Enhancing health security system preparedness: The impact of operational practices on medical supply chain resilience in Kenya

Veronica Aluoch Owuor[1]
Paul M. Gachanja[2]
Mumo Nzau[3]

[1]aluochowuor@gmail.com (0721587240)

[1,2,3] National Defence University, Kenya

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ABSTRACT

This study examined the influence of operational practices on supply chain resilience at the Kenya Medical Supplies Authority (KEMSA). In view of recurrent public health emergencies, strengthening supply chain resilience is essential for national health security preparedness. Anchored in resilience theory, the study employed a convergent mixed-methods research design. Data were collected from 115 questionnaire respondents and 15 key informants, achieving a 100% response rate. Quantitative data were analysed using descriptive and multiple regression analysis, while qualitative data were analysed thematically. The findings indicate a moderate level of supply chain resilience (Supply Chain Resilience Index = 2.97/5) and a relatively high implementation of operational practices (Supply Chain Operational Practices Index = 3.31/5). The regression model explained 53% of the variation in supply chain resilience ($R^2 = 0.53$, $p < .001$). Supplier management emerged as the strongest predictor of resilience ($\beta = 0.41$, $p < .001$), followed by inventory control and policy compliance ($\beta = 0.27$, $p < .001$), system coordination and digitization ($\beta = 0.23$, $p = .001$), governance and control ($\beta = 0.19$, $p = .008$), and demand planning and forecasting ($\beta = 0.16$, $p = .026$). Applying resilience theory, the study demonstrates that operational practices collectively determine the ability of health supply chains to anticipate, absorb, and recover from disruptions. The study concludes that strengthening operational practices enhances supply chain resilience and recommends supplier diversification, improved data integration, stronger governance mechanisms, and enhanced inventory management to improve health system preparedness.

Keywords: Health Supply Systems; Kenya Medical Supplies Authority (KEMSA), Procurement Practices; Public Health Logistics; Supply Chain Resilience; Supplier Management

I. INTRODUCTION

Traditionally, security of the person was assumed to be part of the security of the state; thus, if the state is secure, the human person is secure. However, the last five decades have witnessed several threats to human life that are unrelated to the traditional conceptualization of national security. Global epidemics such as Ebola, HIV, and Covid 19 have not only changed how human beings relate but also national states. The World Health Organization (WHO) defines health security as a set of measures taken to prevent or respond to public health emergencies, undertaken by a state to reduce the risk and impact (World Health Organization, 2024). A public health emergency, on the other hand, may be defined as an event that endangers the health of a large proportion of a country's population, in a way that overwhelms or threatens to overwhelm the capacity of the health system (Gostin & Katz, 2016),

Public health emergencies can result in economic slowdowns, job losses, and disruptions to livelihoods due to response measures such as lockdowns. In severe cases, such disruptions can even contribute to social and political unrest. Consequently, a public health emergency, and by extension health security, may extend beyond healthcare concerns and become a matter of national security (World Health Organization, 2005; Gostin & Katz, 2016; World Bank, 2020).

Recent public health emergencies, such as the global COVID-19 pandemic and the recurrent Ebola outbreaks in Central Africa, have exposed the vulnerabilities of health systems in many countries, with medical supply chains emerging as key points of failure. For instance, during the COVID-19 pandemic, many countries reported severe shortages of essential medical commodities, including personal protective equipment (PPE), diagnostic equipment, and medicines (World Bank, 2020; OECD, 2020; World Health Organization, 2020). Notably, these shortages were attributed to various underlying structural weaknesses in supply chains, including logistical issues, transportation challenges, and import bottlenecks (Ivanov & Dolgui, 2020; Gereffi, 2020).

Although these vulnerabilities occur even in well-resourced health systems, they are more pronounced in low- and middle-income regions, especially in Sub-Saharan Africa. Sub-Saharan Africa is characterized by weak transport infrastructure, limited cold-room capacity due to inadequate electricity, and other logistical challenges (African Centers for Disease Control and Prevention, 2024; Mishra, 2023). These vulnerabilities are further complicated by frequent

disease outbreaks, including Ebola and cholera, often resulting in stockouts and disruptions to essential health services (Moynihan et al., 2015). Furthermore, Sub-Saharan Africa relies heavily on imported medical commodities, which increases its vulnerability to global supply shocks, trade restrictions, and price volatility (Mishra, 2023; International Monetary Fund, 2024).

