

Field investigation of thermal comfort level of patients and surgical staff in operating rooms at St. Olavs hospital

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This paper is an overview of thesis work what is made in Norwegian University of Science and Technology. The purpose of this work is to investigate the thermal comfort level of patient and surgical staff at Trondheim St. Olavs hospital two different operating rooms and give suggestions for improvement.

THE THERMAL COMFORT IN OPERATING ROOM IS CHALLENGING

Unsatisfactory thermal conditions in operating rooms (ORs) will influence the performance of surgical staff and increase the risk of developing surgical site infections (SSIs) possibility of patient. [1, 3] Therefore, there is essential to achieve the environment conditions where the highest possible percentage of the people will meet the thermal comfort. But by only revising the HVAC standard there is difficult to achieve thermal comfort for all occupants in operating room with clarified conditions [2]. Thus there is necessary to investigate the area more to achieve the healthy environment for everyone.

[1] R. Mora, M. J. English and A. K. Athienitis, "Assessment of Thermal Comfort During Surgical Operations," ASHRAE Transactions, p. pg. 52, 2001.
[2] R. V. Gaever, V. Jacobs, M. Diltor, L. Peeters and S. Vanlanduit, "Thermal comfort of the surgical staff in the operating room," 2014.
[3] V. D. Hooper, R. Chard, T. Clifford, S. Fetzer, S. Fossum, B. Godden, E. A. Martinez, K. A. Noble, D. O'Brien, J. Odom-Forren, C. Peterson, J. Ross and L. Wilson, "ASPAN's Evidence-Based Clinical Practice Guideline for the," Journal of PeriAnesthesia Nursing, vol. Vol 25, pp. 346-365, 2010.

OBJECTIVE

What is the thermal comfort level of four occupant group in operating room with LAF and dilution ventilation solution?

Predicted thermal comfort (PMV-PPD)

Real thermal comfort

METHOD

1. Field measurements of indoor thermal environment
2. Observation of real surgical process for estimation
3. Survey – to collect direct thermal comfort feedback from surgical staff

Focus on four occupant group:

- surgeon
- anesthetist
- assistant nurse
- patient

Under investigation was:

Environmental parameters

- air temperature
- operative temperature
- mean radiant temperature
- air velocity
- air humidity

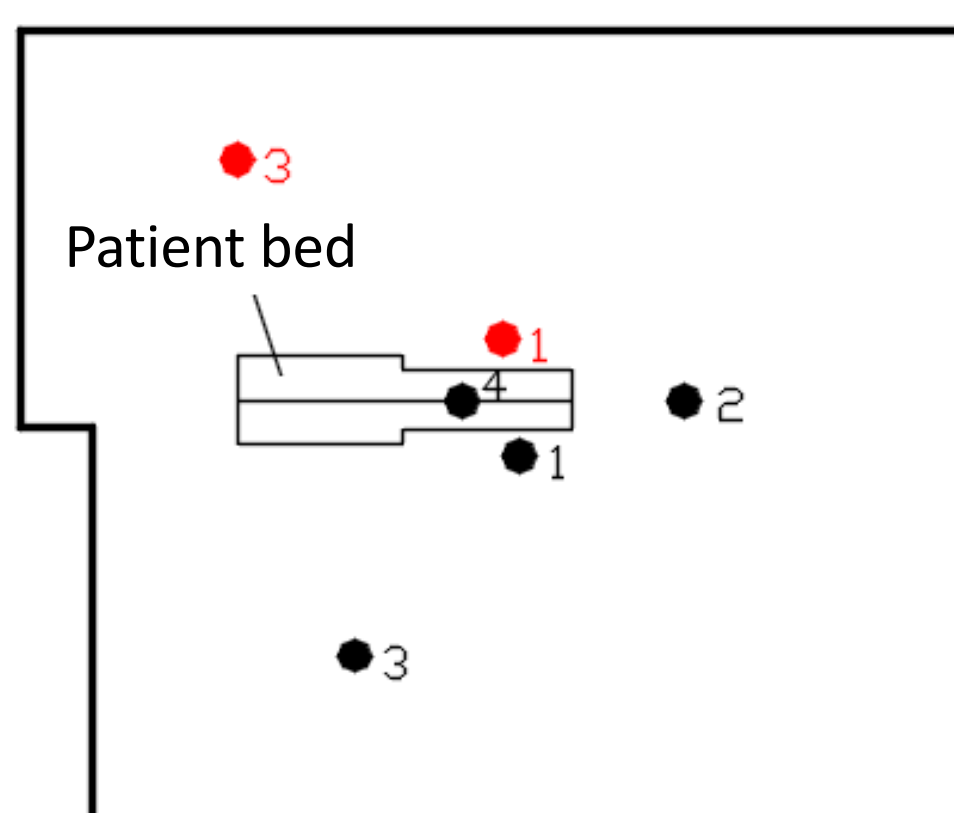
- Individual parameters:
 - activity level
 - clothing

