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Research Article

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Mapping the Medication System: Weaknesses and Risk Management

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Abstract
Secure systems aimed at preventing medication error are the essential. Our objective was to describe and map the medication system of a large hospital in Brasilia, DF, Brazil, and propose risk management strategies for their principal weaknesses. For this cross-sectional, exploratory, and descriptive study, the data was collected with the support of two nurses trained by the researcher. Direct observations and semi-structured interviews of professionals involved in the medication system covered the processes: prescription, dispensing, preparation, and administration of medications. The data collection period was from May 8 to 22, 2012. Eight nursing technicians from this study site, who are responsible for the preparation and administration of medications, participated in the study. We identified 34 activities, undertaken by different professionals, which shows the complexity and greater possibility of error. The weaknesses identified include interruptions, displacement, environmental problems, human resources, lack of patient identification, infrastructure, technical problems during preparation and administration, as well as deficiencies in compliance with rules and security protocols. It was concluded that the more the process is computerized the less weaknesses are present. Therefore, implementation of risk management strategies and the use of technologies are needed to detect and reduce risks to ensure the quality of the executed processes.

Keywords: Medication errors; Medication systems; Nursing.

Introduction
Error is a phenomenon inherent in human nature, which can occur even in the most perfect systems, including a complex health system. One must assume that despite the training and care of people, errors occur in any process that involves human activity [1].

Thus, it is essential to develop safe and efficient systems to assist in error prevention, as well as identify and minimize its consequences. The opportunity to learn from mistakes is a useful strategy to improve the security of the systems and prevent recurrence. Thus, development is necessary of a non-punitive culture that encourages notification and analysis of errors in the context of the system [2].

In health services, a large number of activities are involve in the medication process. According to literature, a safe number of steps would be between 20 and 30, covering the prescription process, dispensing, and administration of the medication [3]. As the system becomes more complex, the risk for errors increases [4].

On the other hand, in developing countries, the increase in medication errors is attributed to several factors, especially the lack of computerization of the health system and limited investment in communication technologies associated with the increasing complexity of therapeutic procedures [5]. The special and assistive character of the health system incorporates advanced technologies and treatments, but at the same time, may not add new procedures to work processes, which are often out of date.

In 2014, the Brazilian Ministry of Health, in partnership with other agencies, published a document that provides information and guidelines for the National Patient Safety Program that was implemented in 2013. This document encourages health care in an effective and error-free manner, with the adoption of protective barriers and establishment of reporting system for events adverse to the patient's health. The National Health Surveillance Agency also has a series of protocols and documents published about the quality and safety of patients in healthcare that can assist in practice [6].

The literature reports several risk management strategies, which can be used in health institutions for system security, including investment in technologies such as implementation of the electronic prescription, use of bar codes, automation of dispensing unit dose, and use of smart infusion pumps [7].

In this context, considering that the error in the medication process should be avoided, it is important to understand and contribute information to support the implementation of risk management and preventive measures that reflect the safety and quality of the healthcare.

Therefore, our objective was to describe and map the medication system of a large hospital in Brasilia, to propose risk management strategies for its main weaknesses.

Materials and Methods

This cross-sectional, exploratory, and descriptive study was performed in a public hospital in the Federal District, in central Brazil, from May 2013 to July 2013.

The present investigation was carried out in the internal medical clinic and the hospital pharmacy, which covers the entire medication system.

The factors that contributed to the selection of the internal medical clinic were: 1) volume of medication; 2) complexity of the medication process (calculation of doses, diversity of injectable medications, and variety of infusions); 3) number and diversity of hospitalized patients; and 4) clinical conditions of the users and types of medicines used.

Data collection was performed with the support of two nurses trained by the researcher. Direct observations and semi-structured interviews with professionals involved in the medication system were conducted with the objective of describing and mapping the system for prescription, dispensing, preparation, and administration of medications.

During the data collection period, the activities in the medical clinical unit were carried out by two doctors, six nurses, and fourteen nursing technicians, totaling 22 professionals. At the pharmacy unit, seven pharmacists, two nursing technicians, seven administrative technicians, and one assistant, totaled 17 professionals.

