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Information Integration, Technology Integration and Performance of Level Four Hospitals in Nairobi City County, Kenya

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Abstract

Level four hospitals in Nairobi City County continue to face stockouts, delayed supplies and weak information flow. Many facilities still rely on manual inventory systems. This study examined the influence of information integration and technology integration on the performance of level four hospitals in Nairobi City County, Kenya. The study was guided by Information Theory and the Technology Acceptance Model. A cross-sectional survey design was adopted. The target population was 246 supply chain managers and procurement officers in 123 level four hospitals listed by the Social Health Authority (2024). A sample of 152 respondents was selected through stratified random sampling. Primary data were collected using a self-administered questionnaire. A total of 125 questionnaires were returned, giving a response rate of 82.2%. Data were analysed using SPSS version 28 through descriptive statistics, Pearson correlation and multiple linear regression. Information integration had a moderate, positive and significant correlation with performance ($r = 0.471$, $p < 0.01$). Technology integration had a weak, positive and significant correlation with performance ($r = 0.291$, $p < 0.01$). The two practices jointly explained 26.5% of the variation in performance ($R^2 = 0.265$, $F = 22.041$, $p < 0.001$). Information integration ($\beta = 0.432$, $p < 0.001$) had a stronger effect than technology integration ($\beta = 0.212$, $p = 0.008$). The study concludes that information integration and technology integration significantly improve the performance of level four hospitals. The study recommends that hospitals adopt clear policies for protecting supply chain information, integrate real-time location systems such as RFID and IoT devices, and base supply chain decisions on analytics drawn from historical and real-time data.

Keywords: *Information integration, Technology integration, Supply chain optimization, Hospital performance, Level four hospitals, Kenya*

INTRODUCTION

Supply chain optimization in healthcare is a critical process aimed at enhancing the efficiency and effectiveness of delivering essential medical supplies and services. It involves the planning, implementation and control of the flow of goods and information from the point of origin to the point of consumption, ensuring timely availability and cost-effectiveness (Schneller et al., 2023). Effective supply chain management is not merely a logistical concern. It directly affects patient outcomes, operational costs and the resilience of healthcare systems. Modern approaches to optimization leverage data, technology and collaborative partnerships to streamline processes, reduce waste and improve responsiveness to fluctuating demand. Digital platforms, such as electronic health records and inventory management

systems, facilitate real-time tracking and decision-making. This enables healthcare facilities to anticipate and address potential disruptions (Schneller et al., 2023).

Globally, information and technology have become central to healthcare supply chain optimization. In the United Kingdom, healthcare wholesalers have adopted AI-driven demand forecasting and automated supplier ordering to reduce stock holding and ensure timely deliveries (Abedi et al., 2023; Jones, 2025). In China, authorities have invested in supply chain management platforms, e-procurement and analytics that link manufacturing, distribution and hospital demand, which shortens lead times and reduces mismatches between supply and local demand (Jiang et al., 2024; Zhang et al., 2024). In Africa, public health supply chains increasingly depend on national forecasting, analytics and centralized coordination to improve visibility across tiers of the health system (Takawira & Pooe, 2024).

In Kenya, supply chain optimization starts with improving visibility across the national and county tiers. Modern optimization emphasizes interoperable Logistics Management Information Systems (LMIS), so that facility consumption directly drives re-supply rather than ad hoc requests (Mwaiwa, 2024). The national push to harmonize LMIS platforms and roll out commodity dashboards has reduced reporting lag and supported better allocation of limited stocks (Mwaura & Noor, 2025). In Nairobi City County, electronic supply chain practices such as e-procurement are increasingly recognized for reducing stock pilferage and delayed deliveries. However, adoption remains uneven, and many public hospitals still face poor demand forecasting and frequent stockouts (Adhiambo & Juma, 2025). At the community level, platforms such as cStock allow health workers to report stock levels and request resupplies in real time (Njagi, 2021).

Level four hospitals in Nairobi City County form a key part of the county's referral network. They include facilities such as Mama Lucy Kibaki Hospital, Mbagathi Hospital and Pumwani Maternity Hospital (Njuguna, 2024). The county's use of electronic health information systems and data-driven decision-making has improved service responsiveness and accountability (Karimi et al., 2025). Performance in these facilities is measured through cost effectiveness, reliability and timeliness of supply chain processes (Kirimi, 2023). Despite investments, stockouts and disruptions continue to undermine service delivery (Bilal et al., 2024).

