Understanding comfort and health of outpatient workers in hospitals, a mixed-methods study

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Understanding comfort and health of outpatient workers in hospitals, a mixed-methods study

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by

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Voor Tekke

Preface

My first and pleasant memory is atmospheric; orange curtains, blowing gently in the wind, the warmth of the sun on the floor, a twittering bird. That is a personal experience. It is hard to tell whether someone else would have experienced the same at that time and place.

When studying architecture, I hoped to learn how building design contributes to a pleasant and positive experience for the occupants, but I didn't find the answer, neither in discussions with teachers nor in books or buildings. Later on, when working on design projects with occupants involved, the drive to research this topic became increasingly stronger. Incidental feedback from occupants after delivery of a building was valuable but rather anecdotic. It was evident, however, that they thought building characteristics important, and I still couldn't find satisfactory information about the subject.

Thus, only one option remained to gain a better understanding of the occupants' perceptions: doing the research myself. I focused on hospital staff because the importance of their wellbeing is evident, and these buildings are complex.

This research finds that building characteristics, among other aspects, are important for their occupants, and that it is possible to find relations between their stated preferences for aspects of a building and their perceptions of a building, even if those preferences may change according to time and place.

That may seem a small step, but it enables academical and practical exploration of those relations and their integration into the design process, making the personal more predictable. A journey toward improved occupants' wellbeing that I hope to be part of.

Acknowledgements

Different places; the faculty, office, and home, helped to achieve balance between research and practice. More importantly, interaction with my supervisors, peers, colleagues, hospital organizations, hospital workers, friends, and family afforded me delight and inspiration to do this work.

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List of Abbreviations and Acronyms

ANOVA	Analysis of variance
AHU	Air handling unit
ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers
BASE	Building Assessment Survey and Evaluation
CFL	Compact fluorescent lamp
CHBS	California Healthy Building Study
CI	Confidence interval
CO2	Carbon dioxide
COVID-19	Coronavirus disease of 2019
dB	Decibel
EBD	Evidence based design
EPV	Events per variable
ERI	Effort reward imbalance
HEPA	High efficiency particulate air
HPL	High pressure laminate
HVAC	Heating ventilation and air conditioning
IBM	International Business Machines Corporation
IC	Indoor environmental quality cluster
ICU	Intensive care unit
IEQ	Indoor environmental quality
I-PANAS-SF	International positive and negative affect schedule short form
LED	Light emitting diode
MCAR	Missing completely at random
MDF	Medium density fibreboard
NA	Negative affect
NIOSH	National Institute for Occupational Safety and Health
NO2	Nitrogen dioxide
OR	Odds ratio
OV	Overcommitment
PA	Positive affect
PCA	Principal component analysis

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PEQ	Perceived esthetical quality (overall quality)
PhD	Doctor of Philosophy
PSI14	Personal symptom index of 14 symptoms
P-value	Probability value
PVC	Polyvinyl chloride
SARS-CoV-2	Severe Acute Respiratory Syndrome - Corona Virus - 2
SC	Social comfort cluster
SD	Standard deviation
SPSS	Statistical Package for the Social Sciences
SR	Standardized residuals
US EPA	United States Environmental Protection Agency
VDU	Visual display unit
VIF	Variance inflation factor
VOC	Volatile organic compound
vs.	Versus
WHO	World Health Organization

Summary

Against the backdrop of an increasing need for healthcare, staff shortages and relatively high rates of sick leave, understanding of wellbeing (comfort and health) of hospital workers is important. This research aims to provide a contribution with the following main research question:

How are comfort and health in hospitals associated with personal, work, and building-related aspects?

A literature review was conducted to define the scope of this research, followed by a field study. The field study included quantitative and qualitative research, because a mixed-methods approach allows for obtaining broad and in-depth insights in comfort. The field study comprised two phases; a questionnaire and building inspection to determine relations of comfort and health with the aforementioned aspects, followed by interviews with occupants to explore in-depth their experiences.

Literature study

The literature review provides an overview of previous field studies in hospitals on the occupants' wellbeing in relation to building characteristics. The review identified that wellbeing can be influenced by building-related aspects, such as the Indoor Environmental Quality (IEQ), characteristics of the layout, and the overall quality, and by personal and work-related aspects, such as age, gender, and work pressure. These variables are all included in the field study.

Furthermore, the literature review found differences in comfort and health between occupant groups, i.e., patients, visitors, and staff, and between different hospital departments, such as inpatient wards, intensive care, or outpatient areas. Previous studies on comfort and health of hospital workers in outpatient areas was missing, while staff was generally less satisfied with comfort than patients. Therefore, the field study focuses on hospital workers in outpatient areas.

Field study

In the first phase of the field study a survey was conducted in the autumn of 2019. The survey consisted of a questionnaire for outpatient workers and checklists for building inspection. Descriptive statistics of the data were conducted, followed by detailed analyses. In the second phase of the field study interviews with the occupants were carried out.

Survey

The questionnaire comprised validated questions on IEQ and health, and translated questions to assess the overall quality (Perceived Esthtical Quality, PEQ). New were questions on satisfaction with social comfort, such as privacy, proximity, and crowding, and on preferences on comfort (IEQ and social comfort). After a pilot study with 25 outpatient workers, a slightly adjusted questionnaire was sent to 1.694 outpatient workers in six hospitals. The questionnaire was answered by 556 of them. Inspection was carried out at the hospitals, including inspection of the location, building services, layout, cleaning protocols and building-related aspects of 127 rooms.

Descriptive analysis

Half of the outpatient workers are dissatisfied with temperature, daylight and found the indoor air too dry. These are the most dissatisfying IEQ aspects. The most prevalent complaints on social comfort are too much distraction and limited privacy. One third of the outpatient workers is hindered by these aspects. Dry eyes and headaches are the most prevalent health complaints, respectively of half and one third of the outpatient workers.

Comfort and health in relation to work

To better understand associations of work with comfort and health, differences in satisfaction with comfort and the prevalence of dry eyes and headaches were compared with the room types (receptions, consultation rooms, offices, and treatment rooms). This was done because work generally varies between room types.

Regression analysis, adjusted for personal aspects, shows that satisfaction with thermal, acoustic, visual, and social comfort aspects varies between room types, while satisfaction with indoor air, PEQ, and the incidence of dry eyes and headaches vary to a lesser extent. Generally, satisfaction with comfort is highest in consultation rooms and lowest in offices.

Dry eyes and headaches in relation to building-related aspects

To better understand associations of health with building-related aspects, the risk factors of dry eyes and headaches were calculated with multivariate regression analysis, adjusted for personal and work-related aspects. Risk factors for dry eyes and headaches are, or tend to be, related to the presence of others and the absence of a window to the façade, the corridor, or both. Again, the association with room types was identified. Furthermore, risk factors for dry eyes are, or tend to be, related to building-related aspects that can influence the indoor air quality, i.e., the presence of a rotating heat exchanger and the cleaning frequency of ventilation grills.

Differences in perceptions and preferences

To do justice to differences between participants, clusters were produced that were based on similar preferences and similar satisfaction with comfort. Therefore, one set of IEQ clusters and a set of social comfort clusters were produced with TwoStep Cluster Analysis. Preferences of the outpatient workers has a larger impact on the production of the clusters than satisfaction.

Subsequently, profiles of both sets of clusters were produced. These show differences based on the comparison of health, personal, work, and building-related aspects with the clusters. The profiles show that:

- The IEQ clusters vary mainly in health. For example, those who prefer control of ventilation are more likely to suffer from building-related symptoms and have sick leave than others.
- The social comfort cluster vary mainly in work-related aspects. For example, those who prefer privacy of patients, are more likely to perform activities with patients.
- Both sets of clusters vary in only a few building-related aspects.

Interviews

Because preferences had a large impact on the production of the clusters, these were investigated in the second, qualitative phase of the field study. In the autumn of 2020, semi structured interviews were carried out with 17 participants of the survey in 2019. The participants explained their preferences on comfort with photos of their room. They made the photos, based on instructions, in advance.

The study included changes due to measures to reduce infection risk because of the COVID-19 pandemic, as these were important in the interviews. Inductive content analysis showed changes in comfort, i.e., worries about the indoor air quality, impoverished interaction, decreased speech intelligibility of the patients, difficulties with patient privacy and more aggressive patients.

After deductive analysis, comparison of the questionnaire (2019) with interviews (2020) showed that preferences seem to vary in strength between outpatient workers and can be influenced by the context and expectations. It is likely that preferences in some clusters have mainly negative, in other clusters mainly positive connotations.

Conclusion

This study highlights four important aspects to understand the outpatient workers' comfort and health:

- Differences in IEQ and social comfort in relation to room types.
- Differences in preferences between individuals.
- Changes of preferences due to contextual changes.
- Associations of health with building-related aspects.

Recommendations

This research builds on previous studies which identified IEQ profiles of home occupants and school children. New are the social comfort profiles, comparison with room types and contextual influence on preferences, as well as the occupant group and building type.

Further studies on the formation of preferences on comfort, on social comfort, and on adaptive strategies of the occupants will enhance understanding of comfort and health. Also, research and design studies on social interaction and control of ventilation in outpatient areas may contribute to improved comfort of outpatient workers.

The profiles show the urgency to develop design strategies for an optimal fit with the varying occupants' needs. Further development and visualisation of the profiles could enhance the usability for students and practitioners to envision the varying needs of future occupants.

The associations of comfort and health with building-related aspects, that were determined in this research, can be used in practice. Because these are relevant to different disciplines, such as architecture, building services, and building maintenance, it is important that all stakeholders set health of hospital workers on the agenda, from the first design until the last cleaning cycle.

Samenvatting

Tegen een achtergrond van groeiende zorgbehoefte, tekort aan ziekenhuispersoneel en bovengemiddeld ziekteverzuim is inzicht in het welbevinden (comfort en gezondheid) van ziekenhuismedewerkers van groot belang. Dit onderzoek beoogt daaraan bij te dragen met de volgende onderzoeksvraag:

Hoe zijn comfort en gezondheid in ziekenhuizen gerelateerd aan persoonlijke, werk- en gebouwkenmerken?

Een literatuurstudie is uitgevoerd om het onderzoekskader precies te bepalen. Een veldstudie volgde, waarin kwantitatief en kwalitatief onderzoek gecombineerd werden, omdat een mixed methods onderzoek geschikt is voor het verwerven van breed en diepgaand inzicht in comfort. De veldstudie bestond uit twee fases: een enquête en gebouwinspectie om relaties van comfort en gezondheid met de genoemde kenmerken vast te stellen, gevolgd door interviews met gebruikers om hun ervaringen diepgaand te onderzoeken.

Literatuurstudie

De literatuurstudie geeft een overzicht van voorgaande veldstudies naar het welbevinden van ziekenhuisgebruikers in relatie tot gebouwkenmerken. Zij toont aan dat het welbevinden zowel beïnvloed wordt door gebouwkenmerken, zoals het binnenmilieu, kenmerken van de plattegrond en de algehele kwaliteit, als door persoonlijke en werkkenmerken, zoals leeftijd, sekse en werkdruk. Deze kenmerken worden in de veldstudie alle onderzocht.

Daarnaast wordt aangetoond dat het welbevinden verschilt voor verschillende gebruikersgroepen, zoals patiënten, bezoekers en medewerkers. Ook voor verschillende afdelingen, zoals een verpleegafdeling, intensive care of polikliniek, zijn verschillen gevonden. Het valt op dat medewerkers over het algemeen minder tevreden zijn dan patiënten en de informatie over comfort en gezondheid in poliklinieken beperkt is. De veldstudie is daarom gericht op medewerkers in poliklinieken.

Veldstudie

Voor de eerste fase van de veldstudie is in het voorjaar van 2019 een enquête uitgevoerd, bestaande uit een vragenlijst voor medewerkers in poliklinieken en checklists voor gebouwinspectie. De data zijn daarna beschrijvend geanalyseerd, gevolgd door gedetailleerder deelonderzoek. De tweede fase van de veldstudie bestond uit interviews met gebruikers.

Vragenlijst en gebouwinspectie

De vragenlijst bestond onder meer uit gevalideerde vragen over gezondheid en tevredenheid met het binnenmilieu, en vertaalde vragen over de beoordeling van de algehele kwaliteit (Perceived Esthetical Quality, PEQ). Nieuw waren vragen over de tevredenheid met sociaal comfort, zoals privacy, nabijheid en drukte, en over voorkeuren voor comfort (zowel binnenmilieu als sociaal comfort). Na een pilotstudie met 25 medewerkers uit poliklinieken is een beperkt bijgestelde vragenlijst verstuurd naar 1.694 medewerkers in zes ziekenhuizen. De vragenlijst is door 556 van hen beantwoord. In de zes ziekenhuizen is inspectie uitgevoerd van de locatie, van gebouwinstallaties, plattegronden, schoonmaakprotocollen en de gebouwkenmerken van 127 kamers.

Beschrijvende data-analyse

Ongeveer de helft van de medewerkers is ontevreden met temperatuur en daglicht en vindt de binnenlucht te droog. Dat zijn de meest voorkomende klachten over het binnenmilieu. De meest voorkomende klachten over het sociale comfort zijn te veel afleiding en te weinig privacy. Een derde van de medewerkers heeft hier last van. Droge ogen en hoofdpijn zijn de meest voorkomende gezondheidsklachten, respectievelijk bij de helft en een derde.

Comfort en gezondheid in relatie tot werk

Voor een beter begrip van verbanden tussen werk enerzijds en comfort en gezondheid anderzijds zijn de tevredenheid met comfort en het voorkomen van hoofdpijn en droge ogen vergeleken tussen verschillende ruimtetypes (recepties, spreek/onderzoekskamers, kantoren en behandelkamers), omdat daarin over het algemeen verschillend werk verricht wordt.

Regressieanalyse, gecorrigeerd voor persoonlijke kenmerken, toont aan dat tevredenheid met thermische, akoestische, visuele en sociaalcomfortkenmerken varieert met het ruimtetype. Dat geldt in mindere mate voor tevredenheid met de kwaliteit van de binnenlucht, de esthetische kwaliteit, en het aantal klachten over droge ogen en hoofdpijn. Over het algemeen is tevredenheid met comfort in de spreek/onderzoekkamers het hoogst en in de kantoren het laagst.

Droge ogen en hoofdpijn in relatie tot gebouw kenmerken

Voor een beter begrip van de verbanden tussen gezondheid en gebouwkenmerken zijn de risicofactoren voor droge ogen en hoofdpijn berekend met multivariabele regressieanalyse, gecorrigeerd voor werk- en persoonlijke kenmerken. Last van hoofdpijn en/of droge ogen is gerelateerd, of neigt gerelateerd te zijn, aan de aanwezigheid van anderen en het ontbreken van een raam naar de gevel, de gang of beide. Ook het eerder gevonden verband met ruimtetypes werd teruggezien. Last van droge ogen is bovendien gerelateerd, of neigt gerelateerd te zijn, aan gebouwkenmerken die de binnenlucht beïnvloeden, zoals de toepassing van een warmtewiel en de schoonmaakfrequentie van ventilatieroosters.

Verschillen in perceptie en voorkeuren

Omdat gemiddelden over alle deelnemers weinig recht doen aan verschillen tussen deelnemers onderling, zijn clusters gemaakt op basis van gelijke voorkeuren en gelijke tevredenheid met comfort. Hiertoe zijn, met tweestap-clusteranalyse, een set binnenmilieuclusters en een set sociaalcomfortclusters geproduceerd. De voorkeuren van de medewerkers hadden een sterkere invloed op de vorming van de clusters dan de tevredenheid met comfort.

Aansluitend zijn voor de verschillende clusters profielen beschreven. Zij geven de verschillen weer tussen de clusters onderling op basis van vergelijkingen met gezondheid, persoonlijke, werk- en gebouwkenmerken. De profielen tonen aan:

- Dat de binnenmilieuclusters onderling met name in gezondheid verschillen. Zo komen bijvoorbeeld last van gebouw gerelateerde symptomen en ziekteverzuim meer voor bij deelnemers met een voorkeur voor controle over ventilatie.
- Dat de sociaalcomfortclusters met name in werk gerelateerde kenmerken verschillen. Deelnemers die de privacy van patiënten belangrijk vinden, voeren bijvoorbeeld meer handelingen met patiënten uit.
- Dat beide sets slechts voor enkele gebouwkenmerken verschil maken.

Interviews

Omdat voorkeuren een belangrijke rol speelden bij de productie van de clusters, zijn zij in de tweede, kwalitatieve fase van de veldstudie nader onderzocht. In de herfst van 2020 zijn semigestructureerde interviews gehouden met 17 deelnemers van de enquête uit 2019. De geïnterviewden lichtten hun voorkeuren voor comfort toe met behulp van foto's van hun werkruimte die zij, daartoe geïnstrueerd, eerder zelf maakten.

De studie omvat ook de veranderingen door de tussentijds geïntroduceerde coronamaatregelen, die in de interviews een grote rol speelden. Inductieve inhoudsanalyse bracht zorgen aan het licht over binnenluchtkwaliteit, gebrekkiger contact, verminderde verstaanbaarheid van patiënten, minder privacy voor patiënten, en agressievere patiënten.

Mede op basis van een vergelijking van de enquête (2019) en de interviews (2020), na deductieve analyse, blijken voorkeuren niet voor iedereen even uitgesproken en mede afhankelijk van context en verwachtingen. Het lijkt aannemelijk dat voorkeuren in sommige clusters hoofdzakelijk uit negatieve, in andere clusters juist uit positieve connotaties ontstaan.

Conclusie

Deze studie bevat vier belangrijke aspecten om het comfort en de gezondheid van medewerkers in poliklinieken te begrijpen:

- Verschillen in tevredenheid met binnenmilieu en sociaal comfort in relatie tot ruimtetypes.
- Verschillen in voorkeuren tussen individuen.
- Veranderingen in voorkeuren door veranderingen in de context.
- Verbanden tussen gezondheid en gebouwkenmerken.

Aanbevelingen

Dit onderzoek bouwt voort op voorgaande studies waarin binnenmilieuprofielen zijn bepaald voor bewoners van huizen en schoolkinderen in hun klas. Nieuw zijn, naast een andere gebruikersgroep en gebouwtype, de sociaalcomfortprofielen, de vergelijking tussen ruimtetypes en de invloed van context op voorkeuren.

Kennis over comfort en gezondheid is gebaat bij vervolgstudies naar de vorming van voorkeuren voor comfort, naar sociaal comfort en naar verschillende aanpassingsstrategieën van gebruikers. Daarnaast kunnen toekomstige ontwerp- en onderzoekstudies naar sociale interactie en controle van ventilatie in poliklinieken bijdragen aan een verbeterd welbevinden van de medewerkers.

De profielen tonen de noodzaak ontwerpstrategieën te ontwikkelen voor een optimale inpassing van de variërende gebruikersvoorkeuren. Nadere ontwikkeling en visualisatie van de profielen verhoogt hun bruikbaarheid voor studenten en professionals om zich de verschillende voorkeuren van toekomstige gebruikers voor te stellen.

De verbanden tussen comfort en gezondheid met gebouwkenmerken, die in dit onderzoek zijn bepaald, kunnen worden toegepast in de praktijk. Omdat zij relevant zijn voor verschillende disciplines zoals architectuur, installatieadvies en gebouwonderhoud, is het van groot belang dat alle betrokkenen de gezondheid van medewerkers in ziekenhuizen agenderen, van het eerste ontwerp tot de laatste schoonmaakronde.

1 Introduction

1.1 Problem definition

The purpose of hospitals is to serve as buildings for the medical treatment and healing of sick or injured people. However, nowadays, the wellbeing of patients and staff in hospitals may be affected negatively by the building characteristics [1-3]. This problem can be caused by multiple factors. A possible factor is the limited understanding of the perceptions of comfort and health due to the complexity of relations with personal, work, and building characteristics [4]. Hospitals are complex building types, as they host multiple activities in different parts of buildings, that are shared with a variety of occupant groups, such as patients, visitors, and staff [5]. Also, limited information on the building characteristics of hospitals may impede understanding of comfort and health [6]. To capture the complexity of the occupants' wellbeing in relation to the building characteristics, incompleteness of existing assessment methods could be one of the causes.

Background

Wellbeing is affected by environmental stimuli, that are influenced by building factors. Antonovsky (1979) stated that environmental stimuli which cause a positive or negative stress reaction, are an inseparable part of the environment [7]. These stress reactions may affect the physiological, or psychological state [4]. For example, hospital occupants may perceive building-related symptoms (e.g., dry eyes, headache, fatigue), impeded sleep quality [8], high work pressure [9, 10], or limited privacy [11, 12], that are influenced by environmental stimuli and building characteristics.

According to Folkman (2013), response to stimuli is a dynamic process, due to the variation in appraisal and controllability of stressors [13]. Reactions and sensitivity to environmental stimuli may vary between occupants, due to demographics, physiological characteristics, and previous experiences [14, 15]. Also, the needs

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of individuals may vary during time, depending on their activities, health state, or other factors. Additionally, the needs of patients may be different from the needs of hospital staff. For example, De Giuli et al. (2013) found that a larger proportion of staff than of patients was dissatisfied with the indoor air quality, acoustic quality, privacy, and other comfort aspects [16].

Hospitals accommodate different departments to serve consultation, diagnostic tests, treatment, inpatient care, supporting facilities, etc. Certain rooms require specific environmental conditions, such as the direction of the airflow for surgical interventions in an operating room. Rashid and Zimring (2008) suggested that the relations between building factors and stress reactions may vary between hospital departments, due to e.g., large differences in layout, performed activities, or duration of stay [14].

The above-mentioned factors show that personal, work, and building-related aspects form a myriad of relations with the perceptions of comfort and health. Taking these variables into account, might contribute to a better understanding of, and eventually improved, comfort and health.

Scientific contribution

Discussions about the influence of building characteristics on comfort and health are far from novel. For example, Vitruvius (50 BC) recommended architects to learn from physicians about the influence of thermal climate and air on health (book 1, chapter 1) [17]. Over 170 years ago, Florence Nightingale acknowledged the positive influence of quiet places, sufficient daylight, sufficient fresh air, and thermal comfort on the health of patients [18]. Her work was based on systematic observation and descriptive statistics. For example, after she had set up a structured administration of mortality in a military hospital during the Crimean war, she compared the mortality rate due to sickness and injury. She concluded that soldiers were more likely to die because of insufficient cleanliness and ventilation in the hospital than from their injuries [19].

The four indoor enironmental quality (IEQ) factors, i.e., thermal comfort, indoor air, lighting, and acoustic quality, became key factors to assess healthy buildings in the late 1980s [4]. Studies on IEQ have been carried out in several building types; particularly office buildings have been studied extensively. These studies are generally performed in the field of building engineering. Quantitative methods are used to assess building characteristics and the occupants' perceptions of comfort and building-related symptoms. Despite the guidelines and standards, needs of comfort do not yet seem to be met [20]. It has been suggested by several authors

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that the study of both IEQ and social comfort aspects is important to gain a better understanding of health and comfort [21-23]. For example, privacy has been included in previous field studies [16, 24, 25]. Yet, factors that are closely related to privacy, such as crowding and social interaction [26], have not been included in IEQ studies previously, while associations of stress with the perceptions of crowding and overall quality of the environment (PEQ) have been found [27, 28].

Studies on wellbeing in hospitals used varying methods and have been conducted mainly in the fields of healthcare, environmental psychology, and architecture [29]. Different building characteristics have been included, i.e., the layout, IEQ factors, and interior design. The studies on layout and IEQ factors included generally one aspect, for example, the layout of a ward [30], the view to the outside [31], or the acoustic quality [32]. The influence of other environmental variables can be a flaw in the one-variable studies. Also, comparison of outcomes is difficult, due to the large variety of used methods.

This thesis intends to contribute to a connection of the field of IEQ and healthcare architecture to gain a better understanding of the perceptions of comfort and health. Therefore, IEQ, social comfort, and overall quality are included, as well as a broad range of personal, work, and building-related aspects. The project is related to ongoing studies of the Chair of Indoor Environment at the faculty of Architecture and the Built Environment. The thesis intends to expand the existing body of knowledge, indicate directions for future research, and provide recommendations for practice.

Societal contribution

The growing demand for healthcare, driven by the aging population and the increasing number of people who suffer from chronic diseases, has a large impact on the finance and organization of healthcare [33]. The outbreak of the coronavirus disease 2019 (COVID-19), which caused a pandemic in 2020, clearly showed the pressure on healthcare. For example, regular hospital care was impeded by care for patients that were infected by the SARS-CoV-2 virus and increased sick leave of hospital staff in The Netherlands [34]. The organization, location, and work methods of healthcare might change in the future, to respond to the growing healthcare demand [35]. Studies including work-related aspects, such as performed activities, may provide insights into health and comfort that are robust for future changes.

With respect to the consequences of design decisions on patient outcomes, architects and other engineers are challenged to conduct Evidence Based Design (EBD) during the design process of healthcare facilities [36]. An EBD process aims to use the best available scientific evidence to support design decisions [37]. The purpose is twofold; to support the well-being of the occupants and to limit future hospital organizations' expenditure. Insights into comfort and health with respect to the specific aspects of a hospital department, building characteristics, and occupant group, can be used in EBD processes.

1.2 Research questions

This thesis aims to better understand the comfort and health of occupants in hospitals, with regards to contextual influences. Therefore, the main research question is:

How are comfort and health in hospitals associated with personal, work, and building-related aspects?

To answer this question, the main aim of this thesis is divided into sub-questions and subsequently into detailed questions. The sub-questions correspond with chapters 2 to 6 in this thesis.

Part 1 State of the art (chapter 2)

Sub question

What are the relations of the physical environment in hospitals with the occupants' comfort and health?

Detailed questions

- What building characteristics are related to the comfort and health of occupants in hospitals?
- What are differences in comfort and health between hospital departments?
- What are differences in comfort and health between patients, visitors, and staff?

These questions, that formed the basis for a literature review, aimed to define the main problems and gaps in previous studies on comfort and health in hospitals. Relations of comfort and health were identified with IEQ, the quality of the layout, and the overall quality. It was concluded that comfort and health can vary between departments, such as inpatient wards, operating rooms and outpatient areas. Outpatient areas are parts were consultations and treatment are performed and patients do not stay overnight. The study identified that outpatient areas and hospital staff had been understudied, while staff was generally less satisfied with comfort than patients. These findings contributed to a refined scope of the field study.

Furthermore, the data of a previous pilot study with patients, visitors, and staff at inpatient areas were analysed to better understand differences in comfort between these groups. The results supported the finding from the literature review that patients were generally more satisfied than staff. Also, the importance of building characteristics varied between patients and staff.

Publications

Eijkelenboom, A., G.A. Blok, and P.M. Bluyssen, *Comfort and satisfaction of patients, visitors, and staff with patient rooms at inpatient wards, a pilot study*, in E3S Web of Conferences, vol. 111, CLIMA 2019, 25-29 May 2019, Bucharest, Romania.

Eijkelenboom, A. and G.A. Blok, *Evaluation of design interventions for hospitality and privacy at inpatient wards*, in Proceedings of ARCH19. Trondheim, Norway 12-14 June 2019. In press.

Eijkelenboom, A. and P.M. Bluyssen, *Comfort and health of patients and staff, related to the physical environment of different departments in hospitals: a literature review.* Intelligent Buildings International, 2019. DOI:https://doi.org/10.1080/17508975.0 19.1613218.

Part 2 Determination of relations of comfort and health of outpatient workers (chapter 3,4,5)

Analysis of associations of comfort and health with work characteristics (chapter 3)

Sub question

How are the comfort and health of workers in outpatient areas of hospitals associated with work-related characteristics?

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Detailed questions

- Is it likely that the proportion of staff suffering from the most prevalent building-related symptoms varies in relation to room types?
- Is it likely that dissatisfaction with the IEQ and the social comfort aspects, which bother most outpatient staff, varies in relation to room types?
- Is it likely that the perceived overall quality (PEQ) varies in relation to room types?

To answer these questions, first the most prevalent building-related symptoms, the most dissatisfying comfort aspects, and satisfaction with the overall quality (PEQ) were identified. Subsequently, differences in health and comfort in relation to room types were analysed and adjusted for personal aspects. It was concluded that satisfaction with the social comfort aspects and IEQ, except the indoor air quality, tended to vary between those working in different room types. The prevalence of the main building-related symptoms and satisfaction with the indoor air quality and overall quality tended to vary least.

Publications

Eijkelenboom, A., D.H. Kim, and P.M. Bluyssen, *First results of self-reported health and comfort of staff in outpatient areas of hospitals in the Netherlands.* Building and Environment, 2020. **177**: p. 106871. DOI: https://doi.org/10.1016/j.buildenv.2020.106871.

Eijkelenboom, A. and P.M. Bluyssen, *A pilot study for a questionnaire on health and comfort of staff, working in outpatient areas of hospitals*. CLIMA 2022, Rotterdam, submitted.

Identification of differences in preferences and perceptions (chapter 4)

Sub question

How do outpatient workers differ in their preferences and comfort perceptions?

Detailed questions

- What are the profiles of the outpatient workers, clustered by their preferences and perception of IEQ?

- What are the profiles of the outpatient workers, clustered by their preferences and perception of social comfort?
- To what extent are IEQ and social comfort clusters similar, regarding personal aspects, work-related aspects, building-related aspects, and health?

First, the main preferences and relations between preferences and satisfaction with corresponding comfort aspects were analysed. Then, six clusters for IEQ and three for social comfort were identified. The preferences had a larger weight in the clusters than satisfaction. Subsequently, differences between both sets of clusters were compared with health, personal, work, and building-related aspects. The IEQ clusters varied mainly in health, such as the prevalence of building-related symptoms and sick leave, the social comfort clusters varied mainly in performed activities. Relations of both sets of clusters with building characteristics were limited. The study showed a need for a more detailed understanding of the outpatient workers' preferences. The study showed the need for analysis of relations between health and multiple building-related aspects.

Publications

Eijkelenboom, A. and P.M. Bluyssen, *Profiling outpatient staff based on their self-reported comfort and preferences of indoor environmental quality and social comfort in six hospitals.* Building and Environment, 2020. **184**: p. 107220. DOI: https://doi.org/10.1016/j.buildenv.2020.107220.

Analysis of associations of health with building-related aspects (chapter 5)

Sub question

How are dry eyes and headaches associated with building-related aspects?

The two most prevalent building-related symptoms of the outpatient workers were dry eyes and headaches. Therefore, associations were calculated of both symptoms with building-related aspects. The calculations were adjusted for personal and work-related aspects and included multiple building-related aspects. It was concluded that the risks for dry eyes and headaches are (or tend to be) associated with the presence of windows, room types, and presence of others in the room. Risk factors for dry eyes only were associated with building-related aspects that can influence the indoor air quality.

Publications

Eijkelenboom, A., M. Ortiz-Sanchez, and P.M. Bluyssen, *Building characteristics associated with self-reported dry eyes and headaches of outpatient workers in hospital buildings.* Indoor and Built Environment, 2021. p. 1420326X211023125. DOI: https://doi.org/10.1177/1420326X211023125.

Part 3 Explanation of preferences for comfort of outpatient workers (chapter 6)

Sub question

Which contextual aspects influence the preferences for comfort of outpatient workers?

To answer this question, first, changes in IEQ and social comfort, that were experienced due to the COVID-19 pandemic, were analysed. The main worries were the indoor air quality and impoverished interaction. Then, the preferences were compared with the preferences from the first phase of this research and the explanation of preferences was compared between the clusters. The study showed that the main preferences can change over time. Furthermore, the reason why IEQ aspects and some comfort aspects were preferred varied between the clusters.

Publications

Eijkelenboom, A., M. Ortiz, and P.M. Bluyssen, *Preferences in indoor environmental and social comfort of outpatient staff during the COVID-19 pandemic, an explanatory study.* International Journal of Environmental Research and Public Health, 2021. **18**(14): p. 7353. DOI: https://doi.org/10.3390/ijerph18147353.

Eijkelenboom, A. and P.M. Bluyssen. *Health and comfort of outpatient workers before and during the COVID-19 pandemic.* ARCH22, Rotterdam. submitted.

TOC

1.3 Methodology

To answer the main question, first, a literature review and the analysis of a previously performed survey were undertaken. This phase was followed by a mixed-methods approach for the field study. The field study included a qualitative and quantitative phase to provide a more complete understanding of the comfort and health of outpatient staff [38]. The rationale behind this approach is the complementary nature of quantitative and qualitative studies [39]. The different types of data can provide greater understanding and insights into the research topics that may not have been obtained by analysis and evaluation of one type of data. The quantitative data enable to determine relations between the occupants' perceptions and other characteristics, while the qualitative data enable to explore the occupants' experience in depth.

Phase 1

A literature review was conducted to provide the state of the art and identify gaps in current research on the comfort and health of occupants in hospitals. A systematic approach was used, including studies from different fields and with different methodologies, both quantitative and qualitative studies. The systematic approach is appropriate to reveal an overview of relevant studies and to identify understudied areas. Also, the data of a previously performed survey were analysed to define the scope for further research. The survey, which was a pilot study, had been carried out with 499 patients, visitors, and staff at inpatient wards in 2016.

The first phase resulted in the identification of the scope for the field study. For the two following phases, an explanatory sequential approach was used, comprising a quantitative and a qualitative phase. This approach was selected to generate a general understanding of comfort and health in outpatient areas and subsequently explain and enrich the findings [40].

Phase 2

First, a survey was conducted to determine associations of comfort and health with work, personal, and building-related aspects. The survey comprised a digital questionnaire and checklists for building inspection. A questionnaire, that builds upon previous studies on comfort and health in other contexts, was used because of its strength to investigate the perceptions of comfort and health [39]. The building checklists provide objective information on the physical environment. The combination of self-reported data (in the questionnaire) and the inventory of building characteristics enables to conduct a multivariate analysis of relations of comfort and health with work, personal, and building-related aspects.

Because the questionnaire was composed of a combination of validated and newly designed questions, it was tested in a pilot study with 25 outpatient workers in a general hospital in advance. After analysis and adaptation, the survey was administered at six teaching (top clinical) hospitals with 556 outpatient workers in the spring of 2019. Only teaching hospitals were recruited to limit bias due to differences between hospital organization types. Teaching hospitals facilitate teaching and research but are not directly related to a university. Teaching hospitals are generally larger than general hospitals and smaller than academic hospitals.

Analysis of the preferences determined the scope for a qualitative follow-up phase.

Phase 3

For validation and explanation of the preferences, semi-structured interviews including photo-elicitation were used in the second phase. This visual research method was selected to support communication about the experience and importance of comfort [41]. In research, images have been used and tested before and support the narrative of a real-life experience [42]. Outpatient workers who had participated in the survey were recruited from all three hospital organizations. The questions and procedure were tested with outpatient workers from similar hospital organization types. The interviews were performed with 17 participants in the autumn of 2020.

A detailed description of the study design and analysis can be found in the chapters, that correspond with the sub-questions

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1.4 Thesis outline

This thesis is composed of an introduction (chapter 1), five chapters that correspond with the research questions (chapter 2-6), and conclusions (chapter 7). The chapters are divided in three parts, corresponding with the three research phases, see Figure 1.1.

Part 1. State of the art (chapter 2).

Chapter 2 is a review of previous field studies in hospitals. The scope of the field study is based on the review.

Part 2 Determination of relations of comfort and health of outpatient workers (chapter 3,4,5).

This part describes the first phase of the field study and shows the results of the analysis of the data from the questionnaire (chapter 3,4,5) and building inspection (chapter 4,5).

In **chapter 3** the design of the questionnaire is explained. Furthermore, this chapter describes the satisfaction with comfort and health of all participants. Finally, differences in the perceptions of comfort and health are compared between those working in different room types. The study stresses the need to further study associations of health with building-related aspects (chapter 5).

Chapter 4 focuses on differences in preferences and perceptions of IEQ and social comfort between individuals. Therefore, a set of six IEQ clusters and a set of three social comfort clusters of the outpatient workers are produced. Subsequently, profiles, which are derived from the clusters, describe differences in health, personal, work, and building-related aspects between the clusters. The chapter shows that further explanation of the preferences is needed (chapter 6).

Chapter 5 focuses on health and building characteristics. Estimations of the risk factors for the two most prevalent building-related symptoms, i.e., dry eyes and headaches, are explained with multivariate models. The chapter supports findings of chapter 3 and 4.

Part 3 Explanation of preferences for comfort of outpatient workers (chapter 6).

This part explains the second phase of the field study. The analysis and results of data, that were collected through interviews and photographs of the participants, are described and discussed.

Chapter 6 explains the preferences and changes in preferences due to contextual changes. Therefore, the changes that are experienced due to the COVID-19 pandemic are analysed. The reasons why IEQ and social comfort aspects are important are compared between the clusters.

This thesis is completed with **chapter 7**. Chapter 7 shows the conclusion by answering the sub-questions and the main question of this research. Subsequently, limitations of the entire research are discussed. Finally, the chapter describes the implications and recommendations for further research and practice.

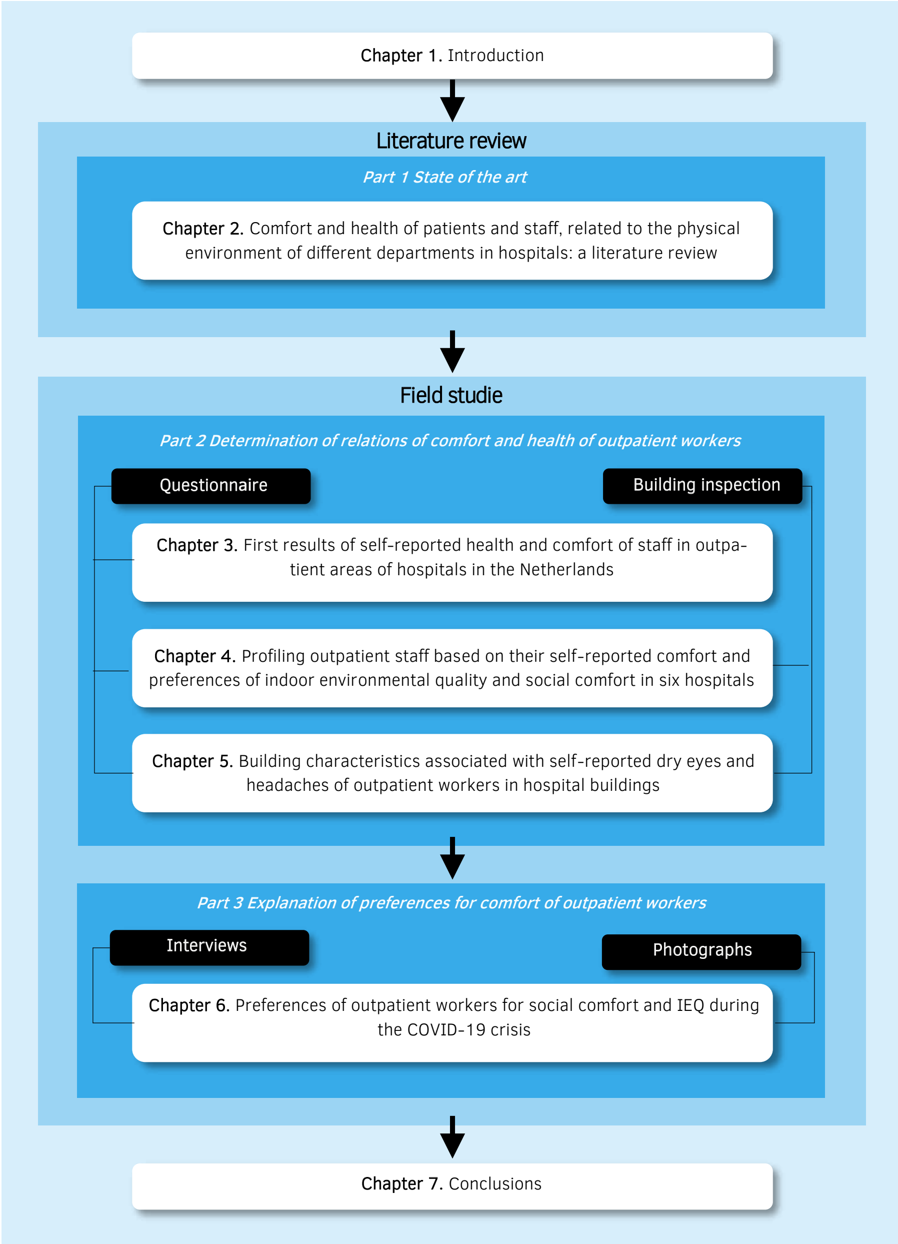

FIG. 1.1 Thesis outline.

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PART 1

State of the art

TOC

2 Comfort and health of patients and staff related to the physical environment of different departments in hospitals

a literature review

This chapter has been published as follows:

Eijkelenboom, A. and P.M. Bluyssen, *Comfort and health of patients and staff, related to the physical environment of different departments in hospitals: a literature review.* Intelligent Buildings International, 2019 DOI: https://doi.org/10.1080/17508975.2019.1613218.

For consistency of the dissertation some typos are adjusted and phrases are reworded without changing the content

ABSTRACT

Due to the increasing demand for healthcare and the large impact on the finance of hospital buildings in the near future, study is needed on aspects that affect health and comfort of patients and staff in hospitals. Therefore, a literature review was performed on studies related to specific hospital departments and occupant groups, in order to contribute to a better understanding of relations of comfort and health indicators and the physical environment. Differences in comfort and health of occupants were compared between departments, and between occupant groups. It was concluded that staff was generally less satisfied than patients were. Some of the indicators studied (occupant, dose, and building-related indicators) varied between departments. Most studies focused on a single dose or building-related indicator,

although the occupant-related indicators, such as privacy, infection rate or mortality, were related to more than one dose or building-related indicator. It was concluded that staff in particular have been understudied in relation to the variation of health and comfort aspects in different departments

2.1 Introduction

Many studies have shown that the physical environment of hospitals may affect health and comfort of the occupants (staff, patients, and visitors). With an increasing demand for healthcare, driven by the ageing population and a growing percentage of people suffering chronic diseases [1], it is necessary to understand comfort and health related to the physical environment in hospitals better.

Environmental stimuli, such as noise or crowding stressors, may cause negative or positive stress reactions [2]. The extent to which environmental stimuli cause stress, depends on the importance of the stressor, duration of exposure and degree of control [3]. These stress reactions may vary between occupants, due to demographics, physiological characteristics, social aspects and previous experiences and exposures [4]. The preferences and needs of individuals may vary during time as well, due to different activities, specific clothing, health state or other personal factors [5].

As hospitals are complex buildings, accommodating multiple functions, the relation between the physical environment and health and comfort of occupants may vary between hospital departments. The complexity of hospital buildings is shown in the former mandatory Dutch guidelines, (there are nowadays no mandatory building standards for hospitals in the Netherlands). General hospitals are required to house 39 different function groups for inpatient care, treatment, diagnostics and supporting facilities [6]. Between departments, there are large differences in performed activities and the health state of patients and staff [7]. Due to differences in role and the duration of stay, the needs of patients can be contradicting to the needs of staff in a hospital [8]. Therefore, health and comfort of staff may differ from patients. Understanding the relation between the physical environment and health and comfort of the occupants, while taking into account the specific preferences and needs of occupants, may contribute to appropriate guidelines for hospital design. Thus, a comparison is needed, regarding health and comfort of different groups of occupants at specific departments.

Within the perspective of this literature review, occupants in previous field studies, assessed comfort on three levels: sensation, perception, and cognition. Privacy is for instance an aspect related to cognition, emphasising the environmental or behavioural adaptation or the modification of expectations [9]. Three types of indicators distinguish aspects for health and comfort: occupant, dose and building-related indicators [10]. Occupant-related aspects are for example work strain, infection incidence (related to the physical environment) or rehospitalisation. Aspects such as temperature, illuminance, and air humidity are defined as dose-related indicators. Building-related indicators comprise for example the orientation of windows, the spatial layout, or the possibility for the growth of fungi.

Previous literature reviews on health and comfort related to the physical environment in healthcare facilities provided their own contribution, varying in scope of studied occupants, study design, effects and building type [11-15]. However, as far as we know, no previous research has been done on health and comfort of occupants related to different hospital departments, occupant groups and the relations of indicators. Therefore, a literature review was performed to study possible differences in indicators found in previous studies between different departments, occupant groups and relations between those indicators.

2.2 Method

Literature was identified with searches in Scopus, Web of Science and JSTOR, in the field of architecture, indoor environment and environmental psychology. For all searches, the keywords 'hospital' and 'healthcare facility' were combined with the search terms: 'wellbeing', 'stress', 'indoor environmental quality', 'comfort', 'health', 'architecture', 'daylight', 'thermal comfort', 'noise', 'air quality', 'patient room', 'waiting room', 'pain', 'layout'. The selection of papers addressing the physical environment and occupants' comfort and health in hospitals took place after screening titles and reading abstracts. Furthermore, references in the selected papers were examined, based on titles and abstracts. The search took place from June 2017 until May 2018. After reading the selected papers, 79 studies were included and 24 studies were excluded, according to the following inclusion criteria:

- Original peer reviewed articles, written in English.
- Field studies on comfort or health related to dose and building-related indicators in hospitals.
- Field studies on occupant preferences, related to dose and building-related indicators in hospitals.
- Study design: controlled clinical trials, case-control studies, cohort studies, cross-sectional studies, and descriptive studies.

The exclusion criteria applied comprised:

- Studies on single indicators, which are beyond the scope of building engineering, such as music or art.
- Studies using dose-related indicators as a therapy (light, music).
- Simulation studies, for instance on thermal comfort.
- Studies performed in nursing homes or other healthcare facilities, not being a hospital.
- Studies with children as patients involved.

Health and comfort aspects, study design, number and type of occupants, instruments and hospital departments were extracted and categorized, according to the reported dose and building-related indicators. The field studies determined relations of dose and building-related indicators with indicators for performance, bodily processes, psychosocial aspects, comfort, and symptoms. The main health and comfort indicators were compared for patients and staff in the different departments, structured according to Table 2.1.

TABLE 2.1 Studied departments.

Care type	Department
Nursing	Inpatient care
	Special care (intensive care, intermediate care, palliative care, isolation)
	Day care*
Treatment and diagnostics	Delivery care
	Operating area (operating room, post anaesthesia, post-operative area)
	Outpatient care
	Emergency department
Complete building	

**Day care is related to nursing as well as treatment.*

2.3 Results

The results are presented in two parts, as showed in Figure 2.1. The first part reports findings related to the spatial layout, visual, acoustic, thermal, indoor air and overall quality, in order to provide an overview of the studied dose and building-related indicators. The second part provides a comparison of occupant groups, departments and relations with dose and building-related indicators for health and comfort aspects.

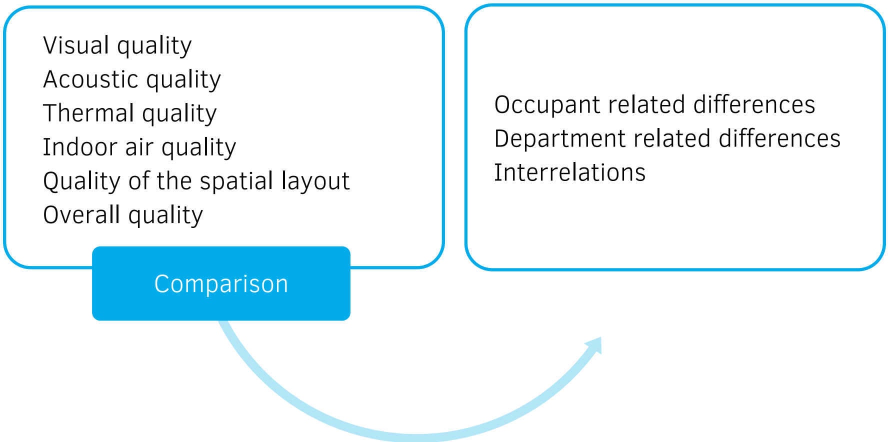

FIG. 2.1 Structure of the reported results.

2.3.1 Part 1

2.3.1.1 Visual quality

Indicators that can be categorized into visual quality, such as the intensity of daylight, illuminance level or window view, were studied at inpatient wards, special care and outpatient areas. Numerous aspects of health and comfort, such as improved sleep quality, decreased incidence of delusion, hope, positive interaction, decreased errors and increased work satisfaction were found to be related to exposure of daylight [16-21]. A high intensity of artificial light appeared to decrease errors in medication preparation and work strain [22] and bright artificial light during the day improved the length and quality of sleep of patients at night [23].

The orientation of windows in patient rooms to the morning sun was associated with decreased duration of stay, reduction of mortality rate and reduction of the intake of pain analgesics [24-26]. In addition to the window orientation, the specific view of a window and the intensity of daylight affected the duration of stay and intake of pain analgesics as well as the satisfaction with the social environment [27-29]. Patients and staff were more satisfied in rooms with large windows and a low sill height; they perceived rooms with windows that were smaller than 15% of the facade, as windowless [29].

2.3.1.2 Acoustic quality

Noise levels, noise sources and noise reducing ceiling panels, which can be considered as aspects of acoustic quality, were studied at inpatient wards, operating rooms, emergency departments and wards for special care. Measured noise levels in hospitals have been found to be significantly higher than recommended in the WHO guidelines and have also increased since 1960 [30]. Although a L_{Aeq} of 35dBA is recommended for treatment and observation areas during the day [31], Darbyshire and Young (2013) reported that L_{Aeq} levels were all above 45 dBA in 5 intensive care units [31]. The L_{Aeq} was between 52 and 57 dBA more than 50% of the time; the highest L_A^{peak} recorded was 127.9 dBA. The main sources for high noise levels were medical devices as well as talking of staff and patients [32, 33]. Staff perceived that high noise levels were related to feeling sick at the end of the day, tension headaches, fatigue and irritation [34]. Although high noise levels were related to an increased heart rate and arousal during sleep [35], high noise levels did not affect the duration of sleep [17]. A reduction of the reverberation time with acoustic ceilings reduced work strain for staff as well as the incidence of rehospitalisation of patients [36, 37].

2.3.1.3 Thermal comfort

Thermal comfort was studied at inpatient wards, operating rooms, and an outpatient ward. In several studies, patients were more satisfied with the thermal conditions than expected according to the ASHRAE guidelines and measurements of air temperature, relative air humidity, air velocity and clothing [38, 39]. Both patients and staff were more satisfied with the indoor temperature in summer than in winter, during the heating season, although the actual temperature did not vary [40, 41]. In winter, the satisfaction with air humidity was low, which was in line with the measured humidity. Staff encouraged patients to drink more water in winter, in order to compensate for the low humidity [40].

2.3.1.4 Air quality

Indicators that can be categorized into air quality, such as filtration, direction of the airflow and ventilation rate, were studied at inpatient wards, operating rooms, day care and overall buildings. In some studies, the decreased incidence of infection and mortality of vulnerable patients were related to filtration of indoor air and laminar airflow [42, 43]. Air filtration with HEPA filters was effective, but the infection rate of patients in rooms with portable filtration did not differ from those without a portable filtration unit [44]. In addition to the infection and mortality rate, aspects of the air quality have been associated with several self-reported symptoms of staff, such as a dry skin, fatigue, nasal inflammation, and ocular symptoms [45-47]. Symptoms were related to a low air humidity, a low ventilation rate, presence of mould in the ventilation units, emission of VOC's and high noise levels of the ventilation system.

2.3.1.5 Quality of the spatial layout

The configuration of rooms, the number of beds in rooms and regulation of privacy with curtains can be categorized into the quality of the spatial layout. Studies were performed at inpatient, special, delivery and day care. Single bedrooms were more supportive to privacy of patients than multiple bedrooms, which were enclosed from the circulation area, or bay wards, which were open to the circulation area [48, 49]. For example, the interaction with family improved and the communication of physicians with patients improved [50]. Unexpectedly, the exchange of medical information was also better at open wards, which comprised 36 beds without separation walls, than at bay wards, with separation walls between 4-6 beds. The background noise at the open wards were supportive to privacy [51]. Although the privacy of patients in single bedrooms improved, staff reported lower work satisfaction, associated with a limited ability to oversee and overhear the patient needs and concerns about patient isolation [52]. Single bedrooms (only) did not have a positive effect on infection control or the intake of pain analgesics [49, 53].

2.3.1.6 Overall quality

Studies on the overall quality identified relations between multiple dose and building-related indicators and health and comfort. The scope of field studies on the overall quality was not limited to building or dose-related indicators; additional features, such as furniture, amenities or artworks were part of the studies as well. An example is the combination of a high number of sinks, filtered air supply and single bedrooms, which was related to an increased infection incidence and mortality rate [54]. Newly well decorated areas, with balanced colour schemes, individual control of temperature and high illuminance levels, were related to improved comfort, alertness, satisfaction with work and with care [55-57]. The findings on satisfaction with care, related to the interior of patient rooms were inconsistent. Patients were more satisfied with care in well-decorated hotel-like rooms, compared to those in basic rooms [58]. On the contrary, Siddiqui et al. (2015), who did not find a relation between room quality and satisfaction with care, suggested that this difference might be caused by the fact that patients had to pay $40 extra per day for the well decorated rooms in the study mentioned before [59].

2.3.2 Part 2

2.3.2.1 Studied population

Previous studies focused mainly on patients only, or patients with staff or visitors, as presented in Table 2.2.

TABLE 2.2 Proportion of the participant types studied.

Type participant	% of studies
Patients	59%
Staff	29%
Patients and staff	10%
Patients and visitors	1%
Patients, visitors, and staff	1%

Some health and comfort indicators were exclusively related to patients or staff, as shown in Table 2.4. In the studies concerned with both patients and staff, staff was less satisfied with spatial layout, thermal, air, acoustic and visual quality [41, 60-

62]. In a study performed by Sattayakorn et al. (2017), patients accepted larger temperature differences compared to visitors and staff, while thermal comfort of patients and staff was generally related to gender and age [63]. In another study, staff rated 50% of the view types more negative than patients [29]. In a study performed by Hashiguchi et al. (2005), staff reported more building-related symptoms than patients did [40].

