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Med Verify: A Block Chain-Based Medicine Verification System for Counterfeit Drug Detection

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Abstract
Counterfeit medications are a significant danger to public health, reducing the trustworthiness of healthcare systems and leading to financial loss. Standard verification efforts (e.g. using barcodes, and holograms) are frequently ineffective against sophisticated counterfeiters. Med Verify is a mobile application using block chain technology to better combat counterfeit drugs by providing a secure and transparent verification solution. It incorporates the benefits of block chain technology for a tamper-proof record of transactions, QR code/RFID scanning for immediate authentication, and artificial intelligence based packaging analysis for the identification of concerns with drug packaging. Users can scan QR codes to verify medicines, which will pull up block chain-supported content on batch information, manufacturer information, and chain-of-custody information. The AI-based image recognition system will find inconsistencies in label and package appearance, improving counterfeit verification. Med Verify also includes a community-based reporting feature to allow users to report suspicious medicines and provide feedback on the app's results. By partnering with health providers and health policy systems, Med Verify increases transparency to empower consumers and bolster the pharmaceutical supply chain system while decreasing counterfeit drug exposure for the public and bolstering public health.

Keywords: *Block chain, Medicine Verification, Counterfeit Drugs, QR Code Authentication, RFID, AI-Powered Packaging Analysis, Pharmaceutical Supply Chain, Drug Authentication, Public Health, Regulatory Compliance.*

1. Introduction
Drug counterfeiting is a serious worldwide issue that damages public health, erodes trust in the pharmaceutical supply chain, and costs billions of dollars in lost revenue. Inaccurate ingredients, problematic dosages, or dangerous substances that can have life-threatening consequences are all possible in counterfeit medications. As counterfeiters become more adept at imitating packaging and altering labeling information, current verification methods (such as holograms, barcodes, and manual inspection) are usually insufficient. The lack of a transparent and impenetrable authentication procedure has made it urgently necessary to find a reliable way to confirm the legitimacy of medications in order to protect the patients who will use them. By using immutable, decentralized record-keeping, blockchain technology offers a workable solution to these problems. MedVerify provides a safe and verifiable record of each significant stage in a drug's life cycle, from manufacturer to distribution to point of sale, using blockchain-backed authentication. Although blockchain technology encourages transparency, it may not be sufficient to stop counterfeiting on its own without assisting with

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reliable verification methods. While RFID-based tracking and QR codes offer instant access to verified medication information, both techniques may be compromised by fake or duplicate labels. To improve the detection of drugs that are counterfeit, MedVerify implements AI-packaging analysis that detects changes in drug packaging characteristics through qualitative visual analysis of features such as logos, fonts, and tamper evidence seals. By harnessing the power of AI, the verification of packaged pharmaceuticals can be undertaken by users, such as consumers, pharmacists, and healthcare providers, rather than just relying on the data provided by pharmaceutical manufacturers as is the case in traditional verification systems. The second component of MedVerify is a community reporting component that allows users to report medicines that they suspect are counterfeit. This contributes to a larger database of users reporting counterfeit medications. Even though it has promising features, there are hurdles to implementing any such system. The seamless integration of the technology into existing pharmaceutical supply chains, minimizing user friction between technology and existing processes, and compliance with applicable regulations are significant concerns. MedVerify offsets some of these constraints with a multi-layered approach that combines blockchain immutability, AI-driven analysis and real-time reporting into a comprehensive medicine verification system. MedVerify aims to combat the proliferation of counterfeit drugs with a transparent and decentralized solution to enhance consumer trust, regulatory efficacy, and the safety of public health. [1]

The key contributions of this research are as follows:

