An assessment of Requirements Status for Blockchain Modeling to Enhance Data Integrity: A Study of Dispensed Drugs at Homabay County Referral Hospital

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ABSTRACT

This study assesses the status of requirements for blockchain modeling towards reinforcing the data integrity of dispensed drugs at Homabay County Referral Hospital. The primary objectives was to, establish the requirements for an effective based model to reinforce data integrity with the aim of addressing challenges such as counterfeiting, data tampering and poor traceability. The research study involved 54 purposively and snowball sampled stakeholders from Homabay County Referral Hospital including pharmacy staff, healthcare providers, administrators, procurement officers and patients out of a target population of 90. Data was collected through interviews and observations, then analyzed qualitatively and quantitatively using thematic analysis across attributes. The findings indicated that the contribution of various blockchain designs by various requirements were platform adherence (20%), distributed ledger technology (28%), consensus protocols (32%) and cryptographic controls (45%). Chi-Square test across attributes revealed a significant association of a block chain requirement of 0.003. Based on the requirements a block chain model was designed. The study recommends upgrading its technological infrastructure by investing in modern hardware and software capable of supporting block chain technology. Future research should focus on evaluating the long-term impacts, scalability, cost-effectiveness and acceptance of blockchain solutions in resource-limited healthcare settings through longitudinal studies to facilitate system refinement and broader adoption.

Keywords: Data tampering, Distributed ledger technology, Cryptographic controls, Stakeholders, System adoption

1. INTRODUCTION

Blockchain technology is based on a number of fundamental elements that cooperate to provide decentralized, transparent and safe data management. These elements include of the blockchain platform itself, distributed ledger maintenance methods, consensus protocols for transaction validation, cryptographic access control for data security and the function of nodes in the network. For example, smart contracts and decentralized applications are made possible by the Ethereum platform, which offers a blockchain environment with an integrated Turing-complete programming language (Buterin, 2014). The shared, tamper-resistant distributed ledger that is kept up to date across several nodes to guarantee data integrity and transparency is the fundamental component of blockchain technology (Nowinski & Kozma, 2017).

Blockchain systems use voting-based processes and consensus algorithms like Proof of Work to verify transactions and reach a consensus on the ledger's current state (Tasatanattakool & Techapanupreeda, 2018). To secure data and enforce access rules in these systems, cryptography including hash functions and public-key cryptography is essential (Zhao, Fan, & Yan, 2016). Furthermore, nodes are the essential components of a blockchain network that verify, store and distribute transactions, guaranteeing security and decentralization (SEBA Bank, 2018). These elements of requirements work together to provide the foundation of blockchain technology, which makes decentralized, transparent and safe data management possible.

1.1 Blockchain Platform itself (Ethereum)

According to Price Waterhouse Coopers (PWC, 2018), a blockchain platform is a shared digital ledger that lets users safely record transactions and exchange data. The register is kept up to date by a dispersed, tamper-resistant network of computers and each transaction is confirmed by agreement among network users. Despite its promise, there are significant obstacles to its actual use at Kenya's Homabay County Referral Hospital. For example, the

adoption of blockchain systems for handling medical data and patient records is hampered by problems such a lack of technical experience, a limited technological infrastructure and aversion to change (Karanja & Mwangi, 2020). Similar gaps exist globally, with healthcare organizations finding it difficult to integrate blockchain because of worries about data protection, scalability and regulatory compliance (Mettler, 2016).

Through its peer-to-peer network that runs and validates application code known as smart contracts, Ethereum, a decentralized blockchain platform, enables safe and transparent transactions (Nowinski & Kozma, 2017). Hospitals without strong governance systems may experience trust challenges, but smart contracts allow parties to trade without depending on a reliable central authority. Due to Ethereum's immutable and verifiable transaction records, which offer complete data visibility, hospital operations and patient data management may become more transparent. However, practical implementation at Homabay County Referral Hospital is limited by issues with the intricacy of smart contract deployment and the requirement for significant computational resources. Similar obstacles exist globally, such as the lack of standards and the high implementation costs (Buterin, 2014; Antonopoulos & Wood, 2018).

Solidity, a Turing-complete programming language built into Ethereum's architecture, enables the creation of unique decentralized apps with particular ownership and transaction format guidelines (Buterin, 2014). When conditions are satisfied, its virtual machine, the EVM, runs smart contracts without the need for a central authority. This is especially important in environments with limited resources, where decentralization can improve resilience. However, before broad adoption can take place in hospital settings like Homabay, problems including data protection, regulatory obstacles, and technical preparedness must

be resolved (Kumar & Singh, 2021). Although there are continuous attempts worldwide to close these gaps, a major obstacle still stands in the form of a lack of infrastructure and experience.

1.2 The Consensus Process

Blockchain technology's consensus mechanisms provide important insights on how to handle data security and integrity issues in healthcare systems, especially in environments with limited resources like Kenya's Homabay County Referral Hospital. Implementing blockchain-based consensus methods might enable safe, transparent and impenetrable data exchange amongst various healthcare providers in settings where medical records are frequently paper-based or dispersed across several platforms (Tasatanattakool & Techapanupreeda, 2018). In clinical decision-making and health resource management, for example, Nakamoto's proof of work (PoW) protocol reduces errors and prevents data manipulation by ensuring that data entries, including patient records, test results and medication histories, are validated through computational consensus (Nakamoto, 2009).

Furthermore, traditional voting-based consensus procedures may be modified to provide for speedier approvals in emergency scenarios, where prompt agreement between medical professionals is necessary to guarantee prompt patient treatment. However, these protocols frequently have scalability issues, particularly in low-resource contexts with high transaction volumes or constrained computational capacity. Thus, creating health information systems that are safe, effective and appropriate for local settings requires knowledge of the trade-offs between various consensus processes (Tasatanattakool & Techapanupreeda, 2018).

Globally, gaps brought on by a lack of confidence in data sharing, poor administration, and resource constraints may be filled by incorporating blockchain consensus methods into health data management. For instance, blockchain might offer an unchangeable ledger for patient records in Kenya's healthcare system, which is rife with data silos and data fabrication. This would guarantee data integrity and promote stakeholder confidence (Nakamoto, 2009). In the end, this technological approach contributes to improved healthcare quality and equity both locally and globally by promoting data transparency, reducing fraud and facilitating efficient resource allocation challenges that are universal but particularly acute in low-resource settings facing infrastructural and systemic constraints.

1.3 Access Control cryptographic requirements of the blocks

To make sure that only authorized parties are able to read, write, or alter data, access control (AC) in blockchain systems primarily depends on encryption. To ensure the secrecy, integrity and validity of sensitive data, cryptographic methods such as Merkle trees, hash functions and public-key cryptography are used (Zhao, Fan, & Yan, 2016). Consensus protocols that limit who can create or alter access control rules which are frequently controlled centrally, via smart contracts, or designated nodes complement these mechanisms in permissioned blockchains, strengthening network security and trust (Zhao, 2016). Especially in delicate industries like healthcare, this layered encryption method is essential for protecting sensitive data.

Implementing blockchain with strong cryptographic access controls in the healthcare context, especially in areas like Homabay County in Kenya, offers promising solutions to persistent issues like data fragmentation, poor interoperability and privacy concerns (Zhao, 2016). However, these efforts are hindered by significant gaps: many healthcare facilities lack the infrastructure needed to deploy and maintain blockchain systems effectively, such as dependable internet connectivity and suitable hardware (Njeri & Muli, 2020); additionally, there is a lack of personnel trained in cryptography and blockchain technology, making it difficult to manage and sustain secure systems over time; and without sufficient capacity, the potential benefits of blockchain-based health records, such as tamper-proof data and improved data sharing, remain largely unrealized.

Additionally, data privacy is still a major issue on a national and international level. Although encryption can safeguard data integrity, privacy management, especially when it comes to medical information, is difficult and calls for fine-grained access restrictions to stop unwanted disclosures (Zhao, 2016). Aligning cryptographic systems with legal frameworks presents extra issues in areas like Homabay, where health data is frequently sensitive and subject to national and international privacy rules like GDPR and HIPAA (Njeri & Muli, 2020). Interoperability problems are made worse globally by the absence of defined encryption protocols and rules, which hinder smooth data transfer across borders and systems crucial aspect of cross-border medical crises and research partnerships.

Governance and consensus mechanisms further complicate the deployment of cryptographic access controls. Ensuring that only authorized actors can modify access policies requires robust governance frameworks, which are often weak or absent in resource-constrained settings like Homabay (Njeri & Muli, 2020). While centralized management of access control nodes simplifies policy enforcement, it introduces single points of failure and potential corruption, undermining the trustworthiness of the system (Zhao, 2016). Additionally, scalability and system performance are issues, as cryptographic operations can become computationally intensive, leading to latency that hampers real-time access and decision-making in healthcare environments.

These gaps security flaws, governance issues, infrastructure shortcomings and legislative inconsistencies highlight the urgent need for specialized approaches to improve cryptographic access control in healthcare systems. To fully utilize blockchain's potential, it is imperative to develop standardized and interoperable cryptographic protocols, strengthen infrastructure, develop local knowledge, and set up transparent governance frameworks (Njeri & Muli, 2020). By tackling these issues, it will be easier to close the gap between theoretical cryptographic solutions and workable, scalable implementations, guaranteeing the security and privatization of health data in Homabay County and throughout the world. In the end, these initiatives will promote trust, improve health outcomes, and assist in the moral handling of private health data in a variety of settings (Zhao, 2016).

1.4 The role of nodes and nodes discover

In the healthcare industry, nodes can be servers, devices, or user endpoints that connect to the blockchain to share and verify health data; however, in Homabay County and around the world, the deployment and management of such nodes face challenges due to infrastructure limitations, lack of technical expertise, and poor network connectivity, which hinder real-time data validation and synchronization across health systems, thereby affecting data accuracy and timeliness. Many health blockchain initiatives worldwide struggle to establish a reliable network of nodes, which is vital for maintaining data integrity and trust, particularly in critical health emergencies or large-scale health data sharing scenarios.

