PATIENT IDENTIFICATION WITHIN A HEALTHCARE SYSTEM:
The Role of Radio Frequency Identification and Bar Code Technologies

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Abstract: Healthcare enterprises require the ability to respond to rapidly changing circumstances. The increasing attention to patient safety and access to efficient health care services has bought about the adoption of new identification and sensor networks technologies. These technologies are being coupled to information systems to help clarify the complex nature of hospital environments. To reduce medical errors it is crucial to identify the correct procedure or medication to the matching recipient. Adverse drug events and medical errors are costly, not only to the hospital but also to the patient. It is important that the correct treatment is provided, in a timely manner to a health care patient, and this includes the ability to access and record pertinent information. The role of identification systems such as bar code or radio frequency identification technologies, is to enhance the positive identification of a patient in a healthcare environment. This paper proposes the integration of different protocols and technologies to strive to achieve the goal of zero misidentifications.

Key-Words: rfid deployment, patient identification, bar codes, medical errors

1 Introduction

The problem of medical errors in a hospital environment is not only a huge impost on the health system, but can cause inconvenience or at the worst prove fatal to a patient. Statistics from America [1] show that up to 98,000 preventable deaths from medical errors, and 770,000 adverse drug reactions occur each year. These errors include unnecessary surgery (12,000 deaths per year), wrong medications (7,000 deaths per year), or adverse drug reactions (106,000 deaths per year) [2]. Some of these errors may be directly linked to patient identification mistakes, which may be related to the wrong medicines being given or prescribed [3], or medical procedures undertaken. Review of studies published shows that one in ten hospital admitted patients suffer from an adverse incident [4]. Human interaction is the key difference in a health care environment compared to many other industries. This interaction is crucial in the delivery of care, and includes the identification of a patient before any medical, or associated treatment is given.

The utilisation of new identification strategies has the potential to reduce the number of incorrectly matched patient incidents. At the time of writing, identification protocols to identify patients range from a verbal interaction between a patient and health care professional to the health care professional reading an identification tag attached to the patient, generally a paper printed wristband. There are electronic systems capable of reading a patient’s identification tag. A hand held device, such as a bar code or radio frequency identification (RFID) reader, may undertake this electronic identification. However, it must be noted, that human interaction at this stage, is still needed in this scenario in some form.

The potential to reduce medical errors is in the best interest of health systems, health workers and the patient themselves. The adoption of improved protocols and the blending of new and old technologies have the potential for creating a safer environment for all interested parties. This paper proposes the integration of the different protocols and technologies to achieve the goal of zero misidentifications.

The paper is structured as follows. Section 2 describes current patient identification systems; Section 3 outlines integration of identification technologies; Section 4 presents limitations and conclusion.
2 Patient Identification Systems

Patient identification methods in hospitals generally range from verbal interaction with a patient, to electronic interaction between a patient's identification tag and an information system. Identification is the matching of a patient, through verbal information or a hospital identification tag, before a procedure can be initiated. Examples of this identification protocol will be highlighted in the following Sections. Subsection 2.1 will outline human identification; the use of electronic systems in Subsection 2.2; and the characteristics of barcode and RFID systems are discussed in Subsection 2.3.

2.1 Human Identification

Human identification is normally carried out as a manual process, in which there is a personal interaction between a patient and a health professional. There are a number of scenarios in which this identification process can occur:

- In a hospital setting a health professional will approach a patient and ask their name before giving them a medical procedure.
- Examining the patient chart and undertaking the previous method,
- Checking the printed or written version of an identification wristband, with or without the verbal interaction.

In all the previous examples there can be issues when the patient is unconscious, unable to communicate, confused or the wristband is illegible to the human eye. There will be times when the patient chart has been removed from the bedside or has been replaced on the wrong bed. These issues will hinder the functionality and accuracy of the identification process, which is critical to the safety of the patient.

2.2 Electronic Identification

Patient identification by an electronic method utilises technologies such as barcode, RFID or smart card systems. Barcode systems print the barcode onto a paper strip, which is then attached to the patient using a wristband. The bar code can be a simple linear or a two dimensional form. The linear bar code usually contains 12 digits that encode the patient identification number, which links to the hospital information system. The two dimensional bar code is able to encode more data such as name, blood type and age. This bar code is scanned by a hand held device, which is used to identify the patient in the information system.