One of the Sub-Saharan countries that is vulnerable to public health emergencies is Kenya, where persistent inefficiencies in the medical supply chain continue to undermine health security. Available evidence indicates that a significant proportion of public health facilities in Kenya experience stockouts of essential medicines (Kalola et al., 2025). According to a 2020 report by the Kenya Medical Supplies Authority (KEMSA), 44% of public health facilities in Kenya are understocked (KEMSA, 2020). More recent evidence suggests that these challenges persist, especially at the county level (Karimi et al., 2025; Ministry of Health, Kenya, 2023).

In Kenya, the agency charged with managing the medical supply system for public health facilities is the Kenya Medical Supplies Authority (KEMSA). The agency is solely responsible for procurement, warehousing, and distribution of medical commodities in the country. KEMSA is therefore responsible for managing the availability and accessibility of medical supplies, including during medical emergencies. However, evidence suggests that KEMSA's medical supply chain is efficient, thereby increasing the country's vulnerability to public health emergencies. For instance, a recent media report indicated that essential medicines worth approximately Kshs 1 billion expired at KEMSA, despite reported shortages in public health facilities (Owoko, 2026). This situation is not unique to Kenya, with similar inefficiencies reported in Ethiopia (Diriba et al., 2022).

These persistent challenges, such as stockouts of medical commodities at the county level and the expiry of essential medicines at the KEMSA warehouse, suggest inefficiencies or gaps in supply chain operations. The challenges suggest inefficiencies in anticipating, absorbing, and responding to supply chain shocks. This study therefore sought to examine KEMSA's supply chain operational practices and determine its influence on national health security preparedness in Kenya.

1.1 Statement of the Problem

Global public health emergencies, such as COVID-19, and regional emergencies, including s recurrent Ebola outbreaks, have exposed the vulnerability of health systems, especially in developing countries. These emergencies have resulted in disruptions to medical supply chains in public health sectors, marked by stockouts, delayed deliveries, and inequitable distribution of essential commodities. These challenges are compounded by weak infrastructure and heavy reliance on imports, which make health systems in developing countries increasingly vulnerable to such shocks. In Kenya, these challenges are evident within the Kenya Medical Supplies Authority (KEMSA), where widespread stockouts at health facilities, as well as significant wastage due to expired commodities, reveal inefficiencies in supply chain operations.

While prior studies have examined elements such as procurement, inventory control, and governance, they largely treat these components in isolation. This results in limited insight into how integrated operational practices may shape overall supply chain resilience. Moreover, most of the evidence is from high-income contexts, leaving a critical gap in understanding how such practices function within resource-constrained systems like KEMSA. Consequently, there remains insufficient empirical evidence on how operational practices collectively influence the capacity of medical supply chains to anticipate, absorb, and recover from disruptions. This study addresses this gap by examining the influence of supply chain operational practices on resilience within KEMSA, situating the analysis within the broader framework of national health security preparedness.

1.2 Research Objectives

i. Assess the effect of supplier management on supply chain resilience at KEMSA.
ii. Evaluate the influence of inventory control and policy compliance on supply chain resilience at KEMSA.
iii. Determine the effect of system coordination and digitization on supply chain resilience at KEMSA.
iv. Examine the influence of governance and control on KEMSA's supply chain resilience.
v. Assess the effect of demand planning and forecasting on supply chain resilience at KEMSA.

II. LITERATURE REVIEW

2.1 Theoretical Review

This limitation points to the need for a theoretical lens that moves beyond fragmented analysis of individual strategies and instead conceptualizes supply chain operational practices as being multidimensional and integrated. In this regard, this study was guided by resilience theory, with a national security perspective. From a resilience theory perspective, health supply chains are not merely administrative logistics systems but also components of national

security. Resilience theory explains resilience as the capacity of systems to anticipate, absorb, adapt to, and recover from disruptions while maintaining essential functions (Boin & van Eeten, 2013; Folke, 2006; Linkov & Trump, 2019). In this context, therefore, resilience refers to KEMSA's strategic capability to ensure the continuity of supply of essential medical commodities during health emergencies. In this study, KEMSA is perceived to function within the broader national security architecture, as disruptions in medical supply chains can directly affect socioeconomic stability.

Supplier management, for instance, may reflect the system's absorptive and adaptive capacities. Reliable and well-managed supplier networks may enable the system to withstand supply disruptions. Furthermore, a diversified supplier base may enhance flexibility during crises. Inventory control and policy compliance may also be closely linked to absorptive capacity, because they determine the system's ability to prevent stock-outs. Governance and control mechanisms may also strengthen medical supply systems' adaptive and transformative capacities. When governance structures are strong, they enable timely and coordinated responses. Additionally, system coordination and digitization may also enhance anticipatory and adaptive capacities by improving visibility and information flow in the supply chain. Digital systems may also enable early detection of potential disruptions and facilitate rapid, data-driven responses.

