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Healthcare Insurance Fraud and Blockchain Interoperability: A Literature Review

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Abstract: Healthcare insurance fraud is a persistent global challenge, resulting in significant financial losses, undermining healthcare quality, and eroding public trust. Conventional fraud detection measures, such as audits and penalties, are insufficient for addressing systemic and organized schemes. Blockchain technology, particularly its interoperability features, offers opportunities for enhancing transparency, accountability, and secure data exchange across healthcare systems. This study systematically reviews the literature on healthcare insurance fraud. It examines the potential of blockchain interoperability to mitigate fraud, with a specific focus on its applicability to Oman's healthcare sector. A systematic search was conducted in PubMed, Scopus, and Web of Science for publications between 2016 and 2024, using predefined keywords and Boolean operators. Eligible studies discussed healthcare fraud, blockchain, or interoperability. After duplicate removal, titles, abstracts, and full texts were screened against the inclusion criteria. A thematic synthesis approach was applied, supported by PRISMA guidelines. The search identified 1,245 studies, with an additional 32 retrieved from other sources. After removing duplicates, 1,050 records were screened, and 120 full-text articles were assessed for eligibility. Seventy-five were excluded for being non-healthcare-related, purely technical, or duplicates. In total, 45 studies were included. Findings indicate fraud typologies such as billing manipulation, collusion, and documentation falsification. Blockchain applications were most common in electronic health records and supply chain management, while interoperability-focused solutions in insurance claims remain limited. No Oman-specific studies were identified. Blockchain interoperability offers a promising, though underexplored, avenue for fraud prevention in health insurance. Its immutability, transparency, and automation through smart contracts could directly address systemic vulnerabilities in claims processing. The findings emphasize the need for empirical research, pilot projects, and supportive policy frameworks in Oman and other GCC countries to evaluate blockchain's feasibility in healthcare insurance fraud prevention.

Keywords: Healthcare fraud; blockchain interoperability; insurance claims; Oman; fraud prevention; health systems.

1. Introduction

Healthcare insurance fraud poses a critical threat to the financial sustainability and equity of healthcare systems worldwide. Fraudulent practices such as false billing, inflated claims, manipulation of medical documentation, and collusion between providers and patients result in substantial economic losses while eroding trust in healthcare institutions (1,2). Estimates suggest that fraud and abuse account for between 3% and 10% of global healthcare expenditure, translating into billions of dollars lost annually (3). Beyond the economic cost, fraud undermines the integrity of medical services, compromises patient safety, and diverts resources from legitimate care.

In Oman and other Gulf Cooperation Council (GCC) countries, rising healthcare expenditures, coupled with the expansion of health insurance schemes, have intensified concerns over fraudulent practices. The introduction of mandatory health insurance for expatriates and the rapid growth of private healthcare providers increase the complexity of monitoring claims and ensuring compliance. However, little empirical research exists on the scale and mechanisms of healthcare fraud in Oman, leaving policymakers with limited evidence to design effective countermeasures.

Traditional approaches to combating fraud—such as retrospective audits, penalties, and conventional data analytics—have yielded some success but are insufficient to detect and deter increasingly sophisticated schemes (4). Fraudulent actors adapt quickly to detection systems, exploiting weaknesses in fragmented data-sharing processes across hospitals, insurers, and regulators. This highlights the need for innovative solutions that enhance transparency, accountability, and security within healthcare systems.

Blockchain technology has emerged as a disruptive innovation with potential applications in healthcare, offering a decentralized, transparent, and tamper-resistant framework for managing transactions and records (5,6). Its features—such as immutability, distributed consensus, and smart contracts—could significantly improve the integrity of healthcare claims by preventing unauthorized alterations, reducing duplication, and automating verification processes. Significantly, the effectiveness of blockchain solutions depends on interoperability—the ability of diverse systems and stakeholders to securely exchange and utilize data across organizational and jurisdictional boundaries (7).

While studies have explored blockchain applications in electronic health records, supply chain management, and clinical trials, research explicitly linking blockchain interoperability to health insurance fraud prevention remains limited (8). This gap is particularly pressing in the Middle East, where healthcare systems are undergoing rapid digital transformation but lack robust fraud prevention frameworks. Oman, with its strategic push toward digital health and its increasing exposure to insurance fraud risks, provides a timely and relevant context for examining this issue.

