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Article

Layout configuration and occupancy in healthcare indoors: A case study in a Turkish research hospital

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ABSTRACT

Space occupancy is acknowledged as a parameter that affects communication, teamwork, and behavior patterns in healthcare settings. This research aims to understand the patterns of space occupancy in two Inpatient Units (IU) with differing indoor environments concerning configuration and morphology. In order to understand and explain the variations in patterns of occupancy, a combination of qualitative and quantitative methods is employed to assess spatial analytics metrics such as visibility, accessibility, and physical proximity. These methods are crucial in providing a comprehensive understanding of the complex relationship between space occupancy and interactions among staff in healthcare settings. The results suggest that different spatial layouts in healthcare buildings affect the patterns of space occupancy and routes preferred by healthcare staff. Even though there are differences between morphologies of the two units studied, the research found that particular segments within corridors in relation to staff-related areas like nurse rooms, nurse stations, and med-preparation rooms affected patterns of space occupancy and movement in healthcare settings. This study may give a broader understanding on the impact of layout morphologies and the configuration and allocation of programmatic elements within layouts of medical surgical units.

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INTRODUCTION

The characteristics of physical environments in healthcare settings can influence various facets of the healthcare experience, impacting physical, psychological, and even behavioral aspects in positive or negative ways (Codinhoto et al., 2009; Ulrich et al., 2008; Zhang et al., 2019). Research shows that the design of healthcare environments may lead to several negative consequences, including medical errors, heightened stress levels, fatigue, burnout, job dissatisfaction and frequent interruptions (Coiera et al., 2002; Donchin et al., 2003; Tyson et al., 2002). Also, research indicates that healthcare settings can foster better

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outcomes, including enhanced improved communication, staff performance, and more effective interaction patterns between patients and medical staff (Cai & Zimring, 2012; Devlin & Arneill, 2003; Ulrich et al., 2008). The layout organization within healthcare environments, and the allocation of programmatic components in particular, have an impact on both staff and patient outcomes in various ways (Codinhoto et al., 2009; Lim et al., 2020; Ulrich et al., 2008). The claim is that an effective spatial arrangement enhances the operation of a healthcare facility, resulting in improved service quality and greater patient satisfaction (Hendrich, 2003; Trinkoff et al., 2005; Zhu & Shepley, 2022). At the same time, healthcare indoors can influence the healing experience of users by facilitating interactions and communication among staff as well as between staff and patients (Cai, 2012; Shepley, 2002).

There are various formulations to study the impact of layouts in healthcare environments. The research into the patterns of space occupancy which involves the presence of inhabitants in space (Gomez-Zamora et al., 2019; Tomé et al., 2015) becomes increasingly important as the specifics of occupancy are considered to influence key parameters including safety (Ampt et al., 2008; Iyendo et al., 2016; Joseph, 2006; Shepley et al., 2022), staff communication (Cai & Zimring, 2012) and healthcare-related outcomes (Lu et al., 2009; Sailer et al., 2013; Zhang et al., 2019). The related literature suggests links between space occupancy, efficiency and inhabitants' satisfaction in healthcare environments (Haron et al., 2012). The central hypothesis in these studies, which reflects a transactional perspective, is that various configurations of built environments affect behavior in space, which in turn influence the quality of services in healthcare.

In Turkey, the design and spatial planning of healthcare environments are established in accordance with national standards and guidelines published by the Ministry of Health of Turkey. These guidelines define the functional, technical and hygienic requirements of healthcare facilities, as well as determining the institutional framework of design decisions. Also, with the Ministry of Health's Inpatient Healthcare Facilities Planning Guide (2011), the current status of hospitals is clearly presented and future goals are determined (Cansever & Gökkaya, 2022). The intention with this investigation is to provide empirical support for developing improved and enhanced guidance in designing safe and efficient healthcare environments in the context of Turkish Healthcare System.

While there is research to account for the perception and evaluation of the built environment from patients' perspective in Turkish Health System (THS) (Ergenoğlu & Tanrıtanır, 2013), the current paper primarily focuses on the activities of nurses who are considered as major actors in healthcare facilities. Recognizing the key role of nurses in delivering care, the current paper aims at providing a perspective to consider and evaluate the allocation of particular programmatic elements (nurse stations, medication room, and nurse room) and the potential impact of spatial configuration on space occupancy in the context of a research hospital. The study specifically targets corridors within inpatient units, exploring two medical-surgical units that feature distinct spatial arrangements, and highlights the contrasts and comparisons between them. The field study took place in a large-scale state hospital in Turkey, where a continuous effort is observed to increase the bed capacity through public-private-partnership model. Accordingly, with this research, the intention is to contribute to the existing literature and to develop guidance concerning the organization of inpatient units in the context of THS.

The major research questions are:

1. What are the most frequently occupied areas by nurses in medical-surgical inpatient units?
2. How do the occupancy levels differ across the indoors of medical-surgical units with varying layouts?
3. How do certain program elements, including nursing stations, medication rooms, and nurse rooms, relate to the frequently occupied areas in medical-surgical units?

BACKGROUND

The modern hospital building, indoor areas in particular, has been a frequent ground for academic investigations starting from the second half of the 20th century. In order to understand how healthcare facilities function, researchers have elaborated on the issues of safety, efficiency, and supervision. Exploring the connection between the qualities of built environments and human behavior, one strong strand within healthcare research deals with the complex relationship between the spatial layout and the occupancy and movement patterns of users in healthcare facilities which are considered to be strong program buildings (Pachilova & Sailer, 2020; Rashid, 2009).

The patterns of occupancy in space, in this context, refers to "the simultaneous existence of inhabitants against the spatial configuration of boundaries accessed by them", whereas the movement patterns "describe the users' spatial trajectories during their interaction with the spatial setting" (Tomé et al., 2015). These two concepts, namely occupancy and movement, are strongly linked as inhabitants' activities, including walking, gathering, encountering, and interacting, generate space occupancy patterns in buildings (Gomez-Zamora et al., 2019).

There is a growing body of research on healthcare indoors to report that both positive and negative outcomes can be influenced by spatial layout and configuration in relation

to spatial occupancy (Haron et al., 2012; Ulrich et al., 2008; Weick & Sutcliffe, 2003). As the causal argument goes, the architecture of healthcare buildings influences the occupancy and movement patterns of inhabitants, which in turn affect awareness, communication, and coordination in space, which are key parameters that impact the quality of care in healthcare settings (Gharaveis et al., 2018; Pachilova & Sailer, 2015). Pachilova and Sailer (2020) studied how hospital ward design affects quality-of-care ratings. They found that the layout impacts visibility and communication for healthcare workers, emphasizing the importance of open areas for staff moving between key locations (Pachilova & Sailer, 2020).