In conclusion, even if the theoretical underpinnings of consensus processes, node architecture and access control cryptography are well-established, there are still a lot of holes in their real-world implementation in health systems, especially in settings with limited resources like Homabay County. These shortcomings include issues with consensus process control, insufficient use of cryptographic security and infrastructure constraints that impact node deployment and discovery. To address these problems, specific infrastructure investment, capacity building and policy development are needed to close the gap between blockchain's promise and its practical effects on health data security and management throughout the world (Zhao, 2016; SEBA, 2018). Only then can blockchain technology's full potential be realized to enhance data security and health outcomes globally.

1.5 The transactions that make up a block and the underlying network

A number of interrelated processes that guarantee data confidentiality and integrity two essential components for health information systems are involved in how blockchain technology operates, especially when it comes to transaction processing inside a decentralized network (PwC, 2018). Before a new block

is made and therefore added to the chain, a transaction request is first transmitted to the network, where it is authenticated by every node in the distributed ledger. In resource-constrained settings like Kenya's Homa Bay County Referral Hospital, where health record management faces obstacles like data fragmentation and lack of interoperability, this process guarantees transparency and immutability to two essentials for handling sensitive health data (Kenya Ministry of Health, 2020).

To maintain the integrity of data chains, certain transactions known as orphan transactions may come out of order due to the network's asynchronous nature. These transactions are temporarily stored in a pool until their parent transactions are received. This approach is particularly significant in health data interchange systems trying to maintain patient histories or prescription records, because incomplete transaction chains might threaten patient safety. Additionally, proposals, endorsements, and answers are all part of the structure of blockchain transactions, and when combined, they enable a safe and verifiable method of carrying out chain activities connected to health, such managing supply chains or updating medical data (PwC, 2018). Gaps still exist at the local and international levels despite these technological developments; in Homa Bay, health information systems are frequently fragmented.

Blockchain solutions that guarantee data confidentiality, consistency and accessibility must be integrated to close these gaps. This will improve health outcomes in disadvantaged areas and advance global health security.

2. METHODOLOGY

The study was conducted at Homabay County Referral Hospital, located in Homabay town near Lake Victoria, Kenya. This hospital serves as a key referral center for the region, which is primarily, engaged in fishing and farming activities major economic drivers in the area (Kenya National Bureau of Statistics, 2022). Homabay County is recognized for its relatively high ranking in healthcare performance within Kenya, ranked among the top ten counties according to IPSOS (2023). Despite this, the hospital faces significant operational challenges, particularly delays in drug procurement and stock-outs of essential medicines, which have been identified as major barriers to effective healthcare delivery (UNICEF, 2018).

2.2 Research Approach

The study adopted qualitative data through interviews and quantitative data through observations to gain in-depth insights into the perceptions, experiences and systemic factors contributing to drug shortages and delays (Creswell, 2019; Patton, 2020). The research approach is suitable for understanding the requirements challenges faced by healthcare providers and patients within the hospital environment (Yin, 2018).This enhances the validity and depth of the findings, providing a holistic understanding of the operational issues affecting healthcare delivery in this setting (Creswell & Plano Clark, 2020).

2.3 Research Design

The research design was structured to address existing knowledge gaps and challenges related to modeling and implementing blockchain technology to enhance data integrity in drug dispensing at Homabay County Referral Hospital. It provided a systematic framework for identifying requirements for blockchain modeling within the hospital's pharmaceutical dispensing processes (Creswell, 2019).

This study adopted a descriptive research design, which was suitable for implementing a blockchain model and comprehensive understanding of the existing requirements for blockchain modeling and the involvement of healthcare stakeholders without manipulating variables. It focused on observing and portraying the existing environment, making it ideal for informing evidence-based decision-making and planning subsequent interventions (Kothari, 2018).

The implementation of this research design involved systematically collecting both qualitative and quantitative data through interviews and observations with healthcare professionals, patients and administrative staff to gather detailed informations about current requirements for blockchain modeling. Data analysis was then conducted to identify patterns, gaps and areas for improvement, ensuring that the findings accurately reflected the operational and practical realities of the hospital.

2.4 The study population

The study population at Homabay County Referral Hospital comprised a total of 1,090 individuals, including 90 healthcare and administrative staff and 1,000 outpatients (KNBS, 2023). The staff members encompassed various departments and roles, including the Head of Department (9), Department of Information Technology (IT) & Innovative Strategies (15), the Pharmacy (10), the Pharmaceutical Store (10), Nurses (10), Doctors (10), Clinical Officers (10), Physicians (5), Accountants (5), Procurement Officers (5), Hospital Administrators (1) and the Chief Executive Officer (CEO) (1).

2.5 Target Population

The target population encompasses relevant stakeholders involved in drug and data management at Homabay County Referral Hospital, totaling 90 individuals. This includes staff from the Head of Department (9), Department of Information Technology (IT) & Innovative Strategies (15), the Pharmacy (10), the Pharmaceutical Store (10), Nurses (10), Doctors (10), Clinical Officers (10), Physicians (5), Accountants (5), Procurement Officers (5), Hospital Administrators (1), the Chief Executive Officer (CEO) (1) and Diabetic Patients (10) (KNBS ,2023).

While the total outpatient population at Homabay County Referral Hospital was 1,000, targeted 10 patients from the Diabetic Sensitive Care Unit. Patients from the diabetic unit are responsible for managing their medication data at home (Sandelowski, 2021), making them critical for understanding outpatient data handling outside the hospital setting. These patients have been on treatment for a specified duration to ensure familiarity with their medication routines, are additionally willing to participate and can provide detailed information about their medication management practices where dispensed drugs are involved. This focused sampling specifically aims to examine data handling in areas with higher risks of data sensitivity and integrity issues (Creswell, 2014).

2.6 Sample size and Sampling Techniques

To determine the appropriate sample size (n), Cochran's Formula was applied, taking into account the finite population correction (FPC) factor to ensure an accurate and representative sample for the population size. This approach, alongside the calculated sample size using Cochran's Formula with FPC, aimed to enhance the validity and reliability of the study findings (Levy, P. S., & Lemeshow, S. (2013).

(a) Cochran's Formula with Finite Population Correction (FPC)

Initial calculation (assuming an infinite population):

$$n_0 = Z^2 * P * (1-P)/e^2$$

Where:

Z = -score for confidence level (e.g., 1.96 for 95%)
p = estimated proportion (often 0.5 for maximum variability)
e = margin of error (e.g., 0.05)

Thus $n_0 = (1.96*95\%)^2 * 0.5*(1-0.5)/0.05^2 = 346.70$

$n_0 = 346.70$ Then sample size (n) = $n_{0/1+(n_0-1)/N}$ = $346.70/1+3.84$ =61.667= 62

2.6.1 Sampling Technique

The study adopted snowball and purposive sampling. The process began by administering purposive sampling to identify an initial group of 5 to 10 staff members involved in drug and data management. These initial seed participants were carefully selected from various departments, such as pharmacy, IT, nursing, clinical officers and hospital administration, to ensure broad network coverage and diversity. Once selected, each seed was asked to refer colleagues within their professional network who were also involved in relevant roles at the hospital. The referred staff members, in turn, participated in the study and were subsequently asked to refer other eligible colleagues. This iterative referral process continued, with each new participant recruiting further staff members until the desired sample size of 62 participants was reached or the network was exhausted. Throughout this process, the focus was on capturing a diverse and

representative sample of staff involved in drug and data management, leveraging existing social and professional networks within the hospital and experienced healthcare staff with more than five years of service (Saunders, Lewis, & Thornhill, 2019).

. **Table 2.1 Sampling Distribution**

Category	Sampling technique	Sample size	Target Population
Head of IT/Innovation Strategist	Purposive	13	15
Head of Doctors	Purposive	5	10
Diabetic Patients	snowball	5	10
Head of Pharmacy	Purposive	5	10
Head of Pharmaceutical Store	Purposive	5	10
Head of Nurses	Purposive	9	10
Head of Clinical Officers	Purposive	5	10
Head of procurements	snowball	1	5
Head of accountants	snowball	1	5
Hospital Administrator	Snowball	1	-
Head of Physician	Purposive	4	5
Chief Executive Officer	Snowball	1	-
Total		62	90

2.7 Data Collection

Data was collected through structured interviews and observations, utilizing standardized interviews schedule and observation checklists as the research instruments. The structured interview questions and observation checklists were organized into various sections aligned with the specific research objectives. During the interviews, data was recorded as respondents provided their answers to the predetermined questions, ensuring consistency across interviews. Observations involved systematically recording behaviors, processes, or conditions related to drug data integrity and pharmacy operations using predefined observation checklists. This approach allowed for the collection of both quantitative data and qualitative data providing a comprehensive understanding of the existence of requirement for modelling blockchain within the hospital's pharmaceutical systems.

2.7.1 Interview Schedule

This document was designed to guide respondents in assessing the existing requirements for blockchain modelling, through structured interviews with doctors (4), nurses (8), clinical officers (5), physicians (4), pharmacists (3), pharmaceutical store staff (3), heads of departments (9), IT department staff (12), patients (3), an accountant (1), procurement personnel (1), the CEO (1) and hospital administrators (1) totaling to 54 individuals. The questions included both closed and open-ended formats to facilitate easy coding, enable quicker responses and ensure that the researcher remains focused on obtaining relevant information on data integrity blockchain requirements. Since the interviews involved a diverse group of participants and both closed and open-ended questions, the researcher used an interview guide (structured question sheets) to facilitate consistency across sessions. For qualitative data collection, audio recorders were used to capture detailed responses accurately, especially for open-ended questions, allowing for thorough transcription and analysis later (Saunders, M., Lewis, P., & Thornhill, A., 2019). Additionally, the researcher used note-taking tools such as pen and paper or a laptop to jot down immediate observations, non-verbal cues, or clarification points during the interviews. The notes complemented audio recordings and helped ensure that all relevant information, including contextual nuances, was captured (Kvale, S., & Brinkmann, S., 2019).