2.2 Empirical Review

2.2.1 Supplier Management and Supply Chain Resilience

Empirical studies have examined supply chain resilience by analyzing operational practices that enable systems to anticipate, absorb, and respond to disruptions. One such operational practice is supplier management. Available literature shows that effective supplier management enhances flexibility and reduces vulnerability to shocks (Queiroz et al., 2022; Ivanov & Dolgui, 2021; UNCTAD, 2021). Empirical studies also indicate that overreliance on a limited number of suppliers contribute significantly to global shortages of essential medical commodities during the pandemic (2022; Ivanov & Dolgui, 2021; UNCTAD, 2021). However, much of this evidence is derived from high-income countries, with limited focus on public health supply chains in low- and middle-income countries.

2.2.2 Inventory Control, Policy Compliance, and Supply Chain Resilience

Studies also show that inventory control and policy compliance are important influencers of supply chain resilience, because the ensure the availability and adequate distribution of medical commodities. According to Ivanov (2021), and OECD (2021) argue that effective inventory management reduces stockouts and improves responsiveness during crises. Notably however, Chopra and Sodhi (2014, and Choi et al., (2020), caution against excessive stockpiling, especially for perishable medical products, as this may result in wastage. Studies have also found that effective inventory management is further reinforced by policy compliance. Policy compliance has been found to promote standardization and accountability across supply chain processes. Nonetheless, existing studies tend to examine inventory practices and compliance mechanisms independently, with limited empirical analysis of how they interact with other components to influence resilience in public supply chain systems.

2.2.3 System Coordination, Digitization, and Supply Chain Resilience

The role of system coordination and digitization in enhancing supply chain resilience has also been analyzed by, among others, Dubey et al. (2023), Ivanov and Dolgui (2020), and World Bank (2022). The authors have found that digital technologies improve supply chain visibility, facilitate real-time information sharing, and enable faster, data-driven decision-making. They also aver that supply chain systems that were digitally enabled during the COVID-19 pandemic, were able to respond to the pandemic better than those that were not. Notably however, Kache and Seuring (2017) note that the effectiveness of digitization depends upon supporting infrastructure, data quality, and human resource capacity. In Sub-Saharan African however, the enabling conditions for digitalization remain underdeveloped, limiting its effectiveness (World Bank, 2021).

2.2.4 Governance and Control and Supply Chain Resilience

Governance and control mechanisms have also been identified as key determinants of the resilience of medical supply chains. OECD (2020), and UNICEF (2021), have linked weak governance structures to inefficiencies in medical supply chains, such as delayed procurement processes, duplication of roles, and wastage. In devolved health systems like Kenya's, poor governance and control mechanisms have also resulted in poor coordination between national and sub-national levels (World Bank, 2022; WHO, 2021; Office of the Auditor-General, Kenya, 2023). However, there is limited empirical evidence on how specific governance and control mechanisms influence the performance of centralized medical supply agencies such as KEMSA.

2.2.5 Demand Planning and Forecasting and Supply Chain Resilience

Demand planning and forecasting also constitute another critical component that influences the resilience of medical supply chains. Poor forecasting has been associated with shortages, overstocking, and wastage (Ivanov &

Dolgui, 2021; WHO, 2021). In low- and middle-income countries, forecasting is often constrained by fragmented data systems, limited analytical capacity, and weak integration across supply chain actors (World Bank, 2022). However, although forecasting is widely recognized as an essential component, it is frequently examined in isolation, limiting understanding of how it interacts with other operational practices to influence resilience in medical supply chains.

III. METHODOLOGY

3.1 Research Design

This study employed a mixed-methods approach, integrating quantitative and qualitative techniques to provide a comprehensive understanding of the research problem (Creswell & Plano-Clark, 2018). The quantitative aspect enabled the study to quantify responses and analyse relationships between variables. The qualitative component provided deeper insights into observed results.

3.2 Study Area

The study was conducted at the Kenya Medical Supplies Authority (KEMSA). KEMSA is the central public agency responsible for procurement, storage, and distribution of medical commodities to all public health facilities in Kenya.