The studies that focus on the spatial dimension of nursing practices repeatedly emphasize the key role of circulation areas in healthcare environments (Jiang & Verderber, 2017). From a particular perspective concerning wayfinding in hospitals, there is a growing body of literature to suggest that the organization of corridors influence wayfinding decisions of users (Aksoy et al., 2020). There is also other forms of research to recognize particular aspects of corridors and hallways (Allison, 2007; Edgerton et al., 2010), which may take up to 40% of the floor area in healthcare facilities (Carthey, 2008). However, to better understand the role of circulation zones in varying contexts, there is a need for more in-depth investigations. With the aim to inform the design of future healthcare spaces in the context of THS which is constantly expanding in the last decade, the current paper examines the potential impact of spatial configuration on space occupancy and assesses the allocation of particular programmatic elements within two medical surgical units including nurse stations, medication rooms, and nurse rooms.

RESEARCH DESIGN AND METHODS

Settings

The research was conducted in inpatient units within a state-owned training and research hospital. Two general surgery inpatient units (GSIU) were included based on variations within floor layouts and their availability. There is no difference in the patient characteristics of patients to be admitted to these two units, namely Case 1 and Case 2, where the nurse-to-patient ratio is 1/10 for both units. While the ratios are considered high compared to Western standards, the numbers and workload represent the situation in a typical state-owned hospital in Turkey.

The two units are located in the same building within the Hospital Campus. The layout properties, however, display certain differences at various scales. Case 1 is considered as a race-track typology with the patient rooms on the perimeter, whereas the center of the layout was equipped with service and staff-related areas. Case 2 can be regarded as an L-shaped corridor typology; the patient rooms were organized on the perimeter of the floor plan, whereas the staff-related areas were distributed within the unit (Figure 1). In Case 1, the medication preparation room, nurse station, nurse room and treatment room are in close proximity and located around the center of the unit layout, while these particular rooms are not clustered in Case 2. In Case 2, nurse station and treatment room are located at the center of the unit, whereas the medication preparation room and nurse room are set apart from the central nurse station.

There is a pool of 70 nurses to provide care in shifts for the two units. All nurses report to the same Chief Nursing Officer for the GSIU services, who follow a flexible assignment strategy. The nursing roster includes individuals ranging from interns who are currently enrolled at the College of

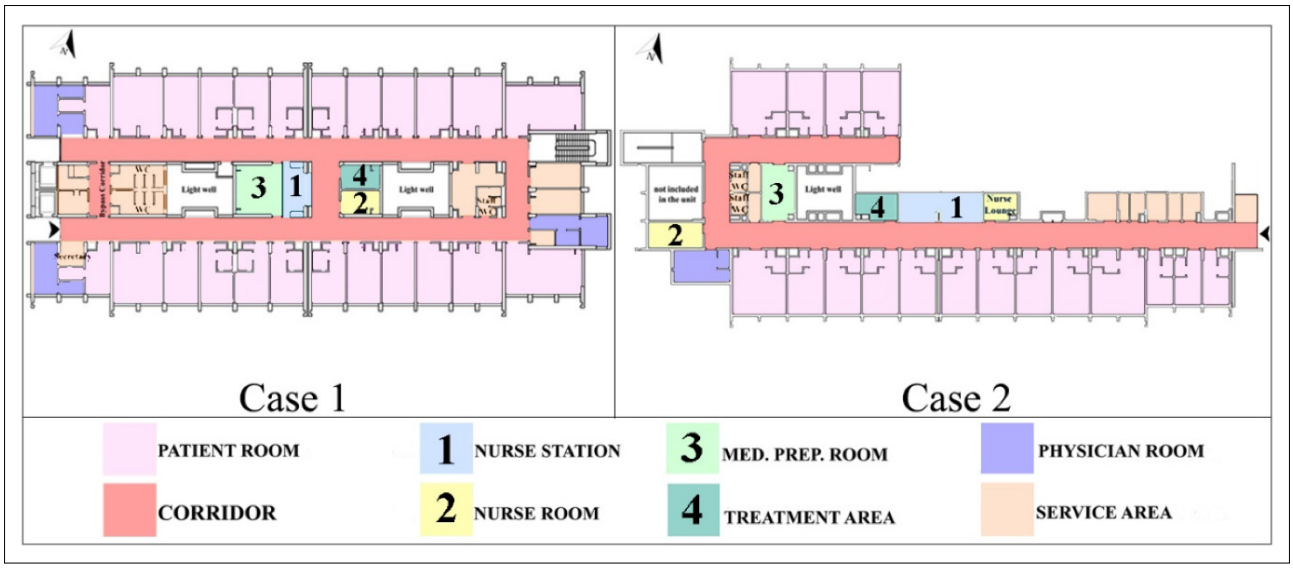

Figure 1. Schematic layouts of case studies.

Nursing of the same university to Registered Nurses with more than 20 years of experience. The same group of nurses, under the same administrative body, provide care for the patients with similar clinical characteristics, which -we presume- leaves the configuration of space as the primary variable to impact space occupancy and related parameters under focus for this research.

Methods

This study follows a mixed-method strategy including, a series of field observations, a survey and off-site techniques to analyze the layouts. Permission from the Ethics Committee of the university was granted prior to the initiation of the field research protocol at the hospital.

Observations: The primary field strategy of this research involved observations that were used to develop insights into nurses' space occupancy and movement by recording the activities of staff members during their daily routines within the two units. To understand the occupancy dynamics in the inpatient units, two types of field observations were used: Location mapping observations (LMO) and nurse activity observations (NAO). Each observation type was conducted for 10 days -mornings and afternoons- for each unit. The total number of recordings for LMO was 105 observation recordings at Case 1, and 115 observation recordings at Case 2, while the overall recordings for NAO were 51 observation sessions at Case 1, and 49 observation recordings at Case 2 (Table 1).

LMO protocol was carried out by recording the locations of occupants by taking a single tour along a pre-determined route 10-12 times a day. The route mainly followed the corridor of the units from end-to-end, and the field researcher digitally recorded the locations of the staff without entering the patient rooms. The LMO recordings included both activities and the exact locations of the nurses.

The obtained plan with LMO recordings was analyzed in detail with a specialized plan analyzer plugin, which is built specially for this task by using Rhino 3D API and C# programming language. The intention was to develop a unified form of representation for both types of observations and space syntax analysis to allow better comparison for the floor plans studied. To create a template for analysis, first, the layout that included the observation data was imported into the Rhino software. The unit layouts were overlapped with a 60 cm by 60 cm cell grid, which generated the template for analysis (Figure 2). Second, a plan analyzer plugin was employed to detect staff location recordings on layouts through circle shapes. Next, upon detection process, the cells of the grid automatically generated the counts of the categorized staff traces on the layout.

The layout grid, then, was converted into a colored heat map based on the results from the plan analyzer plugin. The extracted heat maps –which represented the observation data for each case – were organized through 5 colors – red to blue- where red cells displayed the most occupied areas and blue cells represented relatively less occupied areas on the floor plan (Figure 3). As presented in the findings section, the data set was also analyzed by calculating the ratio of accumulation of areas with respect to the total area of the floor plan.

Each NAO entry, on the other hand, included movement records of a single nurse for ten minutes, conducted five to seven times a day. For each NAO recording entry, a different nurse was inconspicuously followed (Figure 4). Data collected from both NAO and LMO were then gathered and tabulated on floor plans to understand the accumulation of space occupancy in spatial layout.