2.7.2 Observation Checklist

The researcher used an observation checklist to systematically verify information related to modeling requirements within specific departments, such as the IT department and hospital administration. This checklist contained predefined items or criteria that the researcher checked or noted during site visits. The checklist served as a standardized tool to ensure consistency across observations and to gather objective data related to the physical and procedural aspects of data modeling and management (LeCompte & Schensul, 2020). Quantitative data responses from closed-ended questions and checklist items were quantified by counting frequencies or scoring certain criteria and then presented through tables, charts or summary statistics.

3.8 Data Analysis and presentation

In this study, qualitative data analysis and presentation began after the collection of open-ended interview responses, observation notes and narrative insights. These data were analyzed through thematic analysis, involving coding and identifying recurring patterns to generate meaningful categories that captured participants' perceptions and experiences related to data integrity (Leedy & Ormrod, 2017). Thematic narratives, quotes and visual summaries such as charts or diagrams were used to present these qualitative insights (Braun & Clarke, 2019).

On the other hand, quantitative data were obtained from closed-ended questions, observation checklists and numerical responses. These data were analyzed after data cleaning and coding (Field, 2020). Descriptive statistics such as means, percentages, and frequencies summarized the data, while inferential analysis using the Chi-square test examined relationships and differences among variables. The quantitative results were presented through tables, bar graphs, and charts to facilitate clear visualization (Pallant, 2020).

The combination of qualitative and quantitative approach was

applied during the interpretation phase, where qualitative themes and quantitative patterns were integrated to enrich the overall findings. This sequential design allowed one form of data collection to inform the other, from objective one to objective two, thereby enabling an effective blockchain design (Creswell & Plano Clark, 2017).

This triangulation of data facilitated validation and provided a comprehensive understanding of data integrity problems within the hospital setting. It combined the depth of qualitative insights with the generalizability of quantitative analysis, leading to robust and well-rounded conclusions (Denzin, 2020).

2.9 Validity

Validity was ensured by designing clear and well-formatted questions aligned with an established conceptual framework and supported by relevant literature, which provided face validity (Tian F., 2021). A pilot test was conducted at Rongo Sub County Hospital before the main research to evaluate and refine the data collection tools.

2.9.1 Pilot Test Procedures

The selection of participants for the pilot testing involved key stakeholders within the hospital, including the Head of Departments , the IT Innovation & Research Officer, a doctor, a pharmacist, nurses, a clinical officer, a physician, a hospital administrator, public health officers, a pharmaceutical store representative and accountants. A total of ten participants representing 16.3% of the actual sample size of 62 were purposively chosen to provide relevant and comprehensive feedback. This proportion falls within the acceptable range of 10-20% for pilot testing, which is considered sufficient to identify potential issues without overextending the sample (Polit & Beck, 2012).

The measurement instrument was administered to participants under conditions similar to those anticipated in the main study, utilizing both interviews and observations. During this process, participants provided feedback on the clarity, understanding and relevance of the questions, highlighting any items that were confusing or ambiguous. This feedback was crucial in assessing the instrument's comprehensibility and appropriateness.

The responses obtained from the pilot test were then subjected to thematic analysis to identify any inconsistent or unclear questions, as well as items that failed to effectively measure the intended constructs. Based on the analysis and participant feedback, necessary revisions were made to improve the clarity, relevance and overall reliability of the tool. Following these revisions, the instrument was finalized and deemed ready for use in the main study. This iterative process ensured that the data collection instrument was both accurate and consistent, thereby enhancing the validity of the subsequent data collected.

The pilot test percentage was calculated as (10/62) × 100 = 16.3%, which aligns with the recommended benchmark range of 10-20%. This indicates that the pilot test was effective in detecting potential errors suggesting an excessively high problem rate, thus confirming the appropriateness of the sample size for pilot testing (Polit & Beck, 2012).

Pilot Test Percentage = 10/62*100=16.3%. The 16.3% figure falls within the typical benchmark range (10-20%), suggesting that the pilot test was effective in detecting error without indicating an excessively high problem rate (Polit, D. F., & Beck, C. T. 2012)**.**This percentage confirms that the instrument tools were largely clear and relevant, with some minor error identified that could be addressed to enhance reliability and validity.

2.9.2 Reliability

Ensuring that the research instrument yields consistent results was important, so the researcher tested its reliability. The researcher used test-retest approach, which involves administering the same measurement tool to the same group of respondents in Rongo Sub County Hospital at two different times. The two tests were spaced two weeks apart. This duration was carefully chosen to prevent respondents from simply remembering their previous answers, which could artificially inflate consistency, while also avoiding

significant changes in their perspectives that might occur over a longer period. By comparing the responses from both tests, a correlation ratio of 0.83 was established. This was above 0.7 benchmark ratio proposed by cochler Alpha.

2.10 Ethical Considerations

The researcher took approval from Rongo University and NACOSTI, ensuring the study adhered to national research standards. In addition to these approvals, the researcher also sought permission from the hospital where the study was conducted. This step was essential to ensure proper access to patient information and hospital data, in line with institutional policies and ethical requirements. The researcher explained to participants that participation was voluntary, confidential and that their identities would be protected, which helped build trust and ensure informed consent.

3.0 RESULTS AND DISCUSSIONS

3.1 Demographic data

Out of 62 sampled, only 54(87%) responded and 8(13%) did not respond. The majority of the respondents were interviewed.
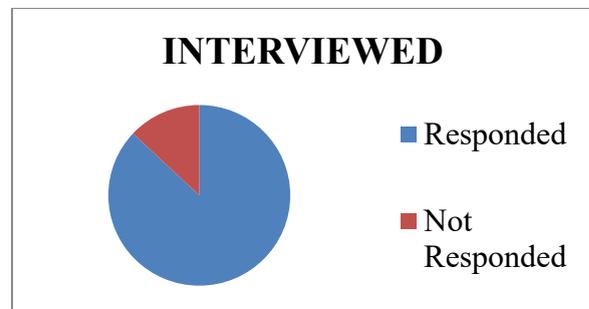

Figure 3.1 Respondents' Demographic Data.

3.2 Response rate

Table 3.1 Frequency and Percentage of Response Rate.

Total Interviewed	Frequency	Percentage%
Responded	54	87
Not Responded	8	13
Total	62	100

Table and figure 3.1 present, Out of 62 Sampled 87% responded, indicating a high participation rate, 13% did not respond, which is relatively low, suggesting good engagement or accessibility. The majority of the respondents were interviewed on blockchain model to reinforce data integrity of dispensed drugs in Homabay County Referral Hospital.

2.3 Respondents' years of service.

Table 3.2 Respondents' years of service

Years of Service (brackets)	Frequency	Percentage %
0-5	15	24
5-10	22	35
10 and above	25	41
Others Specify	0	0
Total	62	100

Table 3.2 present the respondents' years of service , 24% represented respondents, who have worked in the hospital for less than five years, 35% represented respondents who have worked in the hospital for less than10 years, 41% represented respondents who have worked in the hospital for over 10 years and 0% represents none for others. Majority of the respondents have worked in the hospital for 10 years and above. From the findings 41% of the respondents were over 10 years and above having the history and experience on data integrity of dispensed drugs in Homabay County Referral Hospital.

3.4 Analysis based on designation of officers dispensing drugs

Table 3.3 Designation of officers dispensing drugs.

Designation	Total Number of Sampled	Number of completed responses	Response rate%
Head of departments(Units)	9	9	100
Doctors	5	4	80
Nurses	9	8	89
Clinical officers	5	5	100
Pharmacist	5	3	60
IT Department	13	12	92
Patients	4	3	75
Ceo	1	1	100
Hospital Administrator	1	1	100
Accountant	1	1	100
Procurement	1	1	100
Pharmaceutical store assistant	5	3	60
Physicians	4	3	75
Total	62	54	87%
Mean			85.91%
Mode			100%
Median			90.5%

Table 3.3 presents the response rate on designation officers indicated good engagement from most departments, which supported the robustness of the findings. The slightly lower response rates from pharmacists and pharmacy store assistants (60%) suggested potential logistical or possibly less interest or availability among these groups. The high overall responses rate (87%), mean response rate (85.91%), mode (100%) and median response rate (90.5%) reinforced confidence in the representativeness but highlighted the need to pay attention to underrepresented groups in future data collection efforts within the departments in Homabay County Referral Hospital.

3.5 Requirements for Modelling Data Integrity of Dispensed Drugs

This section presents findings on the existence of requirements for modelling blockchain of dispensed drugs at Homa Bay County Referral Hospital. The findings focused on key requirements such as the blockchain platform, distributed ledger technology, consensus processes, access control cryptographic techniques, nodes and node discovery and transaction handling.

3.5.1 Blockchain Platform requirement

The blockchain platform plays a crucial role in ensuring the integrity and security of data related to dispensed drugs. This section evaluated the hospital's implementation of various platform requirements, including control measures, tamper-proof features, automation, changes or additions to data and audit trails.

