Building and Environment 140 (2018) 119–127

Contents lists available at ScienceDirect

Building and Environment

journal homepage: www.elsevier.com/locate/buildenv

Understanding thermal comfort perception of nurses in a hospital ward work environment

M.T.H. Derks[a], A.K. Mishra[a,b,*], M.G.L.C. Loomans[a], H.S.M. Kort[a,c]

[a] Department of the Built Environment, Unit Building Physics and Services, Eindhoven University of Technology, Eindhoven, the Netherlands
[b] Department of Mechanical Engineering, Aalto University, Espoo, Finland
[c] Centre for Health and Sustainable Life, Utrecht University of Applied Sciences, Utrecht, the Netherlands

ARTICLE INFO

Keywords:
Nursing staff
Work performance
Hospitals
Thermal comfort
Thermal zones

ABSTRACT

In indoor comfort research, thermal comfort of care-professionals in hospital environment is a little explored topic. To address this gap, a mixed methods study, with the nursing staff in hospital wards acting as participants, was undertaken. Responses were collected during three weeks in the summer (n = 89), and four weeks in the autumn (n = 43). Analysis of the subjective feedback from nurses and the measured indoor thermal conditions revealed that the existent thermal conditions (varying between 20 and 25 °C) caused a slightly warm thermal sensation on the ASHRAE seven point scale. This led to a slightly unacceptable thermal comfort and a slightly obstructed self-appraised work performance. The results also indicated that the optimal thermal sensation for the nurses — suiting their thermal comfort requirements and work performance — would be closer to 'slightly cool' than neutral. Using a design approach of dividing the hospital ward into separate thermal zones, with different set-points for respectively patient and care-professionals' comfort, would seem to be the ideal solution that contributes positively to the work environment and, at the same time, creates avenues for energy conservation.

1. Introduction

Hospitals are designed with hygiene and safety as the main parameters, often making thermal comfort a secondary concern [1,2]. Several studies conducted to examine thermal comfort in hospitals have focused on the situation in operating rooms and on patients [3–9]. Field studies in hospital wards, focusing on the caretakers, are less common [2,10,11]. Patients are likely to have different thermal requirements from the caretakers due to their health related effects, difference in clothing levels, and markedly different activity levels [10]. However, this does not often make it to design considerations. The implications could be twofold: less attention paid to difference in thermal comfort needs of patients vis-a-vis caretakers and less attention paid to the effect of thermal comfort on the work performance of the caretakers.

At the same time, thermal comfort research and corresponding standards [12,13] have primarily focused on comfort of occupants during steady state whereas the nursing staff have to continuously move around and are, on an average, a lot more active than typical office personnel. Multiple experiments, regarding occupants in transitional situations, both spatial and temporal, have been executed in laboratory settings [14–16]. Studies in field settings, involving actual occupants, are rare [17,18]. Some such studies have indicated the importance of the prior location's thermal conditions and that the gradual attuning to their current thermal conditions may require occupants nearly 20 min [18,19].

This work was hence organised as a pilot exercise in addressing the research gap regarding thermal comfort studies involving care-professionals in hospitals and their thermal comfort perception through their active work schedule. The intention was to better understand the thermal perception and thermal comfort requirements of nurses during their work hours and how their thermal perception possibly impacts their work performance. It is expected that these results can be used as starting ground for future research, as well as stimulating recognition of thermal comfort requirements of nursing staff during design stage of hospital wards.

The case study was taken up in two wards of a hospital. Based on the methods developed through a previous study [18], the current field investigation was organised and the aspects that needed to be considered for occupants moving across different thermal conditions were decided upon. Parameters focused on were clothing levels, activity levels, and the thermal conditions encountered by the nurses.

* Corresponding author. Department of the Built Environment, Unit Building Physics and Services, Eindhoven University of Technology, Eindhoven, the Netherlands.
E-mail address: writeto.asit@gmail.com (A.K. Mishra).

https://doi.org/10.1016/j.buildenv.2018.05.039
Received 14 March 2018; Received in revised form 17 May 2018; Accepted 18 May 2018
Available online 21 May 2018

Fig. 1. Floor plan of the wards, east and west, where the study was undertaken. A–H: locations of the 8 Rotronic sensors. 1–3: locations of the 3 indoor climate measurement stands (ICMS).

Table 1
Demographics and general thermal conditions.

