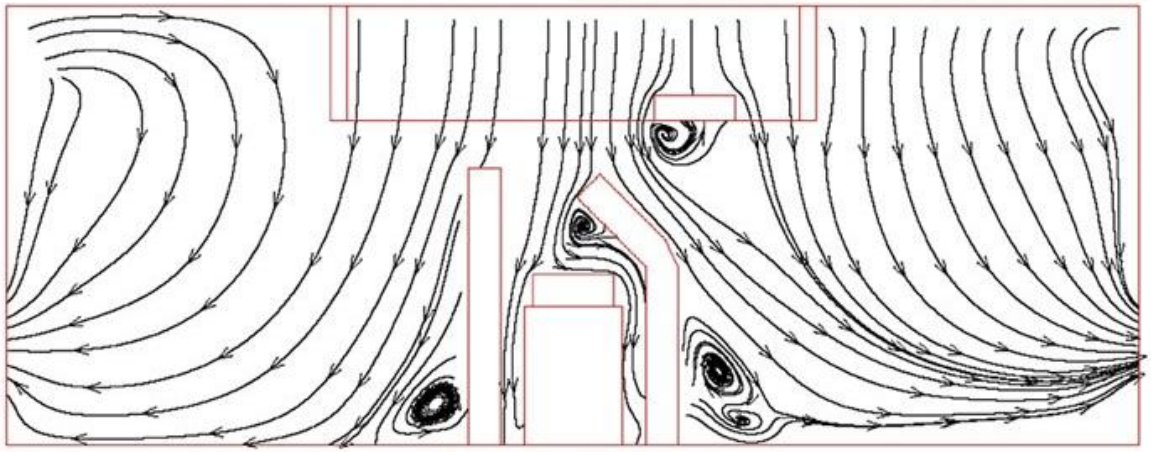
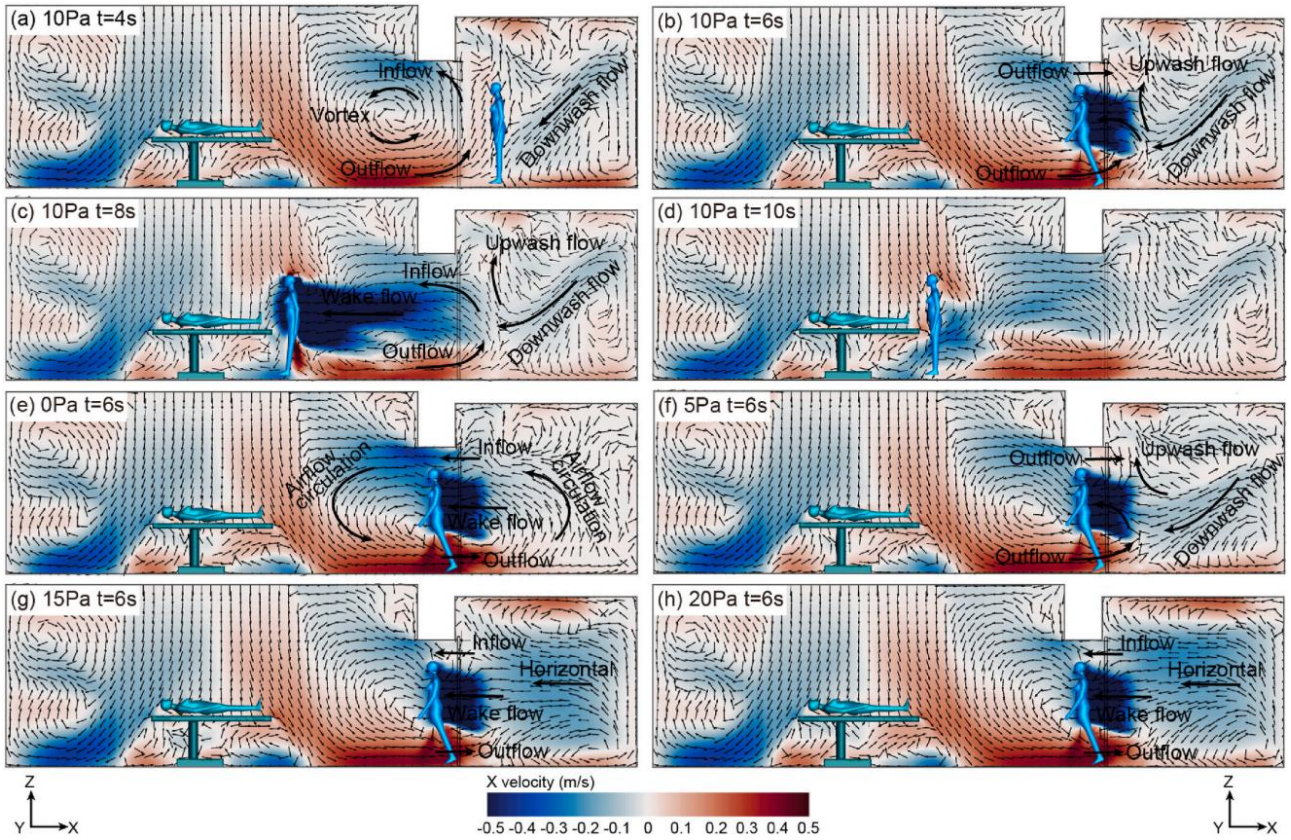
Human behaviour

