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EVALUATION OF THE HOSPITAL EMERGENCY ENVIRONMENT: A STUDY IN THE LIGHT OF THE ERGONOMIC METHODOLOGY FOR THE BUILT ENVIRONMENT (MEAC)

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Abstract

Ergonomics in the Built Environment is part of 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 this study was to perform an ergonomic evaluation of the adult 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 physical environment, measure environmental conditions and perceive the environment. As a result, it was found that several factors are in disagreement with those required by regulations for health environments, and that user 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 emergency hospital environments.

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

1. Introduction

The 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 the development of 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).

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Evaluating the proper performance of a built environment is a complex task due to the influence of several variables, especially when it comes to the perspective of ergonomics. In addition to the physical parameters established by laws and norms, there are also the criteria of pleasantness, which are weighted under the perception of the user in the development of his 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 health professionals play a key 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).

In view of the need to adapt the spaces to users and tasks, this study aims to carry out an ergonomic evaluation 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 if it is quali- quanti, emphasizes a qualitative approach (GIL, 2022) based on ergonomics, considering the perspective of user experience.

The ergonomic evaluation 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, adequacy of materials and sustainability (VILLAROUCO, 2011). MEAC has high adaptability, and several tools can be used to focus on different phases of the process (SARMENTO; VILLAROUCO, 2020).

The 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 from observations and photographs. In the second stage, identification of the environmental configuration, the physical environment is surveyed (dimensions, layout, furniture), measurement of environmental conditions (thermal, lighting and acoustic) and, finally, survey of accessibility elements. The third stage, evaluation of the environment in use, was carried out based on observations.

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

Behavioral mapping, on the other hand, according to Pinheiro, Elali and Fernandes (2008), is a graphic representation of behaviors that can be carried out centered on the place and/or the 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, what are the interactions 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 with each other, in order to develop an ergonomic diagnosis based on both the normative recommendations and the needs of the users of the urgency and emergency of the UH.

This research was submitted to and approved by the Ethics Committee for Research with Human Beings of the Federal University of Santa Catarina (CEPSH-UFSC), by CAAE No. 39124920.0.0000.0121. The participants of the questionnaire signed the Informed Consent Form (ICF), agreeing to participate voluntarily 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 foundation of the hospital. It is currently a reference center with 24-hour care, linked to the emergency care 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 (BRASIL, 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 need evaluation and services of greater complexity, coming from other hospitals and municipalities. In addition, the unit is a state reference for cases of accidents with venomous animals and poisoning, with a link to the Toxicological Information Center of Santa Catarina (CIT-SC) (BRASIL, 2020).

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

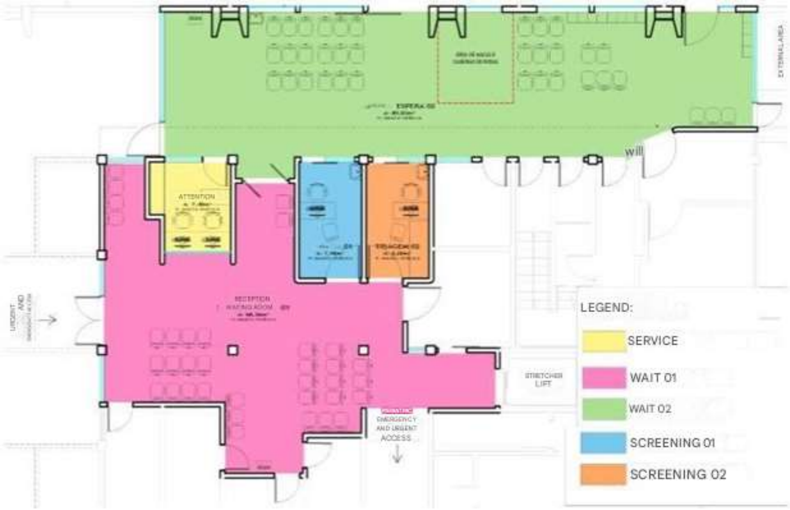
The unit has some problems that were evident in observational visits and conversations with health professionals. In summary, the space presents several problems of physical structure, environmental quality, layout of the environments (especially in relation to the circulation space between chairs),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

Thus, considering these issues, the following environments were selected for the study: reception/service, waiting room 1, waiting room 2, screening 1 and screening 2. It is worth noting that other environments make up the urgency and emergency unit, but the focus of this study was limited to 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 care, waiting room 1 and 2 and triage 1 and 2, as shown in Chart 1 and Figure 2. The care room also receives the pediatric emergency room, which was not explored in the present study.