Statement of the Problem

In an optimally functioning healthcare system, supply chains ensure uninterrupted access to medicines, medical equipment and technologies through integrated digital platforms and real-time inventory tracking. Kenya's Digital Healthcare Superhighway initiative under the Digital Health Act of 2024 envisions such a system, with end-to-end visibility across procurement, distribution and utilization (Josiah et al., 2024). However, the reality in Nairobi City County reflects persistent systemic failures. Despite increased funding, 63% of public health facilities report stockouts of essential medicines, while 41% experience delays exceeding three months in receiving county-allocated medical supplies (Okombo, 2022). Up to 30% of essential medicines are often unavailable in public health facilities in Kenya, with Nairobi experiencing similar challenges (Ministry of Health [MOH], 2023).

Many facilities rely on manual inventory management systems, which are prone to errors and delays. Data systems such as the Kenya Health Information System (KHIS) and the LMIS are not fully integrated, which delays data on stock levels and consumption (Bunyali, 2023). Limited funding and inadequate ICT infrastructure further hinder the adoption of technology-driven solutions (Machanga, 2024). Prior studies in Kenya have examined supply chain management practices in general (Kaitany, 2022; Kirimi, 2023), while policy documents such as the Health Products and Technologies Supply Chain Strategy 2020–2025 present integrated digital platforms largely as recommendations without empirical validation at facility level (MOH, 2020). There is limited empirical evidence on how information

integration and technology integration influence the performance of level four hospitals in Nairobi City County. This study sought to fill this gap.

Objectives of the Study

The general objective was to investigate the influence of information integration and technology integration on the performance of level four hospitals in Nairobi City County, Kenya. The specific objectives were:

i. To examine the influence of information integration on the performance of level four hospitals in Nairobi City County, Kenya.

ii. To analyse the influence of technology integration on the performance of level four hospitals in Nairobi City County, Kenya.

Research Hypotheses

H_{01}: Information integration has no significant influence on the performance of level four hospitals in Nairobi City County, Kenya.

H_{02}: Technology integration has no significant influence on the performance of level four hospitals in Nairobi City County, Kenya.

LITERATURE REVIEW

Theoretical Review

Information Theory

Information Theory postulates that the effective flow, processing and integration of information across a supply chain are critical to reducing uncertainty, enhancing coordination and improving overall system performance. In supply chains, information integration involves the seamless exchange of accurate, timely and relevant data among all stakeholders (Kusumawati, 2025). Information acts as a vital resource that reduces information asymmetry and enables partners to synchronize forecasting, procurement, inventory management and logistics. However, the theory assumes that data are always accurate, timely and accessible. This is often not the case in resource-constrained settings with infrastructure gaps, low automation and poor connectivity (Schneller et al., 2023). In Nairobi's level four hospitals, which face fragmented data systems and delayed information flow (Kaitany, 2022), the theory explains how better information sharing can improve coordination, reduce stockouts and lower costs. The theory anchored the information integration variable.

Technology Acceptance Model (TAM).

TAM postulates that the adoption and use of technology are mainly determined by perceived usefulness and perceived ease of use. These perceptions shape users' attitudes and intentions, which in turn affect actual use (Camilleri & Falzon, 2021). When users perceive a technology as useful and easy to use, their motivation to integrate it into daily operations increases. Critics argue that TAM focuses narrowly on individual perceptions and overlooks organizational barriers such as infrastructure gaps, resistance to change, interoperability problems and management support (Lee et al., 2025). In healthcare supply chains, TAM helps explain how staff adopt digital inventory systems, e-procurement platforms and real-time tracking tools (Nguyen et al., 2020). Given the variable technological readiness of Nairobi's public hospitals, the model guided the technology integration variable.

Conceptual Framework

The conceptual framework in Figure 1 shows the relationship between the independent variables (information integration and technology integration) and the dependent variable (performance of level four hospitals).

