Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 9s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Securing Pharmaceutical Supply Chains: A QR Code Approach To Counterfeit Drug Prevention

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Cite this paper as: Dr. Hanmant N Renushe, Dr. Amit A Jadhav, Dr. Sunita P Lokare, Dr. Vrushali R. Kadam, Dr. Ashwini I Braganza, Prof. Vishal Chavan, Dr. Dhanashri Y Jadhav, Prof. Vikas V. Patil, (2025) Securing Pharmaceutical Supply Chains: A QR Code Approach To Counterfeit Drug Prevention. *Journal of Neonatal Surgery*, 14 (9s), 583-585.

ABSTRACT

The worldwide pharmaceutical sector confronts a continual menace from counterfeit medications, which not only incur economic detriment but also jeopardize human lives. This study introduces a secure, scalable, and economical approach utilizing QR code technology for drug authentication at many levels of the supply chain. The suggested system encompasses QR code production at the manufacturing level, a centralized database for verification, and a mobile application for real-time scanning by customers, merchants, and distributors. The research confirms the efficacy of QR codes in identifying and combating counterfeit pharmaceuticals through a comprehensive implementation plan and pilot trial.

Keywords: *QR code, pharmaceutical supply chain, counterfeit prevention, drug authentication, digital traceability.*

1. INTRODUCTION

The integrity of pharmaceutical supply chains is essential for public health. Counterfeit pharmaceuticals, potentially containing erroneous or deleterious components, represent an escalating global concern. The World Health Organization (WHO) reports that 10% of medical items in low- and middle-income nations are poor or counterfeit. This impacts both patient health and undermines the credibility of healthcare systems and pharmaceutical corporations. Existing strategies to counteract counterfeit pharmaceuticals encompass holograms, barcodes, RFID tags, and physical seals; nevertheless, these solutions frequently prove costly, susceptible to tampering, or impractical for end users. A QR code-based system provides a reliable and cost-effective solution. This research aims to develop and evaluate a QR code-based authentication system to enhance the security of medicine packaging and facilitate real-time verification by all supply chain stakeholders.

2. LITERATURE REVIEW

Sharma, K. (2020). In "A Review of Anti-Counterfeit Technologies in Pharma," Sharma analyzes conventional technologies such as holograms, barcodes, and tamper-evident packaging, assessing their shortcomings. Although prevalent, these methods provide merely a superficial barrier to counterfeiters and lack scalability for extensive application. The analysis emphasizes the increasing demand for digital solutions, such as QR codes and blockchain, which provide real-time traceability. Sharma underscores the necessity of consumer-grade verification methods for establishing trust and transparency. This study establishes a basis for incorporating QR code-based solutions into pharmaceutical anti-counterfeiting frameworks.

Gupta, S., et al. (2019). Gupta and colleagues investigate the technical underpinnings of QR code-based authentication systems across several businesses in their work published in IJCSIT. They examine the capability of QR codes to encapsulate intricate product information and the ability of mobile applications to decode and authenticate this information instantaneously. Their findings endorse the viability of QR codes for safeguarding pharmaceutical products, particularly due to their cost-efficiency and simplicity of deployment. The authors emphasize the significance of backend integration with secure databases, consistent with the proposed solution in this study.

World Health Organization Report (2017). The World Health Organization's 2017 report on substandard and fraudulent medical items presents concerning information regarding the prevalence of counterfeit pharmaceuticals. It underscores the necessity for digital tracking systems in low- and middle-income nations. The paper emphasizes that counterfeiting impacts

not only critical medications but also standard therapies, jeopardizing global health. The WHO endorses legislative and technological measures, highlighting the significance of this study's QR code-based methodology.

Kumar, A. (2021). Kumar assesses blockchain as a secure ledger for pharmaceutical delivery in the research "Blockchain in Drug Supply Chains," published in IEEE Access. Kumar observes that although blockchain provides robust security and transparency, it is associated with significant costs and technical intricacies. He advocates for the integration of blockchain with lightweight technologies such as QR codes for effective implementation in emerging regions. This stratified methodology corresponds with the hybrid solution suggested in the future work of this research.

Lee, H. & Kim, J. (2018). In their work on digital identification inside the supply chain, Lee and Kim examine the enhancement of QR codes by encryption to avert cloning and illicit reutilization. They illustrate that dynamic QR codes—altering frequently or per transaction—can substantially enhance security. Their findings enhance the advancement of more resilient QR-based systems and substantiate the encryption methodologies suggested in this research for pharmaceutical applications.