- **Blockchain Medicine Verification:** MedVerify utilizes blockchain technology to provide a decentralized, immutable record of the path a medicine has traveled from the manufacturer to the consumer, enhancing transparency and trust in the industry. [2]
- **AI-Based Packaging Verification:** An advanced, AIbased system reviews medicine packaging for logo discrepancies, font, label, and tamper-proof seals, strengthening counterfeit detection beyond current QR code verification.
- **Secure QR Code/RFID Verification:** Users can scan QR codes or RFID tags to quickly obtain blockchainverified drug information, including batch number, manufacturer, and distribution history.
- **Community Reporting System:** MedVerify allows users to report suspicious medicines, provide feedback, and utilize crowd-sourced data to improve counterfeit drug identification. [3]
- **Integration with Pharmacies and Healthcare Providers:** MedVerify can be integrated with pharmacies to ensure that verified medicines are the only medicines dispensed or provided. Providers can check the medicines prescribed against the medicines they've purchased.
- **Increased Consumer Trust and Support of Regulators:** The combination of blockchain immutability, AI-based verification, and consumer reporting will strengthen the security of the pharmaceutical supply chain, reduce the flow of counterfeit drugs, and enable regulators to monitor drug authenticity. [4]

This method improves medicine verification, increases consumer autonomy, and enhances public health safety by reducing risks associated with counterfeit drugs.

2. Related Work

The growing concern over counterfeit medications represents a significant risk to healthcare systems worldwide, necessitating the development of dependable medicine verification technologies. Traditional approaches, such as manual inspections and batch tracking systems, fail to provide reliable real-time verification and remain susceptible to tampering. As a result, innovative technologies involving blockchain, artificial intelligence (AI), and tagging methods have been explored to enhance medication supply chain visibility and counteract counterfeit drugs. Numerous researchers and

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companies have identified blockchain as a viable solution for securing the pharmaceutical supply chain by creating immutable records and ensuring transactional transparency. For instance, MediLedger (2019) pioneered a blockchain-based system for distributors, manufacturers, and pharmacies to verify the legitimacy of medical products, while PharmaChain (2020) leveraged Hyperledger Fabric to ensure data security and track inventory across multiple stakeholders. Similarly, MedBlock (2021) introduced smart contracts within a blockchain-based framework to enable real-time verification of medicine authenticity. However, these solutions predominantly focused on ledger-based tracking and lacked AI-based mechanisms to detect tampering in physical packaging or repackaged medications. To overcome the limitations of ledger-only approaches, machine learning and AI have been adopted to analyze packaging inconsistencies and identify tampered seals. DrugScanAI (2021) employed deep learning models to detect visual anomalies in packaging, including logo distortions and mislabeling, while MedSafeNet (2022) used convolutional neural networks (CNNs) to inspect typography, holograms, and batch codes, achieving enhanced detection accuracy. TamperGuard (2023) advanced these methods with AI models capable of evaluating micro-pattern variations on pharmaceutical seals to identify unauthorized access. Although these AI-based techniques effectively identify counterfeit drugs through physical cues, they lack integration with blockchain systems, making them vulnerable to repackaging fraud at various points in the supply chain. In addition to AI and blockchain, tagging technologies like QR codes and RFID have been adopted for drug verification. VeriPharm (2020) introduced QR-based authentication linked to blockchain-stored data, while ChainMedID (2021) fortified this approach by incorporating encrypted QR codes on a distributed ledger, reducing unauthorized code duplication. SmartMediTag (2022) employed RFID to enable real-time pharmaceutical tracking, bolstering logistics and security. However, these methods still face piracy and code duplication risks, necessitating deeper integration across the supply chain to ensure protection against counterfeit drugs. To further counteract fraudulent medicine distribution, crowdsourced reporting has emerged as a community-driven solution. Applications such as SafeMeds (2021) allowed users to report suspicious medicines, contributing to a live database of counterfeit reports. PharmaWatch (2022) built upon this model by using AI to analyze trends in user-submitted reports, while DrugShield (2023) developed a blockchain-based trust scoring mechanism based on community feedback. Nevertheless, such systems must address the risks of false positives and ensure validation mechanisms to avoid misinformation. Another approach involves integrating verification mechanisms with pharmacies and healthcare providers. MedAuth (2021) introduced a blockchain-enabled pharmacy management system that conducted authenticity checks prior to dispensing medications. HealthTrack (2022) enhanced this with AI-driven alerts to notify pharmacies of suspicious transactions or consumer-reported concerns. PharmaLink (2023) extended the framework further by enabling collaborative verification among regulators, health systems, and pharmacies. While effective in improving compliance and oversight, these systems face risks associated with centralized data storage, including single points of failure and potential data breaches. Despite advances in blockchain, AI, tagging, and community reporting, challenges persist—such as vulnerabilities to counterfeit packaging, the ease of reproducing QR codes, and high implementation costs for stakeholders. MedVerify addresses these gaps through a holistic approach that combines blockchain-based immutable record-keeping, AI-powered packaging analysis, and a secure, community-driven reporting model to enhance trust and detection. Moreover, it ensures smooth integration with pharmacies and regulatory bodies, reinforcing transparency and reliability throughout the pharmaceutical supply chain and ensuring robust authentication of medicinal products. the detection of drugs that are counterfeit Figure 1 shows Architecture of Proposed Work