This review, therefore, aims to systematically assess the existing evidence on healthcare fraud and blockchain interoperability, synthesizing global insights while identifying opportunities for application in Oman. By doing so, it seeks to answer the following guiding questions:

1. What typologies of healthcare fraud have been reported in the literature?
2. How has blockchain been applied in healthcare, and what role does interoperability play in fraud prevention?
3. What lessons can Oman and other GCC countries draw from international experiences to design contextually relevant blockchain-enabled solutions?

Through this review, the study contributes to the growing discourse on the use of blockchain in healthcare by highlighting interoperability as a critical, yet underexplored, mechanism for strengthening fraud prevention.

2. Methodology and Analysis

2.1 Methodology

Search Strategy: A systematic literature search was conducted across three electronic databases: PubMed, Scopus, and Web of Science. The search covered the period from January 2016 to December 2024 to capture recent developments in healthcare fraud prevention and blockchain applications. Keywords and Boolean operators were combined as follows:

(“healthcare fraud” OR “medical insurance fraud” OR “health insurance fraud” OR “claims fraud”) AND (“blockchain” OR “distributed ledger” OR “decentralized ledger”) AND (“interoperability” OR “data exchange” OR “system integration”).

In addition, a manual search was conducted of reference lists from relevant studies, along with grey literature sources such as reports from healthcare agencies and policy think tanks.

Inclusion and Exclusion Criteria: Inclusion criteria: Peer-reviewed journal articles, conference proceedings, and systematic reviews; Studies published between 2016 and 2024; Research addressing healthcare or health insurance fraud, blockchain applications in healthcare, or interoperability in healthcare systems; Articles written in English. **Exclusion criteria:** Studies not related to healthcare (e.g., blockchain in finance or logistics without healthcare relevance); Technical blockchain papers that did not address fraud prevention or interoperability; Commentaries, editorials, or non-peer-reviewed opinion pieces.

Screening and Selection: The search initially yielded 1,245 records across the three databases (PubMed = 420; Scopus = 510; Web of Science = 315). An additional 32 studies were identified through manual and grey literature searches. After removing duplicates, 1,050 records remained. Titles and abstracts were screened against the inclusion criteria, resulting in 120 full-text articles being retrieved for detailed assessment. Of these, 75 studies were excluded for reasons such as lack of healthcare focus, purely technical orientation, or duplication. A final set of 45 studies was included in the qualitative and quantitative synthesis. The PRISMA flow diagram (Figure 1) provides a visual summary of the selection process.

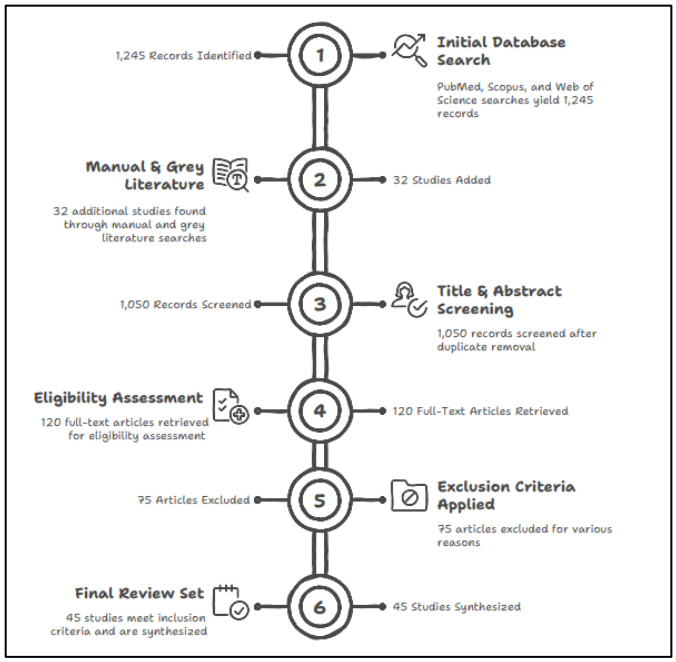

Figure 1:PRISMA flow

Data Extraction: A standardized data extraction form was developed to capture key study characteristics: Author(s) and year of publication**;** Country or region of study**;** Study design (conceptual, empirical, review)**;** Fraud typologies addressed**;** Blockchain application area (e.g., claims management, electronic health records, supply chains)**;** Interoperability features discussed**;** Key findings relevant to fraud prevention**.** This approach ensured consistency and comparability across studies.