Additionally, some studies also showed differences in the preferences between patients and staff. More patients than staff preferred single patient rooms and control of the window view with curtains. While patients preferred carpet in their bedroom, due to the appearance, lower noise and reduced anxiety of falling, staff preferred on the other hand vinyl, due to cleanliness and air freshness [64]. This is in line with some of the studies that identified cleanliness and air freshness among the most important aspects of the physical environment for staff [65, 66].

Differences between patients were found to be related to specific diseases, their vulnerability, and personal factors. Patients suffering psychiatric or neurological diseases did not appear as sensitive as other patients to thermal comfort, to the effect of window orientation or the decoration of the ward [39, 67, 68]. In a study of Leaf et al. (2010), it was seen that only the most vulnerable patients had a higher mortality rate, which was related to the visibility of the patient rooms from the nursing station [69]. In another study, physical strength overshadowed the aspects age and gender for thermal comfort as well [63]. Hweidi (2007) [70] found that aged patients and patients with a lower income reported higher stress levels.

Comfort and health of staff members were associated with health state, demographic, and social factors, as well as with different activities. Building-related symptoms were associated with asthma, hay fever, smoking, a low degree of control and dissatisfaction with comfort [71, 72]. Furthermore, compared to nurses exposed to more than three hours of daylight per day, those exposed to less than three hours of daylight reported lower job satisfaction and increased work-related strain, which were indirectly related to burnout [16]. Higher levels of burnout were directly related to nurses with sleeping disorders. Perception of noise was related to the position of different staff members in the room as well as to their responsibility. The feeling that noise has a negative impact on the job was for anaesthetists stronger than for surgeons and nursing personnel [73]. The head surgeons reported that talking was the main source of noise, in contrast to the other staff members, who reported the air-conditioning systems as the main source of noise. Last, differences on thermal comfort between staff members in operating rooms were related to differences in clothing, metabolic rate, stress and their location in the room [74, 75]. The clothes varied from lead overalls while using X-ray, plastic overalls and paper overalls.

The anaesthetist was cold, wearing short sleeves, sitting next to the patient. The surgeons were hot, wearing lead aprons, performing on a high activity level. With an increasing complexity of the task, the skin temperature of the surgeon increased and the air humidity between skin and overall reached a saturation of 100% (sweat).

It was also found that age, gender and working hours affected the perception of importance of dose and building-related indicators. Staff working more than 40 hours a week perceived thermal comfort, the proximity of wards, illumination, availability of daylight and spaciousness more important than those working less than 40 hours a week [65]. Staff aged over 49 years perceived the air quality in workspaces and patient areas more important than younger staff. Visual privacy was perceived more important in work spaces by staff working longer than 10 years in the building, compared to those working less than 10 years in the building, as well as by nurses, compared to other staff (physicians, therapists, technologists, etc.) [66].

2.3.2.2 Studied departments

Comparison of health and comfort at specific departments was difficult, as half of the studies were conducted only at inpatient wards, as presented in Table 2.3.

TABLE 2.3 Proportion of the departments studied.

Department	studies
Inpatient care	51%
Special care	18%
Day care	3%
Delivery care	4%
Operating area	6%
Outpatient care	5%
Emergency department	1%
Complete building	12%

Some health and comfort indicators were exclusively related to one or a small selection of departments, as shown in Table 2.4. Aspects such as the duration of stay or sleep quality, were inherently related to patients at nursing departments (inpatient, special care). Aspects such as mortality or infection occurred to the most vulnerable patients treated in the operating area and special care. Some conditions were related to a specific (room in a) department as well. The sound pressure levels at the ICU were found to be higher than in the inpatient bedrooms [32, 76]. In the study performed by van Gaever et al. (2014), indicating differences in thermal comfort between staff members, it was seen that the temperature and laminar airflow in the operating room was controlled by a low temperature setting in order to reduce the possibility of infection [75]. Air filtration with HEPA filters was applied in operating and seclusion rooms, in order to reduce the infection incidence [42, 54].

TABLE 2.4 Health and comfort aspects of the included studies at different departments

	Occupant	Inpatient care	Special care	Day care	Delivery care	Operating area	Outpatient area	Emergency	Overall	References
Performance										
Duration of stay	p	x	x							Beauchemin and Hays 1996, 1998; Benedetti et al. 2000; Choi, Beltran and Kim 2012; Joarder and Price 2013; Ulrich 1984
Consumption pain analgesics	p	x	x							Dolce J.J. et al. 1985; Ulrich 1984; Walch et al. 2005
Rehospitalisation	p		x							Hagerman et al. 2005
Medication errors	s	x					x			Booker and Roseman 1995; Buchanan et al. 1991
Bodily process										
Mortality	p	x	x			x			x	Beauchemin and Hays 1998; Leaf, Homel and Factor 2010; Passweg J.R. et al. 1998; Shirani et al. 1986; Yavuz et al. 2006
Delusion	p		x							Keep, James and Inman 1980
Infection	p	x	x			x				Deniz et al. 2017; Engelhart et al. 2003; Oren et al. 2001; Sherertz et al. 1987; Shirani et al. 1986; Yavuz et al. 2006
Stress (heart rate and/ or perceived)	ps	x	x		x		x		x	Andrade C.C. et al. 2012; Applebaum et al. 2010; Hweidi 2007; Leather et al. 2003; Sundberg et al. 2017; Vaaler, Morken and Linaker 2005; Wang and Pukszta 2017
Sleep quality		x	x							Aaron et al. 1996; Bano et al. 2014; Freedman et al. 2001; Wakamura and Tokura 2001
Symptoms										
Building related symptoms	ps	x							x	Andrade K.P. et al. 2016,; De Giuli et al. 2013; Hashiguchi et al. 2005; Hellgren et al. 2011; Nordstrom et al. 1994, 1995; Ryherd et al. 2008; Smedbold et al. 2001; 2002; Wieslander et al. 1999

x=studied relation indicated, p=patient, s=staff, v=visitor

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TABLE 2.4 Health and comfort aspects of the included studies at different departments

	Occupant	Inpatient care	Special care	Day care	Delivery care	Operating area	Outpatient area	Emergency	Overall	References
Evaluation										
Comfort	psv	x	x			x	x		x	Allaouchiche et al. 2002;; Bukh, Tommerup and Madsen 2015; Chaudhury et al. 2006; De Giuli et al. 2013; Del Ferraro et al. 2015; Eijkelenboom et al. 2019; Frank et al. 1992; Harris 2017; Hashiguchi et al. 2005; Hwang et al. 2007; Mazzacane et al. 2006; Moore et al. 1998; Pattison and Robertson 1996; Sadatsafavi et al. 2015; Sattayakorn et al. 2017; Skoog et al., 2004; Sundberg et al. 2017; Tsiou C.G. et al. 2007; van Gaever et al. 2014; Verheyen et al. 2010
Psychosocial										
Satisfaction with job or care	ps	x	x		x		x		x	Alimoglu and Donmez 2005; Becker and Douglass 2008; Donetto et al. 2017; Janssen et al. 2001; Janssen et al. 2000; Maben et al. 2015; Mc Cuskey Shepley et al. 2012; Mroczek et al. 2005; Siddiqui et al. 2015; Sundberg et al. 2017; Swan et al. 2003; Verderber 1986; Wessels et al. 2010
Work strain	s	x	x							Alimoglu and Donmez 2005; Blomkvist et al. 2004; Buchanan et al. 1991
Privacy	psv	x		x	x			x		Barlas et al. 2001; Burden 1998; Maben et al. 2015; Mc Cuskey Shepley et al. 2012; Pattison and Robertson 1996; Pease and Finlay 2002; Verderber 1986; Wang and Pukszta 2017
Positive interaction, mood	s	x								Chaudhury, Mahmood and Valente 2006; Janssen et al. 2000; Pattison and Robertson 1996; Timmermann et al. 2015; van de Glind et al. 2008; Zadeh et al. 2014
Subsidiary behaviour	s	x								Zadeh et al. 2014

x=studied relation indicated, p=patient, s=staff, v=visitor

In several studies it was seen that needs for privacy varied between day-care, special care, emergency departments and inpatient care [49, 77-79]. Although most patients at an inpatient ward preferred single bedrooms, patients at day-care preferred a combination of private, semi-open and open areas. At an emergency department, patients were even satisfied with the privacy in examination rooms, divided by curtains. Stress of patients varied between departments as well [56, 70, 80, 81]. As patients in an ICU perceived only noise as a stressor, patients in inpatient wards perceived stress related to the number of features, such as adjustable temperature, a chair for visitors, a large window, and a clock. In outpatient areas, patients perceived stress related to the layout, light, colours, and decoration of the waiting room. Staff perceived pieces of artwork, daylight and a view to the outside more important in staff areas than in patients' areas or workspaces [66].

2.3.2.3 Relations between dose, building and occupant-related indicators

It can be seen in the discussion of literature results that most occupant-related indicators, such as duration of stay or mortality, were related to more than one dose or building-related aspect, as summarised in Table 2.5.

Duration of stay was related to the window orientation, view on nature and illuminance level in studies performed by Benedetti et al. (2000) [67], Choi et al. (2012) [25] and Ulrich (1984) [28]. Mortality was affected by window orientation, the direction of air flow, filtration of air, line of sight between nursing station and bedroom, and a combination of indicators in studies performed by Beauchemin and Hays (1998) [24], Leaf, Homel and Factor (2010) [69], Shirani et al. (1986) [82] and Passweg et al. (1998) [83].

TABLE 2.5 Relations of occupant, dose, and building-related indicators of the included studies.

Occupant related indicator	Performance	Duration of stay	Consumption pain analgesics	Rehospitalisation	Medication errors	Bodily process	Mortality	Delusion	Infection	Stress perceived*	Sleep quality	Symptoms	Building related symptoms	Evaluation	Comfort	Psychosocial	Satisfaction (with job or care)	Work strain	Privacy	Positive interaction, mood	Subsidiary behaviour
Dose related indicator																					
Illuminance		x	x		x					x	x				x			x		x	x
Luminance															x						
Daylight exposure					x												x	x			
Sound pressure level				x						x	x		x		x			x			
Reverberation time				x						x								x			
Noise source										x					x						
Air temperature													x		x						
Radiant temperature															x						
Relative humidity													x		x						
Air velocity													x		x						
Indoor CO_2													x		x						
Indoor microorganisms									x				x		x						
Indoor VOC's													x		x						
Traffic pollution													x								
Dust concentration													x		x						
Building-related indicator																					
Window orientation		x	x				x														
Window view		x	x														x			x	
Window size																	x			x	
Presence window								x		x										x	x
Lighting fixture					x						x						x	x			
Sound absorbing ceiling				x						x							x				
Closed doors									x						x						
Curtains																			x		
Air filtration							x		x												
Laminar airflow unit							x		x												
Ventilation system													x								
Dampness													x								
Distance bed-window											x										
Single or multiple bedrooms or ward type															x		x	x	x	x	

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TABLE 2.5 Relations of occupant, dose, and building-related indicators of the included studies.

Occupant related indicator	Performance	Duration of stay	Consumption pain analgesics	Rehospitalisation	Medication errors	Bodily process	Mortality	Delusion	Infection	Stress perceived*	Sleep quality	Symptoms	Building related symptoms	Evaluation	Comfort	Psychosocial	Satisfaction (with job or care)	Work strain	Privacy	Positive interaction, mood	Subsidiary behaviour
Proximity of rooms or departments																	x				
Line of sight between nursing station and bedroom							x														
Multiple dose and building-related indicators							x		x	x			x		x				x	x	

** heart rate, pulse amplitude, and/or perceived stress,*

2.4 Discussion

2.4.1 Strengths and limitations

One of the limitations of this study is the search strategy. Some keywords, such as ‘architecture’ or ‘stress’, have different definitions depending on the research field. These words revealed a large number of titles with a low relevance to this review. However, the combination with keywords that are more specific, and the cross-reference procedure may cover the most relevant studies. Another limitation is the difficulty to compare studies on psychological constructs, such as privacy, comfort, or stress, due to a variety of instruments and methods administered in the different studies. Finally, the findings of the field studies are presented equally, although differences in methods and study design imply weaker and stronger relations between dose, building and occupant-related indicators. Detailed information on dose or building-related indicators was scarce, mainly in the studies on psychosocial indicators and bodily processes. However, this literature review intended to reveal information on dose, building and occupant related indicators at different hospital departments for patients and for staff.

2.4.2 Agreements and disagreements with other reviews

Several reviews on the relations between the physical environment and health and comfort in healthcare facilities have been performed before, as mentioned in the introduction. In the reviews of Dijkstra, Pieterse and Pruyn (2006) [11] and Drahota et al. (2012) [12], the studies considered were limited to controlled clinical trials and case-control studies. Dijkstra, Pieterse and Pruyn (2006) found evidence for window-orientation, illuminance, and view, as well as for privacy related to layout, in line with this review. They concluded findings on acoustic quality as inconsistent, which might be related to their limited focus of including studies on “psychological processes as a result of sensory perception.” Also, Drahota et al. (2012) reported evidence for window orientation but they considered the evidence of air quality on infection weak, due to differences in building services and infection sources.

On the contrary, the review of Ulrich et al. (2008) [15] determined a large number of health and comfort indicators, based on “reliable patterns of findings” between empirical studies, theory and knowledge. Inconsistent to findings of this review, is for example the relation between the incidence of infection and single bedrooms compared to multiple bedrooms. Huisman et al. (2012) reviewed literature on wellbeing, faster healing processes and a comfortable environment of patients and staff in healthcare facilities, in order to provide an overview of literature for designers and engineers of hospitals [13]. Studies on thermal comfort were not included. The main conclusion, that staff are understudied, is consistent with the findings of this review as well as with the review of Salonen et al. (2013) [14]. They indicated only different needs for aspects of the spatial layout between patients and staff, and no differences in comfort related to thermal, visual, acoustic and air quality. None of the studies compared differences between departments. Table 2.6 presents an overview of the characteristics of previous literature reviews.

TABLE 2.6 Characteristics of previous literature reviews.

Author	Year	Occupants	Study design	Building type*
Dijkstra, Pieterse and Pruyn	2006	Patients	Controlled clinical trials, case control studies	Healthcare facilities
Ulrich et al.	2008	Patients, visitors, staff	Controlled clinical trials, case control studies, cohort studies, cross sectional, descriptive studies, reviews, expert opinion	Healthcare facilities
Huisman et al.	2012	Patients, staff	Systematic reviews, controlled clinical trials, case control studies, cohort studies, cross sectional, descriptive studies	Healthcare facilities
Drahota et al.	2012	Patients	Controlled clinical trials, case control studies	Hospitals
Salonen et al.	2013	Patients, staff	Controlled clinical trials, case control studies, cohort studies, cross sectional, descriptive studies, reviews	Healthcare facilities

**Healthcare facilities comprise different building types, such as nursing homes, hospitals, dental clinics, etc.*

2.4.3 Population

The comparison of studies on different occupant groups emphasised the gap in studies on staff. Due to staff shortage, increased complexity and the increased workload of hospital staff [84], the need to study health and comfort of staff in hospitals has increased as well. It has been shown in several studies that staff are concerned about the effect of the physical environment on comfort and health of patients [49, 85]. However, it is important to emphasize that concern about comfort and health of staff can be beneficial to patient outcomes as well [86-88]. The variation in the occupants' responses to environmental stimuli, related to health state, demographic, and social aspects, which has been shown in several studies [16, 71, 72], demonstrates that these aspects need to be included in future studies on health and comfort. Determination of user profiles addressing differences in preferences and needs may contribute to a better fit between the occupant and the environment [89].

2.4.4 Departments

The identified differences between departments with respect to privacy, thermal comfort, sound levels and stress of staff and patients, suggest that it is necessary to study specific departments. Differences in privacy might be explained by the definition of Altman (1976) [90], that control of privacy is 'an active and dynamic regulation process', dependent on changes in situation or motivation. Other aspects related to the spatial layout, such as different needs for communication and concentration in offices, due to the heterogeneity of performed activities [91], might occur in hospitals as well. In line with differences in thermal comfort between hospital departments, comfort varied between different building types, such as homes, schools and offices [92].

Analysis of the studied departments indicated a scarcity of previous field studies for treatment and diagnostic areas. Because of differences in health and comfort of staff and patients between departments and the decreasing need for inpatient beds [93, 94], it is relevant to contribute to filling this gap.

2.4.5 Relations

Although most of the studies focused on single indicators, confounding variables may have affected the findings as well. For instance, the window view may affect findings in a study that compares comfort and health in relation to the orientation of windows. The suggestion of Bluyssen (2014) to study relations of both building and dose-related aspects [4], was endorsed by the large number of studied aspects presented according to the six-S shearing layer-model of Brand (1994) [95] in Figure 2.2.

2.5 Conclusions

The literature review performed indicates that health and comfort of staff as well as of patients from different hospital departments vary. The field studies determined relations of dose and building-related indicators with occupant-related indicators such as performance, bodily processes, psychosocial aspects, comfort, and symptoms. Specific indicators, such as duration of stay or high noise levels, were inherently related to one department or care type. Indicators for stress, privacy and preferences varied between departments. Differences in health state, activities, demographic, and social aspects were associated with the perception of health and comfort as well. In line with previous studies on schools, offices and homes, most occupant-related indicators were related to a combination of dose and/or building-related indicators.

Staff were less satisfied than patients with spatial layout, thermal, air, acoustic and visual quality. Due to the increasing demand put on staff and the reduction of inpatient beds, future study is needed on health and comfort of staff working on outpatient wards. An integrative approach, including personal and social factors, as well as the performed activities, may contribute to a better understanding of relations between dose, building and occupant related indicators for comfort and health of staff in hospitals.

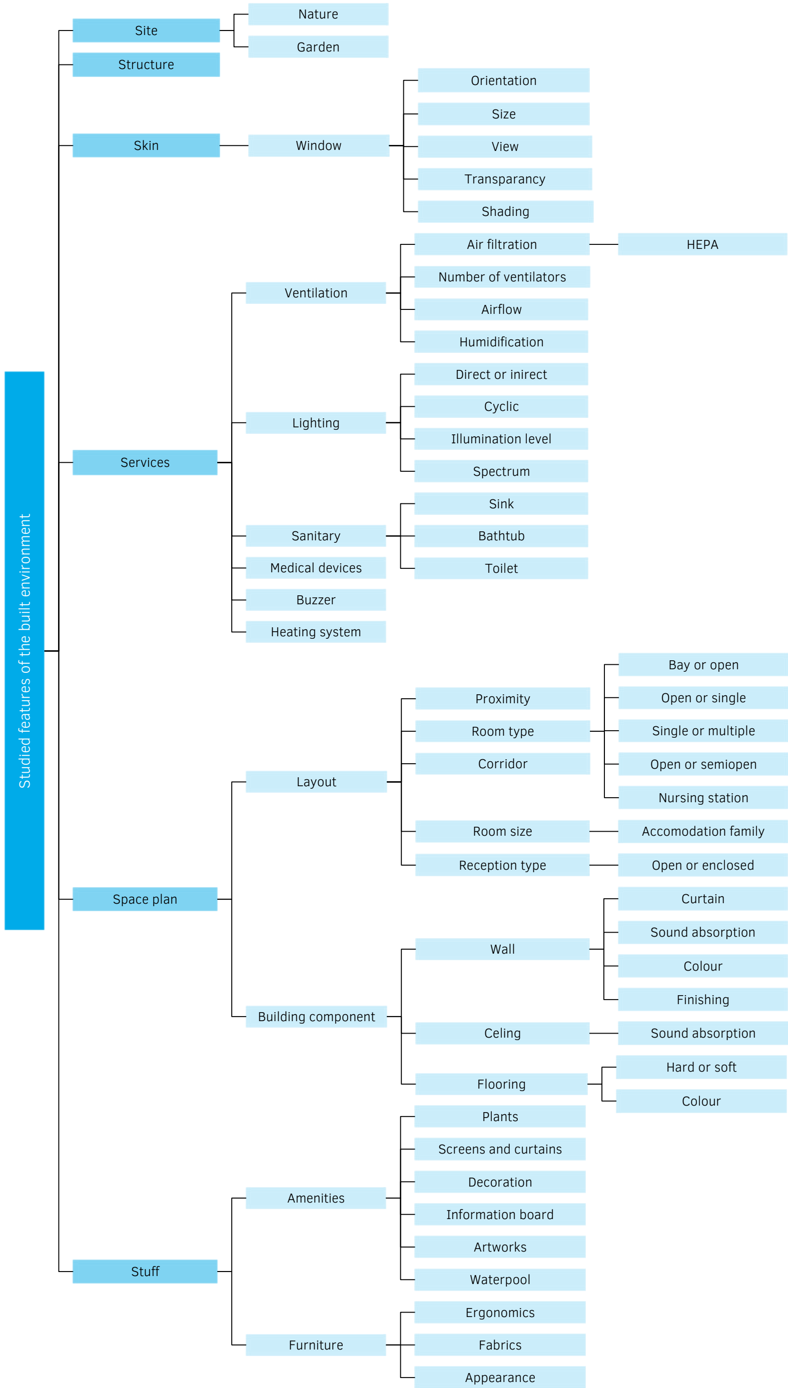

FIG. 2.2 Overview of studied building features of the included studies.

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PART 2

Determination of relations of self-reported comfort and health of outpatient workers

TOC

3 First results of self-reported health and comfort

of staff in outpatient areas of hospitals in the Netherlands

This chapter has been published as follows:

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For consistency of the dissertation some typos are adjusted and phrases are reworded without changing the content.

ABSTRACT

It is well known that the demand on hospital staff is increasing and that their comfort and health may be affected negatively by dose and building-related aspects. Comfort and health may differ between hospital departments. However, outpatient areas are understudied. To better understand comfort and health of staff in outpatient areas a survey was performed in which social comfort, personal and work-related aspects were all accounted for. This study aimed to identify comfort and health in relation to different room types. Of the 1.694 invitations that were sent to outpatient staff of six buildings, 556 respondents (33%) were included in the analysis. There was little difference in the prevalence of the main self-reported symptoms, dry eyes and headache, and indoor air complaints, whereas acoustic, visual, thermal and social comfort differed statistically significantly between those working in different room types. Compared to other (inpatient) hospital and office studies, the prevalence of symptoms and dissatisfaction with comfort was high, especially dissatisfaction with daylight. Considering the dynamic use of workplaces in outpatient areas and the high ERI, this study reinforces the necessity for inclusion of personal and work-related characteristics in studies on comfort and health of occupants.

3.1 Introduction

With an accumulated demand on hospital staff, due to staff shortage and the expanding complexity of tasks, the understanding of health and comfort of staff becomes increasingly important. A review on field studies in hospitals showed that staff was generally less satisfied with comfort than patients [1]. In several Scandinavian studies, a higher prevalence of building-related symptoms and complaints on indoor environmental quality (IEQ) was found among hospital staff workers than office workers [2-4]. More recently, staff working at inpatient departments in a hospital in the Netherlands, was less satisfied with IEQ-aspects, control of IEQ-aspects and privacy than patients [5, 6].

Rashid and Zimring (2008) suggested that IEQ-related problems may vary between hospital departments, as performed activities and the occupancy hours vary [7]. Furthermore, Sadatsafavi et al. (2015) indicated in a field study that different comfort needs of hospital staff are associated with different room types, such as resting rooms for staff or patient rooms [8]. For example, thermal comfort was for hospital staff more important when they were working or resting in rooms only used by staff, than when they were working in patient rooms. Previous studies on IEQ and building-related symptoms focused mainly on inpatient areas, while outpatient areas have been understudied [1]. Therefore, there is a need for a better understanding of comfort and health of staff in relation to the specific context of rooms in a department.

At outpatient areas consultation, diagnostic services and treatment are provided to patients who, usually, do not stay overnight in the building. The patients who stay overnight in hospitals, stay at inpatient departments. Outpatient departments comprise of room types with different functions, such as reception areas, consultation rooms, treatment rooms, and offices. At the reception desk, which is usually adjacent to the waiting area, patients are welcomed and can make appointments. In the consultation rooms interviews and examination are performed for diagnostics. Medical investigation and treatment, such as endoscopy, are performed in the treatment rooms. Most administration and phone calls occur in the offices. Due to the function, the characteristics of the different room types may vary, regarding the number of persons in the room, duration of stay, and performed activities. These aspects may affect health and comfort of hospital staff.

For example, previous studies in other hospital departments, indicated associations with the number of persons in patient rooms and privacy [9], the duration of stay at inpatient areas provided with daylight and work strain and job satisfaction [10] and differences in thermal comfort due to performed activities in operating rooms [11].

It has been suggested by several authors that IEQ, as well as social comfort aspects, are important to understand health and comfort better within a specific context [12, 13]. For example, privacy, acoustic and visual distraction and the perception of crowding, have been included in previous field studies [14-18] to study relations with comfort, health and building characteristics. According to Altman (1975) crowding is closely related to privacy and occurs when people cannot regulate the extent of social interaction and seclusion [19]. Previous field studies have shown associations with stress, crowding and the perceived overall quality (PEQ)[20, 21]. In addition, personal aspects, such as gender, age, work strain, may affect IEQ [22] and building-related symptoms as well [23, 24]. Bluyssen (2019) recommended to study comfort and health integrally, including time-related aspects, personal aspects and interactions between stressors and occupants, in order to capture a view which is more representative for the complexity of a real-world context [25].

To take all of the above-mentioned aspects into account, the aim of the study reported here was to study comfort and health of hospital staff in outpatient areas in relation to different room types. For this purpose, a questionnaire was designed including social comfort, personal and work-related aspects, to answer the following research questions:

- Is it likely that the proportion of staff suffering the most prevalent building-related symptoms, varies between different room types?
- Is it likely that dissatisfaction with the IEQ and social comfort aspects, which bother most outpatient staff, varies between different room types?
- Is it likely that PEQ varies between the different room types?

This questionnaire was distributed to the staff of six top clinical hospital buildings during the spring of 2019. In addition, to explore associations of workplace characteristics at outpatient areas with comfort and health of staff, the buildings were inspected with the use of a newly developed checklist, of which the outcome will be reported elsewhere. This paper reports the first results of the questionnaire and explores comfort and health of staff associated with different types of workplaces.

3.2 Method

3.2.1 Design questionnaire

To address personal and social characteristics that may affect the relations between comfort, health, and building-related aspects, as part of a larger PhD study, the questionnaire consisted of five components: personal, workplace, health, comfort and importance related questions (Table 3.1). For the study reported here, the personal and work-related questions were included in order to analyse if and which aspects were associated with different buildings and needed to be adjusted for in the comparison with room types. The questions on building-related symptoms and comfort were included, to determine the most prevalent symptoms, least satisfying aspects and PEQ, which were included in the comparison with different room types. The questionnaire comprised of validated instruments and newly designed sets of questions.

The components personal, health and subcomponent IEQ were retrieved from the OFFICAIR questionnaire [16]. OFFICAIR was developed to gain more insights into complaints and building-related symptoms of occupants in European offices, with respect to psychological and health aspects. The extent to control IEQ-aspects and a question to assess “noise from (medical) apparatus” were added. For the expression of the actual mood state during completion of the questionnaire a new validated version of the visual scale was used [26].

PEQ, used in previous studies to assess the subjective appraisal of the environment in relation to crowding and physiological stress [20, 21], formed a subcomponent of comfort. The instrument comprises bipolar adjective items, such as “stimulating-boring” or “bright-dull.” Because the scale was only available in English, the adjectives were translated from English to Dutch and back by one native Dutch speaker and two native English speakers. The same words “drab”, “tense”, “cheerful” and “unlively”, were translated differently back by both speakers. After discussion, the Dutch translation of the words “tense” and “unlively” were adapted.

The sets of questions for the component workplace and subcomponent social comfort were specifically designed for this study, as no standardized appropriate instruments were found. The set of questions for 'work' was based on visits of outpatient areas in seven hospitals and information retrieved from one healthcare architect and the project leaders of the hospitals. Questions about social comfort, time and place-related aspects were designed to identify workplace characteristics. Two examples of questions are: "In which types of rooms do you work?" and regarding the most frequently used room "How many hours do you stay in the room without leaving, except for interruptions which are shorter than 5 minutes?"

The set of questions for social comfort was based on literature. In previous studies crowding was related to the number of people in the room, psychological stress and the social context [27, 28]. Privacy supported by building aspects was studied previously in relation to visual and acoustic isolation and distraction, as well as interaction [14, 29-31]. Therefore, thirteen questions and one embedded question were composed for satisfaction with crowding, privacy, interaction, and distraction. The questions consisted of a 7-point rating scale for equivalent assessment with IEQ-questions, from completely disagree (1) to completely agree (7). Examples are: "At my workplace I am too much distracted by noises", and "I perceive my workplace as too crowded with other people." The embedded question for those who worked with patients was "My workplace offers patients sufficient privacy."

As the importance of cleaning has been indicated in previous studies of hospitals [32] and the national cleaning guidelines for hospitals differ in relation to the function of the room [33], satisfaction with cleanliness of the workplace and of the building were questioned separately.

Additionally, two questions were composed to explore differences in the importance of comfort aspects between occupants. The questions were derived from the subcomponents IEQ and social comfort. The first question consisted of twelve psychosocial aspects, the second question fifteen physical aspects. For both questions the participants were asked to select the three most important items.

TABLE 3.1 Components of the questionnaire.

Component	Subcomponent	Instrument
Personal	Demographics: age, sex, education,	OFFICAIR
	Lifestyle: smoking, sports, etc.	OFFICAIR
	Mood	Pick-A-Mood
	Affect	I-PANAS-SF, scale 1-5
	Recent stressful life events	OFFICAIR
	Effort reward imbalance	ERI, scale 1-5 OV, scale 1-4
Workplace	Social characteristics: e.g., function, department, activities	5 questions
	Time-related characteristics: e.g., time spent in the room, weekly working hours at outpatient area	5 questions
	Place characteristics: e.g. (most frequently) used room type, number of persons in the room	4 questions + 10 embedded questions
	General satisfaction with work	1 question, 1-10 scale
Health	Health status	OFFICAIR
	Building-related symptoms	OFFICAIR, 14 symptoms
	Sick leave	3 questions
Comfort	General satisfaction with building	1 question, 1-10 scale
	IEQ	OFFICAIR, 1-7 scale
	Social comfort	14 questions, 1- 7 scale
	Environmental satisfaction	PEQ 12 questions, 1-7 scale
Importance	Psychosocial aspects	3 items selected from 12
	Physical environment	3 items selected from 15

3.2.2 Validation of the questionnaire

The questionnaire was tested in November 2018 by four researchers and two health care architects. After adjustment, a pilot of the questionnaire was conducted in December 2018 with 25 outpatient workers (36 invitations, 30 started, 25 completed) of a general hospital. The pilot was necessary to check the categories, order, and consistency of the newly designed questions. Additionally, the contact persons of two of the participating hospitals provided feedback on the questionnaire during the pilot study.

After analysis and discussion of the descriptive statistics of the data, the questionnaire was adapted. Two questions were found unnecessary and therefore deleted. The categories of five questions were adapted and small changes were made in the order of the questions. The results of the pilot were not included in the analysis reported here. The final questionnaire comprised 148 questions, including 32 embedded questions, one open question for additional remarks and one voluntary question for participation in a follow-up study. Whether the embedded questions were displayed, depended on previous answers.

3.2.3 Selection of the population and buildings

The studied population was restricted to staff members working in outpatient areas. To receive a representative overview of the complete staff group, both sexes of all ages were invited for the survey. Moreover, staff working only in outpatient areas and staff working both in outpatient and in other areas of the hospital (e.g., inpatient area, operation room) were asked to participate. With regards to statistical power, a minimum of 400 respondents was calculated, based on a 95% confidence level, with maximum variety of 50%, and a population size >100.000, according to the formula [34]:

$$n1 = \frac{N}{1 + Ne^2}$$

(*n1*= sample size, N=population size, e=level of confidence)

Sixteen top clinical hospitals were approached with telephone calls and follow-up e-mails, between September 2018 and February 2019. By selecting only top clinical hospitals, the intention was to exclude the type of hospital organization as a confounding variable. Top clinical hospitals in the Netherlands differ from academic and general hospital, in capacity for research and teaching, in specialization and in size. Teaching of physicians and conduction of research are facilitated at top clinical hospitals, although in contrast to academic hospitals, they are generally specialized in one or a few specialities and are not directly related to universities. Top clinical hospitals are generally larger than general hospitals and smaller than academic hospitals.

Selection criteria for the buildings were: different regions (west, middle, east), differences in HVAC systems (e.g., heating with radiators, fan-coil units, supplied air, floor heating), differences in individual control of the indoor environment (manual or automatic), differences in the dimensions of building wings (12-15m, 15-20m, >20m), different building ages (between 1980 and 2018). Buildings needed to be in use in their current form for at least one year prior to the start of the study. Main similarities between the buildings were the finishing materials, such as suspended acoustic ceilings and vinyl floor finishing, presence of internal solar shading at windows in the consultation and treatment rooms, presence of external solar shading, openable windows. The outpatient areas were mainly on the ground floor and the first floor of the buildings.

The main reason for hospitals which refused to participate was the heavy workload of staff. One hospital was kindly rejected by the researchers, as only one department, with 45 employees, showed interest in participation. During the selection process five hospital organizations were visited for explanation and discussion of the research protocol. Finally, three hospitals participated, all with two locations per hospital organization. In two hospitals a presentation was delivered for over twenty department heads, in order to obtain commitment from staff. For each hospital there was one contact person (project leader) involved for planning and procedures. The letter of consent, text on the intranet and questionnaire were discussed with the departments for human resources, communication, and facilities. Participation of hospital organizations and participants was on voluntary basis.

3.2.4 Procedure survey

In the first week an invitation letter, first aligned with the contact person of the hospital organization, was published on the intranet. The purpose of the study, content of the survey and privacy of the participants were explained, as well as details on the invitation for the survey and the building inspection dates.

On Monday of the second week all employees, working in outpatient wards, received an e-mail with a brief explanation of the survey, the time frame for filling in the questionnaire and a link to the digital questionnaire on the Qualtrics XM platform, from the contact person of the hospital. The e-mail was sent to hospital A on 18 February, to hospital B on 18 March, and to hospital C on 1 April 2019. One hospital provided a link to the questionnaire on Intranet as well, in order to enable all persons working at outpatient areas of the two locations to participate. All participants were obligated to agree with the consent form, before they were able to start the questionnaire. The questionnaire was only available in Dutch. The completion of the questionnaire took around 25 minutes according to Expert Review of Qualtrics XM. Participants could save their answers to the survey and resume later (within 14 days). After one week, feedback was provided to the hospitals about the response rate. Reminders to fill in the questionnaires were sent for one hospital once, for the other two hospitals twice. Two hospital organizations allowed to leave leaflets as a reminder to the questionnaire in rooms during building inspection.

3.2.5 Ethical aspects

The Ethics committee of Delft University of Technology approved the study design on 5 October 2018. Data security was assessed by a data manager from Delft University of Technology. To respect privacy of the participants, measures were taken for protection of contact information, safe data storage and withholding of personal information. Therefore, sending and receiving of the questionnaire were separated; an anonymous link to the questionnaire was sent by the hospital organizations, individual e-mail addresses were not shared with the researchers. The data were stored on a secured server. If participants had shared their e-mail address for follow-up, it was separated from the dataset and saved in a secured separate document. Additionally, participants could withhold personal information, as they could leave out questions. Finally, only the data of the participants who confirmed submission at the end of the questionnaire, were saved and included in the study.

3.2.6 Data management and analysis

Data of the survey were imported from the Qualtrics XM platform to IBM SPSS Statistics 25 for analysis of the data. For error analysis the data were checked systematically; textboxes, such as the answer “other, namely…” for the question “what is your highest education level?” were interpreted and, if possible, assigned to an appropriate category. For calculation of the PANAS-SF and overcommitment, the values of the questions were summed to negative affect (NA), positive affect (PA) and overcommitment (OV). Negative scales were recoded from negative to positive and summed to calculate PEQ. The following calculation was performed for calculation of the effort-reward imbalance (ERI): SUM effort/SUM reward·3/7, after recoding scales from negative to positive. Reliability of aforementioned scales was checked with Cronbach’s alpha. Missing value analysis was performed with the values for PA, NA, ERI and PEQ and all items, except the embedded questions.

Building-related symptoms were identified as symptoms which improved when away from the building, based on the question: “Did you ever experience one of the following symptoms during work at your workplace in this building (today included)?” (dry eyes, watering eyes, irritated eyes, …). If one or more symptoms were indicated the following question was exposed, “How many days in the last four weeks (and today) did you experience the following symptoms?” (not in the last four weeks, 1-3 days in the last 4 weeks, 1-3 days a week in the last 4 weeks, every or nearly every working day). If the frequency was at least 1-3 days in the last four weeks, the question “Did it improve or worsen when you were away from your workplace (e.g., holidays, weekend, etc.)?” (better, no difference, worse) appeared. If the answer was “better”, the symptom was counted as a building-related symptom.

For calculation of bipolar comfort scales, such as the perception of dry or humid air, the two last scales on both sides were recoded, similar to OFFICAIR. For calculation of negative scales, such as: “I am too much distracted at my workplace by noise”, the scales were recoded from negative (1) to positive (7). Subsequently, comfort aspects were recoded; IEQ aspects to “dissatisfied” for the values 1-3 and “not dissatisfied” for the values 4-7, and social comfort aspects to “disagreed” for the values 1-3 and “not disagreed” for the values 4-7.

Descriptive analysis was performed to provide an overview of the main personal and work-related characteristics, comfort aspects and building-related symptoms. Differences between the six buildings and between room types were calculated with a Pearson Chi Square (with Bonferroni correction) for categorical questions and Kruskall Wallis for the continuous scales, as the continuous scales were not normally distributed, (Shapiro Wilk <0.001). Due to the low number of participants in Building C2, differences were calculated and compared with and without C2.

Multivariate logistic regression was performed to assess prediction of the most prevalent building-related symptoms and the highest dissatisfying comfort aspects related to those working most frequently in an office, reception, consultation, or treatment room. Identification of covariables was based on literature, differences in the population between the buildings and correlation. First, age was recalculated as a categorical value in three groups (<35, 35-50, >50), ERI in two groups (≤1, >1), satisfaction with work in two groups (≤5, >5), PEQ in two groups (≤48, >48). Then, correlation between covariables was checked with Cramer’s phi for the categorical scales and Spearman rho for the continuous scales. Values for Cramer’s phi >0.10 or Spearman’s rho >0.40 were assessed as moderate correlation and excluded as covariable [35]. Next, the odds ratio with a confidence interval of 95% (CI 95%) was calculated separately for the room types and covariables. The value of categorical variables which was likely to change statistically significantly for most health or comfort aspects, was used as the baseline value in the multivariate logistic regression. Subsequently, the odds ratio (CI 95%) was calculated for room types with the covariables included. Statistical significance of the odds ratio was checked with the Wald Statistic. To check the reliability, the number of events per variable (EPV) was calculated as degrees of freedom divided by the lowest number of participants per aspect, e.g., the number of workers dissatisfied with privacy [36]. Multicollinearity between the independent, included covariables was checked with the Variance Inflation Factor (VIF); values below 10 were considered as low multicollinearity. Goodness of fit was checked with the Hosmer and Lemeshow test (P-value >0.05).

3.3 Results

3.3.1 Response

The questionnaire was completed by 560 (33%) of 1694 invited participants. Four participants were excluded, as they did not work at a hospital location or department which was part of the study. The number of respondents of the three hospital organizations were distributed evenly, but the number of respondents varied between the locations, as shown in Figure 3.1. Although the number of respondents of location C2 was low, they were included, as the provided information was useful for comparison of room type related aspects.

Of the 556 participants, 460 (83%) responded to all questions, excluding embedded questions. Missing values were scattered among the questions; only 7.4% of the questions were completed by all respondents. Missingness of the variables reported in this paper was completely at random (MCAR=0.324). No variables and constructs had more than 5% missing values. Due to inconsistency in answers one participant (no. 149) was excluded from the analysis related to age and the year started in building, as for both questions the same year was reported. Within this study, the reliability of the scales was acceptable for the psychometric scales PA and NA (Cronbach's alpha respectively 0.74, 0.73), good for the scales for work stress (ERI 0.80, OV 0.83) and excellent for the scale for the perceived overall quality (PEQ 0.94).

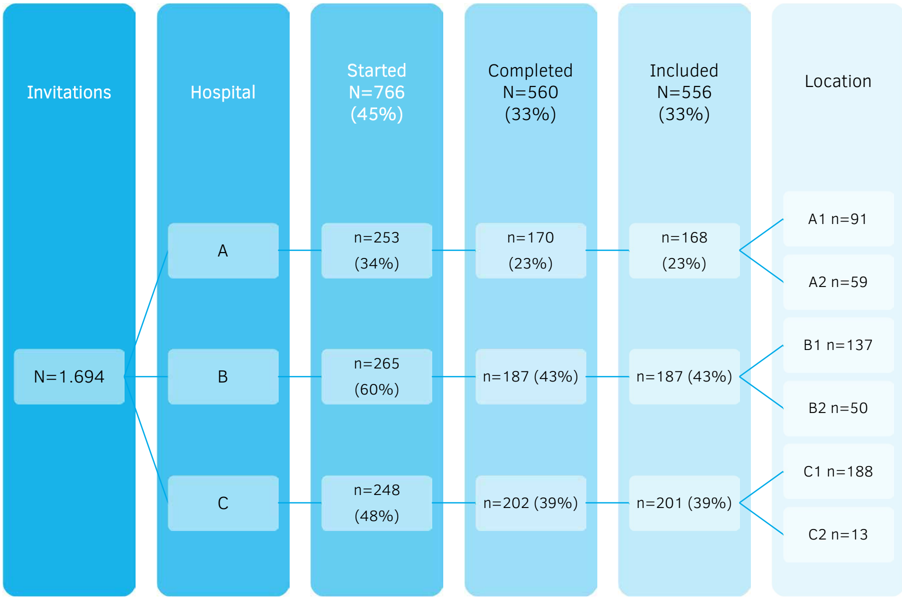


FIG. 3.1 Response per hospital organization and location.

3.3.2 Personal aspects

Table 3.2 shows that 91% of the respondents were female, and 53% had finished intermediate education. Only 37 participants, mainly physicians, did nightshifts (in other parts of the hospital). 76% of the participants were in a positive mood while completing the questionnaire. Their emotions were generally positive as well, as the mean NA was 8.0 (sd 2.5) and the mean PA was 20.0 (sd 2.6), both on a scale from 5-25. The ERI ranged from 0.58 to 3.03. 78% of the participants reported an ERI larger than 1.00, indicating that they felt their effort was higher than the reward they receive. Furthermore, 71% of the respondents was overcommitted (OV>15), while only 8% of the respondents was dissatisfied with their work. Personal aspects were overall balanced at the different locations, except for the following aspects: education level (P-value<0.01), nightshifts (P-value<0.01) and ERI (P-value<0.05).

TABLE 3.2 Comparison of personal and work-related aspects in the six buildings.

Item	Category/ scale	A1	A2	B1	B2	C1	C2	Overall	P-value
N		**91**	**59**	**137**	**50**	**188**	**13**	**556**	
Personal									
Age (mean. SD)	Years	47.6 (11.6)	44.8 (12.5)	47.9 (11.1)	46.6 (12.0)	45.7 (11.4)	48.7 (10.4)	46.6 (11.6)	0.419
Sex (%)	Women	91.2	98.3	86.9	92.0	91.0	100.0	91.0	0.150
Education level (%)**	MSc, PhD	7.7	11.9	24.8	16.3	13.5	7.7	15.0	**<0.000**
	Applied	25.3	18.6	11.7	14.3	24.9	15.4	20.5	
	Intermediate	45.1	55.9	57.7	53.1	52.4	76.9	53.3	
	Secondary	22.0	13.6	5.8	16.3	9.2	0.0	11.2	
Mood (%)	Negative	15.4	15.3	12.9	22.2	13.4	8.3	15.0	0.863
	Neutral	8.8	11.9	11.4	6.7	7.3	8.3	9.0	
	Positive	75.8	72.9	75.8	71.1	79.3	83.3	76.0	
Positive affect (mean, SD)	5-25	20.3 (2.4)	20.5 (2.4)	20.0 (2.8)	19.7 (2.2)	19.9 (2.7)	19.7 (2.8)	20.2 (2.4)	0.335
Negative affect (mean, SD)	5-25	7.9 (2.2)	7.8 (1.9)	8.1 (3.0)	8.0 (2.4)	8.2 (2.4)	8.0 (2.1)	8.0 (2.5)	0.867
Recent positive stress (%)	Yes	26.4	27.1	27.9	32.0	20.7	15.4	24.9	0.466
Recent negative stress (%)	Yes	40.7	39.0	38.0	46.0	31.0	38.5	37.1	0.380
Work									
Contract (%)	Part-time	75.8	72.9	78.1	84.0	72.2	92.3	76.2	0.328
Nightshift (%) • (A1, A2, B1, B2, C1)	Yes	2.2	3.4	13.1	10.2	4.3	0.0	6.5	**0.003**
ERI (mean, SD)*	(3-15)/ (7-35)·7/3	1.3 (0.4)	1.3 (0.4)	1.5 (0.5)	1.3 (0.4)	1.4 (0.4)	1.6 (0.5)	1.4 (0.5)	**0.011**
Overcommit-ment (mean, SD)	6-24	17.2 (3.6)	17.0 (3.1)	16.7 (3.5	16.9 (3.5)	17.3 (3.2)	15.2 (3.5)	17.0 (3.4)	0.465
Sick leave in the last year (%)	None	39.6	54.2	46.7	48.0	37.1	46.2	42.2	0.325
	1-7 days	46.2	35.6	38.7	30.0	47.8	38.5	42.8	
	>7 days	14.3	10.2	14.6	22.0	15.1	15.4	14.8	
Satisfaction with work (mean, SD)	1-10	7.5 (1.3)	7.5 (1.4)	7.6 (1.3)	7.6 (1.7)	7.6 (1.2)	8.2 (1.2)	7.6 (1.3)	0.705

**P-value <0.05 for both C2 included and excluded, ** P-value<0.01 for both C2 included and excluded • due to the value of C2 test violated.*

3.3.3 Work-related aspects

Almost two third of the respondents worked at different locations of the hospital organizations; they commuted between different cities. The proportion of the commuters varied between locations. Only one in four worked in one specific room type, the others worked in two or more different room types. Consultation rooms were mostly used, second offices, third reception desks, and fourth treatment rooms. The majority of the physicians, physician assistants, diagnostic researchers, supportive staff and specialized nurses worked most of the time in consultation rooms. More than half of the general nurses worked in consultation rooms, almost one third in treatment rooms. Managers, administrative staff, and coordinators worked mainly in offices. Three quarter of the reception desk workers worked most frequently at the reception desk, one quarter in offices.

The results show that the proportion of participants who performed a specific activity differed between the room types. For example, 99% of those working most frequently at the reception desks made appointments with patients, versus 46% of those working most frequently in consultation rooms. Concentrated deskwork was mostly performed in offices, routine deskwork in offices and receptions. Meetings and tele-consults with patients and physical investigation of patients were mainly performed by those working most frequently in consultation rooms, medical operations by those working most frequently in treatment rooms. The activities differed all statistically significant between the room types (Pearson Chi-square <0.05), except lab work (only performed by 5% of outpatient staff, P-value=0.322) and telephone calls, specifically not with patients (P-value=0.130). For an overview of the activities per room type see Appendix H.

Flexibility of working places differed between the room types (Pearson Chi-square, P-value<0.000). For example, 61% of those working at the reception had a fixed working place versus 7% in the treatment room. Duration of stay differed between room types as well (Pearson Chi-square, P-value<0.000); 61% stayed shorter than four hours in a treatment room versus 16% of those working at the reception desk. In all rooms the number of persons varied between one to more than nine, except for the treatment room. In the treatment room there were at least two persons present. The proportion of number of persons differed (Pearson Chi-square, P-value<0.000), 21% of the workers in the consultation room worked most of the time alone, versus 8% in the office and 5% at the reception.

TABLE 3.3 Comparison of workplace characteristics related to the six buildings and four room types.

	A1	A2	B1	B2	C1	C2	P-value locations	Office	Reception	Consultation	Treatment	P-value roomtypes	Overall
N	**91**	**59**	**137**	**50**	**188**	**13**		**160**	**115**	**215**	**43**		**556**
Work at different locations (%)													
	18.7	10.2	38.0	20.0	53.2	23.1	**< 0.000**	66.3	66.1	63.3	51.2	0.299	62.9
Years working at the location (mean, SD)													
	14.1 *10.0*	5.2 *4.6*	10.3 *7.6*	12.7 *8.6*	12.4 *9.3*	17.8 *11.4*	**< 0.000**	11.6 *9.6*	11.2 *8.6*	10.5 *8.2*	12.3 *10.6*	0.888	11.2 *8.9*
Working hours at outpatient area (%)													
<17 hours	19.8	11.9	21.2	16.0	15.0	30.8	0.389	15.7	22.6	15.3	18.6		17.7
17-32 hours	65.9	64.4	63.5	72.0	70.6	69.2		67.3	63.5	69.8	74.4		67.4
>32 hours	14.3	23.7	15.3	12.0	14.4	0.0		17.0	13.9	14.9	7.0		15.0
> 1 room types used (%)													
	73.6	78.0	78.8	76.0	69.1	58.3	0.303	71.3	79.1	65.1	90.7	**0.001**	72.8
Most frequently used room type (%)													
Office	48.9	20.7	15.0	12.5	39.7	8.3	**< 0.000**						29.4
Reception	21.1	22.4	40.6	35.4	5.4	16.7							21.8
Consultation	24.4	48.3	37.6	50.0	40.8	66.7							39.9
Treatment	5.6	8.6	6.8	2.1	14.1	8.3							8.9
Duration of stay in most frequently used room type (%)													
<4 hours	42.9	40.7	29.2	38.0	43.1	30.8	0.164	36.3	15.7	45.1	60.5	**<0.000**	38.5
Flexibility workplace (%)													
Flexible	69.0	63.2	62.4	61.7	73.9	58.3	0.255	63.5	38.9	78.5	92.7		66.5
Number of persons in room (%)													
1 person	11.0	5.1	16.8	10.0	9.6	0.0	**0.014**	7.5	5.3	20.5	0.0	**<0.000**	11.4
2 to 4 persons	54.9	50.8	35.0	46.0	47.1	84.6		51.9	53.5	38.1	48.8		46.5
>4 persons	34.1	44.1	48.2	44.0	43.3	15.4		40.6	41.2	41.4	51.2		42.2

3.3.4 Prevalence of health symptoms

Almost three quarter of the hospital staff (72%) suffered in the last four weeks at least from one symptom, that improved when away from the building. As shown in Figure 2.2, the two most prevalent symptoms were dry eyes (50%) and headaches (38%). Regarding seasonal differences, one quarter experienced dry eyes and headaches (respectively 24% and 23%) in particular season(s), namely the winter (respectively 20% and 19%). Dry eyes and headaches occurred for at least to one of two participants during the afternoon (respectively 50% and 60%), while at least one of three participants did not experience these on a specific part of the day (respectively 45% and 35%). Other ocular symptoms, i.e., burning, irritated eyes and watering eyes, were reported to a lesser extent (respectively 27%,13%). With regards to mucus membranes of nose and throat, dry throat was the most prevalent symptom (21%). Lethargy, or unusual tiredness, while working in the building, was experienced by 16% of the outpatient workers.

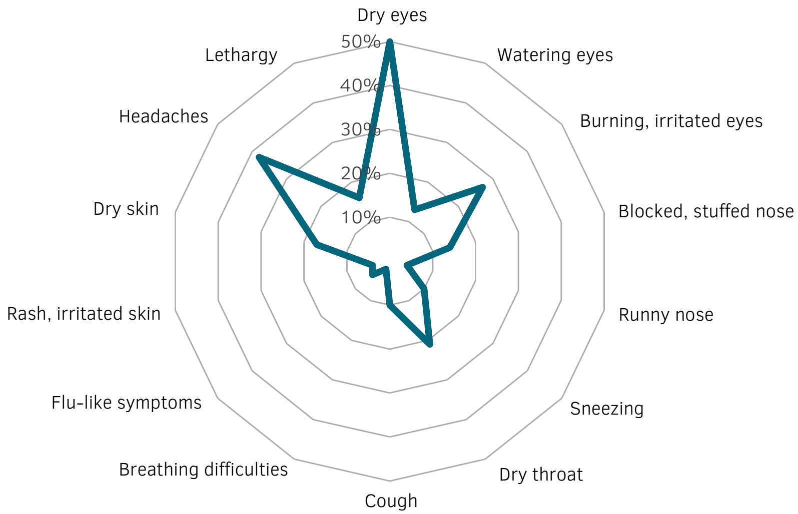
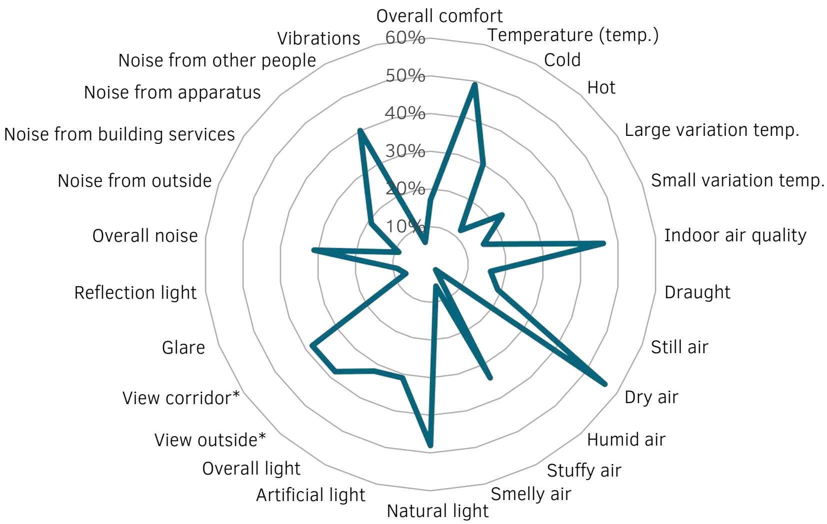


FIG. 3.2 Prevalence of health symptoms of all respondents in the last four weeks, that improved when away from the building.

