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Assessment of the hospital emergency environment: a study in light of the ergonomic methodology for the built environment (meac)

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Summary

Ergonomics in the Built Environment is inserted in a context of proposing design solutions to meet the needs of users during work. In a hospital environment, it is important to provide an adequate work environment in order to generate more efficient services for the population. The objective of the present study was to carry out an ergonomic assessment of the adult urgency and emergency unit of a University Hospital (HU) in the city of Florianópolis (SC), through the Ergonomic Methodology for the Built Environment (MEAC), using tools to survey the environment physical, measurement of environmental conditions and perception of the environment. As a result, it was found that several factors are in disagreement with those required by regulations for healthcare environments, and that the user's perception is of fundamental importance for evaluating the built environment. It is concluded that the construction of the space must be done collaboratively, together with users, in order to provide work environments with greater quality, safety and well-being, especially in urgent and emergency hospital environments.

Keywords: Ergonomics of the Built Environment; Ergonomic Work Assessment; Hospital Environment; Urgency and emergency.

1. Introduction

Ergonomics of the Built Environment (EAC) is based on the basic principles of Ergonomics, which places the human being as a central element. EAC seeks to develop design solutions capable of meeting the physical and dimensional needs of users based on the understanding of multiple environmental, emotional and psychological factors (SARMENTO; VILLAROUCO, 2020).

Assessing the adequate performance of a built environment is a complex task due to the influence of several variables, especially when it comes to an ergonomics perspective. In addition to the physical parameters established by laws and regulations, there are also pleasantness criteria, which are considered according to the user's perception when carrying out their tasks (VILLAROUCO; ANDRETO, 2008; VILLAROUCO, 2009). The interaction between the user and the built environment is constant and reciprocal, whether consciously or unconsciously, influencing the way we perceive this space (PINHEIRO; ELALI, 2011).

In the context of healthcare, the environment is essential in the evolution of clinical care. Well-planned environments for healthcare professionals play a fundamental role in facilitating the provision of care, acting as facilitators, streamlining tasks, thus allowing professionals to dedicate themselves more to patients. Environments that provide greater comfort and safety for patients also favor their physical and mental well-being, contributing to satisfaction and improvements in the healing process (ELY et al., 2006).

Given the need to adapt spaces to users and tasks, this study aims to carry out an ergonomic assessment of the adult urgency and emergency unit of a University Hospital (HU) in the city of Florianópolis (SC), through the application of the Ergonomic Methodology for the Built Environment (MEAC) (VILLAROUCO, 2009).

2. Methodology

The present work is classified as exploratory and, even though it is quali-quanti, it emphasizes a qualitative approach (GIL, 2022) based on ergonomics, considering the perspective of the user experience.

The ergonomic assessment was carried out in May and June 2023. As a methodological basis, the Ergonomic Methodology for the Built Environment (MEAC) was used (VILLAROUCO, 2009). The method proposes to evaluate the environment based on the analysis of several factors - environmental comfort, accessibility, perception

of the environment, anthropometric measurements, suitability of materials and sustainability (VILLAROUCO, 2011). MEAC has high adaptability, and different tools can be used to focus on different phases of the process (SARMENTO; VILLAROUCO, 2020).

MEAC is composed of two phases, one of a physical nature and the other of a cognitive nature (FERRER; SARMENTO; PAIVA, 2022). The first phase consists of three stages. The first stage is the global analysis of the environment, carried out based on observations and photographs. In the second stage, identification of the environmental configuration, the physical environment is surveyed (dimensions, layout, furniture), environmental conditioning factors (thermal, lighting and acoustic) are measured and, finally, accessibility elements are surveyed. The third stage, assessment of the environment in use, was carried out based on observations.

For the second phase, the tools used were a questionnaire and behavioral map. According to Gil (2022), the questionnaire is an appropriate tool for characterizing a population or phenomenon, aiming for qualitative assessment. The questionnaire was aimed at workers in the urgency and emergency unit. Information was obtained about the participant's profile, work environment, environmental factors and perception of the environment.

Behavioral mapping, according to Pinheiro, Elali and Fernandes (2008), is a graphic representation of behaviors that can be carried out centered on the place and/or person. It is possible to learn, through these techniques, about the behavior of individuals or groups of individuals in a given environment. The purpose of this study is to understand, through direct observation, the flow of patients in urgency and emergency rooms, what interactions they have with the environment and how this space is occupied, thus contributing to the qualification of patient care.