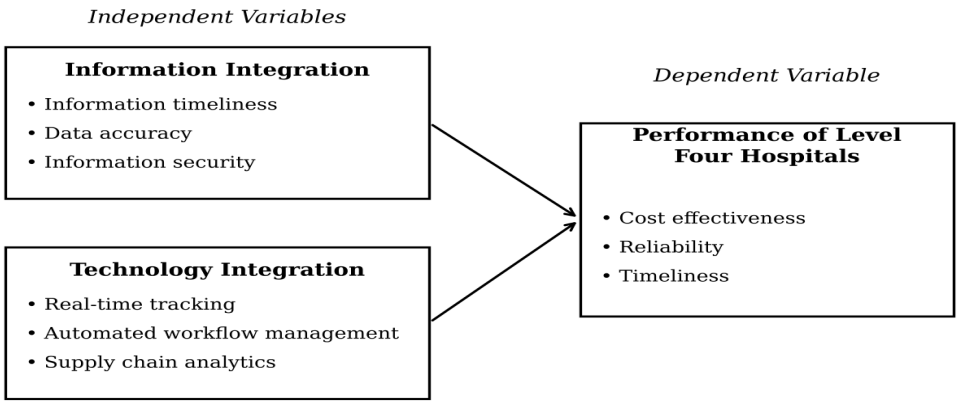


Figure 1: Conceptual Framework

Information Integration and Performance

Timely information is vital for anticipating stock levels, ordering medicines and responding rapidly to disruptions. In Kenya, fragmented systems such as KHIS and the LMIS of the Kenya Medical Supplies Authority delay the availability of data on stock levels and consumption (Bunyali, 2023). Interoperable electronic LMIS platforms and real-time dashboards aim to improve data timeliness across county and national agencies (Friday et al., 2021). Accurate data are equally important. When logistics and inventory data are kept in isolated or manual systems, errors and inconsistencies occur. Many lower-level facilities in Kenya still rely on manual record-keeping, which limits data accuracy (Oyugi et al., 2020). Information integration must also protect sensitive health and supply chain data. User authentication, data encryption and regular audits help safeguard integrated systems against cyber threats (Maraj et al., 2024).

Empirically, Aldoseri et al. (2023) found that integrating IoT, AI and cloud-based platforms improves real-time visibility, reduces manual errors and enhances collaboration in healthcare supply chains, although cost and data security remain challenges. In Tanzania, Mkumbwa et al. (2023) found that fragmented data systems, unreliable connectivity and lack of standard protocols limited the use of electronic LMIS data in public health facilities. In Kenya, the Health Products and Technologies Supply Chain Strategy 2020–2025 identified integrated information systems as a cornerstone of supply chain optimization, but it relied on policy analysis rather than empirical data (MOH, 2020).

Technology Integration and Performance

Real-time tracking systems give supply chain managers up-to-date information on inventory movement and consumption, which minimizes stockouts and expiries. In Kenya, tools such as the electronic community health information system and cStock have enhanced real-time data capture at community and facility levels (Hannedige, 2021). Automated workflow management reduces manual intervention and speeds up operations from ordering to delivery. LMIS implementation in level four and five hospitals has improved tracking, quantification and order traceability. However, limited computer access and internet connectivity remain challenges (Machanga, 2024). Supply chain analytics consolidates data from KHIS, LMIS and facility records into dashboards that support data-driven decisions (Machanga, 2024).

Empirically, Chowdhury (2025) found that RFID, IoT sensors and robotic process automation reduced hospital stockouts by up to 73% and lowered inventory carrying costs by 25–30%. Msowoya (2022) documented how OpenLMIS in Malawi and One Network in Rwanda improved data visibility, raised in-stock levels and reduced wastage in public health supply chains. In Kenya, Gathecha et al. (2023) found that a digital health platform could be integrated into national health data systems with no data loss, provided infrastructure and human capacity were supported.

Research Gap

Most of the reviewed studies were conducted outside Kenya or used case, review or simulation designs (Msowoya, 2022; Aldoseri et al., 2023; Chowdhury, 2025). Kenyan policy documents emphasize integrated digital platforms but lack rigorous empirical validation at facility level (MOH, 2020). Local studies such as Bunyali (2023) and Machanga (2024) focused on commodity availability in other counties. Few studies have examined information integration and technology integration together and tested their influence on the performance of level four hospitals in Nairobi City County. This study addressed this gap.