3.3.5 Dissatisfaction with comfort and main complaints

60% of the respondents were dissatisfied with cleanliness of their most frequently used room. Cleanliness of the building was assessed by more than half as insufficient (55%). Also, more than half of the respondents was not satisfied with the PEQ of their workplace. On a scale from 12-84, with 12-48 as negative, and 49-84 as positive, 53% of the workers perceived PEQ negatively.

As shown in Figure 3.3, almost half of the outpatient staff was dissatisfied with the temperature (49%); for almost one third the workplace was too cold (30%), for around one in eight it was too hot (12%). 23% found the temperature variation large. Regarding the indoor air quality, almost half of the staff (46%) was dissatisfied. Main complaints were dry indoor air (56%) and stuffy air (34%). With regards to the visual quality, most workers were dissatisfied with daylight (48%), one third was dissatisfied with artificial light (31%) and the overall quality of light (32%). Of those who had a window to the façade (n=254) or to the corridor (n=372), two in five were dissatisfied with their view (both 38%). Satisfaction with overall noise was similar to overall light. Noise from other people was the main complaint (40%), second was noise from apparatus (25%).



* Embedded question for those with a window to the façade in their most frequently room

FIG. 3.3 Dissatisfaction with IEQ-aspects of all respondents.

FIG. 3.4 Dissatisfaction with social comfort aspects of all respondents

Figure 3.4 presents the dissatisfaction with social comfort aspects. More than one third of the outpatient staff perceived insufficient privacy at their workplace (36%) and was distracted by noise (36%). Of those who worked with patients (n=382), also more than one third was dissatisfied with the privacy, which they could provide to patients at their workplace (37%). Almost one third perceived their workplace too crowded (32%). Also, one third (32%) was distracted visually, e.g., by people walking along. With regards to the sizes of rooms, around one in three was dissatisfied with the size of their workplace (28%) and available place to storage amenities (32%).

3.3.6 Comparison of reported comfort and health between room types

For comparison of comfort and health associated with work-related characteristics, comfort, and health of groups in their most frequently used room type were compared with logistic regression. The results of the logistic regression were adjusted for demographic variables as presented in Table 3.4.

Inclusion criteria for variables were based on literature, statistically significant differences of demographic variables between the six buildings (P-value<0.05) and absence of a moderate or strong correlation between the variables. Due to the strong correlation of nightshifts and gender with education (respectively Cramer's phi = 0.567, Cramer's phi = 0.419), the low percentage of men (9%) and persons working in nightshifts (7%), education was selected as covariable for adjustment. Overall, more men were high educated than women; almost 90% of the men had applied or academic education of versus 30% of the women. Furthermore, over 90% of the night shift workers had an academic grade. Inclusion of ERI, mood and NA was based on previous studies. Satisfaction with work was included as it was related to headaches, dry eyes, indoor air, noise from other people, cleanliness workplace and building, privacy, distraction by noise, crowding and PEQ. The analysis was performed with complete cases (N=479-484) for abovementioned variables. Subsequently, the results were compared with gender and nightshift instead of education as covariable. The results were similar, with slight differences for the OR and CI values.

The results indicate that it is not likely that complaints for dry eyes and headaches were associated with those working in different room types. Only those who were working in consultation rooms were less likely to perceive dry eyes than those working in offices. The proportion of dissatisfied staff with cleanliness of the workplace was equal for all groups. However, differences in comfort were identified between those working in different room types. Those who worked mostly in the treatment rooms were more likely to be dissatisfied with temperature than the others and experienced more variation in temperature. The chance to be more satisfied with the quality of the indoor air, stuffiness of air and humidity was higher for those working most frequently in consultation rooms than those working most frequently in offices. In contrast, more workers in the offices were satisfied with daylight than those who worked mostly in other room types. The workers in the treatment rooms experienced less distraction by noise than the others. Of those working at the reception desks, more were dissatisfied with privacy than those working in other rooms. PEQ was for all groups equal, except the reception workers who were more likely to appraise their room than staff working in the treatment rooms.

TABLE 3.4 Differences of comfort between most frequently used room types.

		Office vs reception	Office vs. consultation	Office vs. treatment	Reception vs. consultation	Reception vs. treatment	Consultation vs. treatment
Health							
Dry eyes	OR	0.82	0.62	1.04	0.76	1.28	1.67
	95%CI	0.48-1.38	0.39-0.99	0.49-2.19	0.44-1.32	0.58-2.81	0.80-3.50
	P-value	0.448	**0.047**	0.918	0.332	0.544	0.172
Headaches	OR	0.77	0.62	1.09	0.81	1.43	1.75
	95%CI	0.45-1.31	0.38-1.01	0.52-2.30	0.46-1.43	0.65-3.16	0.83-3.69
	P-value	0.331	0.055	0.817	0.477	0.380	0.139
Comfort							
Temperature	OR	0.82	0.70	2.30	0.90	2.81	3.14
	95%CI	0.49-1.38	0.46-1.17	1.04-5.10	0.52-1.54	1.22-6.49	1.43-6.89
	P-value	0.451	0.193	**0.040**	0.69	**0.015**	**0.004**
Quality indoor air	OR	**0.53**	**0.63**	1.12	1.19	2.15	1.80
	95%CI	**0.31-0.89**	**0.39-0.99**	0.53-2.37	0.69-2.06	0.97-4.73	0.86-3.76
	P-value	**0.017**	**0.049**	0.758	0.527	0.058	0.118
Dry indoor air	OR	0.92	**0.56**	1.23	0.61	1.33	**2.17**
	95%CI	0.54-1.56	**0.35-0.90**	0.57-2.64	0.36-1.05	0.60-2.99	**1.02-4.63**
	P-value	0.755	**0.016**	0.602	0.075	0.485	**0.044**
Stuffy air	OR	0.82	**0.52**	0.55	0.64	0.67	1.05
	95%CI	0.48-1.41	**0.32-0.86**	0.24-1.23	0.36-1.14	0.28-1.58	0.46-2.38
	P-value	0.468	**0.010**	0.146	0.127	0.358	0.912
Natural light	OR	**1.73**	**2.28**	**3.78**	1.31	2.18	1.66
	95%CI	**1.02-2.95**	**1.42-3.66**	**1.75-8.14**	0.77-2.25	0.98-4.85	0.78-3.52
	P-value	**0.042**	**0.001**	**0.001**	0.321	0.057	0.188
Noise from people	OR	1.18	**0.58**	0.51	**0.49**	0.43	0.88
	95%CI	0.68-2.04	**0.35-0.95**	0.23-1.14	**0.28-0.87**	0.18-1.01	0.39-1.98
	P-value	0.555	**0.031**	0.100	**0.015**	0.053	0.759
Privacy	OR	**2.71**	**0.46**	0.58	**0.17**	**0.22**	1.31
	95%CI	**1.55-4.73**	**0.26-0.76**	0.26-1.33	**0.09-0.30**	**0.09-0.52**	0.56-3.05
	P-value	**<0.000**	**0.003**	0.199	**<0.000**	**0.001**	0.530
Crowded workplace	OR	0.81	**0.61**	**0.27**	0.72	**0.32**	0.44
	95%CI	0.49-1.45	**0.37-0.99**	**0.10-0.69**	0.40-1.29	**0.12-0.86**	0.17-1.15
	P-value	0.532	**0.049**	**0.007**	0.270	**0.023**	0.095

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TABLE 3.4 Differences of comfort between most frequently used room types.

		Office vs reception	Office vs. consultation	Office vs. treatment	Reception vs. consultation	Reception vs. treatment	Consultation vs. treatment
Distraction by noise	OR	1.16	0.70	**0.23**	0.61	**0.20**	**0.33**
	95%CI	0.68-2.00	0.43-1.15	**0.09-0.61**	0.34-1.07	**0.07-0.54**	**0.13-0.86**
	P-value	0.582	0.158	**0.003**	0.083	**0.002**	**0.024**
Clean workplace	OR	1.24	1.31	1.19	1.06	0.96	0.91
	95%CI	0.72-2.1)	0.82-2.10	0.56-2.53	0.61-1.85	0.43-2.15	0.43-1.91
	P-value	0.439	0.258	0.648	0.835	0.928	0.800
Clean building	OR	0.79	1.52	1.16	**1.93**	1.48	0.76
	95%CI	0.46-1.34	0.94-2.45	0.55-2.47	**1.11-3.36**	0.66-3.27	0.36-1.62
	P-value	0.377	0.087	0.700	**0.020**	0.340	0.483
PEQ	OR	0.71	1.08	1.92	1.51	**2.69**	1.78
	95%CI	0.41-1.23	0.67-1.74	0.85-4.31	0.87-2.64	**1.15-6.30**	0.80-3.97
	P-value	0.221	0.757	0.115	0.661	**0.022**	0.159

Adjusted for age (baseline 35-50 years), education (baseline master), mood, NA, ERI, satisfaction with work.
Significant values in ***bold.*** *OR=odds ratio, 95% CI is the confidence interval at 95%. EPV between 13 and 20. N=479-484.*
VIF between 1.022 and 1.052.

3.4 Discussion

3.4.1 Study design

The broad range of questions in the questionnaire provided a comprehensive overview of the perceived comfort and health of outpatient staff. To our knowledge, no previous study in hospitals on health and comfort of staff has provided such an extensive overview of personal and work-related variables. The use of workplaces in outpatient areas of hospitals is different from offices, as outpatient staff tends to perform a wide range of activities at different places in the building. The analysis showed differences for those working in different room types, duration of stay at a workplace, number of persons in the room and flexibility of workplaces. Inclusion of these characteristics in the questionnaire was relevant, as these aspects may be associated with the indicated differences between the room types.

A limitation was the inequality in sample size between the buildings. A possible explanation is that staff was asked to report their perception of building-related symptoms and comfort of the building they worked most. There was a tendency that they worked most in the largest buildings of the organization (location A1, B1 and C1). Furthermore, the room types were not equally divided between the buildings. At location C1 only 5% worked at the reception desk versus 40% at location B1. This could be explained by organizational factors, as at location C1 the main part of the receptions was automatic. However, the differences in the population between the buildings, which may occur through unequal sample size, were taken account of in the analysis.

3.4.2 Response

The response rate of approximately one third was in line with OFFICAIR (144 questions) [16], but lower than the response on the MM040 questionnaire (35-37 questions) in Swedish, Finnish and Greek hospitals [3, 4, 37] (68%, 82 % and 75%). These differences can be related to the length of the questionnaire and the way of distribution (digitally versus on paper). However, the fact that four out of five respondents, who started participation, completed the questionnaire and one out of four participants provided their e-mail address for participation in future studies, indicate that the outpatient staff who did start, found the study relevant.

Presentation of the survey to the coordinators of the outpatient departments and leaflets with information left in the inspected rooms, as performed in hospital B and C, may have contributed to a higher response rate in hospital B and C than in hospital A. In a review on the response rate of 490 surveys between 2000 and 2005, the promotion of the survey within the organization contributed to an increased response rate [38]. The review also suggested that representativeness of the respondents was more important than the response rate. Comparing the average age and gender of nurses and physicians to the average of all nurses and physicians working in top clinical and general hospitals in the Netherlands in 2017, the gender ratio of both groups in the present study deviated 3% from the average [39]. The age of the physicians was similar, nurses were in the present study slightly older than the average (48 versus 40-45 years).

The sample size of 556 respondents (more than the minimum required of 400) was adequate for multiple logistic regression of the main symptoms and dissatisfying aspects, as the EPV was more than 10.

3.4.3 Personal and work-related aspects

Due to the large proportion of female outpatient workers the results were not adjusted for gender. In contrast to the previous hospital studies, which excluded male workers from the analysis, males were included in order to provide a representative overview of the population [4, 40]. It should be noted that the gender ratio was not reported in all previous studies. Also, the analysis with gender and work shift as covariables instead of education did not differ.

The average score of ERI in the present study was higher than in previous studies in Swiss, German and Dutch hospitals that included the ERI [41-43]. Also, the average ERI in OFFICAIR was lower. Similar to the findings in OFFICAIR, a high ERI was not strongly related to working hours: 77% of the part-time and 82% of the fulltime workers had an ERI larger than one. Furthermore, the correlation of satisfaction with work and ERI in the present study was low (Spearman's rho 0.174). The high work pressure in hospitals in the Netherlands may explain the high ERI in the present study. According to the database of Statistic Netherlands, almost half of the workers in independent outpatient centres, general and top clinical hospitals, experienced in 2018 too high work pressure and almost three out of four reported an increased work pressure in the last twelve months [44]. Nevertheless, in line with the present study, a large group (78%) was satisfied or very satisfied with their work in 2018.

3.4.4 Health symptoms

For comparison of previous studies on building-related symptoms of hospital staff in European hospitals, differences in study design need to be accounted for, as these aspects may contribute to differences in reported symptoms. The MM040 questionnaire, used in studies [3, 4, 37], comprised 12-15 symptoms, including symptoms which were not part of the present study, such as “heavy headed”, “nausea/dizziness” and “difficulties concentrating.” In comparison with the present study, some symptoms were combined in MM040. For example, instead of the symptom “dry eyes”, MM040 comprised one category for “itching, burning or irritation of the eyes” [45]. Also, the MM040 respondents were questioned: “Do you believe that it is due to your work environment?”, while in the present study: “Was it better, when you were away from your work?” However, Raw et al. (1996) found no differences in the prevalence of symptoms between these two questions [46].

Overall, fatigue and dry skin (on hands or face) were reported among the four most prevalent symptoms in the MM040 studies, whereas the prevalence of eye, nose or throat symptoms varied. These findings are in contrast to the present study, with dry eyes as main complaint and headaches as second. Dry eyes and headaches were also the main symptoms reported in OFFICAIR. Similar to the higher prevalence of symptoms in hospitals than in offices in previous studies with the MM040 questionnaire, the prevalence of symptoms was higher in the present study than in the European wide OFFICAIR: the prevalence of dry eyes and headache perceived in the last 4 weeks, were in OFFICAIR respectively 31% and 29% and in the present study 50% and 38% [22].

An explanation of the high prevalence of dry eyes in present study could be the high percentage of female respondents; more women tend to experience dry eyes than men [47]. In contrast to OFFICAIR [48], the prevalence of dry eyes was not associated with ERI in the present study. The high prevalence of dry eyes and headaches in the present study compared to the MM040 studies in hospitals might be related to differences between countries. In the OFFICAIR project the prevalence of dry eyes and headache of female workers in the Netherlands was higher than in the other European countries [49].

3.4.5 Comfort complaints

Comparison of comfort complaints with other studies is difficult, due to differences in study design, different scales and variation of included comfort aspects. For example, the MM040 questionnaire included 11-13 IEQ items on a three-point scale [45], and the Padua hospital study included 11 comfort items on a scale from 1-7 [15]. The questionnaire for the Dutch inpatient study comprised 20 comfort items on a scale from 1-5, and aspects of indoor air were beyond the focus of that study [5]. In the MM040 studies and Padua hospital study “dry air”, “stuffy air” and “poor air quality” were among the main complaints, which corresponds with the results of the present study. These findings do not differ from previous studies in European offices, were complaints with “dry air” and “stuffy air” were also among the main complaints. Complaints for dry air were higher in the present study than in OFFICAIR.

In contrast to previous hospital studies, dissatisfaction with visual aspects were more prevalent than dissatisfaction with acoustic aspects. This might be explained by differences between inpatient areas and outpatient areas, such as differences in activities, and the 24h occupancy of inpatient departments versus 8h occupancy of outpatient areas. For example, noise during the night was by more than half of the staff negatively assessed in inpatient areas [5]. However, in previous office studies the prevalence of noise complaints was also higher than complaints of visual quality. For a comparison of the present study with OFFICAIR, noise from people and noise from apparatus were summed. This resulted in a similar proportion of the workers satisfied with the acoustic quality in OFFICAIR as in the present study.

Almost half of the outpatient staff experienced an uncomfortable temperature, which is in line with the Dutch inpatient study and Padua hospital study. One third of the workers in OFFICAIR was dissatisfied with temperature; half of them was too cold, half of them too hot. In the present study one third was too cold, one out of eight too hot. The differences can be explained by clothing guidelines. Hospital workers who have contact with patients are required to wear short sleeves, due to hygiene guidelines. They are not allowed to adjust their clothing when they are cold. Another explanation can be differences in the metabolic rate between females and males. Kingma and Van Marken Lichtenbelt (2015) determined, based on analysis of biophysical parameters, that the metabolic rate of young females performing light office work, was lower than the ASHRAE standard values [50]. However, as in the MM040 study in Greece [37] and Finland [3] more hospital workers were too hot than too cold, country or hospital department might also be associated with the perception of hot or cold temperature.

Previous hospital studies have reported differences in privacy needs between different departments, e.g., between inpatient areas and emergency departments [1]. The differences in satisfaction with privacy in the present study between those working in different room types, suggest that privacy can differ even within departments. Dissatisfaction with privacy at the reception areas can be explained by the enclosure of the reception desks. The reception desks in outpatient areas were from desk to ceiling open to waiting rooms or circulation areas. Surprisingly, although those working most frequently in the offices were more satisfied with privacy than those working at receptions, a difference (after adjustment of confounding variables) in dissatisfaction with crowding and distraction by noises between these groups was not likely. This may be explained by the performed activities, e.g., most concentrated desktop work is performed in the offices, versus routine desk top work behind the reception desks. In contrast to the findings of Fisher (1974), the PEQ of the groups who perceived their workplace as too crowded (offices and reception areas) or not too crowded (consultation and treatment rooms) was generally the same [21]. It must be noted that in the study of Fisher variation in the perception of crowding was studied in only one room type.

3.5 Conclusions

This study presented the first results of a study on health and comfort of staff in outpatient areas. The study strengthens previous findings of larger prevalence of building-related symptoms and dissatisfaction with comfort aspects in hospitals than in offices. The main symptoms were dry eyes and headaches. Dissatisfaction with air quality as main complaint corroborates with previous studies. Low satisfaction with daylight was specific for this outpatient study, in comparison to previously studied inpatient areas, hospitals and office buildings. This study indicated that dissatisfaction with thermal, acoustic, visual, and social comfort aspects can vary between groups working in different room types, whereas it was less likely that cleanliness and the headaches varied. The largest differences were found for privacy, the smallest for indoor air related aspects and dry eyes. Furthermore, as the use of workplaces in outpatient areas was dynamic and the ERI was high, this study reinforces the necessity for inclusion of personal and work-related characteristics in studies on comfort and health of occupants. Finally, the finding that main health symptoms were in general not related to room types (and indirectly to activities, duration of stay, and number of people in the room), shows the need for looking into possible associations with other building-related and/or occupant-related indicators.

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4 Profiling outpatient staff

based on their self-reported comfort and preferences of indoor environmental quality and social comfort in six hospitals

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For consistency of the dissertation some typos are adjusted and phrases are reworded, without changing the content

ABSTRACT

Comfort and health of outpatient staff is important due to the growing demand of healthcare and its crucial influence on society. Previous studies have mostly focused on the perception of comfort and indicated a large prevalence of building-related symptoms and dissatisfaction with comfort of staff in hospital buildings. Unfortunately, limited information was available of the individual preferences in relation to building characteristics, especially in outpatient areas. This study aims to understand the preferences of outpatient staff in relation to their comfort, health, work and building-related aspects. Data were collected with a survey from 556 outpatient workers in six hospital buildings and building inspection of 107 rooms. TwoStep Cluster Analysis was performed to identify groups with clear differences in preferences and comfort, that justify the variation of individual comfort and preferences of outpatient workers. Six clusters were produced for preferences and comfort with IEQ; three clusters were produced for preferences and comfort with social aspects. The clusters indicated that preferences and comfort of IEQ are related to health. The social comfort clusters varied in activities of outpatient staff. As the overlap of the profiles of the IEQ clusters with the profiles of the social

comfort clusters was limited, the results suggest that it is important to study both simultaneously. Surprisingly, relations with building-related aspects were for both cluster-sets limited. This suggests that outpatient staff members do not relate their preferences to the actual building where they are working.

4.1 Introduction

Previous studies show that the demand on hospital staff is increasing [1-4] and that their comfort and health may be affected negatively by dose and building-related aspects [5-7]. Percieved comfort and needs related to the layout and the indoor environmental quality (IEQ) may vary between hospital departments. This is because hospitals are complex buildings, with e.g., inpatient areas, outpatient areas, operating rooms and intensive care units. Therefore, it is important to study individual hospital departments. However, outpatient areas seem to be understudied [7].

To better understand comfort and health of staff members in outpatient areas, a survey was performed in which personal aspects, work-related aspects, and social comfort (privacy, crowding and interaction) were assessed. A previous study provided an overview of health and comfort and their differences in relation to different room types [8]. The most prevalent symptoms were dry eyes and headaches. Similar to previous studies, it was found that there is a larger prevalence of building-related symptoms and higher dissatisfaction with comfort aspects in hospitals than in offices [9-12]. Satisfaction with IEQ and social aspects varied between those working in different room types in outpatient areas. For example, respondents who worked in consultation rooms were more likely to be comfortable with more aspects, except daylight, than respondents working in offices. However, social comfort aspects were more likely to vary than IEQ aspects, while differences in health were limited.

Since social comfort, IEQ aspects and health are differently related to personal aspects and room types, there is a need to analyse possible relations with building-related aspects. It is important to specify preferences and to understand their associations with the physical environment, in order to improve the comfort and health of the staff in hospitals [6]. Mourshed and Zhao (2012) studied the preferences of hospital workers in hospital buildings and found differences between the occupants, associated with differences in relation to working hours, gender and age [13]. Previous studies in offices indicated that the preferences that were considered more important, were related to comfort [14, 15], to personal, and to work-related aspects [16, 17]. However, the assessment of outpatient staff preferences accounting for personal, work-related, and building-related aspects has not been studied yet.

Vischer (2007) suggested that both the physiological perception of IEQ-aspects and the psychological perception of social comfort, can contribute to satisfaction with the physical environment [18]. Perception of social comfort and IEQ may vary between individuals, due to differences in reactions and sensitivity to building and to dose-related aspects [19]. For example, Boyce and Wilkins (2018) stated that visual comfort depends on the sophistication of the visual system and the expectations of the occupant [20]. Similarly, Hong et al. (2020) found that willingness to discuss control of the indoor environment is related to personal traits [21]. Furthermore, Hoendervanger at al. (2018) found that satisfaction with the physical environment was related to individual differences in needs for privacy [22].

Profiling occupants may justify the variation of individual needs [23]. Based on different clustering and segmentation methods, previous studies have resulted in profiles of occupants based on their comfort perception of IEQ in offices [24], on preferences and comfort of IEQ of schoolchildren [25], on control of indoor climate [21], on comfort related to activities [17], and on preferences for the control of lighting [26]. These studies identified clear differences between groups in preferences and comfort perception, which justify the variation in physiological and psychological reactions of individuals. However, as the perception of comfort can be associated with the specific context of a building and room type, it is important to identify groups of outpatient staff that vary in preferences and comfort. Additionally, there are no previous studies assessing whether the perception of IEQ and social comfort vary similarly between individuals.

Taking all of the above-mentioned aspects into account, the aim of this study was to explore groups of outpatient staff members working in the six buildings. The present study acts as a follow-up to the aforementioned survey [8]. It identifies clear differences in preferences and the perception of comfort of outpatient staff. For this purpose, clusters were produced to answer the following research questions:

- What are the profiles of the outpatient workers, clustered by their preferences and perception of IEQ?
- What are the profiles of the outpatient workers, clustered by their preferences and perception of social comfort?
- To what extent are IEQ clusters and social comfort clusters similar, regarding personal aspects, work-related aspects, building-related aspects, and health?

4.2 Method

4.2.1 Study design

This study is part of a larger field study on comfort and health of outpatient staff, conducted in three hospital organizations in six hospital buildings in the Netherlands [8]. The field study comprised a questionnaire with 148 questions for staff members and of a building checklist to inventory of building-related aspects. The questionnaire was distributed digitally to 1.694 outpatient workers and completed by 556 respondents. For the building inspection, the HVAC-systems of all buildings and 127 rooms were inspected. Table 4.1 shows the main demographic aspects of the respondents and the building characterisitics. All buildings, except A2, had partly been renovated or contained newly built parts, that were attached to the main building.

TABLE 4.1 Demographics of the 556 respondents and building characteristics.

Organization		A		B		C	
Demographic aspects							
Age	Years (SD)	46.4 (2.2)		47.6 (11.3)		45.9 (11.4)	
Sex	Female	94%		88%		92%	
Education	MSc, PhD	9%		23%		13%	
	Applied	25%		12%		24%	
	Intermediate	49%		57%		54%	
	Secondary	17%		9%		9%	
Building aspects							
Location		A1	A2	B1	B2	C1	C2
Region		Middle	Middle	West	West	East	East
Building year main building		1983	2013	1990	1989	1995	1980
Number of building levels		4	6	12	4	8	7
Outpatient area > 15.000 m^2		Yes		Yes		Yes	

The questionnaire was based on the OFFICAIR questionnaire [12], developed for a study on health and comfort in European offices, and had newly developed questions. The questionnaire was tested in a pilot study with outpatient staff of a general hospital in the Netherlands in December 2018. It comprised of five main components: personal aspects, work-related aspects, health, comfort and preferences. Detailed information about the design of the questionnaire, selection of the population and buildings, and the procedure of the survey are reported in Eijkelenboom et al. (2020) [8].

For the building inspection, four checklists were composed to obtain an as complete as possible overview of the building-related aspects of outpatient areas in hospitals: a building checklist, a room checklist, a layout checklist, and a cleaning checklist. The building and room checklists were based on OFFICAIR and adapted with some specific characteristics of outpatient areas. The adaptations were based on visits of hospital buildings, during the preparatory phase. The building checklist was designed to specify characteristics of the HVAC-systems, sources of outdoor light, noise and air pollution and façade characteristics. The room checklist aimed to identify differences and similarities in building-related aspects of the rooms. The layout checklist was created to assess the dimensions, the functions and the structure of circulation areas and rooms. As the importance of cleaning has been indicated in previous studies in hospitals [13, 27], a cleaning checklist was developed, based on national regulations for hospital cleaning (e.g., the frequency of cleaning the floor, wall, and furniture per room type) [28]. Detailed information on the checklists and building-related aspects is reported elsewhere.

This paper explores similarities in perception and preferences of outpatient workers in outpatient areas in the six hospital buildings. For comfort, the perception of temperature, temperature variation, air movement, air humidity, air stuffiness, natural light, artificial light, noise from building services, from apparatus and people are included. Furthermore, the satisfaction with the size of workplace, size of storage place, walking distances, proximity of colleagues, contact with others, distraction by noise, visual distraction, safe workplace, crowding at the workplace, crowding at the building, and privacy of oneself, are included. These aspects were rated on a scale of 1 to 7. For the preferences the question “Which 3 building aspects are for you MOST important to perform your work well?” was included, with the variables “control of temperature”, “control of view”, “control of ventilation”, “control of sunscreen”, “no annoyance by noise”, “furniture which is adjustable in height”, “not too cold or hot”, “cleanliness”, “appearance of interior (colour and texture)”, “view to outside”, “view to corridor”, “sufficient daylight”, “sufficient fresh air”, “sufficient room”, “sufficient storage room” and “skip this question.” Finally, the question “ Which 3 psycho-social aspects are MOST important to perform your work well? ” was included with the variables “proximity of colleagues”, “contact with colleagues”, “contact with patients”, “contact with colleagues and patients”, “safe workplace”, “short walking distances”, “no distraction by noise”, “no distraction by people passing by”, “not too crowded building”, “not too crowded workplace”, “sufficient privacy of oneself”, “sufficient privacy for patient”, and “skip this question.”

4.2.2 Procedure

The survey of each hospital was conducted in the spring of 2019. A link to the questionnaire was distributed digitally by the hospital organizations. While the questionnaire was active, the building inspection was performed in outpatient areas of six top-clinical hospital buildings. To systematically inspect the different room types and renovation periods, rooms were selected and marked on layout drawings before the room inspection. The selection criteria were the function of the room, orientation of the room, whether the room was indoor or adjacent to the façade, and different wards (e.g., opthalmology, dermatology). If one of the preselected rooms was occupied with patients during the walkthrough, a similar room was selected. The building inspections were planned on days when the outpatient area would be least occupied, in order to have access to most rooms. The procedure and room selection were discussed with the facility managers before the inspection. Information on the HVAC-systems and cleaning protocols was provided by the hospital organizations before inspection. Facility managers provided on site explanation of the HVAC-systems in each building. The observations and oral information of the facility manager were reported on the building and room checklists. Room inspection was generally performed with three researchers. Pictures of the building aspects were taken, while respecting the privacy of both patients and staff.

4.2.3 Data management and analysis

The data was analysed with IBM SPSS Statistics 25. First, a descriptive analysis was performed to provide an overview of the comfort perception and preferences. For comfort, the mean and standard deviation were described of the 7-point scales. For the IEQ preferences, the combinations and distribution of all 15 aspects were analysed, to assess which aspects were representative for a substantial part of the participants. Similarly, the distribution and most prevalent combinations of the 12 social preferences were analysed.

Subsequently, the strength of correlations of perceived comfort aspects with similar preferences were analysed to decide whether both perceived comfort and preferences could be included in the cluster analysis. This analysis was performed because, according to Ketchen and Shook (1996), multicollinearity may affect the weight of constructs in cluster-analysis [29]; therefore, Chi square tests were performed.

Then, as preparation for the cluster analysis, principal component analysis (PCA) was performed to reduce the comfort variables into a smaller set of independent components. As recommended by Tabachnick and Fidell (2007), the number of components was determined by an eigenvalue >1; adequacy of the sample was checked with Kayser-Meyer-Olkin >0.6; the selected rotation was orthogonal (varimax), as the components were composed for further analysis [30]. Furthermore, the strength was determined by loadings within components >0.4 and loadings between components <0.4 [31]. For the PCA of the IEQ aspects, all respondents were included who answered the question on the IEQ preferences and the comfort-related questions on IEQ. For the PCA of the social comfort aspects those who answered the question on social preferences and questions on social comfort were included.

After the PCA, TwoStep Cluster Analysis was performed by including the questions on perceived comfort and preferences. TwoStep Cluster Analysis was used because it has several advantages according to Tkaczynski (2017): continuous data (the IEQ-components) and binary data (the preferences) can be clustered simultaneously in contrast to k-means clustering; data can be processed quickly and therefore is suitable for large datasets; the number of clusters are determined by the algorithm, an advantage for exploratory studies, which this study is; and the predictor importance of variables may support further interpretation and analysis based on the cluster solution [32]. For the analysis, Akaike's Information Criterion was selected. According to the recommendations of Tkaczynski, the validation of the final model was based on four steps: 1) the silhouette coefficient was checked to be above 0.0 and preferably above 0.2; 2) differences between the clusters were checked (P-value<0.05); 3) the predictor importance of the variables needed to be 0.02 or larger; and 4) comparison with randomly split samples was performed.

Finally, differences in personal aspects, work-related aspects, health, comfort and preferences were compared. Chi-square tests were used for binary variables and ANOVA for continuous variables, both with Bonferroni correction. This was done to adjust for potential rare events, due to the large number of tests performed.

4.2.4 Ethical aspects

The Ethics committee of Delft University of Technology approved the study on 5 October, 2018. A data manager from Delft University of Technology assessed data security. To respect privacy of the participants, measures were taken for protection of contact information, safe data storage and withholding of personal information. At the start of the digital questionnaire, participants were informed that by completing the questionnaire, they would give their consent to use their responses for research purposes. Only those who confirmed submission at the end of the questionnaire were included in the study.

4.3 Results

4.3.1 Perceived comfort

Figure 4.1 presents the mean and standard deviation (SD) of perceived comfort with IEQ-aspects at the most frequently used workplace. In general, outpatient staff reported dry air (5.4 ± 1.3), stuffy air (3.4 ± 1.6) and cold temperature (3.5 ± 1.6). The average variation in temperature was reported to be slightly high (3.8 ± 1.6), while the mean air movement was almost neutral (4.1 ± 1.6). The mean satisfaction of the respondents was highest with noise from building services (4.9 ± 1.6), followed by noise from apparatus (4.7 ± 1.7), artificial light (4.2 ± 1.6), natural light (3.7 ± 1.9), and noise from other people (4.0 ± 1.8). Concerning social comfort aspects, the outpatient staff was overall neutral to satisfied (Figure 2.2). The mean satisfaction was highest for contact with others (5.8 ± 1.4), and lowest with privacy of oneself (4.3 ±1.97) and distraction by noise (4.3 ± 1.86). The size of the workplace and storage were rated slightly more than neutral (4.8 ± 1.9, 4.6 ± 2.0). The mean of proximity of colleagues was 5.7 ± 1.45 and for walking distances 4.9 ± 1.79. The mean satisfaction of the outpatient workers with crowding at the building (5.1 ± 1.75) was higher than with visual distraction and crowding at the workplace (4.3 ± 1.86, 4.5 ± 1.92). The mean of safety of the workplace was 5.6 ± 1.50.

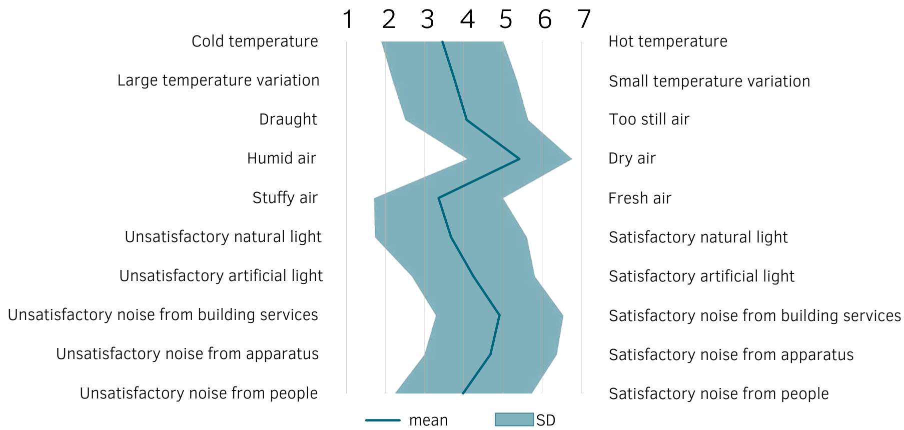

FIG. 4.1 Self-reported comfort with IEQ related aspects.

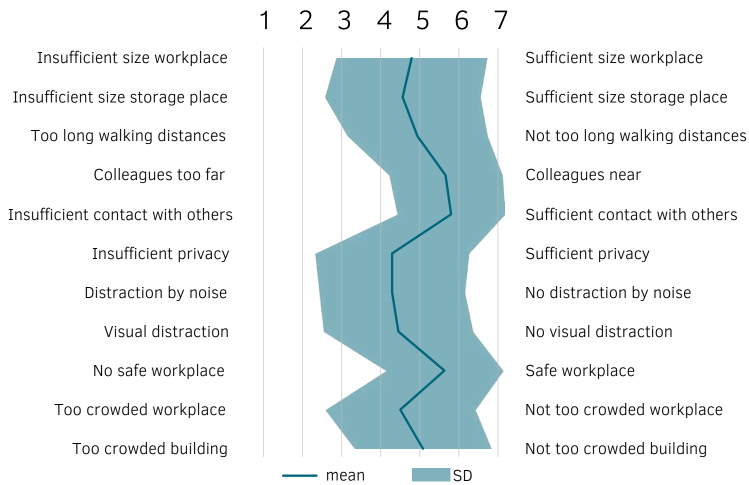

FIG. 4.2 Self-reported comfort with social comfort.

4.3.2 Preferences on IEQ aspects and social aspects

Out of the 15 building or dose-related aspects, the combinations of the three most selected aspects that were regarded to be important for the work performance varied widely. Thus, not one combination of the three aspects was selected by a large part of the outpatient workers. For example, the combination “cleanliness” with “fresh air” and “sufficient daylight” was selected most, but only by 16 respondents

(3%). Almost all respondents (94%) selected "control of temperature", "not too cold or hot", "control of ventilation", "fresh air", "no annoyance noise" or "sufficient daylight." As shown in Figure 4.3, sufficient daylight was selected by the largest proportion of the responding outpatient staff (39%). The second in the ranking of preferences were the aspects related to temperature: control of temperature by 34%, not too cold or hot by 29%. Third were aspects related to indoor air quality: sufficient fresh air and control of ventilation was selected by 27%. Noise was regarded important for fewer outpatient workers than the other IEQ-aspects (18%). Because of the large proportion of respondents that selected "control of temperature", "not too cold or hot", "control of ventilation", "fresh air", "no annoyance by noise" or "sufficient daylight", and because there were no combinations of three aspects with a substantial prevalence, it was decided that these aspects were relevant to include in the TwoStep Cluster Analysis.

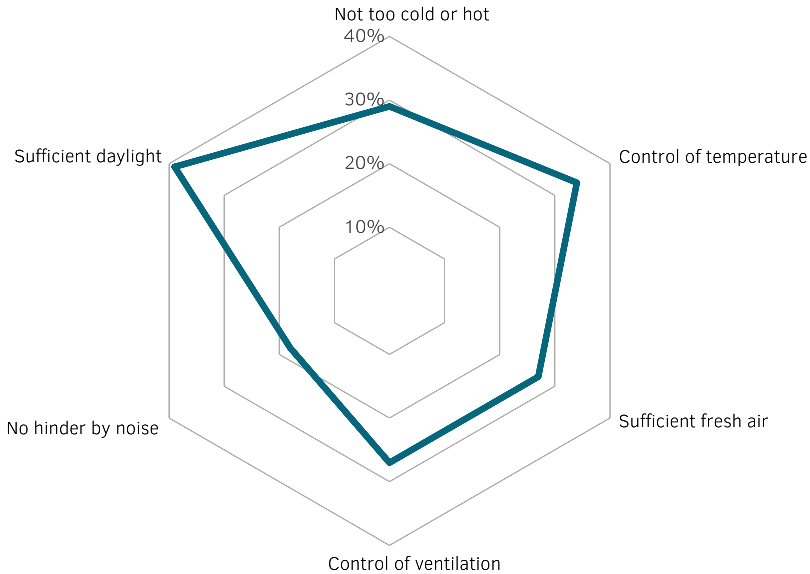

FIG. 4.3 IEQ-aspects that were regarded to be important for work performance.

The outpatient workers could select three out of 12 social aspects that they regarded to be most important for their work performance. The aspects that were selected by more than 25% were "contact with patients and colleagues" (67%), "safe workplace" (52%), "sufficient privacy for patients" (41%), and "no distraction by noise" (27%), see Figure 4.4. 95% of the participants selected at least one of these aspects; the combinations varied widely. The most selected combination was

TOC

“contact with patients and colleagues”, “safe workplace”, “sufficient privacy for patients” (16%). The second most selected combination, “contact with patients and colleagues”, “safe workplace”, and “no distraction by noise”, was selected by 5%. Third was “contact with patients and colleagues”, “no distraction by noise”, and “sufficient privacy for patients”, selected by 4%. As the four variables were selected by a substantial part and the combinations varied largely, the variables were considered relevant to include in TwoStep Cluster Analysis.

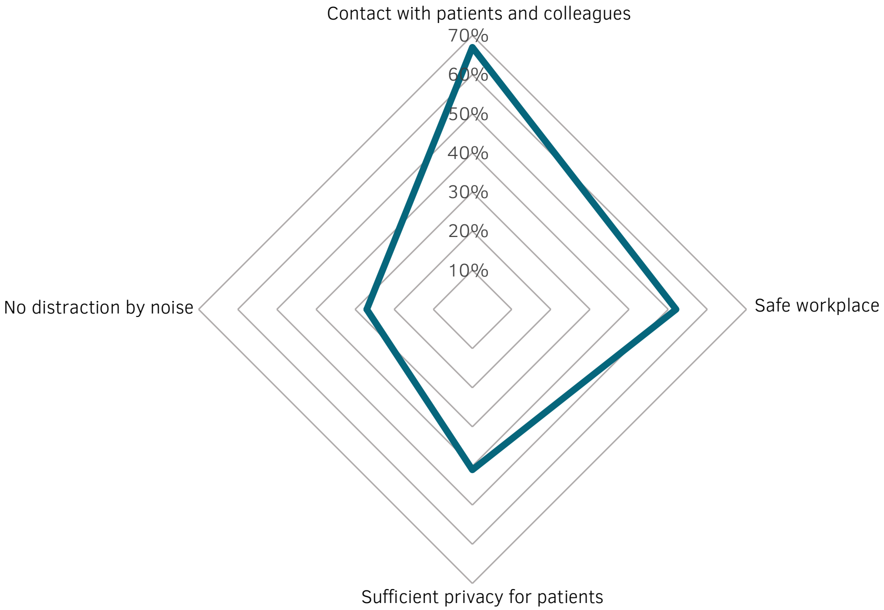

FIG. 4.4 Social aspects that were regarded to be important for work performance.

4.3.3 Correlations between comfort and preferences

Several statistically significant correlations between comfort aspects and preferences (P-value<0.05) were found, but the effect size was generally negligible (phi <0.2), see Table 4.2. The only correlation with a small effect was the perception of distraction by noise with the preference for no distraction by noise. Multicollinearity was limited, both preferences and percieved comfort could be included in the cluster analysis.

TABLE 4.2 Correlations between perceived comfort and preferences.

Preferences	Perceived comfort	Phi	P-value
Sufficient daylight	Satisfaction with daylight	0.124	**0.004**
	Satisfaction with artificial light	0.103	**0.017**
Not too cold or too hot	Cold temperature	0.131	**0.002**
	Hot temperature	0.016	0.714
	Large temperature variation	-0.001	0.981
	Small temperature variation	0.119	**0.006**
	Draught	0.097	**0.025**
	Still air	-0.085	**0.048**
Control temperature	Cold temperature	0.135	**0.002**
	Hot temperature	0.105	**0.012**
	Large temperature variation	0.164	**<0.001**
	Small temperature variation	0.075	0.081
	Draught	0.066	0.127
	Too still air	-0.056	0.195
Sufficient fresh air	Stuffy air	-0.051	0.240
	Dry air	0.032	0.458
	Draught	-0.061	0.157
	Too still air	0.107	**0.013**
Control ventilation	Stuffy air	0.086	**0.047**
	Dry air	0.091	**0.034**
	Draught	0.030	0.486
	Still air	0.096	**0.025**
No annoyance by noise	Noise from building services	-0.018	0.682
	Noise from apparatus	0.054	0.210
	Noise from other people	0.129	**0.003**
Contact with patients and colleagues	Satisfied with contact	0.058	0.179
Safe workplace	Feeling safe	0.038	0.383
Sufficient privacy for patient	Satisfactory privacy self	0.024	0.576
	Satisfactory privacy patients	0.039	0.447
No distraction by noise	Not distracted by noise	0.217	**<0.001**

P-value <0.05 in bold. N between 537 and 554, N=382 for the question on satisfactory privacy of patients, as it was only exposed to those working in reception areas, consultation or treatment rooms.

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4.3.4 Principal component analysis

To reduce the number of variables, the perceived comfort responses to IEQ and social comfort were reduced separately with principal component analysis. For IEQ four components were identified. Component IEQ1 comprised of "noise from building services", "noise from apparatus" and "noise from other people" and was labelled as "noise-related discomfort." Component IEQ2 comprised of "natural light" and "artificial light" and was therefore labelled as "light-related discomfort." The variables of component IEQ3 were "dry air", "air movement" and "stuffy air" and was labelled as "discomfort indoor air." Component IEQ4 was labelled as "thermal discomfort", with excellent loadings to "cold temperature" and "variation of temperature."

For social comfort, three components were identified. To create a representative overview, the question on privacy for patients was not included, as it was not presented to those working only in offices. Component SOC1 consisted of "no distraction by noise", "no visual distraction", "no crowding at the workplace", "no crowding at the building" and was therefore labelled as "disturbance." The loadings for SOC2, i.e., "size workplace", "size storage", "privacy self", "safe workplace", "walking distances", were all related to perception of the layout and therefore labelled as "sense of space." The variables of the third component, SOC3, were "proximity of colleagues" and "contact with others" and was therefore called "interaction." The factor-score of each component was composed of the sum of each variable divided by the number of the included variables. Therefore, the following aspects, suggested by Di Stefano et al. (2009), were taken into consideration: a clear structure, all cross loadings <0.4 and a small variation in weight [33].

4.3.5 TwoStep Cluster Analysis

TwoStep Cluster Analysis was conducted for IEQ and social comfort separately, to reduce the number of variables for analysis. The starting point for the IEQ clusters were the four components of PCA and six main IEQ preferences. After iteratively removing variables with a score lower than 0.02, nine variables were included in the final model. Six clusters were produced for 519 outpatient workers, representing 93% of the total sample. The silhouette measure of cohesion and separation of the clusters in the final model was 0.2, which indicates, according to Tkaczynski (2017) a "fair separation" between the clusters [32]. The predictor importance of the preference variables "sufficient fresh air" was 1.00; for "control of ventilation" 0.99, for "not too cold or hot" 0.81; for "sufficient daylight" 0.59:

for “control of temperature” 0.41; and for “no annoyance by noise” 0.29. The predictor importance of “thermal discomfort” was 0.17, for “discomfort from indoor air” 0.04 and for “discomfort from light” 0.03. All variables varied statistically significantly between clusters. In the last step of the validation, 70% of the sample was randomly extracted twice, only minor changes occurred (Table 4.3).

For the social comfort clusters, the procedure was similar to that of the IEQ-clusters. Initially, there were seven variables included, the final model comprised of five variables. The silhouette measure of cohesion and separation was fair: 0.4. The predictor importance of the preference variable “privacy for patient” was 1.0, “safe workplace” 0.74, “distraction by noise” 0.36, and “sufficient contact” 0.04. The predictor importance of the component called “disturbance” was 0.02. All variables varied statistically significantly between clusters. In the last step of the validation, 70% of the sample was randomly extracted twice. Again, all variables had a good predictor importance, some changes occurred (see Table 4.3).

TABLE 4.3 Comparison of predictor importance of the total sample and two random samples of 70%.

Predictor importance	Total sample	First set of 70%	Second set of 70%
IEQ			
0.68-1.00	Pref. fresh air (1.00)	Pref. no annoyance by noise (1.00)	Pref. no annoyance by noise (1.00)
	Pref. control of ventilation (0.99)		Pref. control of ventilation (0.85)
	Pref. not too cold or hot (0.81)		Pref. control of temperature (0.73)
0.34-0.67		Pref. not too cold or hot (0.67)	
		Pref. sufficient daylight (0.57)	Pref. not too cold or hot (0.64)
	Pref. sufficient daylight (0.59)	Pref. control of temperature (0.48)	Pref. fresh air (0.53)
	Pref. control of temperature (0.41)	Pref. control of ventilation (0.42)	
0.00-0.33	Pref. no annoyance by noise (0.29)	Pref. fresh air (0.27)	Pref. sufficient daylight (0.19)
	Thermal discomfort (0.17)	Thermal discomfort (0.06)	Thermal discomfort (0.05)
	Discomfort indoor air (0.04)	Light-related discomfort (0.05)	Discomfort indoor air (0.02)
	Light-related discomfort (0.03)	Discomfort indoor air (0.02)	Light-related discomfort (0.02)
Social comfort			
0.68-1.00	Pref. privacy patient (1.0)	Pref. privacy patient (1.0)	Pref. privacy patient (1.0)
	Pref. safe workplace (0.74)	Pref. safe workplace (1.0)	Pref. safe workplace (1.0)
		Pref. distraction by noise (1.0)	Pref. distraction by noise (0.99)
		Pref. contact (0.96)	Pref. contact (0.98)
0.34-0.67	Pref. distraction by noise (0.36)		
0.00-0.33	Pref. contact (0.04)		
	Disturbance (0.02)	Disturbance (0.02)	Disturbance (0.02)

Pref. = preference for

4.3.6 Profiles of the six IEQ-clusters and the three social comfort clusters

The IEQ and social comfort clusters were labelled with a code and name, as presented in Table 4.4. The names were based on general satisfaction with comfort and the most distinguishable preferences.

TABLE 4.4 Cluster codes, names, and number of respondents per cluster.

Cluster	Code	Name	N
IEQ	IC1	Uncomfortable with air, preference for control of ventilation	107
	IC2	Moderately comfortable, preference for fresh air	104
	IC3	Moderately thermally uncomfortable, preference for control of temperature	94
	IC4	Comfortable, preference for good acoustics	85
	IC5	Uncomfortable, preference for not too cold or hot temperature	81
	IC6	Moderately uncomfortable, preference for daylight	48
Social comfort	SC1	Distracted by noise, preference for no distraction	165
	SC2	Uncomfortable with walking distances, preference for privacy of patients	198
	SC3	Moderately comfortable, preference for safe workplace	175

The description of the IEQ and social comfort clusters is presented in Appendix I and tables 4.5 and 4.6. Appendix J presents the personal, work, and building-related aspects, that did not vary significantly between the clusters. The description of the IEQ and social comfort clusters was based on statistically significant differences of personal and work-related aspects, as well as comfort, health, preferences and building characteristics, based on the building inspection (see Table 4.5 and Table 4.6).

TABLE 4.5 Preferences and self-reported comfort of IEQ and social comfort clusters.

	IC1 (%)	IC2 (%)	IC3 (%)	IC4 (%)	IC5 (%)	IC6 (%)	P-value	SC1 (%)	SC2 (%)	SC3 (%)	P-value
Preferences											
Control of temperature	46.2	24.3	100	0	21.2	44.4	**<0.001**	32.3	31.1	39.1	0.231
Control of ventilation	100	0	10.4	7.4	28.2	0	**<0.001**	29.2	25.5	24.7	0.612
Not too cold or hot	0	19.6	0	41.5	100	3.7	**<0.001**	27.3	27.6	31.6	0.610
Fresh air	13.5	100	2.1	18.1	0	0	**<0.001**	26.7	29.1	26.4	0.821
Daylight	30.8	41.1	0	0	54.1	100	**<0.001**	37.3	43.9	35.1	0.192
No annoyance by noise	7.7	0.9	41.7	46.8	1.2	22.2	**<0.001**	29.8	9.2	16.1	**<0.001**
Control of the view	3.8	6.5	12.5	16.0	7.1	6.2	**0.032**	9.9	8.2	7.5	0.707
Size room	5.8	11.2	8.3	22.3	9.4	13.6	**0.011**	11.8	12.2	10.9	0.923
Cleanliness	38.5	43.9	50.0	58.5	40.0	44.4	0.073	34.8	54.6	46.6	**0.001**
Esthetics	12.5	4.7	12.5	25.5	5.9	13.6	**<0.001**	12.4	13.3	9.8	0.564
Proximity colleagues	15.5	15.0	20.8	16.1	12.9	20.0	0.789	27.3	7.1	17.6	**<0.001**
Contact with colleagues	26.2	20.6	18.8	25.8	28.2	26.3	0.736	35.2	14.1	25.0	**<0.001**
Contact with patients and colleagues	66.0	68.2	58.3	59.1	67.1	70.0	0.563	56.4	76.3	65.9	**<0.001**
Safe workplace	49.5	58.9	56.3	47.3	54.1	47.5	0.514	0.6	52.5	100	**<0.001**
No distraction by noise	23.3	28.0	25.0	33.3	24.7	16.3	0.200	58.8	0.0	24.4	**<0.001**
No visual distraction	5.8	10.3	10.4	10.8	8.2	10.0	0.838	18.8	6.6	5.7	**<0.001**
No crowding at the workplace	22.3	17.8	29.2	30.1	18.8	20.0	0.249	38.8	13.1	19.3	**<0.001**
Privacy for patient	45.6	46.7	33.3	35.5	37.6	42.5	0.396	14.5	100	0	**<0.001**

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TABLE 4.5 Preferences and self-reported comfort of IEQ and social comfort clusters.

	IC1 (%)	IC2 (%)	IC3 (%)	IC4 (%)	IC5 (%)	IC6 (%)	P-value	SC1 (%)	SC2 (%)	SC3 (%)	P-value
Dissatisfaction											
Overall comfort	22.1	10.3	25.0	14.0	14.1	14.8	0.110	23.6	10.7	14.9	**0.003**
Overall temperature	53.8	44.9	64.6	22.3	70.6	44.4	**<0.001**	45.5	57.6	51.4	0.070
Cold temperature	26.9	17.8	47.9	23.4	52.9	23.5	**<0.001**	31.3	30.3	27.8	0.771
Hot temperature	14.4	19.6	10.4	8.5	4.7	7.4	**0.016**	15.3	9.6	11.9	0.249
Large temperature variation	17.3	22.4	27.1	13.8	37.6	17.3	**0.002**	24.7	21.3	23.0	0.751
Small temperature variation	19.2	15.0	29.2	5.3	17.6	7.4	**0.001**	14.8	13.2	16.1	0.731
Draught	16.3	13.1	18.8	7.4	28.2	16.0	**0.009**	11.5	20.5	14.2	0.052
Too still air	27.9	25.2	14.6	16.0	12.9	14.8	**0.037**	24.8	16.4	18.2	0.112
Overall indoor air	61.5	52.3	47.9	24.5	49.4	39.5	**<0.001**	47.3	44.9	44.6	0.863
Dry air	66.3	57.0	58.3	38.3	58.8	58.0	**0.004**	55.8	57.4	52.6	0.637
Stuffy air	40.4	25.2	29.2	37.2	32.9	34.6	0.257	35.4	27.6	38.9	0.061
Overall light	39.4	34.6	22.9	14.9	36.5	34.6	**0.002**	26.8	34.8	32.0	0.258
Natural light	49.0	46.7	39.6	34.0	58.8	50.6	**0.026**	46.1	54.0	40.2	**0.027**
Artificial light	42.3	32.7	20.8	12.8	29.4	35.8	**<0.001**	26.1	33.3	29.9	0.322
Overall noise	33.7	27.1	35.4	33.0	25.9	28.4	0.713	41.8	25.3	27.4	**0.001**
Noise from building services	23.1	17.8	8.3	14.9	30.6	12.3	**0.008**	23.6	15.7	16.6	0.111
Noise from other people	41.3	30.8	50.0	42.6	43.5	34.6	0.187	52.7	36.9	29.7	**<0.001**
Walking distances	18.3	19.6	14.6	28.0	27.1	20.0	0.292	15.2	25.8	22.2	**0.050**
Contact with others	11.5	7.5	10.4	7.5	3.5	4.9	0.335	10.9	7.1	2.8	**0.013**
No distraction by noise	33.7	33.6	41.7	29.0	42.4	42.0	0.322	49.1	26.8	34.1	**<0.001**
No visual distraction	31.7	21.5	39.6	32.3	40.0	37.0	0.077	41.8	27.3	27.8	**0.005**
No crowded workplace	26.9	29.9	37.5	32.3	31.8	34.6	0.804	40.6	28.3	29.0	**0.023**
PEQ (12-84) mean (SD)	46.8 (12.9)	48.9 (12.0)	52.3 (13.1)	48.2 (14.2)	51.6 (12.8)	50.3 (13.8)	0.079	46.2 (13.7)	51.1 (13.3)	50.1 (12.3)	**0.002**

Note: Perceived Esthetical Quality (PEQ) was the sum of twelve questions on a scale from 1 to 7, after recoding the scale from negative to positive. 12 was regarded as low perceived quality and 84 as high[34].