3.3 Target Population

The target population comprised KEMSA personnel directly involved in supply chain functions, including procurement, warehousing, and distribution. Data from the main respondents was complemented by information from key informants drawn from KEMSA leadership, the Ministries of Health at county and national levels, and national security experts.

3.4 Sampling and sample size

A sample of 115 respondents was determined using Kothari's formula (95% confidence level, 5% margin of error). The sample was proportionally allocated to the different sections within KEMSA's supply chain units, and respondents were selected through random sampling. A total of 15 key informants were identified through purposive sampling.

3.5 Data Collection tools and procedures

A structured questionnaire was administered to the main respondents, complemented by interviews with key informants. The questionnaire collected mostly quantitative data on mitigation strategies in place at the time of the study. Data collection instruments were viewed by experts to establish validity. The test-retest method was used to assess reliability, yielding a Cronbach's alpha of 0.8. The interviews explored contextual, operational, and policy perspectives. Qualitative rigor was enhanced through a standardized interview protocol. Secondary data were obtained through document analysis of KEMSA records, policy reports, and relevant literature.

3.6 Data Analysis

Quantitative data were cleaned, coded, and analysed using SPSS. Descriptive statistics, including means, frequencies, and standard deviations, were applied to summarize key variables. Inferential analysis was conducted to examine relationships between operational practices and supply chain resilience. Qualitative data were transcribed, coded, categorized, and analysed thematically. The data obtained through interviews and documents were triangulated with quantitative results to enhance validity and provide deeper interpretation.

3.7 Ethical Considerations

Before embarking on data collection, a research permit was obtained from the National Commission for Science, Technology and Innovation (NACOSTI). Authorization was also obtained from KEMSA senior management. All ethical considerations were strictly observed, including voluntary participation, informed consent, confidentiality, and secure data handling.

3.8 Operationalization of Study Variables

In this study, the independent variable was supplying chain mitigation strategies while the dependent variable was supply chain resilience, as a component of strategic health security. Supply chain mitigation strategies are the mechanisms employed to anticipate, manage, and reduce the impacts of disruptions in the medical supply chain. Such disruptions may include any event that can affect the timely availability of essential medical commodities, including strikes, procurement delays, stock-outs, funding delays, and logistics breakdowns. Supply chain resilience refers to the

ability to maintain functionality, ensuring the availability and access to medical commodities even during disruptions and health emergencies. Supply chain resilience was operationalized to include availability and access, responsiveness, continuity of service, preparedness, and efficiency.

IV. FINDINGS & DISCUSSIONS

4.1 Response Rate and Respondent Characteristics

This section presents the response rate and the respondents' characteristics. The response rates for both the questionnaire survey and key informant interviews are presented in Table 1.

Table 1

Response Rate for Questionnaire and Key Informant Interviews

Questionnaire Survey	115	115	100%
Key Informant Interviews	15	15	100%
Total	130	130	100%

As shown in Table 1, the study achieved a 100% response rate for both the questionnaire and key informant interviews. This exceptionally high response rate can be attributed to the support of trained research assistants, who engaged participants face-to-face. Face-to-face administration of questionnaires has been shown to significantly improve response rates, especially in institutional settings (Dillman, Smyth & Christian, 2014). Furthermore, the studies institutional setup, whereby all respondents were within a single organization, also contributed to high participation levels. Finally, the official authorization and support from the KEMSA administration also helped encourage participation.

4.2 Descriptive Findings

This section should only present descriptive statistics.

4.2.1 Supply Chain Resilience

The dependent variable for the study was supply chain resilience. Respondents were asked to rate KEMSA's capacity across the five components of resilience on a scale of 1 to 5, where 1 is very low, and 5 is very high. Their responses are presented in Table 2.

Table 2

Respondents' perceptions on KEMSA's resilience capacity

Indicator	**Mean**	**SD**
Availability and Access		
Essential medical commodities are always consistently available, including during disruptions	2.92	0.73
Stockouts of essential commodities are rare	2.71	0.81
Order fulfilment rates are high	3.12	0.69
Lead times for essential medical commodities are acceptable	3.21	0.84
Essential commodities are available across counties without disparities	1.97	0.82
Overall (Composite)	2.79	0.78
Responsiveness		
KEMSA responds efficiently to urgent orders	2.14	0.76
KEMSA has efficient and timely emergency procurement systems	2.72	0.61
There is a flexible system of redistributing supplies across facilities	1.82	0.83
Decision making for urgent orders is fast and effective	2.95	0.77
Overall (Composite)	2.41	0.74
Continuity of service		
Supply is maintained even during disruptions (e.g. strikes)	2.57	0.70
Transport challenges do not significantly affect distribution	2.34	0.51
Supply consistency is maintained across all counties	2.86	0.73
Overall (Composite)	2.59	0.65
Preparedness		
Buffer stocks are adequately maintained	3.36	0.89
KEMSA has in place effective and functional early warning mechanisms	3.12	0.79
KEMSA supply chain staff are well trained in supply chain processes	4.31	0.92
Overall (Composite)	3.60	0.87