Space Syntax: Space syntax analysis was used to better understand the configuration in the inpatient units. Using the space syntax method, the floor plan of the inpatient unit was analyzed via visual graph analysis (VGA), which examines the availability and accessibility of space visually throughout the entire spatial system, considering all edges. The same grid of 60cm by 60cm is employed in processing the syntax analysis, which helps to identify particular zones with high levels of visibility and/or integration within the two case studies. The graphics from the syntax analysis provided a ground for understanding the highly visible areas in the units, which in turn helped us to discuss the results from the two types of observation mappings.

Survey: The field strategies included a survey aimed at better understanding the daily routines concerning care delivery and perceptions of nurses in units. The survey was designed as a paper-based questionnaire with multiple-choice and open-ended questions, along with a drawing task that asked the nurses to draw their most frequently used routes in the units. The intention of the survey was to assess the perspectives of nurse practitioners at units in relation to the research agenda. The survey part of the research protocol

Table 1. The total number of observation recordings

Number of Observation Records	Location Mapping Observation (LMO)			Nurse Activity Observation (NAO)		
	AM	PM	Total Records	AM	PM	Total Records
Case 1	51	54	105	25	26	51
Case 2	59	56	115	24	25	49

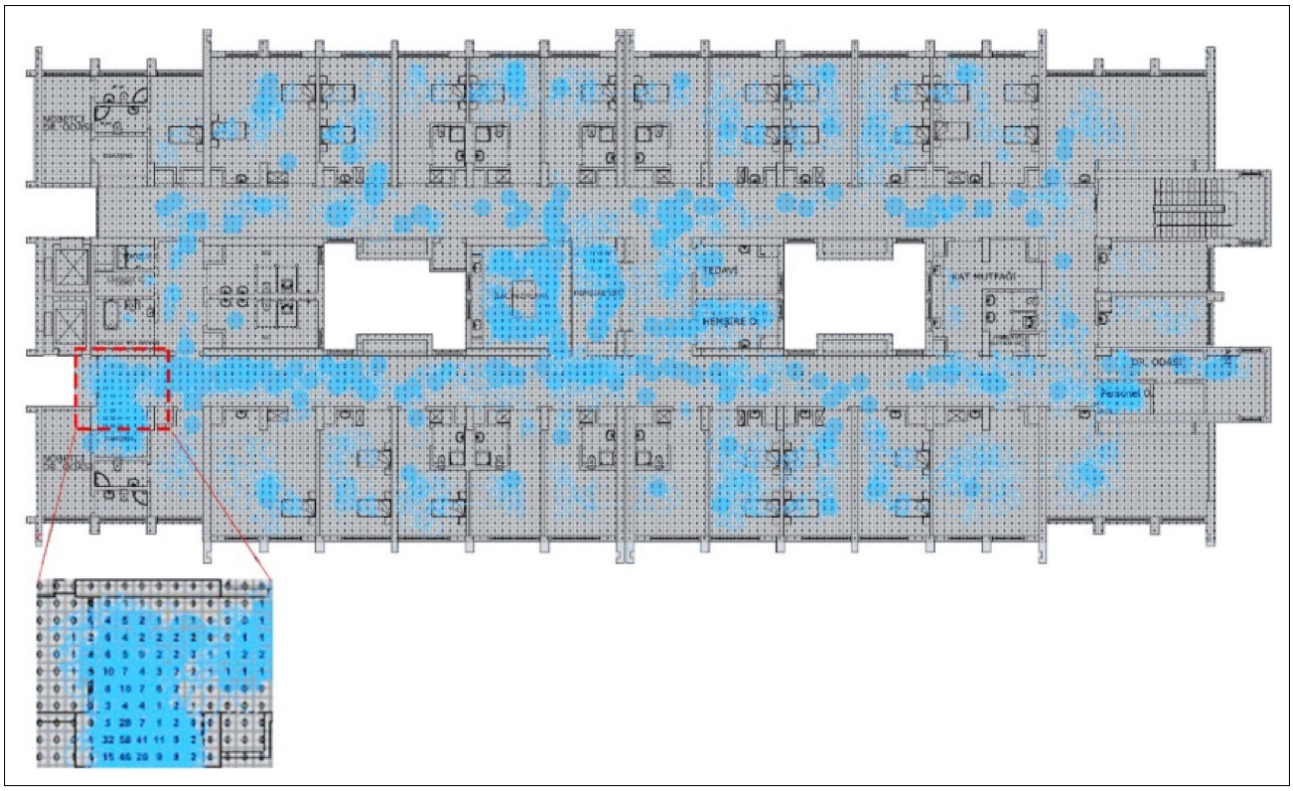

Figure 2. Detecting counts of the categorized staff traces.

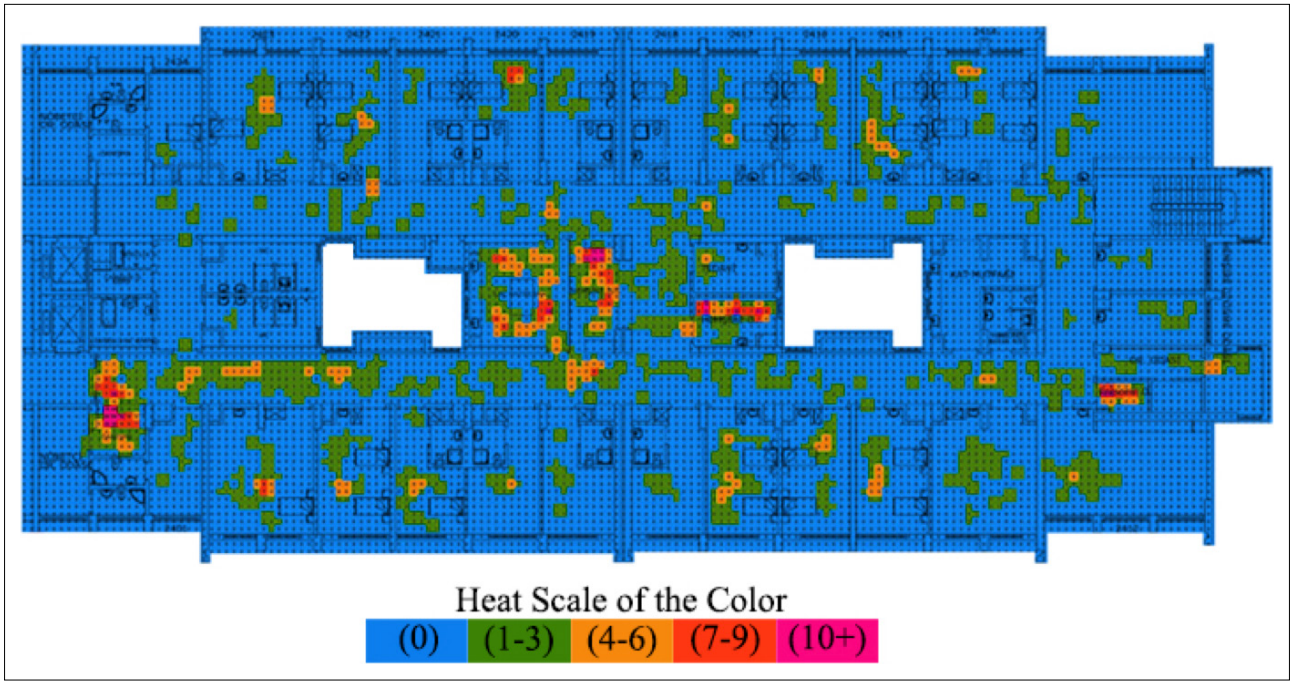

Figure 3. Extracted heat map.