St.Olavs hospitals two ORs with LAF and mixing ventilation solution

On the Figures 1&2 - the location of occupants. (black – during measurements; red – during operation).

Figure 1. Mixing ventilation solution OR

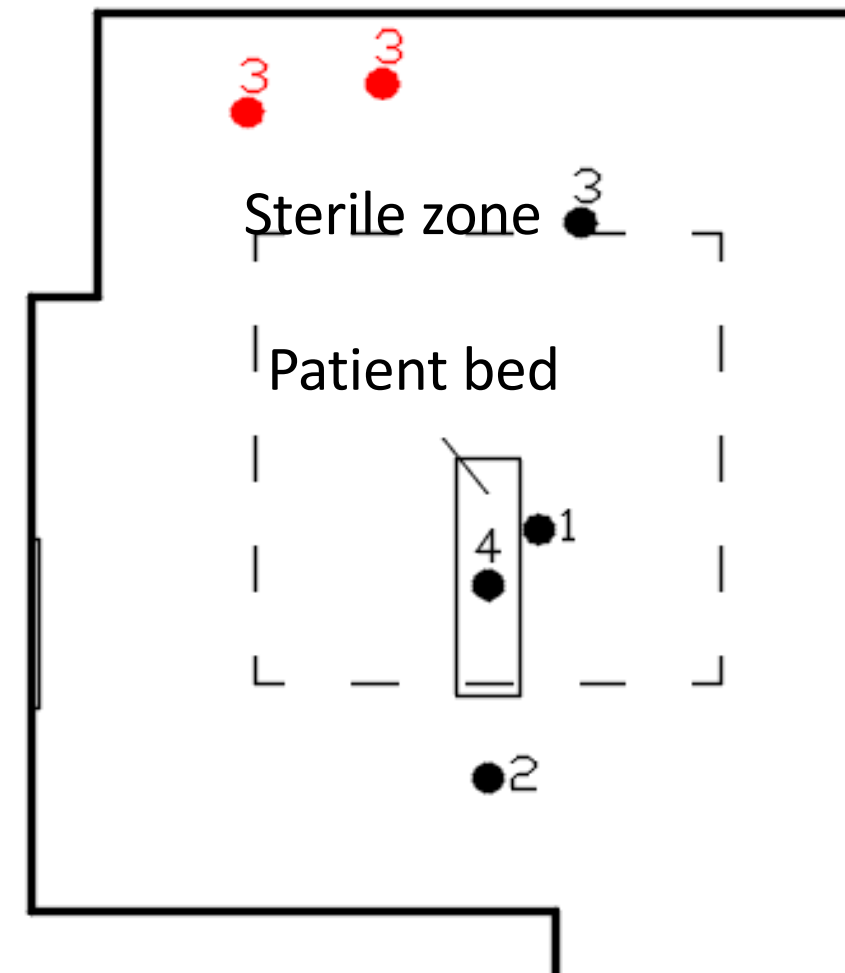
Area: 59.1 m²
Type: Heart and emergency surgery
RH = 12.1% - 39.2%
v_a = 0.0-0.1 m/s



- 1 – Surgeon
2 – Anesthetist
3 – Assistant nurse
4 – Patient

Figure 2. LAF ventilation solution OR

Area: 56.1 m² (LAF area: 4x4m)
Type: Orthopedic surgery
RH = 17.1-44.7 %
v_a = 0.02-0.36 m/s



Clothing

Material: polypropylene film and polyester/polyethylene nonowen. Insulation in Table 1.

Surgical staff surgical underwear, cap, hat, mask, socks, shoes and gloves (in MV OR also lead apron for x-ray). The surgeons will wear in addition to prior sterilized surgical gown.

Patient most of times naked and covered with warm blanket, surgical drape and polyethylene film (in MV OR-s forced-air warming blanket system).

