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Comfort at hospital reception desks

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ABSTRACT

For several years indoor comfort is measured in halls of hospitals by architecture students from the Delft University of Technology. Questionnaires and interviews have shows that patients and visitors have very few complaints about the indoor comfort in hospital halls.
This, in hindsight, is not so very surprising. Patients and visitors usually come out of the cold into the hallway. A hallway which is at least marginally warmer, a hallway where it does not rain and hallway that is sheltered from the outside wind. Secondly, the indoor comfort is not the main concern of the patients and visitors entering the hospital. The patient's and visitor's upcoming consults with the doctors or nurses is much more important. Coming from the consult, patients and visitors always have the choice to immediately leave the hospital if they do not like the indoor comfort. Complaints from staff, however, are very common. Staff personnel usually complain about low temperatures and draught.

A reception desk is the main workplace in a hospital hall. A reception desk can be closed, i.e. physically separates the personnel from the environment of the hall. A reception desk can also be open, thus without a physical separation between personnel and patients and visitors. In a hospital, in general, an open reception desk is favoured for a more welcoming atmosphere for patients and visitors. This more open reception desk, however, often causes the personnel to experience low temperatures and draught.

From this study it is clear that it is very difficult design a thermally comfortable reception desk in a hospital. The quest for a reception that expresses openness and transparency clearly hinders the design for a comfortable reception desk. On the other hand, the small number of people at the reception desk is in no comparison to the hundreds of staff and patients for which the hospital is also designed.

Many solutions to improve thermal comfort at a reception desk are already known. The exact cause of the experienced draught and the best solutions, however, are difficult to determine. Scale models or CFD simulations should be used as a guide for design a reception desk in a hospital or when solving thermal comfort problems.

A new cause of draught, people moving past the reception desk, was identified and quantified. As a result, a completely open reception desk inside a large atrium with a lot of people moving past might not be possible without either closing off the reception desk, or increasing the temperature at the reception desk.

KEYWORDS

Hospital, Comfort, Draught, Reception

1 INTRODUCTION

A reception desk is an important part of a hospital. The reception desk is often the first contact between the patients and visitors with the hospital. Anxious patients are welcomed at the reception desk. Reception desk personnel helps patients and visitors to find their way around the hospital. Happy reception personnel increase the effectiveness of a hospital. To keep the reception desk personnel content, the indoor climate at the reception desk should be comfortable. Masters students from the Delft University of Technology in Delft have investigated if the indoor climate at three hospitals reception desks is comfortable within the master course AR0125 [2018, 2019]. The encountered indoor climate is given in this paper and possible improvements are presented when the indoor climate is not found to be comfortable.

2 LITERATURE

There is very little scientific literature about thermal comfort at reception desks or hospital reception desks [Eijkelenboom, Bluyssen, 2019]. Searching for "reception" in the AIVC database only yields one unrelated paper. Searching the Scopus database is not much better. That does not mean that nothing is known about reception desks in large hospital halls. Common sense and practical experience is available (berkela.home.xs4all.nl, kikk-recreatie.dearbocatalogus.nl, www.arbocatalogusmobiel.nl, www.arbo-online.nl)

2.1 Type of receptions

A reception desk can be either closed or open. A closed reception desk physically separates the personnel from the environment of the hall. An open reception desk has no physical separation between personnel and patients and visitors.

The most important reasons to choose a closed reception desk are: Safety, privacy, thermal comfort and noise. A closed desk ensures the safety of the employees and the products handles at the reception desk such as money and legal documents, but can also raise aggression by visitors. Reception desks that are positioned close to the entrance of a building or are positioned in large atria can suffer from cold airflows that are difficult to control. A closed reception desk can protect the desk from these airflows. The last reason to choose a closed reception desk is to prevent acoustic discomfort by acoustically insulating the reception desk from a lot of background noise. In a hospital, in general, an open reception desk is favoured for a more welcoming atmosphere for patients and visitors.

2.2 Comfort at receptions

Temperatures

A receptionist usually performs a number of tasks, from giving information, answering the telephone to performing light administrative work. According to the literature, see tables 1 and 2, a temperature above 21 °C and air velocities lower than 0.15 m/s is comfortable. The literature also mentions that there is a difference in comfort between men and women and that thermal comfort depends on the tiredness of people. These last two aspects are not taken into account in this paper.