TABLE 4.6 Personal, health, work, and building-related aspects of IEQ and social comfort clusters.

		IC1	IC2	IC3	IC4	IC5	IC6	P-value	SC1	SC2	SC3	P-value
Personal												
Sex (%)	Women	93.3	91.6	89.6	84.0	96.5	88.9	0.086	86.7	93.4	93.2	**0.041**
Education (%)	MSc, PhD	19.4	17.9	18.8	16.1	5.9	15.0	0.151	20.6	15.2	8.7	**0.008**
	Applied	16.5	18.9	25.0	25.8	18.8	23.8	0.509	23.0	18.3	21.4	0.522
	Intermediate	53.4	52.8	45.8	50.5	58.8	52.5	0.794	44.8	55.8	59.5	**0.019**
	Secondary	10.7	10.4	10.4	7.5	16.5	8.8	0.562	11.5	10.7	10.4	0.943
Nightshift (%)	Yes	5.8	8.5	6.3	7.4	1.2	11.1	0.195	9.8	7.1	2.3	**0.016**
ERI, mean (SD)	(3-15)/(7-35)·7/3	1.3 (0.4)	1.4 (0.5)	1.3 (0.4)	1.5 (0.5)	1.4 (0.4)	1.5 (0.5)	**0.050**	1.4 (0.5)	1.4 (0.5)	1.4 (0.5)	0.529
Sick leave (%)	None	32.7	36.4	45.8	57.4	47.1	38.8	**0.008**	48.5	40.3	40.9	0.232
Years in building, mean (SD)		9.6 (8.6)	11.5 (9.0)	11.2 (8.6)	10.4 (8.5)	10.7 (8.5)	11.2 (9.3)	0.710	11.9 (8.7)	10.9 (8.7)	9.5 (8.9)	**0.038**
Health												
Symptom index, mean (SD)	PSI14	3.0 (2.3)	2.5 (2.3)	1.7 (2.1)	1.5 (2.3)	2.7 (2.7)	2.3 (2.0)	**<0.001**	2.3 (2.4)	2.2 (2.1)	2.4 (2.4)	0.812
Symptoms (%)	Dry eyes	68.0	50.9	43.8	30.9	57.6	48.1	**<0.001**	49.4	50.8	50.3	0.966
	Watering eyes	22.3	15.9	2.1	7.4	14.1	8.8	**0.003**	10.4	13.1	15.9	0.320
	Dry throat	27.5	26.2	10.4	11.7	22.6	28.4	**0.014**	26.4	18.3	19.4	0.138
	Cough	12.6	10.4	4.2	4.3	10.6	16.0	0.096	11.6	5.6	12.5	**0.048**
	Headache	50.5	45.8	31.3	25.5	37.6	32.1	**0.003**	37.8	37.4	38.1	0.990
Work												
Number of room types (%)	>1	70.9	79.4	70.8	70.2	75.3	67.9	0.516	64.2	80.3	74.3	**0.002**
Most frequently used room type (%)	Office	39.4	32.0	27.7	29.5	26.5	24.4	0.303	38.4	17.6	35.5	**<0.001**
	Reception	11.1	16.5	25.5	18.2	31.3	24.4	**0.015**	17.0	23.4	24.9	0.186
	Consultation	39.4	45.6	44.7	44.3	31.3	43.6	0.407	38.4	49.5	32.5	**0.004**
	Treatment	10.1	5.8	2.1	8.0	10.8	7.7	0.487	6.3	9.6	7.1	0.485
Duration of stay (%)	<4 hours	32.7	53.3	29.2	40.4	41.2	32.1	**0.012**	34.5	40.9	40.3	0.406
Flexibility workplace (%)	Flexible	71.9	67.3	58.7	65.5	62.7	66.7	0.686	65.0	74.3	60.0	**0.014**
Persons in the room (%)	1 person	11.5	10.3	14.6	13.8	8.2	13.6	0.811	16.4	7.6	10.8	**0.032**
	2-4 persons	53.8	47.7	56.3	35.1	37.6	50.6	**0.031**	46.7	50.8	40.9	0.162
	>4 persons	34.6	42.1	29.2	51.1	54.1	35.8	**0.010**	37.0	41.6	48.3	0.103

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TABLE 4.6 Personal, health, work, and building-related aspects of IEQ and social comfort clusters.

		IC1	IC2	IC3	IC4	IC5	IC6	P-value	SC1	SC2	SC3	P-value
Activities with patient (%)	Diagnosis, meeting	42.7	43.9	45.8	50.0	40.0	49.4	0.745	47.3	56.6	29.7	**<0.001**
	Get patient	37.9	37.4	45.8	40.4	37.6	39.5	0.939	32.1	48.5	34.9	**0.002**
	Appointment	64.1	66.4	72.9	58.5	71.8	61.7	0.383	55.2	70.2	72.6	**0.001**
	Tele consult	38.8	42.1	33.3	50.0	27.1	38.3	0.052	38.8	47.0	32.0	**0.012**
	Physical investigation	31.1	31.8	35.4	38.3	21.2	35.8	0.212	32.7	39.4	21.7	**0.001**
	Medical treatment	40.8	51.4	39.6	39.4	38.8	46.9	0.402	37.0	52.0	40.6	**0.010**
Activities without patient (%)	Planned meeting	35.9	38.3	45.8	45.7	30.6	38.3	0.336	44.8	39.4	29.7	**0.014**
	Unplanned meeting	32.0	38.3	35.4	31.9	28.2	34.6	0.777	40.0	34.3	24.6	**0.009**
	Concentrated office work	63.1	69.2	83.3	66.0	67.1	63.0	0.194	75.2	60.1	68.6	**0.009**
	Routine office work	53.4	60.7	68.8	50.0	58.8	55.6	0.314	55.8	51.0	65.1	**0.021**
	Prepare, cleaning up	48.5	55.1	47.9	47.9	63.5	59.3	0.191	43.0	68.2	53.1	**<0.001**
Building												
Building or renovation year (%)	1980-1999	29.8	33.3	35.6	24.4	30.0	38.5	0.485	37.2	27.3	31.7	0.152
	2000-2009	36.2	38.6	15.6	26.7	25.0	28.2	**0.012**	25.6	34.4	29.9	0.607
	2010-2018	34.0	28.7	48.9	48.8	45.0	33.3	**0.020**	37.2	38.3	38.3	0.972
Outpatient size (%)	< 15.000 m^2	29.3	19.2	19.6	25.6	20.5	25.3	0.540	16.0	22.8	30.0	**0.010**
	>15.000 m^2	70.7	80.8	80.4	74.4	79.5	74.7		84.0	77.2	70.0	
Façade window* (%)	Present	74.0	78.5	81.3	88.3	66.7	80.2	**0.018**	79.4	71.7	82.3	**0.040**
Control of heating (%)	On heater	57.7	66.4	62.5	71.3	52.9	59.3	0.139	68.5	57.6	60.2	0.091
	Thermostat	22.1	15.0	18.8	22.3	23.5	24.7	0.597	16.4	22.2	23.3	0.273
	None	20.2	18.7	18.8	6.4	23.5	16.0	**0.049**	15.2	20.2	16.5	0.414
Control of view (%)	Present	74.7	81.0	87.2	71.1	75.0	75.4	0.413	68.7	81.6	73.8	**0.048**
Direction of lighting (%)	Only direct	75.7	73.3	61.7	73.9	61.9	68.8	0.215	73.9	59.6	76.9	**0.001**
Cleaning protocol of floors (%)	5x per week	79.8	82.2	72.9	84.0	83.5	87.7	0.390	81.2	88.9	76.7	**0.007**
	1x per week	20.2	17.8	27.1	16.0	16.5	12.3		18.8	11.1	23.3	

*Effort reward imbalance (ERI) was the sum of 7 questions on effort divided by the sum of 3 questions on reward multiplied by 3/7, after recoding scales from negative to positive [35]. Building-related symptoms were identified as symptoms that improved when away from the building and occurred at least 1-3 days in the last four weeks. The personal symptom index (PSI14) was the sum of the prevalence of all 14 questioned symptoms per person. *Based on self-report of staff, other building-related aspects retrieved from building inspection or hospital organizations.*

4.4 Discussion

4.4.1 Profiling of outpatient staff

The profiles of the clusters show specific characteristics regarding the perception of comfort and importance of IEQ and social comfort aspects. Additionally, there were similarities within the clusters for some personal, work-related, and building-related aspects. Furthermore, the aspects that varied between the IEQ clusters were different from the aspects that varied between the social comfort clusters, except for the importance of noise, dissatisfaction with natural light and the presence of a façade window.

Those in IC1, who were dissatisfied with indoor air aspects and preferred control of ventilation, were more likely to suffer from building-related symptoms, to have sick leave, to stay longer at their workplace, to work in enclosed rooms (no reception area) and to experience less work pressure (ERI) than most others. It should be noted that the work pressure of all clusters was high in comparison to other studies [1-3]. They were more likely to work in moderately old or renovated building (wings) than those in other clusters. All outpatient workers of IC2 preferred fresh air and were more likely to perceive hot temperature. They were moderately dissatisfied with IEQ aspects, suffering from symptoms, taking sick leave, and experiencing work pressure. The workers of IC2 were more likely to stay shorter than four hours at their workplace and to work in moderately old or renovated building(wings) than those in other clusters. IC3 was moderately thermally uncomfortable, all preferred control of temperature. They tended to be healthy, slightly suffering from symptoms, having moderate number of sick leave days, and experiencing relatively low work pressure. They were likely to stay more than four hours per day at their most frequently used room type, to work with 2-4 persons in the room, and work in new or recently renovated building (wings). Those in IC4 were most comfortable; they preferred good acoustics, esthetics, a view from the window, and an appropriate size of their workplace more than the others. They tended to experience higher work pressure, to suffer less from symptoms and to take fewer sick leave days. They worked in recently built or renovated building (wings), worked in rooms with a window to the façade and an appliance to control the heating manually. In contrast to IC4, the outpatient workers of IC5 were uncomfortable and regarded important not too cold or hot temperatures. There was a tendency of moderate work pressure and a slightly high prevalence of symptoms. They were more likely than the others to work in semi-enclosed rooms (reception areas), in rooms without windows and in rooms without appliances to control heating. IC6 was moderately comfortable, generally slightly more than IC2. They preferred daylight, tended to experience high work pressure, to suffer moderately from symptoms, and to stay longer at their workplace.

Those in SC1, who were dissatisfied with crowding and preferred absence of acoustic distraction and crowding, were more likely to be male, highly educated, working nightshifts, and working since a longer time in the building than those in SC2 and SC3. They tended to work more than the others in one room type, in private rooms, and in large buildings. All workers in SC2 preferred privacy for patients. They were overall comfortable, but less comfortable with walking distances and natural light than the outpatient workers of SC1 and SC3. They were less likely to suffer from cough, to work in one room type, to work in offices, at a fixed working place, and in private rooms. Those of SC2 tended to work more in rooms that were cleaned daily, rooms without a window, with control of the view and with indirect lighting than the others. All outpatient workers of SC3 regarded safety as important, but no one regarded privacy for patients important. They were generally moderately comfortable, but more satisfied with daylight and noise from other people than SC1 and SC2. The cluster represented the largest proportion of intermediate educated outpatient workers, without nightshifts, with fixed working places, working since a shorter time in the building and suffering from cough. A relatively large percentage worked in smaller buildings, had a workplace with a window, only direct artificial lighting, and that was cleaned once per week.

4.4.2 Comparison to other studies

The clusters reveal the complexity of associations between preferences and workplace-related aspects. For example, those in IC1, who all preferred control of ventilation, and those in IC3, who all preferred control of temperature, tended to work in rooms with 2-4 persons, while those in IC5, who preferred not too cold or hot temperature, tended to work in rooms with more than 4 persons. The outpatient workers of IC2, who all preferred fresh air, worked equally in rooms with 2-4 persons and rooms with more than 4 persons. As suggested by O'Brien and Gunay (2014), the presence of others could have affected the motivation to control the indoor environment [36]. Some give up adjusting their comfort to avoid conflicts with others, while others do not. This finding is supported by Hong et al. (2020) [21]. They determined behavioural differences in control of the indoor climate, related to personal traits, such as agreeableness or extraversion. Differences in personal traits may have contributed latently to the clusters in the present study and explain why the preference for control for only IC1, IC3 and IC5 was associated with the number of occupants in the rooms.

The clusters indicate that the preference for control of the indoor climate can also be related to the duration of stay in the more frequently used rooms. For example, those in IC1 and in IC3, who preferred control of ventilation and temperature, tended to work relatively longer at their workplace than those in IC2. Those in IC2 were more likely to prefer fresh air, than control of ventilation. In a previous study in offices, Rothe et al. (2011) found that the importance of control of the indoor environment was related to the time spent at the office [16]. However, Rothe et al. indicated that female and older occupants tend to prefer more control than males or younger occupants. The present study does not confirm these differences in demographic variables, or the differences in preferences between females and males as indicated by Mourshed and Zhao (2012) [13]. In the present study, age was similar among the clusters, while sex only varied between the social comfort clusters. As reported in [8], there were differences in age and sex related to the perception of comfort of the outpatient staff. However, the clusters indicate that the mean age and sex do not differ between the groups that vary in their preferences and perception of IEQ. The differences in sex between the social comfort clusters can be explained by differences in performed activities as reported in [8]; men were generally highly educated, and performed more concentrated work.

Furthermore, the social comfort clusters revealed relations between preferences and activities. For example, those in SC2 were more likely than others to prepare materials for patients and clean up, and they regarded cleanliness as most important. Other similarities were concentrated work with the preference for limited crowding and distraction (SC1); activities with patients and the preference for patient privacy and contact with colleagues and patients (SC2), versus contact with colleagues (SC1). These findings corroborate with the findings of the study of Van den Berg et al. (2020) on preferences in offices, clustered by activities [17]. They found that the preferences for psychosocial aspects, including noise and visual privacy, were related to activities, but preferences for thermal and lighting aspects did not vary.

The clusters suggest that relations between IEQ preferences of the outpatient workers and inspected building aspects are limited. For example, all of IC6 regarded daylight important versus none of IC3 and IC4, while the proportions of those with a window at their workplace were similar for IC1 and IC3 (80%, 81%) and larger for IC4 (88%). The preferences for daylight did not vary between SC1, SC2 and SC3, while the presence of a window did. Furthermore, all respondents in IC1 preferred control of ventilation, and no one did in IC2 and IC6, while the presence of appliances for manual control of mechanical ventilation (16%, 12%, 19%) or operable windows (64%, 63%, 51%) was similar for the clusters. Moreover, the presence of vertical slats or curtains to control the view was similar for IC1 and

IC4 (75%, 71%), while the preference to control the view varied (4%, 16%). These findings do not confirm the general notion that user preferences are associated with building-related aspects of their actual workplace.

Differences between the social comfort clusters and building aspects can be explained when work-related aspects were taken into consideration. For example, although the presence of curtains or vertical slats varied between SC1 and SC2, the preference to control the view did not vary, but the preference to secure privacy of patients varied. Vertical slats or curtains, to ensure the privacy of patients, were present in all the inspected treatment and consultation rooms. Those in SC2, who performed most activities with patients, were more likely to work in rooms with curtains and vertical slats and concerned with the patients' privacy. Furthermore, the outpatient workers in SC2 were more likely than the others to work in daily cleaned rooms. The cleaning protocols were related to room types. For example, the floors of treatment and consultation rooms were cleaned daily in every hospital, according to Dutch guidelines [28], while the cleaning protocols for the floors of reception areas and offices varied between the hospital organizations between once a week and daily. Thus, the preference for cleaning can be associated with the activities and the more frequently used room type of the outpatient workers and can be indirectly related to the cleaning protocol.

The presence of a window and manual control of heating varied between IC1, IC4 and IC5. This confirms previous studies that found positive relations between environmental control and comfort (e.g., [37]), and positive relations between comfort, health and exposure to daylight (e.g., [38-40]). However, perceived operability of the windows (64%, 64%, 56%) and perceived control of temperature (36%, 45%, 27%) did not vary between the clusters. In short, the absence of a window and of an appliance to manually control temperature are likely to be related to discomfort, but not to the perception of control of heating and window operability. These findings confirm previous studies in offices [41, 42]. Hellwig (2015) [43] suggested that the discrepancy between perceived control and available control can be caused by limited knowledge of the occupants, limited responsiveness of the building systems and the social environment.

Similar to the study of Kim and Bluyssen (2020) [24], was that those in an IEQ-cluster who were dissatisfied with indoor air aspects, were also more likely to suffer from symptoms. Also, those in a cluster that were satisfied with comfort, were less likely to suffer from symptoms. As opposed to the aforementioned study, in the present study no differences in education or gender were found between the IEQ clusters. Furthermore, there were only a few building-related aspects that varied for the IEQ-clusters in the present study, in contrast to the office study. These differences can be related to context or study design, as preferences were included only in the present study.

The clusters contribute to a better understanding of why the satisfaction with IEQ-aspects is overall low and the prevalence of building-related symptoms is overall high in hospitals. This is because most outpatient staff members perform their activities in different room types and most rooms are shared with others, while the needs of individuals seem to vary. The differences between the clusters imply that an innovative approach in current planning and design processes is required, beyond the focus on current guidelines and design of generic structures, customized for only specific places. The clusters revealed a discrepancy between the perception of comfort and preferences. For example, the preference for fresh air and control of ventilation varied between the clusters, while the perception of stuffy air did not vary between the clusters. And the proportion of those who were dissatisfied with daylight was higher in IC5, while the preference for daylight was higher in IC6. Furthermore, the limited relations between the preferences and the building aspects imply that the outpatient workers can express their needs, independently of the characteristics of the actual building, where they work. Therefore, it seems possible and important to enhance insight in the preferences of the future occupants in the design practice in order to design an environment that fits best. For example, by development of structured processes for involvement of the future occupants in programming and design phases.

4.4.3 Limitations

One of the limitations of this study is that, due to privacy and practical reasons, it was unknown for which room specifically the outpatient staff reported their comfort. This was accounted for in the study design, as the participants were asked in which department they worked, in which room type and whether they had a window to the façade and corridor to allocate their area. However, a discrepancy is possible between building aspects of the inspection and the exact location of the outpatient workers. For example, Verderber (1986) found in a study with photographs that hospital staff perceived rooms with a window smaller than 15% of the façade as windowless [44]. However, in this study, the windows to the façade of all buildings were generally larger than 15%.

Another limitation is the influence of outdoor climate, which could have affected the perception of comfort and preferences. The study was conducted from February to April, during the heating season, therefore no comparisons with other seasons allowed to assess seasonal effects on comfort or the perceived importance of building aspects. Furthermore, caution is needed for generalization of the results; as especially the social comfort clusters were related to work-related aspects and activities, generalization for office workers or hospital workers in other areas, e.g., inpatient areas, is difficult.

4.5 Conclusions

In conclusion, profiles were determined, differing in personal, work-related and a few building-related aspects. For IEQ six clusters were identified and for social aspects three clusters were identified. The clusters indicate that preferences and comfort of IEQ are related to health. Respondents in clusters IC1 and IC5 suffered most from building-related symptoms. Their preferences were related to the indoor climate; everyone in IC1 regarded control of ventilation most important, while everyone in IC5 regarded a good temperature as most important. The social comfort clusters varied in the activities of outpatient staff. Those in SC1, who preferred a quiet workplace, tended to perform more concentrated office work than those in SC2, who tended to perform activities with patients. They regarded the privacy of patients as important. As the aspects on which IEQ clusters and social comfort clusters varied were limited, it is important to study IEQ and social aspects simultaneously in future studies. In both sets of clusters, preferences had a higher importance index than comfort. The finding that the relations of both cluster sets with building-related aspects were limited to only a few building aspects was surprising. This suggests that outpatient staff members do not relate their preferences to the actual building where they are working. Although further studies are needed to elaborate on these results, the independency of preferences and the actual building might be used in design processes and future research.

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5 Building characteristics

associated with self-reported dry eyes and headaches of outpatient workers in hospital buildings.

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For consistency of the dissertation some typos are adjusted and phrases are reworded, without changing the content.

ABSTRACT

Building-related health symptoms are multifactorial; hence a comprehensive study is needed to identify associations of such symptoms with building aspects. Previous studies have identified certain building characteristics as risk factors for both dry eyes and headaches, which are among the most prevalent symptoms suffered by office workers. This study investigated associations of dry eyes and headaches with building characteristics in outpatient areas because these conditions may vary between office and hospital buildings. A survey was performed in six hospital buildings, which included administering a questionnaire to 556 outpatient workers and an inspection of the building locations, services, and 127 outpatient rooms. Multivariate regression models were produced for dry eyes and headaches. Both models were adjusted for personal and work-related aspects. The prevalence of self-reported dry eyes and headaches in outpatient areas was related to building-related aspects that affect the indoor air quality and visual quality, and to room types. In general, this study is consistent with previous office studies. However, a specific finding of this study is the association of the most frequently used room types and the presence of a window to the corridor with dry eyes and headaches.

5.1 Introduction

Since the demand on healthcare is growing, driven by an ageing population, risks for pandemics, and an increasing prevalence of chronic diseases the pressure on hospital staff is increasing [1]. To better understand relations between comfort and health of hospital staff and the physical environment is important because comfort and health of hospital staff may be affected negatively by the physical environment [2, 3]. Furthermore, the hospital workers' satisfaction, production and wellbeing can be supported by the physical environment [4-7], while satisfaction of staff may be beneficial for patients as well [8-11]. Among health problems, that can be influenced by building characteristics, are building-related symptoms. Building-related symptoms have been identified as a societal problem that may affect the occupants' physiological and psychological health negatively [12]. Other adverse effects of building-related symptoms can be sick-leave [13, 14] or a decrease in productivity [15].

Building-related symptoms are symptoms of an unclear aetiology, related to the eyes, nose, throat, skin, headache, and lethargy [16]. Self-reported health symptoms are defined as building-related symptoms that occurred when the occupants are in the building, and improved when away from the building [16].The symptoms can be identified by a standardized questionnaire, administered to building occupants [17].

The prevalence and causes of building-related symptoms of office workers are mostly investigated, but also of occupants in schools, homes, and hospitals [18]. Rashid and Zimring (2008) suggested that comfort and health may vary between occupants in offices, hospitals, and hospital departments (e.g., inpatient wards, intensive care units, operating rooms), due to differences in performed activities, duration of stay [2]. From a review on field studies in hospitals was concluded that hospital staff was generally less satisfied with comfort than patients, and outpatient areas were understudied as compared to other departments [19]. Previous studies indicate a higher prevalence of self-reported health symptoms in hospitals than in offices [20-22]. Dry eyes and headaches are among the most reported building-related symptoms.

For example, in OFFICAIR, a study with 7446 office workers in Europe, almost one third of the office workers suffered from dry eyes or headaches, which were the most prevalent symptoms [23]. In a study with 556 outpatient workers of six hospitals in the Netherlands, half of the outpatient workers suffered from dry eyes, and more than one third from headaches [21]. Also, in this study dry eyes and headaches occurred more frequently than other mucosal, skin, or general symptoms. While previous studies on building-related symptoms have been performed in hospitals

[24-28], analysis of building-related aspects with dry eyes or headaches was limited. Studies on associations of headaches or dry eyes with building-related aspects were mainly performed in office buildings [29-33].

Dry eyes and headaches are common health complaints [34, 35], that both have a multifactorial character, affected by genes, personal, work, and environmental aspects [36, 37]. With regards to specifically building-related dry eyes and headaches, previous studies indicated that also building-related symptoms can be influenced by personal and work-related aspects [12, 16]. For example, the perception of building-related symptoms can be influenced by gender, smoking, psychological state, and work pressure of the occupants. Therefore, to identify possible causes of building-related symptoms, Bluyssen [38] has recommended studying comfort and health integrally, including personal and work-related aspects as well as building-related aspects.

Because of the high prevalence of dry eyes and headaches found in the outpatient areas of six hospitals [21], the present study aims to investigate integrally possible building-related risk factors (building characteristics) for having headaches and dry eyes symptoms in those buildings. Therefore, a broad range of building-related aspects, as well as personal and work-related aspects were included.

5.2 Method

5.2.1 Study design

This study is part of a survey conducted in hospitals in the Netherlands. The survey comprised of a questionnaire regarding the health and comfort of outpatient staff and of a building inspection with the use of checklists. Detailed information about the design of the questionnaire, selection of the population and buildings, and the procedure of the survey are reported in Eijkelenboom et al. (2020), and therefore summarized [21]. The study was performed in the spring of 2019 at six locations of three hospital organizations (two locations per organization). Simultaneously to the administration of the questionnaire, the locations were inspected systematically by three researchers. The questionnaire was tested in a pilot study with outpatient staff in a general hospital in the winter of 2018.

The Ethics committee of Delft University of Technology approved the study on 5 October 2018. Data security was assessed by a data manager. To respect privacy of the participants, measures were taken for protection of contact information, safe data storage and withholding of personal information. The workers had to give their informed consent for participation. Only the participants who agreed to submit at the end of the questionnaire were included in the analysis.

5.2.2 Survey

The questionnaire was based on OFFICAIR [23] and new questions. OFFICAIR was developed to gain more insights into comfort complaints and building-related symptoms of occupants in European offices, with respect to personal, work and health-related aspects. The new questions were specifically developed for this study because no standardized questionnaire was found. To address building-related aspects from the building inspection to the outpatient workers, the questionnaire comprised questions about which location they mostly worked at, which department, which room type they used most frequently, and the presence of a window to the façade and to the corridor. Furthermore, the questionnaire comprised of questions on demographics, psychological aspects (e.g., positive affect (PA) and negative affect (NA))[39], health (e.g., migraine diagnosed by a doctor), work-related aspects (e.g., effort reward imbalance (ERI), overcommitment (OV))[40], comfort, and building-related symptoms (e.g., dry eyes, headaches). The prevalence of building-related symptoms was defined as having occurred in the last 4 weeks, at least once a week, and that had improved when away from the building.

For an integral inventory of the building-related aspects, a layout checklist, cleaning checklist, building checklist and room checklist were composed. The cleaning checklist was based on national regulations for hospital cleaning [41]. The building checklist and room checklists were based on OFFICAIR and adapted with specific characteristics of outpatient areas, based on visits of hospital buildings, during the preparatory phase. The following aspects, that may affect the perception of comfort or health, were included: possible outdoor pollution sources, façade characteristics, characteristics and maintenance of air handling units, the characteristics of different rooms, (e.g., finishing materials, direction of lighting, control of heater and lighting, height windowsill), layout characteristics, (e.g., dimensions of building wings, size areas) and the cleaning frequency of surfaces and amenities.

5.2.3 Procedure

The questionnaire was digitally distributed by the hospital organizations to all outpatient workers. Participation was voluntary. To systematically inspect aspects that could vary due to the room type, the presence of a façade window or renovation periods, rooms were selected and marked on layout drawings, in advance of the building inspection. Facility managers provided explanations of the HVAC-systems in each building, during the building inspection. Observations and oral information were documented on the checklists, drawings, and with images. To respect privacy of patients and hospital staff, no persons or patient information were included in the images. The cleaning protocol was provided by the hospital organizations. The data of the building inspection were manually put into a database. The sites and building services of six locations and 127 rooms were inspected.

5.2.4 Data analysis

Relations between building-related aspects and scale levels, such as organization, location, building wing, room type, presence of a façade window, were identified with crosstabs. Building-related aspects were assigned to the respondents, when the aspects identified on different scale levels were consistent.

For error analysis the data of the questionnaire were checked systematically. Missing value analysis was performed with pre-validated scales, such as PA, NA, ERI and OV, and all items, except for the embedded questions. Descriptive statistics were used to summarize the demographics of the hospital staff. Multivariate logistic regression was used to assess the risk of having headaches and dry eyes related to building-related aspects. Headaches and dry eyes were analysed separately.

First univariate analysis was performed for the building-related aspects, unadjusted and adjusted for confounding variables. Identification of confounding variables for dry eyes was based on literature. Because confounders, additional to the variables from literature, did not affect the inclusion of building-related aspects in the final model, no additional confounders were included. The value of categorical variables that was most likely to differ was used as the baseline value. Sex, age, education, smoking status, alcohol consumption, and psycho-social work aspects were included for dry eyes. Due to limited literature on headaches in relation to building-related aspects, associations with building, personal and work-related aspects were adjusted for sex, age, and migraine.

Subsequently, aspects associated with a P-value of less than 0.200 [42], completeness of more than 80%, and variance of more than 10% for dichotomous variables [43] were used for the final models. The final model for dry eyes was based on three steps: constant only, confounding variables and building-related aspects. The final model for headaches was similarly produced, except for inclusion of additional personal and work-related aspects in the last step. In the last step the variables with a P-value larger than 0.20 were iteratively removed. Then, to assess the prediction of dry eyes and headaches the odds ratio (OR) and 95% confidence interval (CI 95) were calculated. Statistical significance of the odds ratio was checked with the Wald Statistic. Associations were assessed statistically significant if the P-value was less than 0.05. To check the reliability, the number of events per variable (EPV) was calculated as degrees of freedom divided by the lowest number of outpatient staff per event, thus for “no headaches” and “no dry eyes.” Values below 10 were considered to decrease the validity of the model [44]. Multicollinearity was checked with the Variance Inflation Factor (VIF); values below 5 were considered to have low multicollinearity. The linearity of the continuous variables was checked with interactions with the log transformation of each continuous variable in the final multivariate logistic regression models.

Goodness of fit was checked with the Hosmer and Lemeshow test (P-value >0.05). To check whether there were cases that fitted poorly or had a dominant influence on the model, the following values were inspected: the values of Cook’s distance, standardized residuals (SR), the leverage and difference between the constant for all cases and one case excluded (DF Beta). Cook’s distance <1, DF Beta <1, less than 5% of SR > ± 1.96 and less than 1% > ± 2.58 and leverage smaller than three times the average leverage were considered as good fit [45]. The average leverage was calculated according to the formula:

$$\left(k + \frac{1}{N}\right) \cdot 3$$

in which k is the number of predictors and N the sample size. For analysis IBM SPSS Statistics, version 25 was used.

5.3 Results

5.3.1 General characteristics of the outpatient workers

560 outpatient workers completed the questionnaire; four were excluded because they did not work at a location or department that was part of the survey. Missing values were scattered among the questions. No variables and constructs, such as ERI or NA, had more than 5% missing values.

The personal aspects of the outpatient workers are presented in Table 5.1. The majority (91%) was female, the mean age was 47 years; the youngest was 19 years, the oldest 67. More than half of the outpatient workers (53%) had an intermediate education. The mean NA (scale 5 to 25) was 8. Low values of NA are considered positive. The average ERI was 1.4. Values larger than 1.0 are considered as a larger effort than reward. The average OV (scale 6-24) was 17, with values larger than 14 considered as overcommitment. Half of the outpatient staff (50%) had dry eyes; the prevalence of headaches was 38%.

TABLE 5.1 General characteristics of the outpatient staff.

Item	Category	n (%)/ mean ± SD
Sex	Female	506 (91.0)
	Male	50 (9.0)
Age		46.6 ± 11.6
Education	Academic	83 (15.0)
	Applied	113 (20.5)
	Intermediate	294 (53.3)
	Secondary	62 (11.2)
Negative affect (NA)		8.0 ± 2.46
Smoking	Current	20 (3.6)
	Previous	173 (31.3)
	Never	359 (65.0)
Alcohol consumption	Yes	382 (69.2)
	No	170 (30.8)
Coffee consumption	>5 cups per day	61 (11.3)
	≤5 cups per day	481 (88.7)
Suffering from Migraine	Yes	57 (10.3)
	No	496 (89.7)
Effort Reward Imbalance (ERI)		1.4 ± 0.46
Overcommitment (OV)		17 ± 3.40
Dry eyes	Yes	278 (50.3)
	No	275 (49.7)
Headaches	Yes	210 (37.8)
	No	345 (62.2)

5.3.2 General characteristics of the buildings

The survey was performed in outpatient areas at six locations of three organizations (two locations per organization). The buildings were built between 1980 and 2013. All buildings, except the building from 2013; consisted of parts that had been renovated and extension parts; three buildings had a temporary wing. Three locations were within 100 m of a highway and 1.5 km of industry, one location was near a forest. The main buildings of each organization had an outpatient area larger than 15.000 m^2. Rooms with and without a window to the façade and a window to the corridor were present at all locations. All buildings had a balanced mechanical ventilation system, with air humidified by steam. One building had wings with a climate façade. All buildings had external solar shading. Rooms were heated with

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radiators, floor heating, or heated air, depending on the building (wing) and presence of a window to the façade. Blinds or curtains were present in all consultation and treatment rooms to control the view, while control of the view varied between building wings at receptions and in offices. All rooms had acoustic ceiling panels, the main floor covering was hard, with some exceptions for carpet at offices. The walls were mostly painted, while in some building wings the walls had a vinyl finishing. The cleaning schedules varied between the hospital organizations and room types.

5.3.3 Relations between building-related aspects and self-reported dry eyes

Table 5.2 shows the associations of building-related aspects and self-reported dry eyes from the univariate analysis (fourth and fifth column) and after adjustment for the confounding variables (sixth and seventh column). The first column shows the building aspects with a P-value larger than 0.200, because these were relevant for inclusion in the multivariate analysis. The second column shows the number of participants with no dry eyes compared to the total number of participants with no dry eyes per building-related aspect. For example, of those who worked in a hospital building nearby a forest, 78 participants (n) had no dry eyes, while of all participants 275 (N) had no dry eyes. The third column shows similarly the number of participants with dry eyes.

Dry eyes symptoms were associated (P-value >0.05) with location (forest nearby), potential outdoor pollutants (attached parking garage), layout (depth of building wings, most frequently used room types, number of persons in the room), building services (frequency of filter replacement, presence of a thermal wheel for heat recovery), visual aspects (the presence of a façade window and window to the corridor, the contrast of a window frame with the wall, control of the view), thermal aspects (heating by air, manual control of heating, climate façade), potential indoor pollutants (the presence of plants and curtains for the windows or curtains for the dressing area) and the cleaning protocols (cleaning frequency of walls and ventilation grills in the room). The strongest associations (P-value <0.001, OR >2.00) were found for control of heating versus no control and the presence of window to the façade and corridor, compared to rooms without a window.

TABLE 5.2 Associations between dry eyes and building-related aspects.

	No dry eyes	Dry eyes	Unadjusted		Adjusted	
	n/N	n/N	P-value	OR (CI 95%)	P-value	OR (CI 95%)
Outdoor pollution sources						
Forest nearby: yes vs. no	78/275	109/278	**0.007**	1.63 (1.14, 2.33)	**0.004**	1.75 (1.20, 2.55)
Nearby highway (<100m): yes vs. no	127/266	118/271	0.329	0.84 (0.60, 1.19)	0.139	0.76 (0.53, 1.09)
Nearby industry (<1.5 km): yes vs. no	127/266	118/271	0.329	0.84 (0.60, 1.19)	0.139	0.76 (0.53, 1.09)
Attached parking: yes vs. no	94/275	72/278	**0.034**	0.67 (0.47, 0.97)	**0.042**	0.67 (0.45, 0.99)
Building services						
Height intake ventilation: ground floor vs. 0<10 m	31/266	21/271	0.574	1.20 (0.63, 2.30)	0.215	1.56 (0.77, 3.15)
Height intake ventilatiion: ground floor vs. >10 m	159/266	188/271	0.066	0.69 (0.46, 1.03)	0.083	0.69 (0.45, 1.05)
Rotating heat exchanger: yes vs. no	148/258	122/270	**0.005**	1.63 (1.16, 2.30)	**0.005**	1.70 (1.18, 2.45)
Frequency replacement filters: < 2x vs. 2x per year	78/260	109/271	**0.014**	0.64 (0.45, 0.91)	**0.006**	0.58 (0.40, 0.86)
Layout-related aspects						
Dimensions (depth) building wing: >20 m vs. 12 to 15 m	71/263	56/270	**0.020**	1.67 (1.09, 2.57)	**0.016**	1.76 (1.11, 2.77)
Dimensions (depth) building wing: > 20 m vs. 15 to 20 m	85/263	73/270	**0.036**	1.53 (1.03, 2.29)	**0.067**	1.49 (0.97, 2.28)
Most frequently used room type: office vs. reception	57/264	58/267	0.246	1.33 (0.82, 2.15)	0.162	1.45 (0.86, 2.43)
Most frequently used room type: office vs. consultation room	120/264	93/267	**0.008**	1.75 (1.15, 2.64)	**0.027**	1.67 (1.06, 2.65)
Most frequently used room type: office vs. treatment room	19/264	24/267	0.843	1.07 (0.54, 2.11)	0.721	1.14 (0.56, 2.31)
Number of persons in the room: 1 vs. 2-4	122/274	135/278	**0.002**	0.40 (0.22, 0.72)	**0.010**	0.44 (0.23, 0.82)
Number of persons in the room: 1 vs. >4	109/274	124/278	**0.002**	0.39 (0.21, 0.71)	**0.010**	0.43 (0.23, 0.82)

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TABLE 5.2 Associations between dry eyes and building-related aspects.

	No dry eyes	Dry eyes	Unadjusted		Adjusted	
Façade						
Presence window: no vs. façade and corridor	149/273	124/278	**<0.001**	2.89 (1.74, 4.81)	**0.001**	2.48 (1.45, 4.26)
Presence window: no vs. façade	82/273	72/278	**<0.001**	2.74 (1.58, 4.75)	**0.022**	1.99 (1.11, 3.59)
Presence window: no vs. corridor	15/273	17/278	0.074	2.12 (0.93, 4.86)	0.181	1.82 (0.76, 4.35)
Visual aspects						
Contrast window frame/wall: yes vs. no	82/232	93/196	**0.011**	0.60 (0.41, 0.89)	**0.009**	0.59 (0.39, 0.88)
Control view: no vs. yes	38/230	60/196	**0.001**	2.23 (1.40, 3.54)	**0.003**	2.11 (1.29, 3.47)
Thermal aspects						
Heating: air vs. radiator	171/258	150/265	**0.006**	1.74 (1.18, 2.57)	0.064	1.48 (0.98, 2.23)
Heating: air vs. floor	26/258	22/265	0.077	1.80 (0.94, 3.46)	**0.041**	2.09 (1.03, 4.23)
Control heating: automatic vs. manual	5/199	25/191	**<0.001**	5.84 (2.19, 15.61)	**0.001**	6.08 (2.01, 18.35)
Openable window (technically): no vs. yes	54/230	36/195	0.208	0.74 (0.46, 1.18)	0.153	0.69 (0.41, 1.15)
Climate facade: no vs. yes	251/275	263/278	0.129	1.68 (0.86, 3.27)	**0.032**	2.29 (1.07, 4.89)
Acoustic aspects						
Presence dropseal: no vs. yes	130/199	115/192	0.267	0.79 (0.53, 1.20)	0.127	0.71 (0.45, 1.10)
Indoor air pollutants						
Presence plants: yes vs. no	33/201	60/217	**0.006**	1.95 (1.21, 3.14)	**0.011**	2.01 (1.17, 3.44)
Presence curtains (window/ dress): yes vs. no	100/272	136/276	**0.003**	0.60 (0.43, 0.84)	**0.023**	0.65 (0.45, 0.94)
Cleaning schedule						
Floors: 1x vs. 5x per week	220/275	235/278	0.164	1.37 (0.88, 2.12)	0.166	1.39 (0.87, 2.22)
Walls: < 1x vs. 1x per week	95/275	72/278	**0.027**	0.66 (0.46, 0.96)	**0.031**	0.65 (0.44, 0.96)
Ventilation grills: < 1x per month vs. 1x per month	94/275	72/278	**0.034**	1.49 (1.03, 2.14)	**0.042**	1.50 (1.02, 2.21)

Note: vs.=versus, P-values in bold <0.05, OR is odds ratio, CI 95% is confidence interval at 95%. ''1x per week'' represents ''one time per week.'' The number of participants (N) may vary, due to incompleteness of information. Adjusted P-values, OR and CI 95% are adjusted with logistic regression for sex, age (baseline <35), education (baseline academic), smoking status (baseline current), alcohol consumption, ERI ↑log, over commitment ↑1. Variables with an adjusted P-value < 0.200 are shown.

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Table 5.3 shows the multivariate logistic regression model, after adjustment for the personal variables and building characteristics. Dry eyes symptoms were positively related to working in an office compared to working in a consultation room (OR 1.96, CI 95: 1.19-3.24). An increased risk for dry eyes was found for the presence of a rotating heat exchanger for heat recovery in the air handling unit (OR 1.65, (CI 95: 1.09-2.49) and the absence of a façade window compared to rooms with a window to the façade and corridor (OR 3.42, CI 95: 1.83-6.40), with only a window to the façade (OR 2.55, CI 95: 1.31-4.95) and with only a window to the corridor (OR 2.84, CI 95: 1.10-7.34). Dry eyes symptoms were negatively associated with working mainly solely in a room compared to the presence of two to four persons in the room (OR 0.46, CI 95: 0.23-0.93) and more than four persons in the room (OR 0.42, CI 95: 0.21-0.85). There was a tendency of a risk for dry eyes (P-value <0.20) with working in an office compared to a treatment room (OR 1.92, CI 95: 0.86-4.31), and the cleaning frequency of ventilation grills for air supply and exhaust in the rooms of (OR 1.50, CI 95: 0.97-2.31).

TABLE 5.3 Multivariate logistic regression model of associations between dry eyes and building-related aspects.

	P-value	OR (CI 95%)
Building-related aspects		
Rotating heat exchanger: yes vs. no	**0.018**	1.65 (1.09, 2.49)
Most frequently used room type: office vs. reception	0.308	1.34 (0.76, 2.38)
Most frequently used room type: office vs. consultation room	**0.008**	1.96 (1.19, 3.24)
Most frequently used room type: office vs. treatment room	0.113	1.92 (0.86, 4.31)
Number of persons in room: 1 vs. 2-4	**0.031**	0.46 (0.23, 0.93)
Number of persons in room: 1 vs. >4	**0.016**	0.42 (0.21, 0.85)
Presence window: no window vs. façade and corridor	**<0.001**	3.42 (1.83, 6.40)
Presence window: no window vs. façade	**0.006**	2.55 (1.31, 4.95)
Presence window: no window vs. corridor	**0.031**	2.84 (1.10, 7.34)
Cleaning protocol ventilation grills: <1x per month vs. 1x per month	0.068	1.50 (0.97, 2.31)

Note: vs.=versus, P-values in bold <0.05, OR is odds ratio, CI 95% is confidence interval at 95%.''1x per week'' represents ''one time per week.'' Adjusted for sex, age (baseline <35), education (baseline academic), smoking status (baseline current), alcohol consumption (baseline yes), ERI ↑log, Over commitment ↑1. N=476, Events per variable=11. Variance Inflation Factor between 1.03 and 1.13. Standardized residuals: 2% > ±1.96, 0.3% > ± 2.58, 0% >3.0. For all cases: Cook's distance <1, DF Beta for the constant <1, Leverage < 0.139.

5.3.4 Relations between building-related aspects and headaches

Table 5.4 shows the associations of personal, work and building-related aspects with self-reported headaches from the univariate analysis and after adjustment. Headaches, adjusted for sex, age and migraine, were associated (P-value <0.05) with personal aspects (education, mood while completing the questionnaire and negative affect) and work-related aspects (ERI, work satisfaction and working in nightshifts). There were associations of headaches with layout (most frequently used room type), visual aspects (presence of a window to the façade and corridor, presence of a window to the facade, control of the view), thermal aspects (the presence of a radiator, individual control of heating). The strongest association (P-value <0.001, OR>2.0) was the presence of a window to the façade and corridor (in comparison to no window).

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TABLE 5.4 Associations of personal, work, and building-related aspects with headaches.

	No headache	Headache	Unadjusted		Adjusted	
	n/N	n/N	P-value	OR (CI 95%)	P-value	OR (CI 95%)
Personal						
Education: academic vs. applied	68/345	45/206	**0.025**	0.49 (0.26, 0.92)	0.066	0.54 (0.28, 1.04)
Education: academic vs. intermediate	171/345	123/206	**0.005**	0.45 (0.26, 0.78)	**0.025**	0.50 (0.27, 0.92)
Education: academic vs. secondary	44/345	18/206	0.532	0.79 (0.37, 1.66)	0.549	0.78 (0.35, 1.74)
Actual mood: negative vs. neutral	28/330	20/204	0.437	1.33 (0.65, 2.74)	0.390	1.39 (0.66, 2.92)
Actual mood: negative vs. positive	261/330	145/204	**0.029**	1.71 (1.06, 2.78)	**0.021**	1.80 (1.09, 2.94)
Recent negative stress: yes vs. no	121/344	85/210	0.211	1.25 (0.88, 1.78)	0.170	1.29 (0.90, 1.86)
Negative affect (NA): ↑1 (scale 5-25)			**<0.001**	0.88 (0.82, 0.95)	**0.002**	0.89 (0.83, 0.96)
Daily coffee intake: ≥5 cups vs <5	45/333	16/209	**0.038**	0.53 (0.29, 0.97)	0.100	0.60 (0.33, 1.10)
Work						
Effort Reward Imbalance (ERI): ↑log			**0.004**	2.28 (1.31, 3.98)	**0.019**	1.99 (1.12, 3.54)
Over commitment (OV): ↑1 (scale 6-24)			0.073	1.05 (1.00, 1.10)	0.064	1.05 (1.00, 1.11)
Satisfied with work: dissatisfied vs. satisfied	18/344	26/209	**0.003**	2.57 (1.37, 4.82)	**0.007**	2.45 (1.27, 4.71)
Nightshift: yes vs. no	29/344	6/209	**0.013**	0.32 (0.13, 0.79)	**0.035**	0.37 (0.14, 0.93)
Building-related aspects						
Layout-related aspects						
Size outpatient area: >15.000 m^2 vs. <15.000 m^2	253/333	163/204	0.291	1.26 (0.82, 1.92)	0.187	1.34 (0.87, 2.08)
Level work: ground floor vs. floor 1-4	165/324	118/200	0.072	1.39 (0.97, 1.98)	0.088	1.37 (0.95, 1.98)
Most frequently used room type: office vs. reception	73/330	42/202	0.160	1.42 (0.87, 2.32)	0.185	1.41 (0.85, 2.34)
Most frequently used room type: office vs. consultation room	145/330	69/202	**0.012**	1.72 (1.13, 2.63)	**0.026**	1.66 (1.06, 2.59)
Most frequently used room type: office vs. treatment room	24/330	19/202	0.924	1.03 (0.53, 2.04)	0.867	0.94 (0.47, 1.88)
Number of persons in room: 1 vs. 2-4	159/344	99/210	0.109	0.61 (0.33, 1.12)	0.136	0.62 (0.33, 1.16)

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TABLE 5.4 Associations of personal, work, and building-related aspects with headaches.

	No headache	Headache	Unadjusted		Adjusted	
Number of persons in room: 1 vs. >4	140/344	94/210	0.067	0.56 (0.03, 1.04)	0.115	0.60 (0.32, 1.13)
Façade						
Presence window: no vs. façade and corridor	187/344	86/209	**<0.001**	2.64 (1.63, 4.27)	**<0.001**	2.96 (1.80, 4.86)
Presence window: no vs. façade	96/344	59/209	**0.010**	1.98 (1.17, 3.33)	**0.015**	1.94 (1.14, 3.32)
Presence window: no vs. corridor	42/344	51/209	0.168	1.78 (0.79, 4.01)	0.148	1.86 (0.80, 4.32)
Visual aspects						
Control view: no vs. yes	53/283	45/144	**0.004**	1.97 (1.24, 3.13)	**0.016**	1.79 (1.11, 2.89)
Control lighting: automatic vs. manual	77/325	38/202	0.188	0.75 (0.48, 1.15)	0.099	0.68 (0.44, 1.07)
Thermal aspects						
Heating: air vs. radiator	212/326	109/199	**0.007**	1.71 (1.16, 2.53)	**0.005**	1.77 (1.18, 2.64)
Heating: air vs. floor	31/326	17/199	0.167	1.60 (0.82, 3.13)	0.114	1.74 (0.88, 3.46)
Control heating: automatic vs. manual	12/247	19/144	**0.005**	2.98 (1.40, 6.33)	**0.004**	3.09 (1.44, 6.63)
Indoor air pollutants						
Presence curtains (window/ dress): yes vs. no	205/342	108/208	0.066	0.72 (0.51, 1.02)	0.173	0.78 (0.54, 1.12)

Note: vs. = versus, P-values in bold <0.05, OR is odds ratio, CI 95% is confidence interval at 95%. Adjusted P-values, OR and CI 95% are adjusted for sex, age (baseline <35), suffering from Migraine, that was diagnosed by a doctor. Variables with an adjusted P-value < 0.200 are shown.

Table 5.5 shows the multivariate logistic regression model of associations between headaches and personal, work and building-related aspects. Concerning work-related aspects, ERI (OR 2.18, CI 95: 1.14-4.14) and OV (OR 1.07, CI 95: 1.01-1.14) were risk factors for headaches. The risk for headaches was higher for working in an office than working in a consultation room (OR 2.03, CI 95: 1.24-3.33). Also, the absence of a window was a risk factor in comparison to the presence of a window to the façade and corridor (OR 2.80, CI 95: 1.56-5.03). There was a tendency to increase the risk for headaches with the absence of a window compared to the presence of solely a façade window or corridor window. With regard to personal aspects, negative affect tended to increase the risk for headaches and coffee consumption tended to decrease the risk for headaches (P-value<0.200). Also, the presence of others in the room tended to increase the risk for headaches.

TABLE 5.5 Multivariate logistic regression model of associations between headaches and personal, work and building-related aspects.

	P-value	OR (CI 95%)
Personal		
Negative affect ↑1	0.137	0.94 (0.86, 1.02)
Daily coffee consumption: ≥5 cups vs <5	0.075	0.55 (0.28, 1.06)
Work		
Effort-reward imbalance: ↑log	**0.018**	2.18 (1.14, 4.14)
Over-commitment: ↑1	**0.031**	1.07 (1.01, 1.14)
Building-related aspects		
Most frequently used room type: office vs. reception	0.255	1.39 (0.79, 2.44)
Most frequently used room type: office vs. consultation room	**0.005**	2.03 (1.24, 3.33)
Most frequently used room type: office vs. treatment room	0.305	1.49 (0.70, 3.21)
Persons in room: 1 vs. 2-4	0.106	0.55 (0.27, 1.14)
Persons in room: 1 vs. >4	0.124	0.57 (0.27, 1.17)
Window type: no window vs. facade and corridor window	**0.001**	2.80 (1.56, 5.03)
Window type: no window vs. facade window	0.052	1.85 (1.00, 3.44)
Window type: no window vs. corridor window	0.141	2.03 (0.79, 5.19)

vs.=versus, P-values in bold <0.05, OR is odds ratio, CI 95% is confidence interval at 95%. Adjusted for sex, age (baseline <35), suffering from Migraine (diagnosed by a doctor). N=486, Events per variable=12, Variance Inflation Factor between 1.03 and 1.23. Standardized residuals: 3% > ±1.96, 1% > ± 2.58, 1 case >3.0. For all cases: Cook's distance <1, DF Beta for the constant <1, Leverage < 0.105.

5.4 Discussion

The data allow a first assessment of associations between building-related aspects and dry eyes and headaches of outpatient workers in the Netherlands, accounting for an extensive range of building, personal and work-related aspects. As can been seen in Figure 5.1, the study identified building-related aspects that were a risk for dry eyes and headaches, building-related aspects that were a risk for dry eyes and tended to be a risk for headaches, and building-related aspects that were or tended to be only associated with dry eyes. No building-related aspects were indicated that were only associated with headaches. The building-related aspects that were associated with dry eyes and headaches were work in an office versus consultation room and the absence of windows to the façade and corridor. Additionally, the occurrence of dry eyes was associated with the presence of a rotating heat exchanger, absence of windows to the corridor, absence of windows to the façade and number of persons in the room. The last three tended to be associated with headaches. Dry eyes tended to be associated with the cleaning frequency of the ventilation grills and work in an office versus treatment room. These findings suggest that building-related aspects are a risk factor for the perception of dry eyes and headaches in outpatient areas of hospitals.

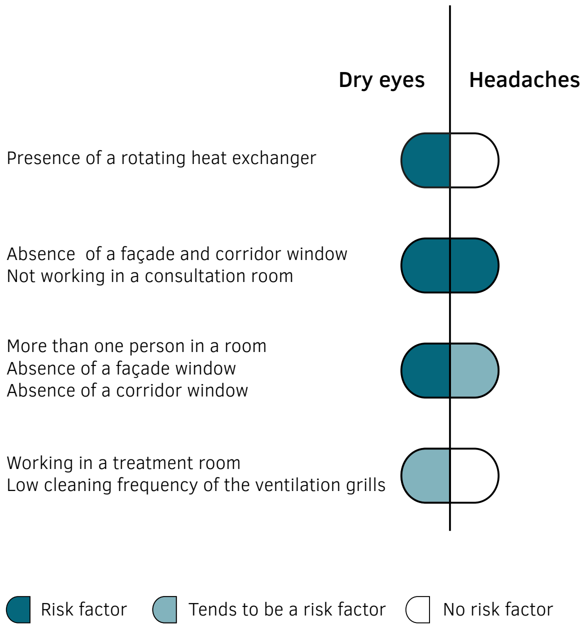

FIG. 5.1 Risk factors for dry eyes and headaches.