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

	Environment	Area	Stocking
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 seated
5	Screening 2	8.00m²	2 people seated

Source: The authors (2023).

Figure 2 - Photos of the study environments.

Source: The authors (2023).

The surface materials are similar in the environments studied. The floor is vinyl in light gray blanket for heavy traffic. The walls are mostly painted with semi-gloss acrylic paint in beige, and in Espera 2 walls are found in exposed concrete and white ceramic tile. In Espera 1 it is possible to find PVC stretcher profiles in yellow. Between Wait 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 has no lining and the roof is in translucent acrylic with a metal structure.

Regarding the furniture, polypropylene stringer chairs were identified in gray, black, navy blue, green and orange; black nylon wheel chairs; Square and rectangular overlapping luminaires with LED lamps that vary between neutral and cool colors. The Attendance, Waiting 1 and both triage environments are air-conditioned with split air conditioning. According to ABNT NBR 9050:2020, there is disagreement with some of the established criteria. There is an absence of tactile warning and directional flooring, the service desk does not have a lowered area for people of short stature or wheelchair users, and there is no audible service signaling. 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 for handling people with paresis. The signage and escape routes are consistent with what is expected and there are fire extinguishers well distributed.

According to NR 32 (2022), according to Item 30.10.1, health services must meet the comfort conditions related to noise levels provided for in NB 95 of ABNT (equivalent to ABNT NBR 10152:2017); lighting conditions according to NB 57 of ABNT (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 for these environments must be followed.

For the evaluation of environmental comfort, different points were determined for measurement, depending on the physical characteristics and occupation of the environment, as shown in Table 1. The measurements took place at different times and days of the week, in order to better cover the conditions of comfort over time.

Table 1 - Measurement points by environment.

Environment	Number of points		
	Thermal	Luminous	Acoustic
Reception/Service	1	2	1
Wait 1	1	13	3
Wait 2	2	14	4
Screening 1	1	1	1
Screening 2	1	2	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 (integration time of 1s), for 30 seconds for each point. The equipment was 1.25m from 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 room was obtained from the logarithmic mean of the points in each room.

Table 2 - Noise by environment.

Environment	Diurnal		Nocturne		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 evaluated environments was in accordance with the standard, either for the average or maximum noise. The biggest contributor to noise in the environments is machines in the vicinity of the emergency room and the sounds generated while waiting. During the day, the flow of people is heavier, with many patients at the reception. During the night, the arrival of patients is lower, but the wait retains more people, increasing the noise coming from people.

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

Table 3 - Illuminance by environment.

Environment	9:00 a.m. [lux]	12:00 p.m. [lux]	3:00 p.m. [lux]	8:00 p.m. [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)

Thermal comfort measurements (Table 4) were used using HOBO MX1101 digital thermo-hygrometers with *a data logger*. The measurements took place between May 16 and 19, 2023 and the data were collected over a period of 24 hours, with records every 5 minutes.

Table 4 - Measurement points by environment.

Environment	Morning		Evening		Nocturne	
	Temperature [ºC]	Moisture [%]	Temperature [ºC]	Moisture [%]	Temperature [ºC]	Moisture [%]
Reception/ Service	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

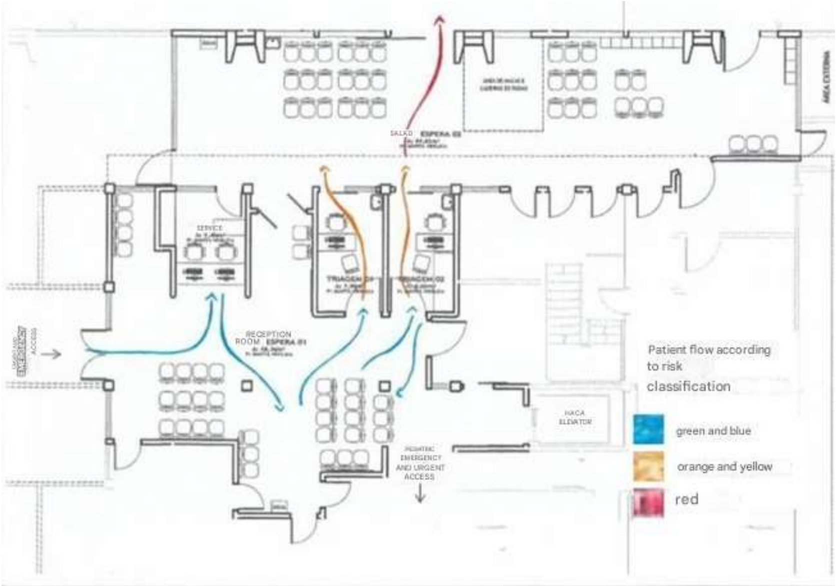
Source: The authors (2023)

The temperature should 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 of the environments in the UH emergency room are in accordance with the determination. Waiting Room 2, in the afternoon and night, had temperatures below those indicated by the standard.