Draught

Fanger defines draught as "an unwanted local cooling of the human body caused by air movement". Most people are affected by draught at locations that are not covered by clothing, such as head, neck and ankles. The air temperature, the turbulence intensity and the average air velocity together define the degree of discomfort due to draught (ISSO 74, 2014).

At the moment the most used draught equation is the draught ratio (DR) by Fanger:

$$DR = (34 - T)(u - 0.05)^{0.62}(3.14 + 0.37uI) \quad (1)$$

Where I is the local turbulence intensity, u the local air velocity and T is the local temperature in ˚C (combined air and radiation temperature). The thermal state of the body also has impact on the degree of disturbance by draught. The activity level has an impact on the maximum acceptable air velocity, see table 2.

Table 1: Comfort temperatures from literature

Reference	Building function	Temperature winter (°C)	Comments
ISSO 74, 2014	not distinguished	> 20	alpha building
CIBSE, 2007	entrance halls/ lobbies/ corridors/ general waiting areas	19-21	max air velocity 0.15 m/s, Met = 1.4, clo = 1.0.
ISSO 7730	office, auditorium, restaurant	22 ± 2	Normal level of expectation, class B, max 10 % dissatisfied, max velocity 0.16 m/s, Turbulence intensity 40 %, Activity 70 W/m^2.
Hospitals 2 and 3	reception	> 21	personal communication

Table 2: Maximum acceptable air velocities at different air temperatures and at different activity levels [AR0125, 2018]

Air Temperature (°C)	maximum acceptable mean air velocity (m/s) at activity level			
	Metabolic rate 85-105 W	Metabolic rate 130 W	Metabolic rate 160 W	Metabolic rate 200 W
20	0.15	0.15	0.20	0.20
22	0.15	0.20	0.20	0.20
24	0.20	0.20	0.20	0.30
26	0.30	0.30	0.30	0.40
28	0.30	0.40	0.40	0.40

2.3 General solutions of problems at receptions

The main causes of thermal comfort complaints are the following according to the Dutch ARBO-online [www.arbo-online.nl]: the position of the reception desk, limited air circulation under the reception desk, unbalanced airflows produced by the heating and ventilation system, the position of the heating elements and the inability of the personnel to influence the temperature themselves. Radiation of a cold floor or from the front of the reception desk can be solved using floor heating or radiators (but beware of uneven heating).

Draught problems can be prevented by separating the personnel from the outside air when the entrance doors are opened. This can be done using an air curtain, a revolving door, a draught lobby and enough distance between the reception and the entrance door.

3 METHOD

3.1 Case study receptions

Three hospital reception desks were investigated.

Hospital 1 [AR0125, 2018]: The entrance hall, which is an atrium consisting of large glass surfaces. The hall is oriented northeast and has, partly, a double storey height of over 7.3

meters. The ground floor of the hospital houses a restaurant, espresso-bar, and small giftshop for the visitors. When people enter the hall through a revolving door, they directly see the welcome desk which is placed centrally in the hall. The hall leads to a long corridor which leads to all different departments situated on the ground floor. The main source of heating during winter, and cooling during summer is the mechanical ventilation system. Several service desks also have their own local heating devices. During warm summer days, the revolving door is fully opened to let in as much fresh air as possible.

Hospital 2 [AR0125, 2019]: The patients, visitors and staff members enter the building through the main entrance. After entering the building, the user must go through a long hallway to go to the reception area. The areas surrounding this reception area are several waiting areas, a coffee corner and a long hallway to the parking garage.

Hospital 3 [AR0125, 2019]: The patients, visitors and staff members enter the building through the main entrance. After entering the building, the user finds a hallway which is were the reception area is situated. The areas surrounding this reception area are a waiting area, a working area and a commercial area.

3.2 Measurements

Eltek Squirrels, HOBO dataloggers, I-buttons and EXTECH air velocity meters were used to measure the temperature, the relative humidity the air velocity and the CO2 concentration, see figure 1. The researcher's nose was used to track and identify any interesting smells at the reception desk and in the surrounding areas. The outdoor temperatures of the nearest airport were taken from the KNMI website. The perceptions of the people from the reception desk were investigated using a questionnaire and additional small talk. The questionnaire consisted of questions about personal characteristics and thermal comfort.