RESEARCH METHODOLOGY

The study adopted a cross-sectional survey design. This design collects data from a population at a specific point in time and describes what exists about the variables (Nardi, 2018). The target population was the 123 level four hospitals in Nairobi City County listed by the Social Health Authority (2024). The hospitals were the unit of analysis, while supply chain managers and procurement officers were the unit of observation, giving a population of 246 respondents. The sample size was determined using the Yamane (1967) formula, $n = N / (1 + N(e)^2)$, at a 5% margin of error. This gave a sample of 152 respondents, who were selected through stratified random sampling.

Primary data were collected using a self-administered questionnaire with closed and open-ended items. Closed items were measured on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Each variable was measured using nine items. The questionnaire was administered through the drop-and-pick method, and respondents had about two weeks to complete it. A pilot test was conducted with 15 respondents from level four hospitals in Kiambu County, who were excluded from the main study. Content validity was established through review by supervisors and experts in procurement and logistics. Construct validity was ensured by restricting items to the operationalized variables and indicators. Reliability was tested using Cronbach's alpha, with 0.7 as the threshold (Drost, 2011).

Data were analysed using SPSS version 28. Descriptive statistics included frequencies, percentages, means and standard deviations. Means were interpreted as: 4.2–5.0 strongly agree, 3.4–4.2 agree, 2.6–3.4 undecided, 1.8–2.6 disagree and 1.0–1.8 strongly disagree (Vivek & Bonny, 2023). Inferential analysis used Pearson correlation and multiple linear regression at the 5% significance level. The regression model was:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon$$

Where Y is the performance of level four hospitals, β_0 is the constant, β_1 and β_2 are the regression coefficients, X_1 is information integration, X_2 is technology integration and ε is the error term.

RESULTS

Response Rate and Reliability

Out of 152 questionnaires distributed, 125 were completed and returned, giving a response rate of 82.2%. This was adequate for analysis, as a response rate of 70% and above is considered excellent (Mugenda & Mugenda, 2003). The reliability results in Table 1 show that all Cronbach's alpha values were above 0.7, indicating satisfactory internal consistency.

Table 1: Reliability Results

Variable	Cronbach's Alpha	No. of Items	Decision
Information Integration	.728	9	Accepted
Technology Integration	.791	9	Accepted
Performance	.906	9	Accepted

Source: Pilot data (n = 15)

Of the 125 respondents, 52.0% were procurement officers and 48.0% were supply chain managers. Most (63.2%) held a bachelor's degree, 20.8% a master's degree and 16.0% a college diploma. Most respondents (92.8%) had served in their facilities for more than five years. This shows that they understood the supply chain practices in their facilities.

Descriptive Results

Information integration. Table 2 shows that respondents strongly agreed that their facility receives supply chain information in time to make effective decisions (mean = 4.40, SD = 0.933) and that information on inventory levels matches actual stock (mean = 4.35, SD = 0.927). They agreed that there are regular reviews of information security measures (mean = 4.20, SD = 1.143) and that real-time information is available for tracking inventory (mean = 4.11, SD = 1.101). However, respondents were undecided on whether their facility has clear policies for protecting supply chain information (mean = 3.26, SD = 1.386). The aggregate mean was 3.98, indicating that information integration was largely practised.

Table 2: Information Integration Practices

Statement	Mean	Std. Dev.
Our facility receives supply chain information in time to make effective decisions	4.40	.933
Real-time information is available for tracking inventory levels	4.11	1.101
Our facility uses technology to ensure timely access to supply chain data	3.87	1.114
Supplier records are free from significant errors or inconsistencies	4.02	1.032
Data accuracy is prioritized during information entry and reporting processes	3.84	1.174
Information on inventory levels matches the actual stock in the facility	4.35	.927
Our facility has clear policies for protecting supply chain information	3.26	1.386
We use secure systems to store and transmit supply chain information	3.74	.977
There are regular reviews of our information security measures	4.20	1.143
Aggregate mean	3.98	

Source: Field data (n = 125)