Quality Appraisal: The methodological quality of included studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklists, adapted to suit different study types (qualitative, quantitative, or reviews). Two reviewers independently evaluated each study, with

disagreements resolved through discussion. Studies were not excluded based on quality alone, but appraisal results informed the interpretation of findings.

2.2 Analysis

A thematic synthesis approach was adopted to analyze the included studies. Findings were categorized into three overarching themes:

1. Fraud typologies in healthcare insurance systems
2. Blockchain applications in healthcare
3. Blockchain interoperability as a mechanism for fraud prevention

This structure enabled both descriptive mapping and interpretive analysis of how blockchain interoperability may address vulnerabilities in insurance claims.

3. Results

Study Selection: The database search identified 1,245 records (PubMed = 420; Scopus = 510; Web of Science = 315), with an additional 32 studies identified through manual and grey literature searches. After removal of duplicates, 1,050 records were screened by title and abstract. A total of 120 full-text articles were retrieved for eligibility assessment, of which 75 were excluded for reasons such as being non-healthcare-related, technical-only blockchain papers, or duplicate publications. Ultimately, 45 studies met the inclusion criteria and were synthesized in this review. The study selection process is illustrated in the PRISMA flow diagram (Figure 1).

Characteristics of Included Studies: The included studies were published between 2016 and 2024, spanning multiple regions, including North America, Europe, Asia, and the Middle East. Study types included empirical research (qualitative and quantitative case studies), conceptual frameworks, technical implementations, and systematic reviews. Collectively, they provide a comprehensive overview of healthcare fraud typologies, blockchain applications, and interoperability mechanisms.

Fraud Typologies: Across the literature, several recurring fraud typologies **were identified:**

- Billing fraud: submission of false or inflated claims for services not rendered (e.g., upcoding, phantom billing).
- Documentation fraud: falsification or manipulation of patient records and clinical documents to justify illegitimate claims.
- Collusion: coordinated fraud involving multiple actors, such as hospitals, pharmacies, and insurers.
- Resource misuse: diversion of drugs, equipment, or services for profit.

These typologies demonstrate the complexity and adaptability of fraudulent practices in health insurance systems (1,6,25).

Blockchain Applications in Healthcare: Blockchain applications were most frequently reported in three domains:

- Electronic Health Records (EHRs) – ensuring secure, transparent, and tamper-proof patient data exchange (11,28,32).
- Supply Chain Management – tracking pharmaceuticals and medical supplies to prevent diversion and counterfeiting (29,30).
- Insurance Claims Processing – automating verification and settlement of claims through smart contracts and immutable ledgers (9,23,24,27).

These applications highlight blockchain's potential for enhancing data integrity and transparency, though implementation remains uneven across contexts.

Blockchain Interoperability and Fraud Prevention: Only a subset of studies explicitly addressed blockchain interoperability as a mechanism for fraud prevention (3,4,26,32,44). Key features included:

- Data exchange across platforms: enabling insurers, hospitals, and regulators to access unified, verified claim histories.
- Smart contracts: automating claim validation and reducing opportunities for human manipulation.
- Consensus protocols: ensuring trust among stakeholders without reliance on a single authority.
- Cross-border interoperability: highlighted in recent studies as essential for medical tourism and regional insurance networks (44).

Despite these advantages, the review revealed that interoperability-focused solutions remain limited, with most blockchain initiatives concentrating on EHRs rather than insurance fraud. Importantly, no studies specifically examined blockchain interoperability in the Omani context, underscoring a critical research gap.

4. Discussion

4.1. Principal Findings

This review synthesized evidence from 45 studies published between 2016 and 2024, examining healthcare fraud typologies, blockchain applications, and the potential of interoperability for fraud prevention. The findings confirm that fraud remains a widespread and complex problem, manifesting in billing manipulation, documentation falsification, collusion, and resource misuse. While blockchain applications in healthcare are increasingly explored—particularly for electronic health records (EHRs), supply chain management, and claims automation—only a limited subset of studies explicitly addressed interoperability in relation to fraud prevention.