5.4.1 Comparison with previous studies

Previous studies identified building characteristics as risk factors for dry eyes and headaches of office workers (see Table 5.6 for detailed information). All studies were cross-sectional, except the Boston Study [30] which was an epidemiological study. All studies used multivariate regression models, adjusted for personal confounding variables. However, the seasons and geographic locations varied. Also, the studied building characteristics varied between the studies. For example, in the US EPA study [31] maintenance and design of the HVAC (Heating Ventilating and Air Conditioning) systems were studied. The Japan Office Study [32] included maintenance of the HVAC systems and some general building aspects, such as floor area, number of stories, construction year [46], while the CHBS study [29] included ventilation type, general building aspects and measurements of indoor environmental parameters. The Boston study [30] included self-reported workplace characteristics and measurements of dust, while the OFFICAIR study [33] included a broad range of building-related aspects, such as maintenance and characteristics of HVAC-systems, finishing materials, cleaning protocol, number of floors and workers. It should be noted that in the US EPA study [31], Boston Study [30] and Japan Office Study [32] dry, itchy, irritated, or dry eyes were asked as one symptom, while in the OFFICAIR study [33] and the present study watering, itchy eyes was a separate symptom. Because of the differences in the definition of dry eyes, seasons, geographics and inspected building characteristics, comparison is not straightforward.

TABLE 5.6 Characteristics of previous studies on building-related dry eyes and headaches.

	CHBS	US EPA	Boston Study	OFFICAIR	Japan Office Study
Studied symptoms	Headaches	Dry eyes, Headaches	Dry eyes	Dry eyes	Dry eyes
Year study	1990	1994-1998	1997-1998	2011-2012	2012
Location	US	US	US	Europe	Japan
Season	Summer	No information	All seasons	Winter	Winter
Study type	Cross-sectional	Cross-sectional	Epidemiologic	Cross-sectional	Cross-sectional
Study method					
Questionnaire	NIOSH	BASE	BASE	OFFICAIR	BASE, MM040
Building inspection	General	HVAC	General	Broad range	HVAC and general
Measurement	Indoor environmental parameters	Indoor environmental parameters	Indoor environmental parameters		

Only symptoms similar to the present study are reported as studied symptoms, in US EPA, Boston Study and Japan Office Study itchy and irritated eyes are included, building inspection in Japan Office study self-reported by building managers

The association of dry eyes and the presence of a rotating heat exchanger may be explained by exposure to potential pollutants in the indoor air. Previous studies found that pollutants in the exhausted air may be passed to the supplied air through leakage, adsorption, and desorption in a rotating heat exchanger [47]. For example, an experimental study in an auditorium and laboratory, indicated that some common building-related VOC's that were injected in the extract duct of the ventilated place, were recycled from the exhaust to the supplied air through adsorption and desorption in the rotating wheel exchanger [48].

Associations of dry eyes with HVAC aspects were also found in the OFFICAIR study [33] and the US EPA study [31]. The specific building-related aspects that remained in the multivariate analysis of previous studies (respectively the presence of portable humidifiers, the maintenance of AHU's and cleaning frequency of cooling coils) were different from each other and from the present study. This can be related to differences in study design, and variation of building-related aspects with previous studies. For example, in the present study no portable humidifiers were found during the building inspection, while all buildings were provided of steam humidifiers, with water heated above 100°C, to disinfect microorganisms. However, in line with previous studies, impurities that remain in the indoor air, due to characteristics of HVAC systems, may be a risk factor for dry eyes in outpatient areas.

The negative associations of dry eyes and headaches with the presence of a façade window can be multifactorial. It might be related to control of fresh air supply and possible removal of contaminants in the indoor air through natural ventilation in rooms adjacent to the façade, with a technically openable window. In the present study 81% of those working most frequently in a room with a façade window, could 'technically' open the window. In the OFFICAIR study [33] the presence of technically openable windows was also negatively associated with dry eyes. The occupants who worked at an office without openable windows were more likely to suffer from dry eyes. In contrast, the US EPA study [31] did not indicate increased eye symptoms and headaches with openable windows. However, they suggested that this could be explained by the strong correlation of sealed windows with air-conditioned buildings in that study. They considered air-conditioned buildings as a risk factor as opposed to naturally ventilated buildings, as has been supported by previous literature [49].

Another explanation for the positive associations of dry eyes and headaches with the absence of windows can be limited daylight access, in line with findings of the CHBS study [29]. They found that the risk for headaches increased, when the distance between workplace and façade window was larger than 5 meters versus workplaces near the façade window. A possible cause is the influence of (higher) illuminance of artificial lighting needed at places without a window. Wilkins et al. (1989) found that flickering of artificial lighting may increase the speed of small eye movements, that can cause eyestrain and headaches [50]. They studied the incidence of headaches and eyestrain with lighting tubes with a high fluctuation of the lighting frequency, versus tubes with a low fluctuation of the frequency. Although the participants were not aware of the differences in the frequency, eye strain and headaches occurred less frequently (50%) when they had lighting with lower fluctuation. Also, those who had higher daylight access in their office, were less likely to have headaches. A more recent study suggested that the flickering frequencies of both fluorescent lighting tubes and LED may affect headaches, because the fluctuation of LEDs is higher than of most fluorescent lamps [51]. In the present study, 94% of the inspected rooms was lit by fluorescent lighting tubes, LED, or a combination of fluorescent lighting tubes with LED or medical lighting.

Also, as suggested by Aries et al. (2013) the full spectrum of daylight, fluctuations in intensity and wavelength of daylight and view to the outside have a beneficial effect on health [52]. For example, they indicated that a distant view, e.g., to the outside through a façade window, provides relaxation of eyestrain. However, future study is needed to better understand the negative association of dry eyes and headaches with a window, particularly with the presence of a window to the corridor.

The negative association of dry eyes and tendency of a negative association of headaches with single person rooms is partly in line with previous studies. In the present study, there was a difference between single person rooms and rooms for more than one person, while the risk for dry eyes did not increase for persons working with one to three others, as opposed to those working with more than three others in a room. Similarly, in the CHBS study [29] positive associations of headaches with offices for more than one person compared to single person offices were found. In the Boston Study [30] and Japan Office Study [32] no associations were found of dry eyes and the number of people in the offices. These studies found associations of non-specific symptoms (including headaches) and upper respiratory symptoms with the number of persons in the office. A possible explanation for the association of dry eyes with the presence of others is the exposure of organic pollutants emitted by other humans, as suggested by Wolkoff (2010) [53]. For example, an experimental study with 25 college students indicated relations of exposure to human bio-effluents with physiological stress reactions [54]. The students were exposed to different levels of CO_2 and CO_2 generated by human subjects (from 500 ppm to 3000 ppm). Stress reactions, such as increased heart rate and blood pressure, occurred when the concentration of metabolically generated CO_2 increased. The incidence of acute symptoms, such as headaches increased only with an increased concentration of metabolically CO_2 , as opposed to CO_2 without bio effluents [55].

In this study, those who worked most frequently in offices were more likely to have dry eyes and headaches, than those who worked most frequently in consultation rooms. This partly confirms the comparison of main symptoms in different room types at the outpatient area in a previous study with the same dataset [21], where building-related aspects were not included in the analysis. Dry eyes were associated with offices, for headaches there was a tendency of a negative association. The outpatient workers who worked most frequently in offices were also more likely to be dissatisfied with the indoor air quality and they were more likely to perceive dry and stuffy air, than those who worked most frequently in consultation rooms. The dissatisfaction with indoor air aspects might have contributed to differences associated with room types. However, as indicated by Brauer et al. (2008) the association of symptoms and indoor air quality can be two-directional [56]. Possibly, the perception of dry eyes and headaches might have contributed to dissatisfaction with indoor air quality aspects.

Also, occupational aspects might have contributed to the differences between those who work more frequently in offices and in consultation rooms. For example, variation in sedentary behaviour and intensive use of a visual display unit (VDU) may increase the risk for dry eyes [37]. More than 25 hours of VDU use per week was positively associated with dry eyes in the OFFICAIR study [33]. In a study with 425 office workers in Osaka (Japan), those with a low tear film stability were generally sitting a larger number of minutes per day, than those with a normal tear film stability [57]. Hours of VDU use and sedentary behaviour were not included in the present study. Further research is needed to better understand why those who work more frequently in offices were more likely to have dry eyes or headaches in comparison to those working more frequently in consultation rooms.

Surprisingly, variables related to outdoor air pollution did not remain in the multivariate models of dry eyes and headaches. For example, in the OFFICAIR study [33] associations of dry eyes with the proximity of potential sources of outdoor pollution, were found. Mendell et al. (2008) found associations of headaches and dry eyes with the height of outdoor air intake; grills lower to the ground level were a risk factor for dry eyes and headaches [31]. Also, in the cross-sectional study of Smedbold et al. (2001) on environmental parameters in relation to measurements of the tear film stability of 176 inpatient workers in geriatric hospitals, associations with nearby heavy traffic and increasing tear-film instability were found [24]. Jung et al. (2018) concluded in a literature study that air pollutants, such as NO_2, particulate matters and dioxin, influence the condition of the ocular surface [58]. It can be hypothesized that variables, such as the presence of a nearby highway or industry, related to the exposure to outdoor air pollutants in the present study were not included in the final multivariate models, due to the presence of nearby traffic and parking places at all locations.

5.4.2 Strengths and limitations

This study included a broad range of building-related aspects at different scale levels, from organization, location, building wing, to room. One limitation can be the limited number of building locations, where the respondents worked. This may have affected the variance in building-related aspects. However, because the buildings on the locations were complex, due to differences between room types, between rooms with or without a window to the façade, or different renovation periods, building-related aspects varied within buildings. Furthermore, some building-related aspects had an (almost) equal distribution. For example, highway and industry nearby, the presence of an attached parking garage and the cleaning protocol of the ventilation grilles for air supply and exhaust in the rooms, were equally distributed. Also, the presence of a forest nearby and cleaning frequency of the filters of the AHU's were equally distributed. The most plausible risk factors, with a logical direction of the association, were selected for inclusion in the multivariate model. Also, the specific rooms of which the outpatient staff reported their comfort were not identified, due to privacy and practical reasons. Therefore, discrepancies between building aspects of the inspection and the exact location of the outpatient workers might have occurred. This was accounted for in the study design, as building inspection was performed systematically, and building-related aspects were included when variation was consistent within a building wing, room type and adjacency to the façade.

Another limitation of this study can be the unequal distribution of gender. The large proportion of female workers is representative for hospitals. Some previous studies in hospitals excluded male workers from the study [24, 59], but this study intended to provide a representative overview of the outpatient workers. Therefore, the logistic regression calculations were adjusted for gender. Also, the type of hospitals can be a bias. Only top clinical (teaching) hospitals were invited for participation, to restrict the possible influence of organizational aspects. Therefore, caution is needed for generalization of the results to the entire Dutch outpatient staff.

The study was cross-sectional and can therefore only indicate associations of risks for dry eyes and headaches. The study design did not allow determining cause – effect relations. Also, indication of dry eyes and headaches was based on self-reported data. However, Burge et al. (1991) compared the prevalence of self-reported building-related symptoms with building-related symptoms that were diagnosed through medical interviews [60]. Self-reported dry eyes and headaches were among the symptoms that correlated with the medical diagnosis.

5.5 Conclusions

The high prevalence of self-reported dry eyes and headaches in outpatient areas may be explained by building-related aspects, in particular aspects that affect the indoor air quality and visual quality, as well as the functionality of rooms (e.g., offices). An overlap was found of building-related aspects that were associated with both dry eyes and headaches.

This study in general showed overall consistency with previous studies in offices. Specific for this study was the association of dry eyes and headaches with room types. Results suggest that taking the specific room type into account is important in future studies. Also, the association of dry eyes and headaches with a window to the corridor, which was a specific finding in this study, needs further investigation. Because the symptoms were associated with building services, the building layout and work-related aspects, this study strengthens the importance of close collaboration of hospital organizations, engineers, and architects during the design phase of outpatient areas. As the prevalence of building-related symptoms of hospital workers is generally high and may affect sick-leave and productivity, further studies can help hospital organizations to accommodate a supportive physical environment.

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PART 3

Explanation of preferences for comfort of outpatient workers

TOC

6 Preferences for indoor environmental and social comfort of outpatient staff during the COVID-19 pandemic

an explanatory study

This chapter has been published as follows:

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For consistency of the dissertation some typos are adjusted and phrases are reworded without changing the content

ABSTRACT

While the pressure on hospital workers keeps growing, they are generally more dissatisfied with their comfort than other occupants in hospitals or offices. To better understand the comfort of outpatient workers in hospitals, clusters for preferences and perceptions of the indoor environmental quality (IEQ) and social comfort were identified in a previous study before the outbreak of the coronavirus disease 2019 (COVID-19) pandemic. This qualitative study explains the outpatient workers' main preferences for comfort during the COVID-19 pandemic. Semi-structured interviews and photo-elicitation were used. Contextual changes due to the COVID-19 pandemic were included. The questions in the interviews were based on the characteristics of the profiles, corresponding with the clusters. The data were

analysed with content analysis according to the steps defined by Gioia. Seventeen outpatient workers who had been part of the previous study participated. For some outpatient workers differentiation of preferences was illogical due to interrelations and equal importance of the comfort aspects. The main changes in perceptions of comfort due to the pandemic were worries about the indoor air quality and impoverished interaction. Because the occupants' preferences for comfort can change over time, it was suggested that further development of occupant profiles needs to accommodate changes.

6.1 Introduction

As the pressure on hospital workers grows due to the increasing demand for healthcare [1], in the Netherlands almost half of these hospital workers experienced high work pressure in 2019 [2]. Stress can have a negative influence on work satisfaction, performance, and healthcare staff turnover [3–5]. One of the factors that can influence stress at work is the physical environment [6]. For example, previous studies showed that work dissatisfaction and hospital workers' turnover were positively related to dissatisfaction with noise [7] and the length of daylight exposure [8].

The study of comfort, specifically that of hospital workers, is important because previous studies identified a tendency of higher dissatisfaction of hospital workers with the comfort compared to patients [9–11]. Other studies have shown that hospital staff are also less satisfied with their comfort and suffer more from building-related symptoms than occupants in office buildings [12, 13]. To improve the health and comfort of the hospital workers it is important to better understand their needs and preferences.

6.1.1 Background

It has been suggested by several authors that IEQ as well as social comfort aspects are important to understand health and comfort [14–16]. Privacy and interaction have been included in previous studies. For example, nurses that moved from open bay wards to a ward with 100% single patient rooms, missed the informal interaction with colleagues in the new wards [17]. Also, the exchange of medical information was better in open wards, that comprised 36 beds without separation walls, than in bay wards with walls between 4–6 beds [18]. Another example is the relation of the type of communication (case-related or comforting) with room types in an emergency department [19].

As hospitals are complex buildings that accommodate a large variety of activities, the hospital workers' needs for comfort can vary between hospital departments [20, 21]. Therefore, it is important to gain insights into comfort in specific hospital areas, such as outpatient areas. Because outpatient areas have been understudied, a survey on the comfort and health of hospital workers in these areas was performed in the spring of 2019 [22]. In these areas, hospital workers consult, diagnose, and treat patients who do not stay overnight in the hospital. Data from 556 outpatient workers were collected with a questionnaire and data from 127 rooms, the building services, and locations of six hospitals were collected with a building inspection. The questionnaire included the occupants' assessment of IEQ factors, (indoor air quality, thermal comfort, lighting quality, and acoustics) and social comfort aspects (privacy, distraction, interaction). The study identified that the satisfaction with IEQ and social comfort varied, depending on the room types where the outpatient workers worked most frequently. For example, those who worked more frequently in a consultation room were more satisfied with privacy than those who worked in offices.

Questions on the preferences that were closely related to the questions on the perception of IEQ and social comfort were also included, in order to identify differences in needs between individual occupants. Because comfort can vary between individuals, due to differences in reaction and sensitivity to building characteristics, profiles of outpatient workers were produced to justify the variation in comfort between individuals [23]. The profiles were produced with) TwoStep Cluster Analysis in IBM SPSS Statistics 25. This is a segmentation method that is suitable to identify groups with similar needs [24]. Two sets of clusters were produced: one set including satisfaction and preferences for IEQ and another one including satisfaction and preferences for social comfort [25]. In both sets of clusters, the preferences had higher importance than dissatisfaction.

The strong differentiation of the preferences between the clusters brought in the question of how occupants differentiate their preferences. Previous studies identified that the preferences of hospital workers were associated with personal and work-related aspects, such as gender, age, working hours [26], working years, and the function of areas [27]. However, these studies did not explain how the occupants perceived their preferences and comfort. Studies on preferences for thermal comfort in offices [28, 29] and housing [30, 31] showed that needs, behavioural strategies, and control of equipment were interrelated with the specific context. Therefore, it is important to explain the preferences of occupants within their context.

However, the context of outpatient areas may have changed because of the outbreak and worldwide spread of the SARS-CoV-2 virus, leading to the coronavirus disease 2019 (COVID-19) pandemic in the spring of 2020 [32]. Previous studies showed that the outbreak of a serious infectious disease may increase work stress and affect the health of hospital workers [33–36]. As rapid changes in care processes may influence the perception of comfort, assessing the hospital environment is needed when changes occur [37].

6.1.2 Objective

Because of limited information on the hospital workers' preferences for comfort, this study aims to explain the differences in preferences of outpatient workers that were identified in the clusters of the 2019 survey. This study provides insights into the comfort experience of outpatient workers during the COVID-19 pandemic and changes of their preferences during the pandemic.

The present study is part of a larger research project that aims to gain a better understanding of the health and comfort of outpatient workers. The study acts as a follow-up to the survey that was performed with outpatient workers of three hospital organizations in the Netherlands before the COVID-19 pandemic started [22, 25] (Figure 6.1).

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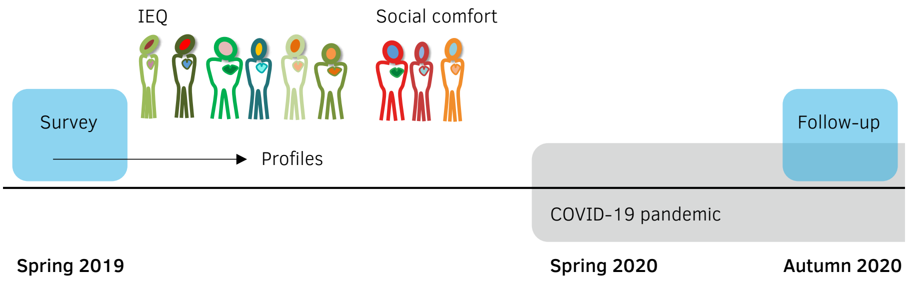

FIG. 6.1 Timeline profiles.

6.2 Method

6.2.1 Study design

A qualitative approach was selected because of the unknown context due to the COVID-19 pandemic and limited information on the experience of comfort preferences. A qualitative approach allows to study possible changes over time and to listen to the real-life experiences of occupants in the built environment [38]. Qualitative data are suitable to refine and explain the results of the quantitative analysis [39], that was used to produce the clusters and their profiles. This explanatory study was based on a pragmatic worldview, considering both the physical world and human experience [40].

The study design combined photography and semi-structured interviews to gain an in-depth understanding of the preferences of the outpatient workers. The critical appraisal skills programme checklist for qualitative research was used for the study design [41].

The participants were selected out of the respondents who participated in the previous survey on comfort and health [25] and had shared their e-mail addresses to participate in a follow-up study. The study intended to include outpatient workers with different functions from all three hospital organizations and all IEQ and social comfort clusters, to gain a representative overview. Participants who were relocated to a location that was not part of the survey or who could not work at one of the six locations due to illness, were not included.

Invitations and reminders were sent by e-mail in October 2020. The outpatient workers who accepted the invitation to participate received a proposal for dates and times and an instruction sheet to take the photographs (Figure 6.2). In the instruction sheet, it was explained that the photographs were needed to provide insights into the importance of IEQ and social comfort aspects during the interview. It was instructed that also other rooms could be photographed to explain the importance of comfort aspects. IEQ was defined as: “aspects from the indoor environment: ventilation, temperature, noise and light.” Social comfort was defined as: “contact with others, distraction, safety, privacy, crowding.” To protect the privacy of patients and staff, instructions were given to exclude persons and personal information from the images.

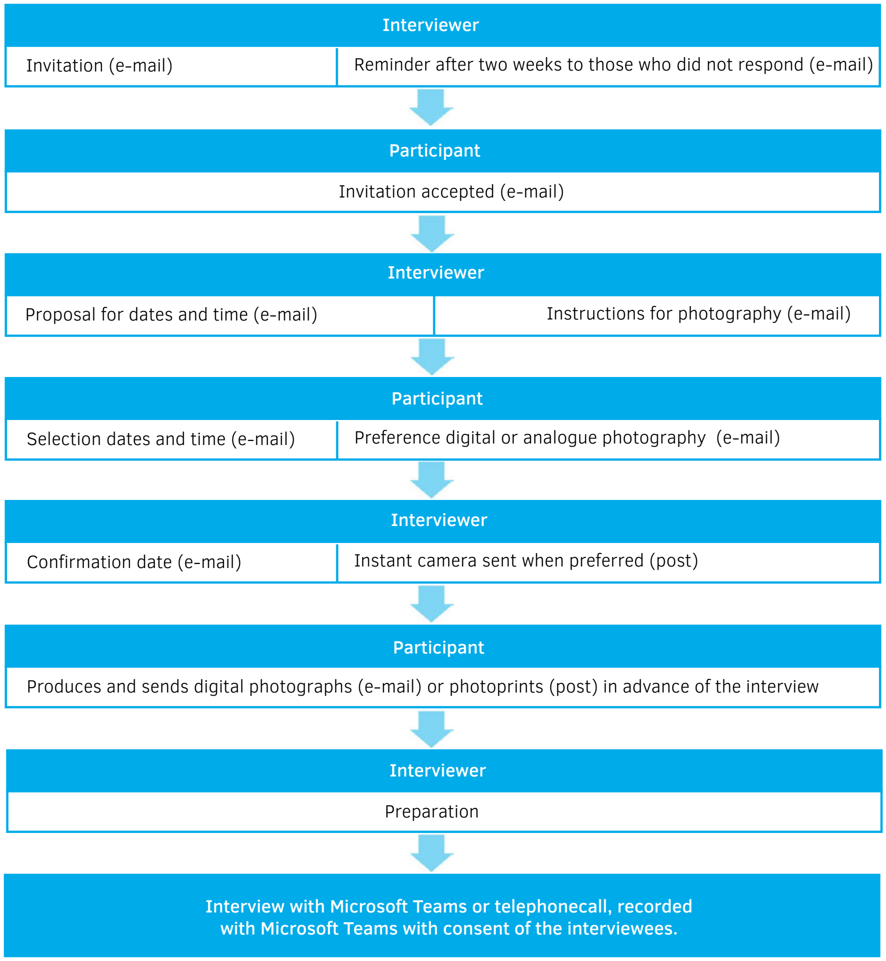

FIG. 6.2 Procedure

Photographs were used because images support communication, as shown in studies on the perception of building characteristics [42]. Images in research have been used and tested before and support the narrative of real-life experiences [43]. For example, in a study that explored the patients' experience when they were lying in a bed, patients took photographs in advance of the semi-structured interviews [44]. It was concluded that visual material cannot only illustrate visual but also auditory or other sensory qualities of the physical environment during the interviews. A practical reason to use photographs was to gain insights into the building characteristics while avoiding infection risk by the interviewer by visiting the hospitals. It should be noted that the interviewer had systematically inspected all hospital buildings before the pandemic started [25].

The semi-structured interviews were conducted via video calls or telephone calls, depending on the participant's preference and technological possibilities. All interviews were audiotaped with Microsoft Teams with the consent of the participants. Semi-structured interviews were used because these enable to explore perceptions of the respondents, while they allow for differences in education, experience, and personal background between individuals [45]. The structure of the interviews enabled follow-up questions to be asked [46]. To reduce the potential bias of the researcher, the interviews started with an introduction and general questions about work. In the introduction it was explained that there was no right or wrong answer. The questions were phrased neutrally, and leading questions were avoided.

The interview guide comprised of newly developed questions, that were discussed and tested in a pilot. The interviews consisted of five main topics: work-related aspects, changes due to the COVID-19 pandemic, preferences for IEQ, preferences for social comfort, and ranking of preferences (Table 6.1). The subtopics were aspects that were differentiated by the profiles of the outpatient workers in the previous survey on comfort and health [25]. For example, the number of persons in the room was a subtopic because it varied between the clusters. A comparison with the data from the survey was done to check whether the room type, department, or location of the participants had been changed. The subtopic "logic to differentiate preferences" was added to gain insight into whether the participants experience clear differences between their preferences. The ranking was performed separately for comfort with IEQ-aspects and social comfort. The aspects that were identified in the previous survey as most important were used for the ranking. The IEQ-aspects were "control of ventilation", "sufficient fresh air", "control of temperature", "not too cold or hot", "sufficient daylight", "no annoyance by noise." For social comfort, the aspects were "contact with patients and colleagues", "a safe workplace", "sufficient patient privacy", "no distraction from noise." The structure of the interview was tested in a pilot interview with an outpatient worker from a similar hospital organization (teaching hospital). The pilot provided insights into the structure of the interview and the use of photographs. Consequently, the researcher piloted two interviews with two outpatient workers from similar hospital organizations.

TABLE 6.1 Topic guide semi-structured interviews.

Main topic	Subtopics	Shared documents
Introduction		
Work-related aspects	Room, room type, number of persons in room, function, job tasks, department, location	
Changes due to the pandemic	Activities, work pressure, physical changes, other	
Preferences IEQ	Thermal, ventilation, lighting, noise	Photographs
Preferences social comfort	Contact, safety, privacy, distraction	Photographs
Ranking preferences	Order of importance Logic to distinguish preferences	List ranking IEQ and social comfort
Other issues related to comfort		
Closing		

6.2.2 Ethical approval

The Ethics committee of the Delft University of Technology approved the study design on 5 October 2018. Data security was assessed by a data manager of the university. The data were stored on a secured server. Participation of the hospital organizations and participants was voluntary. Participants could participate only after their approval of informed consent. The letter of consent and procedure were discussed and approved with the project leader of each participating hospital organization in advance. If the participants had shared their e-mail address in the previous survey, it was separated from the dataset and secured in a separate document. Comparison of the individuals' data between the survey and this follow-up study was enabled by a unique number that was assigned to each participant. To respect the privacy of the participants, persons are not traceable from the results presented.

6.2.3 Data analysis

Data analysis was performed in the steps shown in Figure 6.3. In the first phase inductive analysis was performed to structure the changes due to the COVID-19 pandemic. An inductive approach was used, because of the unknown context. In the second phase deductive analysis was performed to structure the main occupants' preferences and enable comparison with the data of the previous survey. Microsoft Excel was used for the data codes.

The interviews were transcribed verbatim and read to prepare for analysis. The average duration of the interviews was 31 minutes, varying from 14 to 56 minutes, depending on the participants' time and experience. To structure and summarize the changes due to the COVID-19 pandemic, content analysis was used according to the steps of Gioia et al. [47]. Meaningful text segments that explicitly referred to the COVID-19 pandemic were systematically selected, condensed, and paraphrased into first-order codes, that were closely related to the wording of the participants. Subsequently, these first-order codes were grouped into second-order codes, iteratively formed by the main investigator. The second-order codes were translated from Dutch to English. All first and second-order codes of two participants were checked by another researcher, a native English speaker, the second order codes were recoded, and checked until consensus was achieved. Differences were discussed to improve the accuracy of the codes. The second-order codes were grouped into subcategories and categories to form a data structure that was discussed with two other researchers. Subsequently, the second-order codes were assigned independently into subcategories and categories in a digital workshop by seven other researchers to achieve intercoder agreement. Three of the 53 codes were placed in a different subcategory in the digital workshop compared to the initial data structure. Furthermore, it was suggested to add one extra subcategory, and the names of the categories and subcategories were discussed. These results were used to define the final data structure.

To investigate how the comfort preferences changed, the participants' preferences from the survey [25] were compared with their preferences from the interviews. Therefore, all relevant text segments, that referred to the ranked IEQ and social comfort aspects were systematically selected. These fragments were condensed and paraphrased in first-order codes and categorized according to predefined categories per participant. This was done for IEQ and social comfort separately. The IEQ-categories were the four IEQ aspects [23], i.e., indoor air quality, thermal comfort, visual quality, acoustics, and logic of ranking IEQ. The social comfort categories were the four most important social comfort aspects that were determined in the survey [25], i.e., contact with colleagues and patients, a safe workplace, sufficient patient privacy, no distraction from noise, and logic of ranking social comfort. The codes were checked and recoded iteratively by two researchers. Then, the codes and ranking were compared with the individuals' preferences of the survey, the changes due to the pandemic, other changes, and the logic of ranking.

To illustrate the IEQ and social comfort experiences [48], quotations by the participants from transcripts verbatim that were detailed and representative, were selected [49]. To justify the unique experiences of the participants [50], gap words and some repetitions of thoughts were kept in the quotations. The quotations were translated back and forward by the authors (native Dutch and English, see Appendix L for the quotations).

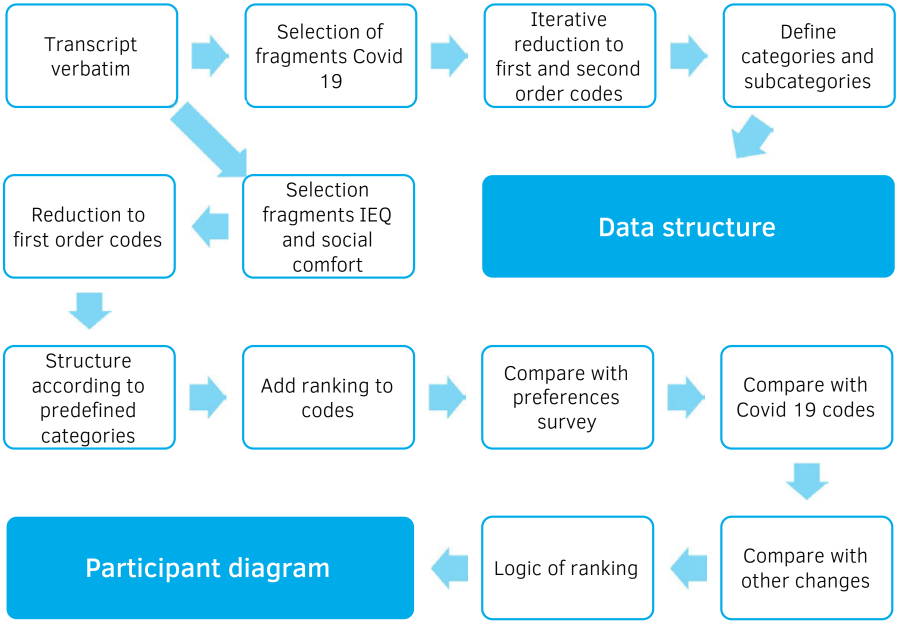

FIG. 6.3 Steps for data analysis.

6.3 Results

6.3.1 Participants

The interviews were performed in the last week of October and the first half of November in 2020. 130 invitations (38+45+47) respectively to organisations A, B, and C were sent, 17 (5+7+5) interviews were included in the analysis, as can been seen in Figure 6.4. The main reason for refusing to participate was work pressure. One audio recording was damaged, therefore that participant was excluded from the analysis.

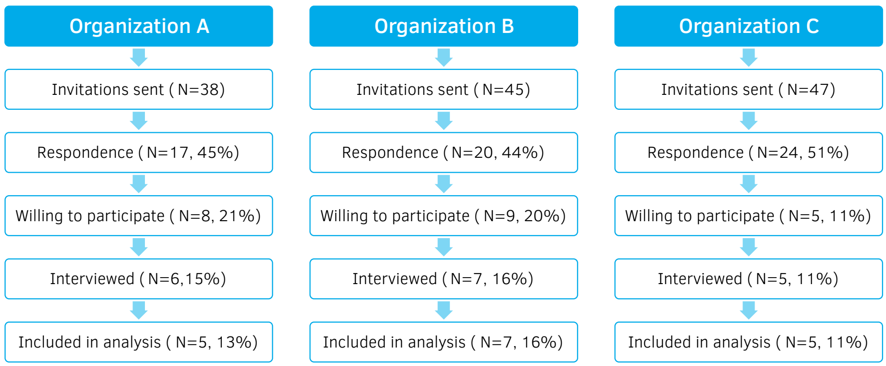

FIG. 6.4 Flow diagram of recruitment.

The participants, who consisted of sixteen women and one man, represented all IEQ and social comfort clusters and belonged to all the hospital organizations that participated in the survey. The participants worked in consultation rooms, treatment rooms, offices, or at reception desks; thirteen of them worked in more than one room type, see figure 6.5. For example, three interviewees worked at reception desks and consultation rooms.

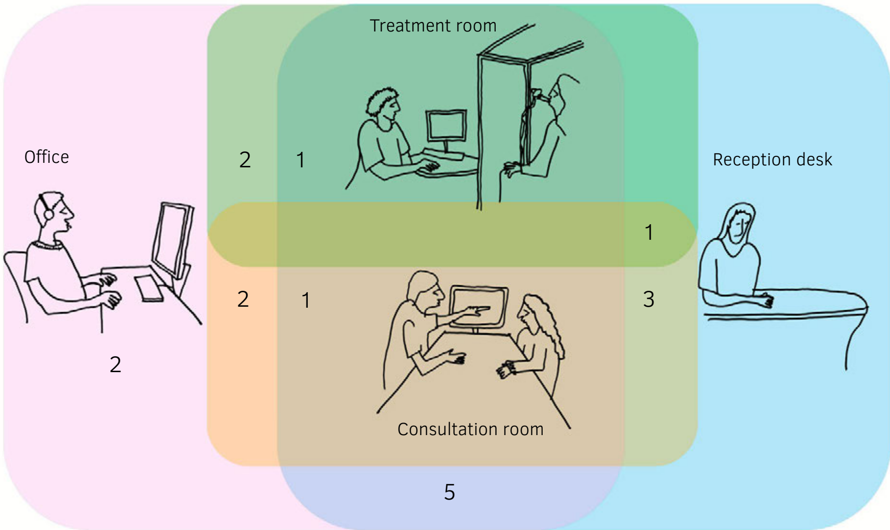

FIG. 6.5 Overlap of workplaces of the participants.

Nine participants regarded the same IEQ-aspect as most important, as selected in the 2019 survey (Table 6.2). For example, one participant regarded “sufficient fresh air” as most important in the autumn of 2020, and “sufficient fresh air” and “not too cold or hot” important in the spring of 2019. Some found the ranking of IEQ aspects from most important to least important logical, while others did not. “No annoyance with noise” or “sufficient daylight” were for some the most important aspects, while the other aspects were equally less important. The main preferences for indoor air quality and thermal quality did not vary, except for one participant who did not answer the question on IEQ-preferences in the survey of 2019. The main preferences for daylight and noise varied.

Ten outpatient workers regarded the same social comfort aspect as most important in both 2019 and 2020. Some outpatient workers found the ranking of social comfort aspects logical, while others perceived an overlap between “contact with colleagues and patients” and “safe workplace.” The importance of social comfort aspects could also depend on a situation or activity. The importance to support the privacy of patients was considered a question of conscience. The main preference for sufficient contact did not vary, while the other preferences did.

TABLE 6.2 Main preference in 2020 compared to 2019.

	Most important aspect	2020	Same preference in 2019
		N	**N**
IEQ	Sufficient fresh air	1	1
	Control of ventilation	2	2
	Not too cold or hot	3	2*
	Control of temperature	1	1
	Sufficient daylight	5	1
	No annoyance by noise	5	2
Total IEQ		17	9
Social comfort	Sufficient contact	7	7
	No distraction by noise	3	2
	Privacy for patients	4	1
	Safe workplace	3	0
Total Social comfort		17	10

**incomplete answer of participant in 2019 excluded.*

6.3.2 Changes due to the Coronavirus Disease 2019 (COVID-19) pandemic

The data structure generated insights into organizational aspects, work-related aspects, physical adaptations, and the experience of changes, that were identified by the participants (Table 6.3). The structure was used to understand the preferences for indoor environmental quality and social comfort during the COVID-19 pandemic. First, the organizational aspects, work-related aspects, and physical adaptations were summarized, to describe the context. Then the experiences, especially related to the indoor environment and social comfort, are explained. See Appendix M for all second-order codes.

TABLE 6.3 Data structure of the changes related to the COVID-19 pandemic.

Category	Subcategory	Example
Organizational adaptations	Capacity	Reduction capacity during first wave of the pandemic
	Number of persons in hospital building	Working partly from home
Adaptations work methods	Corona care	Perform corona tests in triage tent
	Digital care	Prepare digital consultations
	Face-to-face care	Physical examination when urgent
Physical adaptations	Room	Stanchions in front of reception desk
	Protective clothing	Use of facial mask
Personal experiences	Work pressure	Increased work pressure
	Satisfaction with work	Annoyed by extra administration
	Indoor Environmental Quality (IEQ)	Missing control of ventilation
	Social comfort	Missing face-to-face contact

6.3.2.1 Context

In March/April 2020, during the first wave of the pandemic, the capacity of outpatient care had been reduced for most participants. At the time of the interviews, most participants regarded the capacity of outpatient care as normal. The number of patients, relatives, and staff in the hospital buildings was perceived lower than before the COVID-19 pandemic. To limit the number of persons in the hospital buildings, outpatient care had shifted from face-to-face care to digital care. Face-to-face consultations were only performed when necessary or when preferred by patients, also depending on the department. For example, one outpatient worker in an oncology department explained that patients were invited to face-to-face consultations when they were told that they were seriously ill. Diagnostic treatment was performed at the hospital buildings.

The adaptation of work methods resulted in annoyance with extra administration and worries about infection and patient care. Half of the participants perceived increased work pressure at the time of the interviews, while the others did not. Some reception workers had perceived increased work pressure mainly when the COVID-19 pandemic started. Work pressure increased also because of limited staff and prolonged sick leave, not directly related to the COVID-19 pandemic. Positive experiences were easily adjusted to new work methods and satisfaction with the hospital organizations' diligence.

To support social distancing between persons, some adaptations were executed in the reception areas and adjacent waiting rooms. For example, cupboards were replaced; and stanchions in front of the reception desk were placed (Figure 6.6). Also, the number of chairs in waiting rooms was reduced and splash guards were provided between the chairs. Other protective measures were the use of a facial shield or facial mask and a transparent splash guard, placed at reception desks (Figure 6.7). Both photographs are taken by participants.

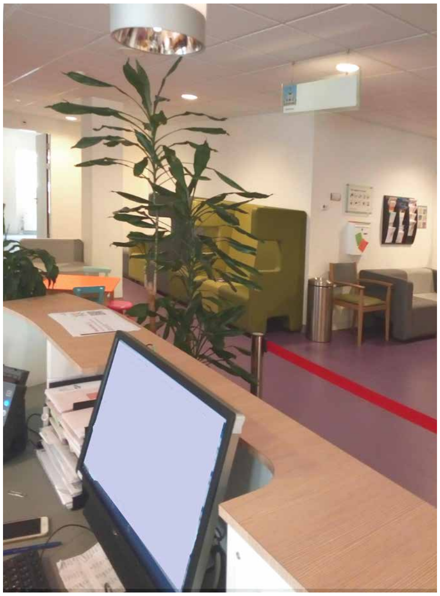

FIG. 6.6 Stanchions in front of reception. (photograph taken by a participant)

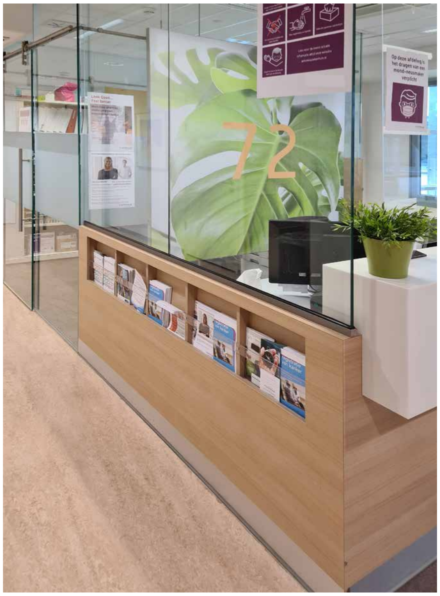

FIG. 6.7 Splash guard installed at reception. (photograph taken by a participant)

6.3.2.2 Indoor environmental quality

The perception of the indoor air quality, thermal comfort, and noise was influenced by the COVID-19 pandemic.

The outpatient workers explained that they preferred to have natural ventilation by opening a window or the door to the corridor, to reduce the risk of infection (For example, quotation 1 in Appendix L, “And I find it annoying too now…”). An adaptive strategy was to open the door to the corridor when the outpatient workers who were in a room without a façade window were dissatisfied with the supply of mechanically ventilated air. This was only possible when it did not affect the privacy of the patients. Another strategy was to open the façade window for natural ventilation. However, this could affect thermal comfort, which might vary between outpatient workers who worked in the same room. When the window was open, it could be too cold for some workers, especially for those in uniform (with bare arms), while it was not too cold for others. An outpatient worker explained that they had clear understanding about control of natural ventilation to achieve a balance of thermal comfort and natural ventilation since the pandemic (quotation 2 in Appendix L, "I like a little bit of air…").

Also, the speech intelligibility of patients was reduced due to the splash guards between the patient and outpatient workers at the reception desk. The noises from colleagues at the back of the reception area were louder because of the splash guards, while the voice from the patients sounded lower. The facial masks increased difficulties with speech intelligibility (quotation 3 in Appendix L," If it weren't any noise annoyances...").

Furthermore, recent changes in preferences that were not explicitly associated with the COVID-19 pandemic, were experienced. This occurred for noise and daylight. For example, one participant who worked mainly in rooms without a façade window missed daylight more than she used to do. Dry eyes and concentration problems were associated with a lack of daylight. The outpatient worker adapted her behaviour to receive daylight, by going out for a walk during lunchtime and working in rooms with a window when possible (quotation 4 in Appendix L, "I have noticed that I used to suffer less with that…"). These strategies were also explained by some other interviewees, who worked generally in rooms without a façade window.

6.3.2.3 Social comfort

The outpatient workers experienced also changes in contact with colleagues and patients, privacy of patients and safety, due to the COVID-19 pandemic.

Some felt less energized because of the reduced face-to-face contact with patients and increased administrational work. The perception of losing information from the patients occurred because of the limited face-to-face contact. For example, one outpatient worker explained that she could not explain doubts to patients anymore after consultation with the physician (quotation 5 in Appendix L, "When you ask…"). Another outpatient worker explained that she was worried about missing details and could give less attention to the patients due to the limited physical examination (quotation 6 in Appendix L, “And yes, the physical check-up is something you miss…”).

A shorter physical distance, which was not allowed due to infection risk, was regarded as advantageous to support the patients’ privacy by speaking softly. The privacy of patients at the reception desk also worsened due to the splash guards and facial masks. For example, the outpatient workers had to ask for personal information, such as the birth date and the name of the general practitioner, while others were in the waiting room. The patients had to talk louder because of the splash guards (quotation 7 in Appendix L, “You discuss everything…”).

Some outpatient workers perceived difficulties through increased aggression. Patients were impatient or angry, for example because of the obligation to wear a facial mask. The opposite was also experienced, because the number of visiting patients had decreased and aggression during telephone calls was less annoying.

6.4 Discussion

The qualitative data allow for a vivid explanation of the context [38] and changes due to the COVID-19 pandemic. Contextual changes were studied to explain the experience and importance of comfort aspects. Because the participants in this study had been involved in the cluster study [25], a comparison of the preferences was possible. This is presented and discussed in the following section.

6.4.1 Explanation of the IEQ clusters

Figure 6.8 shows the preferences for IEQ aspects per cluster, that were found in the survey before the pandemic started, and the preferences during the pandemic. The circles represent the proportion of the outpatient workers who regarded an IEQ aspect important before the pandemic, and the ranking of the outpatient workers during the pandemic. The area of the light circles represents the proportion of the cluster members for a main preference. The largest circles (e.g., cluster 1 “control of ventilation”) represent 100%, the light dots represent 0% of the cluster members.

The area of the dark circles represents the ranking of the preferences; large is most important (1, size 100%), small is least important (6, dot). The size of the dark circles was calculated according to the following equation, with v = the sum of ranking of the participants per cluster, n = number of cluster members:

$$100-\left(\left(\frac{v}{n}\right)\cdot\left(\frac{100}{5}\right)-\left(\frac{100}{5}\right)\right)$$

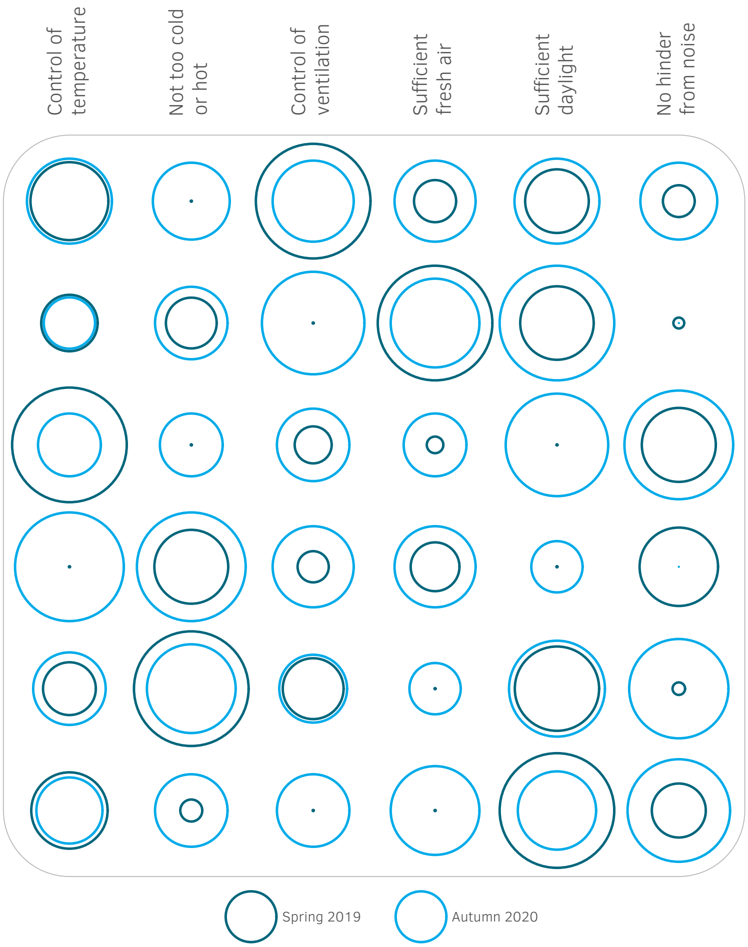

FIG. 6.8 Proportion of preferences selected per IEQ cluster in 2019 and average rating of preferences in 2020.

The number of cluster members from the survey of 2019 and interviews in 2020 are shown as follows: IEQ cluster × (N = a/b): × is the cluster number, a = number of cluster members of the study in 2019, b = number of cluster members of the study in 2020.

The importance of some preferences had limited variation between both data sets. For example, the proportion of outpatient workers in cluster 1 who found *control of temperature* important was intermediate (46%), and ranking was intermediate (3.3, of six aspects with 1 for most important, 6 least for important). Other preferences differed; for example, none of the outpatient workers in cluster 1 selected *not too cold or hot* among the three most important aspects in the quantitative study (0%), while it was ranked intermediately (3.8) in the qualitative follow-up study. The largest differences were “not too hot or cold” (cluster 1), “control of temperature” (cluster 4), “control of ventilation” (cluster 2), “sufficient daylight” (cluster 3), “no annoyance by noise” (cluster 5).

These differences suggest that the clusters that were mainly differentiated by the preferences, could change due to contextual or personal changes. For example, one of the main contextual changes due to the COVID-19 pandemic was the reduced number of persons in the buildings and rooms. The IEQ-clusters mutually differed for those working in rooms with two to four persons and rooms with rooms with more than four persons. It was explained by the outpatient workers of cluster 4 and cluster 5 that the preferences of colleagues were one of the factors that influenced the control of temperature and ventilation.

The reason why the outpatient workers found IEQ aspects important, varied between the clusters. For example, in addition to concerns for infection with the SARS-CoV-2 virus, control of ventilation and sufficient fresh air were preferred because fresh air was experienced as enjoyable and attractive for those in clusters 2 and 6. However, the outpatient workers in cluster 1 found control of ventilation and sufficient fresh air important because they were dissatisfied with the indoor air quality. Those in cluster 1 found thermal comfort important because they were mainly dissatisfied with the temperature variation, while it was important in cluster 4 because of draught. Thermal comfort was important for those in cluster 5 because they experienced mainly too cold temperature, even after adjusted clothing (e.g., cardigan on top of uniform). Daylight was preferred because of dissatisfaction with the absence of a façade window in cluster 1, while some in clusters 4,5,6 did not need or expect a façade window. The view to the outside, which was associated with sufficient daylight, was missed (cluster 1) or enjoyed (cluster 2,3,6). The importance of noise was for those in clusters 1 and 6 mainly related to speech intelligibility of patients, which had decreased due to wearing of facial masks and splash guards, while outpatient workers in clusters 3 and 5 perceived stress due to annoyance by noise.

Based on the explanation of the data from the survey and interviews, it can be suggested that the needs of those in different IEQ clusters do not only vary in importance, but also due to differences in expectations and sensitivity. The clusters seem to be influential for contextual changes or personal changes, due to large differences, especially in clusters 2,3, and 4.

6.4.2 Explanation of the social comfort clusters

Figure 6.9 shows the preferences for social comfort that were found in the survey before the pandemic started, and the preferences during the pandemic. The size of the circles represents the importance of a comfort aspect. The area of the light circles represents the proportion of the cluster members for a preference. The light dots represent 0% of the cluster members. The area of the dark circles represents the ranking of the preferences; large is most important (1, size 100%), small is least important (4, dot). The size of the dark circles was according to the following equation, with v = the sum of ranking of the participants per cluster, n = number of cluster members:

$$100-\left(\left(\frac{v}{n}\right)\cdot\left(\frac{100}{3}\right)-\left(\frac{100}{3}\right)\right)$$

The number of cluster members from the survey of 2019 and interviews in 2020 are shown similarly as in Figure 6.8.

The importance of most preferences for social comfort in 2020 did not vary from 2019. For example, “contact with colleagues and patients” was in all clusters for a large majority (ranging from 56% to 76%) important in 2019, and ranked similarly high (1.5 to 1.8, of four aspects, with 1 for most important and 4 for least important) in 2020. The largest difference was the limited proportion (0%) of outpatient workers who found a safe workplace important in 2019, while it was ranked intermediately (2.5) in 2020. The reason why those in cluster 1 regarded safety as important was different from those in clusters 2 and 3. In cluster 1 safety was associated with building characteristics, such as a safe escape route or cleanliness, while safety was associated with verbal aggression of patients and the proximity of colleagues in clusters 2 and 3.

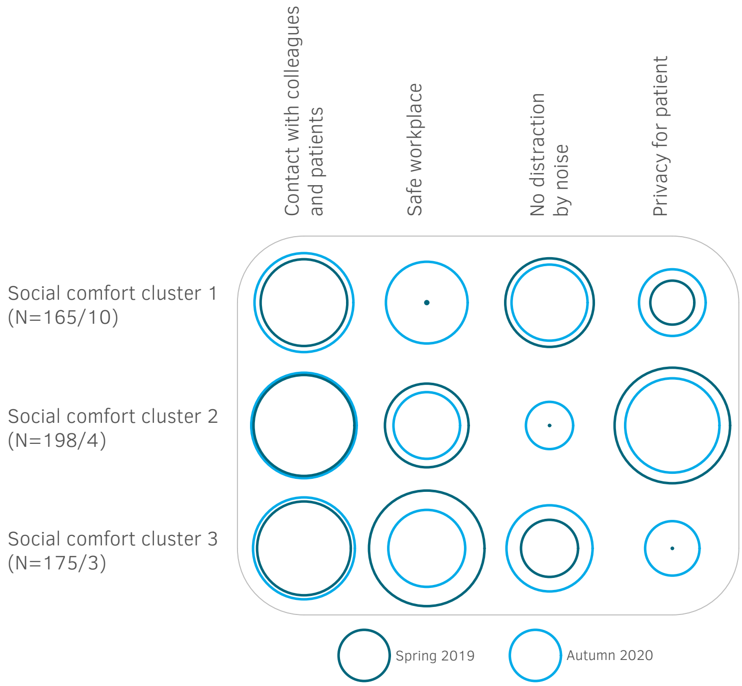

FIG. 6.9 Proportion of preferences selected per social comfort cluster in 2019 and average rating of preferences in 2020.

The reason why the outpatient workers found no distraction by noise important, varied partly. In cluster 1 concentration was necessary, while in all clusters noise from others, particularly telephone calls of colleagues, was perceived as annoying. This can be explained by the results from the survey, that indicated that those in cluster 1 perform generally more concentrated office work in comparison to those in cluster 2 and 3.

The reason why the preferences for privacy of patients and contact with others were important, did not vary between the clusters. Patient privacy was mainly important because of concerns about the audibility of personal information by other patients in the waiting room. Contact with colleagues and patients was perceived as important because of work satisfaction. Among the clusters, both collaboration with colleagues and interaction with patients contributed to work satisfaction.

Overall, it can be suggested that the importance of safety can vary between those in different social comfort clusters, while it is less likely that the reasons for the importance of the other social comfort aspects vary. The social comfort clusters seem generally robust, as the changes were limited between 2019 and 2020.

6.4.3 Changes of preferences

The study shows that it is likely that the occupants' preferences can change due to contextual changes.