did not undergo validity or reliability processes. However, two experienced nurses, one being an academic and the other a practitioner, acted as consultants in generating the questions and parts of the survey. Also, a pilot study was conducted to test the survey administration process on-site. The survey was conducted with 29 nurses (11 nurses in Case 1, 18 nurses in Case 2), and it took no more than ten minutes for each participant. The participant nurses were asked to respond to the questions with regard to the unit they were assigned to on the day of survey

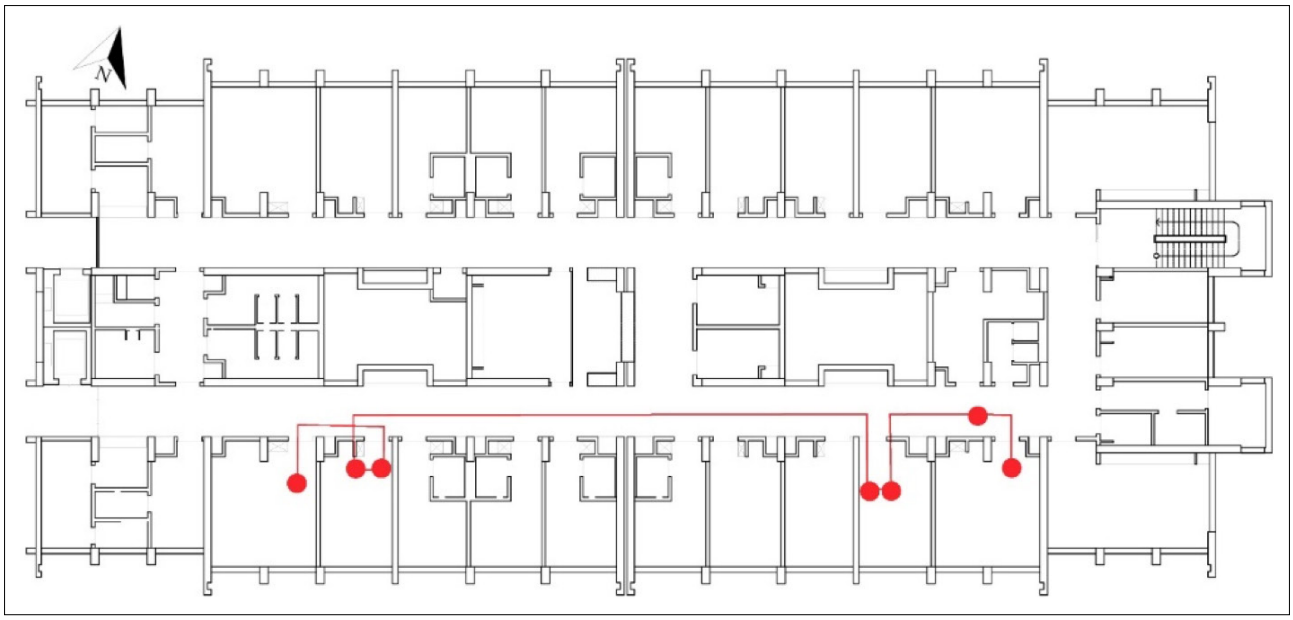

Figure 4. Staff traces of nurse activity mapping in a one session at Case 1.

administration. The survey included four main parts to gather relevant information at sites. The first part contains profile questions, including age, job description, gender, and experience levels. The second part involves questions to understand nurses' perceptions about their levels of communication and access to understanding interaction networks and location and the frequency of interactions between colleagues. The third part of the survey is designed to understand the effects of the spatial layout of the inpatient units on nurses' space occupancy. The last part of the survey is the drawing task, which generated self-reports on staff behavior in the respective units. The drawing task asked staff to mark their typical routes on a layout to understand the frequently occupied areas from nurses' perspective.

FINDINGS

Observations

Location Mapping Observation (LMO): The data emerging from the location mapping was initially transferred onto unit layouts to better understand the occupancy patterns during shifts. Figure 5, below, visualizes the location records for both cases. Although there are morphological and configurational differences between the two units, similar functional zones were observed to be frequently used by nurses in each unit, including particular segments of the corridors and also staff-related areas, including medication preparation rooms, nurse rooms and nurse stations. Case 1 shows that the intersection of the unit entrance and in front of the unit secretary hosts an accumulation due to administrative activities involving patients and their families. In Case 1, the graphic suggested a difference in the patterns of occupancy between the southern and northern corridors of the unit (Figure 5).

Apart from patient rooms, the three components of the functional program within the units –including nurse stations, medication preparation rooms, and nurse rooms- were observed to be densely occupied by nurses. These areas also introduce a level of overcrowding in certain zones across the corridors within the two cases. Around the nurse stations, the staff were observed to interact with both families and patients seeking information about their conditions. At the nurse station in Case 2, trainee nurses were recorded attending the computer stations, which increased the occupant density around the area.

In each of the units, the medication preparation rooms and the nurse rooms were observed to be natural attractors for nurses who were assigned to patients located across the units. In Case 2, the LMO recordings suggest overcrowding in and around the medication room and nurse room, which were located apart from the nursing station, unlike the configuration in Case 1. Thus, the zones on corridors with excessive crowding are observed to be stretched for Case 2, where the nurse station, medication room, and the nurse room were not clustered around the center of the unit.

Nurse Activity Observation (NAO): The second type of observation concerning nurse activity indicated an intersection of a nurse's movement recordings using the shadowing method. In line with the location mappings, it was observed that the similar segments of the corridors at both units were predominantly occupied by nurses. The NAO findings for Case 1 (Figure 6) suggest that the nurse activity recordings mainly cluster around the medication preparation room (indicated by the green area), nurse

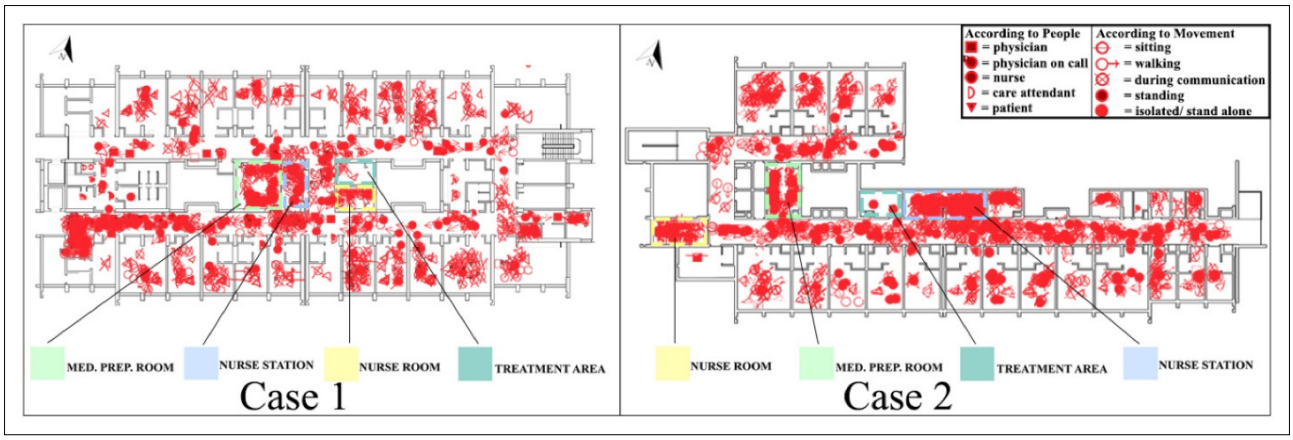

Figure 5. Comparison of staff traces of LMO in each unit.