Figure 1: Equipement Eltek Squirrels, Hobo Dataloggers, I-buttons and air velocity meter, images from the producers.

4 RESULTS

4.1 Measurements

***Hospital 1*:** The measurements were taken between the 5th of May 2018 and the 12th of May 2018. The average outdoor temperature was between 5.0 and 9.0 °C, see figure 2.

Measurement day	day	t_{start}	t_{end}	$T_{outside}$ (°C)
1	05/03/2018	11:09	12:30	6.4
2	07/03/2018	9:36	12:33	5.0
3*	12/03/2018	9:34	12:18	8.6

Figure 2: Outside temperatures (KNMI, closest weather station) of hospital 1.

The temperature at the reception desk was generally between 21 and 23 °C, see measurements 1 and 3 in figure 3. This means that the temperature should in general be comfortable. The personnel of the reception desk had a personal heating system. The air velocities were measured on the 21 of March 2018. The average air velocity (0.1 m, 0.6 and 1.1. m) in front of the reception desk was 0.26 m/s at an average temperature of 20.5 °C and an average turbulence intensity of 0.84.

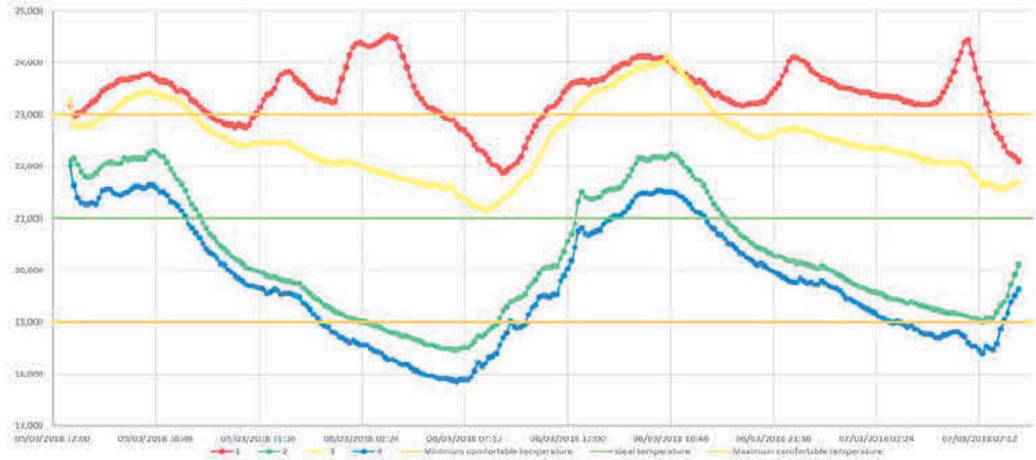

Figure 3: Temperature measurements (red and yellow line) at the reception desk in hospital 1.

Hospital 2**:** The measurements were taken on the 6th of May 2019 between 9.00 and 14:30. The outdoor temperature was between 9.5 and 12 °C with a North wind speed of 11 km/h, see figure 4. The temperature at the reception was between 22.5 and 23.5 °C measured with Eltek, I-button and Hobo's, see figure 6. The CO_2 concentration was below 800 ppm.

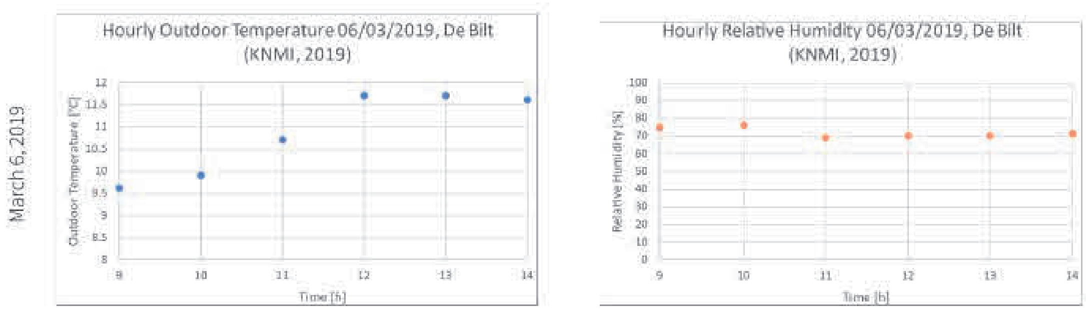

Figure 4: Outside temperatures (KNMI, closest weather station) of hospital 2.

