An Innovative Design of Infant Rooming-in Tracking Mechanism - The Experience of Cathay General Hospital in Taiwan

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Abstract - The promotion of Baby-Friendly Hospital Initiative (BFHI) was launched in 2001 in Taiwan. To increase the ratio of requesting rooming-in, baby-friendly hospitals should prevent the mistake of identifying puerpera and infant and assure the safety of newborn babies. To reach the goal of facilitating the rooming-in care, we propose a tracing system using active RFID-tag and RSSI method to identify and monitor neonates. This system is implemented in Cathay general hospital in Taipei. With the integration of wireless devices and information technology, this system can effectively avoid the situation like stolen baby and switched baby and up to the standard certified by BFHI. The nursing department can easily arrange routine nursing works and increase the quality of nursing cares. The hospitals are benefit from using the system with increased ratio of 24 hours infant rooming-in care and fulfill the requirement of the baby-friendly hospital more effectively.

Keywords: RFID, RSSI, infant rooming-in, BFHI

1 Introduction

The Baby-Friendly Hospital Initiative (BFHI) was launched in the 1990s by the World Health Organization (WHO) and United Nations Children’s Fund (UNICEF) as a global effort with hospitals health services. The promotion of BFHI is intended to improve the service quality in the hospital’s department of gynecology and obstetrics and create a breastfeeding friendly environment in the hospital to support and encourage breastfeeding. Breastfeeding is the best starting point to newborn babies. The infant rooming-in care can not only boost the maternal bonding with the newborn baby, but also can build mother’s confidence of being required and relied by the infant. Due to the previous advantages, medical institutions have gradually obtained the certificate of BFHI and start practicing 24 hours infant rooming-in care. [1]

When performing 24 hours rooming-in care, newborn babies stay in the ward with the mother. However, there are few occasions like bathing, injection, or other nursing care that require to move newborn babies out of the ward. Babies might be stolen or miss placed during transportation. These kinds of tragedies are seriously harmful to both families and medical institutions. The traditional way of identifying newborn babies is to compare the identification band wearing on baby’s wrist or ankle and the identification card hanging on baby’s hospital bed. However, newborn babies look similar and are not easy to distinguish their differences which lead to possible identification error. This is the main reason why most parents with newborn babies refuse to accept rooming-in care and this is the main obstacle of promoting rooming-in care.

The issue of patient safety has been paid attention by many countries including England, United States, Australia, etc. In the report titled “National Patient Safety Goals, NPSGs” published by the Joint Commission on Accreditation of Healthcare Organization (JCAHO), correctly identifying patient is the first and primary goal. [2] The issue of patient identification has gradually gained attention by public. Among the various topics discussed about patient identification, the identification of newborn babies is especially important because newborn babies can not “confirm” their identity which leads to the importance of developing the mechanism to identify newborn babies. [3,4]

Along with the growing of the necessity of efficient wellness systems, there is a mounting demand for new technological solutions able to support remote and proactive healthcare. Wireless transmission through mobile devices combining with information technology can break through the blind spots occurred while objects are moving. Radio Frequency Identification (RFID) technologies can assist the construction of baby rooming-in environment in the baby-friendly hospital.

RFID technologies are composed of three components: reader, tag, and software system. Through the microchip on the tag to transmit ID information to the back-end database, objects like babies can be identified, traced, and confirmed. The advantages of using RFID are non-contact reading,
updated information, massive amount of data storage, better data safety, and capable of reading multiple objects simultaneously. [5,6] With the help of electronic tagging device and the Real Time Location Systems (RTLS), RFID mechanism can monitor baby’s location in real time. Electronic tagging device contains batteries that allow it to actively detect the signals sent by readers in surrounding area and to transmit data to readers. RFID technologies are mainly used in the obstacle-occupied environment and the longest transmission distance can be reached more than 100 meters. RLTS is a system that can locate the position of specific targets promptly using wireless transmission technology in a confined space. Currently, technologies using RTLS to perform locating services are divided into four categories: Angle of Arrival (AOA), Received Signal Strength Indication (RSSI), Time of Arrival (TOA), and Time Difference of Arrival (TDOA). [7] TOA and TDOA locating system are both based on time as the base of measurement and both require the measurement of the time for transmitting signals precisely to receive correct results. Comparing with previous two methods, RSSI and AOA locating systems use signal strength as the base of measurement. However, these two methods can receive incorrect results because of the interruption of obstacles and multiple routes.