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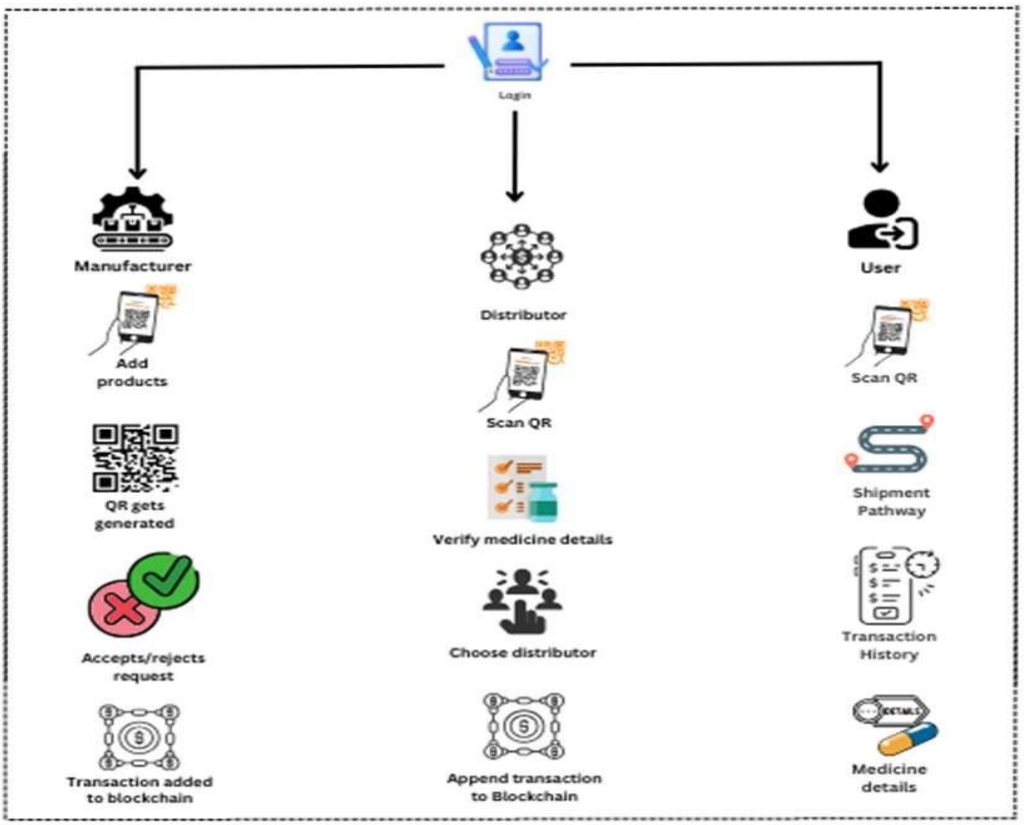