Hospital 3**:** The measurements were taken on the 7th of May 2019 between 9.00 and 14:30. The outdoor temperature was between 9.5 and 10.5 °C with a North East wind speed of 18 km/h, see figure 5. The temperature at the reception was again between 22.5 and 23.5 °C measured with Eltek, I-button and Hobo's, see figure 7. The CO_2 concentration was below 800 ppm and is not further investigated.

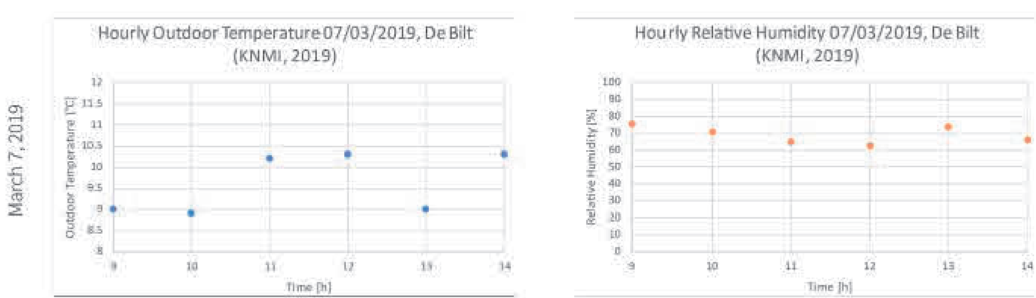

Figure 5: Outside temperatures (KNMI, closest weather station) of hospital 3.

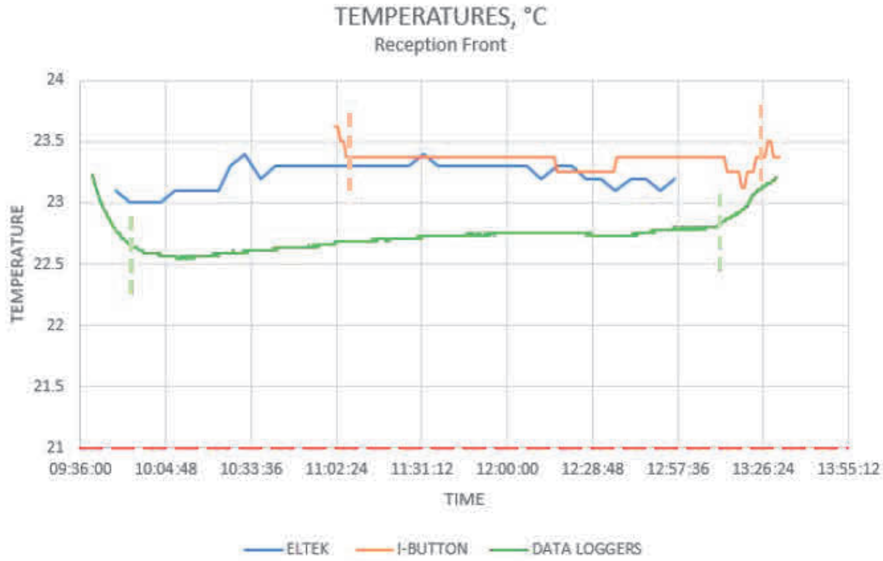

Figure 6: Indoor Temperature at the reception desk in hospital 2.