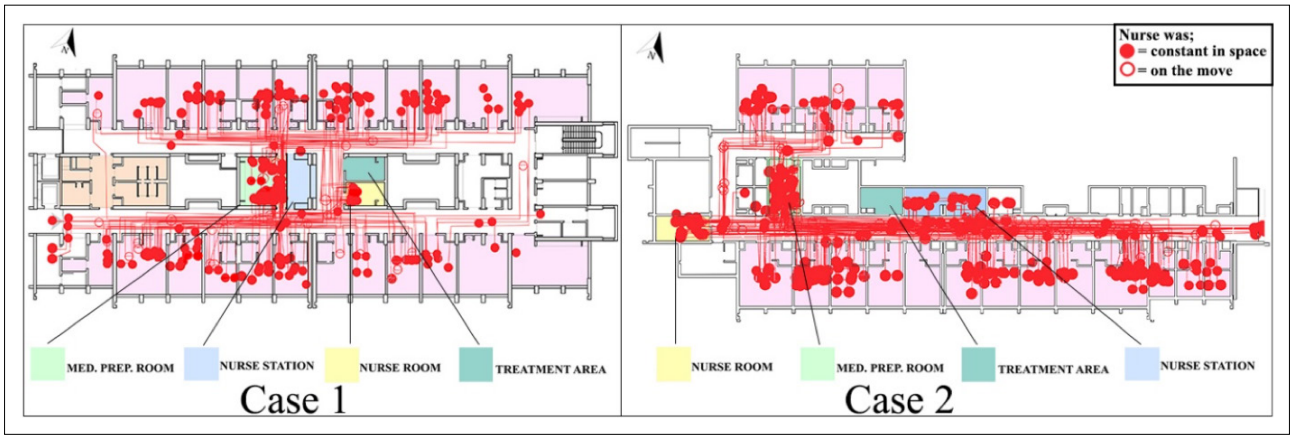

Figure 6. NAO recordings overlapped in each unit.

station (indicated by the blue area), and the nurse room, which is parallel to the findings with occupancy recordings.

The graphic above shows that the auxiliary corridors on the edges in Cases 1 and 2 are less used by nurses for circulation due to availability of other opportunities of transition between the main corridors. In Case 2, it was observed that nurses' movement created excessive accumulation along the main corridor since the main corridor of this unit directly meets the entrance and is the main spine connecting the entire set of functional areas and the welcoming area. Moreover, the medication preparation room in Case 2 was observed to be included as part of the circulation route that links the northern corridor to the main corridor. The two doors for the medication room were predominantly open, and the nurses were observed to be passing through the area, which was used as a shortcut between the nurse station and the northern corridor. This observation also applies to the medication preparation room in Case 1 which also has access to both northern and southern corridors of the unit.

Space Syntax

Space syntax analysis focused on connectivity analysis via visual graph analysis (VGA) to understand 'the visual accessibility of every location in the spatial system through the number of edges traversed to get from each to all others' (Varoudis & Psarra, 2014). Space connectivity analysis indicated that Case 1 has a visually well-connected spatial layout design, especially considering the corridor system. There are four intersection points on the main corridors that are considered the highest connectivity areas, like the crossroads of Case 1 (1 and 2 in Figure 7). The nurse station (3 in Figure 7), which is located at the intersection point, is the most connected area in the plan. In relation to the LMO and NAO recordings presented earlier, these connected areas also emerge as the most densely populated areas within the unit.

The connectivity analysis suggests that the northern corridor in Case 2 (Figure 8) has low connectivity levels compared to the main corridor in the unit, thus providing a level of isolation for the cluster of rooms facing north. The main corridor of the unit, on the other hand, seems to be creating a better-connected spine on which the nurse station, the medication room, and the nurse room are aligned. This segment of the corridor system in Case 2 has the potential to facilitate interactions between staff and patients, and also visitors.

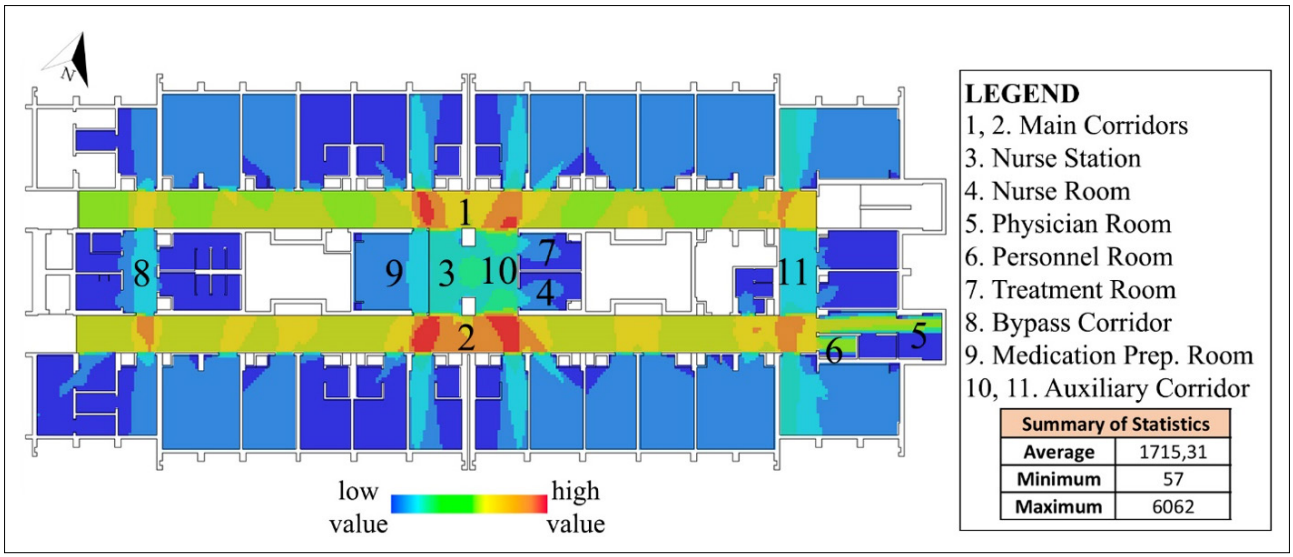

Figure 7. Connectivity analysis of case 1.