As choices for preferences are inevitably made in a context, it is difficult to distinguish contextual influences from preferences [51]. Preferences can be formed unconsciously by habituation and more consciously by reasoning [52]. The latter are more likely to change due to contextual cues [51, 53]. A study that used neuroimaging data, showed that physiological reactions, representing the perceived importance of preferences, can strengthen after selection [54]. Hoeffler and Ariely (1999) suggested that a strong experience is more likely to form a stable preference, than a flawed experience [55]. The present study showed that the main preferences for daylight, noise, privacy for patients, and safety were more likely to change than the other IEQ and social comfort aspects. Future study is needed to indicate whether there are differences between comfort aspects in the strength of the experiences.

6.4.4 IEQ in relation to changes due to the COVID-19 pandemic

The present study shows that the influence and interrelations of physical characteristics, personal, and work-relatd aspects with comfort preferences are complex. For example, while the needs for control of natural ventilation and for sufficient fresh air, due to worries about infection risk, were expressed by seven participants, indoor air-related aspects were most important for three participants. Their main preference for indoor air-related aspects had not been altered since 2019. A possible cause is that some outpatient workers found that other IEQ-aspects affected their work performance more negatively if these were not met. The participants pointed out that opening windows influenced also thermal comfort, while opening doors influenced annoyance by noise.

However, the concern of the outpatient staff about indoor air quality as a possible risk factor for health and infection is not new. In previous studies, hospital staff regarded indoor air quality among the top three most important aspects [26, 56]. Furthermore, evidence of the possible transmission of SARS-COV-2 through (small) airborne particles is growing [57]. For example, a study in isolation wards of intensive care determined contamination with the SARS-COV-2 virus on surfaces at the nursing station and in the indoor air [58]. The ventilation rate in the isolation wards was low, while tracheal intubation, that may increase the concentration of airborne virus-carrying particles, had been performed the day before data collection. Increased ventilation rate is one of the measures that can contribute to a lower concentration of airborne virus-carrying particles. Customization of mechanical ventilation systems and control of air supply through opening windows were among the measures recommended by Morawska et al. (2020), to reduce the risk for the spread of the SARS-COV-2 virus [59].

6.4.5 Social comfort in relation to changes due to the COVID-19 pandemic

The experience of impoverished interaction, due to increased digital care, can be explained by the multi-sensory characteristics of face-to-face interaction. Similarly, the beneficial effects of face-to-face interaction for collaboration were identified in previous studies [60]. For example, a comparative study on the difference between video and face-to-face meetings of physicians found less informal exchange and limited willingness to discuss diagnostic problems through video calls as compared with face-to-face meetings [61].

There is a gap in empirical studies on the perception of caregivers of digital care during the COVID-19 pandemic [62, 63]. However, previous comments on the rapid shift to digital care during the pandemic suggested changes in social interaction through video calls in comparison to face-to-face meetings. For example, Romanick-Schmiedl and Ragu (2020) suggested that face-to-face interaction between patient and caregiver contributed to a trusting relationship, which is essential for the health care process [64]. Furthermore, cues for correct diagnosis of the patient, such as observation of trembling fingers, could be missed in virtual contact. Rosen et al. (2020) suggested that contact with patients might improve through digital care because the patients were comfortable in their own homes [65]. Notwithstanding the benefits of digital care, in terms of infection risk, expenses, travel, and time, the perception of social comfort can be influenced negatively by the shift from face-to-face meetings to digital care.

6.4.6 Methodological considerations

The lens that was specifically chosen for this study provided insights into changes due to the COVID-19 pandemic and other factors. Other lenses, such as the experience of basic and linear factors derived from Kano's model for satisfaction [66] or different adaptive strategies to achieve comfort [14, 15], could have allowed us to examine the preferences. However, because it was unknown whether the outpatient areas were changed due to the COVID-19 pandemic, it seemed most appropriate to form a data structure of the changes, that the participants related to the pandemic.

In the present study, a ranking was used because this method is most suitable to assess a hierarchy of preferences, while rating scales are most suitable to assess appraisal [67]. One of the benefits of ranking preferences instead of rating preferences is to overcome differences in the assessment between persons [68]. Therefore, the ranking was also used for the preferences (three most important aspects) and the rating for satisfaction with comfort (scale 1 to 7) in the survey [25]. Subsequently, the clusters were constructed of the categorical values for preferences (binary data) and components of comfort (continuous data from Principal Component Analysis) with TwoStep Cluster Analysis. This technique is suitable for both types of data [24]. The present study shows that differentiation of preferences can be illogical for outpatient workers because they find some or all comfort aspects evenly important. Furthermore, interrelations were perceived between the comfort aspects. Therefore, future research is needed to compare the consistency of ranking and rating for comfort preferences.

6.4.7 Limitations

One of the limitations of this study can be participation bias. To limit this bias, participants from all clusters, differing in preferences and comfort, were represented in this study. Therefore, it was expected that the participants would constitute a group of outpatient workers with different main preferences and satisfaction with comfort. Although the preferences of some participants had changed since 2019, the main preferences of the total sample differed also in the present study.

Another limitation is that some outpatient workers found the ranking of comfort aspects to be illogical. The perceived lack of logic to rank comfort aspects might have influenced the identification of preferences. For example, participants in IEQ-cluster 3 regarded differentiation of preferences as illogical, while their preference for daylight changed. Furthermore, careful consideration is needed for the generalization of the results, mainly of IEQ clusters 2,3,4, because of the low number of participants. Also, transfer of the findings to other occupant groups (such as patients) or departments (such as inpatient areas) needs careful consideration, because the occupant needs can vary due to differences in building characteristics, duration of stay, activities, etc. [20,21].

6.4.8 Recommendations

This study shows that the main preferences of the outpatient workers can vary. Based on the results it can be suggested that manual control of IEQ aspects is one of the solutions to improve the comfort of individuals. A previous study on thermal comfort of hospital workers at inpatient areas recommended hospital organizations accommodate different set points, related to zones that varied in occupancy and activities [69]. However, as the preferences of individuals that work together in the same area can vary, additional solutions are needed. Other solutions that hospital organizations can accommodate for are e.g., adjusted clothing (uniforms), use of other rooms, or compensation during breaks. In line with compensation during breaks, Lembo et al. (2021) suggested reducing the duration of work shifts during the COVID-19 pandemic because of thermal discomfort of the hospital workers that used personal protective equipment [70]. Also, measures to increase the ventilation rate may improve comfort and reduce worries of outpatient workers. Ventilation could be improved and reduce the risk of the spread of the SARS-CoV-2 virus through the opening of windows, air filtration, disinfection, and accurate operation of the HVAC systems [59,71]. Jain et al. (2021) [72] addressed the importance of a correct balance between the occupants' comfort and energy use of HVAC systems in hospitals. They suggested developing strategies for measurement and control of IEQ including measurement of the system performance. Furthermore, as the intelligibility of patients may decrease due to splash guards and facial masks, additional acoustic measures are needed during an epidemic. Possible solutions are reconsideration of splash guards, application of extra sound absorbing materials and reduction of environmental noises. This is important because a poor acoustic environment and reduced privacy may increase the incidence of burn out of healthcare workers [73], a risk that increased during the COVID-19 pandemic [74]. Furthermore, it can be suggested that places that accommodate safely for face-to-face contact with hospital workers and patients are needed for medical and informal exchange. Places for interaction with others may also decrease the healthcare workers' work pressure [75]. To support social distancing and face-to-face interaction, the occupant density of rooms, areas, and corridors might be considered [71].

6.5 Conclusion

In this study, the preferences for IEQ and social comfort of the outpatient workers during the COVID-19 pandemic were investigated and compared to preferences for IEQ and social comfort identified before the COVID-19 pandemic started. The perceived changes of adaptations to reduce the infection risk with the SARS-CoV2 virus in the hospitals were summarized. The outpatient workers had worries about the indoor air quality, were annoyed by decreased speech intelligibility of patients, impoverished interaction, increased difficulties with patient privacy, and threatening behaviour.

The study allowed us to compare preferences for IEQ and for social comfort with the interviewee's preferences that were identified in a survey before the COVID-19 pandemic started. The results from the previous study identified six clusters for IEQ and three clusters for social comfort, that were distinguished by their preferences and comfort. The present study showed that the reason why IEQ aspects are important, varied between the clusters, while the variation for social comfort aspects was limited. For some of the outpatient workers, differentiation was illogical due to interrelations and equal importance of the comfort aspects. This was experienced with IEQ as well as with social comfort.

Finally, the study implies that the occupants' preferences for IEQ and social comfort can change over time, due to contextual or personal changes. Therefore, it can be suggested that further development of occupant profiles, that might be used in the programmatic or design phase of renovation and newly built outpatient areas is needed.

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7 Conclusion and recommendations

7.1 Introduction

This research aimed at providing insights into the comfort and health of occupants in hospitals. The study was conducted from the perspectives of IEQ and healthcare architecture. A mixed-methods strategy was chosen to justify the occupants' holistic experience of the physical environment. This method combined the strength of quantitative studies to determine relations between health and comfort with other aspects, with the strength of qualitative methods to explain the experience of the occupants.

Different types of data were used to gain insights into comfort and health, such as data collection from previous literature, the occupants, and building inspection. Literature data were systematically collected from databases, such as Scopus, Web of Science, and JSTOR, to define the state-of-the-art and compare findings of previous literature. Occupant data were collected quantitatively with a questionnaire and qualitatively with semi-structured interviews. These data were collected to compare the perceptions and preferences of individual outpatient workers. Building data were collected with checklists, drawings of the buildings, and photographs. These data were collected to study associations of building characteristics with the perceptions and experiences of the occupants.

To identify and explain relations of comfort and health of outpatient workers with personal, work, and building-related aspects, four sub-questions were formulated. The relations were studied consecutively with work, personal, and building-related aspects as starting points. The last sub-question provided an in-depth explanation of the occupants' experiences. The data were analysed with techniques that corresponded with the sub-questions. Therefore, several techniques were used to describe comfort and health (descriptive statistics), compare differences

(Chi-Square, ANOVA), test correlations (Phi), determine associations (multivariate logistic regression), reduce the number of variables (Principal Component Analysis, data reduction according to Gioia (2013) [1]) and identify profiles (Two-Step Cluster Analysis). The use of multivariate analysis techniques enabled to analyse the myriad of variables with coherence [2]. The different techniques and the inclusion of a broad range and different types of variables enable to provide a complete understanding of comfort and health.

This chapter provides the conclusions and recommendations resulting from the research. First, the sub-questions are answered, then the main question is answered. Subsequently, the limitations of this research are discussed, followed by the implications and recommendations for further research and practice.

7.2 Answers to the research questions

7.2.1 Part 1 (chapter 2)

What are the relations of the physical environment in hospitals with the occupants' comfort and health?

This sub-question aimed to define the state-of-the-art and identify possible gaps in studies on health and comfort in hospitals. This was necessary to refine the scope of the field study. Therefore, a systematic literature review was conducted, including 79 peer-reviewed field studies, that varied in methods from controlled clinical trials to qualitative studies. The review was based on the three following detailed questions, that followed from the sub-question.

- What building characteristics are related to the comfort and health of occupants in hospitals?
- What are the differences in comfort and health between hospital departments?
- What are the differences in comfort and health between patients, visitors, and staff?

Comfort and health of occupants in hospitals are related to a broad range of dose and building-related aspects. The occupants' health and their perceptions of comfort are influenced by the four IEQ factors, quality of the spatial layout, and the overall quality. Most studies focused on a single building characteristic, while the studies on overall quality included building and dose-related indicators as well as furniture and decorative elements.

The study identified that some conditions are specifically related to the function of a hospital area or a room type. For example, measures to decrease the infection risk of patients, such as the laminar airflow in the operating room, influence the thermal comfort of the hospital workers. Also, differences in the function of departments or room type can influence the perceptions of health and comfort, such as stress, the need for privacy, or the importance of thermal comfort.

Health outcomes that are associated with building characteristics can be specifically related to patients, e.g., rehospitalisation, mortality, delusion, or to staff, e.g., errors, work stress. Patients are generally more satisfied with their comfort than staff. Also, the proportion of staff that suffers from self-reported building-related symptoms is larger than that of patients. Differences in the comfort of patients are related to specific diseases, their health state and personal factors. The perceptions of comfort and health of hospital workers are influenced by personal factors, such as age, gender, atopic diseases, and by work-related aspects, such as work pressure, working hours or activities. Also, the preferences of hospital staff can vary, due to personal and work-related aspects.

The scope for further research was refined by the review. The field study focused on health and comfort in outpatient areas, because these departments are understudied, while outpatient care is increasing [3]. Staff was studied, because they were generally more dissatisfied with their comfort than patients are. Because of the wide range of confounding variables that were indicated by the review, a comprehensive approach, including a broad range of personal, work, and building-related aspects was chosen.

7.2.2 Part 2 (chapter 3,4 and 5)

To gain insights into the relations of comfort and health with personal, work, and building-related aspects, a survey was conducted in six hospitals. The survey was administered in the spring of 2019. The study was approved by the Ethics Committee of the Delft University of Technology in October 2018. Data on the perceptions of comfort and health were collected from a questionnaire, that was answered by 556 outpatient workers. The questionnaire included questions on health and satisfaction with IEQ, social comfort, and the overall quality (PEQ), as identified in the literature review. The design and validation of the questionnaire, which comprised validated and newly designed questions, and the procedure of the survey are explained in chapter 3. Data of building characteristics were collected from cleaning protocols of the hospital organizations, drawings of the layout and building inspection of the locations, building services and 127 outpatient rooms. Information on the building characteristics is provided in chapters 4 and 5. To understand whether and how the perceptions of comfort and health were influenced, analysis of the data was performed from three different starting points, i.e., work characteristics, personal aspects, and building characteristics. The sub-questions, that are in accordance with the three starting points, are answered in the following three sections.

7.2.2.1 Chapter 3

How are the comfort and health of workers in outpatient areas of hospitals associated with work-related characteristics?

The rationale behind this sub-question is based on the literature review, which identified the differences associated with work characteristics, such as the function of rooms, or activities. Therefore, questions on the use of room types, most frequently used room types, performed activities, flexibility, and the number of persons, were included in the questionnaire. Because preliminary analysis of the data indicated variation of activities, duration of stay and number of persons between room types, room types were taken as a representative indicator for work-related characteristics. The room types were reception area, office, consultation room, and treatment room. The question was broken down into the following three detailed questions:

- Is it likely that the proportion of staff suffering from the most prevalent building-related symptoms varies in relation to room types?
- Is it likely that dissatisfaction with the IEQ and social comfort aspects, which bother most outpatient staff, varies in relation to room types?
- Is it likely that the perceived overall quality (PEQ) varies in relation to room types?

To answer these questions, first the most prevalent building-related symptoms, most dissatisfying comfort aspects, and the perceived overall quality were identified. Logistic regression was used to predict comfort and health in relation to room types because this technique is flexible with regard to distribution and type of variables [2]. The calculations were adjusted for personal factors. The four room types were mutually compared. This resulted in fourteen sets of six comparisons of the room types, i.e., for two building-related symptoms, for eleven comfort aspects (including cleanliness), and for PEQ ((2+11+1)·6).

The most prevalent building-related symptoms were dry eyes (50%) and headaches (38%). Those who worked more frequently in offices were more likely to suffer from dry eyes than the group of workers in the consultation rooms. Because of the limited variation between room types, it was concluded that associations of the occurrence of dry eyes and headaches needed further investigation, which included building-related aspects. This was done in chapter 5.

The most dissatisfying IEQ aspects were temperature (49%), indoor air quality (46%), and daylight (48%). More than half of the outpatient workers found the indoor air too dry (56%), while more than one-third found the air stuffy (34%) and was annoyed by noise from other people (40%). The social comfort aspects that outpatient workers were most dissatisfied with were privacy (36%), distraction by noise (36%), and crowding (32%). The satisfaction with social comfort aspects varied generally more than the satisfaction with IEQ between those working in different room types. For example, the probability for differences in privacy was largest (P-value <0.001), and varied in five of the six comparisons of room types, while satisfaction with the overall indoor air quality varied in two comparisons of room types and with a smaller probability (P-value<0.05). Satisfaction with cleanliness was least likely to vary between those working in different room types. It was concluded that the perceptions of comfort between groups working in different room types can vary and that the extent of variation in satisfaction differs per comfort aspect.

While more than half of the outpatient workers (53%) were dissatisfied with the perceived overall quality (PEQ), the variation thereof between room types was limited. Only those who worked more frequently at reception desks were more likely to be satisfied with PEQ than those who worked most frequently in treatment rooms.

The study identified differences in the comfort of outpatient workers in relation to the room types where they work most frequently. One possible cause for the difference in comfort is a variation of the individuals’ preferences, due to expectations or sensitivity. Although the calculations were adjusted for personal aspects, such as age and mood, differences between individuals with regards to their preferences were not included. Preferences were studied in chapter 4.

7.2.2.2 Chapter 4

How do outpatient workers differ in their preferences and comfort perceptions?

As the perceptions and preferences of comfort can vary between individuals, profiles of clusters with similar preferences and perceptions may justify the differences between individuals. Preferences were included because understanding and fulfilling the preferences can contribute to improved satisfaction. To study preferences, questions were included in the questionnaire that were closely related to the questions on the perception of comfort. Because of differences in IEQ and social comfort, preferences for social comfort and IEQ were studied separately. Therefore, the following detailed questions were asked.

- What are the profiles of the outpatient workers, clustered by their preferences and perception of IEQ?
- What are the profiles of the outpatient workers, clustered by their preferences and perception of social comfort?
- To what extent are IEQ and social comfort clusters similar, regarding personal aspects, work-related aspects, building-related aspects, and health?

The outpatient workers were asked to select the three most important aspects for their work performance on a list of 15 dose or building-related aspects and on a list of 12 social comfort aspects. Six main IEQ preferences were found, selected by 95% of the participants and four social comfort preferences, selected by 94% of the participants. The combination of the three most important aspects varied widely between the participants; the favourite combination of IEQ aspects was selected by 3% of the respondents, and the favourite combination of social comfort aspects was selected by 16% of the respondents, followed by 5% for the second favourite combination. This result shows that individual outpatient workers have different preferences.

To generate profiles for groups with similar preferences and satisfaction with comfort, a set of IEQ clusters and a set of social comfort clusters were produced with TwoStep Cluster Analysis. TwoStep Cluster Analysis was used because this allows to include continuous and binary data and the predictor importance of the included variables can be used for interpretation and understanding of the results. Several steps were needed for the preparation of the analysis. First, the strength of correlations between comfort and similar preferences was analysed to check the multicollinearity between preferences and comfort. Because the strength of correlations between comfort and preferences was negligible, both could be included in the cluster analysis. Subsequently, the comfort variables were reduced with

Principal Component Analysis into a smaller number of independent IEQ and social comfort components. This resulted in four IEQ components, labelled as “noise-related discomfort”, “light-related discomfort”, “discomfort indoor air”, and “thermal discomfort,” and three social comfort components labelled as “disturbance”, “sense of space”, and “interaction.” Using the components and main preferences, a set of six IEQ clusters and a set of three social comfort clusters were produced and internally validated. The main preferences and perceptions of IEQ of the clusters were: “control of ventilation preferred, uncomfortable with air,” “fresh air preferred, moderately comfortable,” “control of temperature preferred, moderately thermally uncomfortable,” “good acoustics preferred, comfortable,” “not too cold or hot temperature preferred, uncomfortable,” and “daylight preferred, moderately uncomfortable” (see Figure 7.1).

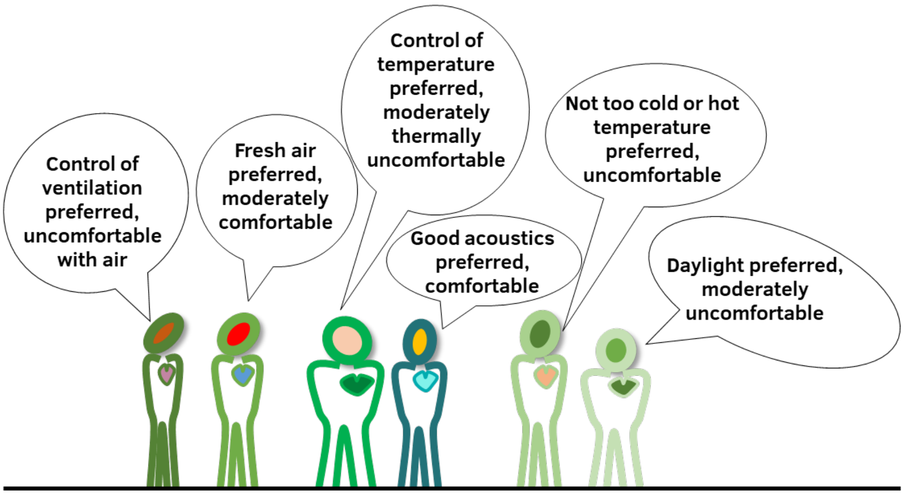

FIG. 7.1 The main preferences and the perception of the comfort of the IEQ clusters

The main preferences and perceptions of the social comfort clusters were “no distraction by noise preferred, high disturbance,” “privacy of patients preferred, moderate disturbance” and “safe workplace preferred, moderate disturbance” (see Figure 7.2).

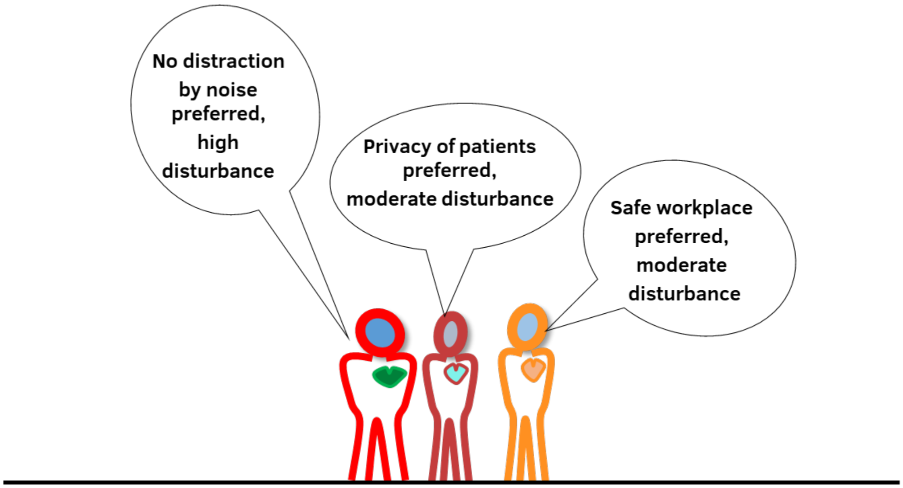

FIG. 7.2 The main preferences and the perception of the comfort of the social comfort clusters

Subsequently, profiles were based on comparisons of personal, work, and building-related aspects between the clusters. The IEQ profiles varied mainly in health. For example, those with the main preference for control of ventilation were most likely to suffer from building-related symptoms and to have sick leave. The profiles for social comfort were mainly differentiated by work-related aspects, such as activities. Those who regarded privacy for patients important were more likely to perform activities with patients, such as medical treatment, than those in the other two clusters. The IEQ and social comfort profiles had limited overlap. More than 120 variables were compared and only the preference for no annoyance from noise and the presence of a façade window varied in both sets of profiles. Furthermore, two variables had an overlap between the two sets of clusters for different categories; the room type and the number of persons in the room. For example, the social comfort clusters were differentiated by single-person rooms, while the IEQ clusters were differentiated by rooms for more than one person. Surprisingly, only a few building-related aspects differed within the set of IEQ profiles or social comfort profiles.

Because the preferences put more weight on the clusters than the perceptions of comfort, it can be suggested that the occupants' preferences are to a large extent independent from the actual building characteristics, while preferences can be influenced by work characteristics and health. Risk factors for health can be determined with multivariate analysis, including personal, work and building-related aspects, as suggested in chapter 3. This was done in chapter 5.

7.2.2.3 Chapter 5

How are dry eyes and headaches associated with building-related aspects?

Building-related symptoms, that can affect the occupants' health, sick leave, and productivity, are a problem with a societal impact. The prevalence of building-related symptoms in hospitals is generally higher than in office buildings. Therefore, it is important to gain insight into the risk factors.

Relations between building-related symptoms and building-related aspects were studied. The most prevalent building-related symptoms of the outpatient workers were dry eyes and headaches. Previous literature indicated that building-related symptoms are multifactorial because they can be influenced by personal, work and building-related aspects. Multivariate logistic regression was used for the analysis because these calculations enable to predict an outcome (dry eyes/ no dry eyes) that can include multiple independent variables (building-related aspects) and is adjusted for the influence of confounding variables (e.g., personal aspects).

First, associations of dry eyes with all investigated building-related aspects were analysed with and without adjustment of confounding variables. The personal aspects, that were included as confounding variables, were based on previous literature. The calculations were used to get an overview of the building-related aspects that needed to be included in the final calculations. Inclusion criteria for calculation of the final model for dry eyes were building-related aspects that were associated after adjustment for confounding variables with a probability of more than 80% (P-value >0.200), completeness >80%, and variance >10%. These criteria were used to ensure that building-related aspects that could be a risk factor were included, while not strongly influenced by building-related aspects that were present for only a few occupants and were representative of all participants [2].
For headaches, associations with personal, work, and building-related aspects were analysed, because previous literature on confounding variables of building-related headaches was limited. Personal, work, and building-related aspects, that were associated with headaches in the first calculations, were included in the calculation of the final model according to the aforementioned criteria. The final models were produced step-by-step and checked for reliability and validity.

The final models showed associations of dry eyes and headaches with building-related aspects. The risk for dry eyes or headaches is higher for outpatient workers who work most frequently in an office than for those who work most frequently in a consultation room. Also, the presence of others in the room increases the risk for dry eyes and tends to increase the risk for headaches. Furthermore, the absence of a window to the façade and corridor is a risk factor for dry eyes and headaches, while the absence of a window to the façade or corridor is a risk for dry eyes and tends to be a risk for headaches.

Risk factors for dry eyes only were associated or tended to be associated with building-related aspects that can influence the indoor air quality (i.e., the presence of a rotating heat exchanger, and the cleaning frequency of the ventilation grills for indoor air supply and exhaust in the rooms).

7.2.3 Part 3 (chapter 6)

Which contextual aspects influence the preferences for comfort of outpatient workers?

The preferences for IEQ and social comfort were the main identifiers for the clusters and profiles of the outpatient workers (chapter 4). The strong differentiation of the preferences between the clusters brought in the question of how occupants differentiate their preferences. Furthermore, it was unknown to what extent the COVID-19 pandemic had influenced the context of the outpatient workers since the survey, that was performed in the spring of 2019 (Part 2). Therefore, this study intended to explain the outpatient workers' preferences and explore to what extent preferences can change. The study was performed in the Autumn of 2020 with outpatient workers who had participated in the survey in the spring of 2019.

A qualitative approach was chosen to explore in-depth the experiences and preferences for IEQ and social comfort. The study design combined photography and semi-structured interviews. Photographs, that were taken by the outpatient workers in advance, were used to support the narrative about comfort during the interviews. The semi-structured interviews allowed for follow-up questions during the interviews, while the answers could be compared to the answers on the survey in the spring of 2019. The interviews comprised the following main topics: work characteristics (to compare with the survey), changes due to the pandemic, preferences for IEQ, and preferences for social comfort. The participants were asked to rank and discuss the ranking of IEQ and social comfort aspects for comparison with the survey. The IEQ and social comfort aspects that were asked to be ranked were identified in chapter 4. The interviews were performed through videocalls and telephone calls, depending on the technical possibilities of the participants. To get a representative overview of the outpatient workers, 18 outpatient workers representing all IEQ and social comfort clusters and the three hospital organizations were recruited. One participant was excluded from the analysis because the audio recording was damaged.

Data were analysed according to the Gioia method (2013) [1]), following the steps for the inductive content analysis of the contextual changes due to the COVID-19 pandemic. A lens on the COVID-19 pandemic was specifically chosen for data reduction because of the new context. This resulted in a data structure that was validated in a workshop with other researchers. Then, fragments related to comfort and preferences were systematically selected, iteratively coded, and structured according to the predefined IEQ and social comfort aspects. Subsequently, a participant diagram was produced, to compare the preferences of the outpatient workers with the results from the survey, changes due to the pandemic, other changes, and perceived logic to rank preferences (i.e., perceived overlap of comfort aspects).

The outpatient workers experienced differences in IEQ and social comfort due to changes from the COVID-19 pandemic. The outpatient workers were worried about the indoor air quality, they were annoyed by the decreased speech intelligibility of patients, impoverished interaction, increased difficulties regarding patient privacy, and threatening behaviour. The study showed that the main preferences can change over time. The changes in preferences can be explained by contextual changes and by a lack of logic to differentiate preferences. The data allowed explaining the preferences of the clusters. The reason why IEQ aspects are important varied between the clusters. The reason why some social comfort aspects are important varied between the clusters, while other social comfort aspects did not vary between the clusters.

7.3 Answer to the main question

How are comfort and health in hospitals associated with personal, work, and building-related aspects?

The sub-questions, that were derived from this main question were studied in different steps (chapters 2-6).

A systematic literature review identified differences in comfort and health associated with different hospital departments, such as inpatient areas or intensive care, between occupant groups (patients, visitors, or staff), within occupant groups, and a broad range of building characteristics. The gap in the literature on the comfort and health of outpatient workers defined the scope of the field studies.

The data that were collected in the first phase with a questionnaire and building inspection, allowed for analysis of associations of the outpatient workers' health and comfort with personal, work, and building-related aspects.

First, with work characteristics as a starting point, the variation of comfort and health was studied between those working most frequently in different room types (chapter 3). The calculations were adjusted for personal aspects. Because of the limited relations of room types with building-related symptoms, it was decided to further analyse associations of building-related symptoms with building-related aspects. The main finding was that the perception of social comfort differed largely, followed by that of IEQ, while the variation of PEQ and health between room types was limited.

Then, with personal characteristics as a starting point, profiles for IEQ and social comfort were produced to justify differences in perception and preferences of individuals (chapter 4). The variation of IEQ and social comfort between room types that was determined in chapter 3, was strengthened by the profiles for social comfort, which varied in the use of offices and consultation rooms, and the profiles for IEQ, which varied in the use of reception areas. The main finding was that the IEQ clusters, social comfort clusters and building characteristics had limited mutually overlap.

Associations of building characteristics with health were identified in chapter 5. The association with room types was slightly stronger than in chapter 3. The association of the presence of a façade window with dry eyes and headaches strengthened the profiles for IEQ (chapter 3). Those in IEQ cluster 1 were most likely to suffer from dry eyes and headaches and had no façade window, while it was the opposite for those in IEQ cluster 4. Also, the presence of others in the room as a risk factor for dry eyes was in line with the profiles of IEQ. The main finding was that building-related aspects that can influence the layout, indoor air and visual quality are, or tend to be, associated with dry eyes and headaches.

The associations of building-related aspects with the outpatient workers' comfort and health, that were identified by answering the sub-questions of the first phase of this research are shown in Figure 7.3. The associations of building-related aspects with satisfaction, the IEQ, and the social comfort clusters, are not adjusted for mutual relations with building-related aspects.

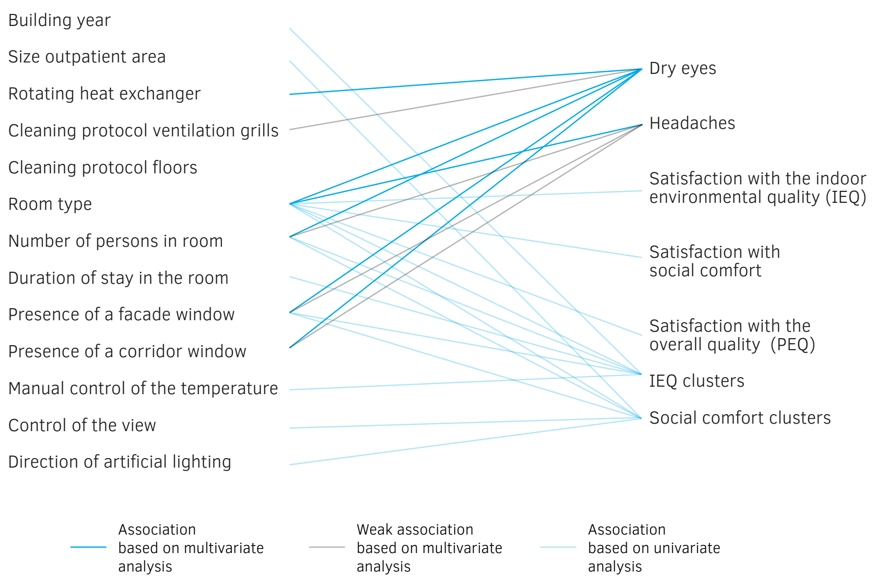

FIG. 7.3 Associations of building-related aspects with comfort and health of hospital workers in outpatient areas.

In the second phase of this research, qualitative data were collected with semi-structured interviews and photo-elicitation. The data allowed explaining of the preferences in the clusters, that had been identified in chapter 4. Changes in comfort and preferences due to the COVID-19 pandemic or other personal changes were identified in chapter 6. One of the main contextual changes was the reduction of the number of persons in the rooms. This was also one of the factors that distinguished the IEQ (2-4 and > 4 persons) and social comfort profiles (1 person) (chapter 4). The main findings were that the preferences can change and that the reason why IEQ and some social comfort aspects are important, varied between the clusters.

In conclusion, to understand the perception of comfort and health of outpatient workers, this research highlights four important aspects:

- Differences in IEQ and social comfort in relation to room types.
- Differences in preferences between individuals.
- Changes of preferences due to contextual changes.
- Associations of health with building-related aspects.

7.4 Limitations

This research had a few limitations with regard to the study design and data analysis; these limitations are explained in this section and suggestions are provided.

The type of hospital organization that was studied was a limitation. To avoid bias in organizational aspects, only teaching (top-clinical) hospitals were included in this study. To strengthen mutual comparability the main location and a satellite location of all three organizations were included. However, teaching hospitals differ from academic and general hospitals in their research capacity, teaching, specialization, and size. Teaching hospitals are generally larger than general hospitals and smaller than academic hospitals. Teaching hospitals teach physicians and conduct research activities but are not directly related to a university, in contrast to academic hospitals. The capacity for teaching is generally larger than in general hospitals. Future research involving outpatient workers of academic and general hospitals could determine whether there are differences in comfort and health associated with hospital types, due to differences in specialized care, presence of students for educational purposes, etc.

The sequential data collection of first quantitative data and then qualitative data had strengths and limitations. The reason to start with a quantitative study was to determine the questions and the sample for the follow-up phase [4]. The qualitative phase intended to build upon the quantitative results, that needed a more in-depth explanation. A questionnaire was designed based on existing and newly developed questions for the quantitative phase. The questionnaire was piloted in a general hospital. However, the questions might have limited the scope of the research. An alternative way of developing the questionnaire could be by first conducting interviews or focus groups to identify possible hidden themes related to comfort [5].

The sample size of the survey (556) was sufficient for the statistical analyses that were performed. For the study design, an initial calculation was made. A sample size of 400 was required for a confidence interval of 95% and a maximum degree of variability of 50% [6]. The starting point for this calculation was that all participants would answer all questions that were included in the analysis. In this study, 83% responded to all questions. The sample size was large enough for the logistic regression analysis, which was used to determine relations of comfort and health with room types and relations of health with building-related aspects. The sample size was tested according to the following recommendations of Peduzzi et al. [7]. The authors recommended at least 10 events per variable (EPV), based on simulation studies to determine the number of participants relative to the number of variables and categories included. The EPV was calculated as the degrees of freedom in the analysis divided by the lowest number of participants per aspect. For example, because more outpatient workers were satisfied with their privacy than dissatisfied, the EPV was calculated for the number of outpatient workers that was dissatisfied with privacy. In the present study between 11 and 20 events per variable were included.

For the TwoStep Cluster Analysis, the number of participants was sufficient according to simulation studies on an adequate sample size of cluster studies by Dolnicar et al. (2014) [8]. Based on simulation with a separation level between the clusters that was similar to the present study (0.0), a sample size of at least 40 participants per variable was needed. This means that for the IEQ clusters at least 360 participants were needed (519 included), and for the social comfort clusters at least 200 participants (538 included). The external validity of the profiles was checked with the follow-up study. However, a larger sample size increases the statistical power. Also, a larger sample size allows for multivariate analysis of building-related symptoms and comfort aspects per cluster, to further investigate building patterns in relation to the clusters.

The sample of the qualitative study comprised of outpatient workers of all IEQ and social comfort clusters, with varying functions and from the three hospital organizations that participated. This was important to cover possible different perceptions of the outpatient workers [9]. The sample size was sufficient according to the recommendation of Guest et al. (2006) with regards to data saturation [10]. Their recommendation was based on the comparison of the occurrence, definition, and variability in the frequency of codes of sixty semi-structured interviews. Participants that varied in socioeconomic status, and from two different countries were included. The first twelve interviews identified almost all categories, stable definitions for the categories and equal importance (derived relative to the number of participants) in comparison to the following 48 interviews. Based on their recommendation of at least 12 interviews, the number of participants in the present study (17) was sufficient for analysis of the changes due to the COVID-19 pandemic. However, the sample size was too low for validation of the clusters. More participants are needed to verify the profiles and develop more detailed recommendations for the planning and design of outpatient areas.

Furthermore, validation of the profiles was complex because of a changed context, due to the outbreak of the COVID-19 pandemic. The pandemic started between the quantitative phase and the qualitative phase. The study showed that preferences could change due to the measures that were taken to reduce the infection risk with the SARS-CoV-2 virus. These changes might have influenced the explanation of the clusters. However, the sequential study design allowed to account for the unforeseen pandemic, in contrast to a parallel collection of quantitative and qualitative data.

7.5 Implications and recommendations

This research offers results that contribute to science and practice, including new questions and directions that need further investigation in the future. Topics and questions are suggested that build on the findings of this research and may contribute to the further substantiation of knowledge on health and comfort. To clarify the suggestions, examples for study methods are included.

7.5.1 Research

This is the first study on the comfort and health of outpatient workers that includes a broad range of personal, work, and building-related aspects. The methods that were used and variables that were included allow for comparison with findings of studies in other building types and areas. This contributes to a better understanding of the differences and similarities of the occupants' comfort, health, and preferences in different building types. An example is the comparison of risk factors for dry eyes and headaches in previous studies in offices and the present study. Building upon exisiting sets of questions, new variables were included, such as room types. As the differences in comfort between room types imply that comfort and health can be influenced by different situations [11], inclusion of such variables in further studies could be relevant. The questionnaire and checklists can be used to further investigate and compare comfort and health in different building types and areas in the future (Appendix A to F).

The production of profiles of hospital occupants builds upon previous studies on home occupants [12], office workers [13-15], and schoolchildren [16]. The profiles contribute to the research model for an integrative approach that justifies differences due to the context and between individuals, to assess comfort and health more comprehensively [11].

The profiles showed that the preferences can differ within an occupant group (patients, visitors, staff) of one department. One of the reasons to study hospital workers is that they are generally less satisfied with comfort than patients and visitors according to previous studies [17-19]. However, the comfort of patients in outpatient areas should not be neglected and is an important indicator for their satisfaction with care [20, 21]. The next step is to identify profiles of patients and visitors. These profiles need to be compared with the profiles of the outpatient workers, to better understand the preferences of all occupants at outpatient areas.

The changes in preferences during the COVID-19 pandemic imply that comfort and health can be influenced by the context. To increase the validity of the profiles, it is important to determine to what extent preferences can change when the context changes. Hoeffler and Ariely (1999) suggested that a strong experience is more likely to form a stable preference, than a flawed experience [22]. Future studies need to determine possible differences in the stability and strength of the occupants' experience of preferences. The preferences that were identified as important in the present research [23] and the data structure of the COVID-19 changes [24] can be used to determine differences in the experience of comfort aspects. To better understand the preconditions for changes in preferences for comfort, the differences in the changeability between specific preferences and between individuals need to be assessed.

The profiles for social comfort are new, in comparison to previous studies on IEQ profiles [12, 13, 15, 16, 25, 26]. This research contributed to the scientific field of IEQ by including social comfort, based on studies in the field of environmental psychology [27-29]. The reason to include social comfort was because of the

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importance of both physical and social characteristics that can influence comfort [28]. While social comfort aspects, such as privacy, have been included in previous IEQ studies [30-32], social comfort was more specifically defined and elaborated in this research. Because of the limited overlap of IEQ and social comfort profiles, it might be useful to study both simultaneously in the future. The set of questions for social comfort was based on previous literature [31, 33-37]. A validated set of questions was not available. More studies of social comfort with focus groups can contribute to further validate the set of questions. The questions can be included in studies in other hospital areas to improve understanding of comfort.

One of the new findings in this study was the association of indoor windows with dry eyes and headaches [38]. Those who worked in a room with a window to the corridor were (or tended to be) less likely to have dry eyes or headaches than those who worked in a room without a window to the corridor. This needs further exploration, because the explanation of the associations of dry eyes and headaches with the presence of a corridor window is not straightforward, while it is relatively simple to apply corridor windows in buildings. A question on the presence of a corridor window can easily be included in future surveys on health and comfort in outpatient areas and other building areas or types. Also, causal relations of dry eyes and headaches with different lighting conditions, views to the corridor, ventilation rate, and ventilation flow, could be investigated in an experimental study. This study could be conducted in the experience room of the Sense Lab [39], where the amount of glass to the corridor can be adjusted with panels in front of the glass.

This research offers detailed insights into the differences in preferences for IEQ and social comfort. It clearly shows that standardized solutions do not fit all. Factors that contribute to the complexity for improved comfort of individuals are the dynamic use and shared use of rooms. The outpatient workers work in rooms with others, in more than one room type, not in fixed rooms, and at different locations. This implies frequent adaptation of the outpatient workers to the conditions of a room or negotiation with others about adjustment of the conditions in the room. The participants explained different adaptive strategies, varying from e.g., manual control, adjusted clothing, use of other rooms, compensation during breaks. However, this topic needs more in-depth exploration as to how different strategies are formed, used, and affect comfort and health. This can be done with varying methods. For example, ethnographic methods could be useful to explore the aspects associated with the formation and use of adaptive strategies. This allows to identify and understand the underlying factors (such as others in the room, duration of stay) of adaptive strategies [40]. A building inspection and mapping or simulation of the use of rooms enable to specify the relations of adaptive strategies with the building characteristics. Measurements of the pulse rate can contribute to an objective assessment of physiological arousal, as was previously included in a study to assess the patients' appraisal of waiting rooms [41]. To investigate the influence of adaptive strategies on the physical conditions, measurements of IEQ parameters could be executed close to the occupant before and after adaptive behaviour. For example, a humanoid robot could be used that carries measurement instruments and follows the occupant [42]. The measurements can be compared with the perception of comfort, physiological arousal, and information from the building inspection and building management systems. In short, multidisciplinary research, including building engineering, design, health sociology, physiology, environmental psychology, toxicology, etc. may allow for a more in depth-understanding of adaptive strategies of the occupants. This may open a new horizon to accommodate for flexibility and variety beyond standardized solutions.

7.5.2 Research and design

Some research and design questions, which are derived from this research, can be solved through knowledge exchange between research and practice. This can be beneficial to achieve research outcomes that are closely related to the needs of healthcare and design [43]. The first question is stressed by the strong and general preference of the outpatient workers for social interaction. Before the COVID-19 pandemic, 92% of the outpatient workers were satisfied with interaction with others, while impoverished interaction was a main complaint during the pandemic. One of the reasons was the accelerated shift from face-to-face care to digital care. Digital care may continue due to future epidemics of infectious diseases or because of organizational reasons. Therefore, it is important to investigate the influence of the changes in work processes and the occupants' preferences on the design of outpatient areas. New layouts can be iteratively designed, simulated, and evaluated, to assess whether the design can support face-to-face interaction and the care processes. Therefore, a collaboration of outpatient workers, policymakers, researchers, and architects can contribute to appropriate design solutions.

Another research and design question is derived from the need to control ventilation. Control of ventilation was a main worry during the COVID-19 pandemic. Previous literature suggested that indoor air quality is the main preference of hospital workers [44, 45]. Furthermore, control of ventilation was the main preference of those in the cluster with the highest frequency of sick leave. Also, an increased ventilation rate can contribute to a lower concentration of airborne virus-carrying particles [46]. Therefore, it is important to design solutions that enable the occupants to control ventilation in an energy-efficient way. This is a question that includes the design

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and well-structured assessment of the façade, layout, and air supply and exhaust systems. Therefore, close collaboration is needed between architects, building service engineers, hospital organizations, and researchers.

The profiles, that revealed the variation of preferences between the outpatient workers can support practitioners to envision the varying needs of the future occupants. To provide inspiration and to support awareness of facility managers, architects, and engineers, the IEQ and social comfort profiles are visualized into paper cubes (see Figure 7.4). These can be folded from the model in Figures 7.5, 7.6. The cubes show the preferences, satisfaction, personal, work, and building-related aspects from the survey in the spring of 2019. The colours represent a cluster (group of outpatient workers with similar preferences and satisfaction). The sizes of the coloured rectangle represent the proportion of outpatient workers in a cluster. A large rectangle (square) represents all outpatient workers of the cluster, a small rectangle (line) represents no outpatient workers in that cluster. For example, in IEQ cluster 1 all outpatient workers preferred control of ventilation, which is represented by a square. No outpatient workers preferred not too cold or hot temperature, which is represented by a line. The lines enable navigation within a cluster from e.g., preferences to personal aspects. On the top lie the numbers of the clusters. The cube could be used as a tool in conversations with and about the occupants' preferences and needs during design and maintenance. The usability of the tool could be investigated with focus groups, including all stakeholders who are involved in the design, occupation, and maintenance of outpatient areas.

FIG. 7.4 Image of the folded model of the IEQ and social comfort profiles of hospital workers in outpatient areas.

7.5.3 Education

The findings of this research can contribute to the education of architecture students. This work, among other studies, stresses the importance to address health in building design through the associations of building characteristics and health that were found. While most architects are not taught about the influence of design on health [47, 48], architects can offer a large contribution to the design of buildings that support health [49]. The evaluation of an education program, that intended to engage students with health in architecture, showed that practicing architects consciously addressed the influence of architecture on health after eight years [50]. Those students were educated by architects and public health specialists. As the design of a healthcare facility is one of the more complex assignments this may offer students a challenging project [51]. Because the profiles show the myriad relations of personal, work, and building-related aspects with preferences and perceptions, these could be used as a design tool that enables to capture (a part of the) complexity of hospital buildings.

7.5.4 Practice

Based on the main conclusion and the underlying studies, the following recommendations can be made:

- Design strategies could be developed to design an optimal fit with the specific function of rooms or areas, while the occupants' perceptions within a room or area can vary and change.
- Awareness of the differences in the preferences within occupant groups could be raised during the design, construction, and maintenance process.
- Awareness of the influence of integral design decisions (i.e., the decisions about architecture, building services, building maintenance, and building systems control) on the occupants' health could be raised.

This work implies that a next step is needed, building on the established requirements to design buildings that accommodate for the actual care vision and functional needs that balance with the flexibility for changes in the future. The next step is to accommodate the varying needs for IEQ and social comfort. The possibility to select rooms to work at that fit with the occupants' preferences, as enacted by some participants in this study, may contribute to the development of innovative design strategies for improved comfort. The paper cubes (Figure 7.4, 7.5, 7.6) could be used in the development of new design strategies to address the outpatient workers' comfort and health. Furthermore, differences in comfort and health could be addressed in design meetings with the occupants to improve their satisfaction in the future.

The findings of this work can be used for planning and design of renovation and newly built outpatient areas, to support the comfort of the outpatient workers. Application of the findings contributes to Evidence Based Design, which recommends using the best available research to support design decisions [52]. Detailed results are offered of the preferences and perceptions of IEQ and social comfort in relation to the use of rooms and building characteristics, as can been seen in Figures 7.3, 7.5, and 7.6. The building-related aspects of the outpatient areas can been seen in Appendix G. Discussion and nuances of the results can be found in chapters 3-7. Furthermore, the literature review comprised of a list with relations of the occupants' wellbeing and building characteristics which have been determined in previous studies in hospitals (Table 2.4, Table 2.5, and Figure 2.2 in chapter 2).

Furthermore, the risk for dry eyes and headaches could be reduced when the IEQ profiles and analysis of building-related symptoms are considered during the design process and maintenance (Figure 5.1, 7.3, 7.5). The profiles imply increased sick leave of those who suffer mainly from building-related symptoms, which is in line with previous studies [53, 54]. As the sick leave of healthcare workers in the Netherlands is relatively high [55], it is important to limit building-related symptoms. Also, physiological and psychological health can be negatively influenced by building-related symptoms [56]. Furthermore, it is vital to take the comfort and health of hospital workers seriously, because of the increasing pressure on hospital workers. The building-related aspects that can influence the risk for dry eyes and headaches are covered by the scope of different disciplines, such as architecture, building services, and building maintenance. Therefore, it is recommended that all stakeholders during the complete design, construction, and maintenance process put collaboratively health on the agenda.

FIG. 7.5 Unfolded model of the IEQ profiles of hospital workers in outpatient areas.

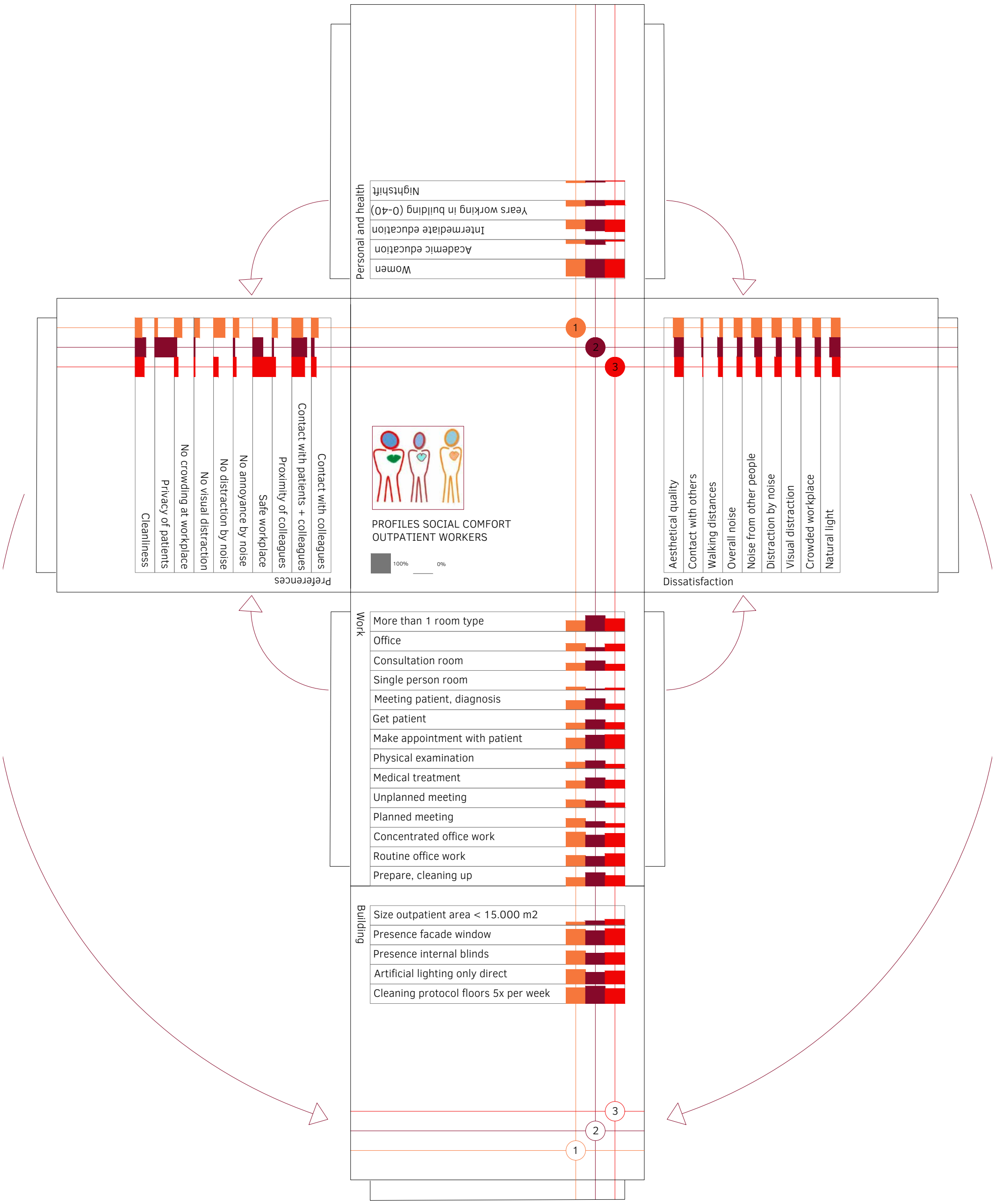

FIG. 7.6 Unfolded model of the social comfort profiles of hospital workers in outpatient areas.

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Appendices

APPENDIX A

Structure of the questionnaire

Toestemmingsformulier
↓
Persoonlijke informatie
↓
Algemene toestand
↓
Werkplek
↓
Medische achtergrond
↓
Ziekteverzuim
↓
Gezondheid op het werk
↓
Comfort
↓
Controle comfort
↓
Ruimtelijke aspecten
↓
Voorkeuren
↓
Leefstijl
↓
Psycho-sociale werkomgeving
↓
Afronding

APPENDIX B

Questionnaire

Onderzoek naar comfort en gezondheid in poliklinieken

Inleiding Graag danken we u bij voorbaat voor uw bijdrage aan dit onderzoek. Uw deelname wordt zeer op prijs gesteld. In verband met visievorming over toekomstige verbeteringen van poliklinieken, werkt het xxx ziekenhuis, samen met andere topklinische ziekenhuizen, graag mee aan dit onderzoek.

Doelstelling van de vragenlijst Het onderzoek is gericht op de rol die het binnenmilieu en interieur van een ziekenhuis hebben op het welbevinden van medewerkers in poliklinieken, en hoe dit verbeterd zou kunnen worden. Het onderzoek maakt deel uit van een promotieonderzoek aan de TU Delft.