3.5.1.1 Control Measures as Platform Requirement

This subsection focuses on evaluating the implementation of such control measures at Homabay County Referral Hospital. Data were collected through an observation checklist from IT department, accountants and procurement department in maintaining a robust and secure drug management system as shown in table 3.4 and figure 3.2

Table 3.4: Extent of the presence of Control Measures as a platform requirement

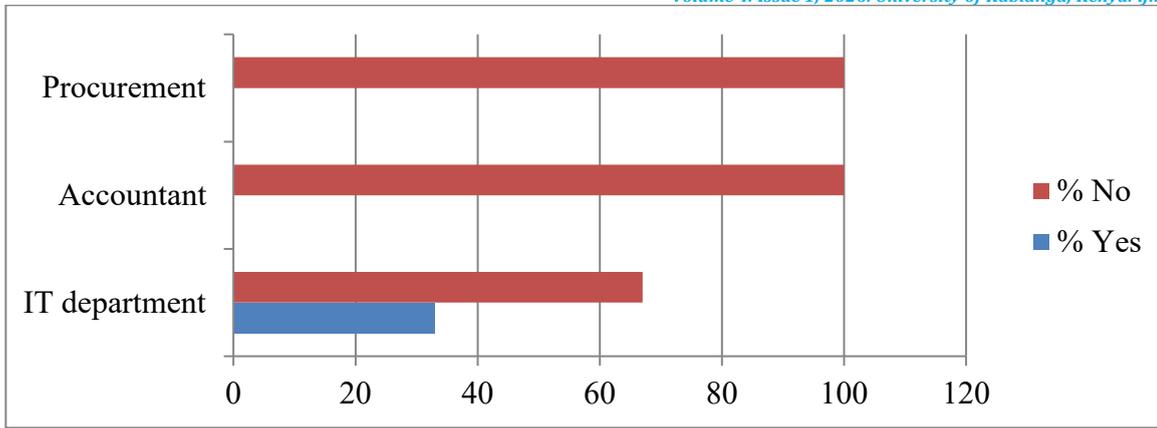| Participants	Number of Respondents	Response on the presence of Control Measures as a platform requirement	
		% (Yes)	% (No)
IT department	12	33%	67%
Accountant	1	0%	100%
Procurement		0%	100%
Total	14	4	10
Percentage%	100%	11%	89%

Figure 3.2 Extent of the presence of Control Measures as a platform requirement

Table 3.4 and figure 3.2 present a low implementation of control measures, with only 11% confirming their presence. Checklist ticked Yes or No. The analysis showed significant vulnerabilities in the system's security and integrity, highlighting the urgent need to strengthen control mechanisms to enhance data security and system reliability. Therefore the extent of Control Measures as a platform requirement was low at 11%, requires critical attention as a requirement for modelling, hence the absence of requirements for data integrity of dispensed drugs; in alignment with existing research emphasizing the importance of robust controls in healthcare blockchain systems (Kuo, Kim, & Ohno-Machado, 2019).

3.5.1.2 Tamper-Proof Features as Platform Requirements

At Homabay County Referral Hospital, tamper proof features as requirements play a crucial role in maintaining the system's reliability. To evaluate the hospital's implementation of these features, data was collected through structured interviews with CEO, Hospital Administrator and members of the IT department as shown in table 3.5 and figure 3.3

Table 3.5: Extent of presence of Tamper-Proof Features as platform requirement

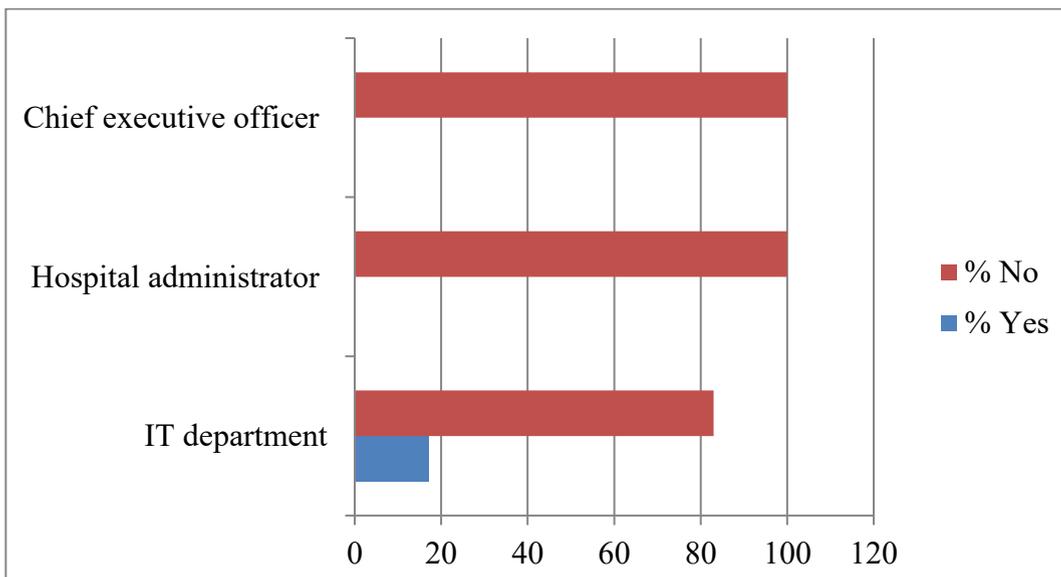| Participants	Number of Respondents	Response on the presence of Tamper-Proof Features as a platform requirements	
		% (Yes)	% (No)
IT department	12	17%	83%
Hospital administrator	1	10%	100%
Chief executive officer	1	0%	100%
Total	14	2	12
Percentage%	100%	5.7%	94.3%

Figure 3.3: Extent of Presence of Tamper-Proof Features as platform requirement

Table 3.5 and figure 3.3 findings present that CEO, IT department and Hospital Administrator answered "Yes" or "No" to indicate whether specific control measures or tamper-proof features had been implemented. The data were analyzed by calculating the percentage of respondents affirming each feature, revealing that only 11% confirmed the presence of control measures and 5.7% confirmed tamper-proof features. These findings suggest that most units lacked these critical security measures, highlighting potential vulnerabilities. Therefore the extent of tamper-proof features as

platform requirements requires urgent attention, hence the absence of requirement for modelling of data integrity in alignment with existing literature emphasizing the importance of tamper-proof mechanisms in healthcare information systems (Nguyen et al., 2020; Kuo, Kim, & Ohno-Machado, 2019).

3.5.1.3 Automation as a Platform Requirement

This subsection examines the extent to which automation has been integrated into the processes at Homabay County Referral Hospital. Data was collected through structured interviews directed primarily at the hospital's IT staff as shown in table 3.6 and figure 3.4

Table 3.6: Extent of the Presence of Automations as a Platform Requirement

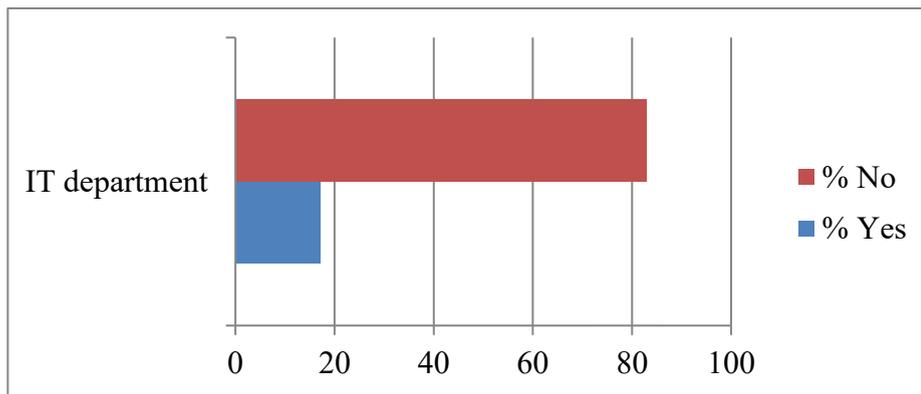| Participants	Number of Respondents	Response on the presence of automation as platform requirements of Processes	
		% (Yes)	% (No)
IT department	12	17%	83%
Total	12	2	10
Percentage%	100%	17%	83%

Figure 3.4: Extent of presence of automations as a platform Requirement

Table 3.6 and figure 3.4 present automation was coded as '1' and manual responses as '0'. The findings revealed that only 17% of processes were automated, indicating a predominantly manual system. Therefore the extent of automation as a platform requirement in Hospital processes requires critical attention as a requirement for modelling, hence the absence of requirement for data integrity of dispensed drugs, in alignment with existing literature highlighting infrastructural and resource constraints in resource-limited settings (Kio, 2020; Mwangi & Kamau, 2019).

3.5.1.4 Changes or Additions to Data Verified as a Platform Requirement

This subsection examines the practices implemented by Homabay County Referral Hospital to verify data changes or additions. Quantitative data collected through structured interviews with staff members from the hospital's IT department as shown in table 3.7 and figure 3.5

Table 3.7: Extent of presence of Changes or Additions Practices as a platform requirement

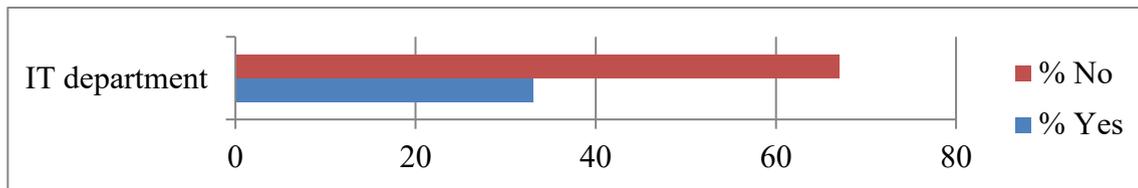| Participants	Number of Respondents	Response on presence of Changes or Additions to Data as a platform requirement of dispensed drugs	
		%(Yes)	% (No)
IT department	12	33%	67%
Total	12	4	8
Percentage%	100%	4/12= 33%	8/12=67%

Figure 3.5: Extent of presence of Changes or Additions Practices as a platform requirement

Table 3.7 and figure 3.5 present how responses were analyzed by calculating the percentages of "Yes" and "No" answers to assess system implementation. At the hospital, 33% of IT staff reported making changes to dispensed drug data, while 67% did not, indicating most staff follows data integrity protocols. Therefore the extent of changes or additions practices as a platform requirement requires urgent attention as a requirement for modelling data

integrity of dispensed drugs at Homabay County Referral Hospital hence the absence of existence requirement, in alignment with standard health informatics practices recommended by WHO (2021) and other industry standards (Kelley et al., 2020).

