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Review Article

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Use of a Real-Time Locating System in Infection Control

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ABSTRACT

Real-Time Locating Systems (RTLS) have emerged as powerful tools for revolutionizing healthcare by improving patient safety, optimizing workflow efficiency, and enhancing resource management. From patient tracking to infection control and emergency response, RTLS offer a plethora of applications. Although challenges such as privacy and integration need to be addressed, the benefits of RTLS in healthcare remain undeniable. As technology continues to evolve, the future holds exciting possibilities for RTLS, paving the way for smarter, more efficient, and patient-centered care.

Keywords: Real time locating system; Infection control; Healthcare facilities

INTRODUCTION

In the modern era, characterized by rapid developments, technology continues to transform different sectors, including healthcare. In environments where numerous individuals interact across complex settings spanning multiple locations, such as healthcare, it is essential to achieve optimal functionality by effectively managing the interactions among patients, staff, and equipment [1]. Healthcare providers can improve the safety of vulnerable patients and the efficiency of handling their unpredictable environments by minimizing redundant tasks, decreasing time constraints, and optimizing resource allocation. To manage extremely unpredictable circumstances, it is crucial to record the actions of every person and asset involved. Challenges in smooth mobility can result in delays, inefficiencies, and elevated costs [2]. Following the coronavirus disease 2019 (COVID-19) pandemic, there has been an increased interest in implementing tracing technologies within hospitals, driven by the necessity for accurate data to effectively address this issue.

Real-Time Location Systems (RTLS) are an emerging technology that has gained prominence for this purpose

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[3, 4]. RTLS function similarly to Global Positioning Systems, allowing the identification and real-time tracking of specific entities with near-real-time or real-time precision [5]. RTLS technology involves radio frequency identification (RFID) and Wi-Fi tracking systems. RFID calculates the distance and duration of human-to-human interactions by analyzing the signal from an RFID tag worn by users, which is captured by exciters installed in hospital wards and workplaces (**Fig. 1**) [6]. The effectiveness of the hospital environment can further be enhanced by employing several software applications designed to integrate data and interfaces with different operational systems [5, 7, 8]. The ability of the technology to quantify interactions effectively and affordably, regardless of the number of contacts, enables its extensive use [4]. Consequently, the body of evidence supporting the validity of this technology within hospital environments is steadily increasing, notwithstanding concerns regarding privacy and cost-benefit considerations [9, 10]. In this review, we aimed to explore the accomplishments of RTLS in real-world settings, focusing specifically on their impact in the field of infection control.

RTLS IN HEALTHCARE

Although healthcare has previously hesitated to adopt RTLS technology, increasing expectations for efficiency and improved care delivery are expected to accelerate the adoption of various RTLS solutions within the healthcare sector [11-13]. Several surveys conducted since 2008 have shown growing interest in implementing RTLS technology in healthcare. A survey conducted with United States (US) hospital administrators revealed that 15% had already implemented a tracking system, while 43% expressed interest in adopting it [14]. Subsequent research within the largest US public health system further highlighted the enthusiasm for this technology [15]. RTLS technology primarily focuses on medical devices, asset management, patient tracking, and workflow optimization [16-19], showing significant research potential and the ability to analyze and enhance current healthcare processes [20, 21].

Previous research has acknowledged that RTLS effectively identify workflow inefficiencies and improves time management. The evaluation of workflow, from

