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Research Article

Tracking in Patient Healthcare in an ICU via the Incorporation of RFID Technology

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A B S T R A C T

Patient safety is a major concern for healthcare professionals in the treatment process and it is therefore important to provide information management systems for each hospital unit, capable of tracking patients and medication to minimize the occurrence of adverse events, thus increasing the quality of care received by patients during their hospital stay. This paper provides a tool for the Intensive Care Unit (ICU), a vital facility with special features that computerize and monitors admissions, vital monitoring, care plans, the prescription and medication administration process. To attain this, it is important to incorporate revolutionary and cutting-edge technologies such as Near Field Communication (NFC) technology that is now being applied in a variety of environments, adding a range of benefits to the purposes for which it is employed.

Keywords: NFC, ICU, Traceability, RFID

Introduction

A major concern for hospital health professionals is to reduce the occurrence of adverse events[1-6] in the patient's care process. An adverse event is understood as any complication that occurs during the patient's hospital stay and is not directly related to the underlying disease or reason for admission. Such accidents can have serious consequences for the patient and family, leading to high costs and undermine confidence in the health care system, thereby undermining institutions and the health care professional. There are many international studies[7-12] dedicated to studying adverse events in health systems, the origin and the improvements that can be undertaken to improve the tasks involved in clinical practice.

This is reflected in the National Health Plan's 8th Quality Assurance Plan, which is aimed at refining safety in national health centers through a range of initiatives among which are: promote and develop culture and awareness of safety among professionals and patients; design and establish information and notification systems of adverse events for learning purposes; and contrivance optional safety practices in national health centres. This strategy is based on the World Alliance for the Safety of Patients (related to the WHO) and other international bodies recommendations.[13] The concept of traceability can bring many advantages to these processes. Detectability is known as arranging all the data identified with an item from its birthplace to conveyance and additionally utilization. In the wellbeing administration climate, this can be deciphered as the exact ID of the patient, prescription and administrated persistent/ medicine connection. The entirety of this limits the frequency of antagonistic occasions, subsequently expanding the wellbeing of the patient. Through the tracking register data analysis, the efficiency of each of the systems can be calculated, bottlenecks can be detected so that steps can be taken to enhance the detected weak points in the process under analysis. Innovative and state-of-the-art technologies such as RFID (Radio Frequency Identification) are now incorporated into healthcare environments[14-18] and can promote the accomplishment of the tasks described above.[19-22]

RFID Technology

For several reasons we chose the RFID technology:

- To provide additional value to the hospital's WIFI network
- To avoid the installation of a new antenna network (more expensive, implies interrupting the hospital's functioning)

In addition, RFID meets the requirements for patients to be identified and located. In recent years, RFID technology has been used in many different areas and has provided substantial benefits. It is therefore interesting to study the feasibility of its implementation in healthcare environments to improve the safety of patients and the quality of service provided during the treatment process. The diverse features of RFID technology components allow a large number of different systems to be launched. The basic operation of RFID, however, is fundamentally identical in all, a tag is attached to the entity or person to be identified, which then sends a radio frequency signal with the required identification information. Readers can be fixed (antennae, ARCHS, access points, etc.) or mobile (tablet, PDAs, phones, etc.). Tags can be passive if they use the same energy source as the reader or active when they are fitted with their own energy source, semi-active if their own energy is not used to transmit, but to power the microchip's internal circuitry. Other significant differences exist between active and passive tags, such as cost, available sizes and coverage variations (higher in active and lower in passive) (See Table 1).

Table 1.Comparison of RFID Readers and Tags

Fixed Reader	Mobile Reader	Active Tags	Passive Tags
Antennae	Tablet	Battery	No Battery
Arches	PDA	Higher cost	Lower cost and coverage
Access points	Mobile phone	Larger size	Longer life-time

The maximum distance at which communication can be established is the RFID component coverage (to read or write data in its memory, change its settings, etc.). Apart from the operating frequency of the system, coverage quality depends on factors such as the power provided by the reader antenna and available on the tag itself, the orientation of the tag at the time of reading, the surrounding conditions, etc. The previously assumed values for each tag are therefore merely indicative. An RFID system can work at four possible operating frequency, as shown in Table 2.

