Journal of Architectural/Planning Research and Studies (JARS) Vol.23(2).2026 https://doi.org/10.56261/jars.v23.277340

Issues and Enhancement Strategies for the Physical Environment in Rehabilitation Medicine Unit Workspaces

Nitchakarn Pittayaporn and Tanut Waroonkun*
Faculty of Architecture Chiang Mai University, Chiang Mai, Thailand
*Corresponding author email: tanut.w@cmu.ac.th
Received 29/3/2025 Revised 28/4/2025 Accepted 21/7/2025

Abstract

This study aims to investigate the physical environment of rehabilitation medicine units and propose strategies for enhancing environments that promote the well-being of medical staff. The study employed three methods for data collection: a physical environment survey, a pairwise comparison questionnaire, and in-depth individual interviews with medical staff from three service areas in Maharaj Nakorn Chiang Mai hospital, which is a tertiary care facility affiliated with the Faculty of Medicine at Chiang Mai University: the treatment room (5 participants), outpatient department (10 participants), and inpatient department (10 participants). The findings highlight obstacles to medical staff's well-being, such as the lack of private spaces for both work and relaxation. Analysis using the Analytical Hierarchy Process (AHP) approach revealed that privacy during work was ranked the highest priority among medical personnel (with eigenvector scores of 0.45, 0.36, and 0.34), followed by access to nature and interior design factors. The in-depth interviews were analyzed using content analysis, resulting in three main themes: (1) problems from existing environmental conditions, (2) space management, and (3) equipment and facility management. The study makes four design recommendations for rehabilitation medicine units: ensuring privacy, incorporating relaxation-enhancing elements, optimizing spatial and equipment arrangements to support workflow, and addressing structural issues within the building. The comprehensive case study, along with its interconnected data collection methodology, strongly illustrates a clear alignment between the identified factors and existing research. This compelling evidence suggests that these findings hold relevance for the design of similar facilities.

Keywords

Medical staff well-being; Rehabilitation medicine; Evidence-based design; Physical environment; Analytical Hierarchy Process

1. Introduction

Designing a suitable work environment is crucial for promoting well-being, influencing perspectives, efficiency, and job satisfaction among medical staff. Hospital design inherently is complex, as each ward has distinct spatial characteristics. Rehabilitation medicine units focus on treatments for physical recovery, necessitating unique environmental considerations such as therapy duration and space allocation (The American Institute of Architects Academy of Architecture for Health [AIA], 2001).

This study examines the physical environment of a rehabilitation medicine unit and proposes improvements that support the well-being of medical staff. The literature review regarding the relationship between physical environmental factors and the well-being of medical staff reveals a lack of extensive research, especially within Asian or tertiary hospitals. Additionally, the demand for rehabilitation services is anticipated to rise, further impacting the context of similar hospitals. Through inspections of various rehabilitation units in Thailand, it was found that the buildings under investigation exhibited physical environmental issues that potentially could affect the well-being of the users. This observation led to the selection of the case study site for our research. This research was conducted in the Rehabilitation Medicine Unit of Maharaj Nakorn Chiang Mai Hospital, chosen due to its distinct architectural characteristics compared to other rehabilitation units typically built in newly constructed buildings. The case study involves an old building that exhibits various usage-related issues, such as structural deterioration and physical separation from the hospital's main buildings (Figure 1). Additionally, the use of wooden materials in the facility potentially reduces stress and anxiety (Asfour, 2019), making this setting uniquely intriguing.

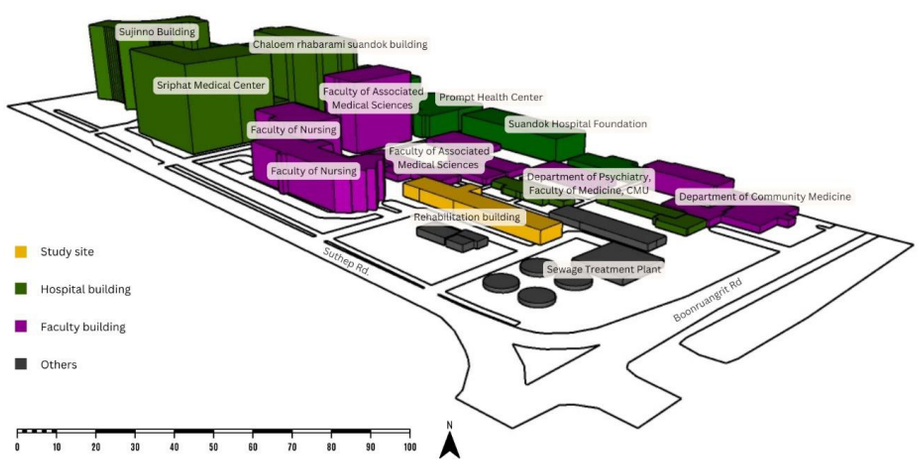


Figure 1. Layout plan of the case study and surroundings.

A single case study approach allows for an in-depth examination of specific conditions, differing from multiple case studies, focusing on comparative analysis (Gustafsson, 2017). The study employs three data collection methods to ensure a holistic understanding: physical environment surveys, pairwise comparison questionnaires, and in-depth interviews with current users (medical staff). There were two research questions that guided the study:

1. What are the current environmental conditions and do they promote well-being?

2. What physical environmental factors can enhance the well-being of medical staff in rehabilitation medicine units?

This study identifies key factors through a comprehensive literature review and analysis, categorizing them into two primary aspects: space design and space management. The analysis emphasizes the relationships among physical environmental factors, space management-related elements, and those factors that influence the well-being of medical staff.

2. Literature Review

Work environments impact well-being, emotions, and work performance. This is particularly true for medical staff operating within interdisciplinary healthcare teams and serving many patients daily. A well-designed and promoted well-being workplace must provide adequate, balanced, safe, and functionally appropriate spaces tailored to specific job requirements (Bamforth et al., 2023; Kinman et al., 2020). Hospital environments introduce additional complexity due to the diverse services across different wards.

Evidence-based design (EBD) has been developed to enhance healthcare environments and follows the process of researching and designing healthcare-built environments to support patients and medical staff effectively. Research has shown that well-designed healthcare environments reduce stress and anxiety and improve job satisfaction (Hamilton, 2004; Ulrich, 2003). Workplace stress affects physical, mental, and emotional well-being, particularly among healthcare professionals and has been identified as a contributor to stress burnout. This stress affects healthcare providers and patient outcomes through many physical factors such as the privacy of medical staff, noise and acoustics, the environment that inadequately mitigates occupational fatigue, and also the quantity of work each day (Joshi et al., 2022; National Institute for Occupational Safety and Health, 2023). Well-being encompasses more than just physical health; it also includes mental, emotional, and social health, and residing in a conducive or positive environment. Factors like access to nature, cleanliness, adequate ventilation, and appropriate noise levels contribute to a supportive setting. Additionally, a well-structured and organized workspace can reduce stress, promote overall well-being, and enhance the quality of healthcare service delivery to patients. (Litchfield, 2021; Torres-Soto et al., 2022; Ulrich et al., 2008) The study by Shepley et al. (2025) on perspectives regarding outpatient rehabilitation ward environments highlights key factors, including considering the balance between private and shared spaces, the use of music as a therapeutic aid, designated rest areas for medical staff, access to outdoor spaces, window views and natural light exposure, and the appropriateness of furniture selection.