The nursing work in the institution is divided according to the model of classic nursing care. Nursing technicians are responsible for the preparation and administration of medications as well as bathing, feeding, and primary health care. Nurses are responsible for administrative activities, work schedules, and application of dressings and catheters, among other functions, for executing comprehensive care. The work schedules of nursing technicians are organized by the responsible nurse on duty considering the number of patients per professional, and the severity of the patients and care they require.

The inclusion criteria for study participants included professionals directly involved in the steps of the medication process, who accept to participate in the study and were not on vacation or leave for the period of data collection.

Interviews were conducted with the pharmacist responsible for dispensing medications, the director of the hospital pharmacy, two administrative technicians responsible for services at the hospital pharmacy, the nurse technician of the medical clinic responsible for requesting medication from the pharmacy, two nursing assistants, the head nurse of the medical clinic, and the physician responsible for prescribing medications to the patients in the medical clinic. The participants were interviewed in order to collect information about their sociodemographic profile (age, sex, education, amount of professional experience, and their time working in the unit) and workload (hours and number of patients under their care) as well as the operating characteristics of the pharmacy, how many workers per shift, their activities, and the routine of the sector. Questions were asked about the routine preparation and administration of the medications and how the system operation. The medical team was asked about the routine activity of prescriptions and operation of the electronic prescription system.

The researcher and research assistants spent 15 days examining the medication system. These observations lasted five days in each step (prescription, dispensing, preparation, and administration), distributed in morning, afternoon, and evening shifts. Observations were made on more than one step per day.

Systematic observation was done for each step of the medication system, medical prescription (prescription room), dispensing (dispensing room), preparation (preparation room), and administration (unit wards).

Observations were made of the prescription, dispensation, preparation, and administration of the medications. Adapted from the study of literature, issues examined included: the environment (physical space) where the activities are performed, organization, lighting, noise level, interruptions; data about the professional responsible for the activity and information about the activity; resources used to develop the activity, such as consultation and prescription context for the completion of prescription (whether electronic or manual); professional responsible for the prescription; record of patient's prior evaluation; number of professionals involved in the observed step; description of prescription situations; quality of prescription printing; routines to control the dispensing of psychotropic drugs; controlled and refrigerated dispensing; and medication monitoring system. In other words, we sought to understand and record in detail of Who? Where? How? and What was done? in the context of the dispensing activity. Finally, variables related to the adequacy of preparation technique and administration of medicine, dilution, labeling, guidance to the patient, verification, and record of the procedure were observed.

Each observer recorded observations in a field diary and, when necessary, noted additional comments considered relevant. Records contained information on the environment of each step of the medication process, as well as aspects of the work process.

The data collected was organized into Microsoft Office Excel® spreadsheets. Descriptive and inferential analyzes were used to examine the differences between the groups. The analysis was performed using the Package for the Social Sciences (SPSS®) software version 18.0.

Categorical variables are reported as absolute and relative frequencies, numerical variables are reported as mean and standard deviation (minimum and maximum).

The development of the study met national and international standards of research ethics involving human subjects.

Results

The eight nursing technicians that participated in the study were responsible for the preparation and administration of medications at the studied location. They were observed during drug preparation and administration activities in order to describe and track the medication system. The socio-professional data of the participants showed that 6 (75.0%) professionals were females with a mean age of 39.12.

A flowchart was used to map of the medication system. This helped to visualize of the macroprocess, subprocesses, and activities carried out in order for the medication to reach the patient.

The macroprocess of the system is composed of 4 subprocesses: prescription, distribution, preparation, and administration of the medication. Figure 1 is the flowchart of the mapped macroprocess and its subprocesses.