Ali, M. et al. (2020). Ali and his colleagues performed a comparative analysis of counterfeit detection systems in the pharmaceutical, electronics, and food industries. They determine that QR codes provide the optimal equilibrium among cost, usability, and convenience of deployment, particularly in developing areas. Their research substantiates the claim that QR codes can be extensively implemented with negligible interruption to current supply chains. This research provides empirical support for the selection of QR codes.

Patel, R. (2019). Patel's research examines consumer behavior and trust in digital verification systems. He examined more than 500 consumers engaging with QR-based authentication applications and discovered that 87% of participants favored QR codes over alternative methods of product verification. The research revealed heightened consumer trust, diminished return rates, and enhanced satisfaction following the integration of QR code verification. The behavioral insights endorse the user-centric design of the mobile application described in this paper.

Problem Statement

Despite numerous measures, counterfeit drugs remain a major concern. Challenges include:

- Inability of end-users to verify drug authenticity
- Lack of standardized tracking across manufacturers and distributors
- High cost and complexity of implementing advanced anti-counterfeit measures

A simple, low-cost, and scalable solution is needed that allows stakeholders to verify authenticity in real-time without specialized equipment.

Proposed Methodology

The system architecture comprises the subsequent components:

1. QR Code Generation: During the production process, each pharmaceutical unit is affixed with a distinctive QR code that encompasses information such as batch number, manufacturing and expiration dates, drug identification, and an encrypted validation token.

2. Centralized Database: All QR code data is securely maintained in a database that associates each code with a legitimate drug profile. Real-time updates transpire while the medication traverses the supply chain.

3. smartphone Application: Distributors, merchants, and consumers may utilize a smartphone application to scan the QR code. The application authenticates the code by searching the database and delivers responses instantaneously.

4. Audit Trail: Each scan is documented to create a traceability trail that illustrates the drug's progression through the supply chain.

Technologies employed: Android Studio for mobile application development, MySQL for database management, and Pabbly Connect for facilitating communication between the mobile application and the MySQL database.

Implementation

A prototype was developed using Android Studio , MySQL and Pabbly Connect. QR codes generated using QR-Tiger API. A pilot test was conducted on a batch of vitamin supplements.

- **Manufacturer Stage:** QR codes printed on product packaging.
- **Distributor/Retailer Stage:** App used to scan and update transit status.
- **Consumer Stage:** End users scanned the code to verify legitimacy before purchase.

Positive authentication results displayed drug details; invalid or reused codes generated alerts.

Results, Evaluation and Discussion

- **Detection Accuracy:** 100% detection of valid and invalid codes during the pilot.
- **Verification Speed:** Average scan and response time: 1.2 seconds.
- **User Feedback:** 95% of users found the system easy and reliable to use.
- **Comparison with other methods:** QR-based system was significantly cheaper and easier to deploy than RFID or blockchain systems.

The QR code-based system is:

- **Scalable:** Can be implemented by small and large manufacturers.
- **Affordable:** Minimal cost per unit.
- **Accessible:** Uses smartphones without special hardware.

Nonetheless, QR codes remain susceptible to duplication if inadequately encrypted. Integrating QR codes with distinctive encryption tokens and regular code expiration can reduce this risk. Regulatory agencies can impose such a mechanism to fortify the pharmaceutical supply chain.

3. LIMITATIONS

A key disadvantage of the system is its reliance on internet access for real-time verification, potentially impeding its functionality in remote or low-connectivity regions. The security of the underlying database is paramount, requiring stringent protection against any hacking efforts to avert illegal access or data tampering. A notable disadvantage is the potential for QR code duplication in the absence of encryption, which may result in misuse or fraud. Furthermore, the perceived intricacy of the system may dissuade smaller firms from its adoption, particularly if they lack the technological infrastructure or resources necessary for its implementation and maintenance.

4. CONCLUSION

This study presents a QR code-based solution specifically engineered to prevent counterfeit pharmaceuticals throughout supply chains. The prototype successfully exhibited several essential functionalities, including real-time authentication of pharmaceutical items, comprehensive traceability across the supply chain, and an intuitive interface for both consumers and stakeholders. The method substantially mitigates the risk of counterfeit pharmaceuticals entering the market by enabling users to promptly authenticate a product via a straightforward QR code scan. Furthermore, the system is economically viable and straightforward to adopt, rendering it an attainable solution for pharmaceutical enterprises of diverse scales. Its simplicity guarantees reduced training and integration expenses, hence enhancing its scalability. This method signifies a potential technical solution to the significant public health threats posed by counterfeit pharmaceuticals. With suitable regulatory backing, standardization, and promotion for adoption throughout the pharmaceutical sector, this technology might significantly enhance drug safety and reinstate global consumer confidence.

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