Table 1 Clothing insulation and the activity level of occupants

Occupant group	Clothing insulation, m ² K/W (clo)		Activity level, W/m ² (met)	
	LAF solution OR	MV solution OR	LAF solution OR	MV solution OR
Surgeon	0.202 (1.3)	0.234 (1.5)	138.3 (2.38)	103.0 (1.78)
Assistant nurse	0.154 (0.99)	0.193 (1.25)	74.8 (1.29)	92.2 (1.59)
Patient	0.165 (1.06)	0.165 (1.06)	68.4 (1.18)	68.4 (1.18)
Anesthetist	0.154 (0.99)	0.193 (1.25)	90.1 (1.55)	85.0 (1.47)

Activity level – The value for surgical staff on the Table 1 is evaluated according to Standard ISO 8996. For patient, it has been evaluated according to the earlier study and the weight and length of averaged person.

RESULTS

Overall thermal comfort in MV OR

Occupants in real operations, are more dissatisfied than can estimate from theoretical calculations (Figure 3). Actual sensation is warmer - **surgeon** and **assistant nurse** have high activity level (Table 1) and operative temperature (Figure 4).

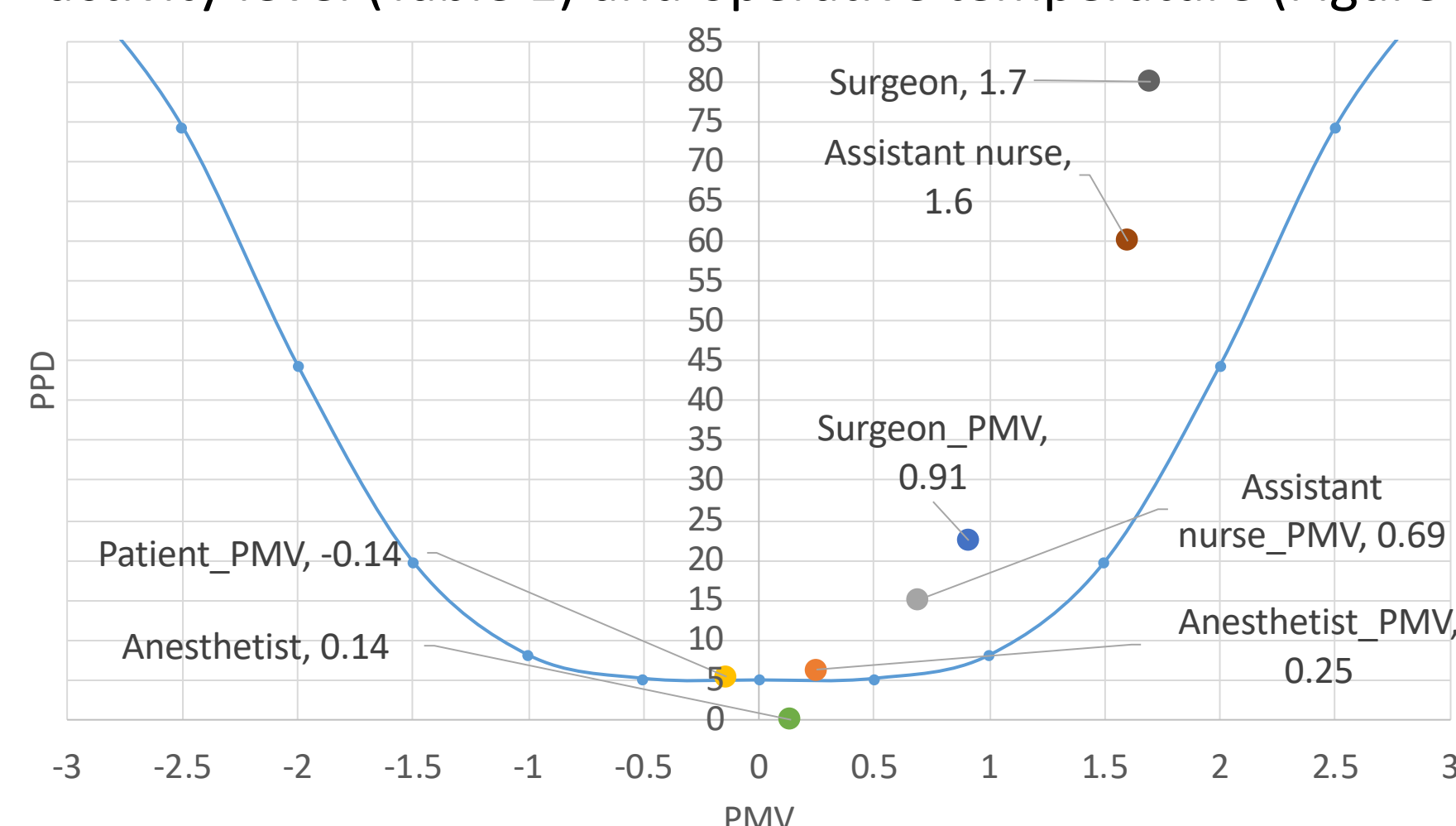


Figure 3. The comparison between of predicted and real thermal comfort in MV OR

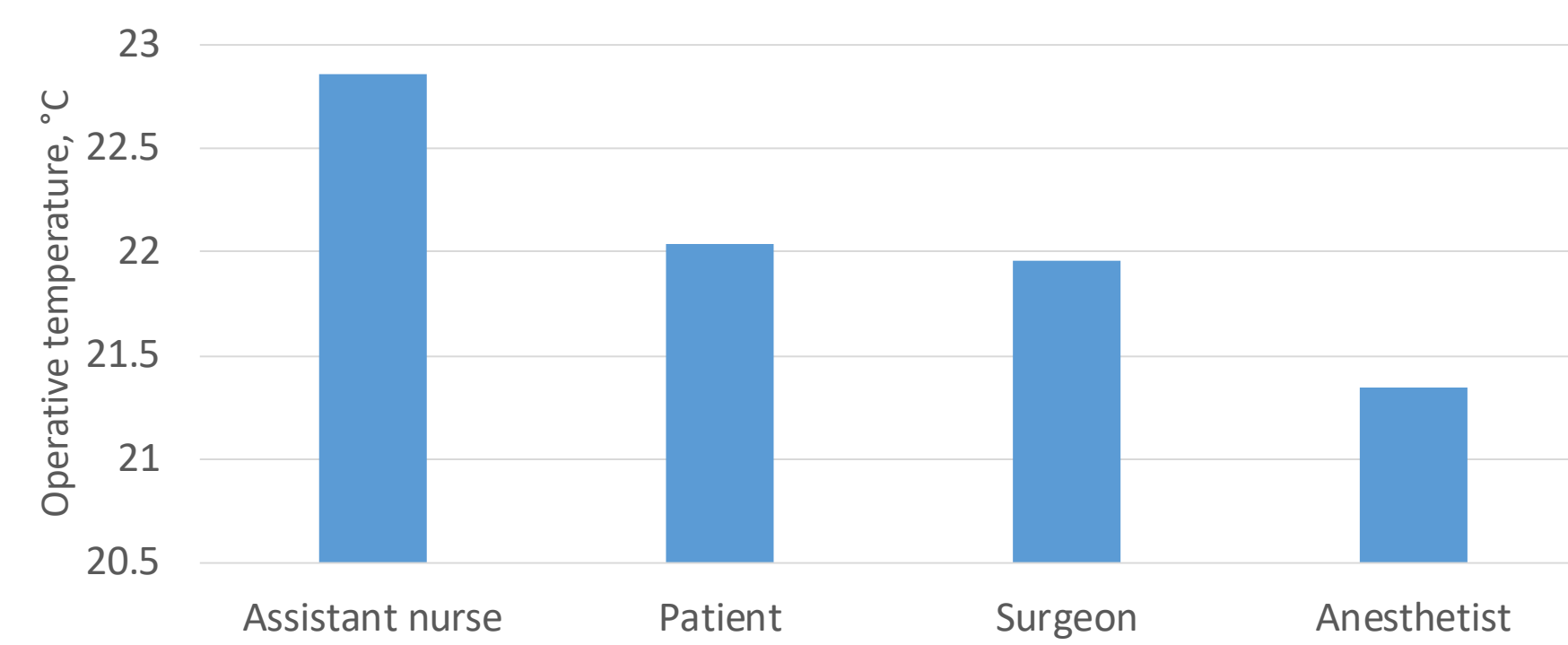


Figure 4. Operative temperature in MV OR

The operative temperature and activity level of **anesthetist** is lower. The predicted sensation of **patient** will be in the boundary of thermal comfort, but the real sensation will be slightly cool.