Efficiency		
KEMSA has minimal wastage due to expiry or loss	2.11	0.87
Procurement processes are cost effective	4.16	0.78
Distribution processes are effective and well-coordinated	3.89	0.84
Inventory and stock management systems are efficient and effective	3.72	0.79
Overall (Composite)	3.47	0.82

The results in Table 2 show that preparedness and efficiency recorded high means (3.60 and 3.47, respectively) compared to the other resilience components. Within the preparedness construct, staff training had the highest mean score, 4.31, with a standard deviation of 0.87. However, the study found that only 61.74% of respondents possess formal professional qualifications in supply chain management. This shows a slight discrepancy between perceived training adequacy and actual formal training. However, findings from qualitative interviews with key informants provide contextual clarification, indicating that KEMSA conducts frequent in-service capacity building sessions for all staff, including supply chain personnel. This may contribute to the high perceived adequacy of training, despite the moderate levels of professional qualifications revealed in the study. Overall, the preparedness data indicate that while human resource capacity may be high, institutional capacity may be limited.

Regarding efficiency, although the composite mean was relatively high at 3.47, wastage due to expiry or loss recorded a low mean of 2.11. Similarly, the other elements of resilience recorded relatively low composite means, ranging from 2.41 (responsiveness) to 2.79 (availability and access). This finding indicates weak operational responsiveness and inequitable commodity distribution throughout the supply chain.

4.2.2 Supply Chain Resilience Index (SCRI)

To provide an overall measure of supply chain resilience, the study developed a Supply Chain Resilience Index (SCRI) by aggregating the five dimensions of resilience: availability and access (AVA), responsiveness (RES), continuity of service (CON), preparedness (PRE), and efficiency (EFF). Composite indices are widely recommended for measuring multidimensional latent constructs that cannot be adequately represented by a single indicator (DeVellis, 2017; Nardo et al., 2005; Saisana & Tarantola, 2002). The index was computed as:

$$SCRI = (AVA + RES + CON + PRE + EFF) / 5$$

Where, AVA represents availability and access, RES responsiveness, CON continuity of service, PRE preparedness, and EFF efficiency. Using the composite mean scores for the five dimensions, the overall SCRI was 2.97, indicating a moderate level of supply chain resilience at KEMSA. This finding suggests that while the organization demonstrates strengths in preparedness and operational efficiency, improvements are required in availability, responsiveness, and continuity of service to strengthen resilience against future supply chain disruptions.

4.2.3 Supply Chain Operational Practices

The independent variable in the study was supply chain operational practices. To measure these variables, respondents were asked to rate the extent to which specific supply chain operational practices are implemented within KEMSA, on a five-point Likert scale, where 1 represents never, and 5 is all the time. The results are presented in Table 3.

Table 3

Respondents' Rating of the implementation of supply chain operational practices

Construct	Mean	SD
Demand Planning and Forecasting		
Procurement decisions are routinely guided by demand forecasting	3.91	0.93
Procurement planning is based on consumption data	3.89	0.83
Demand patterns are regularly updated based on facilities data	3.61	0.89
Overall (Composite)	3.78	0.86
Supplier Management		
Supplier performance is routinely evaluated and documented	3.21	0.78
KEMSA maintains relations with multiple suppliers per commodity	2.83	0.62
Supplier selection is competitive, based on reliability and past performance	1.18	0.85
Supplier contracts are regularly reviewed and updated	2.39	0.76
Overall (Composite)	2.40	0.75
Inventory Control and Policy Compliance		

KEMSA routinely sets, monitors, and abides by minimum and maximum stock levels	3.61	0.72
Reordering of commodities is informed by predefined stock thresholds	3.12	0.67
Inventory records are regularly monitored and updated	4.23	0.91
Stock management SOPs are consistently adhered to	2.98	0.80
Overall (Composite)	3.49	0.78
Governance and Control		
Procurement processes consistently follow established SOPs	2.28	0.74
Internal controls are routinely applied in all processes	3.62	0.89
Audits are consistently conducted as normal governance practice	4.11	0.93
Accountability measures are applied in all supply chain processes	2.39	0.64
Overall (Composite)	3.10	0.80
System Coordination and Digitization		
All decisions in the supply chain process are informed by data	3.13	0.58
Coordination is routinely maintained between all departments/components	4.26	0.76
Coordination is routinely maintained with all counties	3.69	0.82
Communication between supply chain components is institutionalized	4.02	0.84
Overall (Composite)	3.78	0.75