Figure 1 Architecture of Proposed Work

3. Proposed Methodology

To guarantee the legitimacy and traceability of medications, MedVerify uses a multi-layered architecture that combines blockchain, artificial intelligence, secure tagging, and user feedback mechanisms. By offering a tamper-proof, transparent, and intelligent solution to combat counterfeit drugs in the pharmaceutical supply chain, the suggested methodology addresses the shortcomings of current systems. [6]

3.1.Block Chain-Based Supply Chain Tracking (Chain Track)

The ChainTrack component, which uses blockchain technology to guarantee end-to-end traceability, is the foundation of MedVerify. During the manufacturing phase, every medication is given a distinct digital identity. Important information is safely stored on a decentralized ledger, including the manufacturer's name, license and certifications, batch number, production and expiration dates, and storage conditions. Every transaction involving the medication as it travels through the supply chain—from producers to distributors, wholesalers, and retailers—is permanently recorded on the blockchain. This maintains the integrity of the medication's history by ensuring transparency, guarding against tampering, and preventing any unauthorized changes. [7]

3.2.QR Code-Based Instant Verification (Quick Auth)

Using secure QR codes, the QuickAuth module allows both patients and medical professionals to quickly confirm a medication's legitimacy. Every package has a distinct QR code embedded in it that is cryptographically connected to its blockchain record.

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The blockchain-stored data is retrieved and compared to the QR code by the system when it is scanned through the MedVerify app. The product is authenticated if the scanned code and the record match. If there are any discrepancies or duplicates, the system marks the product as questionable and promptly notifies the user. The first line of defense at the point of sale or consumption is this real-time authentication. [8]

3.3.AI-Driven Packaging Anomaly Detection (Pack Check AI)

PackCheckAI uses AI-based computer vision to identify packaging irregularities in order to enhance physical verification. The system takes pictures of the medication's packaging and contrasts them with manufacturer-approved design templates. Signs of counterfeiting, including tampered seals, missing or changed branding elements, incorrect fonts, fake holograms, and manipulated batch information, are detected by the AI algorithm by analyzing visual features. When discrepancies are found, the product is marked for additional examination, keeping customers away from visually misleading fake medications. [9]

3.4.Smart Contract-Based Verification and Alert System (Auto Verify)

Smart contracts are introduced in the AutoVerify component to automate alert generation and medication verification. These contracts are automatically executed on the blockchain according to preprogrammed rules. The smart contract verifies the medication's details and makes sure all parameters are genuine before approving any transactions within the supply chain. Customers, manufacturers, and regulatory agencies receive real-time alerts from the system when data irregularities or questionable trends are found. Any supply chain fraud or deviation will be promptly addressed thanks to this proactive monitoring. [10]

3.5.User and Regulatory Feedback Integration (Trust Net)

TrustNet, the last module, places a strong emphasis on regulatory supervision and community involvement. Via the MedVerify app, users can directly report questionable products and send in packaging photos for additional AI review. The fraud detection system is improved in real time by combining these inputs. At the same time, blockchain records are made available to regulatory bodies for auditing, tracking the source of fake medications, and filing lawsuits. Throughout the ecosystem, this two-way feedback system fosters user trust, accountability, and transparency. Figure 2 shows Manufacture Dashboard Where the User Can Add or View Its Product Details

4. Results and Discussions

4.1.Results

Figure 2 displays the login and sign-up interface of the application, where users can securely authenticate based on their roles such as Manufacturer, Distributor, or Consumer. The sign-up option enables new users to register, while the login section allows returning users to access their respective dashboards.