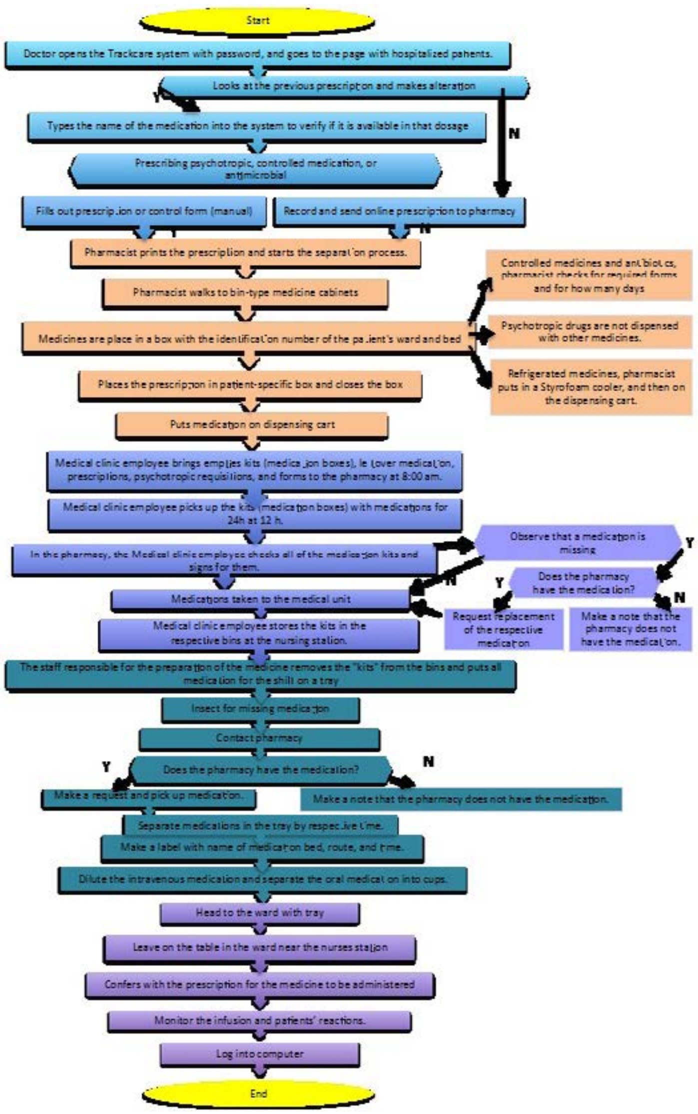

Figure 1: Flowchart of the medication system, regional hospital, 2013.

The critical points / weaknesses of the subprocesses are shown schematically by the symbol and the numerical sequence (1 to 25). Figure 2 shows the critical points (weaknesses) identified in the medication system.

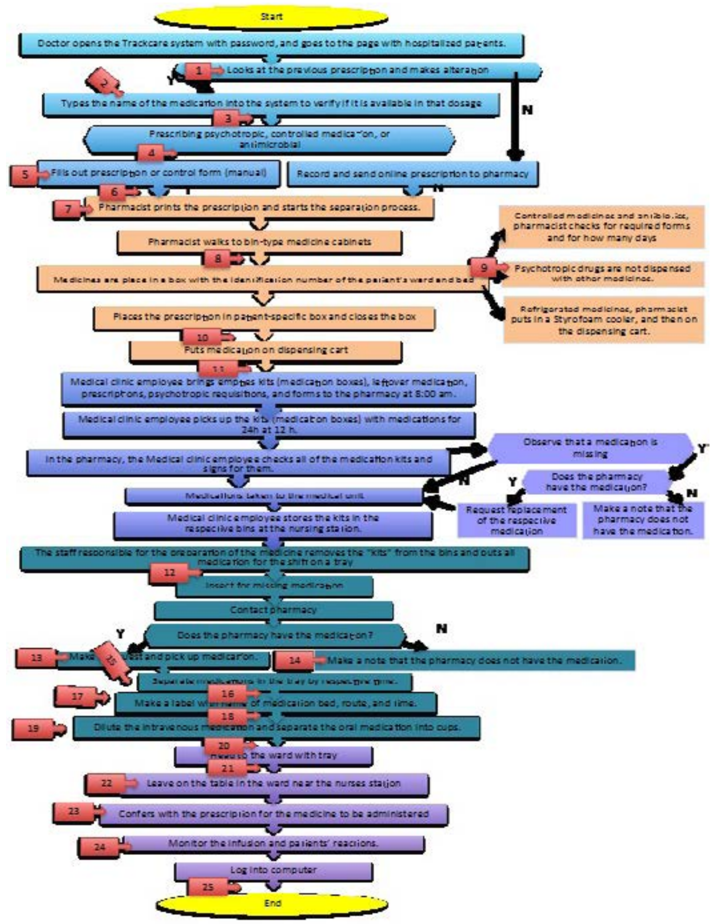

Figure 2: Flow chart of the medication system, indicating the weaknesses in the system, regional hospital, 2013.