Huisman et al. (2012) examined the impact and relationships among factors associated with the healing environment—a theory focused on designing hospital physical environments to support recovery, reduce hospital stays, and enhance user experiences, including the well-being of healthcare professionals. Their study identified three primary environmental factors that contribute to the well-being of medical staff: (1) Organization and functionality; (2) Technical support; and (3) Comfort. A detailed analysis of each category revealed several key environmental factors relevant to promoting healthcare workers' well-being, as summarized in Table 1.

Table 1. Summary of Physical Environmental Factors which Promote Well-being of Medical Staff

Environmental factors	Definition	Source
1. Organization and functionality	Efficient resource use, effective space management, and accessibility.	Huisman et al., 2012
1.1 Accessibility	The facility should be easily accessible, with adequate parking spaces for medical personnel, designated drop-off areas, and emergency vehicle access. It should be located on the ground floor and feature automatic doors with a minimum width of 81.5 cm.	International Health Facility Guidelines, 2023; The Americans with Disabilities Act:ADA, 2010 Department of Justice (2010)
1.2 Lighting	Appropriate lighting should be provided, with an illumination level of approximately 200-300 lux.	Nielsen P., 2010
1.3 Space for medical staff	There should be sufficient restroom facilities and locker spaces, with a minimum width of 6 square meters. A multipurpose room of at least 15 square meters should be available for medical staff.	AIA (2001); International Health Facility Guidelines, 2023
1.4 Layout	Open-plan spaces should be designed for shared use between physical and occupational therapy activities.	AIA (2001); Indian Health Facilities Guidelines, 2014
1.5 Privacy	Private areas for medical personnel should ensure confidentiality from patients and their families while remaining easily accessible from the main workspace.	International Health Facility Guidelines, 2023; Indian Health Facilities Guidelines, 2014
1.6 Safety	The area should be free of slippery surfaces and sharp edges, with stable and durable equipment and furniture to ensure safety.	International Health Facility Guidelines, 2023
2. Technical support	Proper equipment uses and functional workspaces.	Huisman et al.,2012
2.1 Equipment	Equipment should be arranged for ease of movement and accessibility, avoiding obstructions. Furniture should be flexible and multifunctional to accommodate various uses.	Engineer et al., 2021; International Health Facility Guidelines,2023
2.2 Privacy during work	Enclosed rooms should be provided for specialized assessments and therapy sessions, and curtains should be installed to enhance privacy during treatment.	AIA (2001)
2.3 Facilities	A designated storage area should be provided for large equipment such as wheelchairs and walkers, ensuring clear pathways. Shelves or cabinets should be available for storing smaller medical tools.	AIA (2001), Indian Health Facilities Guidelines, 2014; International Health Facility Guidelines, 2023
2.4 Work space	Occupational therapy areas should include dedicated spaces for daily living practice, wheelchair-accessible counters, and private treatment beds with curtains in physical therapy zones.	AIA (2001)
2.5 Acoustics	Noise levels should be maintained at an appropriate threshold, not exceeding 45 dB. Controllable background music should be available to reduce stress.	International Health Facility Guidelines, 2023; Ulrich, 2003; United States Environmental Protection Agency (US EPA,1978)
3. Comfort	Psychological well-being, access to nature, and ergonomic considerations	Huisman et al., 2012
3.1 Nature accessibility	Windows should provide access to green spaces or natural light to support well-being.	Ulrich.,1984 ; Torres-Soto et al., 2022
3.2 Decorations	The facility should incorporate decorative elements and indoor gardens to promote relaxation and emotional well-being.	Engineer et al., 2021
3.3 Temperature	Air conditioning systems should allow temperature adjustments within a range of 17.66–24.51°C.	International Health Facility Guidelines, 2023; Van Gaever et al., 2014
3.4 Cleanliness	The materials used should be easy to clean and resistant to pathogens, ensuring a hygienic environment free from unpleasant odors.	AIA (2001); International Health Facility Guidelines, 2023

The main and secondary factors of the physical environment that contribute to the well-being of medical staff in the rehabilitation medicine unit can be summarized as shown in Figure 2. These factors were integrated into the study's three-part data collection process, which consisted of: (1) a survey of the physical environment; (2) a questionnaire-based assessment; and (3) interviews with medical staff.

This research employed a post-occupancy evaluation (POE), a method used to assess the effectiveness and user experience of buildings or spaces after their use. Specifically, a clinic design post-occupancy evaluation was applied to analyze the usability and suitability of clinical spaces (The Center for Health Design, 2015). This approach was particularly relevant to the case study, as this research aimed to examine the existing physical environment and propose appropriate design solutions tailored to the needs of rehabilitation medicine staff within hospitals and clinical settings.

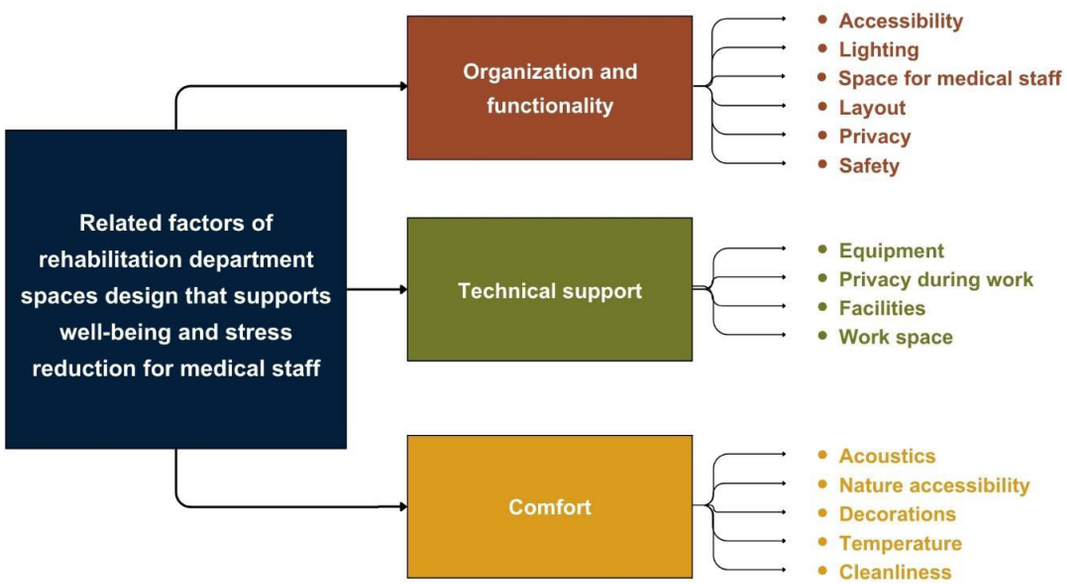


Figure 2. Diagram of physical environmental factors which promote medical staff's well-being.