3.5.1.5 Summary of Platform Requirements for Dispensed Drugs

Table 3.8: Summary of Platform Requirements for Dispensed Drugs

| Platform aspects	Current requirement status (Percentage %)	(WHO,2019) &(ISO,2019) Standards	Presence of / Absence of requirement for modelling
Control measures	11%,	90% and above	Absence of requirement
Tamper proof	5.7%,	95% and above	Absence of requirement
Automation	17%	80% and above	Absence of requirement
Changes or additions	33%	95% and above	Absence of requirement
Total%	16.7%	90% and above	Significant absence of requirement inferred
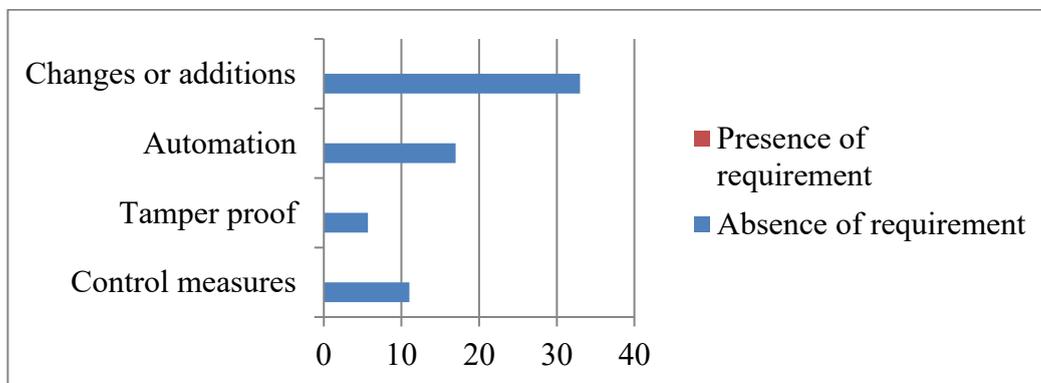
Figure 3.6: Summary of Platform Requirements for Dispensed Drugs

Table 3.8 and figure 3.6 present a summarized data on the platform attributes at Homabay County Referral Hospital, with 11% of control measures and 15% of tamper-proof features were in place, both significantly below the over 90% international guidelines, compliance benchmark standards for platform requirements in pharmaceutical dispensing set by WHO (2021). Aggregated results indicated that overall compliance at 12%, revealing lack of existing requirement for modelling in the hospital Therefore platform as a requirement for modelling data integrity of dispensed drugs was absence as requirement.

3.5.2 Distributed Ledger Technology (DLT) Requirements for Dispensed Drugs

This section outlines the findings related to the requirements for

Distributed Ledger Technology (DLT) in maintaining the integrity and security of dispensed drugs at Homa Bay County Referral Hospital. Specifically, it examined the effectiveness of verification processes and access control measures in ensuring the authenticity and security of drug-related data.

3.5.2.1 Verification as a DLT Requirement for Stakeholders, Healthcare Professionals and Patients

This subsection examines the verification practices adopted by Homabay County Referral Hospital, focusing on how effectively these processes are embedded within the DLT system. Data was collected through systematic observation from IT staff department as shown in table 3.9 and figure 3.7

Table 3.9: Extent of presence of Verification of Stakeholders, Healthcare Professionals and patients as DLT Requirement

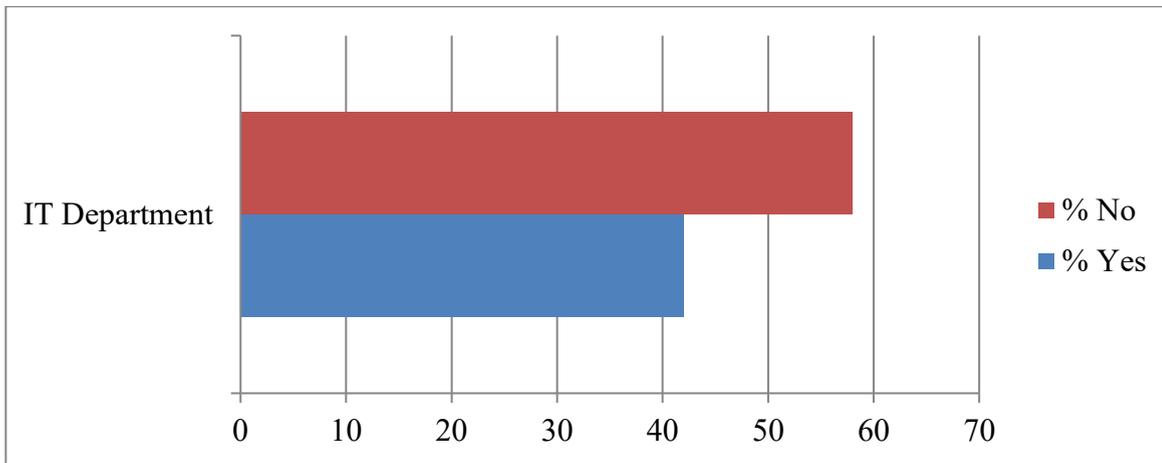| Participants	Number of Respondents	Response on the presence of Verification of stakeholders, Healthcare professionals and patients as DLT requirements	
		%(Yes)	% (No)
IT department	12	42%	58%
Total	12	5	7
Percentage%	100%	42%	58%

Figure 3.7: Extent of presence of Verification of Stakeholders, Healthcare Professionals and patients as DLT Requirement

Table 3.9 and figure 3.7 present that only 42% of the IT staff confirmed active verification of stakeholders; healthcare professionals and patients, while 58% reported no verification activities. This limited level of verification suggests vulnerabilities in data security and system integrity, aligning with findings from existing literature (Smith et al., 2021; Johnson & Lee, 2020). Therefore the extent of verification of stakeholders, healthcare professionals and patients in Distributed Ledger Technology (DLT)

of dispensed drugs requires acritical attention at Homabay County Referral Hospital hence absence of requirement for modelling.

3.5.2.2 Extent of Access Control as a DLT Requirement

It highlights the importance of restricting data access to authorized individuals such as healthcare providers, pharmacists and regulators, to protect the security and integrity of sensitive drug-related information. Quantitative data was collected through direct observation with IT department and hospital administrator, as shown in table 3.10 and figure 3.8

Table 3.10: Extent of Presence of Access Control as a DLT Requirement

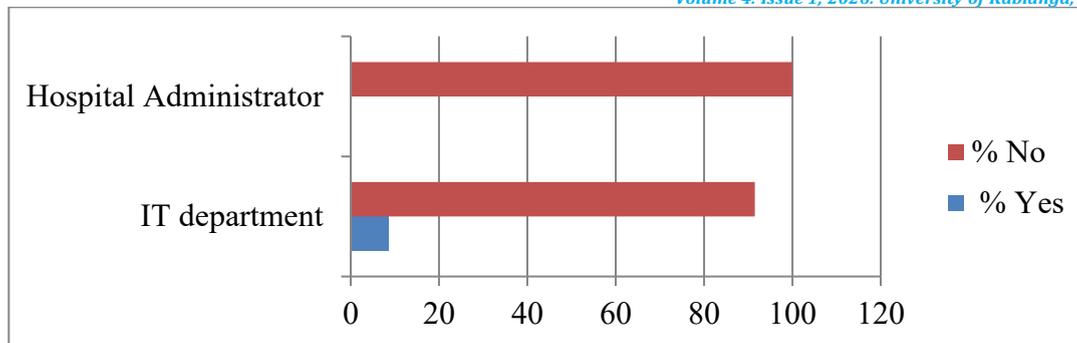| Participants	Number of Respondents	Response on the presence of Access Control for authorized parties as DLT requirement	
		% (Yes)	%(No)
IT department	12	17%	83%
Hospital Administrator	1	0%	100%
Total	13	2	11
Percentage %	100%	4/13=8.5%	14/16=91.5%

Figure 3.8: Extent of Presence of Access Control as a DLT Requirement

Table 3.10 and figure 3.8 present a significant security gap: only 17% of the IT staff confirmed implementing access controls and the hospital administrator reported that no formal measures were in place. 8.5% of respondents indicated the existence of access control mechanisms, indicated a critical vulnerability that could allow unauthorized access to sensitive health data. (Kuo et al., 2020; Zhang & Li, 2019; WHO, 2021). Therefore extent of access control as a DLT Requirement of dispensed drugs in Distributed Ledger Technology requires critical attention at Homabay County Referral Hospital hence the absence of requirement for modelling.

3.5.2.3 Summary of DLT Requirements for Dispensed Drugs
Table 3.11: Summary of DLT Requirements for Dispensed Drugs

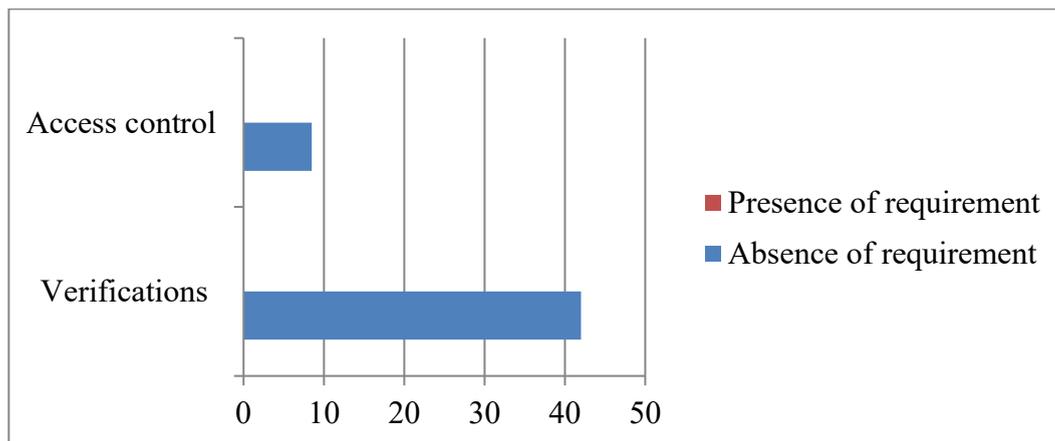| Distributed Ledger Technology Attributes	Current Requirement Status Percentage%	(WHO,2019),(ISO 2019) Standards	Presence / Absence of Requirement
Verifications	42%	90% and above	Absence of requirement
Access control	8.5%	85% and above	Absence of requirement
Total%	25.25%	90% and above	Significant absence of requirement inferred

Figure 3.9: Summary of DLT Requirements for Dispensed Drugs

Table 3.10 and figure 3.9 present how DLT requirement were collected using a structured observation checklist, The collected data was then analyzed by calculating the percentage of compliance for each attribute; verification processes showed a compliance rate of 42%, while access control measures was only 8.5%. These percentages were compared to international benchmarks, such as those recommended by the WHO (2019), which suggest over 90% compliance for verification and 85-90% for access controls to ensure data security and integrity. Therefore summary of distributed ledger technology requirement requires urgent attention for Dispensed Drugs, hence absence of requirement for modelling in alignment with the best practices in health informatics, which utilize standard measures like percentage compliance and benchmark comparisons to evaluate system performance (WHO, 2019).