RFID systems use a tag that can be passive or active, and is interrogated by a RFID reader. This interrogation utilises radio waves and the data received by the reader is used to query an information system. A hand held device such as PDA with a reader can perform this interaction between a tag and reader and display the relevant data. Smart cards hold information about the patient without always needing to interact with the hospital information system. This paper will focus on the possible utilisation of RFID and barcode technologies to identify patient in a healthcare environment.

2.3 Characteristics of Barcode and RFID

There are a number of characteristics that are important, when considering the utilisation of RFID and/or barcode identification technologies. The following subsections will outline these characteristics with pertinent examples.

2.3.1 Line of Sight

Reading and identifying bar codes require the reader to be in line of sight of the barcode. This means the user or machine must be aiming the laser at the barcode. One example is when the nurse has to line up the barcode with a hand held device on the patient wrist. In doing so, the nurse may have to wake up the patient to be able to access a clear line of site to the barcode. The barcode is designed to be read by a scanner or a human, and in this case must be legible for either of these processes to be successful.

Line of sight is not a crucial requirement for a RFID tag to be identified. The tag emits radio waves, and this radio wave carries data about the tag and can be utilised to identify a patient. This may be an important consideration if the tag is applied to a carton of medical products on a pallet. In this case, the hospital worker does not have to see the object to retrieve its information. Another example is finding a patient chart that is not at the end of a patient's bed. The chart has a tag attached and when the RFID tag enters the interrogation zone [5] of the reader it is identified and queried. This gives the health professional the ability to query the location of the patient chart and save time looking for the chart.

2.3.2 Read Range

The distance that a barcode can be read depends on the machine, but generally, it ranges from two to 10 centimetres. However, the reader must be in line of sight of the barcode to allow the reading process to occur. This distance parameter is an important factor between the two identification technologies. An RFID tag, depending on its properties may be read from a two
centimetres to 30 metres. This relates to the different capabilities between a passive and an active tag, and is also affected by the operating power of the reader’s antenna.

The movement of patients in a hospital system cannot be tracked, if barcode identification is utilised. Whereas, with RFID tags a patient can be tracked as they move from one area of a hospital to another. This gives an added dimension of incorporating this functionality in monitoring patients with dementia or mental illness. Beth Israel Deaconess Medical Center uses RFID tags to track babies in their neonatal intensive care unit [6].

2.3.3 Cost

The barcode is cheaper to create compared to a RFID tag. The barcode typically cost around 1-cent where as a RFID tag can range from 15 cents to $5 for passive tags, while active tags are priced from a low of $10 to at least $100 each. The associated cost of infrastructure required for RFID is far greater than barcode implementation. Typically, a RFID reader starts from $2000 and requires peripherals such as antennas, wiring, testing, site analysis, employee training and integration with existing information systems [5].

2.3.4 Memory Capability

This characteristic is related to the ability to change the data available on the tag. The barcode data is created at the point of manufacture and cannot be changed. In this case, the barcode is read only. This is also the case with some passive RFID tags, where the tag has only an identification number assigned and cannot be changed. Generally, the passive tag identity data, has already been encoded when the organisation procures them. In this case both the barcode and RFID tag are write once and read multiple times. There are also RFID tags that can be written and read multiple times allowing the data to be updated. One example is when a patient has an allergic reaction to a drug and their patient tag and medical data is updated. In this case, the tag has general information about the patient encoded into it.

2.3.5 Data Storage and Identity Information

The amount of data that can be stored on a barcode is static once it has been printed. The 13 digits on a typical linear barcode represents the country, the company the product item number and usually a check digit. The RFID tag can also show the individual number of the product, and will normally hold 96 bits of data up to 1 megabyte compared to the barcode.

The ability to identify an individual product by a RFID tag is an important capability. In general the barcode will identify a product type. This difference becomes obvious when tracking the same product in a hospital environment. The barcode will identify that we have a bag of normal saline but it does not let us know if it was delivered recently or in the last few months.

2.3.6 Read Rate and Data Capture

RFID tags can be read more rapidly than barcode technology. When tracking medical equipment or supplies this is crucial for efficiency. Theoretically, RFID reader can interrogate up to 1000 tags per second. Trials have shown successful read rates of up to a hundred objects in a few seconds. This read rate must be tempered with the problems of interference from electromagnetic or magnetic sources, for example water, metal or electrical equipment [7], [5]. There are also problems with RFID standards and equipment between different countries and manufacturers, which can inhibit the percentage of successful reads [7]. A positive aspect of bar codes is that they rarely produce incorrect data [6]. This is due to the scanner being able to read the barcode or an unsuccessful read occurs due to a bar code being damaged.