The prescription subprocess is performed the prescription room, used by prescribers for this activity. There are 6 computers to carry out the activity.

The furniture does not meet the ergonomic principles. The environment has artificial lighting and ventilation, and it is noisy due to the parallel conversations between professionals and the use of mobile phones. There is a large circulation of people (Figure 2, number 1).

In this sub process, displacements are frequent to visit patients or to find forms (Figure 2, number 2). The presence of only one professional was observed to make prescriptions for approximately 25 patients daily. The communication between the pharmacy and the clinic is not a good. When it occurs, it is only to report missing medicines, pending requests, and problems with prescriptions (Figure 2, number 3).

Interruptions occur during all subprocesses, on average a total of six (6) per observation period. These interruptions included attending cell phone and talking with patients' relatives, pharmacy representatives, sector employees with questions about patients, other doctors, residents, and students. (Figure 2, number 4).

Prescribers must fill out a large number of forms, such as pharmacy requisitions (psychotropic drugs), non-standard medication form when the family needs to purchase the medication, inpatient examination requests, and medical certifications (Figure 2, number 5).

Other sources of information were not consulted by the medical team to prepare the prescription (Figure 2, number 6).

The subprocess of dispensing and distributing medications occurs in the dispensary of the hospital pharmacy, which is adjacent to the storage areas. The lighting is artificial, free of sunlight. The ventilation is also artificial, through central air-cooling and air conditioners.
The physical space for dispensing is small, with many boxes of materials and medicines and, therefore, not adequate for the activity. The inadequacies in the hospital infrastructure were observed. The person in charge of the sector indicated that this area is scheduled to be renovated (Figure 2, number 7).

In the dispensing room, the professionals work on side benches, and on their side is a table with a computer for printing the prescriptions to be dispensed. The furniture also does not meet ergonomic principles. The rack with shelves and drawers are identified according to the active principle. Psychotropic medications are stored in a specific cabinet, not locked and without any control (Figure 2, number 8).

Interruptions occurred to solve problems, to dispense medications to the ICU, or to assist professionals requesting medication. Parallel conversations and extensive circulation of people in the area during the dispensing were observed. Dislocations were frequent, as the pharmacist often had to go to the storeroom to fetch medicines that were missing from the dispensing shelves (Figure 2, number 9).

Other weak points were the lack of diagnostic information in the prescriptions printed at the pharmacy, and the lack of communication between pharmacist and doctor to notify about medicines not provided by the network. There was no double conference about the medications, as recommended in the literature. In addition, no notification was sent to the requesting unit about the lack of medications in the pharmacy and on the collective distribution of medications such as ointment, creams, and eye drops (Figure 2, number 10).

Strengths include the printing of prescription at the pharmacy and the participation of pharmacists in the dispensing with a consultation about the medication before it was taken to the unit.

The subprocess of preparation and administration of the drug was carried out in a room adjacent to the nursing station, in an area with a large circulation of people, which poses a risk factor for increased errors (Figure 2, number 11).

Safety failures were observed in the preparation subprocess, noting that often the professionals did not observe aseptic principles (hand hygiene), although the location is suitable for it (Figure 2, number 12). They also did not use universal protection barriers, such as procedure gloves, nor comply with basic aseptic procedures, such as disinfection of the ampoule and absence of aseptic access (Figure 2, number 13).

Failure to identify the medication was another observed risk factor. One issue was the labeling of the medications to be administered (on the medication cups, only the bed number was identified, and the injectables only contained the bed number and ampoule attached to the syringe) (Figure 2, number 14).

The medications for several patients were often prepared at the same time (Figure 2, number 15). In addition, the number of employees was less than needed (Figure 2, number 16).

Another risk factor was the preparation of the medication near the nursing station (in the ward), without adequate conditions (Figure 2, number 17). Likewise, the medication based on the transcription of the prescribed drugs was prepared in inappropriate places (Figure 2, number 18). Transcription can be considered a critical and precarious aspect, because when transcription is based on memory, it might be copied wrong and thus generate errors such as changing the name of the drug, dose, and route.

Preparation and administration of medications were done in advance (Figure 2, number 19), and administration of medications for two different schedules occurred at the same time (14:00 and 16:00 at 14:00) (Figure 2, number 20). The numerous interruptions and the constant noise of telephone, students asking, other professionals talking, television at the nursing station during preparation of the medicine (Figure 2, number 21) were also risk factors observed in this subprocess.