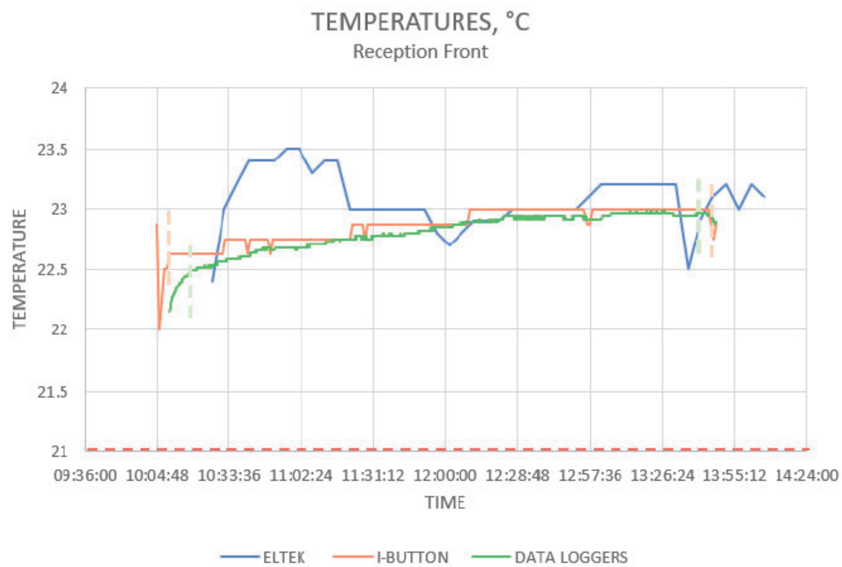

Figure 7: Indoor Temperature at the reception desk in hospital 3.

4.2 Questionnaires

Hospital 1: 24 employees were surveyed, 60 patients and 36 visitors. 43.8% of the employees were feeling (slightly) cool or cold (where only 12.5% felt slightly warm or hot); and a lot of employees felt draught (68.4%). Those two ways of expressing thermal discomfort are likely to be related. For people that are feeling cool, together with high turbulence intensities – draught can be a serious cause of discomfort, even at locations were no high values are measured for the air velocity.

The main outcome of the questionnaires in hospitals 2 and 3 is that the reception desk personnel (9 responses in hospital 2 and 6 responses in hospital 3) found the temperature at the reception desk to be slightly cool and that the personnel suffered from draught. 80 % of the people in hospital 2 and 100 % in hospital 3 often suffered from draught. In hospital 2 the personnel thought the draught came from the parking garage and in hospital 1 from the entrance near the reception area.

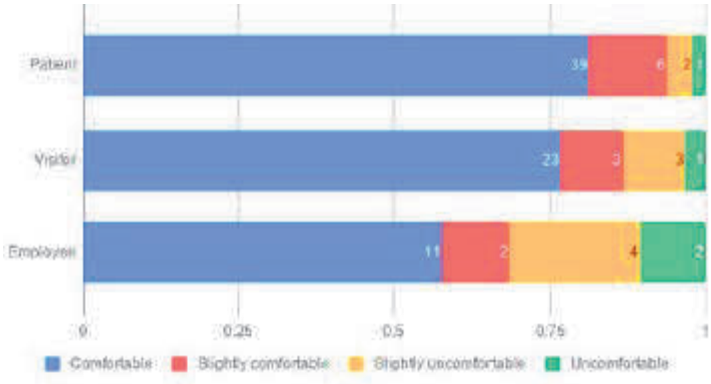

Figure 8: Level of comfort according to patients, visitors and employees in hospital 1.

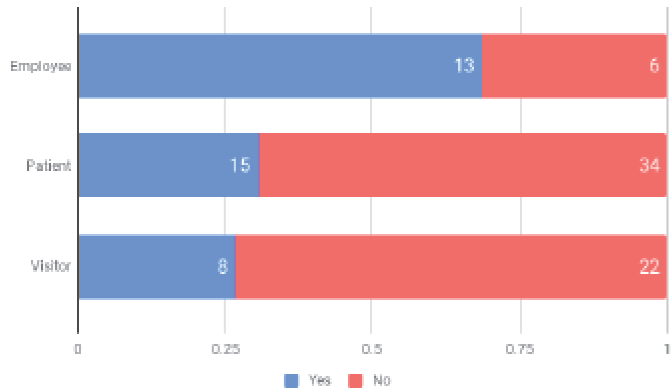

Figure 9: Perception of draught by employees, patients and visitors in hospital 1.

4.3 Conclusion

All three reception desks suffered from low perceived thermal comfort. The air temperatures were not the problem, they were generally above the comfortable 21 °C. Personnel mainly complained about draught, which was supported by measurements in hospital 1.

5 INVESTIGATION INTO THE CAUSE OF THE COMFORT PROBLEMS

5.1 General causes of discomfort

Hospital 1:

The main source of draught is probably the revolving door. Revolving doors increase the energy efficiency of the building and prevent draught, while allowing lots of people to enter a building in a short amount of time. Nevertheless, air leakages are inevitable and occur in two ways: when the door is closed through its seals and cracks, and when opened through the passage of people. Those air leakages can cause discomfort.