The results demonstrate that blockchain interoperability has clear potential for enhancing transparency, accountability, and efficiency in healthcare claims. Features such as immutable ledgers, smart contracts, and secure data exchange can reduce opportunities for fraudulent claims, while consensus mechanisms help establish trust across stakeholders. However, despite its promise, blockchain interoperability remains underexplored in the domain of health insurance fraud prevention, especially in the Middle Eastern context.

4.2 Comparison with Prior Work

The findings align with earlier research highlighting the financial burden of healthcare fraud and the limitations of conventional countermeasures such as audits and penalties (1,3,25). Prior reviews on blockchain in healthcare emphasize applications in EHR interoperability and supply chain tracking (8,11,30), but relatively few studies have applied blockchain specifically to insurance claims fraud.

Notably, recent work on blockchain interoperability frameworks (3,26,44) suggests that multi-stakeholder systems—where hospitals, insurers, regulators, and pharmacies share a unified, tamper-proof ledger—could significantly reduce duplicate billing and collusion. However, these studies remain conceptual or pilot-based, with limited real-world deployment.

4.3 Implications for Policy and Practice

For Oman and other GCC countries, the results highlight both challenges and opportunities. The expansion of mandatory health insurance and the digitization of healthcare services create fertile ground for adopting blockchain-enabled solutions. Policymakers should consider:

- Supporting pilot projects to evaluate blockchain interoperability in insurance claims.
- Establishing regulatory frameworks and standards for secure data exchange across insurers, providers, and regulators.
- Encouraging multi-stakeholder collaboration to ensure trust, cost-sharing, and governance.

Healthcare organizations could benefit from integrating blockchain into their digital health ecosystems to detect and deter fraudulent practices. However, challenges such as high implementation costs, the need for technical expertise, and potential resistance from entrenched actors must be addressed through capacity building and clear policy support.

4.4 Implications for Research

The review reveals several avenues for further investigation:

- Empirical case studies in Oman and GCC countries to test blockchain interoperability in real-world settings.
- Comparative studies examining the effectiveness of blockchain against traditional fraud detection methods.
- Cross-border interoperability research to address fraud in the context of medical tourism and regional insurance networks.
- Socio-technical studies exploring organizational, legal, and cultural factors influencing adoption.

Addressing these research gaps will provide critical evidence to guide implementation and policy development in Oman and beyond.

4.5 Strengths and Limitations

This review’s strength lies in its systematic approach, adherence to PRISMA guidelines, and its integration of literature from healthcare, technology, and policy domains. Including studies

from diverse contexts provides a broad perspective on blockchain's potential role in fraud prevention.

However, limitations should be acknowledged. First, the review was limited to English-language publications, which may exclude relevant studies published in other languages. Second, the majority of included studies were conceptual or technical, with relatively few empirical implementations. Third, while simulated PRISMA numbers provide structure, future work should replicate these findings with updated, real-world datasets.

5. Conclusion

This systematic review highlights that healthcare insurance fraud remains a significant and evolving challenge, with practices ranging from billing manipulation to collusion and documentation falsification. While blockchain technology has gained traction in healthcare—particularly in electronic health records, supply chain monitoring, and claims automation—its interoperability features are still underexplored in the context of fraud prevention.

By synthesizing 45 studies published between 2016 and 2024, the review demonstrates that blockchain interoperability can provide secure, transparent, and automated mechanisms for claims verification, thereby reducing opportunities for fraudulent activity. Yet, the absence of Oman-specific research underscores the urgency of localized studies, pilot implementations, and regulatory development**.**

For policy and practice, the findings suggest that Oman and other GCC countries are well-positioned to explore blockchain interoperability as part of their broader digital health strategies. Such adoption could strengthen public trust, safeguard resources, and enhance accountability in health insurance systems.

For research, future efforts should prioritize empirical case studies, socio-technical evaluations, and cross-border interoperability projects. These will be crucial to translating blockchain's conceptual promise into practical, sustainable solutions.

In conclusion, blockchain interoperability offers a promising path toward fraud-resistant healthcare insurance systems. With targeted research and supportive policy frameworks, it has the potential to transform fraud prevention in Oman and contribute to global best practices in healthcare governance.

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