		Summer	Autumn
Demographics		**Responses**	
Total	N	89	43
Age	Mo [perc]	21-30 [75.3]	21-30 [53.5]
Gender	Mo [perc]	Female [64.0]	Female [76.7]
Work length	Mo [perc]	>3 months [92.8]	>3 months [87.8]
Work shift	Day	49 [66.2]	14 [32.6]
(n [perc])	Evening	16 [21.6]	20 [46.5]
	Night	9 [12.2]	9 [20.9]
Outdoor conditions			
T_{out} (°C)	M [SD]	18.7 [4.0]	9.7 [3.5]
	Max.	32.2	18.7
	Min.	8.4	−0.4
RH (%)	M [SD]	78 [15]	86 [11]
Solar radiation (J/cm^2)	M [SD]	74 [87]	26 [43]
Indoor conditions			
$T_{air;shiftmean}$			
$T_{air;in}$ (°C)	Day	23.5[0.7]	22.4[0.7]
(M [SD])	Evening	23.6[0.8]	22.5[0.7]
	Night	23.2[0.7]	22.3[0.8]
RH (%)	Day	54.1[2.5]	40.3[2.7]
(M [SD])	Evening	52.5[2.9]	40.3[2.4]
	Night	54.1[2.6]	38.9[2.6]

2. Methods

The study was executed in two wards of a hospital in the Netherlands, from July 11th till July 29th (summer) and October 7th till November 11th (autumn), 2016. During the study, objective and subjective data were obtained to determine thermal comfort perception of the nursing staff. The two measurement periods were so chosen as to have representative observations from summer and autumn season. A floor plan of the wards has been provided in Fig. 1. The middle of the V-shape separates the east and west oriented wards. Each ward consists of six one-person, six two-person, and four six-person patient rooms. All patient rooms are located near the perimeter. The reception, medicine room, staircase and staff rooms, such as meeting room and chief's office, are positioned towards the core of the building, keeping them ~8 m away from the building envelope. All the rooms in the wards that nurses had to move across due to work requirements, were monitored: patient rooms, reception, meeting room, break room, and medicine room.

2.1. Study participants

The target group in this research was the nursing staff. The focus was on their thermal comfort perception and its perceived influence on their work. As gathered from the hospital administration, there had been generic complaints from the nursing staff regarding the indoor environment causing warm discomfort. The general demographic of the participating nurses has been summarized in Table 1, along with the thermal conditions they faced during these investigations.

The distance between the hospital entrance and the ward is a ~ 5 minutes walk. When the nurses come in for their shift, they stop in the changing room in the basement to put on their uniforms. So, from entering into the building to entering into the ward, they had to spend upwards of 30 min. Due to this time gap, the direct effect of outdoor–indoor transitions was excluded since past studies showed that this effect lasts about 20 min [18,19]. Throughout the year, the nursing staff is obligated to wear the same work clothing, shown in Fig. 2, with the choice for an additional vest (represented along with the uniform). More clothing may be worn as long as it does not constitute the outermost layer. This is for reasons of uniformity and hygiene. Fig. 3a) represents the nurses' work schedule, indicating the typical transitions they made during their shift, as gathered from the head nurse.

2.2. Objective measurement of indoor thermal conditions

Objective indoor environmental measurements were performed and surveys were conducted in three phases: during summer, during autumn, and a set of preliminary measurements. Measurement data was collected at several positions in the wards. These positions were determined during preliminary measurements.

The purpose of the preliminary measurement — carried out two weeks prior to first survey period, for two days, in multiple locations around both wards — had been to determine presence of thermal non-uniformities, thermal stratification, and to decide on locations where measurements could be conducted to provide a representative view of the ward's thermal conditions. Air temperature and relative humidity (RH) were measured at different locations, based on typical nurses' transition within the ward, using three Rotronic sensors placed on two stands — at 0.6, 1.1, and 1.7 m height — in accordance with ISO 7726 and ASHRAE 129 [20,21]. Results of the preliminary measurements showed air temperature and RH differences, for devices positioned on a particular stand, kept lower than the device accuracies. Therefore, stratification concerns were absent. Measured temperature differed across the patient rooms having different number of beds. Hence measurements were conducted in each room type, based on the number of beds in a room. Furthermore, temperature and humidity were also measured in several patient rooms falling under the same type in order to take into account differences arising due to room orientation.

The final measurement locations have been shown in the floor plan in Fig. 1. Three indoor climate measurement stands (ICMS), image given in Fig. 3 b), positioned in two patient rooms and near the reception, had measurement equipment for air temperature, globe temperature, omni-directional air velocity, RH, and CO_2 concentration. The Rotronic devices measured air temperature and RH. The measurements were taken in accordance with ISO 7726 [20], at a height of 1.1 m, which approximately corresponds to a standing person's centre of gravity. Measurement equipment specification has been provided in Table 2.

Weather data was obtained from the Royal Dutch Meteorological Institute's (KNMI) [22] location “De Bilt”, which was within a 3 km radius of the hospital. Outdoor conditions during the measurements have been summarized in Table 1. Following the survey measurements,