The air infiltration when the door rotates depends on the type of revolving door, the rotation speed of the door, the size of the opening, the temperature differential and to a certain extent on the outdoor wind speed and direction and the air velocities indoors. Revolving the door causes an exchange of indoor air and outdoor air of approximately equal volume. If more people are entering, the infiltration decreases with about the volume of the people occupying the space in the revolving door. According to Humphreys et al. this impact is only small [Humphreys et al., 1961]. Figure 10 shows that a higher wind speed outside, and a higher indoor air velocity, lead to a higher infiltration rate.

The air flows close to the revolving door in the hospital were measured. The average air temperature was 20.0 °C, the average air velocity was 0.38 m/s and the average turbulence intensity was 0.40. These values show that the revolving door is a source of unwanted air flows. When the distance between the revolving door and the reception area is small, the effect of the revolving door on the perceived draught is high. Fortunately the high temperature measured is caused by the air curtain included in the revolving door.

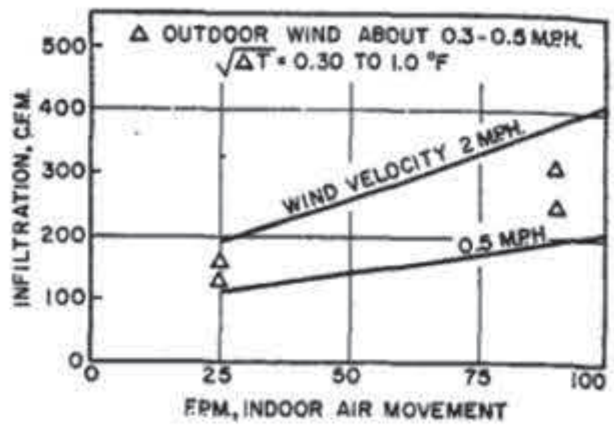

Figure 10: Effect of wind and indoor air movement on infiltration for small tempreature differences and indoor speed of 5 rounds per minute [Humpheys et al,, 1961].

Hospitals 2 and 3:
The draught problems for hospital 2 and 3 were investigated using both a physical model and a CFD (Phoenics) simulation model. The physical model was made from cardboard. The air flow was simulated with a computer fan and the air flow was visualised with a smoke tube.

Hospital 2: The physical model showed a possible discomfort in hospital 2. The air from the parking garage passes the reception to the entrance or the other way around. The CFD model showed that the air current from the entrance and the parking garage does not seem to influence the reception area. The diffusers appear to have a big influence in the microclimate of the reception. The diffusers reach the desks and contribute to the cold draught. There are numerous diffusers at the reception area and they are placed directly next to each other, creating discomfort. Besides this, there is an emergency stairway door located directly in front of the reception area. This door constantly opens and closes creating sudden currents of air as it sucks the air from the outside. This scenario includes an open door, sucking the air from the hallway.

Hospital 3: The physical model showed no discomfort in hospital 3, neither from the air inlets nor from the entrance. The reception desk is positioned in such a way that the main air flow does not pass the reception desk directly. The CFD model of hospital 3 shows that the current coming from the entrance is not a source of discomfort in the reception desk.

5.2 Other causes of discomfort

Due to the fact that in hospital 3 still no explicable source could be found for the draught, the possibility of people being the source of the draught was investigated. To be able to show that people's movement can cause draught felt by the receptionist, an experiment was conducted. In this experiment, the air velocity was tracked of an area, first without people's movements, second with some movement and third with a lot of people moving. The area where the experiment was conducted is the hallway at the Building Technology studio. Figure 11 shows a scheme of how and where the experiment was conducted.