3.5.3 Consensus Processes or Protocols Requirements for Dispensed Drugs

This section presents findings related to the consensus processes or protocols required for ensuring the integrity and accuracy of dispensed drugs within the network at Homa Bay County Referral Hospital. The analysis focuses on the validity of these processes and the selection of participants responsible for validating transactions.

3.5.3.1 Validity of Consensus Processes or Protocols

This subsection explores the measures in place to verify the validity of consensus processes among network participants. Quantitative data was collected through structured observation checklist with hospital's IT department responsible for managing DLT processes as shown in table 3.12 and figure 3.10

Table 3.12: Extent of Presence of Validity Consensus Processes

Participants	Number of Respondents	Response on the presence of validity of consensus processes among network participants.

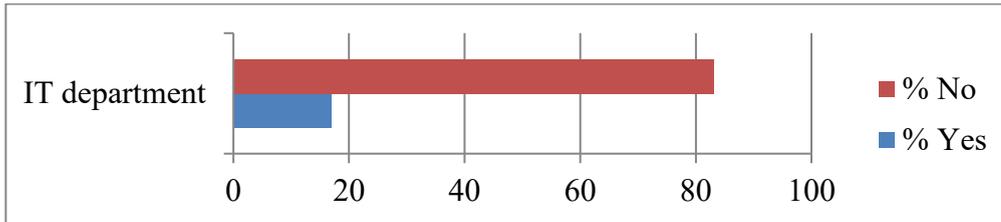|		% (Yes)	%(No)
IT Department	12	2/12=17%	10/12=83%
Total	12	2	10
Percentage %		2/12=17%	10/12=83%

Figure 3.10: Extent of Presence of Validity Consensus Processes

Table 3.12 and figure 3.10 shows that only 17% (2 out of 12) of IT staff believed that the hospital ensured the validity of consensus processes, while 83% (10 out of 12) believed otherwise. This indicated that extent of validity consensus processes or protocols requires acritical attention as a requirement for modelling.Therefore extent of validity consensus processes or protocols of dispensed drugs at Homabay County Referral Hospital showed the absence of requirement especially in resource-limited settings like Homabay County Referral Hospital (Yue et al., 2022).

3.5.3.2 Extent of Selection Participants consensus for Validating Transactions

This subsection evaluated whether the hospital appropriately selects participants for this role. The quantitative data was collected through an observation checklist from the IT department as shown in table 3.13 and figure 3.11

Table 3.13: Extent of Presence of Selection Participants on Consensus for Validating Transactions

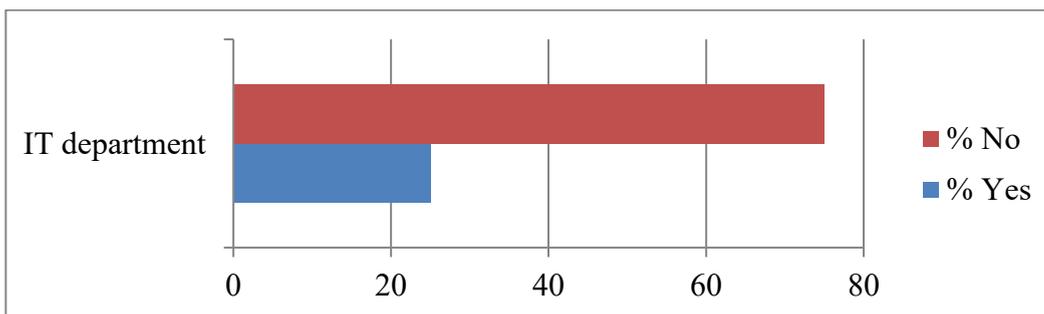| Participants	Number of Respondents	Response on the presence of selection participants on consensus for validating transactions.	
		% (Yes)	% (No)
IT department	12	25%	75%
Total	12	3	9
	Percentage %	3/15=25%	12/15=75%

Figure 3.11: Extent of Presence of Selection of Participants on Consensus for Validating Transactions

Table 3.13 and figure 3.11 present that only 25% of respondents from the checklist in IT department believed the hospital was appropriately selecting participants for transaction validation, while 75% felt the process was inadequate. This suggested that there was an absence of requirement for modelling which requires critical attention. Therefore the extent of selection of participants consensus for validating transactions of dispensed drugs showed the absence of requirement, in alignment with established standards in health informatics (Creswell & Creswell, 2018; WHO, 2021).

3.5.3.3 Summary of Consensus Processes Requirements for Dispensed Drugs

Table 3.14: Summary of Consensus Processes Requirements for Dispensed Drugs

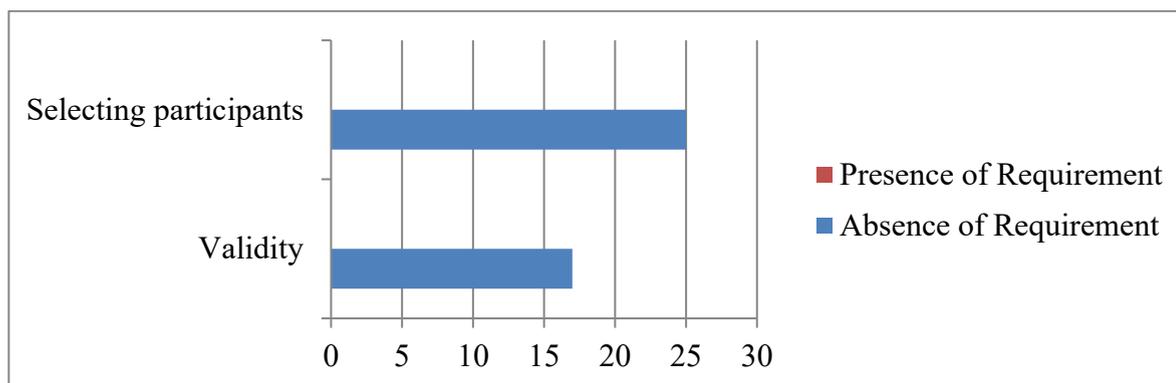| Consensus process or protocol Indicator	Current Requirement Status (Percentage %)	(WHO,2020),(FIP,2019),(ISO,2019) Standards	Presence of /Absence of requirement
Validity	17%	90% and above	Absence of requirement
Selecting participants	25%	90% and above	Absence of requirement
Total%	29.5%	90% and above	Significant absence of requirement Inferred

Figure 3.12 Summary of Consensus Processes or Protocols Requirements for Dispensed Drugs

Table 3.14 and figure 3.12 present a summarized data on the consensus mechanism at Homabay County Referral Hospital. Only 17% of dispensed medications met the validity standards recommended by WHO (2020), indicating a high prevalence of expired or compromised drugs being issued. Additionally, documentation of staff involved in the dispensing process was recorded at just 25%, far below the recommended 90% threshold (FIP, 2019). Overall compliance across all assessed areas was 29.5%, reflecting systemic deficiencies in implementing consensus standards as a requirement. Therefore summary of consensus processes or protocols requirements for dispensed drugs at Homabay County Referral Hospital showed the absence of requirement in alignment with hospital practices with international standards (WHO, 2020; FIP, 2019).

3.5.4 Access Control Cryptographic Techniques as a Requirement for Dispensed Drugs

This section addresses the use of access control cryptographic techniques to protect drug-related information during the storage and transmission of dispensed drugs at Homa Bay County Referral Hospital. The analysis evaluates the effectiveness of these techniques in ensuring the confidentiality and integrity of sensitive drug data.

3.5.4.1 Protected Access Control Cryptographic Techniques for Drug-Related Information

This subsection explores the implementation of cryptographic techniques by the use of key passwords and third key authentications within hospital settings, emphasizing their role in securing drug-related data. Data were systematically collected through a structured observation checklist with IT staff department by observing the servers and machines passwords level and third key authentications as shown in table 3.15 and figure 3.13

Table 3.15: Extent of presence of Protected Access Control Cryptographic Techniques for Drug-Related Information

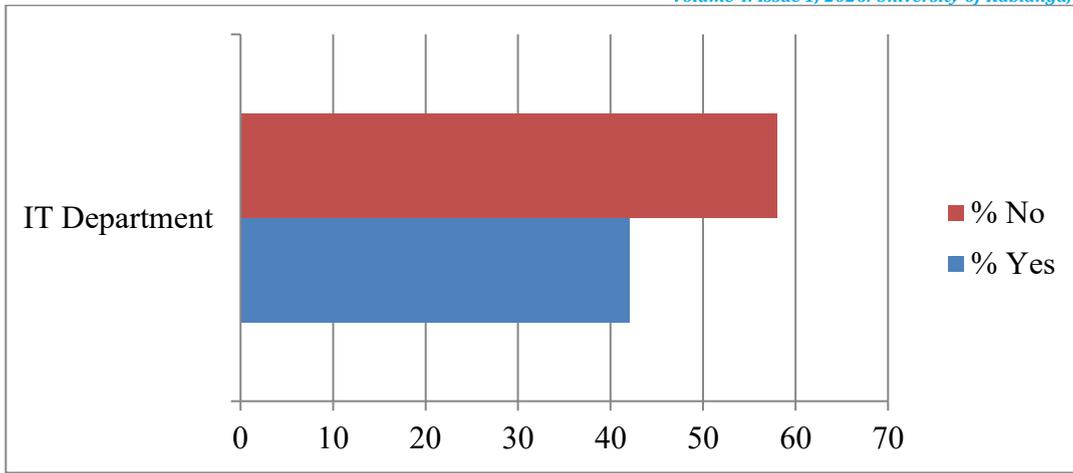| Participants	Number of Respondents	Response on the presence of protected access control (password level and third key authentication) of dispensed drugs	
		% (Yes)	% (No)
IT Department	12	42%	58%
Total	12	5	7
Percentage%`	100%	5/12=42%	7/12=58%

Figure 3.13: Extent of Presence of Protected Access Control Cryptographic Techniques

Table 3.15 and figure 3.13, present the extent of cryptographic safeguard implementation at Homabay County Referral Hospital that only 42% of IT staff reported using cryptographic methods, highlighting a low level of adoption and suggesting potential vulnerabilities in drug-related data security. Therefore extent of implementing protected access control cryptographic techniques as

requirement was absent at Homabay County Referral Hospital in alignment with Kenya's Data Protection Act (Government of Kenya, 2019).