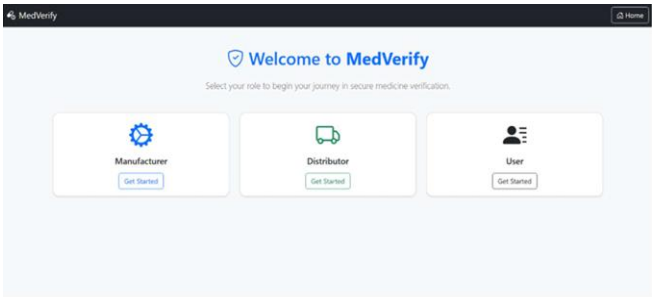

Figure 2 Login and Signup Page of the Project

Figure 3 showcases the Manufacturer dashboard, which allows the user to add product details such as name, batch number, and expiry date. The manufacturer can also view and manage previously added products for effective inventory control.

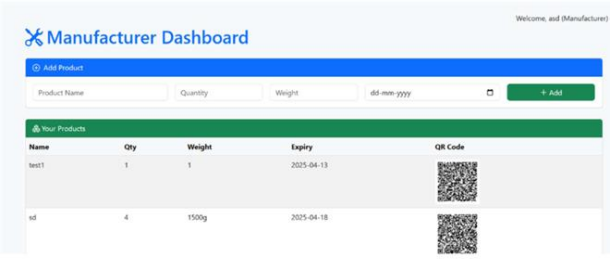

Figure 4 Manufacture Dashboard Where the User Can Add or View Its Product Details

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Figure 5 illustrates the alert notification system that warns manufacturers when a product has expired. This feature helps maintain product safety and ensures that expired items do not enter the distribution chain. [11]

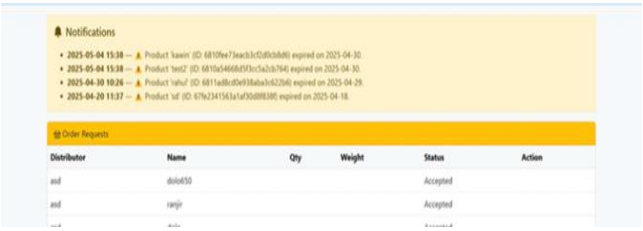

Figure 5 Alert Notifications If Product Get Expires

Figure 6 presents the Distributor dashboard. It enables distributors to view their own product inventory, request products from manufacturers, and manage supply requests seamlessly from a single interface. [12]

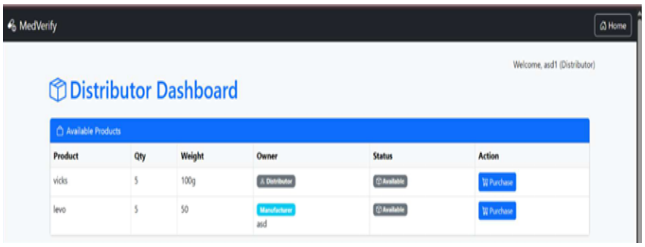

Figure 6 Distributor Dashboard Where the User Can Add or View Its Product Details and Request to Buy Others Products

Figure 7 indicates how the Manufacturer dashboard displays incoming product requests from distributors. This helps manufacturers track and manage requests in real time. [13]

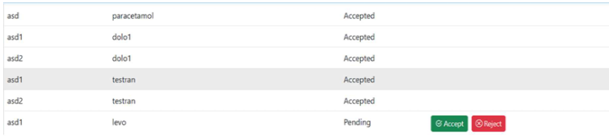

Figure 7 Request Indication to The Manufacturer in His Dashboard

Figure 8 demonstrates the approval interface where the manufacturer accepts a distributor's request. Upon acceptance, the transaction process progresses and is recorded for future reference.

Figure 8 Manufacturer Accepts the Request for His Product

Figure 9 shows the automatic creation of a new block in the block chain once the manufacturer accepts the distributor's request. This block securely stores transaction details, ensuring tamper-proof records.