Finally, the data obtained in the first two phases were cross-referenced to prepare an ergonomic diagnosis based both on normative recommendations and on the needs of users of the urgency and emergency department of the HU.

This research was forwarded and approved by the Ethics Committee on Research with Human Beings of the Federal University of Santa Catarina (CEPSH-UFSC), by CAAE no. 39124920.0.0000.0121. The questionnaire participants signed the Free and

Informed Consent Form (ICF), agreeing to voluntarily participate in the research, anonymously and confidentially.

3. Results and discussions

3.1. Global Environmental Analysis

The urgency and emergency unit under study, located in a HU in Florianópolis (SC), was created in 1980, with the founding of the hospital. It is currently a reference center with 24-hour service, linked to the emergency service and focused on providing services to the population where there is a need for immediate assistance or treatment, covering the areas of medical clinic and surgical clinic (BRAZIL , 2020).

Priority care is intended for patients in serious condition brought by SAMU or Firefighters and cases referred from Emergency Care Units (UPAs) and Basic Health Units (UBSs), also receiving patients who require evaluation and more complex services, coming from other hospitals and municipalities. Furthermore, the unit is a state reference for cases of accidents with venomous animals and poisoning, having a link with the Santa Catarina Toxicological Information Center (CIT-SC) (BRASIL, 2020).

Regarding service, there has been a growing demand in the last 3 years. In 2020, 17,492 consultations were recorded, in 2021 there were 33,565, arriving in 2022 with 47,720, a daily average of 130 consultations. It is important to highlight that these data vary depending on seasonality and the situation of the other doors of the Urgency and Emergency Network (RUE) (PRADO, 2022).

The unit presents some problems that became evident during observational visits and conversations with health professionals. In summary, the space presents several problems regarding physical structure, environmental quality, room layout (mainly in relation to the circulation space between chairs), flow of care processes and communication difficulties between professionals and patients.

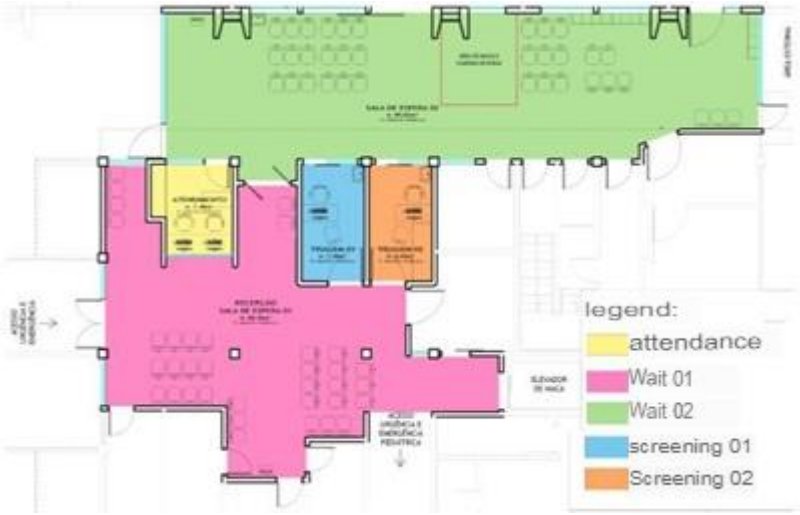
Therefore, considering these issues, the following environments were selected for the study: reception/service, waiting room 1, waiting room 2, triage 1 and triage 2. It is

worth noting that other environments make up the urgency and emergency unit, but the part of this study focused on those mentioned.

3.2. Environmental Configuration Identification

An on-site survey was carried out to understand the configuration of the space. The colored areas in Figure 1 refer to the environments evaluated in the present study. The unit consists of other environments, which will not be considered.

Figure 1 - Floor plan of the study area.



Source: The authors (2023).

The emergency area is divided into reception and service, waiting room 1 and 2 and triage 1 and 2, as shown in Table 1 and Figure 2. The service room also receives the pediatric emergency, which was not explored in the present study.

Table 1 - Specification of the environments analyzed in this work.

	Environment	Area	Capacity
1	Reception/Service	7,49m²	2 attendants
2	Waiting room 1	68,36m²	33 people seated
3	Waiting room 2	89,82m²	35 people seated
4	Screening 1	7,98m²	2 people sitting
5	Screening 2	8,00m²	2 people sitting

Source: The authors (2023).

Figure 2 - Photos of study environments.

Source: The authors (2023).

