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Smart medical environment at the point of care: Auto-tracking clinical interventions at the bed side using RFID technology

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ABSTRACT

We developed a wireless auto-tracking system for tracking clinical intervention such as drug administrations and blood tests at the patient bedside. The system can not only authenticate patients and nurses, but also confirm medications and provide relevant information, depending on the clinical situation and personnel location. We conducted a feasibility experiment and examined whether or not the system could work as a patient safety measure in terms of reducing misidentifications of patients and medical errors including wrong medication type, dose, time, and route. Also, the duration of clinical interventions in the system were measured to compare with the BCMA system. Moreover, we conducted a qualitative evaluation with nurses and received feedback clarifying their perceptions of the system. The results showed that the system correctly recognized medical staff, patient ID, and medication data in real time. With regards to workflow time, a significant reduction of time of clinical interventions was observed, when compared to a bar-coding system. In addition, on the nurses' evaluation, we received mostly positive comments although they also clarified some issues to consider with regards to operability and privacy issues. We concluded that the system had great potential for reducing medical errors and nurse workload with high efficiency.

1. Introduction

Barcode medication administration (BCMA) systems have been implemented in some institutions to reduce medical errors and improve workflow efficiency at the point of care [1,2]. In fact, their effects have been demonstrated, especially in the reduction of medical errors [2–6]. However, these systems still may not be fully efficient. For example, barcodes have to be scanned one by one. Also, searching for relevant patient data on the system results in an increase in workload [7]. Minimizing nurses' workloads as much as possible is essential since, in many places, there is a serious shortage of nurses. Also, there are other potential issues, such as difficulties in scanning bar codes on the medication labels, lack of awareness of bar codes on medication labels, delays in responses from the computerized system in the event of time constraints, and administration of medication before prescription [8]. Therefore, nurses sometimes do workarounds which potentially result in a new type of misidentification or medical error [9].

In addition, some medical errors cannot be reduced after implementing BCMA systems because medical treatment constantly changes, depending on the patient condition. Given serious time constraints, accurately identifying patients is an important factor in providing safe medical treatment.

To address these issues with the current system, our approach was to develop a new system for auto-tracking of clinical interventions at the patient bedside using radio frequency identification (RFID). RFID technology is known for its auto-tracking capabilities and also is expected to prevent some types of medical errors, which BCMA systems cannot. Its capabilities include passively identifying people in real time and matching data with IDs and location [10,11].

As reported before [12], the main purpose of the RFID system we studied is to allow seamless monitoring of certain nurse–patient interactions at the bedside, leading to improvements in the workflow that increase nurse efficiency, which in turn has the potential to enhance patient safety. The system was designed to prevent the misidentification of patients and consequent administration of the wrong medications (including dose and route) or inappropriate clinical interventions. Specifically, our system focused on drug administration and blood sampling, because medical errors in these clinical interventions may directly cause the most serious harm for patients.

For the system to be effective in dealing with complex clinical situations, it not only identifies clinical intervention at the

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bedside, but also tracks the status of patients, and in addition, provides relevant information, depending on the situation and location, to help nurses access relevant data easily.

Since the system is automated, it does not add to the staff workload, automatically performing identification of objects and people. The system was developed with two different types of RFID technology integrated through a wireless network for the purpose of tracking all objects and people in a patient room.

In this study, we conducted an experiment with the preliminary system in a clinical environment based on scenarios of drug administration and clinical intervention. Also, to compare with a BCMA system, we measured the duration of the clinical tasks such as drug administration and blood sampling with the RFID system and with the BCMA system. Moreover, qualitative evaluations were conducted to clarify the nurses' perceptions of the new system. We verified that our new system has great potential for improving patient safety with high efficiency based on the system evaluation and nurses' evaluations.

2. Methods

2.1. System description

The main functions of the smart point of care system are to authenticate identification of patients and medical staff, to confirm drug administrations and support medical staff at point of care by providing adequate information based on the locations. As for tracking clinical interventions, we focused on drug administrations and blood sampling. It was important that the system operation not add any extra effort in the identification of objects and people and be user-friendly.