3.5.4.2 Summary of Access Control Cryptographic Techniques as a Requirement for Dispensed Drugs

Table 3.16 Summary of Access Control Cryptographic Techniques as a Requirement for Dispensed Drugs

Access Control Cryptographic Techniques Aspects	Current Requirements Status (Percentage %)	WHO,2020,(ISO,2020) Standards	Presence of / Absence of Requirements
Protected Access Control	42%	90% and above	Significant absence of requirements Inferred
Total%	42%	90% and above	

3.5.5 Nodes and Node Discovery Requirements for Dispensed Drugs

This section evaluates the resilience of nodes and node discovery mechanisms in the system managing dispensed drugs at Homa Bay County Referral Hospital. These mechanisms are critical for ensuring that the system remains operational and that data integrity is maintained even in the face of potential disruptions.

3.5.5.1 Resilience of Nodes and Node Discovery as a

Requirement

This subsection explores the importance of node resilience and discovery mechanisms as fundamental components of system robustness, particularly in the context of healthcare settings where accurate and accessible drug-related data are crucial. Qualitative data were collected through an observation checklist with hospital's IT staff department by observing on and off premises servers of the nodes as shown in table 3.16

Table 3.16: Resilience of the System Against Data Loss for Dispensed Drugs

Participants	Response on How to Ensure Resilience of the System Against Data Loss for Dispensed Drugs
IT department	- Regular Data Backups - Disaster Recovery Planning - Data Replication

Table 3.16 present features that ensure resilience of the system against data loss for dispensed drugs such as regular data backups, disaster recovery plans and node discovery mechanisms were in place. The findings indicated that while several critical resilience strategies had been implemented, there were gaps that needed to be addressed to strengthen system robustness. Therefore resilience of the system against data loss as nodes requirements for dispensed drugs showed the absence of requirement at Homabay County Referral Hospital.

3.5.6 Transactions as a Requirement for Dispensed Drugs

Transactions are a fundamental component of managing dispensed drugs, requiring robust network management, motivation of participants and effective exchange mechanisms. This subsection evaluated the effectiveness of these transaction-related requirements at Homa Bay County Referral Hospital.

3.5.6 .1 Network Transactions and Adaptation to Participant Changes

This subsection evaluates the extent to which Homabay County Referral Hospital's network infrastructure demonstrates adaptability

in response to participant changes. Data was collected through a structured observation checklist with IT department as shown in table 3.17 and figure 3.14

Table3.17. Extent of Presences of Network Transactions and Adaptation to Participant Changes

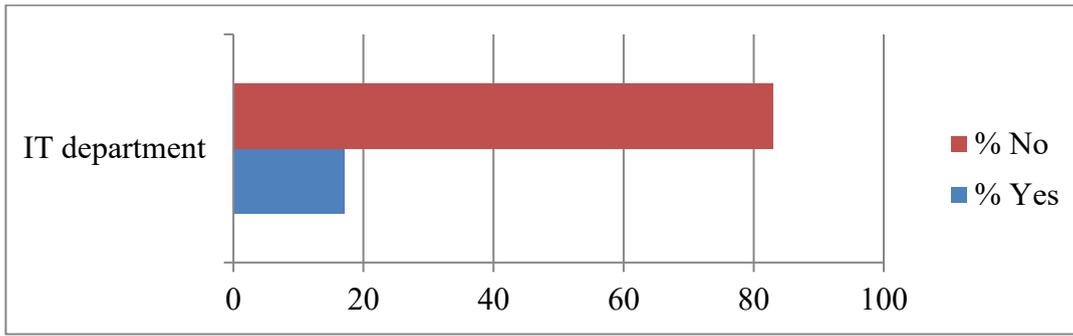| participants	Number of Respondents	Response on the Presence of Adapting Network to Participant Changes as a transaction requirement.	
		% (Yes)	**% (No)**
IT Department	12	17%	83%
Total	12	2	10
Percentage%		2/12=17%	10/12=83%

Figure 3.14: Extent of Presence of Network Transactions and Adaptation to Participant Changes

Table 3.17 and figure 3.14, the findings present that only 17% of staff changes resulted in network updates, suggesting limited adaptability within the hospital's network system. Therefore the extent of network adaptability to participant changes as node requirements of dispensed drugs at Homabay County Referral Hospital showed the absence of requirements, in alignment with the best practices in health IT management (WHO, 2019; Ministry of Health Kenya, 2020).

3.5.6.2 Motivation of Departments (Nodes) to Act Honestly and Follow Protocols as Transactions Requirement

This subsection explores the factors influencing the motivation of hospital departments (nodes) to act honestly and comply with established transaction protocols. Through qualitative observation checklists in the IT department and Hospital Administrator office, the study examines how adherence to protocols, engagement in peer review processes and leadership modeling contribute to fostering an environment of integrity and compliance among staff as shown in table 3.18

Table 3.18 Strategies Employed to Motivate Departments (Nodes)

Participants	Response on How to Motivate Departments (Nodes)
IT Department	- Clear Governance Framework
	- Continuous Improvement
	- Peer Review and Oversight:

Hospital Administrator	- Training and Education
	- Incentive Structures
	- Ethical Leadership
	- Accountability Mechanisms
	- Transparent Communication

Table 3.18 present organizational strategies such as clear policies, ethical leadership, peer oversight and transparent communication. Qualitative observation checklists demonstrated that adherence to protocols, active participation in peer review and leadership modeling positively influence staff behavior. Kibet (2023) and Mutua et al. (2022) highlighting that structured policies, committed leadership, continuous ethics education and accountability mechanisms are critical for cultivating ethical conduct in healthcare settings. Standard measures like compliance rates, participation in oversight activities and staff perception surveys serve as valuable indicators to assess progress in fostering a culture of honesty and ethical practice within healthcare institutions. Therefore honesty and
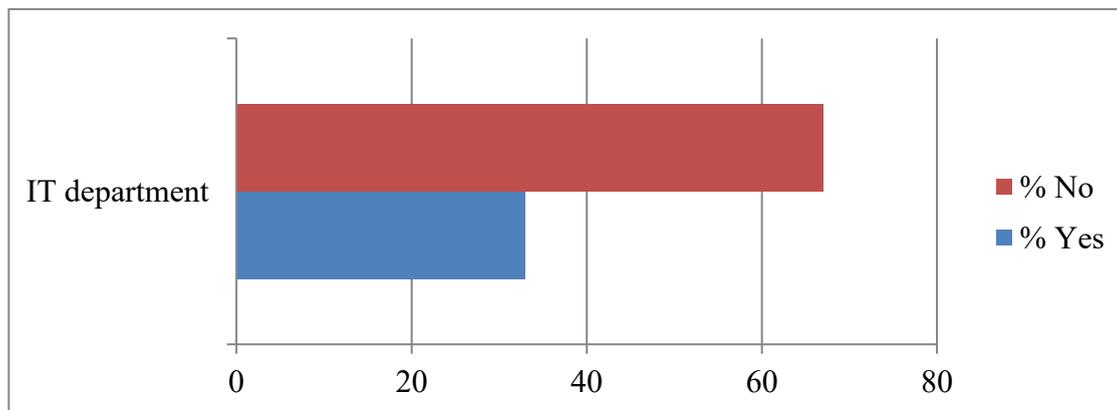
ethical behavior among healthcare workers as transactions requirements of dispensed drugs at Homabay County Referral Hospital showed the presence of requirement for modelling.