Surface materials are similar in the environments studied. The flooring is light gray vinyl blanket for heavy traffic. The walls are mostly painted with beige semi-gloss acrylic paint, with 2 walls in exposed concrete and white ceramic tiles found in Espera. In Wait 1 it is possible to find PVC stretcher profiles in yellow. Between Waiting 1 and Service there is a half wall of glass blocks and a glass panel with speakers for communication. The lining is made of PVC sheets with a smooth white outer surface. Espera 2 does not have a lining and the roof is made of translucent acrylic with a metal structure.

Regarding the furniture, long polypropylene chairs were identified in gray, black, navy blue, green and orange; black nylon wheelchairs; square and rectangular overhead lamps with LED lamps that vary between neutral and cold colors. The Service, Waiting 1 and both screening areas are air-conditioned with split air conditioning. According to ABNT NBR 9050:2020, there is disagreement with some of the established criteria. There is no tactile warning and directional flooring, the service counter does not have a lowered area for people of short stature or wheelchair users, and there is no sound signaling for service. The positive points are a waiting area dedicated to wheelchair users and obese people, doors with sufficient width, automatic doors or doors with adequate weight to handle people with paresis. Signage and escape routes are as expected and fire extinguishers are well distributed.

According to NR 32 (2022), according to Item 30.10.1, health services must meet the comfort conditions regarding noise levels provided for in NB 95 of ABNT (equivalent to ABNT NBR 10152:2017); lighting conditions in accordance with ABNT NB 57 (equivalent to ABNT NBR 8995-1:2013); and thermal comfort conditions in accordance

with ANVISA's RDC 50:2002, which determines that the parameters of ABNT NBR 16401-2:2008 be followed for these environments.

To assess environmental comfort, different measurement points were determined, depending on the physical characteristics and occupancy of the environment, according to Table 1. Measurements took place at different times and days of the week, in order to better cover comfort conditions. over time.

Table 1 - Measurement points per environment.

Environment	Number of points		
	Thermal	Luminic	Acoustic
Reception/Service	1	2	1
Wait 1	1	13	3
Wait 2	2	14	4
Screening 1	1	1	1

Source: The authors (2023).

To measure noise in emergency environments (Table 2), a Minipa MSL-1355B sound level meter was used, operating on the A-weighting curve, fast integration speed (1s integration time), for 30 seconds for each point. The equipment was 1.25m above the ground, at least 1.50m away from walls, reflective surfaces and other obstacles that could interfere with the results. The measurement data were integrated and the equivalent sound pressure level for each environment was obtained from the logarithmic average of the points in each environment.

Table 2 - Noise by environment**.**

Environment	Daytime		Nocturnal		NBR 10152	
	Average [dB]	Maximum [dB]	Average [dB]	Maximum [dB]	Average [dB]	Maximum [dB]
Reception/Service	71,03	78,4	56,8	63,2	45,0	50,0
Wait 1	66,85	77,3	67,5	79,0	45,0	50,0
Wait 2	64,68	73,1	63,64	71,7	45,0	50,0
Screening 1	58,87	63,2	59,7	65,6	35,0	40,0
Screening 2	60,39	70,3	58,9	68,8	35,0	40,0

Source: The authors (2023).

None of the environments evaluated were in accordance with the standard, whether for average or maximum noise. The biggest contribution to noise in

environments are machines close to the emergency room and the sounds generated while waiting. During the day, the flow of people is more intense, with many patients at reception. During the night, the arrival of patients is lower, but the wait delays more people, increasing the noise coming from people.

To evaluate emergency lighting, illuminance levels were measured using a Minipa MLM-1332 digital lux meter. It is worth noting that the lighting points, as well as the noise points, must not be too close to walls or other obstacles and follow a regular grid, resulting in a greater number of measurement points. The average illuminance of the environment is obtained through the arithmetic mean of all points (Table 3).

Table 3 - Illuminance by environment.

Environment	9h00 [lux]	12h00 [lux]	15h00 [lux]	20h00 [lux]	NBR 8995-1 [lux]
Reception/Service	274,5	291,5	383,5	191,0	300
Wait 1	257,3	400,8	809,9	153,9	200
Wait 2	340	459,43	1569,86	38,1	200
Screening 1	327,0	337,0	428,0	344,0	500
Screening 2	507,5	503,5	570,0	486,0	500

Source: The authors (2023)

To measure thermal comfort (Table 4), HOBO MX1101 digital thermo-hygrometers were used, with a data logger. Measurements took place between May 16 and 19, 2023 and data were collected over a period of 24 hours, with recordings every 5 minutes.