Kamar, H.M., Wong, K.Y. and Kamsah, N., 2020. The effects of medical staff turning movements on airflow distribution and particle concentration in an operating room. Journal of Building Performance Simulation, 13(6), pp.684-706.





Chow, T.T. and Wang, J., 2012. Dynamic simulation on impact of surgeon bending movement on bacteria-carrying particles distribution in operating theatre. Building and environment, 57, pp.68-80.



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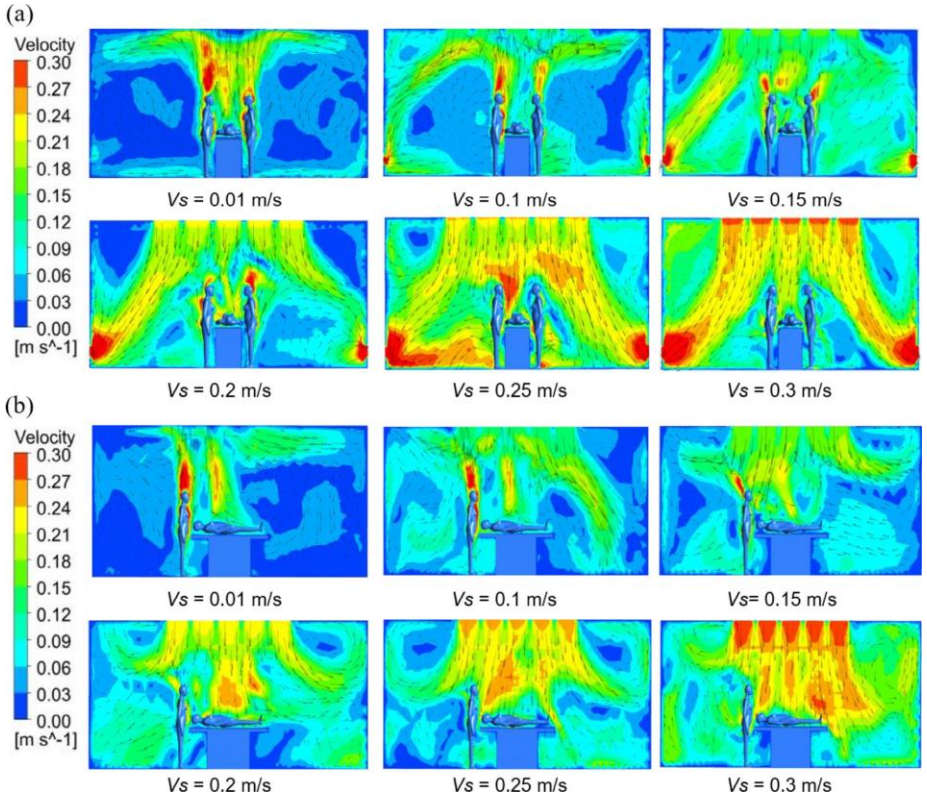