RFID systems are able to concurrently identify and interrogate multiple tags within the interrogation zone. On the other hand, barcodes can only be read one at a time by a scanner. The ability to only read one barcode at a time, is not significant if the health professional is identifying one patient. This would be a major obstacle, if as previously stated in the case of tracking patients with illnesses such as dementia or infectious diseases [8], [9] as they move about a particular ward or the hospital. The bar code system does not allow the real time tracking of objects unless the bar code can be read by a scanner, which would be difficult, due to line of sight and read range limitations.

2.3.7 Privacy and Security of Information

Privacy and security of patient information is critical to the governance and operation of identification technologies. Privacy and security issues have been discussed due to concerns that tags can be read without line-of-sight, and without evidence that they are being read [10], [11]. Questions have been raised, whether or not the concern is justified [12]. It would be quite reasonable to to assume a patient would be aware of someone reading their wristband barcode. [11] notes, that there are encryption problems, especially with the passive tags, since this tag type has minimal computational capacity.

2.3.8 Medical Equipment Interference

RFID operates within the industrial, scientific and medical (ISM) band, and as noted in subsection 2.3.6.
can be prone to interference, from operating equipment and environmental issues. There is conflicting research that alleges RFID systems cause interference to existing medical equipment [13]. This is due to the read range of the RFID systems and the power output of the antenna [13]. The Center for Devices and Radiological Health (CDRH) reported one incidence of an RFID system causing interference to an implantable device [14].

The idea of a context aware operating system [15] showed that in a pilot, there was no reported interference to medical equipment. Research [16] reported no interference with implants such as a pace maker and medical equipment, though this research was undertaken in a controlled environment.

2.3.9 Durability

Bar codes are generally printed onto paper and are susceptible from contact with water, being torn and can become illegible from being wrinkled. In the course of patient care, the tag will go through the shower, or bath, and general wear and tear from the patient movements in bed.

RFID tags are generally more robust and can be encased in hardened plastic, thereby still operate if it becomes wet and are less susceptible to general wear and tear. This durability allows the tag to continue being operational, when it is tracked in harsh environments or handled roughly. For example, it is possible to track the patient as they enter a shower cubicle and know that, as the patient returns to their bed the tag will still be readable. The next section will discuss the integration of different identification strategies and technologies to enhance the process of patient identification in a healthcare system.

3 Integrating Technologies

The goal of patient identification is to negate the possibility of misidentification before, during or after a medical treatment. Utilisation of bar code or RFID technology with human interaction may improve this crucial process for patient safety. This paper proposes the integration of the different protocols and technologies to achieve the goal of zero misidentifications. In the unlikely occurrence of an unsuccessful electronic identification process, then the health professional will manually read the bar code band on the patient. This entails looking at the number printed on the band and then checking this number on the information system. The locum process is a verbal identification of this patient, and if this is not possible, then the medical procedure may not be performed. The final decision will ultimately depend on the critical nature of a patient medical condition, and the treatment regime to be initiated.

This section will present different scenarios where identification is required and outline the role of blending human and electronic processes. It is implied, that the following examples have a RFID and barcode infrastructure in place and an electronic medical record (EMR) and number (EMN) for each patient. This enables additional capabilities of the said systems, to be enhanced as outlined in the examples given. To improve the safety of the patient, for the following scenarios the patient has a RFID tag that is encoded with the data as shown in Table 1.

<table>
<thead>
<tr>
<th>RFID Tag Data</th>
<th>Standard</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Allergies</td>
<td></td>
</tr>
<tr>
<td>EMN</td>
<td>Diet</td>
<td></td>
</tr>
<tr>
<td>DOB</td>
<td>Treatment</td>
<td></td>
</tr>
<tr>
<td>Blood Group</td>
<td>Time</td>
<td></td>
</tr>
<tr>
<td>Photo</td>
<td>StaffID</td>
<td></td>
</tr>
</tbody>
</table>

The columns in Table 1 are related to data that is stable (Standard) during a hospital stay and data that will be updated at least daily (Variable). The recording of a specific treatment at a specific time by specific staff (Three S’s) is an integral aspect of a patients interaction within a healthcare environment.