RFID innovation's predominance and accomplishment over other recognizable proof advancements are fundamentally because of the capacity of its labels to store a lot of data on subjects and additionally different things. Because of the scope of safe materials utilized in their development, for example, epoxy, which can withstand extraordinary temperatures (as low as 21°C) and many of them can be perused, composed and altered simultaneously without the requirement for direct contact with the per user because of which labels are not harmed by use. These highlights make RFID the ideal innovation for detectability frameworks in a medical care climate (to recognize patients and track drugs, for cool/ frozen or room temperature products). Tags are the main segments in RFID: the articles or subjects being followed totally choose their plan. There is an incredible assortment of labels (measurements and shape) and they can be perused regardless of the material on which they are appended if the suitable seclusion is chosen.

Table 2.RFID Technology Frequency of Operation

Frequency of Operation	Band
Low Frequency	Below 135 kHz
High frequency	13.56 MHz
Ultra High frequency	433 MHz, 860 MHz and 928 MHz
Microwaves	2.45 GHz and 5.8 GHz

Proposed Methods

The proposed research methodology plays a very vital role in any types of research. It shows scientific way to solve the problem. Equally, here the system's technical architecture comprises two subsystems hardware and software.

Software Subsystem

The software subsystem must comply with operating conditions and objectives. Once the system has authenticated, each professional profile will have access to the information according to their professional category and once registered, they will be able to consult any change in the patient's condition, almost in real-time, as shown below:

- **Healthcare personnel:** authenticate, read NFC of the patient, visualize the information of the patient, manage the monitor of vital signs
- **Doctor:** discharge of the patient, search for patients based on administered medication lot reference, prescribe medication, consult medical history
- **Nursing staff:** administration of prescribed medication
- **Auxiliary nurse:** management of care plans

It ensures wellbeing during the patient's consideration cycle since no client can do clinical practice errands for which they have not been approved. Three specialists have been related to various undertakings and advantages: specialists, nursing faculty and nursing associates who offer assignments at a fundamental level. To encourage the plan

of the product subsystem, it is isolated into independent modules, each speaking to every one of the entertainers referenced previously. Login, Logout, Read quiet NFC code, Add observing, View personal data are the functions available to all of the users. It is important to emphasize that everyone has to start the session by reading the NFC tag that clearly recognizes them in the system. Once discovered, the user can then read the identity of the admitted patient through the RFID technology, in the case of a patient already assigned, it allows management for the patient's monitoring (recording relevant fields: time, temperature, blood, arterial blood pressure). The user can only access the admitted patient's personal data in compliance with the professional protocol for which he/ she has been assigned. The specialist module helps the specialist in release a distinguished patient after the passage of information for the release. Every module contains a progression of obligatory fields to be finished by the client to proceed with the undertaking. This module permits patient's distinguishing proof (practically progressively) to whom prescription has been regulated from a particular group. This encourages the administration of drug cautions and requires just the name and part number of the medication being looked to be entered. The nursing personnel module facilitates the patient's administration of prescribed and pending medication. First, the nurse must read the patient's NFC tag and then the NFC tags which identify the medicine to administer. Nursing personnel can consult the list of all the pending and prescribed medication to administer in accordance with their particular shift. The auxiliary nurse module allows the auxiliary nurse to manage (add and modify) the care plans assigned to each patient. This auxiliary nurse can also view the list of prescribed or administered medication to the admitted patient.