Displacements to search for materials and to respond to requests were other verified risk factors, as well as failures to register the administration of medication, which were performed only once, at the end of the shift. In addition, the control of drugs brought from home or purchased by family members for treatment, which were kept at the ward (Figure 2, number 22).

There was a lack of orientation regarding the administration of medication (Figure 2, number 23) and failures in the monitoring of this subprocess, with an error in monitoring the infusion (Figure 2, number 24). Another critical point was the registering of the administration of medication, which, due to the distance of the computer or forgetfulness of the professional, was often not performed (Figure 2, number 25).

Discussion

The system installed in August 2011 was completely electronic. Thus, in the electronic medical records, information was recorded and only available by the system, including prescription of the medication, request and results of exams, registration of nursing professionals, medical progress, and request of materials and medications. In addition to this information, it provides data that facilitate the practice of efficient and safe prescriptions, for example: allergy alerts, duplicate data, drug interactions, dose quantity validation, verification of drug information and therapeutic substitution, dose calculation, and BMI.

Several interruptions occur during all the subprocesses. These interruptions can divert attention, which affects the concentration and security of the task. However, some protective barriers were observed. Strong points of the prescription subprocess included the prescribers' preliminary assessment of the patients and consultation with the previous prescription, as well as the doctor and nurse's evolution before writing the prescription. The electronic system also showed no failures or problems during the observation period. Strengths also present in the subprocess include no reuse or contamination of materials and identification of the patient by name. In general, a consultation was made at the time that the medication was administration, either with the prescription, when available, or with the transcript.

In the medication system and its subprocesses, 34 activities are performed by different professionals, which shows the complexity and great possibility for error.
This study demonstrates that an electronic prescription system is a favorable factors, which is in agreement with the reports in the national and international literature, and contributes to the reduction of medication errors [8, 9].

Risk factors such as interruptions, dislocations, environmental problems, sufficient human resources, lack of patient identification, poor infrastructure, non-compliance with safety rules and protocols, and technical failures during preparation and administration were also described by other authors [9].

The weakness in complying with safety rules and protocols proposed by the Ministry of Health stands out as one of the critical and difficult management points, and it is necessary to sensitize professionals to adopt good safety practices. Opting for the unit-dose distribution system and the centralized preparation of parenteral solutions is a management strategy that can help to minimize the risk potential when the space is available exclusively for the preparation of the medication and controlled from external conditions.

The professionals involved in the medication system must understand that this is a complex system. Therefore, they must have the knowledge that allows them to analyze and intervene in order to provide responsible and safe care for both the patient and the medical team [10]. In this and other studies [7], the nurses' performance is still a little distant when it comes to working with process mapping. These professionals supervise their personnel in the process of preparation and administration of medicines, but they lack a more defined action within the system.

According to the US Institute of Medicine Committee on Quality of Health Care in America, to make systems safer, processes must improve to respect human limitations, i.e. not rely on memory or simplify processes by reducing the number of steps. Mechanisms that stimulate actions to prevent errors are necessary, such as not providing medication in the absence of important patient data as weight, height, and allergies [5].

Regarding the risk management strategies to avoid relying on just memory, the use of individual electronic devices, such as tablets, associated with the electronic prescription system is recommended to allow the nursing technicians easy and quick access to patient information, both for access to prescription and other user data and for recording their own activities. This conduct would allow a more integrated system and the incorporation of the technology into the subprocesses of the preparation and administration of the medication.

Some steps in the system such as checking, documentation, and monitoring were often not observed [11]. However, failure to comply with these actions may result in medication error, because the process, as a systemic organization, begins with the prescription and ends with proper registration and monitoring by the nursing administration [12].

Bedside computers in association with computerized system make this registry faster and with less potential for failures. A study found that implementation of a computerized system, reduces by 30% the time required for documentation, leaving the professional more time available to invest in the nursing process as a whole [13,14].

Other technological strategies that can also be adopted to improve the preparation and administration processes include the use of the smart infusion pumps, which can contribute to system safety, because they have a wide range of acceptable programming parameters. Smart pumps are designed with drug-specific safety software to help nurses solve programming errors [15, 16].

