# Thermal comfort evaluation of an operating room through CFD methodology

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## 1. INTRODUCTION

Operating rooms are exigent places where it is important to set the appropriate air quality patterns as well as the aseptic conditions to ensure the success of the operations. These conditions are obtained using Heating, Ventilation and Air Conditioning systems (HVAC), whose main purpose is to prevent the risk of infection to the patient during the surgical procedures, what ensures safety and an appropriate comfort level for both staff and patient. To ensure good settings for all the operating rooms, the parameters are standardised in the number of air changes per hour, temperature range, relative humidity and pressurisation (ASHRAE Standard 170P, 2006). In a study elaborated by Zwolińska and Bogdan, it was concluded that the surgeon, working with a high metabolic rate, feels uncomfortable after a time (Zwolińska & Bogdan, 2012). While the human body tries to metabolically adapt to the environment conditions, the necessary effort will result in thermal discomfort sensation and, therefore, in lower work performance with fatigue and irritability (Parsons, 2002; Zwolińska & Bogdan, 2012). This means that studies concerning indoor thermal conditions are very important in defining, for instance, the satisfactory comfort temperatures range in health care facilities. Thermal comfort is often assessed by Fanger's model, which is considered a good method for most of the cases.

The Computational Fluid Dynamic (CFD) models are a practical, fast and cost effective way to predict fluid behaviour in complex situations (Versteeg & Malalasekera, 1995). These techniques have suffered major developments in recent years and became a low-cost state-of-art tool for the design of efficient HVAC systems. In a study elaborated by Paul Roelofsen (Roelofsen, 2011), it was demonstrated that the CFD analyses are a great asset to the ISO 7730 standard, allowing better predicting of the draughts and local gradients that can cause discomfort. In this study, thermal comfort of an operating room is assessed, specifically in an orthopaedic ward of a Portuguese hospital. A CFD simulation was carried out accounting for surgical lamps' radiation heating, air humidity, airflow patterns and temperature distribution. The post processing of data has allowed the calculation of PMV index values for the entire domain.

## 2. MATERIALS AND METHOD

The environmental variables were measured using a Brüel&Kjær climatic station. This device is equipped with several electronic sensors which quantify the environmental variables. The sensors used in the station are an air temperature transducer as well as surface temperature, radiant temperature asymmetry and air velocity ones. Several measures were undertaken until sensor's stabilisation, and average values were then calculated. Personal variables were calculated through a questionnaire for the users of the surgical block for a larger sample. These data together with measures of the geometry of the operating room were used to create a CFD model, see Figure 1. For the PMV values' representation in the post processing, a script coded in Python programming language was created in order to make the necessary calculations.

## 3. RESULTS AND DISCUSSION

After running the CFD simulation, the average values of temperature, humidity, air velocity and air temperature from the entire domain were retrieved. These values were combined with a total of 72 combinations of metabolic rate and clothing insulation, and an iso-contour plot was calculated, as shown in Figure 2.

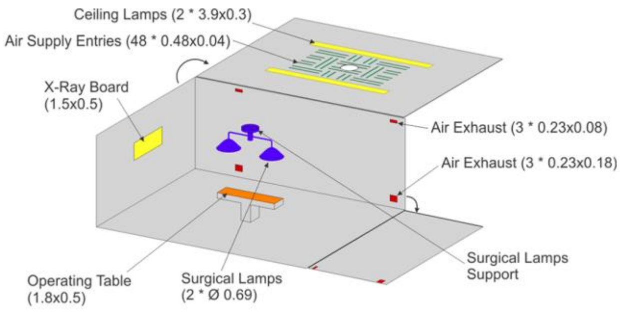


Figure 1 – Operating room geometry.

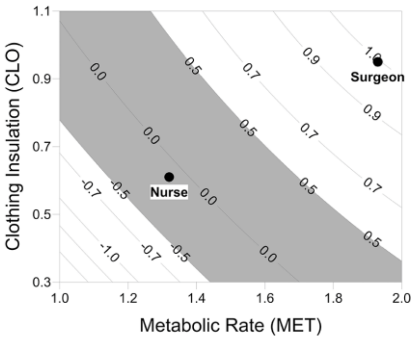


Figure 2 – PMV values map for clothing insulation vs. metabolic rate.

The results for the PMV on Figure 3 show that there is a clear difference between the thermal sensation experienced by surgeons and nurses inside the same surgical room. The differences within the results were obtained due to the positions with respect to the ventilating system and the lamps. The results are in agreement with previous studies in the literature and the questionnaire responded by the medical personal, supporting the idea that surgeons have a hotter thermal sensation [4].

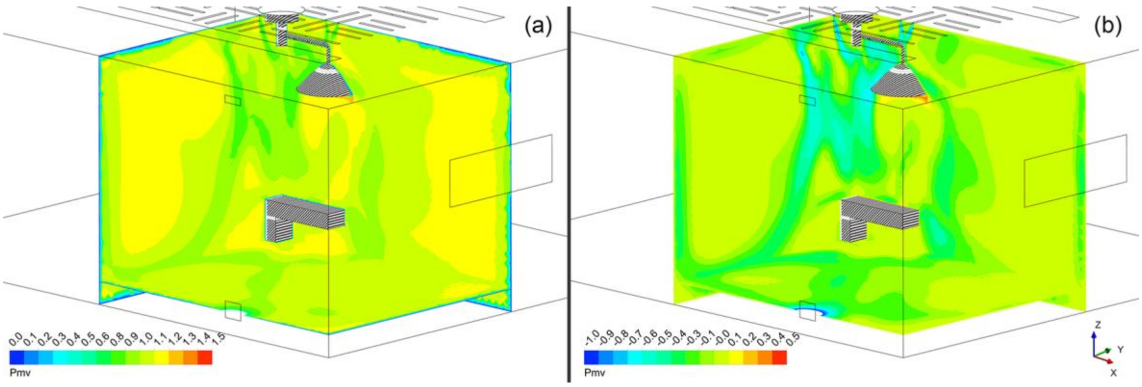


Figure 3 – Node representation of PMV values. Where a) and b) represent the surgeons and the nurses case respectively.

The surgeon PMV field (see Figure 3 (a)) goes from neutral thermal sensation of 0 to a slightly warm sensation of 1.5, while the nurse PMV thermal sensation (see Figure 3 (b)) ranges from a -1 (slightly cold) to a maximum of 0.5 (warm/neutral). It is noticeable that for the same domain locations each one has distinct thermal sensations. It is also important to mention that, although the average PMV values for the room indicated 1 for the surgeon and 0 for the nurse, the PMV local value inside the surgical room varies with the location where the person is positioned.

## 4. CONCLUSIONS

The main objective of the present work was the evaluation of the thermal comfort sensation experienced by surgeons and nurses inside a Portuguese orthopaedic surgical room, by analysing the PMV index. This was achieved using CFD tools, saving time and resources. Calculating the PMV for each domain node, enlightened us to the fact that using average ventilation values to calculate the PMV does not provide a correct and enough descriptive evaluation for the thermal environment of the surgical room as a whole.

It is noticeable that surgeons and nurses feel different thermal sensations in the same surgical room. For the studied case, the surgeon feels the room environment hotter than the nurse. The nurses feel a slightly cold sensation under the air supply diffuser and a neutral zone is located in the air stagnation zones close to the walls. As expected for both cases, lamps provide an uncomfortable sensation.

## 5. REFERENCES

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