The results in Table 3 show notable variation in the implementation of the different components of supply chain operational practices. Demand planning and forecasting, as well as system coordination and digitization, recorded the highest composite mean (M=3.78 each). Other components that recorded an above-average mean were inventory control and policy compliance (M=3.49) and governance and control (M=3.10).

In contrast, supplier management recorded a low composite mean (M = 2.40). This finding is especially critical because it suggests significant weaknesses in upstream supply chain processes. Notably, under this construct, supplier selection recorded the lowest mean (M=1.18), followed by regular review and updating of suppliers (M=2.39) and maintenance of multiple suppliers per medical commodity (M=2.83). Only routine evaluation and documentation of supplier performance registered a relatively high mean of 3.21.

For the other constructs, the application of accountability measures across all supply chain processes recorded a low mean (M=2.39), and so did consistent adherence to stock management SOPs (M=2.98). However, several elements had very high means. These included coordination between departments (M = 4.26), regular updating of inventory records (M = 4.23), audits as a routine governance practice (M = 4.11), and institutionalized communication across supply chain components (M = 4.02).

4.2.4 Supply Chain Operational Practices Index

To provide an overall measure of the extent to which supply chain operational practices are implemented at KEMSA, the study developed a Supply Chain Operational Practice Index (SCOPI) by aggregating the five operational practice dimensions: demand planning and forecasting (DPF), supplier management (SUP), inventory control and policy compliance (INV), governance and control (GOV), and system coordination and digitization (COORD). Composite indices are widely used to summarize multidimensional constructs into a single measure, thereby facilitating interpretation and comparison across variables (DeVellis, 2017; Nardo et al., 2005; Saisana & Tarantola, 2002). The index was computed as:

$$SCOPI = (DPF + SUP + INV + GOV + COORD)/5$$

Where, DPF represents demand planning and forecasting, SUP supplier management, INV inventory control and policy compliance, GOV governance and control, and COORD system coordination and digitization. Using the composite mean scores for the five dimensions, the overall SCOPI was 3.31, indicating a moderately high level of implementation of supply chain operational practices at KEMSA. This finding suggests that although operational practices are generally well established, implementation is uneven across the different dimensions. In particular, supplier management recorded substantially lower implementation levels than the other operational practices, highlighting an area requiring strategic attention.

Since the study sought to determine the individual contribution of each operational practice to supply chain resilience, the subsequent inferential analysis employed the five disaggregated dimensions rather than the composite SCOPI. This approach provides a more precise assessment of the relative influence of each operational practice while retaining SCOPI as an overall indicator of implementation.

4.3 Regression Analysis

A multiple linear regression analysis was conducted to examine the effect of supply chain operational practices on supply chain resilience. The model is specified as: $SCRIi=\beta 0+\beta 1DPFi+\beta 2SUPi+\beta 3INVi+\beta 4GOVi+\beta 5COORDi+\epsilon i$
Where:

SCRI = Supply Chain Resilience Index
DPF = Demand Planning & Forecasting
SUP = Supplier Management
INV = Inventory Control & Policy Compliance
GOV = Governance & Control
COORD = System Coordination & Digitization
B_0 = Intercept
B_1–β_5 = Coefficients (effects of each practice)
ε = Error term

Prior to the regression analysis, the study tested key assumptions of regression. Linearity was confirmed through a visual inspection of the scatter plots, which indicated a linear relationship between the predictors and the dependent variable. The residuals were approximately normally distributed on the Q–Q plot. Examination of residual plots showed no evidence of heteroscedasticity. Multicollinearity was at acceptable levels, with variance inflation factor (VIF) values below the recommended threshold of 5. The Durbin–Watson statistic suggested no significant autocorrelation of residuals. The model summary is presented in Table 4. The results in Table 4 show that the model explained 53% of the variance in supply chain resilience (R^2 = 0.53, Adjusted R^2 = 0.51). This suggests a moderate-to-strong explanatory power of the model.