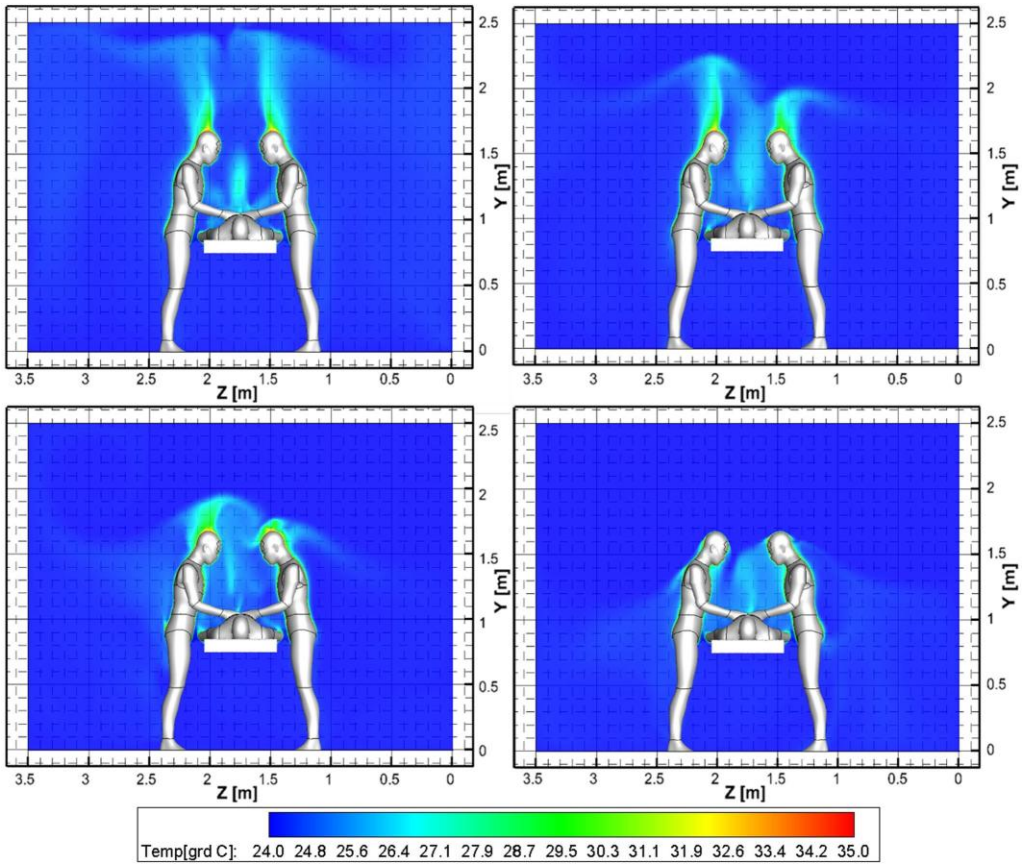
Convective flows



Liu, Z., Yin, D., Niu, Y., Cao, G., Liu, H. and Wang, L., 2022. Effect of human thermal plume and ventilation interaction on bacteria-carrying particles diffusion in operating room microenvironment. Energy and Buildings, 254, p.111573.



Tacutu, L., Bode, F., Năstase, I., Croitoru, C. and Dogeanu, A., 2022. Experimental and numerical study on the thermal plumes of a standing and lying human in an operating room. Science and Technology for the Built Environment, 28(1), pp.2-20.