To provide a safe baby rooming-in environment and prevent the mistake of switched or missing babies, this paper proposes an infant rooming-in tracking mechanism using RFID technologies which can produce a statistical index record approved by BFH. The rest of this paper is organized as follows: section 2 gives a detailed presentation of the methodology of building the infant rooming-in tracking mechanism and section 3 shows the experiment results. We conclude the paper in section 4 with remarks on future work.

2 Methodology

The infant rooming-in tracking system framework includes the active RFID positioning mode and RSSI positioning method. The rooming-in rate plays an important role in the designing of the system and is discussed in this section as well.

2.1 The System Environment Framework

As shown in Fig. 1, the mobile area refers to the place for the baby’s bath, vaccinations, or other nursing measures requiring the mother to go back and forth from the baby-friendly maternity ward (hereinafter referred to as the ward) to the baby room within the 24-hour rooming-in period. Inside the mobile area, active RFID readers are installed in important locations. When signals sent out by the RFID tag worn by the baby are received by the reader located closest to the tag, the reader sends out information, including the reader MAC address, the tag ID, the received signal strength and so on. This information is sent back to the middleware server of the RFID control center.

The RFID control center includes four components: Middleware server, system database, Hospital Information System (HIS), and rooming-in tracking system. When the middleware server receives the tag data sent back by the reader, through positioning calculation and processing, the multiple information content in the data is converted into interpretable original data and is stored in the system database. Once the rooming-in tracking system receives a query request from the remote services, the system will obtain positioning information and patient related information from its own database and the HIS. Then, through information integration and logic processing, a response is sent back to the device interface where the user sends out the request of the remote services. Remote services refer to remote user devices that sends out request commands to the rooming-in tracking system, including desktop computers used by nursing personnel, mobile devices for puerpera.

![Figure 1. System environmental framework](image)

2.2 The deployment of the active RFID positioning system

In this study, the 2.45 GHz active RFID tag was worn around the ankle of newborns for positioning and tracking because newborns often wave their hands near their faces. As shown in Fig. 2, it is relatively safer and less likely to be detached if wearing the tag around the ankle. 4 hours after the birth of the newborn, the tag was put on the newborn, and it was removed before the newborn was discharged from the hospital. Before putting on and after taking off the tag, the newborn is exposed under the risk of identification “window period”. The active RFID tag is enclosed in a waterproof case. Rinsing and disinfecting with alcohol are allowed. Therefore, recycled uses are acceptable.
Active RFID network readers are located at each ward door on the fifth floor, entrances and exits of the baby room on the second floor, and the newborns’ mobile spaces and ceilings of elevator entrances on the second and fifth floor, which are used to collect newborn positioning and tracking related information. The reading range of a reader can reach above 100m. This distance is adequate for the newborn safety during transportation.

2.3 The Active RFID Positioning Method and RSSI Positioning Method

During the 24-hour rooming-in period, the newborn underwent bath, vaccinations, and other nursing measures. The newborn is necessary to go back and forth from the ward to the baby room; therefore, in this study, active RFID readers were installed in important indoor locations within the mobile spaces. When the signals sent out by the active RFID tag are received by the reader closest to the tag, the reader will send its own information such as the reader MAC address and information carried by the tag, such as tag ID, RSSI received signal strength, and so on back to the intermediary software for the process of positioning. Then, the intermediary software converted the multiple data into interpretable original positioning data for storage in the system database. Once the rooming-in tracking system received a query request sent by the remote devices, the system automatically obtained related information from its system. After processing, it responds to the user’s device that sent out the request, such as desktop computers, smart phones, etc.