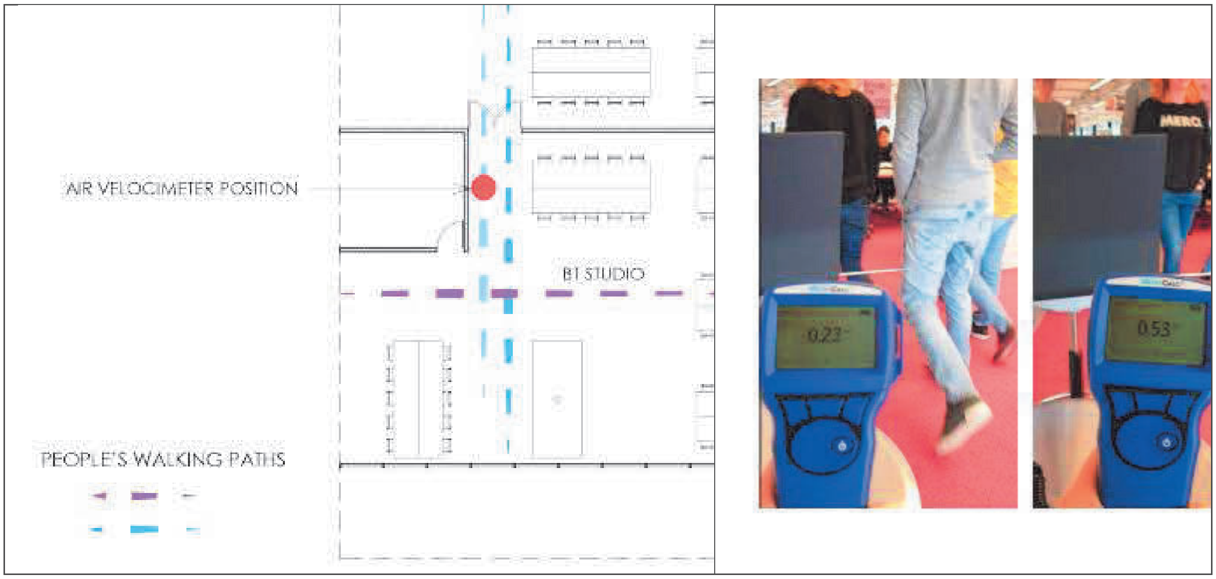

Figure 11: Building Technology Studie Floor plan, left, and group of four people walking from and towards the air velocity meter right [AR0125, 2019]

The air velocity in the hallway when there is no movement of people is 0.01 m/s, which means that there is practically no movement of air. Figure 11 shows the air velocity at the hallway when there is movement of a group of four people walking. In this case the air velocity is 0.23 m/s, measured when the group is walking by and 0.53 m/s, measured when the group is walking back. This experiment shows that when people move, they attract the air around them and that this follows the same path as the people moving. Therefore, it can be concluded that people's movement can be the cause of the air draught felt by the receptionist and the source of discomfort.

5.3 Solutions

From this study it is clear that it is very difficult to make a reception desk thermally comfortable. The quest for a reception that expresses openness and transparency clearly hinders the design for a comfortable reception desk. On the other hand, the few people at the reception desk are in no comparison to the hundreds of staff and patients for which the hospital is also designed.

The solutions given in section 2.3 are a good start to improve the thermal comfort at the reception desk. A different position in hospitals 1 and 2 might help to move the reception desk out of the main airstream. The main cross ventilation airflow through the hospitals can be reduced by rearranging the entrance and exit areas through air curtains, obtaining a different position of the revolving door, adding a revolving door, or creating a draught lobby. Further closing up the reception desk should help in all three hospitals, although this will challenge the openness and transparency of the reception desk design.

6 LIMITATIONS AND DISCUSSIONS

This research is performed by Master students from the faculty of Architecture of the Delft University of Technology. This means that there was limited time for the measurements. Besides limited time, the outside temperature in March can be either cold, as in 2018, or warmer, as in 2019, making comparisons between the hospitals more difficult. There is also limited equipment to do the measurements because equipment needed to be shared with other students. The air flow measurements at the height of the reception desk of hospitals 2 and 3 are sadly missing.

7 CONCLUSIONS

From this study it is clear that it is very difficult design a thermally comfortable reception desk in a hospital. The quest for a reception that expresses openness and transparency clearly hinders the design for a comfortable reception desk. On the other hand, the few people at the reception desk are in no comparison to the hundreds of staff and patients for which the hospital is also designed.

Many solutions to improve thermal comfort at a reception desk are already known. The exact cause of the draught and the best solutions, however, are difficult to determine. Scale models or CFD simulations should be used as a guide for design a reception desk in a hospital or when solving thermal comfort problems..

A new cause of draught, people moving past the reception desk, was identified and quantified. As a result, a completely open reception desk inside a large atrium with a lot of people moving past might not be possible without either closing off the reception desk more, or increasing the temperature at the reception desk.

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