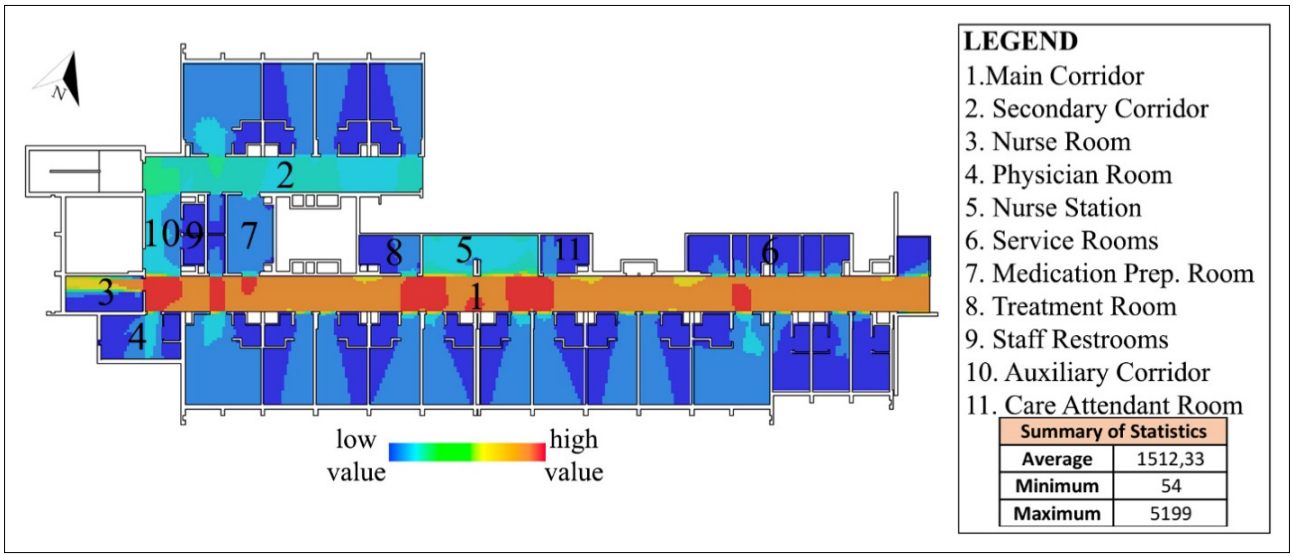

Figure 8. Connectivity analysis of Case 2.

Survey

The staff survey results suggest that the nurses regarded themselves as accessible to co-workers in terms of daily communication and work-related interactions. The nurses reported no significant barriers concerning visual and verbal communication which seemed to contribute to a level of situational awareness within the team. Most of the nurses stated that they were knowledgeable about the care processes of patients who were assigned to other nurses in the units.

According to the survey results obtained on the use of space, the most preferred areas for communicating with colleagues are nurse rooms, which are essential backstage areas for the mundane needs of staff (Figure 9). However, there is a slight difference between the two units that a small number

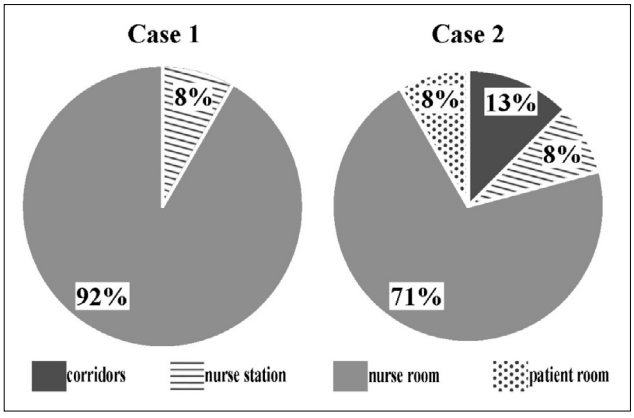

Figure 9. The most preferred place to communicate with colleagues.

of participants from Case 2 (13% of nurses) stated that they mostly preferred corridors to communicate with their colleagues, while other participants mentioned the nurse rooms and nurse stations. Contrary to the results obtained from observations, most of the nurses did not consider corridors as spaces for care-related communication.

The low number of participants made it difficult to conduct a deeper analysis beyond descriptive statistics. The drawing task within the survey, on the other hand, provided us with insights concerning occupants' perspective. The task requested nurses to mark their frequent routes during the shifts on a unit layout. The gathered data shows that nurses preferred similar destination points and routes in each unit. The findings from the drawing task indicate that the medication preparation area, represented in green, is the primary destination for both units. As shown in Figure 10 which represents two sample drawings from two participants, the medication preparation room at both units were emphasized as both a destination and a transition area (a by-pass passage) between the corridors within the units.

Key Findings

1. The LMO and NAO recordings suggest that the allocation of the three key areas within the units,

Figure 10. Drawings produced by two participants to show the most frequent routes within units.

namely the nurse station, the nurse room, and the medication preparation room, impacts the distribution of occupancy densities across the corridors. When these areas are located apart from each other, as in Case 2, the most densely occupied segment within the corridor spaces extends to include the route that links these three rooms. On the other hand, in Case 1, where the three rooms are clustered around the unit's center, the nurse activity traces were limited to the core area that included the nurse station, the nurse room, and the medication room.

2. The syntax analysis suggested that the nurse stations on both units were located on the most connected areas across the units. The most connected area in Case 1 also included the medication preparation room and the nurse room, thus making the key functional elements on the floor visually connected. In Case 2, the connectivity graph suggests a series of disconnected zones with high levels of connectivity distributed across the floor.
3. According to the observation results, corridors are the spaces where the nurses spend the majority of their time during shifts. However, the survey results suggest that the nurses mainly prefer nurse rooms for communication concerning care-related issues. In both units, the nurse rooms offer a level of isolation for nurses to maintain a level of privacy and confidentiality, which is considered as vital in a setting with no single-bed patient rooms.
4. The results of the drawing task within the nurse survey were in line with the NAO recordings. The nurses at the units are observed to be knowledgeable about the features of the units they work in, and were able to illustrate graphically the most frequent routes they follow on a daily basis.
5. The medication preparation rooms at both units emerges as one of the key attractors to generate high levels of occupancy. Both rooms have doors that connect the major circulation routes within units, thus creating by-pass passages to be employed by the nurses during their shifts. Both LMO and NAO observations and the drawing task provide data to confirm the situation with the medication preparation rooms.

DISCUSSION

The current section involves an interpretation of findings concerning the two cases studied. The discussion is presented through four key functional areas, namely corridors, nurse stations, nurse rooms and medication preparation rooms, which emerged as central to the analysis in relation to the research questions.

Corridors

The results show that the corridors were most frequently occupied areas by nurses in the two medical-surgical inpatient units. This may not seem like a novel finding because, typically, the corridors are acknowledged to be key areas to provide accessibility, control, and circulation in healthcare indoor environments (Carthey, 2008). There is research to suggest that corridors in healthcare settings are important as these spaces are key in coordination and communication (Carthey, 2008). The results indicate that there are specific zones that may contribute to even higher levels of circulation for certain segments across corridors, namely nurse room, nurse station, and medication preparation room. These staff-only areas are positioned as a cluster –in close proximity- in Case 1, while the mentioned areas are distributed across the corridor in Case 2. Accordingly, the observation recordings point out to the difference in circulation densities across corridors that link these key staff-related areas (Figure 11). Also, the dense areas within observation mappings seem to overlap with the zones with high levels of visual connectivity according to the space syntax analysis. This finding may suggest that the nurses tend to prefer locations or routes with high visibility.