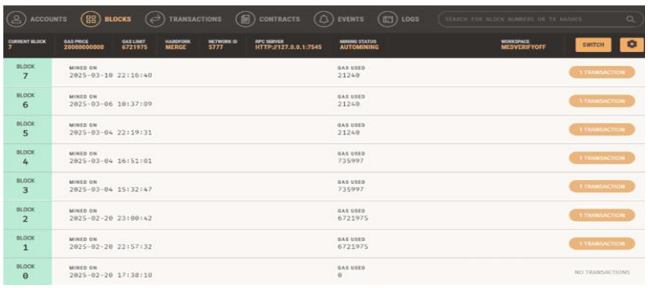

Figure 9 Block Creation When the Transaction Gets Accepted

Figure 10 displays the internal structure of a blockchain block. It includes the block hash, previous block reference, timestamp, product information, and transaction participants, ensuring transparency and traceability. [14]

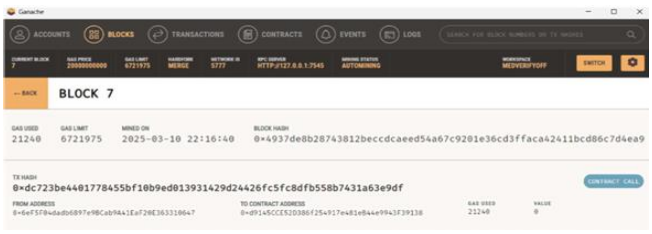

Figure 10 Block Details With Transaction And Other Block Details

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Figure 11 illustrates the result of scanning a product's QR code. It reveals complete transaction history, product details, and verification data, empowering users to confirm the authenticity and origin of the product. [15]

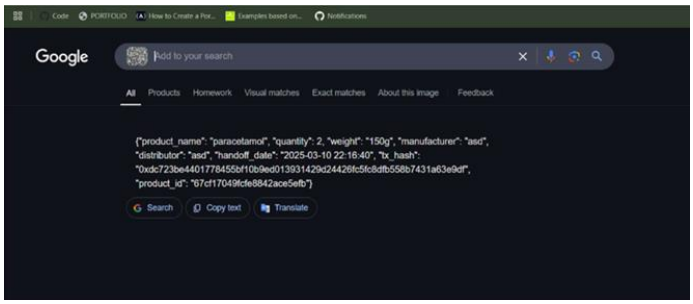

Figure 11 Details Displayed When the QR Code Gets Scanned

4.2. Discussion

The presented figures collectively demonstrate the seamless interaction between different stakeholders in the supply chain using a blockchain-backed system. From secure user authentication to real-time alerts, transaction verification, and QR-based product validation, every feature contributes to greater transparency and accountability. By recording each transaction as an immutable block and providing consumers with easy access to product history through QR scanning, the system builds trust among manufacturers, distributors, and end users. It significantly reduces the chances of counterfeit drugs entering the market and improves confidence in the legitimacy of pharmaceutical products. Hence, the proposed solution not only enhances operational efficiency but also increases the trustworthiness of the entire pharmaceutical supply chain.

Conclusion

MedVerify aims to revolutionize the pharmaceutical industry by leveraging blockchain technology to combat counterfeit medicines. By integrating QR code scanning, AI-powered packaging analysis, and a transparent supply chain tracking system, MedVerify ensures the authenticity and integrity of medicines from manufacturers to end consumers. The implementation of blockchain guarantees tamperproof records, enabling stakeholders—including manufacturers, distributors, pharmacists, and consumers—to verify the legitimacy of medical products in real time. Additionally, the use of AI enhances counterfeit detection by analyzing packaging details and identifying anomalies that indicate fraud. Despite challenges such as adoption barriers and initial setup costs, the long-term benefits of MedVerify outweigh these obstacles. Enhanced consumer trust, regulatory compliance, and a significant reduction in counterfeit drugs make this solution a crucial step toward a safer healthcare system. In conclusion, MedVerify provides a secure, transparent, and efficient approach to medicine verification. By embracing blockchain and AI, this project not only safeguards public health but also fosters innovation in pharmaceutical supply chain management, paving the way for a future where counterfeit medicines are effectively eliminated.

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