3. Methodology

A single-case study methodology was used to explore the unique architectural and functional characteristics of the Rehabilitation Medicine Unit at Maharaj Nakorn Chiang Mai Hospital by employing a comprehensive data collection approach based on the physical environmental factors affecting medical staffemployed therein. . The study involved 25 participants, including occupational therapists, physical therapists, and healthcare administrative staff. Data collection included three methods:

- Physical Environment Survey – Using a checklist from the literature review and photographic documentation.
- A Pairwise Comparison Questionnaire – An Analytical Hierarchy Process (AHP) questionnaire was adopted, which focused on 31 environmental factors.
- In-depth interviews were conducted with 19 medical staff to gather qualitative insights, analyzed using content analysis.

3.1 Case Description

Site analysis

The Rehabilitation Medicine Building at Maharaj Nakorn Chiang Mai Hospital is a tertiary care hospital under the Faculty of Medicine, Chiang Mai University. The hospital is a medical treatment centre and a teaching hospital for health science students. The current Rehabilitation Medicine Building originally was the Chiang Mai Municipal Hospital, first constructed in 1939 (B.E. 2482) before Maharaj Nakorn Chiang Mai Hospital was established in 1956 (B.E. 2499). This two-story teakwood structure is noteworthy for its historical significance. The building underwent renovations in 2012 (B.E. 2555) to enhance its rehabilitation medicine facilities. Further modifications were made in 2020 (B.E. 2563) to accommodate COVID-19 patient care. The facility has since returned to its original purpose as a rehabilitation medicine unit. While these renovations have increased the building's versatility, they did not fully address the specialized design requirements unique to rehabilitation medicine, as illustrated in Figure 3.



Figure 3. Surrounding environment of the rehabilitation medicine unit, Maharaj Nakorn Chiang Mai Hospital.

3.2 Data Collection, Data Analysis, and Participants

Data collection consisted of three parts: (1) a physical environment survey using a checklist and photographic documentation; (2) a pairwise comparison questionnaire analyzed using the Analytical Hierarchy Process (AHP); and (3) in-depth individual interviews analyzed through Content Analysis. An overview of the data collection process, methods, objectives, and analysis is provided in Figure 4.

Data collection	Method&Tools	Aims	Data analysis
Observations	• Checklist • Camera	To study the current physical environment in rehabilitation wards.	Analyze by checklist, photo and architectural building plan
Surveys	• Analytic Hierarchy Process (AHP) Questionaire	To study the physical environmental factor in rehabilitation unit.	Analyze by Analytic Hierarchy Process (AHP)
Interviews	• Individual interview • Semi-structure interview	To study factors in detail which promote the well-being of medical staff	Analyze by content analysis

Figure 4. Diagram summarizing the research methodology.

Step 1: A physical environment survey

This data collection step gathered information using a checklist based on physical environmental factors, with sub-factors derived from the literature review. This process was combined with photographic documentation across three areas: the treatment room, the outpatient rehabilitation therapy room, and the inpatient rehabilitation therapy room. The collected data were analyzed by examining the relationships between physical environmental factors, using photographic records alongside architectural floor plans of the case study area. The photos and observational data from the physical environment survey were analyzed in collaboration with the research team. The overall analysis and conclusions also were compared with data from two other components in Step 2 and Step 3.

Step 2: A pairwise comparison questionnaire

Data were collected using a pairwise comparison questionnaire, divided into three main factor groups with sub-factors of physical environmental conditions, as shown in Table 2. The questionnaire consisted of 31 items and participants took approximately 15–20 minutes to complete. The questionnaire used a 9-point scale, where one indicated that both compared sub-factors were equally important, and nine indicated that one sub-factor was more important than the other. The scores from each study area were then aggregated and analyzed using the Analytical Hierarchy Process (AHP), which facilitates decision-making by ranking multiple hierarchical sub-factors and reducing complexity (Saaty, 1990). This approach helped determine the priority ranking of each physical environmental factor.

Table 2. Example of Answering a Pairwise Comparison Questionnaire

Main factor	Paired comparison method questionnaire			Main factor
	More important	Equal	Less important	
Factor A	9 8 7 6 ⑤ 4 3 2	1	2 3 4 5 6 7 8 9	Factor B
Factor A	9 8 7 6 5 4 3 2	1	2 3 4 ⑤ 6 7 8 9	Factor C

The results obtained from the questionnaire are presented in a table, ranking the importance of each sub-factor that contributes to the well-being of medical staff in rehabilitation medicine units. The key analytical components of AHP and their general calculation method are described as follows:

Eigenvector: represents the weight assigned to each sub-factor based on relative importance. It is calculated using the equation $\boldsymbol{AW= \lambda_{max}\ w}$ from the Normalized Matrix.

Consistency Ratio (C.R.): Measures the consistency of the pairwise comparisons. A C.R. value below 0.1 is considered acceptable. Th C.R. is determined by comparing the ratio of the Consistency Index (C.I.) to the Random Consistency Index (R.I.) using the formula: $C.R. = \frac{C.I.}{R.I.}$

Consistency Index (C.I.): Indicates the consistency of the data within the matrix. It is calculated using the formula: $C.I. = \frac{(\lambda_{max} - n)}{(n-1)}$ where $\boldsymbol{\lambda_{max}}$ is the maximum eigenvalue and n is the number of compared factors.

Step 3: In-depth individual interview

In-depth individual interviews were conducted, each lasting approximately 15–30 minutes. These interviews were structured around two key questions: *(1) What are your perceptions of the current physical environment in the rehabilitation medicine unit?; and (2) What do you consider to be the ideal physical environment for*

promoting the well-being of medical staff in the rehabilitation medicine unit? Participants provided detailed insights and opinions on each factor, which were then analyzed using content analysis. The interview recordings were transcribed and categorized into themes to systematically organize the large volume of data into specific categories relevant to the research objectives (Erlingsson & Brysiewicz, 2017). An example of content analysis is illustrated in Figure 5.