Wat gaat er gebeuren? U wordt gevraagd een vragenlijst in te vullen over uw ervaring van het binnenmilieu en interieur van uw werkplek in de polikliniek. Ook worden vragen gesteld over uw gezondheid en klachten die gerelateerd kunnen zijn aan het gebouw, evenals andere factoren (levensstijl, gezondheid, werk). U krijgt vragen over uw leeftijd, sekse, medische achtergrond, werk (functie, parttime/fulltime), comfort (lawaai, luchtkwaliteit), ruimtegebruik (hoeveelheid ruimte), sociale werkomgeving (werkdruk), ziekteverzuim, mentale en fysieke aspecten (humeur, symptomen). Het invullen zal ongeveer 25 minuten in beslag nemen.

Voordelen van het onderzoek De door u verstrekte gegevens dragen bij aan kennis hoe het binnenmilieu en interieur in ziekenhuizen de gezondheid en het comfort van medewerkers kan beïnvloeden. Deze informatie helpt het ziekenhuis om in de toekomst optimale poliklinieken te realiseren.

Brengt deelname aan dit onderzoek nadelige effecten of risico's met zich mee? Nee, deelname brengt geen nadelige effecten of risico's met zich mee.

Privacy Deelname is anoniem. Als u belangstelling heeft om deel te nemen aan een vervolgonderzoek, kunt u uw e-mailadres achterlaten. Persoonlijke gegevens worden na afronding van het onderzoek vernietigd. Alle data worden op een beveiligde server opgeslagen, toegankelijk met een wachtwoord voor alleen het onderzoeksteam van de TU Delft. Het onderzoek is op 5 oktober 2018 door de Ethische Toetsingscommissie goed gekeurd.

Vrijwillig Uw deelname is vrijwillig. U kunt op ieder moment stoppen. Mocht u zich niet comfortabel voelen bij een bepaalde vraag, dan kunt u deze overslaan. Als u wilt stoppen met invullen, kunt u gewoon het venster sluiten. Alleen als u op ‘’VERSTUREN’’ aan het eind van de vragenlijst klikt, wordt uw informatie in het onderzoek meegenomen.

Hoe worden de gegevens gebruikt? De resultaten worden alleen voor bovengenoemd onderzoek gebruikt. Ze worden gepresenteerd op conferenties, lezingen en in wetenschappelijke publicaties. Echter, uw gegevens blijven ten alle tijde anoniem. Uw ziekenhuisorganisatie ontvangt een beknopte rapportage, specifiek op uw ziekenhuis gericht. Ook in deze rapportage zijn uw gegevens anoniem, en is uw identiteit nooit te herleiden. De ziekenhuisorganisatie neemt de aanbevelingen mee bij de visie- en planvorming voor de renovatie van de poliklinieken. De ziekenhuisorganisatie verplicht zich niet om eventuele klachten die naar voren komen, op te lossen.

Contactgegevens Indien u bezwaar of vragen heeft, dan kunt u contact opnemen in het ziekenhuis met xxx of bij de TU Delft met AnneMarie Eijkelenboom (a.m.eijkelenboom@tudelft.nl). Indien u mee wilt doen, klik op akkoord

Hierbij ga ik akkoord met bovenstaande en neem graag deel aan het onderzoek. Ik kan op ieder moment stoppen en mijn deelname terugtrekken.

PERSOONLIJKE GEGEVENS

Wat is uw geslacht?	
☐	Man
☐	Vrouw
☐	Anders

Wat is uw hoogst behaald onderwijsniveau?	
☐	Basisonderwijs
☐	Vmbo, havo-, vwo-onderbouw, mbo 1
☐	Havo, vwo, mbo
☐	Hbo-, wo-bachelor
☐	Hbo-, wo-master, doctor
☐	Anders, namelijk ....

Wat is uw geboortejaar?								
Geboortejaar	☐ 1935	☐ 1945	☐ 1955	☐ 1965	☐ 1975	☐ 1985	☐ 1995	☐ 2005

Werkt u fulltime of parttime?	
☐	Fulltime
☐	Parttime

Hoe zou u het werk omschrijven dat u doet (onafhankelijk van de functiebenaming)?	
☐	Administratief
☐	Arts-assistent
☐	Balie/ receptiemedewerker
☐	Coördinator
☐	Gespecialiseerd verpleegkundige
☐	Leidinggevende
☐	Medisch specialist
☐	Ondersteunend (facilitair, ICT, veiligheid etc.)
☐	Physician assistent
☐	Spreekuur assistent
☐	Verpleegkundige
☐	Verpleegkundig specialist
☐	Vrijwilliger
☐	Anders, namelijk ....

Op welke afdeling werkt u? (u kunt meerdere afdelingen kiezen)	
☐	Anesthesiologie
☐	Cardiologie
☐	Chirurgie
☐	Dermatologie
☐	Geboortezorg
☐	Gynaecologie
☐	Interne geneeskunde
☐	Kaakchirurgie
☐	Kindergeneeskunde
☐	KNO
☐	Longziekten
☐	Neurologie
☐	Oogheelkunde
☐	Orthopedie
☐	Plastische chirurgie
☐	Psychiatrie & psychologie
☐	Slaapcentrum (longen)
☐	Urologie
☐	Anders, namelijk ....

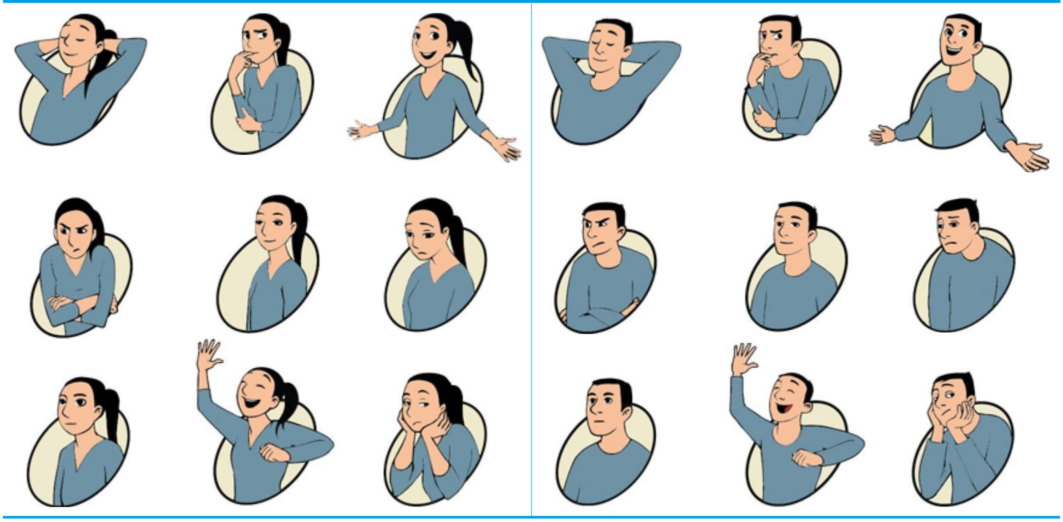
Werkt u 's nachts?	
☐	Ja, gemiddeld meer dan één nacht per maand
☐	Ja, gemiddeld één nacht per maand
☐	Nee

Hoe lang werkt u per week gemiddeld op de POLIKLINIEK? *	
☐	0-4 uur
☐	5-8 uur
☐	9-16 uur
☐	17-24 uur
☐	25-32 uur
☐	33-40 uur
☐	Meer dan 40 uur

** Dus niet in een ander deel van het ziekenhuis?*

PSYCHOSOCIALE ASPECTEN

Kunt u het plaatje kiezen dat het best past bij hoe u zich voelt?



In welke mate zijn onderstaande bijvoeglijke naamwoorden in het algemeen voor u van toepassing?					
Op een schaal van 1 (helemaal niet van toepassing) tot 5 (in grote mate van toepassing)					
	1	**2**	**3**	**4**	**5**
Overstuur	☐	☐	☐	☐	☐
Vijandig	☐	☐	☐	☐	☐
Alert	☐	☐	☐	☐	☐
Beschaamd	☐	☐	☐	☐	☐
Geïnspireerd	☐	☐	☐	☐	☐
Nerveus	☐	☐	☐	☐	☐
Vastberaden	☐	☐	☐	☐	☐
Oplettend	☐	☐	☐	☐	☐
Bang	☐	☐	☐	☐	☐
Actief	☐	☐	☐	☐	☐

Heeft u recent een ingrijpende POSITIEVE gebeurtenis* ervaren?	
☐	Ja
☐	Nee

** huwelijk, geboorte, etc.*

Heeft u recent een ingrijpende NEGATIEVE gebeurtenis* ervaren?	
☐	Ja
☐	Nee

** (sterfgeval, ongeluk, ernstige ziekte, etc.)*

WERKPLEK

Werkt u op verschillende ziekenhuislocaties?	
☐	Ja
☐	Nee

Op welke van onderstaande locaties werkt u het meest?	
Bij een verdeling van 50% kiest u een locatie.	
☐	A
☐	B

Wij zouden het op prijs stellen als u alle vragen beantwoordt voor de ziekenhuislocatie waar u het meest werkt.

Hoe tevreden bent u over het gebouw waar u (het meest) werkt?	
Op een schaal van 1 (heel ontevreden) tot 10 (heel tevreden	
▢	1
▢	2
▢	3
▢	4
▢	5
▢	6
▢	7
▢	8
▢	9
▢	10

Hoe tevreden bent u over uw werk?	
Op een schaal van 1 (heel ontevreden) tot 10 (heel tevreden	
▢	1
▢	2
▢	3
▢	4
▢	5
▢	6
▢	7
▢	8
▢	9
▢	10

In welk jaar bent u in het gebouw, waar u het meest werkt, begonnen met werken?									
Jaar	▢ 1980	▢ 1985	▢ 1990	▢ 1995	▢ 2000	▢ 2005	▢ 2010	▢ 2015	▢ 2020

Uit welke activiteiten bestaat uw werk?	
(u kunt meerdere mogelijkheden kiezen)	
☐	Afspraak maken met patiënt
☐	Patiënt ophalen, de weg wijzen
☐	Gesprek, overleg, diagnose met patiënt
☐	Teleconsult met patiënt (telefonisch of met videoverbinding)
☐	Lichamelijk onderzoek patiënt
☐	Medische verrichting
☐	Gepland overleg (niet met patiënt)
☐	Telefonisch overleg (niet met patiënt)
☐	Ongepland overleg (niet met patiënt)
☐	Geconcentreerd bureauwerk
☐	Routinematig bureauwerk
☐	Dingen klaar leggen en opruimen
☐	Lab werk
☐	Anders, namelijk ....

In welke ruimtes voert u uw werk uit?	
(meerdere antwoorden mogelijk)	
☐	Kantoor (inclusief backoffice)
☐	Receptie (balie)
☐	Spreekkamer
☐	Onderzoekskamer
☐	Gecombineerde spreek- en onderzoekskamer
☐	Behandelkamer (ook laserbehandeling, echoscopie etc.)
☐	Overlegruimte
☐	Anders, namelijk ....

Welke ruimte gebruikt u tijdens uw werk het meest?	
☐	Kantoor (inclusief backoffice)
☐	Receptie (balie)
☐	Spreekkamer
☐	Onderzoekskamer
☐	Gecombineerde spreek- en onderzoekskamer
☐	Behandelkamer (ook laserbehandeling, echoscopie etc.)
☐	Overlegruimte
☐	Anders, namelijk ....

Hoe lang verblijft u op een werkdag gemiddeld in uw meest gebruikte werkruimte gedurende een aaneengesloten periode?	
(onderbrekingen korter dan 5 minuten niet meegenomen)	
☐	Minder dan 1 uur
☐	1 tot 2 uur
☐	2 tot 3 uur
☐	3 tot 4 uur
☐	4 tot 5 uur
☐	5 tot 6 uur
☐	6 tot 7 uur
☐	7 tot 8 uur
☐	8 tot 9 uur
☐	Meer dan 9 uur

Heeft u een vaste of flexibele KANTOOR werkplek?	
☐	Vast, altijd dezelfde werkplek
☐	Flexibel, gedeeld met collega's van dezelfde afdeling
☐	Volledig flexibel

Welke omschrijving sluit het best aan bij de KANTOOR werkplek waar u het meest werkt?	
Een ruimte met:	
☐	1 werkplek
☐	2 werkplekken
☐	3 werkplekken
☐	4 werkplekken
☐	5 tot 8 werkplekken
☐	9 of meer werkplekken

Voert u uw kantoorwerkzaamheden MET NAME uit in de spreek- en/of onderzoekskamer?	
☐	Ja
☐	Nee

Werkt u in een vaste of flexibele SPREEKKAMER, ONDERZOEKSKAMER OF GECOMBINEERDE SPREEK/ONDERZOEKSKAMER?	
☐	Vast, altijd in dezelfde ruimte
☐	Flexibel, gedeeld met collega's van dezelfde afdeling
☐	Volledig flexibel

Werkt u in een vaste of flexibele BEHANDELKAMER?	
▢	Vast, altijd in dezelfde ruimte
▢	Flexibel, gedeeld met collega's van dezelfde afdeling
▢	Volledig flexibel

Werkt u achter dezelfde of verschillende receptie balies?	
▢	Vast, altijd dezelfde receptie balie
▢	Flexibel, verschillende receptie balies

Met hoeveel personen (patiënten, collega's, medewerkers of anderen) bent u over het algemeen op uw werkplek?	
▢	Alleen
▢	2 personen
▢	3 personen
▢	4 personen
▢	5 tot 8 personen
▢	9 of meer personen

Welke omschrijving sluit het best aan bij het uitzicht vanaf uw werkplek naar buiten?	
▢	Volledig transparant
▢	Half afgeschermd (door folie op het glas, lamellen of anders)
▢	Volledig afgeschermd (door matglas of gordijn)
▢	Geen raam

Kunt u het raam op uw werkplek opendoen?	
▢	Ja
▢	Nee

Welke omschrijving sluit het best aan bij het uitzicht vanaf uw werkplek door glas in de deur of een raam naar de gang?	
▢	Volledig transparant
▢	Half afgeschermd (door folie op glas, lamellen of anders)
▢	Volledig afgeschermd (door matglas of gordijn)
▢	Geen raam of glas in de deur

MEDISCHE ACHTERGROND

Heeft uw dokter u ooit verteld dat u lijdt aan:	
(meerdere antwoorden mogelijk)	
☐	Migraine
☐	Astma
☐	Eczeem
☐	Allergie
☐	Hoog vetpercentage in het bloed (bijv. cholesterol, triglyceriden)
☐	Hoge bloeddruk
☐	Diabetes
☐	Depressiviteit
☐	Angst
☐	Hartaandoeningen
☐	Andere ademhalingsziekten
☐	Andere psychische problemen
☐	GEEN van bovenstaande ziektes/aandoeningen

Lijdt u **NOG STEEDS** aan de ziektes/ aandoeningen, zoals u in de vorige vraag heeft beantwoord?		
(wordt u ervoor behandeld en staat u onder controle)	**Ja**	**Nee**
Migraine	☐	☐
Astma	☐	☐
Eczeem	☐	☐
Allergie	☐	☐
Hoog vetpercentage in het bloed (bijv. cholesterol, triglyceriden)	☐	☐
Hoge bloeddruk	☐	☐
Diabetes	☐	☐
Depressiviteit	☐	☐
Angst	☐	☐
Hartaandoeningen	☐	☐
Andere ademhalingsziekten	☐	☐
Andere psychische problemen	☐	☐
GEEN van bovenstaande ziektes/aandoeningen	☐	☐

Heeft u DE AFGELOPEN TWAALF MAANDEN voor de ziektes/aandoeningen waaronder u nog steeds lijdt, een medische behandeling, inclusief medicatie, ondergaan?		
	Ja	**Nee**
Migraine	☐	☐
Astma	☐	☐
Eczeem	☐	☐
Allergie	☐	☐
Hoog vetpercentage in het bloed (bijv. cholesterol, triglyceriden)	☐	☐
Hoge bloeddruk	☐	☐
Diabetes	☐	☐
Depressiviteit	☐	☐
Angst	☐	☐
Hartaandoeningen	☐	☐
Andere ademhalingsziekten	☐	☐
Andere psychische problemen	☐	☐
GEEN van bovenstaande ziektes/aandoeningen	☐	☐

Is ooit door de dokter/huisarts aan iemand uit uw directe familie* verteld dat hij/zij lijdt aan:	
(meerdere antwoorden mogelijk)	
☐	Migraine
☐	Astma
☐	Eczeem
☐	Allergie
☐	Hoog vetpercentage in het bloed (bijv. cholesterol, triglyceriden)
☐	Hoge bloeddruk
☐	Diabetes
☐	Depressiviteit
☐	Angst
☐	Hartaandoeningen
☐	Andere ademhalingsziekten
☐	Andere psychische problemen
☐	GEEN van bovenstaande ziekte/aandoeningen

** ouders, broers, zussen, kinderen*

ZIEKTEVERZUIM

Hoe vaak heeft u zich de afgelopen 12 maanden gedurende een week, of korter dan een week, ziekgemeld?	
☐	Nooit
☐	1 keer
☐	2 keer
☐	3 keer
☐	4 keer of vaker

Hoe vaak heeft u zich de afgelopen 12 maanden langer dan een week ziekgemeld?	
☐	Nooit
☐	1 keer
☐	2 keer
☐	3 keer
☐	4 keer of vaker

Hoeveel dagen in totaal heeft u zich de afgelopen 12 maanden ziekgemeld?	
☐	1 tot 3 dagen
☐	4 tot 7 dagen
☐	8 tot 30 dagen
☐	31 tot 90 dagen
☐	Meer dan 90 dagen

GEZONDHEID OP HET WERK

Heeft u ooit een van de volgende symptomen tijdens het werk op uw werkplek in dit gebouw ervaren (inclusief vandaag)?	
(meerdere antwoorden mogelijk)	
☐	Droge ogen
☐	Tranende of jeukende ogen
☐	Brandende, geïrriteerde ogen
☐	Verstopte of volle neus
☐	Lopende neus
☐	Droge/geïrriteerde keel
☐	Hoesten
☐	Niezen
☐	Drukkend gevoel op de borst
☐	Griepachtige symptomen
☐	Uitslag of geïrriteerde huid
☐	Droge huid
☐	Hoofdpijn
☐	Lusteloosheid, ongebruikelijke vermoeidheid
☐	Andere symptomen, namelijk ....
☐	GEEN symptomen

Op hoeveel dagen in de afgelopen vier weken (inclusief vandaag) heeft u tijdens het werk op uw werkplek de volgende symptomen ervaren?				
	Niet in de afgelopen vier weken	1-3 dagen in de afgelopen 4 weken	1-3 dagen per week in de afgelopen 4 weken	Elke of bijna elke werkdag
Droge ogen	☐	☐	☐	☐
Tranende of jeukende ogen	☐	☐	☐	☐
Brandende, geïrriteerde ogen	☐	☐	☐	☐
Verstopte of volle neus	☐	☐	☐	☐
Lopende neus	☐	☐	☐	☐
Droge/geïrriteerde keel	☐	☐	☐	☐
Hoesten	☐	☐	☐	☐
Niezen	☐	☐	☐	☐
Drukkend gevoel op de borst	☐	☐	☐	☐
Griepachtige symptomen	☐	☐	☐	☐
Uitslag of geïrriteerde huid	☐	☐	☐	☐
Droge huid	☐	☐	☐	☐
Hoofdpijn	☐	☐	☐	☐
Lusteloosheid, ongebruikelijke vermoeidheid	☐	☐	☐	☐
Andere symptomen, namelijk, ...	☐	☐	☐	☐
GEEN symptomen	☐	☐	☐	☐

Werd dit beter of slechter wanneer u weg was van uw werkplek (bijv. tijdens vakantie, weekend, etc.)?			
	Beter	Geen verschil	Slechter
Droge ogen	☐	☐	☐
Tranende of jeukende ogen	☐	☐	☐
Brandende, geïrriteerde ogen	☐	☐	☐
Verstopte of volle neus	☐	☐	☐
Lopende neus	☐	☐	☐
Droge/geïrriteerde keel	☐	☐	☐
Hoesten	☐	☐	☐
Niezen	☐	☐	☐
Drukkend gevoel op de borst	☐	☐	☐
Griepachtige symptomen	☐	☐	☐
Uitslag of geïrriteerde huid	☐	☐	☐
Droge huid	☐	☐	☐
Hoofdpijn	☐	☐	☐
Lusteloosheid, ongebruikelijke vermoeidheid	☐	☐	☐
Andere symptomen, namelijk, ...	☐	☐	☐
GEEN symptomen	☐	☐	☐

In welk jaargetijde zijn de symptomen het ergst? (meerdere antwoorden mogelijk)	
☐	Zomer
☐	Herfst
☐	Winter
☐	Lente
☐	Geen specifiek jaargetijde

Tijdens welk deel van de dag zijn de symptomen het ergst? (meerdere antwoorden mogelijk)	
☐	Ochtend
☐	Middag
☐	Avond
☐	Nacht
☐	Geen specifiek dagdeel

COMFORT MEEST GEBRUIKTE WERKPLEK

Hoe tevreden was u met de volgende comfort aspecten op uw meest gebruikte werkplek gedurende de AFGELOPEN VIER WEKEN?

op een schaal van 1 (heel ontevreden) tot 7 (heel tevreden)

	1	2	3	4	5	6	7
Algemeen comfort	☐	☐	☐	☐	☐	☐	☐
Temperatuur	☐	☐	☐	☐	☐	☐	☐
Lucht kwaliteit	☐	☐	☐	☐	☐	☐	☐
Natuurlijke verlichting	☐	☐	☐	☐	☐	☐	☐
Kunstverlichting	☐	☐	☐	☐	☐	☐	☐
Licht algemeen	☐	☐	☐	☐	☐	☐	☐
Uitzicht naar buiten	☐	☐	☐	☐	☐	☐	☐
Uitzicht naar de gang	☐	☐	☐	☐	☐	☐	☐
Lawaai algemeen	☐	☐	☐	☐	☐	☐	☐
Lawaai van buiten het gebouw	☐	☐	☐	☐	☐	☐	☐
Lawaai van gebouwinstallaties (leidingen, ventilatie, etc.)	☐	☐	☐	☐	☐	☐	☐
Lawaai van apparaten (printer, medische apparatuur, etc.)	☐	☐	☐	☐	☐	☐	☐
Lawaai van mensen (telefoongesprekken, pratende collega's, etc.)	☐	☐	☐	☐	☐	☐	☐
Trillingen	☐	☐	☐	☐	☐	☐	☐

Kunt u hieronder beschrijven hoe u de volgende aspecten GEDURENDE DE AFGELOPEN 4 WEKEN heeft ervaren?								
op een schaal van 1 tot 7								
	1	2	3	4	5	6	7	
Temperatuur								
Te koud	☐	☐	☐	☐	☐	☐	☐	Te heet
Varieert te veel tijdens de dag	☐	☐	☐	☐	☐	☐	☐	Te weinig variatie
Luchtbeweging								
Tochtig	☐	☐	☐	☐	☐	☐	☐	Te weinig luchtbeweging
Luchtkwaliteit								
Vochtig	☐	☐	☐	☐	☐	☐	☐	Droog
Stoffig	☐	☐	☐	☐	☐	☐	☐	Fris
Stinkt	☐	☐	☐	☐	☐	☐	☐	Geurloos

Bij luchtkwaliteit heeft u de geur lager dan 4 beoordeeld (stinkt). Kunt u hieronder benoemen waar uw werkplek naar stinkt?	
☐	Chemicaliën/ desinfectiemiddelen
☐	Lichaamsgeur
☐	Voedsel
☐	Vocht
☐	Afvoer/ fecaliën
☐	Anders, namelijk ....

Verlichting								
	1	2	3	4	5	6	7	
Verblinding	☐	☐	☐	☐	☐	☐	☐	Geen verblinding
Reflectie van zon en lucht	☐	☐	☐	☐	☐	☐	☐	Geen reflectie

Uitzicht								
	1	2	3	4	5	6	7	
Dichtbij	☐	☐	☐	☐	☐	☐	☐	Veraf
Op natuur	☐	☐	☐	☐	☐	☐	☐	Op gebouw(en) en/of wegen

CONTROLE OVER HET COMFORT VAN UW WERKPLEK

Hoeveel controle heeft u over de volgende aspecten op uw MEEST GEBRUIKTE werkplek?

Op een schaal van 1 (geen) tot 7 (veel)

	1	2	3	4	5	6	7
Temperatuur	☐	☐	☐	☐	☐	☐	☐
Ventilatie (toevoer van frisse lucht)	☐	☐	☐	☐	☐	☐	☐
Zonwering	☐	☐	☐	☐	☐	☐	☐
Verlichting	☐	☐	☐	☐	☐	☐	☐
Uitzicht/inkijk	☐	☐	☐	☐	☐	☐	☐
Lawaai	☐	☐	☐	☐	☐	☐	☐

Hoe tevreden bent u over de controle van de volgende aspecten op uw MEEST GEBRUIKTE werkplek?

Op een schaal van 1 (heel ontevreden) tot 7 (heel tevreden)

	1	2	3	4	5	6	7
Temperatuur	☐	☐	☐	☐	☐	☐	☐
Ventilatie (toevoer van frisse lucht)	☐	☐	☐	☐	☐	☐	☐
Zonwering	☐	☐	☐	☐	☐	☐	☐
Verlichting	☐	☐	☐	☐	☐	☐	☐
Uitzicht/inkijk	☐	☐	☐	☐	☐	☐	☐
Lawaai	☐	☐	☐	☐	☐	☐	☐

RUIMTELIJKE ASPECTEN VAN UW MEEST GEBRUIKTE WERKPLEK

In welke mate bent u het eens met de volgende stellingen over uw MEEST GEBRUIKTE werkplek?							
Op een schaal van 1 (heel ontevreden) tot 7 (heel tevreden)							
	1	2	3	4	5	6	7
Ik vind mijn werkplek ruim genoeg.	☐	☐	☐	☐	☐	☐	☐
Ik heb genoeg bergruimte.	☐	☐	☐	☐	☐	☐	☐
Ik hoef NIET te veel te lopen tijdens mijn werk.	☐	☐	☐	☐	☐	☐	☐
De collega's met wie ik veel samenwerk, zijn NIET te ver weg.	☐	☐	☐	☐	☐	☐	☐
Ik heb op mijn werkplek voldoende contact met andere mensen.	☐	☐	☐	☐	☐	☐	☐
Ik heb op mijn werkplek voldoende privacy.	☐	☐	☐	☐	☐	☐	☐
Mijn werkplek biedt patiënten voldoende privacy.	☐	☐	☐	☐	☐	☐	☐
Ik word op mijn werkplek te veel afgeleid door geluiden.	☐	☐	☐	☐	☐	☐	☐
Ik word op mijn werkplek te veel afgeleid door beweging van anderen (bijv. mensen die langslopen).	☐	☐	☐	☐	☐	☐	☐
Ik voel me voldoende veilig op mijn werkplek.	☐	☐	☐	☐	☐	☐	☐
Ik vind het te druk (met andere mensen) op MIJN WERKPLEK.	☐	☐	☐	☐	☐	☐	☐
Ik vind het te druk (met andere mensen) in HET GEBOUW.	☐	☐	☐	☐	☐	☐	☐
Ik vind MIJN WERKPLEK schoon en hygiënisch. (	☐	☐	☐	☐	☐	☐	☐
Ik vind HET GEBOUW schoon en hygiënisch.	☐	☐	☐	☐	☐	☐	☐

Hoe zou u de ruimtelijke kwaliteit/uitstraling van uw MEEST GEBRUIKTE werkplek omschrijven?								
	1	2	3	4	5	6	7	
Kleurrijk	☐	☐	☐	☐	☐	☐	☐	Eentonig
Negatief	☐	☐	☐	☐	☐	☐	☐	Positief
Stimulerend	☐	☐	☐	☐	☐	☐	☐	Saai
Aantrekkelijk	☐	☐	☐	☐	☐	☐	☐	Onaantrekkelijk
Stress opwekkend	☐	☐	☐	☐	☐	☐	☐	Rustgevend
Comfortabel	☐	☐	☐	☐	☐	☐	☐	Oncomfortabel
Deprimerend	☐	☐	☐	☐	☐	☐	☐	Opgewekt
Goed	☐	☐	☐	☐	☐	☐	☐	Slecht
Saai	☐	☐	☐	☐	☐	☐	☐	Levendig
Helder	☐	☐	☐	☐	☐	☐	☐	Dof
Niet motiverend	☐	☐	☐	☐	☐	☐	☐	Motiverend
Aangenaam	☐	☐	☐	☐	☐	☐	☐	Onaangenaam

VOORKEUREN

Welke 3 psychosociale aspecten zijn voor u het MEEST belangrijk om uw werk goed te kunnen doen?	
☐	Collega's dichtbij
☐	Contact met collega's
☐	Contact met patiënten
☐	Contact met collega's en patiënten
☐	Een veilige werkplek
☐	Korte loopafstanden
☐	Niet te veel afleiding door geluid
☐	Niet te veel afleiding door mensen die langslopen
☐	Niet te veel drukte (door mensen) in het GEBOUW
☐	Niet te veel drukte (door mensen) op de WERKPLEK
☐	Voldoende privacy voor uzelf
☐	Voldoende privacy voor de patiënten
☐	DEZE VRAAG OVERSLAAN

Welke 3 gebouw gerelateerde aspecten zijn voor u het MEEST belangrijk om uw werk goed te doen?	
☐	Controle over temperatuur
☐	Controle over uitzicht en inkijk
☐	Controle over ventilatie (toevoer van frisse lucht)
☐	Controle over zonwering
☐	Geen geluidsoverlast
☐	In hoogte verstelbare bureaus en bureaustoelen
☐	Niet te koud, niet te warm
☐	Reinheid, hygiëne
☐	Uitstraling interieur (kleur en materiaal)
☐	Uitzicht naar buiten
☐	Uitzicht naar de gang
☐	Voldoende daglicht
☐	Voldoende frisse lucht
☐	Voldoende ruimte
☐	Voldoende bergruimte
☐	DEZE VRAAG OVERSLAAN

LEEFSTIJL

Hoe reist u naar uw werk? (meerdere antwoorden mogelijk)	
☐	Auto/taxi
☐	Motor/bromfiets/scooter
☐	Openbaar vervoer
☐	Fiets/ elektrische fiets
☐	Te voet

Hoe lang reist u gemiddeld per werkdag naar uw werk (ALLEEN HEEN)?

	0 tot 15 minuten	15 tot 30 minuten	30 minuten tot 1 uur	1 tot 1,5 uur	Meer dan 1,5 uur
Auto/taxi	☐	☐	☐	☐	☐
Motor/bromfiets/scooter	☐	☐	☐	☐	☐
Openbaar vervoer	☐	☐	☐	☐	☐
Fiets/ elektrische fiets	☐	☐	☐	☐	☐
Te voet	☐	☐	☐	☐	☐

Sport u? (Hieronder wordt matig intensieve of intensieve beweging verstaan)	
☐	Ja
☐	Nee

Hoeveel dagen sport u gemiddeld per week?

Aantal dagen	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

Hoeveel minuten sport u gemiddeld per keer?	
☐	Minder dan 30
☐	30-60
☐	Meer dan 60

Drinkt u wel eens koffie en/of thee?	
☐	Ja
☐	Nee

Hoeveel koppen koffie en thee drinkt u op uw werk gemiddeld PER DAG?						
(bij meer dan 10 kiest u 10)						
Aantal koppen koffie	0	2	4	6	8	10
Aantal koppen thee	0	2	4	6	8	10

Drinkt u wel eens een glas alcohol?	
☐	Ja
☐	Nee

Hoeveel glazen alcoholische dranken drinkt u gemiddeld PER WEEK?									
(bij meer dan 16 kiest u 16)									
Aantal glazen	0	2	4	6	8	10	12	14	16

Rookt u?	
☐	Ja
☐	Nee

Heeft u ooit gerookt?	
☐	Ja
☐	Nee

In welk jaar bent u met roken begonnen?								
(inschatting)								
Jaar	1950	1960	1970	1980	1990	2000	2010	2020

Hoeveel sigaretten, e-sigaretten, pijp en/of sigaren rookt u gemiddeld PER DAG?							
(bij meer dan 30 kiest u 30)							
Aantal sigaretten	0	5	10	15	20	25	30
Aantal e-sigaretten	0	5	10	15	20	25	30
Aantal sigaren/pijp	0	5	10	15	20	25	30

Rookt er iemand bij u in huis?	
☐	Ja
☐	Nee

PSYHOSOCIALE WERKOMGEVING

Kunt u omschrijven in welke mate u het eens bent met onderstaande stellingen over uw werk?	
Er is vaak hoge tijdsdruk door een hoge werkdruk	
☐	Nee
☐	Ja, maar ik heb er GEEN last van
☐	Ja, ik heb er EEN BEETJE last van
☐	Ja, ik heb er NOGAL VEEL last van
☐	Ja, ik heb er VEEL last van
Tijdens mijn werk word ik vaak gestoord en onderbroken.	
☐	Nee
☐	Ja, maar ik heb er GEEN last van
☐	Ja, ik heb er EEN BEETJE last van
☐	Ja, ik heb er NOGAL VEEL last van
☐	Ja, ik heb er VEEL last van
Ik draag veel verantwoordelijkheid in mijn werk.	
☐	Nee
☐	Ja, maar ik heb er GEEN last van
☐	Ja, ik heb er EEN BEETJE last van
☐	Ja, ik heb er NOGAL VEEL last van
☐	Ja, ik heb er VEEL last van
Van mijn leidinggevenden krijg ik de waardering die ik verdien.	
☐	Nee
☐	Ja, maar ik heb er GEEN last van
☐	Ja, ik heb er EEN BEETJE last van
☐	Ja, ik heb er NOGAL VEEL last van
☐	Ja, ik heb er VEEL last van
De waardering en aanzien die ik krijg zijn in overeenstemming met al mijn inspanningen en prestaties.	
☐	Nee
☐	Ja, maar ik heb er GEEN last van
☐	Ja, ik heb er EEN BEETJE last van
☐	Ja, ik heb er NOGAL VEEL last van
☐	Ja, ik heb er VEEL last van
De promotiekansen in mijn werk zijn slecht.	
☐	Nee
☐	Ja, maar ik heb er GEEN last van
☐	Ja, ik heb er EEN BEETJE last van
☐	Ja, ik heb er NOGAL VEEL last van
☐	Ja, ik heb er VEEL last van

>>>

Kunt u omschrijven in welke mate u het eens bent met onderstaande stellingen over uw werk?	
Mijn persoonlijke kansen op promotie in het werk zijn in overeenstemming met al mijn inspanningen en prestaties.	
☐	Nee
☐	Ja, maar ik heb er GEEN last van
☐	Ja, ik heb er EEN BEETJE last van
☐	Ja, ik heb er NOGAL VEEL last van
☐	Ja, ik heb er VEEL last van
Mijn persoonlijke kansen op promotie in het werk zijn in overeenstemming met al mijn inspanningen en prestaties.	
☐	Nee
☐	Ja, maar ik heb er GEEN last van
☐	Ja, ik heb er EEN BEETJE last van
☐	Ja, ik heb er NOGAL VEEL last van
☐	Ja, ik heb er VEEL last van
Mijn inkomen/salaris is in overeenstemming met al mijn inspanningen.	
☐	Nee
☐	Ja, maar ik heb er GEEN last van
☐	Ja, ik heb er EEN BEETJE last van
☐	Ja, ik heb er NOGAL VEEL last van
☐	Ja, ik heb er VEEL last van
De laatste jaren is mijn werk veeleisender geworden.	
☐	Nee
☐	Ja, maar ik heb er GEEN last van
☐	Ja, ik heb er EEN BEETJE last van
☐	Ja, ik heb er NOGAL VEEL last van
☐	Ja, ik heb er VEEL last van
Mijn eigen baan loopt gevaar.	
☐	Nee
☐	Ja, maar ik heb er GEEN last van
☐	Ja, ik heb er EEN BEETJE last van
☐	Ja, ik heb er NOGAL VEEL last van
☐	Ja, ik heb er VEEL last van
In mijn werk kom ik gemakkelijk in tijdnood.	
☐	Helemaal mee eens
☐	Mee eens
☐	Niet mee eens
☐	Helemaal niet mee eens
Het gebeurt vaak dat ik bij het wakker worden al aan werkproblemen denk.	
☐	Helemaal mee eens
☐	Mee eens
☐	Niet mee eens

>>>

Kunt u omschrijven in welke mate u het eens bent met onderstaande stellingen over uw werk?	
☐	Helemaal niet mee eens
Als ik thuiskom kan ik mijn werk heel makkelijk van me afzetten.	
☐	Helemaal mee eens
☐	Mee eens
☐	Niet mee eens
☐	Helemaal niet mee eens
Degenen die mij het meest dierbaar zijn, zeggen dat ik me te veel voor mijn werk opoffer.	
☐	Helemaal mee eens
☐	Mee eens
☐	Niet mee eens
☐	Helemaal niet mee eens
Het werk laat mij zelden los, zelfs 's avonds spookt het nog door mijn hoofd.	
☐	Helemaal mee eens
☐	Mee eens
☐	Niet mee eens
☐	Helemaal niet mee eens
Als ik iets uitstel dat ik vandaag had moeten doen, kan ik 's nachts niet slapen.	
☐	Helemaal mee eens
☐	Mee eens
☐	Niet mee eens
☐	Helemaal niet mee eens

AFRONDING VRAGENLIJST

Indien u belangstelling heeft om mee te werken aan het vervolg van dit onderzoek, kunt u uw e-mailadres invullen. De gegevens worden opgeslagen op een beveiligde server, die alleen voor het onderzoeksteam van de TU Delft toegankelijk is. Na afronding van het onderzoek worden de persoonlijke gegevens vernietigd. Alle gegevens worden geanonimiseerd.

E-mailadres	....
Heeft u nog vragen of opmerkingen?	....

APPENDIX C

Checklist building

Name hospital	....
Investigation date dd/mm/yyyy	....
Name investigator 1	....
Name investigator 2	....
Name investigator 3	....
Year of construction	....

Have parts of the outpatient area been renovated since the last ten years?	
☐	No
☐	Yes, specify areas and years ....

OUTDOOR CHARACTERIZATION

Number of levels above ground	....

Are there nearby (within 100 meters) potential AIR POLLUTION sources that might influence the indoor environment?	
☐	None
☐	Car parking
☐	Attached parking garage
☐	Kiss and ride (inclusive taxis, small buses)
☐	Helicopter landing
☐	Highway
☐	Power plant for the building
☐	Other power plant (up to 1 km)
☐	Gasoline dispensing facilities
☐	Industry (up to 10 km)
☐	Cooling towers
☐	Waste management site (up to 3 km)
☐	Agricultural sources (up to 3 km)
☐	Other, specify ....

Are there nearby (within 100 meters) potential NOISE sources that might influence the indoor environment?	
☐	None
☐	Car parking with min. 50 places
☐	Entrance ambulance
☐	Kiss and ride (inclusive taxis, small buses)
☐	Helicopter landing
☐	Busy road
☐	Highway
☐	Railway or station
☐	Subway
☐	Sea, river, or canal traffic
☐	Construction activities (building, roads, etc.)
☐	Sports events
☐	Other entertainment or leisure
☐	Factories
☐	Commercial premises
☐	Forestry, farming, etc.
☐	Community buildings (churches, halls, etc.)
☐	Other, specify ....

Are there nearby (within 100 metres) potential LIGHT sources that might influence the indoor environment?	
☐	None
☐	Nearby reflection from cars near the building (parking, road)
☐	Large pond, river, or canal reflection
☐	Reflection from nearby buildings
☐	Sun blocking from nearby buildings
☐	Other, specify ....

Are the windows in the outpatient areas openable?	
☐	Yes
☐	Yes, some.
☐	Yes, but occupants are not allowed to open them.
☐	No

Type of solar shading	
☐	None
☐	Fixed blinds on the outside
☐	Sun shading on the outside, specify type ....
☐	Sunscreen between glass panels
☐	Sun protective glass

On which facades are solar shading devices?	
☐	Not applicable
☐	South
☐	West
☐	North
☐	East

BUILDING SERVICES

Is the heating system similar for all outpatient areas?	
☐	Yes
☐	No, different systems within the outpatient area, specify areas ....

Is there a cooling system in the outpatient areas?	
☐	No
☐	Yes, in the complete outpatient area.
☐	Yes, in some parts of the outpatient area, specify ....

Which type of cooling system is present?	
☐	Not applicable
☐	Top cooling, specify area ....
☐	Air conditioning, specify area ....
☐	Floor cooling, concrete core activation, specify area ....
☐	Other, specify system ....

Is mechanical ventilation present in the outpatient areas?	
☐	No
☐	Yes, in the complete outpatient area.
☐	Yes, in some parts of the outpatient area, specify …………

Ventilation strategy	
☐	Not applicable
☐	Mechanical (only exhaust), specify area …………
☐	Mechanical (only supply), specify area …………
☐	Balance ventilation, specify area …………
☐	Displacement ventilation, specify area …………
☐	Other, specify …………

What type of control system is there for mechanical ventilation?	
☐	Not applicable
☐	Central, manual, specify area …………
☐	Central, clock, specify area …………
☐	Central, demand control, specify area …………
☐	Local, manual, specify area …………
☐	Local, clock, specify area …………
☐	Local, demand control, specify area …………
☐	Recirculation control, specify area …………

To what extent in the local system controlled?	
☐	Not applicable
☐	Per room
☐	Per area, specify …………

Air handling units	
☐	Not applicable
☐	100% fresh air
☐	Recirculating fresh air
☐	Recirculating fan, free cooling system
☐	Dual duct system and recirculating air
☐	Other, specify …………

What type of humidification?	
☐	Not applicable
☐	None
☐	Spray
☐	Evaporative
☐	Steam
☐	Ultrasonic
☐	Infrasonic
☐	Other, specify ....

What type of water purification?	
☐	Not applicable
☐	None
☐	Ozone
☐	Biocide
☐	High voltage
☐	UV
☐	Other, specify ....

Is the system equipped with water droplet eliminators?	
☐	Not applicable
☐	Yes
☐	No

Is the system designed and maintained to collect and drain condensed water from cooling coils adequately?	
☐	Not applicable
☐	Yes
☐	No

What type of outdoor filters is used?	
☐	Pre-filter, specify type ....
☐	Pre-filter, specify, class ....
☐	Main filter, specify type ....
☐	Main filter, specify class ....

What type of heat recovery is used?	
☐	Not applicable
☐	None
☐	Fixed plate exchanger
☐	Rotating wheel exchanger
☐	Heat pipes
☐	Two-coil glycol water exchanger
☐	Other, specify ....

What is the position of the ventilation system intake?	
☐	Not applicable
☐	Roof
☐	Facade
☐	Ground
☐	Other, specify ....

What is the height of the ventilation intake above the ground level (in meters)?	
☐	Intake 1: ....
☐	Intake 2: ....
☐	Intake 3: ....
☐	Intake 4: ....
☐	Intake 5: ....

What is the distance from the ventilation system intake to potential air pollution sources? (in meters)	
☐	None ....
☐	Car parking ....
☐	Attached parking garage ....
☐	Kiss and ride (inclusive taxis, small buses) ....
☐	Helicopter landing ....
☐	Highway ....
☐	Power plant for the building ....
☐	Gasoline dispensing facilities ....
☐	Cooling towers ....
☐	Other, specify ....

Do you have any remarks/comments which are relevant for interpretation of the results?
....

APPENDIX D

Checklist room

email address investigator 1	
email address investigator 2	
email address investigator 3	
What is the main function of the room?	

What is the room number?	
Please mark the room number on the drawing as well.	
☐	Reception
☐	Office or back office.
☐	Consultation and/or examination room.
☐	Treatment room specify type of treatment ....

To what extent is the room enclosed from the adjacent circulation area or other rooms?	
☐	Completely enclosed with walls, (inclusive doors, glass panels, etc.) from floor to ceiling.
☐	Partly enclosed with half height walls, panels, or cupboards, partly with walls from floor to ceiling.
☐	Other, specify ....

WINDOWS

Presence of glass in the door and/or a window to the corridor?	
☐	Yes
☐	No
☐	Other, specify ....

Is there a window present in the facade?	
☐	Yes
☐	No

Is the window openable?	
☐	Yes
☐	No
☐	Other, specify ....

Height parapet (the underside of the glass line):	
☐	0-20 cm
☐	21-90 cm
☐	More than 90 cm
☐	Other, specify ....

Contrast of window frames.	
☐	Light window frame, light wall
☐	Light window frame, dark wall
☐	Dark window frame, light wall
☐	Dark window frame, dark wall

WALLS

Are the lower parts of the walls provided with wainscot?	
☐	Yes
☐	No
☐	Other, specify ....

Are parts of the walls covered with acoustic panels?	
☐	Yes
☐	No
☐	Other, specify ....

Main type of wall covering.	
☐	Paint
☐	Wallpaper
☐	Glass
☐	Gypsum/plaster
☐	Plain concrete
☐	Brick
☐	Synthetic smooth (HPL, PVC, linoleum, vinyl, rubber)
☐	Plywood
☐	Ceramic tiles, natural stone
☐	Other, (specify) ....

Main type of wainscot	
☐	Synthetic smooth (HPL, PVC, linoleum, vinyl, rubber)
☐	Paint
☐	Wallpaper
☐	Glass
☐	Plain concrete
☐	Brick
☐	Gypsum/plaster
☐	Plywood
☐	Ceramic tiles, natural stone
☐	Other, (specify) ....

FLOOR

Main type of floor covering.	
☐	Synthetic smooth (linoleum, PVC, rubber, epoxy)
☐	Carpet
☐	Stone/ ceramic tiles
☐	Laminate (parquetry)
☐	Wood/cork
☐	Paint
☐	Other, specify ....

CEILING

Is there an acoustic ceiling?	
☐	Yes, completely suspended.
☐	Yes, partly with islands, baffles, or zones.
☐	No
☐	Other, specify ....

Main covering of (not acoustic) ceiling	
☐	Paint
☐	Gypsum plaster
☐	Plain concrete
☐	Wood
☐	Wood fibre, plywood
☐	Metal
☐	Wallpaper
☐	Other, specify ....

Main covering of acoustic ceiling panels.	
☐	Mineral fibre tiles
☐	Gypsum/plaster
☐	Synthetic
☐	Metal with perforations
☐	Wood fibre tiles, perforated plywood
☐	Wood, cork tiles
☐	Other, specify ....

VENTILATION

How is the room ventilated?	
☐	Mechanical balanced
☐	Mechanical assisted (only exhaust)
☐	Displacement ventilation
☐	(Only) natural ventilation
☐	Other, specify ....

Location of ventilation grills (multiple answer possible)	
☐	Ceiling
☐	Facade (inside)
☐	Wall above 1.80m
☐	Wall below 1.80m
☐	In the door
☐	On the duct
☐	Other, specify ....

Control ventilation	
☐	Manual local (in the room)
☐	Manual central
☐	Automatic
☐	CO2 Controlled
☐	Other, specify ....

Presence of mould or damp?	
☐	Yes, noticeable mould odour.
☐	Yes, visible damp spots on walls, floor, or ceiling.
☐	No
☐	Other, specify ....

Presence of visible dust?	
☐	Yes
☐	No
☐	Other, specify ....

INSULATION

Type of glass	
☐	Single glass
☐	Double glass
☐	HR++ glass
☐	Triple glass
☐	Other, specify ....

Are visible leaks in the structure present?	
☐	Yes, specify location ....
☐	No
☐	Other, specify ....

HEATING (AND COOLING, IF PRESENT)

What are the heating (and cooling) units (more than 1 answer is possible)?	
☐	Hot water radiator or convector
☐	Floor heating or cooling, concrete core
☐	Airconditioning cabinet
☐	Air supply in ceiling
☐	Air supply in wall
☐	Air supply in floor
☐	Radiant ceiling
☐	Radiant wall
☐	Other, specify ....

Are heaters located below windows to prevent downdraught in winter?	
☐	Yes
☐	No
☐	Other, specify ....

How is the room temperature controlled?	
☐	Manual, local (e.g., on thermostat on the wall, radiator valve)
☐	Manual central
☐	Automatic
☐	Other, specify ....

SUNSCREEN

Type of sun shading devices or glare protection (more than 1 answer possible)	
☐	None
☐	Fixed blinds on the outside of the facade
☐	Moveable sunscreen on the outside of the facade
☐	Sunscreen between glass panels
☐	Glass coating
☐	Light screen inside
☐	Other, specify ....

Control sunscreen	
☐	Individual
☐	Central down, individual up
☐	Automatic
☐	Other, specify ....

ARTIFICIAL LIGHTING

Direction of artificial lighting	
☐	Direct
☐	Indirect
☐	Combination

Type of main lighting	
☐	Fluorescent
☐	LED
☐	CFL (lightbulb)
☐	Medical lighting
☐	Combination
☐	Other, specify ....

Control of main lighting	
☐	Manual local
☐	Manual central
☐	Automatic time
☐	Automatic presence detection
☐	Other, specify ....

ACOUSTICS

Are there one or more freestanding acoustic panels?	
☐	Yes
☐	No
☐	Other, specify ....

Is the door provided with a dropseal?	
☐	Yes
☐	No
☐	Other, specify ....

APPARATUS

Which (functional) apparatus are in the room?	
(more than 1 answer is possible)	
☐	(Desktop) computer
☐	Medical apparatus
☐	Printer/ multi copier
☐	None
☐	Other, specify ....

Which other apparatus are in the room?	
(more than 1 answer is possible)	
☐	None
☐	Air cleaner
☐	Humidifier
☐	Dehumidifier
☐	Other, specify ....

FURNITURE

How many working places are present?							
Count number of tables for working places (desktop or laptop work), number of chairs for meeting places.							
	0	**1**	**2**	**3**	**4**	**5≥8**	**≥9**
Working	☐	☐	☐	☐	☐	☐	☐
Meeting	☐	☐	☐	☐	☐	☐	☐

Is the furniture for the working places (desktop or laptop work) adjustable in height?	
☐	Both tables and chairs
☐	Only tables
☐	Only chairs
☐	None
☐	Other, specify ....

How are the monitors of the desktop or laptops general positioned?	
☐	Parallel to windows, with window in the back
☐	Parallel to windows, with windows in the front
☐	Perpendicular to windows
☐	None of the above

How is the surface of the table desk?	
☐	Light unicolour, reflecting light.
☐	Light unicolour, not reflecting light.
☐	Dark unicolour, reflecting light.
☐	Dark unicolour, not reflecting light.
☐	Wooden like, reflecting light.
☐	Wooden like, not reflecting light.
☐	Other, specify ....

Are the following materials present in furniture or decoration elements?		
	Yes	No
MDF or particle board, less than one year old	☐	☐
Rugs	☐	☐
Curtains for window	☐	☐
Curtains for dressing area	☐	☐
Cushions	☐	☐
Plants in pots (not artificial)	☐	☐
Whiteboard with markers	☐	☐

If you did detect any important aspect that can help in the interpretation of the results, please explain in this textbox.
....

APPENDIX E

Checklist cleaning

Naam Ziekenhuis:	....
Totaal vloeroppervlak in m²:	....
Gemiddeld aantal gebruikers (patiënten + bezoekers + medewerkers):	....

SCHOONMAAK:

Hoe is de schoonmaakfrequentie en het type schoonmaak van de vloer, meubilair en voorwerpen in de polikliniek?

De tabel is ingevuld volgens de WIP-richtlijnen 2009, kunt u het aanpassen als hiervan afgeweken wordt?

	Vloer		Meubilair/voorwerpen	
		Frequentie (per week)		*Frequentie (per week)*
Behandelkamer	R	5	R	5
Spreekkamer harde vloer	R	5	R(SA)	2
Spreekkamer zachte vloer	R(S)	2	R(SA)	2
Onderzoekskamer	R	5	R	5
Receptie				
Backoffice/kantoor				

R=droog of nat reinigen, SA= stof afnemen, S=stofzuigen

Wanneer vindt schoonmaak in de poliklinieken in het algemeen plaats?

☐	's Ochtends vroeg, voordat de polikliniek opengaat
☐	Tijdens werktijden
☐	Tijdens de lunchpauze
☐	's Avonds, na sluitingstijd
☐	Van 's ochtends vroeg tot 's avonds laat
☐	Anders, namelijk..

Hoe is de schoonmaakfrequentie van de WANDEN in de polikliniek?							
	Min.1x per week	1-3 x per maand	½ tot 1x per maand	2-6 x per jaar	1x per jaar	Onregel-matig	Onbekend
Behandelkamer	☐	☐	☐	☐	☐	☐	☐
Spreekkamer	☐	☐	☐	☐	☐	☐	☐
Onderzoekskamer	☐	☐	☐	☐	☐	☐	☐
Receptie	☐	☐	☐	☐	☐	☐	☐
Backoffice/kantoor	☐	☐	☐	☐	☐	☐	☐

Hoe is de schoonmaakfrequentie van de PLAFONDS in de polikliniek?							
	Min.1x per week	1-3 x per maand	½ tot 1x per maand	2-6 x per jaar	1x per jaar	Onregel-matig	Onbekend
Behandelkamer	☐	☐	☐	☐	☐	☐	☐
Spreekkamer	☐	☐	☐	☐	☐	☐	☐
Onderzoekskamer	☐	☐	☐	☐	☐	☐	☐
Receptie	☐	☐	☐	☐	☐	☐	☐
Backoffice/kantoor	☐	☐	☐	☐	☐	☐	☐

Hoe is de schoonmaakfrequentie van de RAMEN in de polikliniek?							
	Min.1x per week	1-3 x per maand	½ tot 1x per maand	2-6 x per jaar	1x per jaar	Onregel-matig	Onbekend
Behandelkamer	☐	☐	☐	☐	☐	☐	☐
Spreekkamer	☐	☐	☐	☐	☐	☐	☐
Onderzoekskamer	☐	☐	☐	☐	☐	☐	☐
Receptie	☐	☐	☐	☐	☐	☐	☐
Backoffice/kantoor	☐	☐	☐	☐	☐	☐	☐

Hoe is de schoonmaakfrequentie van de VERLICHTINGSARMATUREN in de polikliniek?							
	Min.1x per week	1-3 x per maand	½ tot 1x per maand	2-6 x per jaar	1x per jaar	Onregel-matig	Onbekend
Behandelkamer	☐	☐	☐	☐	☐	☐	☐
Spreekkamer	☐	☐	☐	☐	☐	☐	☐
Onderzoekskamer	☐	☐	☐	☐	☐	☐	☐
Receptie	☐	☐	☐	☐	☐	☐	☐
Backoffice/kantoor	☐	☐	☐	☐	☐	☐	☐

REINIGING EN ONDERHOUD LUCHTBEHANDELINGSKASTEN EN VENTILATIESYSTEEM:

Hoe vaak vindt onderhoud/schoonmaak van de volgende onderdelen plaats?	
Schoonmaak luchttoevoerroosters + toebehoren	
☐	Onregelmatig
☐	2x per jaar of vaker
☐	1x per jaar
☐	1x per twee jaar
☐	Minder dan 1x per twee jaar
Laatste keer	....
Schoonmaak luchtafvoerroosters + toebehoren	
☐	Onregelmatig
☐	2x per jaar of vaker
☐	1x per jaar
☐	1x per twee jaar
☐	Minder dan 1x per twee jaar
Laatste keer	....
Schoonmaak luchtkanalen	
☐	Onregelmatig
☐	2x per jaar of vaker
☐	1x per jaar
☐	1x per twee jaar
☐	Minder dan 1x per twee jaar
Laatste keer	....
Vervangen luchtfilters	
☐	Onregelmatig
☐	2x per jaar of vaker
☐	1x per jaar
☐	1x per twee jaar
☐	Minder dan 1x per twee jaar
Laatste keer	....