Hardware Subsystem

The hardware subsystem consists of various RFID systems, which is the source of information for the software subsystem. The operating frequency is a key point in the design of the RFID system. This determines the distance at which tags can be read/ written, therefore, the procedure to detect patients, staff or medication identified through RFID. After a thorough study of the opportunities offered by the different operating frequencies of RFID, NFC was found to be the most suitable in this case. This is because the aim is to identify patients, medicines for administration and the health professionals involved in each of the activities unequivocally. This allows the subsequent availability of a comprehensive registry and the tracking of a patient in his/ her route through the service almost in real-time. NFC adapts to the requirements of this work because patients are mostly found at a specific location and readers work at short distances. However, patients are usually separated by short distances which favors the functioning of NFC and reducing errors in reading patients, medication or nearby personnel that require identification. The major advantage of NFC is that a single mobile device provides all the required functionalities (reading and writing) so that health professionals can manage the RFID system in a rapid, safe and efficient manner. Figure 1, presents a design of the RFID system for traceability in the ICU.

Figure 1.RFID System for Tracking in the ICU

The medication to administer, health personnel and the patient are identified through an NFC tag in the RFID system. To obtain the Unique Identifier (UID) and manage the pending tasks related to the patient's care process, the system must read this tag. The tracking process requires the patient, prescription and health provider to be unambiguously identified through an NFC tag. For this purpose, it was decided to use the Unique Identifier (UID) of the tag to manage the storage of the information relating to the database to improve the protection of the RFID system as an external reader cannot access the information related to the patient's progress. At the same time, it is only possible to read tags to avoid writing on tags.

Result

The metrics used to test the system include: number of clicks to accomplish a task (1-3), the number of screens consulted to carry out a task (1-3). The amount of information required to perform routine tasks on a single screen, has been evaluated. Consequently, the execution time of the tasks is always dependent on the user but is much shorter than before (the traditional paper method) due to the design and implementation. Using the application, the process lasts about 15s and the handwritten process is clearly longer. In order to ensure the system's proper functioning, it was essential to test each of the modules individually from two perspectives: patient tracking, medication and health personnel, on the other hand, the key elements involved in the care process for each of the health professionals involved. There is a clear need for a staff training phase during which time it is recommended that both the traditional paper system and the developed system coexist so that the number of patients treated under the new system rises progressively to include all patients in the service. The system is efficient, safe and accurate as the computerization of the data minimizes the possibility of human error during the care process. An

application integrated in the health environment is generally different from any other area, it must not only comply with the predefined protocol for those tasks performed in daily clinical practice but also in the necessity for an interface where each screen displays the appropriate and comprehensive information required by the clinician in order to assist the patient safely and rapidly. This research is considered both innovative and cutting-edge, not only to automate the tasks involved (it contributes to increased safety by reducing adverse events and thus the quality of care provided to the patient) but also to integrate RFID technology into those tasks.

Conclusion

This research has shown the technological feasibility of RFID technology in the care process in an ICU with the benefit of requiring only a low-cost infrastructure. Despite the nearby personnel, medication, patients, the selected operating frequency assures the correct reading of the tags. The mobile device, as a reader, is easy to use and reduces learning time for future users. The system makes it possible for identification, in almost real-time, of patients to whom those lots of medication have been administered, to manage pharmaceutical alerts. Confirmations by NFC are handled through the application's alerts. By reading the patient's NFC tag and the NFC tag of the medication, the system will determine whether the medication has been agreed by the doctor and is pending in this shift for administration, on the contrary, should not be administered by the nursing personnel as it has not been prescribed or is not scheduled for this particular shift. This research has shown the technological feasibility of RFID technology in the care process in an ICU with the benefit of requiring only a low-cost infrastructure. Despite the nearby personnel, medication, patients, the selected operating frequency assures the correct reading of the tags. The mobile device, as a reader, is easy to use and reduces learning time for future users. The system makes it possible for identification, in almost real-time, of patients to whom those lots of medication have been administered, to manage pharmaceutical alerts. Confirmations by NFC are handled through the application's alerts. By reading the patient's NFC tag and the NFC tag of the medication, the system will determine whether the medication has been prescribed by the doctor and is pending in this shift for administration or, on the contrary, should not be administered by the nursing personnel as it has not been prescribed or is not scheduled for this particular shift. It is possible to integrate this system into other existing tracking systems and it may also be compatible with other identification technologies. Above all, its design has been prepared to be easily transferable to other hospital intensive care units.

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