Table 4 - Measurement points per environment.

Environment	Morning		Evening		Nocturnal	
	Temperature [ºC]	Moisture [%]	Temperature [ºC]	Moisture [%]	Temperature [ºC]	Moisture [%]
Recepção/ Atendimento	22,15	57,46	21,88	64,79	21,54	64,53
Wait 1	22,55	62,61	21,67	67,34	21,35	64,93
Wait 2	21,49	62,36	20,28	67,73	20,66	63,98
Screening 1	22,79	60,47	23,01	59,77	22,47	59,47
Screening 2	23,16	61,12	22,84	58,82	22,14	59,3

Source: The authors (2023)

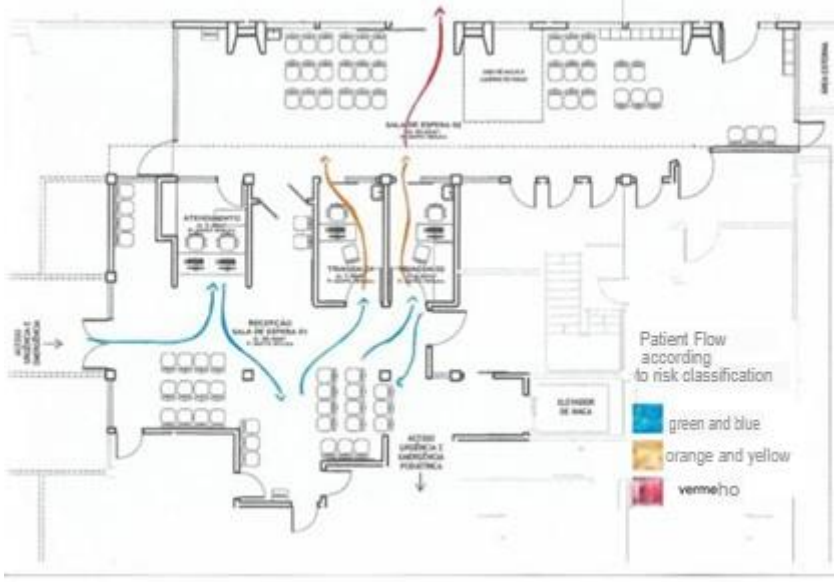
The temperature must be between 21.0 °C and 23.5 °C when relative humidity is close to 60% (ABNT, 2008, p. 03). Therefore, when considering the average per period of the day, most HU emergency environments are in accordance with the determination.

Waiting Room 2, in the afternoon and at night, presented temperatures below those indicated by the standard.

3.3. Assessment of the Environment in Use

The physical space includes: access for patients and companions, reception and service; a waiting room 1 that provides access to the pediatric emergency care offices; to another waiting room 2 and to two triage rooms. In addition to access to the elevator.

Figure 2 - Floor plan with Layout and Service Flows



Source: The authors (2023)

Patients and companions arrive to be seen at reception/service, after registering, they wait in waiting room 1 until triage. During screening, they receive a risk classification following the Manchester Protocol. If it is green and blue, they wait for medical care in waiting room 1 and if it is orange or yellow, they go to waiting room 2, as they have priority care, to be seen by doctors. Red classification access passes to immediate service. Access for emergency patients, those considered red according to the risk classification protocol, brought by ambulance by SAMU or the Fire Department, has secondary access to the emergency.

In waiting room 1 there were 33 chairs and in waiting room 2, 35 chairs. In waiting room 2, only yellow (urgent) and orange (very urgent) patients were waiting for care. In waiting 1 there are accessible bathrooms, one for female patients and the other for male patients.

The triage rooms have access to the two waiting rooms. People assessed with a red/yellow level go to waiting room 2 directly from the triage room to await priority medical care. People assessed with other risk levels return to waiting room 1 to be subsequently seen by doctors.

Table 6 - Assessment of the Environment in Use of the university hospital emergency room.

Environment	function	Summary of Analysis of the Environment in Use
Reception and Service	Provide information to the public, receive documents and formalize administrative processes.	The 2 attendants sit on upholstered chairs and record the services on the computer by entering various data. One is next to the other in the same environment.
Waiting room 1	Accommodate people until they are called by triage, after assessment only those with a green and blue severity level, and subsequently seen by doctors.	People served at reception sit on plastic chairs or stand when there are no more chairs available. Wheelchairs are placed in the hallway next to plastic chairs, sometimes obstructing the passage.
Waiting room 2	Accommodate people until they are called after triage, with a red, orange and yellow severity level and subsequently seen by the doctor.	People who have already gone through the screening and receive red or orange and yellow level identification wait sitting in plastic chairs or wheelchairs.
Screening 1 and 2	Carry out risk classification.	The patient is attended to by a nurse sitting in front of the table, where the nurse sits recording information on the computer and taking the patient's temperature and pressure measurements.
Circulation	Provides access to environments and connects them	People circulate to access the environments and use them as a waiting place for care.