As mostly emphasized in the literature, the corridors are favorable places where healthcare staff spend most of their shift time in a day, so these areas hold the potential to facilitate various forms of interactions between colleagues (Adams, 2008; Iedema et al., 2006; Pachilova et al., 2013; Setola et al., 2013). With particular focus on nurses' movement, a study by Hendrich et al. (2009) demonstrated that the patient assignments have a predictable impact on how nurses move through indoors. While the nurse assignment strategy is acknowledged to be a variable, the results of the current study suggest a reconsideration of the adjacencies of certain programmatic elements, other than patient rooms, which

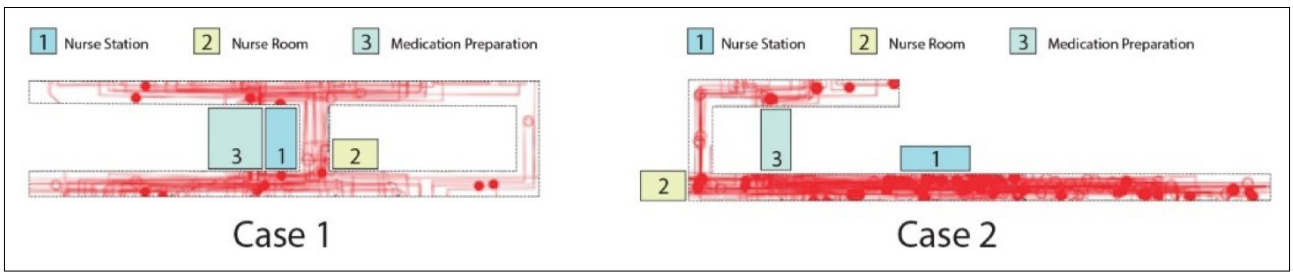

Figure 11. The densities of observation recordings at the unit corridors.

may have an impact on the frequently occupied locations and patterns of movement. The allocation of the three elements of the functional program, namely nurse stations, nurse rooms, and medication preparation rooms, and the proximities in-between raise further research questions concerning travel distances, planned and unplanned communication opportunities among colleagues and patient surveillance.

Yi & Seo (2012), to our knowledge, provide the only study to specifically focus on walking behavior and draw conclusions concerning the interrelation between paths that nurses follow and allocation and proximities for medication preparation room and nurse stations. They argue that "characteristics of the path that connects functional spaces such as patient room and medication area might better {Citation} nurses' walking behavior" (Yi & Seo, 2012, p. 66) than the unit shape. In addition, the study suggests that the frequency of interruptions –for experienced nurses in particular– was influenced by the relationship between certain functional areas within units. While the current paper did not concern with the counts of unnecessary stops or unplanned interactions, our observations concur with Yi & Seo's (2012) findings that micro-spatial organization of indoor environments and its influence on occupancy and movement patterns of nurses emerge as a critical factor to be further studied.

Nurse Stations

In the context of THS, centralized nurse stations are still predominantly used in inpatient units as opposed to emerging progressive models including distributed nurse station layouts. In Case 1 and 2, the nurse stations were located at the center of the units and were observed to be frequently occupied by staff members for a variety of purposes including coordination, face-to-face or phone-based communication, charting and related administrative duties. In both cases, nurse stations create a certain level of occupancy and circulation density around them which implies the potential for all forms of social interaction beyond care-related communication.

The literature suggests that centralized nurse stations positively contribute to nurse cooperation and communication (Zborowsky et al., 2010). Zborowsky et al. (2010) emphasize the importance of nurse stations as "the setting for frequent social interaction and formal and informal teaching and learning activities". This situation is critical for the cases observed in this research in which the trainee nurses from the College of Nursing were always present to support care processes during shifts. The activities in and around the nursing stations within Case 1 and 2 certainly create an environment where less experienced members of the group learn by observing the behaviors, practices and decisions of seasoned nurses.

Other than the nurses of the units, the stations in both Case 1 and 2 were observed to be places inhabited temporarily by individuals from other departments. Zook et al. (2019) support the idea that during shifts the unit includes various temporary staff members, some of whom work in different parts of the hospital during the day. Integrated work areas within the unit, especially the stations, facilitate interaction among these groups, creating temporary communities of practice. Thus, understanding the patterns of activity for various participants in and around nursing stations and considering associated parameters, including proximities to other areas, levels of visual and acoustical privacy, and access, becomes critical in the centralized nurse station models.

Nurse Rooms

Considering the communication among colleagues, the nurse room is the most preferred space in both cases, according to the survey results (92% of the respondents in Case 1, 71% in Case 2). Moreover, it is noticeable in the drawing task that most of the respondents in both cases preponderantly marked the nurse room as part of their frequent routes during shifts. The observations also support the fact that nurse rooms were among the most frequently occupied areas within the two units (Figure 12).

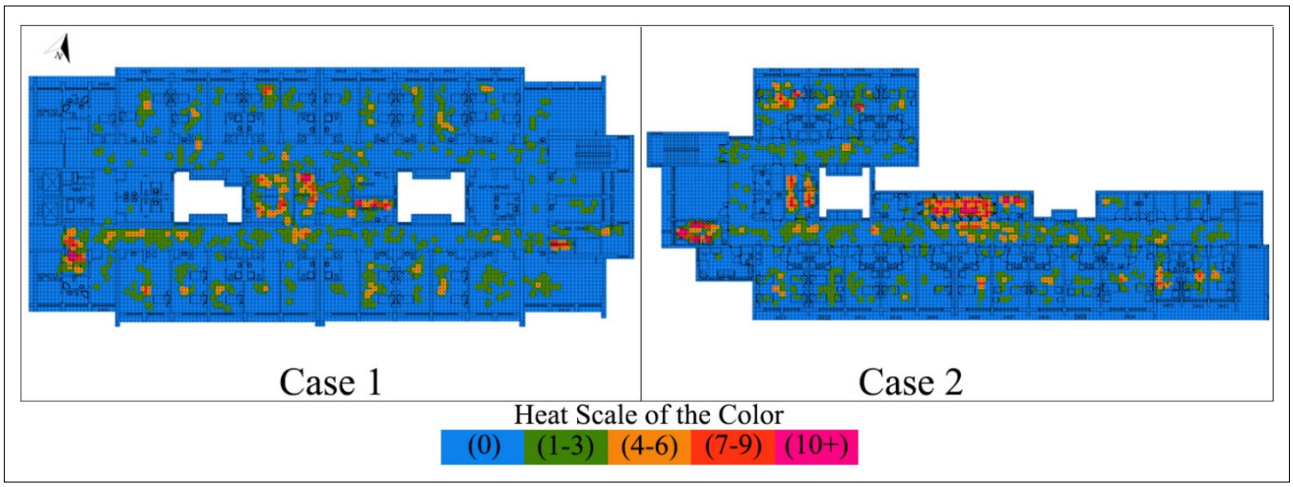

Figure 12. Heat maps from LMO Data to show densely occupied areas.

