MEDINFO 2025 — Healthcare Smart × Medicine Deep
M.S. Househ et al. (Eds.)

doi:10.3233/SHTI251163

Digital Transformation of Medication Identification: Technological Evolution

Hoang Nam NGUYEN[a], Samaneh MADANIAN[a], Minh NGUYEN[a], Alan MERRY[b], Dave PARRY[c]
[a] *Department of Data Science and Artificial Intelligence, AUT*
[b] *Department of Anaesthesiology, University of Auckland*
[c] *School of Information Technology, Murdoch University*
ORCiD ID: Samaneh Madanian https://orcid.org/0000-0001-6430-9611

Abstract. Medication errors pose a significant health challenge, contributing to thousands of deaths annually. This systematic review explores the technological evolution of medication identification: Barcode/Quick Response (QR) Code systems, Radio Frequency Identification (RFID)/Near-Field Communication (NFC), and Computer Vision, used to reduce errors and enhance patient safety. 140 articles from different databases were reviewed to compare their strengths, limitations, and applications. While barcodes offer cost-effective scanning, they require line-of-sight, RFID/NFC provide robust data retrieval yet faces high costs, and Computer Vision excels in flexibility despite computational demands. Combining these technologies could optimize safety.

Keywords. Digital Health, Medication Identification, RFID, Computer Vision

1. Introduction

Medication errors, defined as unintended mistakes in the medication process, are a critical issue in anaesthesia and intensive care. Studies show that errors occur in about 5% of hospital medication administrations, with 20% potentially leading to adverse drug events, especially in perioperative settings [1]. These errors often stem from stress, fatigue, and poor system design in fast-paced environments like operating theatres [2]. Technologies like Barcode/QR Code, RFID/NFC, and Computer Vision aim to automate identification, reducing human error and improving safety. This study reviews these approaches, highlighting their evolution, strengths, and limitations to guide healthcare practitioners and researchers.

2. Methods

This systematic review followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for a rigorous process. We searched databases, retrieving the following number of articles: PubMed (390), Scopus (5), ScienceDirect (98), and IEEE (44), totaling 537 records. After removing 183 duplicates, 354 records remained. Screening excluded 203 irrelevant studies, leaving 151 for full-text review. 11 misaligned articles were removed, refining the selection to 140 relevant studies (from

2010 to 2024) on Barcode/QR, RFID/NFC, or Computer Vision in medication safety. Qualitative analysis assessed technical aspects, benefits, and limitations.

3. Results

Barcode/QR Code systems are cost-effective and widely adopted, reducing errors via tools like Barcode Medication Administration (BCMA) [3]. However, they need line-of-sight and are prone to damage. RFID/NFC technologies offer non-line-of-sight scanning and high data capacity, improving safety (e.g., tablet verification [4]), but incur high costs and potential electromagnetic interference. Computer Vision, using deep learning models like Convolutional Neural Networks (CNNs), identifies medications flexibly without tagging (e.g., 100% accuracy on blister packs [5]), yet relies on image quality and lacks standardization. Table 1 compares these technologies' trade-offs.

Table 1. Advantages and Limitations of Medication Identification Technologies

Technology	Advantages	Limitations
BarCode/QRCode	Cost-effective and easy to use Quick and reliable Effective data storage	Line-of-sight and damage-prone Barcode policies variations
RFID/NFC	Non-line-of-sight and durable High data capacity	High cost and interference risks Disruption by electronic devices.
Computer Vision	No labeling or tagging requirement Medication identification based on visual characteristics	No international standards High computational resources Sensitivity to image quality

4. Discussion and Conclusion

Barcode/QR systems excel in affordability, RFID/NFC in robustness, and Computer Vision in adaptability, yet each has limitations. While computer vision is emerging as a flexible and powerful for medication identification, offering significant potential to improve accuracy, the limitations hinder its implementation. Therefore, hybrid solutions (e.g., Computer Vision aiding damaged Barcode scans with RFID backup) could enhance reliability. Future research should develop real-time Artificial Intelligence (AI) models for operating theatres, addressing diverse packaging and security via encryption. This evolution underscores technology's role in safer medication practices, with integration as a key next step.

References

[1] Nanji KC, Patel A, Shaikh S, Seger DL, Bates DW. Evaluation of perioperative medication errors and adverse drug events. Survey of Anesthesiology. 2016 Dec 1;60(6):259-60.

[2] Wheeler SJ, Wheeler DW. Medication errors in anaesthesia and critical care. Anaesthesia. 2005;60(3):257-73.

[3] Shah K, Lo C, Babich M, Tsao NW, Bansback NJ. Bar code medication administration technology: a systematic review. Can J Hosp Pharm. 2016;69(5):394-402.

[4] Chang CH, Lai YL, Chen CC. Implement the RFID position based system of automatic tablets packaging machine. J Med Syst. 2012;36(6):3463-71.

[5] Hnoohom N, Maitrichit N, Chotivatunyu P, et al. Blister package classification using ResNet-101. In: 2021 25th International Computer Science and Engineering Conference (ICSEC); 2021 Nov 18-20; Chiang Rai, Thailand. IEEE; 2021. p. 406-10.