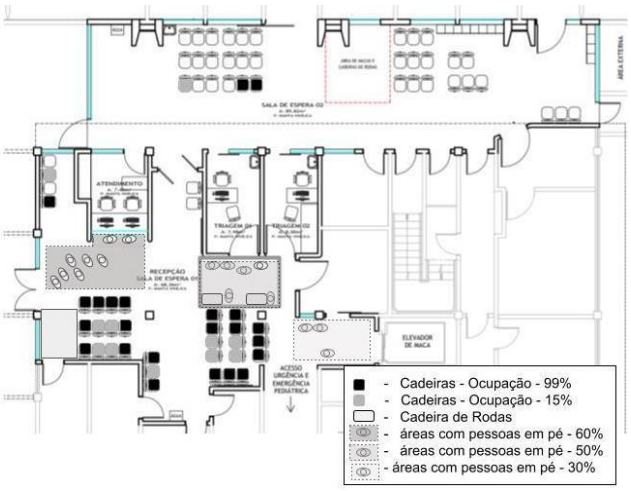
Source: The authors (2023)

3.4. User Environmental Perception

The observations took place on the ground floor of the University hospital, service, screening and two receptions. For behavioral mapping of the environment and person, direct observation techniques, observations were made every 15 minutes, within two hours. The observations began at 1:57 pm and ended at 3:03 pm, with six observations made in total, on Friday, May 5, 2023, at reception and service. Another observation was carried out on Monday, May 8th from 12:50 pm to 2:10 pm. As the number of patients to be attended to was very large in the morning, the management determined that care would stop at 1pm and only return at 4pm.

During the periods in which the observations were made, it was found that some chairs remained empty in almost 100% of the observations. These chairs were located between two rows and there was little space for movement between them. Next to one of the rows there was a pillar that made access difficult, as shown in Figure 3.

Figure 3 - Environment-centric mapping

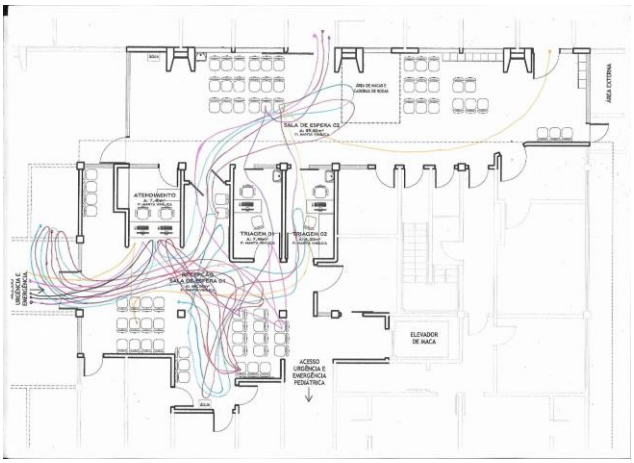


Source: The authors (2023)

At different times, people arrived in wheelchairs and companions and staff positioned them in the corridor, making circulation in the space difficult. In waiting room 2, only 3 people were waiting for care throughout the observation period, on Friday. On Monday, the number increased to 5 people. Waiting times do not correspond to the number of patients.

Observations for person-centered behavioral mapping: in 2 hours of observation, approximately 47 people entered and left the building, only four of them had their behavior recorded and the others were unable to be monitored during the period. Six patients, selected at random, from the moment they entered the building, their behaviors were observed and recorded. The routes they took were recorded. The average waiting time (from the patient's arrival at the unit to the start of the consultation) was 1 hour. Figure 4 shows the routes used by patients.