Overall thermal comfort in LAF OR

In real operation the occupants will feel more comfortable, than the PMV calculations show (Figure 5). However, the measurements show lower operative temperature (Figure 6) and higher air velocity than usual, then due to higher activity, the thermal sensation of **surgeon** is warm.

The operative temperature near **anesthetist** and **assistant nurse** is higher, activity level lower and thermal sensation is neutral. Due to low operative temperature and high air velocity, the **patient** will feel uncomfortable.

SUMMARY

1. Surgeons thermal sensation is warm.
2. Assistant nurse feels in MV OR warm and in LAF OR neutral.
3. Anesthetist experiences thermal comfort in both OR.
4. In MV OR are more occupants, who are dissatisfied with thermal environment than in LAF OR.
5. In LAF OR, the air temperature is lower and velocity is higher => the thermal comfort of patient is disturbed.

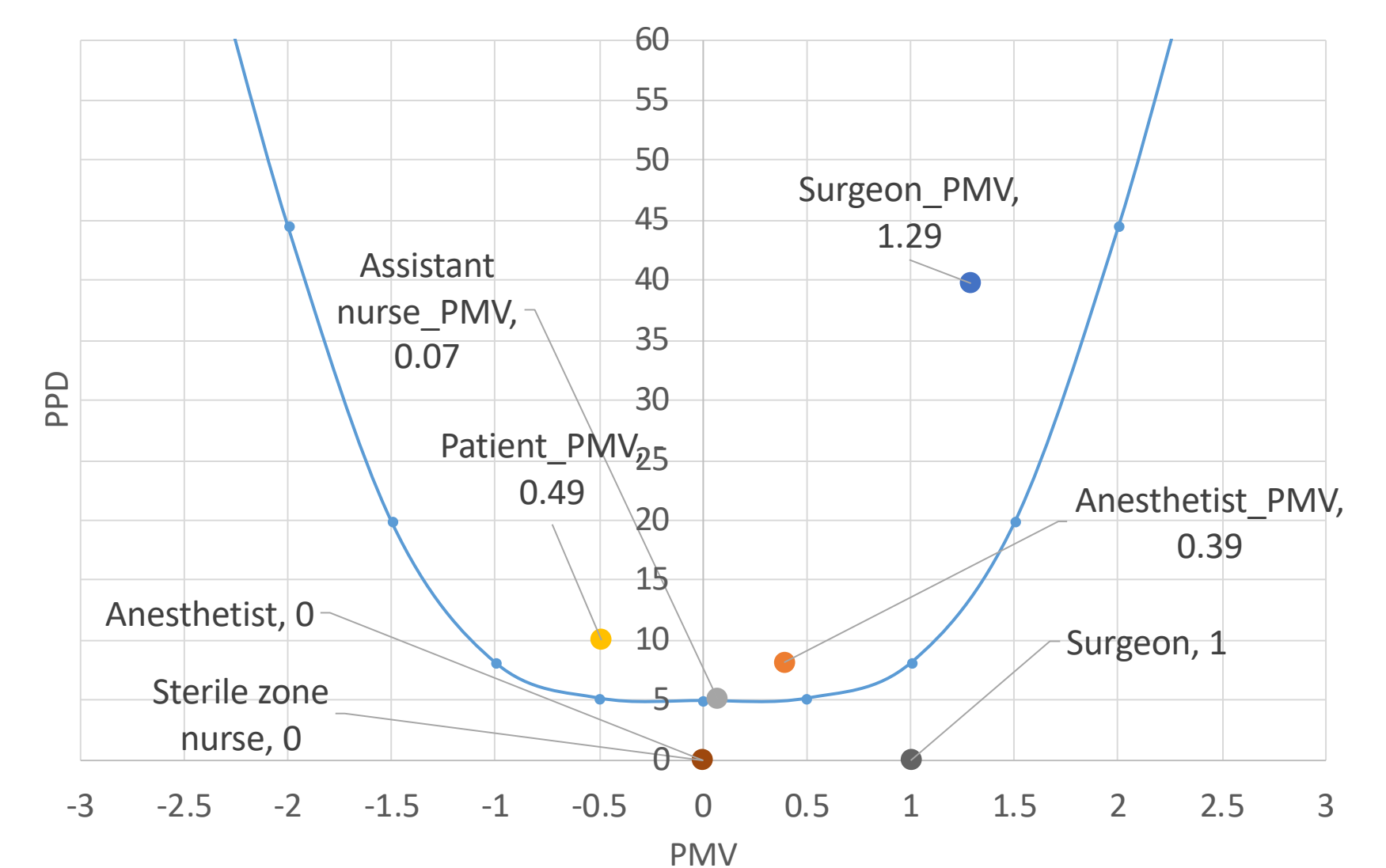


Figure 5. The comparison between of predicted and real thermal comfort in LAF OR

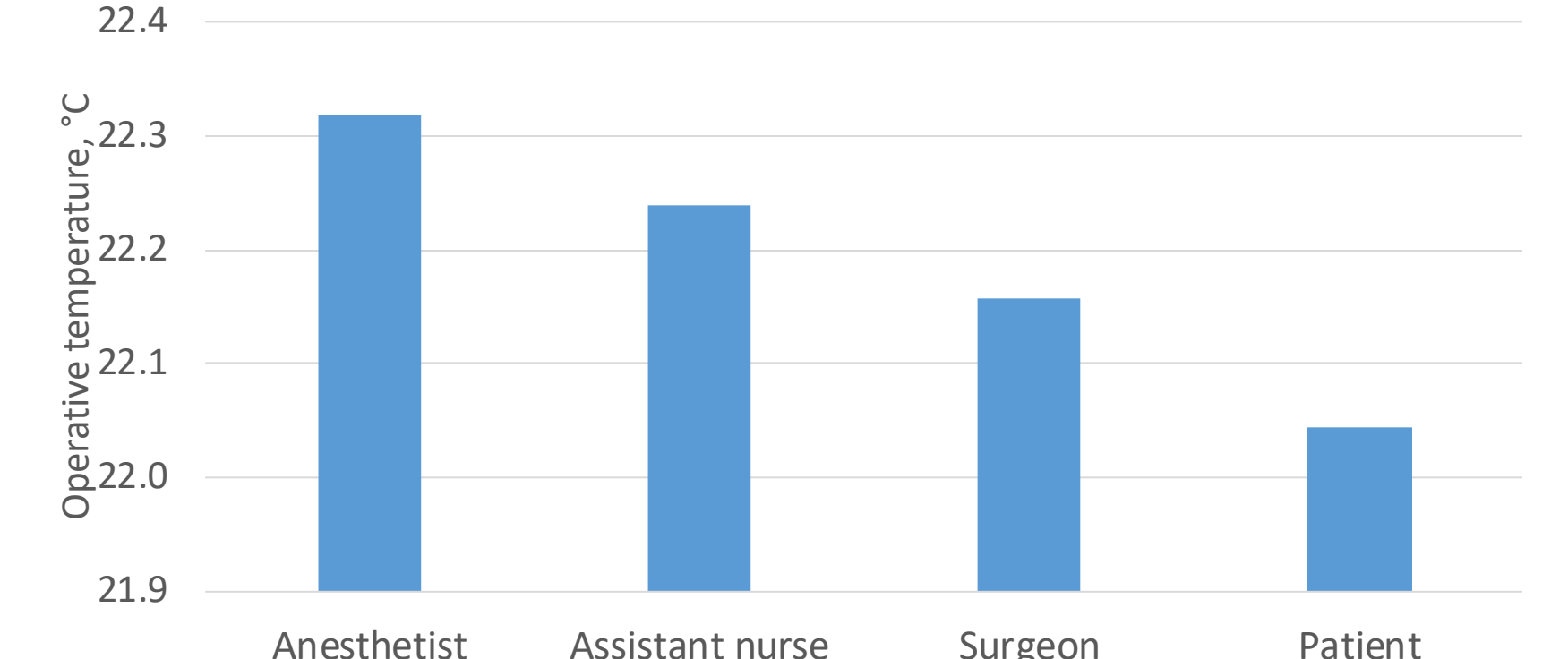


Figure 6. Operative temperature in LAF OR

SUGGESTIONS:

1. Investigate, how to reduce the thermal impact of surgical light
2. Investigate, how much it is possible to raise the air change rate in dilution ventilated OR to take out the heat gain produced by equipment
3. Focus on the clothing in OR to achieve the environment conditions where the highest possible percentage of the people will meet the thermal comfort

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Abbreviations:

OR – operating room; MV – mixing ventilation; LAF – laminar air flow

Thermal comfort scale:

(-3) cold; (-2) cool; (-1) slightly cool; (0) neutral; (+1) slightly warm; (+2) warm; (+3) hot