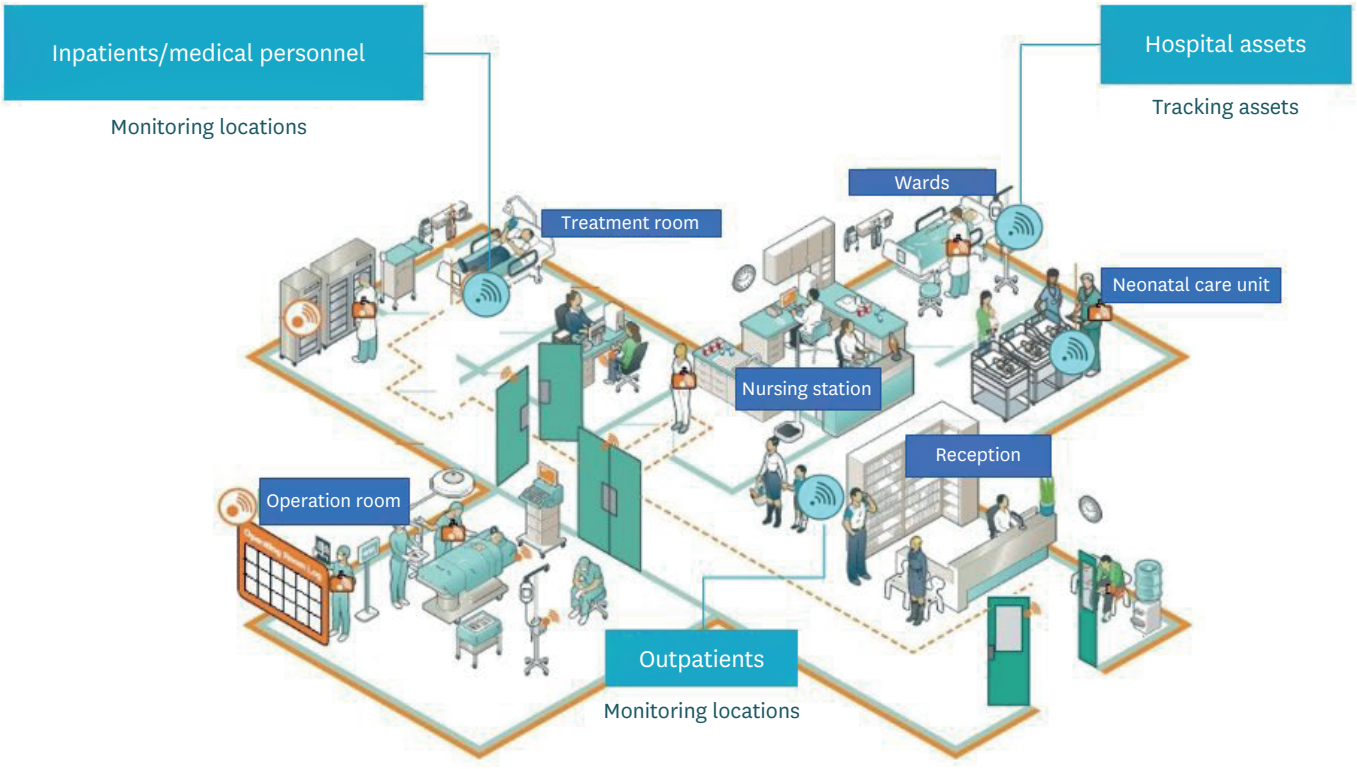

Figure 1. Overview of real-time locating system operation.

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the staff perspective, involves assessing how RTLS technology addresses workflow challenges, enhance communication among caregivers, and reduce inefficiency in hospital environments. The productivity benefits of RTLS are especially notable in high-stress environments, such as emergency departments, as they enhance the well-being and productivity of care providers [22-25]. A comprehensive review by Leila et al. demonstrated the effectiveness of RTLS-guided tracking in caring for elderly patients, enhancing their security by sending alert messages to the attending staff [26]. Moreover, RTLS facilitate the efficient tracking of medical samples and medications, such as blood products and prescription drugs, promoting patient adherence to drug programs by monitoring their consistent use [27]. The latest advancements in RTLS, when applied to healthcare, are poised to uncover research directions for future applications of this technology.