RFID tags were attached not only to patients, nurses, and major medical equipment, such as medical carts and an IV poles, but also to medications and small medical supplies.

Both kinds of RFID technology were used in conjunction with a wireless network. Earlier passive ID systems that were used to identify individuals in the clinical environment required staff involvement to operate RFID readers or the acquisition of expensive and intrusive gates, which created a burden for the system and users [1,13]. Therefore, for tracking individuals and their locations, we focused on auto-recognition capabilities of active RFID (300 MHz), in which the tags themselves emit signals and the RFID antenna can obtain the data automatically. For tracking medications, we used 13.56 MHz passive tags and non-obtrusive readers, which have been widely used for tracking small objects, placed on the carts (Fig. 1). Multiple IV bottles, syringes, and blood sampling tubes on a tray can be identified all together at one time without adding any extra effort in the process of drug administration and other clinical interventions. We used a medical cart as a base, equipping it with the passive RFID system as well as components of the active system. This cart system was used for recognizing medications at the bedside. In addition to this medical cart, other equipment that identifies location of patients, medical staff, and medical equipment was embedded in the environment.

2.2. RFID systems

2.2.1. Active RFID tag

For recognizing people and medical equipment, we applied a new active tag technology named Power Tag (from Matrix Inc., Japan) [14] that can remotely recognize IDs and their locations when the tag is triggered in a specific field. This system has been certified, in compliance with the Pharmaceutical Affair Act, as causing no interference with other medical equipment. In addition, this system has already been used for tracking newborn infants in Japanese hospitals [15].

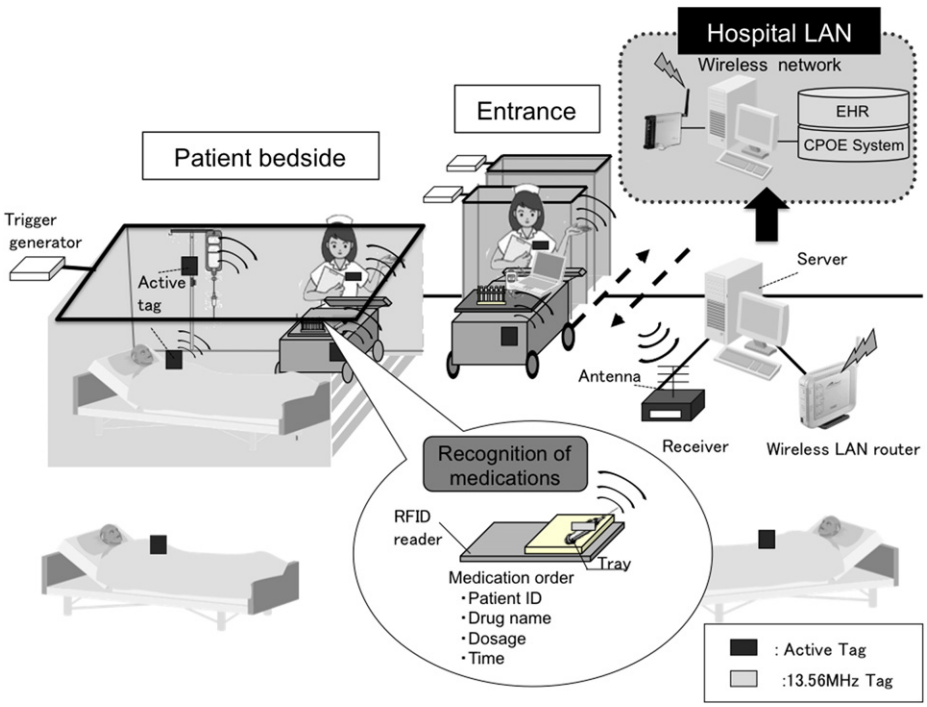

Fig. 1. Auto tracking clinical intervention system. Active tag antennas were placed in the ceiling at each patient bedside and at the entrance of the patient room. One 13.56 MHz RFID reader was placed on a medical cart for recognition of medications.