3.3. Assessment of the Environment in Use

In the physical space are located: the access of patients and companions, reception and service; a waiting room 1 that gives access to the pediatric emergency care offices; to another waiting room 2 and to two screening rooms. In addition to elevator access.

Figure 2 - Floor plan with Layout and Service Flows



Source: The authors (2023)

Patients and companions arrive to be seen at the reception/service, after registration they wait in waiting room 1 until the screening service. In the triage, they receive the risk classification following the Manchester Protocol. If it is green and blue, they are waiting for medical care in waiting room 1 and if it is orange or yellow, they go to waiting room 2, since they have priority care, to be attended by doctors. Access from the red classification passes to immediate care. The access of emergency patients, those considered red by 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) level patients were waiting for care. In waiting 1 there are accessible bathrooms, one for female patients and one for men.

The screening rooms have access to the two waiting rooms. People evaluated with the red-yellow level move to waiting room 2 directly from the triage room to wait for priority medical attention. People assessed with other levels of risk return to waiting room 1 to be later seen by doctors.

Chart 6 - Evaluation of the Environment in Use of the emergency room of the university hospital.

Environment	Function	Synthesis of the Analysis of the Environment in Use
Reception and Service	Provide information to the public, receive documents and formalize administrative processes.	The 2 attendants sit in upholstered chairs and record the calls 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 the triage, after the evaluation only those with green and blue severity level, and later attended by the doctors.	People served at the front desk sit in the plastic chairs or stand when no more chairs are available. Wheelchairs are placed in the aisle next to plastic chairs, sometimes obstructing passage.
Waiting Room 2	Accommodate people until they are called after screening, with red, orange and yellow severity level and later attended by the doctor.	People who have already gone through the screening and receive the red or orange and yellow level identification wait sitting in plastic chairs or in wheelchairs.
Screening 1 and 2	Perform the risk classification.	The patient is attended to by a nurse sitting in front of the desk, where the nurse sits recording information on the computer and taking measurements of the patient's temperature and pressure.

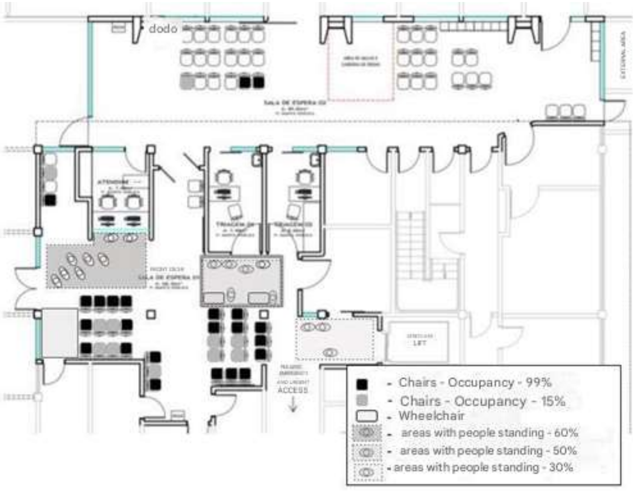
Source: The authors (2023)

3.4. User's Environmental Perception

The observations took place on the ground floor of the University Hospital, attendance, triage and two receptions. For the behavioral mapping of the environment and the person, direct observation techniques, observations were made every 15 minutes, at an interval of two hours. The observations began at 1:57 pm and ended at 3:03 pm, with six observations being made in total, on Friday, May 5, 2023, at the reception and service. Another observation was made on Monday, May 8, from 12:50 p.m. to 2:10 p.m. As in the morning the number of patients to be seen was very large, the management determined that they stop the services at 1 pm and only return at 4 pm.