3.1 Operating Theatre

Incorrect surgical procedures on a patient [17] necessitate a rigorous and robust identification regime. This information encoded in the RFID tag Table 1 will be the basis of a patient requiring a surgical procedure. The second form of identification is a bar code printed in an electronic and human readable format. A linear bar code is scanned, and this data will be used to access the patient electronic health record, via an electronic viewing device.

The initial (electronic) identification of the patient’s RFID tag, is verified with the hospital information system, once the patient enters the operating room. If the patient data is not consistent, with the surgical list for that particular operating room, then the computer screen displays a warning. A secondary process is initiated by scanning the barcode on the patient wrist. The problem of cross reads is negated by utilising the bar code scanning procedure. The objective of this two-step interaction between patient tag and information system is to check that the correct patient has entered the correct operating theatre, for the correct procedure (Three C’s).

The safety of the unconscious patient will further
be enhanced, with RFID tags attached to the surgical packs. This enables the pack to be identified as it enters the operating room and then checked against the surgical procedure to be performed. In other words, if a pregnant woman is brought into the operating room for a removal of a cyst, a warning is displayed on the computer screen if a gynaecological pack is bought into the room. In this case, it is inappropriate that a gynaecological surgical pack is associated with the required medical procedure.

3.2 Infusion Pumps

Infusion pumps are utilised to deliver fluids into a patient via a blood vessel. Examples of these fluids are blood, electrolytes or normal saline. Transfusion of the wrong type or to the wrong patient can cause a serious health risk to a recipient [21]. In this scenario the infusion pump, patient tag and item (blood or fluids) to be transfused, communicates to verify the initial identification by the health professional. In initial identification, the nurse brings a blood product bag to replace the one in the infusion pump. The nurse checks the patient treatment schedule and also identifies the patient and fluid using the RFID tag or bar code. Once the fluid bag is attached to the infusion pump, a secondary identification process begins. The steps of this process are outlined as follows:

- Firstly the infusion pump reads the RFID tag data of the fluid,
- Infusion pump reads the patient RFID tag data,
- The blood type of the patient and bag are checked,
- If the blood types are the same, transfusion begins,
- If not, the infusion pump sounds an alarm.

The use of two identification methods reduces the risk of a patient receiving the wrong blood transfusion.

3.3 Patient Dietary Requirements

A patient will be prescribed a specific dietary regime depending on the medical condition and requirements of a medical procedure. For example, if a patient is scheduled for an operation, they will be placed on a nil by mouth order for a stipulated time frame before the operation. This is crucial safety component of their care, since they may asphyxiate during the operation if they are given food [3].

To negate this problem all food trays will contain a rewritable RFID tag. This tag is encoded with what type of dietary group is on the food tray. This group consists of diabetic requirements, fluid only, religious concerns, blended meals etc. At the time, the tray is placed on a patient bed, the tray and patient tag is scanned and compared. This process allows the health professional to be aware of the latest information in regards to the dietary needs of a patient. When the electronic health care record of the patient shows that they cannot have food, this process may avoid a potential life-threatening scenario.

4 Conclusion and Future Work

Recent research indicates that electronic identification can reduce the number of patient misidentifications [18]. What seems to be lacking as far as the authors are aware is the integration of different strategies to identify a patient. It is crucial to have a fail back protocol in case of failure in any of the systems. Further work in the use of finger print strategies is advantageous in the unlikely scenario of the RFID or bar code technology, or verbal identification not working. However, there is an obvious issue of privacy and big brother issues, when a patient or health professional are identified by biometric methods. This work is limited, as it only proposes the blending of technologies and will need further empirical resolution.

The correct identification of a patient is crucial to their safety and care in a health care environment. The integration of electronic and human identification platforms has the capability to negate misidentification of a patient. Important characteristics of bar code systems are the ability to be human readable and the narrow scanning range. These factors increase the one on one interaction with a patient. RFID systems are capable of tracking patients as they move through a hospital, and the RFID tag can be encoded with a subset of the latest patient data. Reliance on one identification system is prone to errors. With the combination of electronic systems, and human interaction as a fail-safe process, it is possible to enhance patient safety. Careful analysis of security and privacy issues relating to electronic identification systems is important for the well-being of patient and healthcare workers. The adoption of improved protocols, and the blending of new and old technologies, has the potential for creating a safer environment for all interested parties in a healthcare system.

References:


