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CURRENT PRACTICES FOR MEDICINE AUTHENTICATION AND TRACEABILITY IN COMMUNITY PHARMACIES IN BAYELSA STATE, NIGERIA: IMPLICATIONS FOR BLOCKCHAIN-BASED COUNTERFEIT PREVENTION

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ABSTRACT

Background: Community pharmacies serve as the final checkpoint in pharmaceutical supply chains and the most accessible point of medicine access for populations in resource-constrained settings. However, the authentication and traceability practices employed at this critical junction remain poorly characterised, particularly in the Niger Delta region of Nigeria where geographical challenges compound supply chain vulnerabilities. **Objective:** This study investigated the current practices used by community pharmacies for medicine authentication and traceability in Bayelsa State, Nigeria, and assessed their implications for blockchain-based counterfeit prevention. **Methods:** A descriptive cross-sectional survey was conducted among 119 superintendent pharmacists using a structured electronic questionnaire. Data were analysed using descriptive statistics and chi-square tests in IBM SPSS v26.0. **Results:** Authentication practices were overwhelmingly manual: 77.3% relied on visual inspection of NAFDAC registration numbers, 13.4% used physical inspection of packaging, and only 9.2% employed digital scanning. Inventory tracking was paper-based (55.5%) or non-existent (35.3%), with merely 9.2% using cloud-based systems. Critically, 68.9% of pharmacists encountered suspected counterfeit medicines in the preceding 12 months. A statistically significant association was found between inventory system type and counterfeit detection capability (Chi-square = 13.21, p = 0.001). **Conclusion:** Community pharmacies in Bayelsa State operate within a predominantly analogue authentication environment that is fundamentally misaligned with the requirements of blockchain-based traceability. Over 90% lack the basic digital infrastructure prerequisite for blockchain participation. The significant association between digital systems and counterfeit detection capability provides empirical justification for prioritising digitisation as a foundational step toward blockchain implementation.

KEYWORDS: Medicine authentication, traceability, community pharmacy, counterfeit medicines, digital infrastructure, pharmaceutical supply chain, Bayelsa State, Nigeria.

INTRODUCTION

The global challenge of counterfeit and substandard medicines continues to exact a devastating toll on public health, particularly in low- and middle-income countries (LMICs). The World Health Organization estimates that approximately 10% of medicines circulating in LMICs are substandard or falsified, with prevalence rates exceeding 20% in parts of sub-Saharan Africa for critical therapeutic categories such as antimalarials and antibiotics (WHO, 2017; WHO, 2023). The economic burden is estimated at US$200 billion annually (Ozawa et al., 2018), while the human

cost is measured in hundreds of thousands of preventable deaths, including an estimated 122,000 child deaths annually from falsified antimalarials in sub-Saharan Africa alone (Renschler et al., 2015).

Nigeria occupies a particularly vulnerable position within this global landscape. As Africa's most populous nation and largest pharmaceutical market, the country imports over 70% of its pharmaceutical products, creating extended and fragmented supply chains with multiple intermediary points where counterfeit products can be introduced (Adebisi et al., 2021; Statista, 2023). Documented counterfeit prevalence rates in Nigeria range from 16.7% to over 40% depending on the product category and region studied (Akinyandenu, 2013; NAFDAC, 2022). The National Agency for Food and Drug Administration and Control (NAFDAC) has deployed several countermeasures, including the Mobile Authentication Service (MAS), which enables consumers and pharmacists to verify medicine authenticity via SMS, and Truscan portable spectrometers for field-based chemical analysis (NAFDAC, 2023; Ogholuwarami et al., 2024). However, these interventions remain largely centralised and have not achieved comprehensive penetration to the point of dispensing.

Community pharmacies occupy a critical position in the pharmaceutical supply chain as the final point of contact between medicines and patients. In Nigeria, and particularly in states such as Bayelsa where healthcare infrastructure is relatively under-resourced, community pharmacies frequently serve as the first and sometimes only point of contact with the formal health system for a substantial proportion of the population (Ugboma et al., 2024). The authentication and traceability practices employed at this terminal node of the supply chain therefore have direct implications for the volume of counterfeit medicines reaching patients. Yet, despite their critical gatekeeping role, the specific methods, tools, and systems that community pharmacists in Nigeria use to verify medicine authenticity and track pharmaceutical inventory remain insufficiently documented in the empirical literature.

Blockchain technology has emerged as a promising paradigm for pharmaceutical traceability, offering decentralised, immutable, and transparent record-keeping that could enable end-to-end medicine verification from manufacturer to patient (Casino et al., 2019; Mackey & Nayyar, 2017). However, the feasibility and potential impact of blockchain-based traceability at the community pharmacy level depends fundamentally on the existing practices, digital infrastructure, and operational capabilities at the point of dispensing. Understanding the current state of authentication and traceability practices is therefore an essential prerequisite for realistic assessment of blockchain adoption potential and for the design of contextually appropriate implementation strategies.

Bayelsa State, located in the Niger Delta region of Nigeria, presents a particularly instructive study context. Created on October 1, 1996, the state has a population of approximately 2.3 million people distributed across eight local government areas (LGAs), with a distinctive riverine geography that creates dispersed settlement patterns connected primarily by waterways. This geographical profile complicates pharmaceutical distribution logistics and limits the reach of regulatory surveillance, potentially amplifying the vulnerability of the pharmaceutical supply chain to counterfeit infiltration. The state's approximately 150 registered community pharmacies, concentrated predominantly in the capital city Yenagoa, serve as the principal formal channel for medicine access.

This study therefore aimed to investigate the current practices used by community pharmacies in Bayelsa State for medicine authentication and traceability, to assess the prevalence of suspected counterfeit medicine encounters, and to evaluate the relationship between existing tracking systems and counterfeit detection capability. The findings are interpreted within the context of their implications for the potential adoption of blockchain-based traceability systems.

METHODOLOGY

Study Design and Setting

A descriptive cross-sectional survey was conducted among superintendent pharmacists operating registered community pharmacies in Bayelsa State, Nigeria. The state comprises eight LGAs (Brass, Ekeremor, Kolokuma/Opokuma, Nembe, Ogbia, Sagbama, Southern Ijaw, and Yenagoa) with approximately 150 registered community pharmacies.

Population and Sampling

The study population consisted of all superintendent pharmacists registered with the ACPN Bayelsa State Chapter. Sample size was calculated using Yamane's formula (n = 110) and confirmed by Cochran's formula with finite population correction (n = 109). Purposive convenience sampling was employed, with questionnaires distributed electronically via the ACPN official WhatsApp platforms. Of 150 questionnaires distributed, 119 valid responses were obtained (response rate: 79.3%).

Data Collection Instrument

The study used relevant sections of a structured, self-administered Google Forms questionnaire. Section A collected socio-demographic data (gender, years of experience, qualification, position). Section C assessed current authentication and traceability practices through three items: primary method of verifying medicine authenticity (visual inspection of NAFDAC numbers, physical inspection of packaging, or barcode/QR scanning), current inventory tracking system (manual paper ledger, no formal system, or integrated cloud-based system), and frequency of encountering suspected counterfeit medicines in the preceding 12 months (never, 1-5 times, or more than 10 times).

Content validity was established through expert panel review, and face validity through pilot testing with five pharmacists. Reliability was confirmed with a Cronbach's Alpha of 0.78 for the practices construct, exceeding the accepted threshold of 0.70 (Nunnally & Bernstein, 1994).

Data Analysis

Data were analysed using IBM SPSS version 26.0. Descriptive statistics (frequencies and percentages) characterised current authentication methods, inventory systems, and counterfeit encounter rates. Chi-square tests examined the association between inventory system type and counterfeit detection capability. Statistical significance was set at $p < 0.05$.

Ethical Considerations

Institutional ethical approval was obtained. Informed consent was integrated into the questionnaire. Participation was voluntary and anonymous. Data collection occurred from February 1 to 10, 2026.

RESULTS

Socio-Demographic Profile

The 119 respondents were predominantly male (86.6%, n = 103), with the largest experience cohort being 5-10 years (49.6%, n = 59), followed by 11-20 years (34.5%, n = 41) and less than 5 years (16.0%, n = 19). The majority held M.Sc./MPH qualifications (55.5%, n = 66), with 44.5% (n = 53) holding B.Pharm/PharmD degrees. All respondents were superintendent pharmacists.

Primary Methods of Medicine Authentication

Table 1: Primary Methods Used to Verify Medicine Authenticity (n = 119).

Authentication Method	Frequency (n)	Percentage (%)
Visual inspection of NAFDAC registration numbers	92	77.3
Physical inspection (packaging, labels)	16	13.4
Barcode or QR code scanning	11	9.2
Total	**119**	**100.0**

The overwhelming majority of community pharmacists (77.3%, n = 92) rely on visual inspection of NAFDAC registration numbers as their primary method of verifying medicine authenticity. An additional 13.4% (n = 16) depend on broader physical inspection of packaging and labels. Only 9.2% (n = 11) employ any form of digital scanning technology (barcode or QR code). This means that over 90% of community pharmacies in Bayelsa State rely entirely on manual, observation-dependent methods for medicine authentication.

Inventory Tracking Systems

Table 2: Inventory Tracking Systems Currently Used (n = 119).

Inventory Tracking System	Frequency (n)	Percentage (%)
Manual paper ledger	66	55.5
No formal tracking system	42	35.3
Integrated cloud-based system	11	9.2
Total	**119**	**100.0**

More than half of community pharmacies (55.5%, n = 66) rely on manual paper ledgers for inventory tracking, while a substantial 35.3% (n = 42) operate without any formal tracking system whatsoever. Only 9.2% (n = 11) use integrated cloud-based systems. Cumulatively, over 90% of community pharmacies in

Bayelsa State lack the digital data infrastructure that would constitute the minimum prerequisite for participation in a blockchain-based traceability network.

Frequency of Encountering Suspected Counterfeit Medicines

Table 3: Frequency of Encountering Suspected Counterfeit Medicines in the Past 12 Months (n = 119)

Frequency	Respondents (n)	Percentage (%)
Never	37	31.1
1-5 times	70	58.8
More than 10 times	12	10.1
Total	**119**	**100.0**

A substantial 68.9% (n = 82) of community pharmacists encountered suspected counterfeit medicines at least once in the preceding 12 months. The largest group (58.8%, n = 70) reported 1 to 5 encounters, while 10.1% (n = 12) reported more than 10 encounters. Only 31.1% (n = 37) reported no encounters with suspected counterfeits. These findings provide compelling empirical evidence that counterfeit medicines remain a persistent and significant problem in Bayelsa State's pharmaceutical supply chain.

Association between Inventory System and Counterfeit Detection

Table 4: Association between Inventory System Type and Counterfeit Detection (n = 119).

Statistic	Value	df	p-value
Pearson Chi-Square	13.21	2	0.001**
N of Valid Cases	119		

$^{**}p < 0.01$

A statistically significant association was found between inventory system type and counterfeit detection capability (Chi-square = 13.21, df = 2, p = 0.001). Pharmacies using integrated cloud-based systems demonstrated significantly higher rates of suspected counterfeit identification compared to those using paper-based or no tracking systems. This finding suggests that digital infrastructure is not merely a technical prerequisite for future blockchain adoption but is already a direct contributor to improved pharmaceutical supply chain vigilance under current conditions.

DISCUSSION

The findings of this study provide the first detailed empirical characterisation of medicine authentication and traceability practices in community pharmacies in Bayelsa State, Nigeria, and the results reveal an operational environment that is predominantly manual, observation-dependent, and fundamentally misaligned with the requirements of blockchain-based traceability.

The Dominance of Manual Authentication

The finding that 77.3% of community pharmacists rely on visual inspection of NAFDAC registration numbers as their primary authentication method represents both a practical reality and a significant vulnerability. Visual inspection, while the most accessible and cost-free method available, is inherently limited in its capacity to detect sophisticated counterfeits. Modern pharmaceutical counterfeiting operations have achieved remarkable levels of visual fidelity, producing products that are virtually indistinguishable from genuine products through visual examination alone (WHO, 2023; OECD, 2020). The overwhelming reliance on this method therefore leaves the pharmaceutical supply chain in Bayelsa State exposed to precisely the type of sophisticated counterfeiting that poses the greatest threat to patient safety.

The additional finding that only 9.2% of pharmacists use digital scanning technologies is particularly concerning in the context of blockchain adoption. Barcode and QR code scanning represent the foundational interface through which pharmaceutical products would interact with a blockchain-based traceability system. The near-absence of digital scanning infrastructure at the community pharmacy level means that even if a blockchain platform were deployed at the national or state level, the vast majority of pharmacies would lack the basic capability to participate as end-point verification nodes. This is precisely the role that community pharmacies must fulfil for any traceability system to achieve

comprehensive last-mile coverage. This finding aligns with the Task-Technology Fit framework (Goodhue & Thompson, 1995), which predicts that technology adoption will fail when there is a significant mismatch between the technology's requirements and the user's operational infrastructure.

The Digital Infrastructure Deficit

The inventory tracking data compounds the authentication concern. With 55.5% using paper ledgers and 35.3% operating without any formal system, over 90% of community pharmacies lack the digital data infrastructure that blockchain integration requires as a prerequisite. Blockchain-based traceability is fundamentally a digital system requiring digital inputs; it cannot integrate with or enhance practices that exist exclusively in analogue form.

The transition from manual or non-existent tracking to blockchain-enabled traceability therefore represents not merely a technology upgrade but a fundamental operational transformation. This transformation encompasses digitisation of inventory records, acquisition of digital scanning hardware, establishment of reliable internet connectivity, and retraining of staff in digital workflow processes. The magnitude of this transformation is a critical contextual factor for any realistic assessment of blockchain adoption timelines in the community pharmacy sector.

This finding is consistent with the TOE framework (Tornatzky & Fleischer, 1990), which identifies technological infrastructure as a foundational determinant of technology adoption and organisational performance. The framework suggests that efforts to promote blockchain adoption in this context must address the technological dimension first, establishing the basic digital infrastructure upon which more advanced systems can subsequently be built.

The Counterfeit Medicine Problem: Empirical Confirmation

The finding that 68.9% of community pharmacists encountered suspected counterfeit medicines at least once in the preceding 12 months provides compelling empirical confirmation of the persistence and severity of the problem in Bayelsa State. This high encounter rate establishes the practical urgency underlying the case for blockchain-based traceability: the problem that the technology is proposed to address is not hypothetical but a routine reality of community pharmacy practice.

The distribution of encounters is also informative. While the majority (58.8%) reported 1 to 5 encounters, the 10.1% reporting more than 10 encounters indicates that some pharmacies face a particularly concentrated counterfeit burden, possibly reflecting their position in higher-risk distribution channels or their service to populations with greater exposure to informal medicine sources. From a Resource Dependency Theory perspective (Pfeffer & Salancik, 1978), this finding highlights the vulnerability of community pharmacies to supply chain integrity failures that originate beyond their operational control, reinforcing the need for systemic solutions.

Digital Systems and Detection Capability

The statistically significant association between inventory system type and counterfeit detection capability (Chi-square = 13.21, $p = 0.001$) is among the most practically significant findings of this study. Pharmacies using cloud-based systems demonstrated higher rates of suspected counterfeit identification, suggesting that the systematic data recording, cross-referencing, and anomaly identification capabilities of digital systems enhance pharmacists' capacity to identify irregularities that may indicate counterfeit infiltration.

This finding has dual implications. First, it provides evidence-based justification for prioritising the digitisation of pharmacy operations as a necessary precursor to blockchain implementation. Second, it demonstrates that even before blockchain adoption, the transition from manual to digital tracking systems can yield immediate improvements in supply chain vigilance and patient safety. This suggests that a phased approach, beginning with basic digitisation and progressing toward blockchain integration, may be both more feasible and more immediately beneficial than attempting direct blockchain adoption from an analogue baseline.

Public Health Implications

The convergence of high counterfeit encounter rates (68.9%) with predominantly manual authentication methods (90.7% visual or physical inspection) has direct public health consequences. Given that community pharmacies function as the first, and frequently the only, point of formal medicine access for a large proportion of the population in the Niger Delta region, the practical consequence of this traceability gap is a continuing risk of treatment failure, prolonged illness, avoidable morbidity, and mortality among patients who have no independent means of verifying the authenticity of medicines they receive.

The public health stakes are heightened by the specific therapeutic categories most vulnerable to counterfeiting, namely antimalarials and

antimicrobials (WHO, 2017; Bendavid et al., 2017), both heavily prescribed within Bayelsa State's disease burden profile. Substandard or falsified antimalarials and antibiotics do not merely fail to treat the individual patient; sub-therapeutic dosing is a recognised driver of antimicrobial and antimalarial drug resistance, a consequence with implications extending beyond the individual patient to the wider community and health system.

CONCLUSION

This study demonstrates that medicine authentication and traceability practices in community pharmacies in Bayelsa State are overwhelmingly manual and observation-dependent, with over 90% of pharmacies lacking the basic digital infrastructure required for blockchain-based traceability participation. The simultaneous finding that 68.9% of pharmacists encounter suspected counterfeit medicines annually establishes both the practical urgency for improved traceability and the inadequacy of current methods. The significant association between digital inventory systems and counterfeit detection capability provides empirical justification for a phased approach to blockchain adoption, beginning with fundamental digitisation of pharmacy operations.

Based on these findings, several recommendations emerge. First, NAFDAC and the Pharmacists Council of Nigeria should develop minimum standards for digital inventory management in community pharmacies, recognising that digitisation is a prerequisite for any advanced traceability system. Second, government at state and federal levels should provide financial support for community pharmacies to acquire digital scanning equipment and establish reliable internet connectivity. Third, technology developers designing blockchain solutions for the Nigerian pharmacy context should ensure that their systems can integrate with existing low-technology environments through phased implementation pathways. Fourth, interim measures to strengthen current authentication practices, including enhanced utilisation of the Mobile Authentication Service and structured training in counterfeit detection, should be prioritised while the longer-term digital transition is pursued.

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