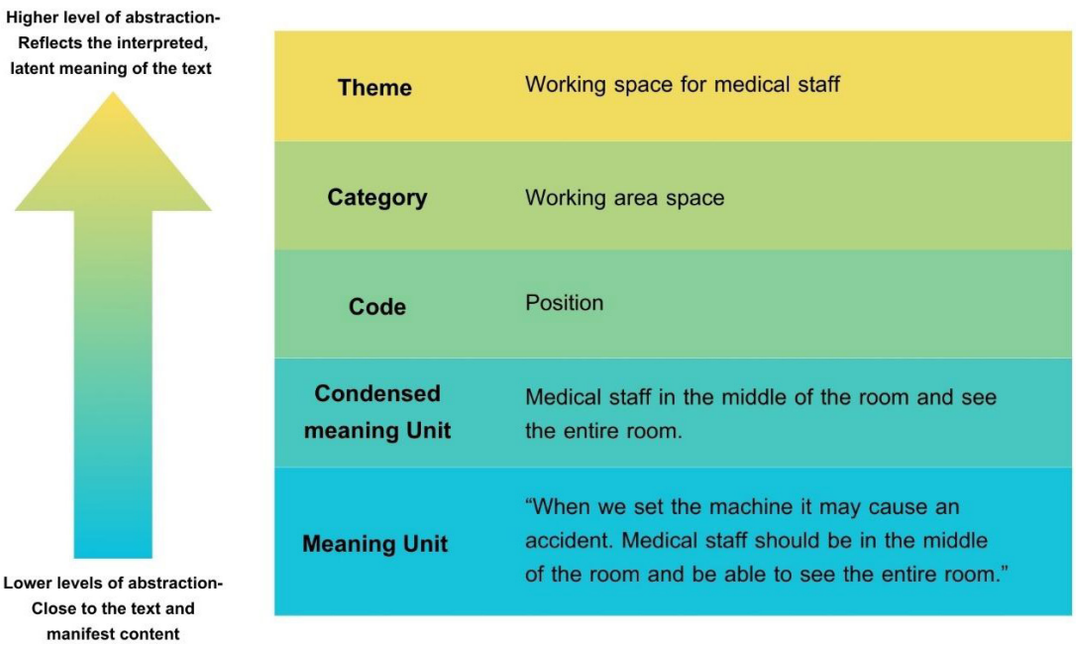


Figure 5. Example of data analysis using content analysis. Adapted from Erlingsson & Brysiewicz (2017).

The study participants were medical staff who regularly utilized the space, including occupational therapists, physical therapists, and staff members. This research received ethical approval from the Faculty of Medicine, Chiang Mai University (Approval No. NONE-2567-0106). During the physical environment survey conducted to identify issues within the rehabilitation unit of Maharaj Nakorn Chiang Mai Hospital, the target population size was clearly defined. This allowed for the selection of an appropriate and statistically reliable sampling method. Therefore, this study determined the sample size for each area using Yamane's (1973) formula.: $n = \frac{N}{1+Ne^2}$. As such, a total of 25 participants were recruited from three areas, distributed as follows: Treatment room: 5 participants; Outpatient rehabilitation therapy room: 10 participants; Inpatient rehabilitation therapy room: 10 participants.

4. Results

This study employed a mixed-methods approach, incorporating qualitative data (from observation and in-depth interviews) and quantitative data (from questionnaires) to achieve a comprehensive and well-rounded understanding of the study area, use, and user perceptions. This integration of depth and breadth in data collection supports a thorough analysis aimed at developing a physical environment model that promotes the well-being of medical personnel in rehabilitation units. The results from the data collection can be divided into three main parts, discussed in the following sections.

4.1 Results From Observation

The physical environment survey of the Rehabilitation Medicine Unit at Maharaj Nakorn Chiang Mai Hospital (Figure 6) was conducted by a walk-through assessment, which included a checklist and photographic documentation. The findings indicated that the total service area of the case study covered 420 square meters, distributed across two floors: **Ground Floor (1st Floor):** *Treatment Room:* Approximately 120 square meters and Outpatient Rehabilitation Therapy Room (OPD): Approximately 156 square meters. **Second Floor (2nd Floor):** *Inpatient Rehabilitation Therapy Room (IPD)*: Approximately 144 square meters. The building primarily is constructed from teakwood, with some areas being modified or extended (Figure 7). Staircases, an elevator, and a ramp connect the first and second floors. The findings of the walk-through assessment are summarized in Table 3.



Figure 6. Architectural floor plan of rehabilitation medicine unit, Maharaj Nakorn Chiang Mai Hospital.



Figure 7. Physical environment of rehabilitation medicine unit, Maharaj Nakorn Chiang Mai Hospital.

Table 3. Results from the Physical Environment Survey

Main factor	Sub-factor	Treatment room	Out-patient department (OPD)	In-patient department (IPD)
Organization and functionality	1.1 Accessibility	- Located on the first floor, near the parking area and drop-off point, with access via stairs and a ramp. - Sliding door with a width of more than 815 mm.	- Located on the first floor, near the parking area and drop-off point, with access via stairs and a ramp. - Sliding door with a width of more than 815 mm.	- Located on the second floor, accessible via stairs, a ramp, and an elevator. - Swing door with a width of more than 815 mm.
	1.2 Lighting	350 lux	500 lux	600 lux
	1.3 Space for medical staff	No designated room for medical staff, but a curtained-off area is provided for rest within the Treatment Room.	A meeting room and a multipurpose room are available for dining.	No designated room for medical staff
	1.4 Layout	- Open-plan layout. - Bed areas separated by curtains. - The medical staff counter is located in the center of the room.	- Open-plan layout. - Shared space with a reception area separated by a central counter. - Open-plan layout.	- Shared space.
	1.5 Privacy	The relaxing area is inadequate and lacks privacy, as it is located within the Treatment Room, with only a curtain partition for separation.	The relaxing area is inadequate and lacks privacy, as it is adjacent to the therapy room, which has a transparent glass door that allows patients and relatives to see and access the space.	The relaxing area is inadequate and lacks privacy, as it shares the same space with the therapy room.
	1.6 Safety	Meets hospital standards.	Meets hospital standards.	Meets hospital standards.
Technical support	2.1 Equipment	Equipment is placed at designated service points and is not movable.	Large equipment (e.g., training devices, beds, tables) is fixed in place, while smaller training equipment is movable.	Large equipment (e.g., training devices, beds, tables) is fixed in place, while smaller training equipment is movable.
	2.2 Privacy during work	Curtains	No	No
	2.3 Facilities	There are storage areas for essential equipment, such as towel carts and waste bins for used linens.	There are cabinets for storing small equipment and designated zones for storing large equipment, including wheelchairs and mobility aids such as walkers, canes, and crutches.	There are cabinets for storing small equipment, designated zones, and a storage room for large equipment, including wheelchairs and mobility aids.
	2.4 Work space	Open space, with work areas separated by beds and curtains.	Open space, shared area, but with zoned separation for physical therapy and occupational therapy.	Open space, shared area.
Comfort	3.1 Acoustics	40-45 dB	55-60 dB	60-65 dB
	3.2 Nature accessibility	Curtains are always closed.	Access to nature (rehabilitation garden) through windows.	Access to nature (rehabilitation garden) through windows.
	3.3 Decorations	Artificial plants	No decorations	No decorations
	3.4 Temperature	Air conditioner 25°C	Air conditioner 25°C	Air conditioner 25°C
	3.5 Cleanliness	Hospital standards	Hospital standards	Hospital standards

4.2 Results from Analytic Hierarchy Process Questionnaire

The questionnaire used in this research was a pairwise comparison questionnaire designed to assess the relative importance of various environmental factors. Data were collected from 25 medical staff working in the Rehabilitation Medicine Unit at Maharaj Nakorn Chiang Mai Hospital, distributed as follows: Treatment Room: 5 participants; Outpatient Rehabilitation Therapy Room (OPD): 10 participants; Inpatient Rehabilitation Therapy Room (IPD): 10 participants

Through the analysis using the Analytic Hierarchy Process (AHP) approach, eigenvector values were derived to represent the weights or relative importance of each factor. A higher eigenvector value indicates that medical staff in the rehabilitation unit prioritize that factor more significantly. The questionnaire results are presented in Table 4, ranking the importance of physical environmental factors. For each sub-factor, the Consistency Ratio (C.R.) was below 0.1, which is considered an acceptable threshold. The top-ranked factor (Rank 1) indicates the aspect that medical staff prioritized the most in that area.

Table 4. Results from Analytic Hierarchy Process (AHP)

ranking	Treatment room				Out-patient department (OPD)				In-patient department (IPD)			
	Factor	eigenvector	C.R.	C.I.	Factor	eigenvector	C.R.	C.I.	Factor	eigenvector	C.R.	C.I.
1	Privacy during work (T)	0.45	0.02	0.02	Privacy during work (T)	0.36	0.01	0.01	Privacy during work (T)	0.34	0.01	0.01
2	Nature accessibility (C)	0.40	0.05	0.04	Decorations (C)	0.26	0.01	0.01	Nature accessibility (C)	0.27	0.01	0.01
3	Privacy (O)	0.32	0.05	0.04	Equipment (T)	0.24	0.01	0.01	Decorations (C)	0.26	0.01	0.01
4	Decorations (C)	0.27	0.05	0.04	Acoustics (C)	0.24	0.01	0.01	Equipment (T)	0.24	0.01	0.01
5	Lighting (O)	0.24	0.05	0.04	Nature accessibility (C)	0.22	0.01	0.01	Acoustics (C)	0.24	0.01	0.01
6	Equipment (T)	0.24	0.02	0.02	Layout (O)	0.22	0.02	0.02	Facilities (T)	0.22	0.01	0.01
7	Facilities (T)	0.22	0.02	0.02	Lighting (O)	0.21	0.02	0.02	Lighting (O)	0.20	0.01	0.01
8	Acoustics (C)	0.19	0.05	0.04	Work space (T)	0.21	0.01	0.01	Work space (T)	0.20	0.01	0.01
9	Space for medical staff (O)	0.14	0.05	0.04	Facilities (T)	0.19	0.01	0.01	Privacy (O)	0.18	0.01	0.01
10	Accessibility (O)	0.13	0.05	0.04	Space for medical staff (O)	0.17	0.02	0.02	Space for medical staff (O)	0.17	0.01	0.01
11	Safety (O)	0.09	0.05	0.04	Temperature (C)	0.15	0.01	0.01	Layout (O)	0.16	0.01	0.01
12	Work space (T)	0.09	0.02	0.02	Accessibility (O)	0.15	0.02	0.02	Safety (O)	0.16	0.01	0.01
13	Temperature (C)	0.08	0.05	0.04	Safety (O)	0.13	0.02	0.02	Accessibility (O)	0.13	0.01	0.01
14	Layout (O)	0.08	0.05	0.04	Cleanliness (C)	0.13	0.01	0.01	Cleanliness (C)	0.12	0.01	0.01
15	Cleanliness (C)	0.06	0.05	0.04	Privacy (O)	0.12	0.02	0.02	Temperature (C)	0.12	0.01	0.01

O = Organization and functionality, T = Technical support, C = Comfort

All three areas prioritized privacy during work as the most critical factor, with eigenvector scores of 0.45, 0.36, and 0.34, followed by access to nature and interior decoration. As shown in Table 4, the sub-factors of the physical environment that contribute to the well-being of medical staff in the Rehabilitation Medicine Unit at Maharaj Nakorn Chiang Mai Hospital were ranked highest in the Technical Support and Comfort categories. Specifically, factors such as equipment arrangement and acoustic conditions were considered more critical than sub-factors under Organization and Functionality, such as accessibility and building-related aspects.

4.3 Results from Individual Interviews

The in-depth individual interviews were conducted with 19 medical staff, each lasting approximately 15–30 minutes. The analysis of interview responses identified three main themes related to factors influencing the well-being of medical staff in the Rehabilitation Medicine Unit at Maharaj Nakorn Chiang Mai Hospital: 1) Current Environmental Issues – Problems stemming from existing environmental conditions; 2) Space Management Factors – Elements related to the organization and use of space; and 3) Equipment and Facility Management Factors – Considerations regarding the arrangement and accessibility of medical equipment and amenities. The details of each theme are discussed in the sections that follow.

Theme 1 Current Environmental Issues refers to factors that medical staff identified as affecting their well-being in the workplace. These include Structural and Safety Issues, Privacy Issues, and Odor Pollution.

1. Structural Issues and Their Impact on Well-being: Concerning the building's condition and safety risks. Building structure-related problems affect the well-being of medical personnel by causing distress, anxiety, and, in some cases, safety concerns for staff and patients.

- Noise Issues: The case study building has wooden flooring, which, while providing a warm and home-like atmosphere that can reduce stress for patients and medical staff, also amplifies noise disturbances from activities on the second floor. These include footsteps, wheelchair movements, dropped objects, and equipment handling, which can disrupt those working on the first floor. In some cases, this results in discomfort and concern, while at other times, it contributes to noise pollution, as reflected in the following statements:

  "Sometimes, when something falls, I get startled, thinking a patient has collapsed, which causes concern." (Outpatient department medical staff, personal communication, October 20,2024)

  "When I need to concentrate at work or rest during break time, it's impossible to relax because the noise from the wooden floor upstairs is too loud." (Treatment room medical staff, personal communication, September 22,2024)

- Safety Concerns: Certain areas of the building show signs of wear and damage, leading to water leakage issues, which pose potential hazards to patients and medical personnel. In some cases, the presence of water containers or cloths used to absorb leaks creates an unpleasant visual environment, affecting workplace comfort.

  "The wooden flooring also causes issues, such as slipperiness. If it's too slippery, patients might fall. Sometimes, I even worry that the structure might collapse." (Inpatient department medical staff, personal communication, October 22,2024)

2. Privacy Issues: Challenges regarding the lack of personal or workspace privacy were categorized into two aspects: privacy during rest and privacy during work

- Privacy During Rest: Many medical staff (42%) identified privacy during rest as an ongoing issue. Currently, there is no dedicated rest area, such as a designated break room, forcing staff to rest in easily accessible areas where outsiders may enter. The lack of personal storage spaces, such as lockers, also contributes to discomfort and insecurity, making it difficult for staff to relax fully. Most medical staff rest in the patient beds during their lunch breaks, but no proper rest area is available throughout the day.

"Everyone agrees that we need our break room, perhaps with lockers to store our bags, because they are scattered everywhere. There is an empty room available, but the issue is budget constraints." (Inpatient department medical staff, personal communication, October 15,2024)

- *Privacy During Work:* Specific assessment and therapy procedures require a dedicated, private space to ensure accurate evaluation and treatment outcomes. For instance, swallowing therapy and cognitive function assessments require a quiet, distraction-free environment. However, the current layout lacks separate spaces for these treatments, sometimes causing patients to underperform due to discomfort, ultimately making the work more challenging.

"The current setting isn't ideal. For example, patients undergoing cognitive function assessments need a separate area, but our facility makes it difficult because we don't have truly private rooms. Swallowing therapy also requires privacy, but achieving that is very difficult, even though we try to arrange spaces accordingly." (Outpatient department medical staff, personal communication, October 11,2024)

"For certain therapies like these, we need distance and privacy for the patients." (Treatment room medical staff, personal communication, September 22,2024)

3. Odor Pollution Issues: Unpleasant smells affect the work environment. Workspaces and rest areas are shared in all areas within the same space. As a result, food odors linger after lunch breaks and meals, creating an unpleasant environment. This issue is particularly pronounced because the rooms are air-conditioned, which limits ventilation and prevents odors from dissipating quickly. In the outpatient rehabilitation therapy room on the first floor, the dining area is located near the workspace, and a grease trap is installed beneath the sink, leading to unpleasant odors that negatively impact the working environment.

"The lunch area has a strong smell from the grease trap because it's installed indoors, so the odor lingers." (Outpatient department medical staff, personal communication, October 10,2024)

Theme 2 Space Management Factors refer to physical environmental aspects related to space organization. They are divided into two key areas: workspace-related and supporting facility-related factors.

1. Workspace-Related Factors: Most medical staff (68%) agreed that workspaces should be open-plan shared spaces with a central counter to facilitate workflow and overall supervision. Additionally, a designated room for meetings or tasks requiring concentration and privacy is necessary. Furthermore, specific equipment in the Treatment Room generates waves or radiation that may impact surrounding areas. It necessitates protective measures, such as curtains or proper spatial distancing based on safety standards for each type of equipment. However, the current space limitations may not fully comply with the recommended safety distance requirements.

"Our workspace is shared, without clear divisions. The benefit is that we can always monitor patients during therapy." (Inpatient department medical staff, personal communication, October 14,2024)

2. Supporting Facility-Related Factors: This factor includes dedicated areas for medical staff, such as rest spaces, restrooms, personal storage areas, and parking facilities.

Private spaces for medical staff, including rest areas and meeting rooms, should be located near workspaces for easy access during work hours and breaks. The private space should be shared among colleagues to promote collaboration and convenience. Restrooms should be separate from work and rest areas to prevent unpleasant odors, but located nearby for accessibility. Personal lockers should be provided for staff to secure their belongings, reducing concerns about personal storage. Parking spaces should be sufficient for medical staff and situated near the workspace while ensuring they do not obstruct pathways.

> *"Having a parking lot in front of the building is fine, but with the high number of cars and space is limited. Sometimes, cars park in front of the stairs, making it difficult to access the building." (Inpatient department medical staff, personal communication, October 20,2024)*

3. Stress-Relief Factors: Several factors contribute to stress reduction for medical staff, including music, access to nature, interior decoration, and air temperature control.

- Music is used as a therapeutic aid in rehabilitation settings. In workspaces, music playback should be controlled, allowing adjustment of both volume and selection to create a pleasant work environment. Music also can help relax patients or stimulate them during therapy, making treatments more effective. However, it is essential to have the ability of adjusting or turning off music when concentration is needed.

  > *"We should have music where we can control the volume—this level to stimulate the patient and relax them. If a patient arrives feeling tense or spastic, music can help them relax. Both the view and soft background music can have an effect." (Outpatient department medical staff, personal communication, October 10,2024)*

- Green Spaces and Connection to Nature: Having green spaces or nature-integrated areas can enhance relaxation. These could include gardens that serve both therapeutic and recreational purposes, such as areas for walking practice and wheelchair training. By reducing stress, these gardens benefit both patients and medical staff.

  > *"Having windows with a view is important. Windows help reduce the feeling of confinement and make the space feel more open." (Outpatient department medical staff, personal communication, October 11,2024)*

- Interior Decoration: Extensive decoration is not necessary, but spaces could be designed to include areas for displaying patients' work to foster encouragement and engagement and seasonal decorations to stimulate patient awareness and cognition, such as Lantern Festivals (Loy Krathong), New Year, Songkran, and other festive events.

  > *"Some decorations are nice, especially for seasonal festivals—they make things more enjoyable. But if there's too much decoration, it could just become a dust trap." (Outpatient department medical staff, personal communication, October 20,2024)*

- Air Conditioning and Temperature Control: 100% of medical staff in the rehabilitation unit reported that temperature control is essential. Rehabilitation therapy often involves physical activity, leading to heat and discomfort for medical staff and patients. Maintaining an adjustable air-conditioning system is crucial for ensuring comfort during therapy sessions and preventing excessive sweating, which may affect the functionality of some medical devices and disrupt treatment effectiveness.

"Our equipment generates heat, and if the room isn't air-conditioned, the patient's skin will sweat. When we apply heat therapy, the moisture can cause skin blistering. Air conditioning is essential. We prioritize the patients' well-being." (Treatment room medical staff, personal communication, September 25,2024)

Theme 3 Factors Related to Medical Equipment and Other Facilities: This theme focuses on managing medical equipment in the Rehabilitation Medicine Unit and recommends furniture that supports functionality and efficiency.

1. Management of Medical Equipment in the Rehabilitation Medicine Unit: The space contains both small, movable equipment and large, stationary equipment. Due to limited space, it is essential to organize storage efficiently to ensure that equipment is stored neatly without obstructing the workspace. The following considerations should be addressed:

- Storage cabinets should be available for small medical equipment.
- Large equipment should be strategically positioned for easy access, ensuring it is wheelchair-friendly.
- Dedicated storage areas or rooms should be designated for mobility aids, such as wheelchairs and walkers.