The literature proposes that nurse rooms should be positioned centrally within the unit and close to the nurse station (Adams, 2008; Nejati et al., 2016), and providing facilities for nurses to take respite, thereby potentially contributing to a positive impact on staff (Zhu & Shepley, 2022). The positioning of nurse rooms within units and how the nurses utilize these rooms are relatively different in both cases. The nurse room in Case 1 is used as a break room for the mundane activities of staff, and its door was observed to be closed all times during the shift in order to create a level of privacy. On the other hand, the nurse room in Case 2 –provided with a computer workstation- was being used as both a break room and an office. The healthcare facility regulations in Turkey do not provide specific guidance concerning the location and utilization nurse rooms in inpatient units. Although the nurses did not express any complaints concerning the utilization of nurse rooms within the two units, it is important to clearly differentiate between whether the nurse room will serve as a nurse's office or a nurse's break room within the unit.

Medication Preparation Rooms

Keers et al. (2013)'s comprehensive review on medication administration errors reports eleven research studies that link occurrence of such adverse events to environmental features within healthcare facilities. Chaotic, distracting, and busy environments, for instance, were emphasized as conditions to cause medication errors. Existing research suggests that interruptions and distractions that medical staff experience are likely to increase the chances to result in errors (Duruk et al., 2016; Fore et al., 2013; Huckels-Baumgart et al., 2021)

The implementation of the "sterile cockpit" strategy in healthcare has been acknowledged to be an environment-related improvement to reduce medication administration errors (Fore et al., 2013). The model suggests that having a separate room for medication preparation (Huckels-Baumgart et al., 2021) and elimination of all forms of potential distractions and interruptions in inpatient units result in minimized occurrence of errors. For the cases observed in this research, the medication preparation rooms were not located as isolated and distant from the circulation areas while doors of both rooms in both units were always observed to be open during the fieldwork. Moreover, in Cases 1 and 2, the medication preparation area was used as a transition area between the main corridors, according to the observational data and the results of the drawing task in nurse survey. In other words, the medication preparation rooms in Cases 1 and 2 were among the frequently occupied areas within the unit as the rooms are being utilized as a by-pass passage within nurses' circulation routes (Figure 13).

Huckels-Baumgart et al. (2021)'s observational study reports that having a separate medication preparation room, in order to limit frequent interruptions and distractions, mostly initiated by colleagues, has a positive effect to decrease medication errors. The suggestion to implement a separate area reserved for medication preparation is already implemented in the units studied in this research. The location and configuration of these areas, and daily work practices of nursing staff in the unit seem to contribute to the heavy traffic within and around the medication preparation rooms. The current research did not seek any correlation between the number of medication errors and the features of indoors for the cases. However, the issue is acute in the context of THS, and further research is needed to better understand the role of environments within causal links that result in medication errors and to guide and influence regulatory documents in healthcare construction.

This section discusses that the findings of this study regarding the spatial occupancy practices of nurses indicate a remarkable situation when evaluated in the context of national spatial standards for healthcare facilities in Turkey. The Ministry of Health of Turkey's guidelines (such as Ministry of Health of Turkey Inpatient Health Facilities Planning Guide (2011)) focus on technical aspects like facility functionality, hygiene, accessibility, and security. However, they only briefly address how healthcare staff, especially nurses, interact with the space, which requires more qualitative consideration. Moreover, the circulation, communication and care activities that nurses carry out between different spaces in their daily workflow are a direct output of spatial organization. This situation demonstrates a gap between current standards and user experiences, highlighting the need for new initiatives aligned with user-centered and evidence-based design principles. Although it can be argued that the knowledge concerning the user experience is already known implicitly by healthcare designers in the context of Turkey, it is still important to

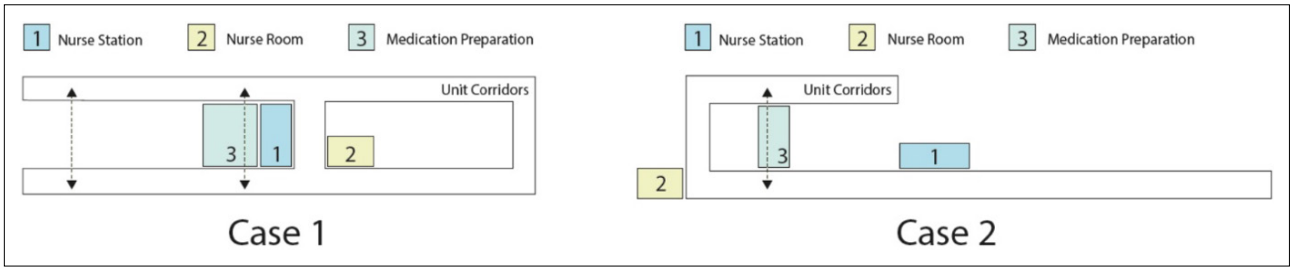

Figure 13. Unit corridors and by-pass passages.

express abovementioned design concerns explicitly in the next editions of healthcare design guidelines.

CONCLUSION

A growing body of research suggests a strong link between the layout of spaces and communication within healthcare settings, especially among staff, as it has a consequential effect on the quality of care and patient outcomes.(Cai & Zimring, 2012; Haron et al., 2012; Pachilova et al., 2013). Spatial measurements correlate robustly with nurses' distribution, interaction, and mutual awareness (Cai & Zimring, 2012) since the spatial arrangement within healthcare facilities can bring together healthcare staff during their shifts, influencing their experiences, communication, and behavior. Continuing the discussion on communication and interaction in healthcare environments, this study aimed to investigate key factors –occupancy and movement- which are recognized as primary variables affecting the levels and frequency of communication among nurses within inpatient units.

The study's findings revealed that the different spatial layouts and the allocation of programmatic elements within created different patterns of occupancy and movement. While there are morphological distinctions among the units, the results indicate that specific functions arise to influence occupancy and movement. Particular segments within corridors emerge as crucial areas where nurses predominantly spend their time, having potential to facilitate a level of awareness among colleagues. The study has highlighted various key elements within corridors that encourage increased movement, including nurse stations, nurse rooms, and medication preparation areas in the examined units.

According to current research, the medication preparation room, a key area for care procedures within units, should be strategically designed on the floor plan to minimize unnecessary traffic flow. Furthermore, the room should adhere to design principles to reduce distractions, as the literature indicates that communication and interruptions in medication preparation areas can contribute to medical errors. However, the results of this research show that the medication preparation room is utilized for interaction, communication, and information exchange, as well as for preparing drugs. The room for preparing medications serves as a connecting corridor between the main hallways during specific cases. Consequently, the presence of these two medication preparation rooms in cases 1 and 2 has influenced both the intensity and the trajectory of nurse circulation on the corridors, as they have become the most frequent destination for nurses. Hence, when planning the design of medication preparation rooms, designers must take into account various factors, including selecting appropriate locations and sizes within the unit, and their integration with circulation pathways and other high-traffic areas.

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