Table 4
Model Summary

Model	R	R2	Adjusted R2	Std. Error of the Estimate
1	0.73	0.53	0.51	.52

Table 5 presents the ANOVA results testing the overall significance of the model. The model was statistically significant (F = 31.22, p < .001), indicating that the components of operational practices jointly predict supply chain resilience.

Table 5
ANOVA Output

Model	Sum of Squares	df	Mean Square	F	P
Regression	42.18	5	8.44	31.22	<0.001
Residual	37.42	109	0.34		
Total	79.60	114			

Table 6 presents the regression coefficients. The results show that all five components of supply chain operational practices significantly affect supply chain resilience, in varying degrees.

Table 6
Regression Coefficients

Constant	0.64	0.31	_	2.07	.041
Demand planning and forecasting	0.18	0.08	0.16	2.25	.026
Supplier management	0.38	0.07	0.41	5.43	<.001
Inventory control and policy compliance	0.24	0.06	0.27	4.00	<.001
Governance and control	0.19	0.07	0.19	2.71	.008
System coordination and digitization	0.21	0.06	0.23	3.50	.001

The regression model was statistically significant (F = 31.22, p < .001) and explained 53% of the variation in supply chain resilience (Adjusted R^2 = 0.51). All five operational practice dimensions significantly influenced supply chain resilience. Supplier management exerted the strongest effect (β = 0.41), followed by inventory control and policy compliance (β = 0.27), system coordination and digitization (β = 0.23), governance and control (β = 0.19), and demand planning and forecasting (β = 0.16). The findings are discussed below according to the study objectives.

The quantitative findings were corroborated by evidence from the key informant interviews. Respondents consistently identified operational challenges that corresponded with the statistically significant predictors of supply

chain resilience. Regarding supplier management, participants reported that strict regulatory requirements, bulk procurement arrangements, and a limited pool of prequalified suppliers constrained supplier diversification. One key informant explained:

> "*KEMSA does bulk purchases, and we are very strict with regulatory compliance not only of the medical commodities, but also the legal status of the supplier. This tends to lock out many would-be suppliers, leaving us with only a limited pool to pick from*" (Senior KEMSA Official, Interview, 12th March 2026).

With respect to demand planning and forecasting, participants indicated that delayed reporting from health facilities, fragmented information systems, and fluctuations in disease patterns reduced forecasting accuracy. As one respondent observed:

> "*COVID-19 showed us that past data is not always a reliable predictor of future demand*." (Senior KEMSA Official, Interview, 14th March 2026).

For inventory control and policy compliance, respondents acknowledged that although inventory management guidelines exist, their implementation is not always consistent because of operational and infrastructure constraints. One participant stated:

> "*We have clear inventory guidelines, but implementation is not always consistent, mostly due to inadequate infrastructure and resources*." (Senior KEMSA Official, Interview, 17th March 2026)

Participants also identified inconsistencies in the enforcement of governance and control mechanisms, particularly during emergency situations. One respondent remarked:

> "*KEMSA has good policies and oversight structures, but enforcement may not always be consistent, especially during emergencies when systems are under pressure*." (Senior KEMSA Official, Interview, 17th March 2026)

Finally, respondents emphasized that system coordination and digitization had improved communication, visibility, and coordination across the supply chain. One respondent noted:

> "*We can now track commodities across the system, from central stores to counties, which helps us respond faster when shortages are reported*." (Senior KEMSA Official, Interview, 20th March 2026).

Another added:

> "*The information system has improved coordination between departments. Procurement, warehousing and distribution are now more aligned than before"*. (Senior KEMSA Official, Interview, 15th March 2026).

The qualitative findings complemented the quantitative results by identifying practical operational experiences associated with supplier management, demand planning and forecasting, inventory control and policy compliance, governance and control, and system coordination and digitization within KEMSA.

4.4 Discussion

4.4.1 Supplier Management and Supply Chain Resilience

The study found that supplier management is the strongest predictor of supply chain resilience at KEMSA. This finding is consistent with previous studies that identify supplier diversification, strategic supplier relationships, and supplier performance management as fundamental determinants of resilient supply chains (Ivanov & Dolgui, 2020; Qureshi & Syeda, 2025; OECD, 2024). Reliable and diversified supplier networks enhance supply continuity, reduce vulnerability to disruptions, and improve organizational responsiveness during emergencies.