2. Furniture: The selected furniture should be flexible and adjustable, allowing for height modifications or free movement. Moreover, the furniture should be stable and secure, ensuring safety and ease of use during medical procedures.

5. Discussion

This study focuses on a case study of the Rehabilitation Medicine Unit at Maharaj Nakorn Chiang Mai Hospital, which has unique and distinct contextual characteristics related to both external and internal building environments. Nevertheless, its functional layout closely aligns with the design guidelines for rehabilitation medicine units, as outlined in the International Health Facility Guidelines (2023) and the AIA (2001).

The research aims to evaluate physical environmental factors that promote the well-being of medical staff. This study effectively addresses the two key research questions detailed below.

1. What are the current environmental conditions, and do they promote well-being?

The current environment does not adequately support the well-being of medical personnel. The case study presents some stress-reducing architectural features, such as the use of wood materials and a high number of windows that connect with nature (Asfour, 2019; Ulrich,1984). In addition, the interior spatial organization follows an open-plan design that encourages social interaction and supports teamwork. However, several physical environmental factors still hinder the well-being of medical personnel in the Rehabilitation Medicine Unit, as follows:

- **Privacy during work:** Privacy was the most critical factor for medical personnel across all areas (with eigenvector scores of 0.45, 0.36, and 0.34). Surveys and interviews indicated that the current workspace lacks sufficient privacy. Shared spaces do not include proper enclosed rooms for therapy and insufficient space allocation results in inadequate separation between workstations, reducing the sense of privacy and concentration and ultimately making the space less conducive to efficient work.

- **Access to nature and interior decoration:** Treatment rooms and inpatient departments (IPD) ranked access to nature as the second most important factor, whereas the outpatient department (OPD) ranked it fifth. Observations revealed that the window views from the Treatment Room and IPD do not feature natural scenery or any elements that promote relaxation (Ulrich,1984 ; Torres-Soto et al., 2022). Additionally, the interior lacks decorative elements, maintaining a clinical, hospital-like atmosphere.
- **Privacy in rest areas:** The current rest areas lack privacy and suitability, as there are no dedicated relaxing rooms. Instead, workspaces are repurposed as temporary break areas during lunch hours, limiting the ability of medical staff to rest fully.
- **Lighting conditions:** In the Treatment Room, protective measures are required to prevent sunlight exposure from damaging medical equipment, leading to the constant closure of curtains. Consequently, some areas lack sufficient natural light, affecting visibility and work conditions.
- **Equipment management:** The OPD and IPD share a similar service model, with medical personnel ranking equipment management as their third (eigenvector value of 0.24) and fourth (eigenvector value of 0.24) priority, respectively. Currently, some medical equipment is not optimally placed, making it difficult to use, and storage space remains insufficient.
- **Noise issues from building structure:** Activities on the second floor generate noise disturbances on the first floor, primarily due to the wooden construction of the building, which has been in use for over 70 years. This structural condition impacts concentration levels, causing disruptions in the work environment.

The building modifications were implemented without following evidence-based design principles (Hamilton, 2004). As a result, some areas were not designed with functional efficiency in mind, leading to spatial management challenges in both work and rest areas.

2. What physical environmental factors can enhance the well-being of medical personnel in rehabilitation medicine units?

Based on the study of the physical environment in this case study, the following environmental factors were identified as suitable for enhancing the well-being of medical staff working in rehabilitation medicine:

- **Ensuring privacy in both work and rest areas:** Rest areas for medical staff should be within or close to the workspace, with a strong emphasis on privacy. Access to relaxing areas should be limited to medical staff only. These areas should feature personal storage solutions and dedicated zones for private therapy and assessments, ensuring they remain functionally connected to the main work area. Incorporating curtains or partitioned rooms within therapy spaces can enhance privacy and concentration, improving the efficacy of medical staff and patient therapy sessions (AIA, 2001; International Health Facility Guidelines, 2023).
- **Promoting relaxation through environmental factors:** Such factors can include access to nature, interior decoration, music, and adjustable air conditioning, which reduce stress and anxiety for patients and medical staff (Engineer et al., 2021; Torres-Soto et al., 2022; Ulrich,1984 ; Ulrich, 2003 ; Van Gaever et al., 2014).
- Optimizing space layout and equipment placement: Workspaces should be well-organized, with separate zones for large medical equipment and open space for gait and movement training. A centrally located counter for medical personnel should allow easy supervision of patients and an

overview of the workspace. Lighting should be adequate and large, non-movable medical equipment should be placed strategically with appropriate spacing for easy access by both wheelchairs and medical staff. Small, movable equipment should be stored in secure, well-organized cabinets or shelves, ensuring stability, accessibility, and efficiency (AIA, 2001; Engineer et al., 2021; Indian Health Facilities Guidelines, 2014; International Health Facility Guidelines, 2023).

- Addressing structural challenges: While wooden construction elements promote a calming atmosphere for staff and patients, certain material limitations must be managed. Using sound-absorbing materials and carefully selecting material placement can mitigate noise issues and enhance functionality.

A comparison with previous studies and related research reveals consistent findings despite differences in context—such as variations in building design and space management approaches examined by other studies. This study highlights that the primary factor contributing to the well-being of medical staff working in rehabilitation units is a physical environment that facilitates or supports their work. The data collection and analysis emphasize the importance of work-supportive environmental factors. However, due to the in-depth nature of this study—conducted through a three-step process—the findings are based on a specific case study area with a relatively small sample size. Future research could build upon the key findings of this study by applying them to other rehabilitation units, thereby extending and adapting the insights for use in designing similar healthcare facilities.

6. Conclusion

The findings of the study indicate that the key environmental factors contributing to the well-being of medical staff in the case study area can be categorized into two main groups: (1) Technical Support Factors – Enhancing work efficiency through privacy in workspaces and (2) Comfort Factors – Promoting relaxation through access to nature. While building-related factors such as organization and functionality also are relevant, medical staff prioritized them as secondary concerns. Medical staff emphasized the importance of privacy during work, stating that it is critical for improving overall work efficiency. Additionally, access to natural elements was identified as a vital aspect of stress reduction and overall well-being. Regarding organization and functionality, staff expressed the need for private spaces for focused tasks, such as documentation and meetings, as well as for relaxation. When comparing the building structure and external design to the organization of interior spaces, the medical personnel in the Rehabilitation Medicine Unit prioritized functional space layouts that support both work efficiency and relaxation over the architectural design of the exterior. These findings align closely with existing research and standard guidelines for rehabilitation medicine facilities. Consequently, the proposed strategies for developing a supportive work environment can be adapted and applied to other rehabilitation units or similar medical departments aiming to enhance workplace well-being. Future research could focus on the physical environmental factors that promote the well-being of rehabilitation service users, particularly individuals with physical impairments and older adults undergoing physical and occupational therapy. This research might explore how the environment affects the efficacy of therapy and identify the spatial design approaches that are most suitable through user participation. These future investigations could build on the foundational factors identified in the current study.