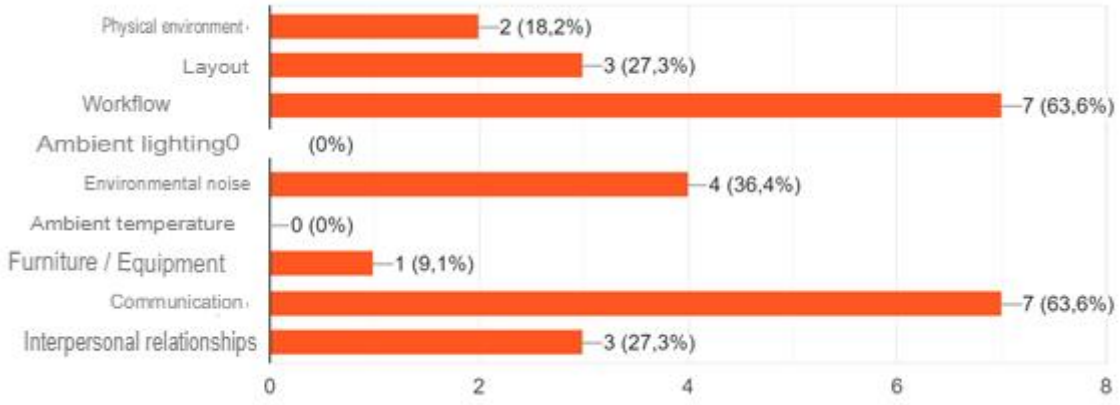
Figura 4 - Mapeamento centrado no Usuário



Source: The authors (2023)

With the questionnaires, dissatisfaction in the work environment was found with some specific factors (Figure 5). Workers face challenges related to staff shortages and a lack of organization in care, resulting in poorly optimized workflows, generating delays and congestion. There were also reports of poor communication between team members, making it difficult to exchange information and coordinate activities. Environmental noise was identified as a significant source of dissatisfaction, impairing concentration and the quality of the work performed.

Figura 5 - Fatores que mais causam insatisfação no ambiente de trabalho da emergência.



Source: The authors (2023)

3.5. Ergonomic Diagnosis and Recommendations

During the application of the methodology, ergonomic problems were identified in the studied location, covering issues related to several factors, such as environmental comfort, accessibility, flows, communication and staff shortages. This analysis made it possible to identify critical points that affect the efficiency, safety and well-being of users.

Based on this information, Table 4 presents recommendations to guide possible actions, in order to adapt the environment to the activities carried out and improve the general quality of the space. These recommendations are convenient to support and direct improvement measures in the university hospital emergency.

Table 4 - Diagnosis and recommendations for the university hospital emergency room.

Diagnosis	Recommendation
Dimensions of the environment inadequate for activities	Expansion of task areas, enabling better performance by the professional in activity.
Layout	Reorganization of space for better circulation, safety and accessibility.
Conflicting flow	Restructuring of circulation and reorganization of the layout of environments, allowing flow to flow without discomfort.
Poor communication between professionals and between professional and patient.	Implementation of an integrated information system between professionals and care and a visual and audible communication system for waiting patients.
Poor accessibility	Adequacy of spaces, signage and service in accordance with ABNT NBR 9050:2020 and Law No. 13,146/2015.
Insufficient waiting space for low priority waiting	Restructuring of the waiting space to accommodate a high number of waiting users.
Uncomfortable furniture	Acquisition of ergonomically suitable furniture for users with different needs.
Reception/Service with inappropriate organization for simultaneous services	Workstation with acoustic treatment for better speech intelligibility and suppression of noise from the adjacent workstation.
Environmental Comfort Conditions outside of those prescribed.	Readjust the lighting, temperature and noise in the environment to current standards, especially lighting and noise, which showed greater discrepancy with the standard and greater user dissatisfaction.
Insufficient number of professionals	Hiring professionals to provide services according to the unit's capacity and demand.

Source: The authors (2023)

4. Conclusions

The present work integrates with current EAC studies by addressing the application of MEAC to identify and analyze ergonomic problems present in the hospital environment. Through this approach, several aspects that impact the performance, safety and well-being of workers were examined, paying special attention to how they perceive the environment.

By evaluating user perception and behavior, it was possible to identify that some of the environmental factors had a greater impact on work performance than expected by normative indications. For example, even though lighting was

characterized in environmental studies as very poor, it caused less dissatisfaction than noise. Therefore, the results from the application of MEAC emphasize the importance of approaching the user of the environment during the design and implementation phases of changes, aiming to improve operational efficiency and the well-being of workers in the workplace.

Furthermore, it is hoped that this work will serve as support for future research and ergonomic interventions, further developing understanding of the factors that influence performance and well-being in the workplace. The continuous integration of MEAC in the design and maintenance of built environments can contribute to promoting healthier, safer and more productive environments, benefiting both users and organizations.

5. Acknowledgments

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