APPENDIX F

Checklist layout

Name building	....

Total number of floors above the ground	
☐	1
☐	2
☐	3
☐	4
☐	5
☐	6
☐	7
☐	8
☐	9
☐	10
☐	11
☐	12
☐	13
☐	14
☐	15

Height of the building (m)	....
Construction year	....
Name building wing	....
Total outpatient area (m2)	....
Depth building wing (m)	....

Levels outpatient area	
☐	Ground floor
☐	First level
☐	Second level
☐	Third level
☐	Fourth level

Departments and levels					
	Ground floor	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Anesthesie	☐	☐	☐	☐	☐
Cardiologie	☐	☐	☐	☐	☐
Dermatologie	☐	☐	☐	☐	☐
Gynaecologie	☐	☐	☐	☐	☐
Interne geneeskunde	☐	☐	☐	☐	☐
Kaakchirurgie	☐	☐	☐	☐	☐
Kindergeneeskunde	☐	☐	☐	☐	☐
KNO	☐	☐	☐	☐	☐
Longgeneeskunde	☐	☐	☐	☐	☐
Neurologie	☐	☐	☐	☐	☐
Oncologie	☐	☐	☐	☐	☐
Oogheelkunde	☐	☐	☐	☐	☐
Orthopedie	☐	☐	☐	☐	☐
Pijnpoli	☐	☐	☐	☐	☐
Prikpunt	☐	☐	☐	☐	☐
Orthopedie	☐	☐	☐	☐	☐
Plastische chirurgie	☐	☐	☐	☐	☐
Anders, namelijk	☐	☐	☐	☐	☐

APPENDIX G

Building characteristics per building wing

Organization		*A*					*B*									*C*				
Location		*A2*			*A2*		*B1*				*B2*					*C1*				*C2*
Building wing		*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*
Cleaning																				
Floor (weekly)																				
Office/ reception	5x						x	x	x	x	x	x	x	x	x	x	x	x	x	x
	1x	x	x	x	x	x														
Consultation/ treatment	5x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	1x																			
Wall (weekly)																				
Office/ reception	1x	x	x	x	x	x														
	<1x						x	x	x	x	x	x	x	x	x	x	x	x	x	x
Consultation/ treatment	1x	x	x	x	x	x														
	<1x						x	x	x	x	x	x	x	x	x	x	x	x	x	x
Furniture (weekly)																				
Office/ reception	5x	x	x	x	x	x										x	x	x	x	x
	<5x						x	x	x	x	x	x	x	x	x					
Consultation/ treatment	5x	x	x	x	x	x										x	x	x	x	x
	<5x						x	x	x	x	x	x	x	x	x					
Ventilation grills (monthly)																				
1x		x	x	x	x	x														
<1x							x	x	x	x	x	x	x	x	x	x	x	x	x	x

>>>

Location																				
Pollutants																				
Highway <100 m					x	x	x	x	x	x	x	x	x	x	x					
Industry <1.5 km					x	x	x	x	x	x	x	x	x	x	x					
Pine forest <50 m																x	x	x	x	
Attached parking garage		x	x	x	x	x														
Cars parked close to the building		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Helicopter platform																				
Size outpatient																				
<15.000 m^2					x	x					x	x	x	x	x					x
>15.000 m^2		x	x	x			x	x	x	x						x	x	x	x	
Building or renovation year																				
1980-1989		x											x							
1990-1999			x					x									x			
2000-2009							x			x	x							x		x
2010-2018				x	x	x			x			x		x	x	x			x	
Dimension building wing																				
12<15 m					x		x			x										
15<20 m		x	x	x				x	x											
>20 m						x					x	x	x	x		x	x	x	x	x
Air handling units																				
Height intake ventilation AHU																				
Ground floor		x	x	x												x				
0<10 m										x	x	x	x	x	x					
>10 m					x	x	x	x	x								x	x	x	x
Type heat recovery																				
Nne		x	x	x																
Rotating heat exchanger					x	x										x	x	x	x	x
Two coil or cross flow							x	x	x	●	x	x	x	x	●					
Frequency replacement filters																				
2x per year																x	x	x	x	
< 2x per year		x	x	x	x	x	x	x	x	●	x	x	x	x	●					x
Type filters																				
Fine		x	x	x	x	x	x										x	x	x	x
Very fine								x	x	●	x	x	x	x	●	x				

>>>

Room aspects																				
Layout aspects																				
Enclosure room																				
Reception	Half open	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	
	Closed					x														x
Other rooms	Half open																			
	Closed	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Thermal aspects																				
Type heater																				
Facade window present	Radiator	x	x	x		x	x	x	x							x	x	x	x	x
	Air				x					x					x					
	Floor										x	x	x	x						
Facade window absent	Air	x	x	x	x		x	x	x	x							x	x	x	
	Floor										x	x	x	x		x				
Manual control heating																				
Facade window present	Y	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	●	●	x
	N																			
Facade window absent	Y	●	●	●	x	●	●	●	●	●	x	x	x	x	●	x	●			
	N																	x	x	
Openable window (technically)																				
Y		x	x	x	x	x		x	x	x					x	x	x	x	x	x
N							x				x	x	x	x						
Climate facade																				
Y											x		x	x						
N		x	x	x	x	x	x	x	x	x		x			x	x	x	x	x	x
Visual aspects																				
Mainly contrast window frame and wall																				
Y		x	x	x	x	x	x	x	x	x										
N											x	x	x	x	x	x	x	x	x	x
Height windowsill																				
<20 cm					x															
20<90 cm		x	x	x			x						x	x		x	x	x	x	x
>90 cm						x		x	x	x	x	x			x					
Control view (blinds or curtains)																				
Reception	Y	x	x	x	x		x	x	x							x	x	x	x	x
	N					x				x	x	x	x	x	x					
Office	Y	x	x	x	x	x			x											x
	N						x	x		x	x	x	x	x	x	x	x	x	x	

>>>

TOC

Consultation/ treatment	Y	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	N																			
Manual control lighting																				
Office, reception	Y	x	x	x			x	x	x	●	x	x	x	x	x		x	x	x	
	N				x	x										x				x
Consultation	Y	x	x	x			x	●	x		x	x	x	x	x		x	x	x	
	N				x	x				x						x				x
Treatment	Y	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x
	N				x	x														
Direction lighting																				
Reception	Direct	x	x	x	x	x					x		x	x	x	●		x	x	x
	Dir. + ind.						x	x	x	x		x					x			
Office	Direct	x	x	x	x	x	x	x	x	●	●	●	x	x	●	x	x	x	x	x
	Dir. + ind.																			
Consultation	Direct	x	x	x		x	●	●	●	x	x	x	x	x	x	●	x	x	x	x
	Dir. + ind.				x															
Treatment	Direct	x	x	x		x	●	●	●	x	x	x	x	x	x		x	x	x	x
	Dir. + ind.				x											x				
Acoustic aspects																				
Presence sound absorbing ceiling tiles																				
Y		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
N																				
Presence dropseal																				
Reception	Y					●				●	●		x	x		●				
	N	x	●	x	x		x	x	x			x			x		x	x	x	x
Office	Y		●	x	x	x				●		●			●	x		x	x	
	N	x					x	x	x		x		x	x			x			x
Consultation	Y					x		x	●	●	x		x	x	x	x	x	●	●	x
	N	x	●	x	x		x					x								
Treatment	Y		x	●	x	●		●	●	x	x		●	●	●	x	●	x	x	x
	N	x					x					x								
Covering materials																				
Main wall covering																				
Reception	Paint	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x
	Vinyl						x	x												
Office	Paint	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x
	Vinyl						x													
Consultation/ treatment	Paint	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x
	Vinyl						x													

>>>

Main floor covering																				
Reception	Hard	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
	Carpet																x			
Office	Hard	x	•	x	•		x	x	x	x	x	x	x	x	x	•	x	x	x	x
	Carpet		•			x														
Consultation/ treatment	Hard	x	x	x	x	x	x	x	x	x	x	x	x	x	x	xxx	x	x	x	x
Ergonomics																				
Adjustable furniture																				
Reception	Chair	x	x	x	•		x	x	x	x	x	x	x	x	x	•	x	x	x	
	Table + ch. air					x														x
Office	Chair	x	x	x	•	•					•	•					x			
	Table + ch. air.						x	x	x	•			x	x	x	x		•	•	x
Consultation	Chair	x	x	x	•					x										
	Table + ch. air.					•	x	x	x		x	x	x	x	x	x	•	•	•	x
Treatment	Chair	•	•	•	•					x							x			
	Table + ch. air.						x	•	x		•	x	x	x	•	x		•	•	•
Pollutants																				
Presence curtains																				
Reception/office (no window)	Y																			
	N	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Reception/office (window)	Y	x	x	x	x	x														
	N						x	x	x	x	x	x	x	x	x	x	x	x	x	x
Consultation (no window)	Y				x	x	x	x	x	x						x	x	x	x	x
	N	x	x	x							x	x	x	x	x					
Consultation (window)	Y	x	x	x	x	x	x	x	x	x						x	x	x	x	x
	N										x	x	x	x	x					
Treatment	Y	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	N																			
Presence plants																				
Reception	Y	•	•	•	•	x	x	x		•	x	x				•	x			x
	N								x				x	x	x			x	x	
Office	Y	•	•	•			•	x		•	•	•			•		x			x
	N				x	x			x				x	x		x		x	x	
Consultation/ treatment	Y																			
	N	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Y = Yes, N = No, Present = X, Ambiguous or limited information = •

APPENDIX H

Comparison of the activities per room type

Pertaining chapter 3

	Office	Reception	Consultation	Treatment	P-value
Appointment with patient**	71,9%	99,1%	45,6%	51,2%	**<0.000**
Get patient**	27,5%	39,1%	41,9%	62,8%	**<0.000**
Meeting/diagnosis with patient**	24,4%	20,9%	69,8%	44,2%	**<0.000**
Tele consult with patient**	26,3%	31,3%	52,6%	32,6%	**<0.000**
Physical investigation patient**	10,0%	13,0%	56,3%	37,2%	**<0.000**
Medical operation**	20,0%	33,0%	59,1%	76,7%	**<0.000**
Planned meeting (not with patient) **	37,5%	21,7%	45,1%	39,5%	**0.001**
Telephone calls (not with patient)	43,8%	32,2%	41,4%	30,2%	0.130
Unplanned meeting (not with patient) **	37,5%	21,7%	35,3%	20,9%	**0.010**
Concentrated desk work**	88,8%	77,4%	52,1%	39,5%	**<0.000**
Routine desk work**	75,0%	80,0%	39,1%	27,9%	**<0.000**
Lay things out**	48,8%	65,2%	48,8%	83,7%	**<0.000**
Lab work	2,5%	7,0%	5,6%	7,0%	0.322

**P-value <0.05, ** P-value<0.01*

APPENDIX I

Description of the clusters

Pertaining chapter 4

IEQ clusters

IC1 Uncomfortable with air, preference for control of ventilation
IC1 is the largest cluster with 107 outpatient workers, representing 21% of all outpatient workers included in the TwoStep Cluster Analysis.

Comfort. The outpatient workers in IC1 were generally dissatisfied with indoor air related aspects. The proportion of those who were dissatisfied with the overall quality of indoor air (62%) was higher than in the other clusters. Dissatisfaction with the overall quality of light was similar to IC2, IC5 and IC6 (39%, 35%, 37%, 35%) and higher than in the other clusters; dissatisfaction with artificial light was similar to IC2 and IC6 (42%, 33%, 36%) and higher than in the other clusters. This cluster represented the largest proportion of those who perceived dry air (66%) and too still air (28%).

Preferences. The three most important aspects of the workplace were control of ventilation (100%), control of temperature (46%) and cleanliness (39%). None of the outpatient workers in this cluster found “not too cold or too hot” one of the three most important aspects. IC1 represented the smallest proportion of those who found control of the view (4%) and the size of the workplace (6%) important.

Personal aspects. The effort reward imbalance (ERI), which is a scale for perceived work pressure and reciprocity at work[1], was equal to IC3 (1.3 (SD 0.4)) and lower than in the other clusters. The percentage of those who did not take sick leave in the

1 Siegrist, J., *Adverse health effects of high-effort/low-reward conditions.* Journal of Occupational Health Psychology, 1996. **1**(1): p. 27-41. DOI: https://doi.org/10.1037/1076-8998.1.1.27.

past year (33%) was lower than in the other clusters; the outpatient workers in this cluster tend to take more sick leave than those in other clusters.

Health-related aspects. The perceived symptom index (PSI14) of the outpatient workers in IC1was the highest of all clusters (3 (SD 2.3)). PSI 14 was calculated as the mean number of reported symptoms, which occurred in the last four weeks while they were working in the building and improved when they were not in the building. In this cluster the largest proportion reported suffering from dry eyes (68%) and watering eyes (22%). The percentage of those who reported headache was similar to IC2 (51%, 46%) and higher than in other clusters. The prevalence of dry throat was similar to IC2 and IC6 (respectively 28%, 26%, 28%), and higher than in the other clusters.

Workplace-related aspects. The cluster represented the smallest proportion of those who work most frequently in reception areas (11%), the variation of consultation, offices and treatment rooms did not vary between the clusters. Most (67%) stayed more than 4 hours per day at their most frequently used workplace. The largest proportion stayed with 2 to 4 persons in the room.*Building-related aspects.* The proportion of those who worked in a new building or renovated building(wing), which was built or renovated between 2010 and 2018, was in IC1 lower than in IC3, IC4 and IC5.

IC2 Moderately comfortable, preference for fresh air

IC2 comprises of 104 workers, 20% of the total sample.

Comfort. Those in IC2 were generally most dissatisfied with indoor air aspects and daylight. The percentage of outpatient workers who were dissatisfied with comfort aspects was generally similar to the mean of all clusters, except the perception of hot and cold temperature. The cluster represented the lowest percentage of those who perceived cold temperature (18%) and the highest percentage of those who perceived hot temperature (20%).

Preferences. The three most important aspects in this cluster were sufficient fresh air (100%), cleanliness (44%) and sufficient daylight (41%). Control of ventilation was for none of those in IC2 regarded as one of the three most important aspects. The proportion of those who were annoyed by noise (1%) and esthetics (5%) important was similar to IC5 and lower than the other clusters.

Personal aspects. The average ERI was 1.4 (SD 0.49), which was similar to the mean (1.4 ± 0.46). The percentage of those who did not have sick leave days (36%) was lower than the mean of all clusters (43%).

Workplace-related aspects. The percentage of those who stayed shorter than 4 hours in their room was the highest (53%).

Health-related aspects. The mean number of symptoms was slightly higher than the mean of all clusters (respectively 2.5 ± 2.26, 2.4 ± 2.34). The proportion of those who suffered from headache (46%) was similar to IC1(51%) and higher than in the other clusters. The prevalence of dry throat was similar to IC1 and IC6 and higher than in the other clusters.

Building-related aspects. The outpatient workers of IC2 worked in relatively old building(wings), the cluster represented the smallest proportion of workers in building(wings), which were built or renovated between 2010 and 2018.

IC3 Moderately thermally uncomfortable, preference for control of temperature
The sample size of IC3 was 94, comprising 18% of the clustered outpatient workers.

Comfort. In general, the outpatient workers in IC3 were most dissatisfied with the overall temperature (65%), and noise from other people (50%). The main complaints were cold temperature (48%) and dry indoor air (58%). The percentage of outpatient workers who perceived a small variation of temperature (29%) was larger than of the other clusters. The proportion of those who were dissatisfied with noise from building services (8%) was smaller than of the other clusters.

Preferences. All outpatient workers in IC3 regarded control of temperature as one of the three most important aspects, half of them (50%) regarded cleanliness important and 42% regarded annoyance by noise as one of the three most important aspects of their workplace. Among the least important aspects were *"not too hot or cold"* (0%), *"sufficient daylight"* (0%) and *"sufficient fresh air" (*0%).

Personal aspects. The ERI was similar to IC1 and lower than in all the other clusters.

Health-related aspects. The PSI14, which was the second lowest of all clusters, was 1.7 (SD 2.13). The proportion of those who suffered from watering eyes was the lowest (2%); the proportion of those suffering from a dry throat was similar to IC4 (10%, 12%) and lower than the other clusters.

Workplace-related aspects. The proportion of outpatient workers who stayed shorter than 4 hours in their room was similar to IC1 and IC6 and smaller than in the other clusters.

Building-related aspects. Most of those in IC2 (49%) worked in building(wings), which were built or renovated between 2010 and 2018; the cluster represented the smallest proportion of outpatient workers of building(wings) from between 2000 and 2009 (16%).

IC4 Comfortable, preference for good acoustics
IC4 comprised of 85 outpatient workers, representing 16% of the total sample.

Comfort. The outpatient workers in IC4 were generally more satisfied with comfort than those in other clusters. IC4 represented the smallest percentage of those who were dissatisfied with the overall temperature (22%), overall quality of indoor air (25%), overall quality of light (15%), natural light (34%) and artificial light (13%). The percentage of those who perceived large and small temperature variation (14%, 5%), draught (7%) and dry air (38%) was lower than in the other clusters.

Preferences. The three aspects which were regarded important by the largest percentage in this cluster were cleanliness (59%), no annoyance by noise (47%) and not too cold or hot temperature (42%).

None of the outpatient workers found control of temperature and daylight important. A larger percentage of the outpatient workers in IC2 found control of the view (16%), esthetics (26%) and the size of the workplace 22%) important than outpatient workers in the other clusters.

Personal aspects. The ERI in IC4 was similar to C6 (1.5 ± 0.48, 1.5 ± 0.50), and higher than in the other clusters. The proportion of those who did not have sick leave was the largest (57%).

Health-related aspects. IC4 represented the lowest PSI14, the average number of symptoms in this cluster was 1.5 (SD 2.25). The percentage of outpatient workers who suffered from dry eyes (31%) and headache (26%) were the lowest percentages of all clusters. The proportion of those suffering from dry throat was similar to IC4 (10%, 11%) and lower than in the other clusters.

Workplace-related aspects. IC4 represented, similar to IC1, the smallest proportion of outpatient workers who worked in rooms with 2 to 4 persons and the largest proportion of outpatient workers in rooms with more than 4 persons.

Building-related aspects. Almost half of the workers (49%) worked in building(wings), which were built or renovated between 2010 and 2018. The cluster represented the largest proportion of those working most frequently in a room with a window to the façade (88%). 6% had no appliance for manual control of the temperature in the room (e.g. button on radiator or thermostat), which was less than in the other clusters.

IC5 Uncomfortable, preference for not too cold or hot temperature.
The sample size of IC5 was 81, representing 16% of all outpatient workers included in the analysis.

Comfort. The outpatient workers in IC5 were generally dissatisfied with IEQ aspects. The cluster represented the largest proportion of those who were dissatisfied with the overall temperature (71%), natural light (59%) and noise from building services (31%). The proportion of those who perceived cold temperature (53%), large temperature variation (38%), draught (28%) was larger than in the other clusters. IC5 represented the smallest proportion of those who perceived still air (13%).

Preferences. The three most important aspects for the outpatient workers in this cluster were not too cold or hot temperature (100%), sufficient daylight (54%) and cleanliness (40%). None of them regarded sufficient fresh air important, no annoyance by noise was for 1% important. The importance of esthetics was similar to IC2 (6%, 5%) and less important than in all other clusters.

Personal aspects. The average ERI, days of sick-leave and duration of stay were similar to the mean. Similar to IC4 worked the largest proportion (54%) most frequently in a room with more than 4 persons.

Health-related aspects. PSI14 was second highest (2.7 ± 2.65). The percentage of those suffering from dry eyes (58%) was higher than the average (51%), the percentage of those suffering from watering eyes (14%), dry throat (23%) and headache (38%) was similar to the average (respectively 13%, 22% and 38%).

Workplace-related aspects. Almost one third (31%) worked at reception areas, which was the highest percentage of all clusters.

Building-related aspects. Almost half of the workers (49%) worked in building(wings), which were built or renovated between 2010 and 2018. The cluster represented the smallest proportion of those working most frequently in a room with a window to the façade (67%). 24% had no appliance for manual control of the temperature in the room (e.g. button on radiator or thermostat), which was most of all clusters.

IC6 Moderately comfortable, preference for daylight

IC6 was the smallest cluster, comprising of 48 outpatient workers (9%).

Comfort. The outpatient workers in IC6 were generally moderately comfortable, except for light related aspects. Dissatisfaction with overall light quality was similar to IC1, IC2, IC5 and higher than in IC3 and IC4. The proportion of those who were dissatisfied with artificial light was larger than in IC3, IC4, IC5 and similar to IC1 and IC2.

Preferences. All outpatient workers in IC6 selected daylight as one of the three most important building or dose related aspects of their workplace, almost half of them regarded control of temperature and cleanliness important (respectively 44%, 44%). No outpatient worker in this cluster regarded fresh air and control of ventilation important, 4% regarded not too cold or hot temperature important.

Personal aspects. The average ERI of the outpatient workers in IC6 was similar to the ERI in IC4 and higher than in all other clusters.

Health-related aspects. The mean number of symptoms was in IC6 similar to the average of all clusters. The prevalence of dry throat was similar to IC1 and IC2 and higher than the average of all clusters.

Workplace-related aspects. 32% stayed shorter than 4 hours in their room, which was similar to IC1 and IC3 and a lower percentage than in the other clusters.

Building-related aspects. The proportion of those who worked in in new building(wings) was similar to IC1 and lower than IC3, IC4 and IC5. 80% had a window to the façade, 84% control of the heating at the workplace.

Social comfort clusters

SC1 Distracted from noise, preference for no distraction
SC1 was the smallest cluster, comprising of 165 outpatient workers.

Comfort. The outpatient workers in SC1 were in comparison to the other two clusters more dissatisfied with distraction, crowding and contact with others. Furthermore, were they less satisfied with overall comfort, overall noise and noise from others. The PEQ, a scale of 12 questions about the perceived esthetic quality [34], was the lowest (14%).

Preferences. They tended to prefer mostly no distraction by noise, no crowding and contact with colleagues and patients. The proportion of those who regarded contact with patients and colleagues important was smaller and contact with only colleagues was larger than of the other clusters. Furthermore, was it more likely that nearness of other colleagues and noise were important and less likely that cleanliness was important for those in SC1 than SC2 and SC3.

Personal aspects. The percentage of women (87%) was smaller than in the other clusters (93%, 93%). The majority had an intermediate education level (45%), but the percentage was lower than in the other clusters and a larger percentage was highly educated (21%). The cluster represented the largest part of nightshift workers (10%). They worked averagely 12 years in the building, which was relatively long.

Health-related aspects. The PSI14 and prevalence of symptoms did not vary between the clusters, except cough. The prevalence of cough was in SC1 moderately (12%).

Workplace-related aspects. Those in SC1 tended to work more in 1 room type than the others (64%, 80%, 74%). Two of five worked most frequently in offices, two of five most frequently in consultation rooms. The cluster represented the largest proportion of workers in a private room (16%). SC1 had the largest proportion of those who had meetings and performed concentrated work.

Building-related aspects. The proportion of those who worked in a large building was larger than the others (84%, 77%, 70%). Of those with a window at the workplace (79%) had a smaller proportion control of the view with curtains or vertical slats (69%) than in SC2 and SC3.

SC2 Uncomfortable with walking distances, preference for privacy of patients
SC2 was the largest cluster, comprising of 198 outpatient workers.

Comfort. The outpatient workers in SC2 tended to be more dissatisfied with walking distances and less dissatisfied with distraction by noise than the others. Furthermore, they were least dissatisfied with overall comfort, with natural light and the PEQ was the highest.

Preferences. All outpatient workers of SC2 regarded the privacy of patients as one of the three most important aspects, three of four regarded contact with colleagues and patients important, more than half cleanliness. All these aspects were more likely to be important for SC2 than SC1 and SC3. Noise, distraction from noise, crowding, nearness of colleagues and contact with colleagues tended to be less important than in the other clusters.

Personal aspects. The percentage of women was 93%. The majority had an intermediate education level (56%).

Health-related aspects. The prevalence of cough was in SC2 the lowest (6%).

Workplace-related aspects. Those in SC2 tended to work more in different room types than the others. The cluster represented the smallest percentage of office workers (18%), and the largest percentage of those who worked most frequently in consultation rooms (50%). The cluster represented the largest proportion of workers who did not have an assigned workplace, but worked at flexible workplaces, and the smallest proportion of workers in a private room (8%). SC2 represented the largest proportion of those who worked with patients.

Building-related aspects. The workers of SC2 were more likely to work in a room without a window (28%) and have a combination of direct and indirect lighting (40%). Of those with a window had a larger proportion control of the view with curtains or vertical slats (82%) than in SC1 and SC3. With regards to the cleaning protocol represented the cluster the largest group of those working in rooms were the floors were cleaned daily.

SC3 Moderately social comfortable, preference for safe workplace
SC3 comprised of 175 outpatient workers.

Comfort. The outpatient workers in SC3 tended to be overall moderately comfortable. They were similarly to IC2 dissatisfied with visual distraction, crowing and overall noise, and least dissatisfied with noise from other people and natural light.

Preferences. All outpatient workers of SC3 regarded safety important, two third contact with patients and colleagues, almost half cleanliness. None regarded privacy for patients important.

Personal aspects. The percentage of women was 93%. The majority had an intermediate education level (60%), which was a larger percentage than in IC1 and IC2. A minority was highly educated (9%), which was a lower percentage than in IC1, IC2. IC2 represented the smallest percentage of nightshift workers (2%). They worked relatively short in the building, for 10 years.

Health-related aspects. The prevalence of cough was in SC3 the highest (13%).

Workplace-related aspects. One in three worked most frequently in an office and one in three most frequently in a consultation room. The proportion of those who had flexible workplaces was the smallest (60%). This cluster represented the largest proportion of workers who performed routine office work.

Building-related aspects. 30% of SC3 worked in a small building, which was more than in the other clusters. They were most likely to have a window at their most frequently used workplace (82%) and have only direct lighting (77%). The cluster represented the percentage of workers in rooms which were cleaned 1x per week (23%).

APPENDIX J

Variables that do not differ between the clusters

Pertaining chapter 4

Personal data		IC1	IC2	IC3	IC4	IC5	IC6	P-value	SC1	SC2	SC3	P-value
Age	Mean	45.3	43.7	47.3	47.4	46.3	47.3	0.183	47.3	45.3	45.2	0.200
	(SD)	(11.7)	(12.1)	(12.1)	(11.3)	(11.4)	(10.7)		(11.2)	(11.8)	(11.9)	
Mood (%)	Negative	18.6	10.8	15.6	13.0	15.7	18.2	0.645	19.4	10.4	15.0	0.060
	Neutral	8.8	12.7	11.1	9.8	6.0	2.6	0.220	9.4	9.4	9.0	0.990
	Positive	72.5	76.5	73.3	77.2	78.3	79.2	0.901	71.3	80.2	76.0	0.146
Positive affect	Mean	20.3	19.8	20.1	20.2	20.0	20.2	0.604	19.8	20.2	20.1	0.222
	(SD)	(2.4)	(2.6)	(2.7)	(2.7)	(2.7)	(2.5)		(2.5)	(2.5)	(2.8)	
Negative affect	Mean	8.3 (	7.7	8.2	8.1	8.1	8.1	0.836	8.2	7.8	8.0	0.662
	(SD)	(2.6)	(2.3)	(2.9)	(2.2)	(2.6)	(2.2)		(2.6)	(2.3)	(2.4)	
Medical condition (most prevalent) (%)	Migraine	10.6	11.2	2.1	7.4	14.1	13.6	0.247	9.1	12.1	9.7	0.595
	Asthma	8.7	4.7	8.3	9.6	4.7	6.2	0.667	5.5	9.1	4.5	0.166
	Eczema	8.7	7.5	8.3	5.3	7.1	6.2	0.957	6.1	7.6	5.7	0.732
	Allergy	21.2	18.7	27.1	18.1	18.8	11.1	0.334	19.4	14.6	21.0	0.249
	High blood pressure	13.5	9.3	8.3	19.1	7.1	11.1	0.144	10.9	14.6	12.5	0.563
Symptoms (%)	Burning eyes	34.0	28.0	16.7	22.3	34.1	25.9	0.148	25.0	27.8	28.4	0.754
	Blocked nose	18.4	14.2	10.4	12.8	16.4	14.8	0.801	12.2	12.6	16.6	0.424
	Dry skin	19.6	16.0	12.5	7.4	22.4	18.5	0.097	14.0	16.2	16.0	0.823
	Lethargy	19.4	13.1	12.5	8.5	23.5	18.5	0.078	14.0	17.2	14.8	0.681

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Personal data		IC1	IC2	IC3	IC4	IC5	IC6	P-value	SC1	SC2	SC3	P-value
Work												
Contract (%)	Part-time	76.7	82.2	68.8	72.3	82.4	71.6	0.209	70.9	79.8	78.3	0.112
Overcommitment	Mean	17.2	17.3	17.0	16.7	17.1	16.7	0.894	16.6	17.2	17.4	0.216
	(SD)	(3.5)	(3.1)	(4.1)	(3.4)	(3.5)	(3.5)		(3.6)	(3.2)	(3.5)	
Satisfaction with work	Mean	7.6	7.7	7.5	7.8	7.5	7.8	0.595	7.5	7.8	7.6	0.317
	(SD)	(1.5)	(1.1)	(1.7)	(1.0)	(1.5)	(1.2)		(1.4)	(1.2)	(1.4)	
Working hours at outpatient (%)	<17 hours	15.5	23.4	22.9	22.3	11.8	11.1	0.094	20.6	16.7	17.1	0.582
	17-32 hours	68.9	67.3	60.4	59.6	74.1	71.6	0.288	65.5	68.7	66.3	0.790
	>32 hours	15.5	9.3	16.7	18.1	14.1	17.3	0.561	13.9	14.6	16.6	0.778
Building-related aspects												
Hospital organization (%)	A	34.6	27.1	41.7	31.9	27.1	27.2	0.396	30.3	26.8	33.5	0.363
	B	29.8	32.7	27.1	28.7	36.5	40.7	0.456	29.7	35.9	34.7	0.434
	C	35.6	40.2	31.3	39.4	36.5	32.1	0.814	40.0	37.4	31.8	0.272
Building location												
Highway or industry <100 m (%)	Yes	46.5	40.0	43.5	46.2	45.8	51.9	0.744	39.3	48.9	48.8	0.123
Forest nearby (%)	Yes	29.8	36.4	31.3	37.2	35.3	32.1	0.863	38.8	33.8	29.5	0.197
Attached parking garage (%)	Yes	31.3	25.7	39.1	28.6	25.3	25.3	0.528	28.8	23.7	31.2	0.265
Building layout												
Number of building levels (%)	1 to 4	33.7	42.3	41.3	31.8	43.2	41.8	0.478	41.0	33.9	42.6	0.197
	5 to 12	66.3	57.7	58.7	68.2	56.8	58.2		59.0	66.1	57.4	
Depth building wing (%)	12<15 m	27.3	18.3	26.1	30.0	19.8	26.6	0.380	19.3	27.1	25.9	0.240
	15<20m	25.3	32.7	37.0	21.1	32.1	26.6	0.194	33.5	25.5	27.6	0.819
	>20m	47.5	49.0	37.0	48.9	48.1	46.8	0.297	47.2	47.3	46.5	0.985
Building level (%)	level 0	51.1	57.3	48.9	45.3	64.6	50.0	0.159	55.4	47.8	57.2	0.171
	level 1	35.1	30.1	44.4	39.5	25.6	34.6	0.244	32.5	40.9	28.9	0.052
	>level 1	13.8	12.6	6.7	15.1	9.8	15.4	0.671	12.1	11.3	13.9	0.760
HVAC												
Building ventilation (%)	Mechanical exhaust and supply	92.3	93.5	97.9	94.7	92.9	88.9	0.488	95.2	94.4	89.2	0.059
	Mechanical supply	7.7	6.5	2.1	5.3	7.1	11.1		4.8	5.6	10.8	
Operable window (%)*	Yes	63.6	63.1	66.7	63.9	56.1	50.8	0.467	61.8	57.0	61.4	0.665
Control of ventilation (%)	No	85.4	87.9	83.7	82.9	87.8	80.3	0.757	86.9	83.1	85.8	0.630
Heating (%)	Radiator	55.1	62.9	60.9	69.7	52.4	57.0	0.218	66.9	56.4	56.5	0.081
	Floor	8.2	7.6	4.3	9.0	11.0	13.9	0.527	6.7	7.4	13.7	0.053
	Air	36.7	29.5	34.8	21.3	36.6	29.1	0.212	26.4	36.2	29.8	0.129

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Personal data		IC1	IC2	IC3	IC4	IC5	IC6	P-value	SC1	SC2	SC3	P-value
Cooling (%)	Top cooling	86.7	91.4	84.8	82.0	90.4	88.6	0.413	90.2	88.3	85.8	0.465
	Airconditioning	13.3	8.6	15.2	18.0	9.6	11.4		9.8	11.7	14.2	
Visual												
Height parapet (%)	<20 cm	15.5	8.8	18.9	12.7	10.9	11.1	0.661	9.4	14.3	12.3	0.485
	20<90 cm	70.4	70.0	67.6	70.9	72.7	65.1	0.960	74.8	66.2	66.7	0.240
	> 90 cm	14.1	21.3	13.5	16.5	16.4	23.8	0.624	15.7	19.5	21.0	0.531
Window to corridor (%)*	Present	47.1	57.0	56.3	57.4	55.3	58.0	0.647	57.0	51.0	59.1	0.262
Control solar shading (%)	No solar shading	13.7	11.3	10.8	9.6	10.7	17.2	0.792	10.1	15.6	12.0	0.392
	Automatic	52.1	43.8	48.6	60.2	51.8	39.1	0.157	51.2	51.1	43.7	0.356
	Individual control	34.2	45.0	40.5	30.1	37.5	43.8	0.383	38.8	33.3	44.4	0.170
Control of lighting (%)	Manual control	74.7	85.8	71.7	73.6	73.5	83.5	0.117	82.8	75.8	77.2	0.247
	Automatic	25.3	14.2	28.3	26.4	26.5	16.5		17.2	24.2	22.8	
Acoustic (acoustic ceilings in all rooms)												
Presence dropseal (%)	Mainly present	50.5	51.4	67.4	56.3	53.7	62.0	0.327	56.2	52.4	60.2	0.334
Perceived control*												
Temperature (%)	Yes	35.6	41.1	39.6	44.7	27.1	30.9	0.140	34.5	31.8	42.0	0.108
Ventilation (%)	Yes	26.9	20.6	22.9	33.0	18.8	13.6	**0.043**	20.7	20.2	26.7	0.262
Solar shading (%)	Yes	41.3	37.4	43.8	47.9	29.4	37.0	0.199	40.5	34.3	41.1	0.327
Lighting (%)	Yes	48.1	53.3	62.5	68.1	50.6	53.1	0.062	55.2	53.3	57.1	0.758
View (%)	Yes	31.7	28.0	41.7	33.0	17.6	29.6	0.073	27.3	30.3	29.5	0.810
Noise (%)	Yes	34.6	25.2	41.7	28.7	20.0	23.5	0.059	21.3	27.3	32.4	0.073
Maintenance												
Cleaning protocol walls (%)	1x per week	34.6	27.1	41.7	31.9	27.1	27.2	0.396	30.3	26.8	33.5	0.363
	1-2x per month	35.6	40.2	31.3	39.4	36.5	32.1	0.814	40.0	37.4	31.8	0.272
	2-6x per year	15.4	16.8	10.4	18.1	12.9	22.2	0.509	16.4	16.7	14.8	0.870
	No protocol	14.4	15.9	16.7	10.6	23.5	18.5	0.304	13.3	19.2	19.9	0.218
Cleaning protocol furniture (%)	5x per week	72.1	68.2	72.9	77.7	67.1	64.2	0.434	73.9	66.7	67.6	0.280
	2x per week	13.5	15.9	10.4	11.7	9.4	17.3	0.637	12.7	14.1	12.5	0.878
	No protocol	14.4	15.9	16.7	10.6	23.5	18.5	0.304	13.3	19.2	19.9	0.218
Visible dust/ dirt (%)	Yes	37.9	35.9	39.1	34.9	33.8	39.7	0.968	41.8	32.8	37.5	0.229
Visible damp spots (%)	Yes	16.2	19.0	23.9	13.2	16.9	15.2	0.692	20.2	12.1	18.2	0.097

** Based on self-report of staff, other building aspects retrieved from building inspection or hospital organizations.*

APPENDIX K

Building characteristics per participant

Pertaining chapter 5

		N (%)
Outdoor pollution sources	Forest nearby	188 (33.8)
	Nearby highway (<100m)	247 (45.7)
	Nearby industry (<1.5 km)	247 (45.7)
	Attached parking	167 (30.0)
	Cars parked close to the building	556 (100)
	Helicopter platform	0 (0)
Air handling units		
Height intake ventilation	Ground floor vs. 0<10 m	191 (35.4)
	Ground floor vs. >10 m	349 (64.6)
Rotating heat exchanger	Yes	260 (49.0)
	No	271 (51.0)
Frequency replacement filters	<2x per year	346 (64.8)
	2x per year	188 (35.2)
Type filters	Fine	314 (58.3)
	Very fine	225 (41.7)

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		N (%)
Layout-related aspects		
Size outpatient area	>15.000 m^2	416 (77.3)
	<15.000 m^2	122 (22.7)
Level work	Ground floor	284 (54.1)
	Floor 1 to 4	241 (45.9)
Dimensions (depth) building wing	12 to 15 m	128 (23.9)
	15 to 20 m	158 (29.5)
	> 20 m	250 (46.6)
Enclosure room	Half open	112 (20.2)
	Wall to ceiling	442 (79.8)
Most frequently used room type [a]	Office	160 (30.0)
	Reception	115 (21.6)
	Consultation room	215 (40.3)
	Treatment room	43 (8.1)
Number of persons in room [a]	1	63 (11.4)
	2 to 4	258 (46.5)
	>4	234 (42.2)
Presence window [a]	Facade and corridor	273 (49.3)
	Facade	156 (28.2)
	Corridor	32 (5.8)
	No	93 (16.8)
Visual aspects		
Contrast window frame/wall [b]	Light frame and light wall	176 (40.9)
	Dark frame and light wall	254 (59.1)
Control view [b]	Internal blinds or curtains	330 (77.1)
	No	98 (22.9)
Control lighting	Manual	413 (78.2)
	Automatic	115 (21.8)
Direction lighting	Direct	360 (79.1)
	Direct and indirect	95 (20.9)
Height windowsill [b]	<20 cm	49 (11.9)
	20<90 cm	287 (69.7)
	>90 cm	76 (18.4)

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		N (%)
Thermal aspects		
Type heater	Air	156 (29.7)
	Radiator	321 (61.0)
	Floor	49 (9.3)
Control heater	Manual	361 (92.1)
	Automatic	31 (7.9)
Openable window (technically) [b]	Yes	347 (81.3)
	No	80 (18.7)
Openable window (perceived) [a b]	Yes	257 (59.6)
	No	174 (40.4)
Climate facade	Yes	40 (7.2)
	No	516 (92.8)
Acoustic aspects		
Acoustic ceiling	Yes	556 (100)
	No	0 (0)
Presence dropseal	Yes	147 (37.5)
	No	245 (62.5)
Covering materials		
Main wall covering	Paint	492 (89.6)
	Vinyl	57 (10.4)
Main floor covering	Hard	537 (99.1)
	Carpet	5 (0.9)
Indoor air pollutants		
Presence plants	Yes	93 (22.1)
	No	327 (77.9)
Presence curtains (window/dressing area)	Yes	313 (56.8)
	No	238 (43.2)
Ergonomics		
Adjustable furniture	Chair	186 (53.9)
	Table and chair	159 (46.1)
Cleaning schedule		
Floors	1x per week	98 (17.6)
	5x per week	458 (82.4)
Wall	1x per week	168 (30.2)
	< 1x per week	388 (69.8)
Furniture	5x per week	386 (69.4)
	<5x per week	170 (30.6)
Ventilation grills	1x per month	167 (30.0)
	<1x per month	389 (70.0)

Number of outpatient workers may vary because of missing information, a= information from the questionnaire, b= only when a window is present.

APPENDIX L

Quotations of changes on comfort

Pertaining chapter 6

Quotation 1

"En ik vind dat wel een lastig iets, nu met die Covid natuurlijk ook. Want er was toen nog onderzoek geweest dat het zolang blijft hangen in liften. En dan denk ik: "Hoelang blijft het hier in mijn kamer hangen?" Ik kan niet even een raam openzetten of zoiets. Of de ventilatie aanzetten. Want dat is er niet!" (Verpleegkundige, vrouw)

"And I find it annoying too now, with the covid. Because there was a study saying that it lingers in the air for a long time in the elevators. So, I think: how long does it linger in my room? I can't open a window or anything. Or turn on the ventilation. Because we don't have it!" (Nurse, female)

Quotation 2

"Ik houd van een beetje lucht, he. En nu gaan ze [de collega's] *er* [raam openzetten] *weer in mee he, omdat ze weten dat het met de corona beter is. Als je met zijn allen in een ruimte zit natuurlijk. We kunnen dat redelijk dealen. 's Ochtends als ik binnenkom, zet ik hem open en als ze het zat zijn dat gaat hij dicht. Zo hebben we het met elkaar afgesproken en dat doen we ook met de lunch. Dan gaat hij ook een half uurtje open en dan gaat hij ook weer dicht." (Administratief medewerkers, vrouw)*

"I like a little bit of air. And now they [the colleagues] *also go ahead with it* [opening windows]*, because they know that during coronavirus it is better to do it, especially if you're all together in a room. We do it pretty well. In the morning when I arrive, I open the windows, and when they've had enough of it, we shut them. That's what we agreed, and we also do it at lunchtime. We open them for half an hour and then shut them again." (Administrative worker, female)*

Quotation 3

"Geen geluidsoverlast zou wel fijn zijn. Dat vind ik wel belangrijk. Juist omdat je de patiënt nu zo moeilijk kan verstaan. Ik merk nu, doordat die schermen daar hangen en mensen mondkapjes op hebben, dat ik op dit moment daar meer problemen mee heb dan dat ik voor coronatijd zou hebben." (Receptie medewerker, vrouw)

"If there weren't any noise annoyances, it would be nice. I think that's pretty important. Exactly because now you can't understand the patients well. I notice that now, with the hanging splash guards and people wearing face masks, that I have more problems with that than I had before the coronavirus." (Reception desk worker, female)

Quotation 4

"*Ik merk gewoon dat ik daar, en misschien heeft dat ook wel met de leeftijd te maken, vroeger had ik daar minder last van. Maar ik kan echt wel merken dat ik behoefte heb aan daglicht. En ik heb van de zomer zelfs momenten gehad als ik van mijn werk kwam zei ik tegen mijn man: " ik ga nog even in de tuin zitten, want ik wil nog even een beetje zonlicht opvangen." Dat ik echt dacht: "ik moet heel even naar buiten"* [lachen]*." Diagnostisch medewerker, vrouw)*

"I've noticed that I used to suffer less with that, but that may be because of my age. But I really see that I do need daylight. I remember from the summer, there were times I came back from work and told my husband: "I'll be out in the garden for a while, I'd like to get some sunlight." I was actually thinking: "I do have to go out" [laughs]*." (Diagnostic researcher, female)*

Quotation 5

'Als je vraagt: [...] *"Heeft u alles begrepen?" "Ja." Maar dat is niet altijd zo. Dan kun je nog wel eens merken van: "Oh, er zit daar een stukje wat nog niet begrepen wordt." En daar kun je dan* [..] *op reageren. Maar dat is wel weggevallen.' (Receptie medewerker, vrouw)*

"When you ask: [...] *"Is everything clear so far?"; "Yes." But they don't always say yes. So, you can sometimes notice: "oh, they still don't understand something." So that's when you can say something more. But that doesn't happen anymore." (Reception desk worker, female).*

Quotation 6

"En ja dat lichamelijk onderzoek is wel iets dat je mist met de telefonische of de uh videoconsulten. [..] *de opbrengst is niet altijd heel evident veel. Maar het is wel dat je iets kunt zien. Dat iemand zegt:" Mijn maag doet pijn." En dan met lichamelijk onderzoek dan wijzen ze hun onderbuik bijvoorbeeld aan. Dus dat je op die manier extra informatie kunt vergaren en uh* [..], *ik heb zelf het idee dat de aandacht die je besteed bij lichamelijk onderzoek uh is dat het, patiënten zich ook serieus genomen voelen." (Physician assistent, vrouw)*

"And yes, the physical check-up is something you miss during phone or video consultations [..] *the output isn't always that evident. But it is something that you can see. If someone is telling you "My stomach hurts"; with a physical check-up they'll point at their lower abdomen, for example. So, you get some extra information and* [uh], *I actually feel that the attention you give them during a physical check-up makes them feel that they are being taken seriously." (Physician assistant, female).*

Quotation 7

"Je staat alles te bespreken, je moet een geboortedatum vragen, je moet de huisarts vragen, de patiënten moeten het hard zeggen, nu nog harder, en diegenen in de wachtkamer kunnen alles horen en volgen. Dus er is niet heel veel privacy. Ik vind het persoonlijk vind ik dat vervelend. Want ja je hebt het toch in mijn geval over kanker en ja iedereen weet wel waarom je daar zit maar dat hoef je toch niet zo aan de grote klok te hangen [..]. *Dat komt door die schermen, maar ook die mondkapjes ook, he. Anders kon je nog een beetje aan de mond zien wat ze zeiden. Maar dat kan ook niet meer."*

"*You discuss everything, you have to ask them their birthdate, you have to ask the general practitioner, the patients already had to be loud, but now even louder, and the others in the waiting room can overhear and follow everything. So, there isn't that much privacy. I personally find it disturbing. Because for example, in my case, you'll be talking about cancer, and so everyone knows why you are there, but it doesn't need to be that obvious.* [..]*All of this is because of the splash guards but also the face masks. Otherwise, you could still see their mouths and see what they were telling you. But that's not possible anymore." (Reception worker, female)*

APPENDIX M

Codes of the changes due to the COVID-19 pandemic

Pertaining chapter 6

Category	Subcategory	Second order codes
Organizational adaptations	Capacity care	Capacity care reduced during first wave (7)
		Recent capacity care normal (4)
		Capacity care not reduced during first wave (2)
		Waiting list for patients after first wave (3)
	Number of persons in hospital	Number of workplaces reduced (4)
		Number of visitors reduced (4)
		Number of patients reduced (3)
		Working partly from home (5)
		Spread staff among locations (2)
Adaptations work methods	Corona care	Determine corona policy (1)
		Buddy corona care (2)
		Perform corona tests (2)
	Digital care	Digital meeting (1)
		Digital consultation (4)
		Prepare digital consultation (6)
	Face-to-face care	Face-to-face consultation when urgent (3)
		Physical examination when urgent (3)
		Decreased medical acts (2)
		Adjusted workflow (2)

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Category	Subcategory	Second order codes
Physical adaptations	**Room**	Seating in waiting room reduced (3)
		Stanchions in front of reception desk (5)
		Amount of stuff reduced (1)
		Increased disinfecting acts (2)
		Location furniture adapted (3)
		Splash guard (2)
	Protective clothing	Use of facemask
		Use of face shield
		Protective suit, glasses, and gloves (1)
Experience of changes	**Work pressure**	Work pressure increased (8)
		Work pressure unchanged (4)
		Work pressure increased during first wave (4)
		Suffering from Burn-out (1)
		Stressed feelings (2)
	Perception work methods	Adjusted to new work method (3)
		Annoyed by extra administration (4)
		Worries about quality patientcare (3)
		Worries about infection (4)
		Satisfied with organization (1)
		Unsafe feelings because of dirt and dust (1)
	Social comfort	Social distancing difficult (6)
		Missing face-to-face contact (8)
		Preferred to see facial expression (3)
		Increased privacy (1)
		Less annoyance by aggression (1)
		Annoyance by aggression (4)
	Indoor environment	Missing control of ventilation (4)
		Decreased intelligibility through facemask or splashguard (3)
		Preferred natural ventilation (3)
		Decreased discussion about control of temperature (1)
		Breathing difficulties through facemask (1)
		Protective suit too hot (1)
		Face shield reflects light in screen (1)

Curriculum Vitae

AnneMarie Eijkelenboom

Date of birth: 17 March 1971
Place of birth: Rotterdam

Education

- 2017-2021 PhD candidate, Chair of Indoor Environment, Delft University of Technology
- 2013 EDAC certification, Center for Health Design
- 1990-1997 MSc. Architecture, Delft University of Technology
- 1989-1990 Oriëntatiejaar, Vrije Hogeschool, Zeist
- 1983-1989 Gymnasium β, Van Maerlantlyceum, Eindhoven

Professional experience

- 1995-1999 Architect at several architecture companies
- 1999-2006 Projectarchitect at DKV Architecten
- From 2006 Projectarchitect/ Researcher at EGM Architecten

List of recent projects (project architect) 2017-2021

- ○ 2021 Expansion of a clinic for forensic psychiatry
- • 2020 Expansion of a care hotel
- ○ 2019 New construction of housing for people with substance use disorder
- ○ 2018 New construction of a rehabilitation centre
- • 2018-2020 Transformation of outpatient areas for mental health care
- • 2017-2019 New interior of areas in a nursing home
- ○ 2017 Feasibility studies for a centre for posttraumatic stress disorders
- • 2017 Feasibility studies for housing
- • 2017 Transformation of a nursing home
- • 2017-2021 Several acquisitions

○ ongoing project • finished project

Other projects/ activities

- 2020-2021 Member Scientific Committee CLIMA2022
- 2019-2021 Research on future housing with care
- 2018 Research and design of the ''Fluid ICU''

Presentations and conferences 2017-2021

- 2020 Convergence healthcare and technology, Delft University of Technology, Erasmus University, Erasmus MC, attendee
- 2020 VOGON PhD event, Vereniging van Onroerend Goed Onderzoekers Nederland, Amsterdam, presenter
- 2019 NRC live, Utrecht, presenter
- 2019 BNR Radio, Amsterdam, interview
- 2019 EuHPN 2019 Workshop, European Health Property Network, Basel, attendee
- 2019 ARCH19: Building for better health, Conference, Norwegian University of Science and Technology, Trondheim, presenter
- 2019 CLIMA2019, The 13th REHVA World Congress, Boekarest, presenter
- 2019 Governing Healthy Cities, Erasmus University, Rotterdam, guest lecture
- 2019 Technoledge, Delft University of Technology, Delft, lecture
- 2019 Regionale Refereeravond de IC van de toekomst, Ikazia ziekenhuis, Rotterdam, presenter
- 2018 Thuisgevoel in verpleeghuizen, congres, FMT-gezondheidszorg, Eindhoven, presenter
- 2018 NVvH Najaarsdag, Nederlandse Vereniging voor Heelkunde, Ede Wageningen, presenter
- 2018 Health@BK platform research week, Delft University of Technology, presenter
- 2018 Healthy City Design International Congress 2018, SALUS Global Knowledge Exchange, London, presenter
- 2018 EuHPN 2018 Workshop, European Health Property Network, Gothenburg, presenter
- 2018 Hospital Design, Conference, Erasmus MC and EGM architects, Rotterdam, attendee
- 2018 Inspiratiedag wonen met dementie, Lensen, Zaltbommel, presenter
- 2017 Architecture and Health, intersections of care, Erasmus University, keynote speaker and workshop leader
- 2017 Smart Architectural Technologies, Eindhoven University of Technology, guest lecture

List of publications

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21#19

Understanding comfort and health of outpatient workers in hospitals, a mixed-methods study

AnneMarie Eijkelenboom

Against the backdrop of an increasing need for healthcare, staff shortages and relatively high rates of sick leave, understanding of wellbeing (comfort and health) of hospital workers is important. This research aims to provide a contribution, through a mixed-methods approach, with broad and in-depth insights into comfort and health. Therefore, data have been collected from questionnaires, building inspections, interviews, and photos, and analysed with several techniques.

Personal, work, and building-related aspects were included in data collection, because a preliminary literature review identified mutual relations with comfort and health. As previous studies on outpatient workers were missing, while staff is generally less satisfied with comfort than patients, this research focuses on staff in outpatient areas.

To gain insights into the outpatient workers' comfort and health, four important aspects are highlighted: differences in comfort in relation to room types, occupant profiles differentiated by the individuals' preferences and satisfaction, changes of preferences due to contextual changes, and associations of health with building-related aspects.

This research builds on previous studies which identified indoor environmental quality (IEQ) profiles of home occupants and school children. New are social comfort profiles, comparison between room types and contextual influence on preferences, as well as the studied occupant group and building. The study enables academical and practical exploration of preferences and perceptions of comfort and their integration in the design process.

AnneMarie Eijkelenboom, architect with 25 years' experience, is determined to improve wellbeing of occupants through expansion and integration of academical knowledge and practical experience in design of buildings.

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