Technology integration. Table 3 shows that respondents agreed that their facility employs robotic process automation or equivalent technology (mean = 4.16, SD = 1.081) and that predictive analytics are used to anticipate disruptions (mean = 3.99, SD = 1.323). They also agreed that automated systems manage routine processes (mean = 3.86, SD = 1.050) and that data analytics tools identify inefficiencies (mean = 3.86, SD = 1.127). However, respondents were undecided on the use of real-time tracking systems (mean = 3.22, SD = 1.319), the integration of RFID and IoT devices (mean = 2.60, SD = 1.596), cost savings from workflow automation (mean = 2.97, SD = 1.508) and the use of analytics-based insights in decisions (mean = 3.13, SD = 1.586). The aggregate mean was 3.51, indicating moderate technology integration.

Table 3: Technology Integration Practices

Statement	Mean	Std. Dev.
We use real-time tracking systems to monitor the movement of	3.22	1.319

Statement	Mean	Std. Dev.
medical supplies		
Real-time tracking improves the visibility of inventory across different departments	3.78	1.005
Real-time location systems (e.g., RFID, IoT devices) are integrated into our supply chain management	2.60	1.596
Automated systems are used to manage routine supply chain processes, reducing manual intervention	3.86	1.050
Our facility employs robotic process automation (RPA) or equivalent technology to streamline supply chain tasks	4.16	1.081
Workflow automation improves overall efficiency and reduces supply chain operational costs	2.97	1.508
Data analytics tools are employed to identify inefficiencies within the supply chain	3.86	1.127
Predictive analytics are used to anticipate supply chain disruptions or emergency needs	3.99	1.323
Supply chain decisions are supported by analytics-based insights from historical and real-time data	3.13	1.586
Aggregate mean	3.51	

Source: Field data (n = 125)

Performance. Table 4 shows that respondents agreed that their facility minimizes wastage and loss of medical supplies (mean = 4.10, SD = 1.046), that supply chain processes are dependable in meeting patients' needs (mean = 4.00, SD = 1.143) and that stock is replenished rapidly when demand increases (mean = 3.98, SD = 1.205). They were undecided on whether investments in supply chain optimization have led to measurable cost reductions (mean = 2.94, SD = 1.477) and whether contingency plans are in place to handle disruptions (mean = 3.20, SD = 1.529). The aggregate mean was 3.68.

Table 4: Performance of Level Four Hospitals

Statement	Mean	Std. Dev.
Cost-saving measures are regularly identified and implemented in supply chain activities	3.69	1.043
Our facility minimizes wastage and loss of medical supplies through effective cost control	4.10	1.046
Investments in supply chain optimization have led to measurable cost reductions	2.94	1.477
Our suppliers meet agreed delivery schedules with minimal errors	3.73	1.088
Supply chain processes are dependable in meeting patients' healthcare needs	4.00	1.143
Contingency plans are in place to handle supply chain disruptions effectively	3.20	1.529
The supply chain enables rapid replenishment of stock when demand increases	3.98	1.205
Delays in the supply chain are promptly communicated and	3.78	1.046

Statement	Mean	Std. Dev.
managed		
Our facility prioritizes timely processing of supply chain orders to meet patient needs	3.74	1.106
Aggregate mean	3.68	

Source: Field data (n = 125)

Correlation Analysis

Table 5 shows that information integration had a moderate, positive and significant correlation with performance ($r = 0.471$, $p < 0.01$). Technology integration had a weak, positive and significant correlation with performance ($r = 0.291$, $p < 0.01$). The correlation between the two independent variables was weak ($r = 0.182$), which shows that multicollinearity was not a concern.

Table 5: Correlation Matrix

Variable	Information Integration	Technology Integration	Performance
Information Integration	1		
Technology Integration	.182* (.043)	1	
Performance	.471** (.000)	.291** (.001)	1

*** Significant at the 0.01 level; * significant at the 0.05 level (2-tailed); p-values in parentheses; n = 125*

Regression Analysis

Table 6 shows that information integration and technology integration jointly explained 26.5% of the variation in the performance of level four hospitals ($R^2 = 0.265$, adjusted $R^2 = 0.253$). The remaining 73.5% is explained by other factors not covered in this study.