THE USE OF RTLS IN INFECTION CONTROL

As the global health community grappled with overwhelmed healthcare systems during the COVID-19 pandemic, the World Health Organization and various countries investigated how technology can be utilized to tackle the public health crisis [28]. Contact tracing, the process of identifying individuals who have been in contact with an infected person, plays a crucial role in curbing the spread of infectious diseases [29]. In response to the COVID-19 pandemic, there has been a significant increase in research focusing on the implementation of digital devices such as RTLS for contact tracing, which has been extensively documented in the literature. Owing to its high accuracy and substantial data-handling capabilities, RTLS have proven to be a valuable tool for enhancing the scalability of contact tracing. In a study by Lee et al., the tag-based RTLS performed effectively for contact tracing of COVID-19 patients within clinical settings in comparison to TraceTogether, a portable electronic device that exhibited lower sensitivity than RTLS tags in identifying patient contacts within the clinical environment [30]. The performance of the RTLS was also investigated and compared with the conventional contact-tracing method using electronic medical records (EMR). RTLS-based contact tracing showed higher sensitivity and specificity than the EMR reviews. The integration of both methods provided the best performance for rapid contact tracing, although technical adjustments to RTLS and increasing user compliance with the wearing of RTLS tags remain necessary [10]. The performance of this technology in identifying secondary transmission rates has also presented promising results. The study by Kim et al. demonstrates that RTLS are beneficial when used as an adjunctive approach to the conventional method for contact tracing associated with secondary transmission [31]. However, the authors suggested that RTLS could not completely replace traditional contact tracing. Researchers have also examined the effectiveness of telemedicine in conjunction with RTLS. Analysis of RTLS movement data showed no notable alterations in face-to-face interactions between staff and patients investigated for severe acute respiratory syndrome coronavirus 2 infection [32].

The use of RTLS to improve infection control measures beyond contact tracing in healthcare facilities has yielded promising results. RTLS can automatically monitor hand hygiene using location-based sensors and RFID tags. This technology enables the real-time tracking of hand hygiene and enhances compliance by providing immediate feedback and interventions when necessary. According to Cook et al., integrating RTLS with automated hand hygiene monitoring increased compliance rates by 25% within a short implementation time [16, 33]. Additionally, RTLS can play a significant role in identifying infection hotspots within healthcare facilities. It is assumed that patterns and potential sources of infection can be identified by examining live data, such as patient movements, staff activity, and equipment utilization. RTLS pinpoint locations with high levels of activity, allowing for adjustments of workflow or cleaning routines to minimize the risk of cross-contamination. By identifying areas of infection hotspots, healthcare facilities can implement measures aimed at reducing the spread of the infection in advance [34].

CHALLENGES IN RTLS

Although RTLS hold promise for enhancing efficiency in the healthcare industry, it is crucial to acknowledge certain shortcomings associated with this technology. Despite the promising outlook indicated by the abovementioned research, several limitations have been consistently addressed in RTLS implementation. The application of surveillance technologies, especially for vulnerable people who are unable to communicate verbally or have cognitive impairments, poses important ethical issues related to privacy in addition to the

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infringement of autonomy and respect for personal dignity [21, 35]. Privacy concerns are not limited to hospitalized patients. A potential reduction in employee privacy can adversely affect technology recruitment and implementation. This issue has consistently been highlighted as a significant limitation in the adoption of technology [18]. Given the significance of this issue, efforts to address it include public campaigns aimed at encouraging staff participation by enhancing privacy through advanced security methods, signal handling, and smarter equipment design. The effectiveness of these campaigns in promoting the application of the technology needs to be investigated.

Practical difficulties also exist in implementing and adopting RTLS technology. Ineffective technology is a major obstacle to the successful implementation of RTLS. Issues such as limited range and signal strength, short tag battery life, antenna strength, and connectivity pose significant challenges [16]. However, the absence of extensive large-scale research restricts the applicability of this technology to specific populations and sectors [18].

Technological limitations are also significant constraints on RTLS. RTLS can accurately and reliably locate patients and objects in real-world healthcare environments with good sensitivity and specificity [36]. However, the environment in which an RTLS is implemented must fully support its functionality. Challenges such as technology that does not meet expectations, difficulties in interoperability with other institutional systems, and weakened signal strength can impede the successful adoption of RTLS in long-term care facilities [16]. Furthermore, the additional cost of implementing this technology in preexisting systems needs to be considered. To overcome these challenges, a thorough strategy that considers the ethical considerations, practical hurdles, and technological constraints involved in implementing and adopting RTLS in long-term care environments is needed. By addressing these challenges, healthcare facilities can leverage advanced technologies to enhance hospital environments. Future large-scale research on the cost-benefit analysis of RTLS utilization is warranted.

CONCLUSION

RTLS are gradually being recognized as useful tools for improving the healthcare environment by enhancing resource management and improving infection control. Despite the challenges related to privacy and integration that must be resolved, the advantages of employing RTLS in healthcare are indisputable. Further investigation is warranted to explore how the RTLS technology can be more effectively integrated into existing systems.

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