3 Experimental results

Based on the medicinal and clinical on-site environment, integrated information monitoring management system was developed, as shown in Fig. 3, to provide medical management personnel a user-friendly interface and real-time location monitoring information. As for the path tracking under special circumstances, detailed information for queries was designed, as shown in Fig. 4. In addition, based on the statistical model of the rooming-in standard construct, the server received information was converted into standard rooming-in records for storage. In Fig. 3, the functions of statistical index related records are listed in the area covered with an oval. The matching list of mother’s name and newborns’ name is in the area covered with dot-line. Newborns’ current location is shown in the area covered with black line.
3.1 Development Tools

In view of the J2EE platform, the web-based application system with MVC as the framework was developed and constructed. At the front-end, the Java Servlet & JSP technology was mainly adopted as the basis, coupled with the SVG dynamic mapping technology to present a visually user-friendly interface. At the back-end, the RFID intermediary software-based MS SQL Server database and the HIS-based IBM DB2 database were connected. Finally, under the safe and flexible IBM WebSphere environment, the complete application program was constructed, deployed, and executed.

3.2 Statistical Definitions

According to Measurement 7 of the criteria certified by baby-friendly hospitals in 2011: the description of the “baby-friendly maternity ward implementation” assessment and the project content of baby-friendly hospitals under the Taiwan Association of Obstetrics and Gynecology [8], the following rooming-in statistical definitions and formulas were introduced.

3.2.1 The 24-hour Rooming-in Rate

The so-called vaginal delivery (caesarean session) pregnant women’s 24-hour rooming-in rate refers to the rate of pregnant women that undergo vaginal delivery (caesarean session), which is calculated by dividing the number of people engaged in 24-hour rooming-in by the number of pregnant women opting for normal delivery. Among them, the number of 24-hour rooming-in are expressed as the number of 24-hour rooming-in babies delivered through vaginal delivery (caesarean session), while the number of pregnant women opting for vaginal delivery (caesarean session) among the pregnant women opting for normal delivery is expressed by the number of babies delivered through vaginal delivery (caesarean).

\[
\frac{\text{Vaginal Birth Infant} \cap 24 \text{H Infant Rooming-In}}{\text{Rate of Vaginal Birth}} \times \frac{\text{Vaginal Birth Infant}}{\text{Rate of Caesarean Birth}}
\]

3.2.2 The Implementation of the 24-hour Rooming-in Certified Criteria

The certified criteria for implementing the 24-hour rooming-in include: three months before the on-site certification, at least 10% of the pregnant women hospitalized for vaginal delivery (normal newborns) implemented the 24-hour rooming-in during the period of hospitalization, and at least 5% of the pregnant women among the pregnant women opting for caesarian session (normal newborns) implemented the 24-hour rooming-in during the period of hospitalization.

3.3 The Display of Information Monitoring System

Fig. 4 shows the route and related information presented by the tracking and query of escort locations during the escort process. The detailed information about the path tracking is shown in the area blocked with black line. The red connected part consists of the path and the frame produced from the message feedbacks, which were effectively detected by the RFID. When the tag reached the elevator, the RFID reader automatically sent a message to the post-end server. Valid message requests continued to be sent, and new messages continued to be updated to present the real-time

![Figure 4. Detailed information for path tracing](image-url)
4 Conclusions

This paper proposes an infant rooming-in tracking system that provides a friendly and promptly tracking interface, traces newborn babies’ delivery path and time, presents the distribution of infants, and calculates the total amount of newborns precisely. This system can identify newborns and their location. It also keeps records of their location, delivery path, and staying time to effectively avoid the mistakes of identification error. It also sends alarms when abnormal situation occurred to prevent the incident of missing babies.

In terms of management effectiveness, the proposed system can enhance the quality of the process control for 24 hours rooming-in service and can produce various indexes and statistical reports approved by BFHI that were used to be collected manually. By using the proposed system, hospital management can be performed more effectively. In the future, we intend to develop visualized tracking mechanism which combines cloud computing technology and smart phone as the base of the designed mechanism and allows nursing personnel to conduct routine nursing tasks and the same time to acquire prompt information about rooming-in services.

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5 References

Number in square brackets (“[ ]”) should cite references to the literature in the main text. List the cited references in numerical order at the very end of your paper (under the heading ‘References’). Start each referenced paper on a new line (by its number in square brackets).