3.5.6.3 Exchange Transactions with External Systems

Hospital's proficiency in exchanging information with external systems was examined; highlighting both strengths in staff adherence to internal procedures and existing challenges related to technical barriers, Data was collected through observation checklist in 3.19 and figure 3.15

Table 3.19 Extent of Presence of Exchange of Relevant Information with External Systems:

Participants	Response on the presence of exchange of relevant information with external Systems		Total
	% (Yes)	**% (No)**	
IT Department	4/12=33%	8/12=67%	12
Total	4	8	12
Percentage% 4/12=33%	8/12=67%	100%	

Figure 3.15: Extent of Presence of External Data Sharing and Interoperability Challenges

Table 3.19 and figure 3.15 present that only 33% of IT staff are engaged in external data exchange activities. Therefore, to enhance data sharing and healthcare delivery, it is essential to strengthen leadership support, develop clear policies and adopt recognized data standards and measures, such as those outlined by HL7 (2019). These measures are expected to improve interoperability, data security and overall health information exchange. Therefore extent of external data sharing and interoperability challenges as transactions requirement of dispensed drugs at Homabay County Referral Hospital showed the absence of existing requirement

3.5.6.4 Summary of Transactions as a Requirement for Dispensed Drugs

Table 3.20 Transactions as a Requirement for Dispensed Drugs

Transaction Aspects	Current Requirement Status (Percentage %)	(WHO, 2020), (ISO, 2020) & (HL7 2019), (FIP, 2019) Standards.	Presence of /Absence of Requirements

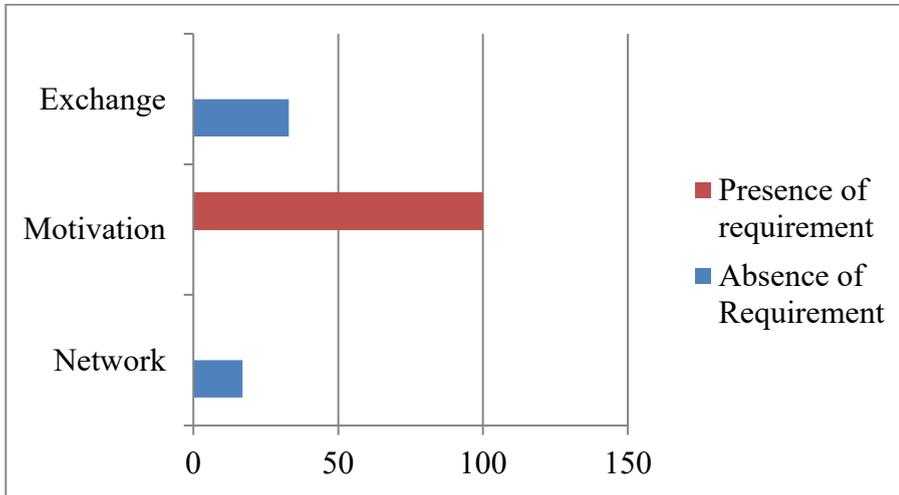|			
Network	17%	90% and above	Absence of requirement
Motivate	100%	90% and above	Presence of requirement
Exchange	33%	90% and above	Absence of requirement
Total %	50%	90% and above	Significant absence requirement inferred.

Figure 3.16: Summary of Transaction Requirements for Dispensed Drugs

Table 3.20 and figure 3.16 present that both quantitative and qualitative data were utilized to assess transaction requirements for dispensed drugs at Homabay County Referral Hospital. Quantitative data involved calculating compliance rates for each transaction aspect network, motivate and exchange based on structured observations or standardized checklists. These figures were compared against the recommended thresholds (>90%) established by international standards such as WHO (2020) and FIP (2019). For example, the network aspect's compliance at 17% indicated a significant gap, while the motivate aspect's 100% compliance demonstrated no gap. The overall compliance of 50%, which falls short of international standards. Therefore transaction requirement for dispensed drugs at Homabay County Referral Hospital showed the absence of requirement aligning with guidelines from WHO (2020) and FIP (2019).

3.5.6.5 Summary of Requirements for Dispensed Drugs

Table 3.21 Summary of requirement for dispensed drugs

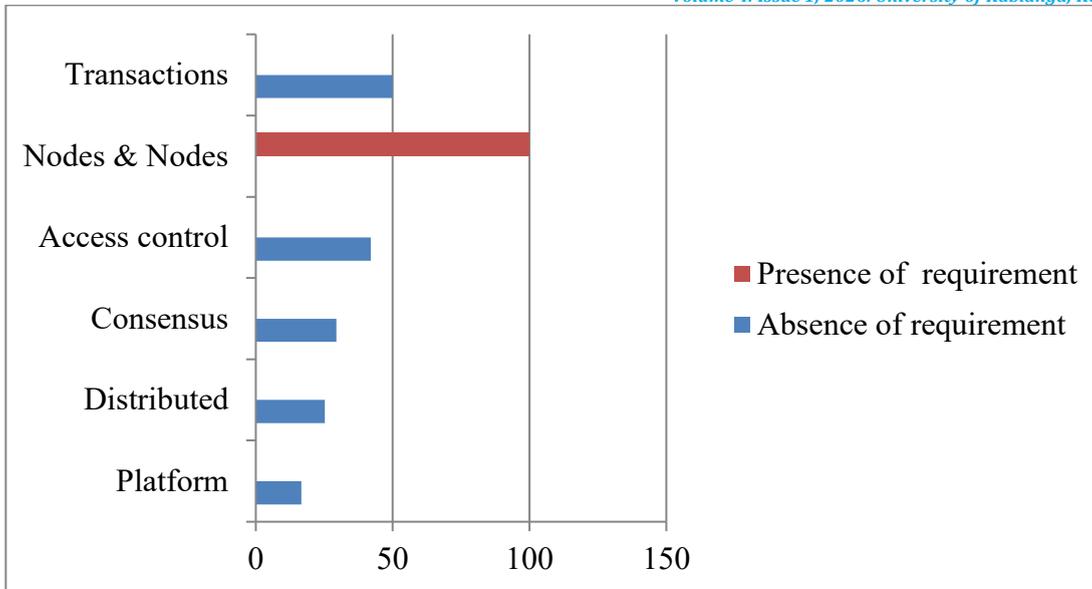| Requirements Attributes	Current Requirement Status (percentage %)	(WHO,2020),(FIP2019),(HL7,2019) Standards	Presence of /Absence of Requirement
Platform	16.7	90% and above	Absence of requirement
Distributed Ledger Technology	25.25	90% and above	Absence of requirement
Consensus Processes or Protocols	29.5	90% and above	Absence of requirement
Access Control Cryptographic Techniques	42	90% and above	Absence of requirement
Nodes and Node Discovery	100	90% and above	Presence of requirement
Transaction	50	90% and above	Absence of requirement
Total%	43.9%	90% and above	Significant absence of requirement Inferred

Figure 3.17: Summary of Requirements status.

Table 3.21 and figure 3.17,present summarized findings from quantitative and qualitative data attributes such as platform, distributed ledger technology, consensus protocols, cryptographic access control, node discovery and transactions based on standardized criteria aligned with national and international standards (Ministry of Health Kenya, 2022; WHO, 2020). The scores were analyzed by calculating mean compliance percentages, which resulted in an overall compliance rate of 43.9%. When compared to the benchmark threshold of 90%, this indicated significant systemic gaps and deficiencies. Building on this, qualitative insights obtained through interviews and observations offered contextual understanding of the underlying causes of the low compliance scores, such as infrastructural limitations and policy gaps. Therefore summary of requirement attributes of dispensed drugs at Homabay County Referral Hospital showed the absence of requirement for modeling indicating low compliance levels across most attributes (WHO, 2020).

Table 3.22 for Chi-Square Tests

Attribute Pair	Value	df	Asymp. Sig. (2-sided)
Consistency vs Platform	Pearson Chi-Square = 12.042	1	.001
DLT vs Consensus	Pearson Chi-Square = 0.068	1	.795
Access Control vs Transaction	Pearson Chi-Square = 0.396	1	.529

3.5.6.6 SPSS-style Interpretation

For Consistency vs Platform, the chi-square test was significant, χ^2 (1, N = 108) = 12.04, p = .001. The effect size (Cramer's V = .333) suggests a moderate association.

All other attribute pairs were not significant (p > .05).

3.5.6.6.1 Justification and Link to Chi-Square Results

This gap directly supports the findings from the Chi-Square/Fisher's Exact tests. Among the tested attribute pairs, only Consistency vs Platform (χ^2 = 12.04, p < 0.001) showed a statistically significant association. This implies that the design of platform requirements has a direct influence on the level of data consistency. Since consistency recorded only 50% integrity status while the platform showed 16.7% requirements compliance, the Chi-Square result confirms that weaknesses in the platform requirements are significantly linked to integrity issues in consistency (Laerd Statistics. (2019). The significant link between platform quality and data consistency suggests that the current systems may lack the robustness needed to reliably track dispensation activities, which can exacerbate issues like drug shortages, wastage, or misadministration. Given these insights, addressing the root cause platform inadequacies is essential. A system that ensures data integrity, transparency and auditability can dramatically reduce errors and gaps. This is particularly crucial in settings where manual or semi-digital systems are vulnerable to human error, data manipulation, or loss.

In essence, the statistical evidence underscores a fundamental truth that the platform used for data capture and management is a critical leverage point. Investing in a blockchain-based system is a strategic move to transform data governance, foster trust among stakeholders and ultimately ensure that patients receive the right medication at the right time, with accurate records to support safe and effective care

4.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

4.1 Summary of Findings

4.1.1 What are the requirements for blockchain model for the reinforced data integrity of dispensed drugs?

The study revealed significant deficiencies in the technological infrastructure of Homabay County Referral Hospital for implementing blockchain to secure dispensed drug data. Key findings showed platform compliance at only 16.7%, adherence to Distributed Ledger Technology at 25.25%, consensus protocols at 29.5% and access control cryptography at 42%, all below the recommended standards. Nodes and node discovery processes achieved full compliance (100%), but transaction process compliance was only 50%, leading to an overall compliance rate of 43.9%, significantly below the >90% threshold advised by health information system standards (Ministry of Health, Kenya, 2022; WHO, 2020). In conclusion, the current technological framework is inadequate for modeling an effective blockchain system and targeted improvements are essential to ensure data integrity, security and compliance with global health standards, thereby improving drug dispensation and patient safety.

4.2 Conclusions

The study identified that the hospital's technological infrastructure was inadequate for modeling an effective blockchain system, with compliance levels falling well below recommended standards in key areas such as platform adherence, consensus protocols, and security measures. These deficiencies highlighted the necessity of upgrading infrastructure, enforcing protocol adherence and enhancing security features to meet global health information standards, which would be essential for ensuring data integrity and improving drug dispensation processes.

4.3 Recommendations

This study recommends that the hospital prioritize upgrading its technological infrastructure by investing in modern hardware and software capable of supporting blockchain technology. Additionally, it was essential to develop and enforce protocols for platform compliance, consensus mechanisms and security measures, which

can be vital for meeting international standards and ensuring the integrity and security of drug dispensation data.

4.4 Suggestion for Further Research

It was suggested that future research examined the feasibility and scalability of implementing blockchain technology within similar healthcare settings. Studies could analyze the cost-benefit aspects, technical challenges and user acceptance of blockchain systems, providing insights into best practices for infrastructure development and protocol adherence in resource-limited environments.

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