Smart pumps with bar code readers are designed to minimize these administration errors. In this case, the pump digitizer can be used to register the bar code on the patient's wristband, nurse's badge, and IV medication label. The bar code pump can detect if the infusion has been given to the right patient. In a fully integrated system, the bar code pump has a server that communicates with the electronic prescription system and/or the pharmacy information system, which guarantees compliance. However, this fully integrated approach is still rare [15, 16].
Systems that use information technology, such as electronic prescription, automated distribution, barcoded medication administration, electronic medication reconciliation, and personal health records are vital components of broader strategies to avoid medication errors. Therefore, a growing body of evidence calls for its widespread application [17-19].

A computerized distribution system associated with the unit dose would also be a proposal to simplify the preparation step, making it safer. In this system, the medication is dispensed in the exact dose, according to the medical prescription, requiring neither manipulation and / or reconstitution of the medication by the nursing team nor the need for mathematical calculations. This system allows the nursing team to administer the correct dose, minimizing the risks of adverse events, as well as reducing the time spent by professionals to prepare medications [8, 20, 21].

A measure to reduce drug errors, in order to ensure compliance with the nine rights of medication administration (right patient, drug, dose, route, pharmaceutical form, schedule, documentation, action, and response), is a barcode system for quick identification of the patient submitted to the procedure [22]. Studies confirm that the use of bar codes can prevent medication errors [23, 24]. They reduce errors by 54-87% at this stage [25-27].

In the context of the present study, it was possible to verify that, with the computerization of the prescription, the implementation of these strategies becomes easier. The system itself could block and issue reminders, which would make eliminate the exclusive trust of memory. It could also solve the problem of lack of data, because it could block prescription in the absence of essential information such as weight, height, and allergies.

It was verified that the subprocesses that used the computerized system more, such as prescription, dispensing and distribution, presented less weaknesses. This corroborates the fact that these technologies are a management strategy to increase users' safety.

However, the results also found that, even with these advances of the electronic system, there are two systems within the same macroprocess: electronic, which goes through the subprocess of prescription, dispensing, and distribution, and manual, in the subprocesses of preparation and management.

In this sense, some measures can be implemented to reduce errors in this institution, in the field of the present research, among them: to form commissions composed of a multi professional team, whose purpose is to provide safe and quality assistance to the users, establishing management plans and thus a culture of risk monitoring.

These results are expected to provide integration of health education institutions and health services, which together can develop drug preparation and administration protocols as well as training programs. They could also promote continuing education of professionals, because information is one of the team's key tools for delivering safe, high-quality care.

A suggested measure to promote risk management is the investment in improvements in electronic prescription, which includes adaptations of the system, standardization of prescription items, and implementation of a unit-dose drug distribution system. It is believed this can improve the preparation and administration of medications, directly helping reduce medication errors and improve patient care.

Conclusion

The results point to a medication process with critical points, which can be considered unsafe and risky, that compromise the activity of the professionals involved and the safety of their users. The study indicates that implantation of an electronic prescription system reduces risk factors for medication errors.

The processes that use the computerized system more, which include the prescription, dispensing, and distribution system, presented less weaknesses, which corroborates that the use of technologies is a management strategy that can guarantee the safety of users. Even with the advances provided by the electronic system, the study found the coexistence of two systems within the same macroprocess, the electronic one for subprocess of prescription, dispensing, and distribution, and the manual one in the subprocesses of preparation and administration.

The measures to be taken to reduce errors in this institution include: creating of multi-professional commissions to discuss and establish strategies that can promote patient safety; elaborating protocols for preparation and administration of medication and enforce them, and establishing reward plans by creating incentives for professionals who excel in performing their activities.

The findings of the study corroborate some research already existing in the field of Patient Safety and contribute to the elimination of weaknesses in the current system of the medication process. Adoption and fortification of security protocols are clearly indispensable to avoid errors that can occur even with the implantation of a digitized system in the health environment.

Nursing is vitally important to avoid medication errors, because such errors, depending on the situation, may even result in death of the patient. Thus, the adequate training of professionals with current and evidence-based technical-scientific knowledge, as well as ethical commitment and the recognition of their importance in the health system are also fundamental, because professionals act as a protective barrier for the patient.

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