Human Subjects

The study participants were medical staff who regularly utilized the space, including occupational therapists, physical therapists, and staff members. This research received ethical approval from the Faculty of Medicine, Chiang Mai University (Approval No. NONE-2567-0106).

Funding Statement

This research received no specific fund from any funding agency.

Data Availability Statement

All the data generated or analyzed during this study are included in this published article. The restricted data has been kept safe by researchers with a password.

Use of Generative Artificial Intelligence (AI) and AI-Assisted Technologies

This research has no Use of Generative Artificial Intelligence (AI) and AI-Assisted Technologies.

Author Contributions

Conceptualization, N.P., T.W.; methodology, N.P., T.W.; validation, N.P., T.W.; reviewing and formal analysis, N.P., T.W.; writing-original draft preparation, N.P.; Writing - Review & Editing, N.P.; visualization, N.P.; supervision, T.W. All authors have read and agreed to the published version of the manuscript.

References

Asfour, K.S. (2019). Healing architecture: Aspatial experience praxis. *Archnet-IJAR, 14*(2), 133-147. https://doi.org/10.1108/ARCH-03-2019-0055

Bamforth, K., Rae, P., Maben, J., Lloyd, H., & Pearce, S. (2023). Perceptions of healthcare professionals' psychological wellbeing at work and the link to patients' experiences of care: a scoping review. *International Journal Of Nursing Studies Advances, 5*, 100148. https://doi.org/10.1016/j.ijnsa.2023.100148

Department of Justice. (2010). *2010 ADA Standards for Accessible Design.* https://archive.ada.gov/regs2010/2010ADAStandards/2010ADAStandards.pdf

Engineer, A., Gualano, R.J., Crocker, R.L., Smith, J.L., Maizes, V., Weil, A., & Sternberg, E.M. (2021). An integrative health framework for wellbeing in the built environment. *Building and Environment, 205*, 108253.

Erlingsson C., & Brysiewicz P. (2017). A hands-on guide to doing content analysis. *African Journal of Emergency Medicine, 7*(3), 93-99. https://doi.org/10.1016/j.afjem.2017.08.001

Gustafsson, J. (2017). *Single case studies vs. multiple case studies: A comparative study* (pp. 1–15). Academy of Business, Engineering and Science Halmstad University. http://www.diva-portal.org/smash/record.jsf?pid=diva2:1064378%0Ahttp://www.diva-portal.org/smash/get/diva2:1064378/FULLTEXT01.pdf

Hamilton, D.K. (2004). *Four Levels Of Evidence-Based Practice*. The American Institute of Architects. www.aia.org

Huisman, E.R.C.M., Morale E., Hoof J. van, & Kort H.S.M. (2012). Healing environment: A review of the impact of physical environmental factors on users. *Building and Environment, 58*, 70-80. https://doi.org/10.1016/j.

buildenv.2012.06.016

Indian Health Facility Guidelines. (2014). *Part B – Health facility briefing & design: Volume 1*. https://india.healthfacilityguidelines.com/Guidelines/Index/HFG-India

International Health Facility Guidelines. (2023). *Part B – Health facility briefing & design*. https://www.healthfacilityguidelines.com/ViewPDF/ViewIndexPDF/iHFG_part_b_rehabilitation_allied_health

Jain, M. (2008). *A visual reference for evidence-based design*. The Center for Health Design. https://www.healthdesign.org/store/visual-reference-evidence-based-design

Joshi, K., Modi, B., Singhal, S., & Gupta, S. (2022). *Occupational stress among health care worker*s. IntechOpen. https://doi.org/10.5772/intechopen.107397

Kinman, G., Teoh, K., & Harriss, A. (2020). Supporting the well-being of healthcare workers during and after COVID-19. Occupational Medicine, 70(5), 294–296. https://doi.org/10.1093/occmed/kqaa096

Litchfield, P. (2021). Workplace wellbeing. *Perspectives In Public Health, 141*(1):11-12. https://doi.org/10.1177/1757913920951388

National Institute for Occupational Safety and Health. (2023). *Healthcare workers and work stress.* Center of Disease Control and Prevention. https://www.cdc.gov/niosh/topics/healthcare/workstress.html

Nielsen, P. (2010). *Australian standard design for access and mobility - Enhanced and additional requirements - Buildings and facilities*. SAI Global Limited.

Pan American Health Organization. (2020). Smart hospital: Save energy lighting [Flyer]. https://www.paho.org/en/documents/smart-hospital-save-energy-lighting-flyer

Saaty, T.L. (1990). How to make a decision: The analytic hierarchy process. *European Journal of Operational Research, 48*(1), 9–26. https://doi.org/10.1016/0377-2217(90)90057-i

Shepley, M. M., Joyce, K., Ashour, M., Anderson, A., Bilec, M., Bosch, S., Joseph, A., Kang, S. H., Steinfeld, E., & White, E. (2025). Staff, patient, and designer perspectives on outpatient rehabilitation therapy environments: A pilot study. *HERD: Health Environments Research & Design Journa*l. Advance online publication. https://doi.org/10.1177/19375867241304029

The American Institute of Architects Academy of Architecture for Health. (2001). *Guidelines for design and construction of hospital and health care facilities. Facility Guidelines Institute.* https://www.fgiguidelines.org/wp-content/uploads/2015/08/2001guidelines.pdf

The Center for Health Design. (2015). *A guide to clinic design post-occupancy evaluation toolkit.* https://www.healthdesign.org/system/files/res_files/Clinic%20POE_Process%20Guide_July%202015_0.pdf

Torres-Soto, N. Y., Corral-Verdugo, V., & Corral-Frias, N. S. (2022). The relationship between self-care, positive family environment, and human wellbeing. *Wellbeing, Space and Society, 3*, 100076. https://doi.org./10.1016/j.wss.2022.100076

Ulrich, R. S. (2003). *Evidence based environmental design for improving medical outcomes* [Conference presentation]. Center for Health Systems and Design, Texas A&M University.

United States Environmental Protection Agency. (1978). *Protective noise level condensed version of EPA levels document*.

Van Gaever, R., Jacobs, V., Diltoer, M., Peeters, L., & Vanlanduit, S. (2014). Thermal comfort of the surgical staff in the operating room. *Building and Environment, 81*, 37–41. https://doi.org/10.1016/j.buildenv.2014.05.036

Yamane, T. (1973). *Statistics: An introductory analysis* (3rd ed.). Harper and Row.