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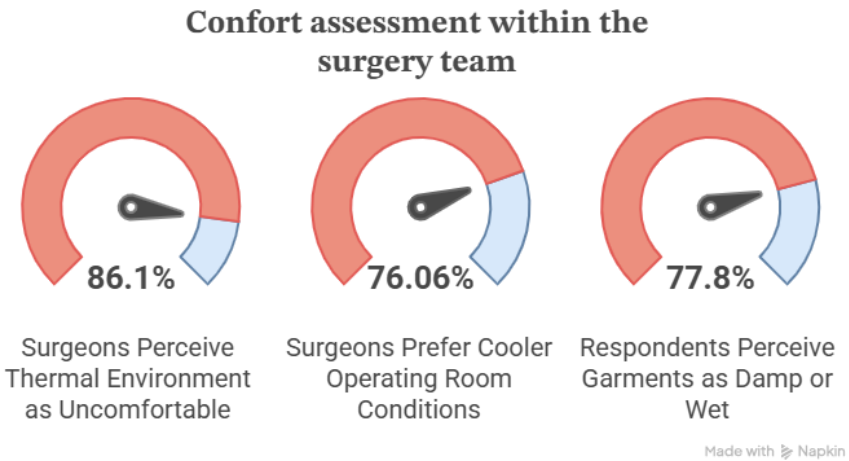
Thermal comfort



Survey conducted by:

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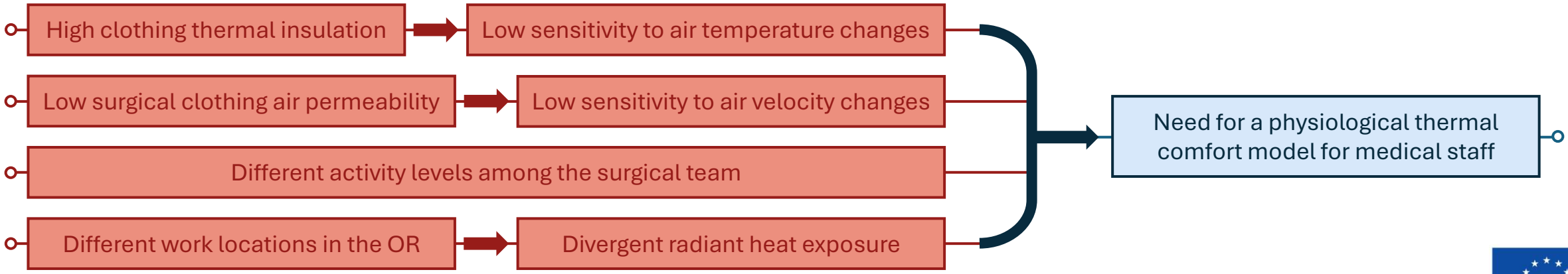
Components	Fabric material:	Fabric structure	Weight, [g/m^2]	Thermal insulation, I_{cl} [clo]	Citation
Scrub suit	n. r. % polyester, n. r. % coal fibre	n. r.	n. r.	parallel - 0.794; series - 0.994	Bogdan and Sudoł-Szopińska; Magdalena and Bogdan
Gown	Front and sleeves: Liquid-proof fabric of higher resistance Remainder of gown: n.r. % polyester, n.r. % carbon fibre	n. r.	300 g	parallel - 0.974; series - 1.303	Bogdan and Sudoł-Szopińska; Magdalena and Bogdan
	Front and sleeves: PTFE (polytetrafluorothylene) Remainder of gown: n.r. % polyester, n.r. % carbon fibre	Front and sleeves: laminated membrane Remainder of gown: n. r.	n. r.	parallel - 1.032; series - 1.406	
	n.r. % cotton, n. r. % of other material	n. r.	n. r.	parallel - 1.071; series - 1.490	Bogdan and Sudoł-Szopińska



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Thank you!

I'm happy to share the presentation with those interested

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