Table 6: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of Estimate
1	.515	.265	.253	.948

Predictors: (Constant), Technology Integration, Information Integration

The ANOVA results in Table 7 show that the model was statistically significant ($F = 22.041$, $p < 0.001$). This means that information integration and technology integration jointly have a significant influence on the performance of level four hospitals.

Table 7: ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	39.593	2	19.796	22.041	.000
Residual	109.575	122	.898		
Total	149.168	124			

Dependent variable: Performance

Table 8 presents the regression coefficients. Information integration had a positive and significant effect on performance ($\beta = 0.432$, $t = 5.479$, $p < 0.001$). Hence, H_{01} was rejected. Technology integration also had a positive and significant effect on performance ($\beta = 0.212$, $t = 2.690$, $p = 0.008$). Hence, H_{02} was rejected. Information integration was the stronger predictor.

This implies that a unit increase in information integration increases performance by 0.626 units, and a unit increase in technology integration increases performance by 0.179 units, holding the other variable constant.

Table 8: Regression Coefficients

Model	B	Std. Error	Beta	t	Sig.
(Constant)	1.371	.572		2.397	.018
Information Integration	.626	.114	.432	5.479	.000
Technology Integration	.179	.067	.212	2.690	.008

Dependent variable: Performance

Discussion

The study found that information integration had a positive and significant influence on the performance of level four hospitals. Timely supply chain information and stock records that match physical stock were the strongest practices. This agrees with Aldoseri et al. (2023), who found that real-time data sharing reduces manual errors and improves responsiveness in healthcare supply chains. It also supports Friday et al. (2021), who noted that shared, timely data help hospitals maintain optimal inventory and reduce stockout risks. The finding is consistent with Information Theory, which holds that accurate and timely information reduces uncertainty and improves coordination (Kusumawati, 2025). However, the study found weak policies for protecting supply chain information. This agrees with Maraj et al. (2024), who noted that integrated health information systems require strong security protocols such as authentication, encryption and audits. It also reflects the fragmented data systems reported by Bunyali (2023) and Mkumbwa et al. (2023).

Technology integration also had a positive and significant influence on performance, although its effect was weaker than that of information integration. Facilities reported using automation and predictive analytics. However, real-time tracking, RFID and IoT devices were not widely integrated, and many respondents were unsure whether automation had reduced costs. This agrees with Machanga (2024), who found that LMIS improved order traceability in level four and five hospitals but was limited by poor computer access and connectivity. The positive effect is consistent with Chowdhury (2025) and Msowoya (2022), who found that automation and digital supply chain platforms improve stock availability and reduce wastage. The weaker effect may be explained by TAM and its critics. Technology adds value only when staff accept and use it, and adoption in public hospitals is constrained by infrastructure, skills and management support (Lee et al., 2025; Nguyen et al., 2020).

Together, the findings suggest that technology produces better results when it is backed by accurate, timely and secure information. Facilities that have invested in information systems are better placed to convert technology into improved cost control, reliability and timeliness.

Conclusion and Recommendations

Conclusion

The study concludes that information integration significantly improves the performance of level four hospitals in Nairobi City County. Timely and accurate supply chain information enhances responsiveness and reduces delays in procurement. The study also concludes that technology integration significantly improves performance. Automation and analytics tools help facilities identify inefficiencies and anticipate disruptions. Information integration was the stronger predictor of the two practices.

Recommendations

Level four hospitals should develop clear policies for protecting supply chain information and use secure systems to store and transmit data. They should ensure that technology is used to give timely access to supply chain data and that supplier records are free from errors. The hospitals should also integrate real-time location systems such as RFID and IoT devices into

supply chain management. They should ensure that workflow automation delivers measurable cost savings and that supply chain decisions are supported by analytics from historical and real-time data. The county government and the Ministry of Health should invest in ICT infrastructure and staff training to support these practices.

Limitations and Areas for Further Research

The study used a cross-sectional design and self-reported data from level four hospitals in one county. This limits causal inference and generalization. The two practices explained 26.5% of the variation in performance. Future studies should examine other supply chain practices, use objective performance data and extend the study to other counties and levels of care.

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