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

Figure 3 - Environment-Centered Mapping

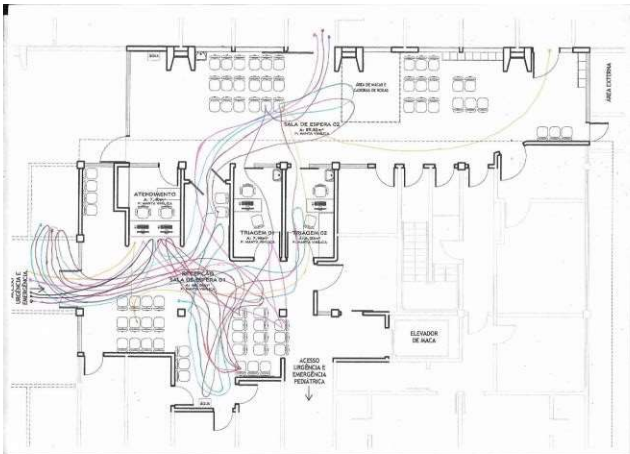


Source: The authors (2023)

At different times, people arrived in wheelchairs and companions and employees positioned them in the corridor, making it difficult to circulate in the space. 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. The size of the waits does not correspond to the number of patients.

The 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 could not be followed in the period. Six patients, randomly selected, 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 beginning of the consultation) was 1 hour. Figure 4 shows the routes used by the patients.

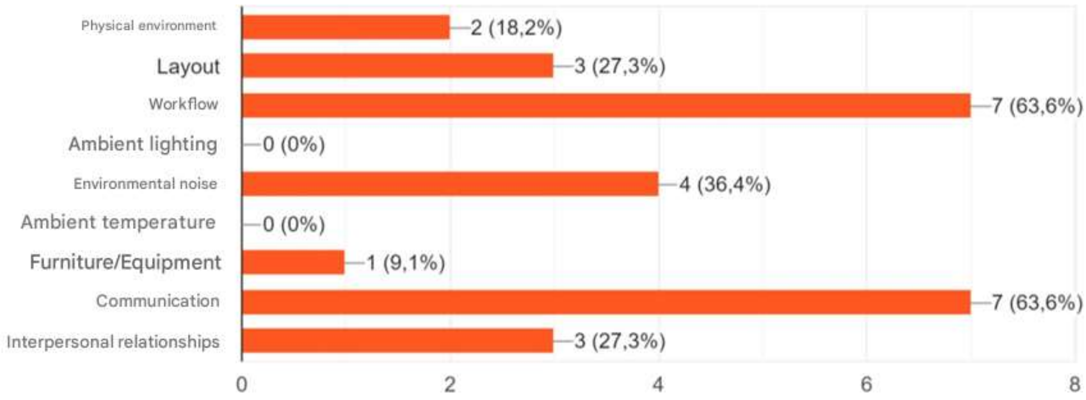
Figure 4 - User-Centered Mapping



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 lack of organization in care, resulting in poorly optimized workflows, leading to delays and congestion. There were also reports of poor communication among team members, making it difficult to exchange information and coordinate activities. Environmental noise was pointed out as a significant source of dissatisfaction, impairing the concentration and quality of the work performed.

Figure 5 - Factors that most cause dissatisfaction in the emergency work environment.



Source: The authors (2023)

3.5. Ergonomic Diagnosis and Recommendations

During the application of the methodology, ergonomic problems were identified in the studied place, covering issues related to several factors, such as environmental comfort, accessibility, flows, communication and shortage of personnel. This analysis made it possible to identify the critical points that affect the efficiency, safety and well-being of users. Based on this information, Chart 4 presents recommendations to guide possible actions in order to adapt the environment to the activities carried out and improve the overall quality of the space. These recommendations are convenient to support and direct the improvement conducts in the emergency room of the university hospital.

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

Diagnosis	Recommendation
Dimensions of the environment inadequate for the activities	Expansion of task areas, enabling better performance of the professional in activity.
Layout	Reorganization of the space due to better circulation, safety and accessibility.
Conflicting flow	Restructuring of circulations and reorganization of the layout of the environments, allowing flow flow without discomfort.
Failed 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 large number of waiting users.
Uncomfortable furniture	Acquisition of ergonomically suitable furniture for users with different needs.

Source: The authors (2023)

4. Conclusions

The present work is integrated with current studies of EAC by addressing the application of ECM 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 the user's perception and behavior, it was possible to identify that some of the environmental factors had a greater impact on work performance than expected by the normative indications. As an example, even though lighting was characterized in environmental studies as very deficient, it caused less dissatisfaction than noise. Therefore, the results of the application of MEAC emphasize the importance of addressing 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 work environment.

In addition, it is hoped that the present work will serve as a support for future ergonomic research and interventions, further developing the 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.

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