However, despite its importance, supplier management recorded the lowest implementation score among the operational practice dimensions. This suggests that weaknesses in supplier diversification and competitive supplier selection continue to constrain KEMSA's resilience. The qualitative findings indicate that strict regulatory requirements, bulk procurement arrangements, and a limited pool of prequalified suppliers reduce opportunities for supplier diversification. These findings are further supported by previous audit reports highlighting procurement irregularities and weaknesses in supplier selection during the COVID-19 pandemic. Collectively, the findings suggest that strengthening supplier management represents the greatest opportunity for improving medical supply chain resilience within KEMSA.

4.4.2 Inventory Control and Policy Compliance

The study established that inventory control and policy compliance have a significant positive effect on supply chain resilience. This finding supports earlier studies which demonstrate that effective inventory management improves commodity availability, minimizes stock-outs and wastage, and enhances organizational preparedness during supply chain disruptions (Guo et al., 2025; Ivanov, 2021). Effective policy compliance also promotes consistency, accountability, and standardization across supply chain operations.

Although inventory management practices were generally well implemented, adherence to stock management standard operating procedures was comparatively lower. Interview findings suggest that operational constraints,

including inadequate warehousing infrastructure and inconsistent implementation of inventory guidelines, limit the effectiveness of existing inventory systems. These findings imply that strengthening operational compliance and improving inventory management infrastructure would further enhance supply chain resilience.

4.4.3 System Coordination and Digitization

The findings demonstrate that system coordination and digitization significantly enhance supply chain resilience. This result is consistent with existing literature, which emphasizes the role of integrated information systems in improving visibility, coordination, and decision-making across supply chains (Ivanov & Dolgui, 2020; OECD, 2024; World Health Organization, 2017). Digital platforms facilitate real-time information sharing, improve coordination among supply chain actors, and enable faster responses to emerging disruptions.

The relatively high implementation scores for system coordination and digitization indicate that KEMSA has made substantial progress in strengthening internal communication and operational integration. Interview evidence further suggests that digital systems have improved commodity tracking and coordination between procurement, warehousing, distribution, and county health facilities. These findings demonstrate that investments in digital infrastructure contribute directly to improving supply chain responsiveness and resilience.

4.4.4 Governance and Control

The study further established that governance and control significantly influence supply chain resilience. Effective governance enhances transparency, accountability, and adherence to procurement procedures, thereby strengthening the integrity and reliability of public health supply chains. This finding agrees with previous studies that identify governance as an essential component of resilient public sector supply chains (OECD, 2020; UNICEF, 2021).

Despite the existence of governance structures, the study found relatively low implementation of procurement standard operating procedures and accountability measures. Qualitative evidence indicates that enforcement of governance mechanisms may become inconsistent during emergencies when operational pressures increase. Previous audit reports documenting procurement irregularities during the COVID-19 pandemic reinforce these findings. The results therefore suggest that strengthening governance enforcement and accountability mechanisms is essential for improving both procurement integrity and overall supply chain resilience.

4.4.5 Demand Planning and Forecasting

The study found that demand planning and forecasting positively and significantly influence supply chain resilience. Although this variable recorded the smallest standardized regression coefficient, the results demonstrate that accurate forecasting remains an important determinant of resilient medical supply chains. These findings are consistent with previous research showing that demand forecasting improves procurement planning, resource allocation, and preparedness while reducing the likelihood of stock-outs and excess inventory (Choi et al., 2020; OECD, 2024).

Interview findings indicate that forecasting at KEMSA is constrained by delayed reporting from health facilities, fragmented information systems, and rapidly changing disease patterns. These operational challenges reduce forecasting accuracy, particularly during public health emergencies. The findings therefore highlight the need for more integrated information systems and data-driven forecasting approaches capable of supporting timely and evidence-based procurement decisions.

V. CONCLUSIONS & RECOMMENDATIONS

5.1 Conclusions

This study concludes that supply chain operational practices significantly influence supply chain resilience at KEMSA. Among the five operational practices examined, supplier management emerged as the strongest predictor of resilience, followed by inventory control and policy compliance, system coordination and digitization, governance and control, and demand planning and forecasting. These findings indicate that strengthening operational practices enhances the capacity of medical supply chains to anticipate, absorb, and recover from disruptions, thereby improving national health security preparedness.

5.2 Recommendations

Based on the conclusion, the study recommends deliberate and integrated interventions to expand and diversify the supplier base. This could be done by reviewing prequalification frameworks and supporting local manufacturing capacity, without compromising quality and regulatory standards. The study also recommends strengthening

governance and control systems through stricter enforcement of procurement policies, enhanced transparency mechanisms, and routine audits to close the gap between policy and practice.

Declaration of Interest

The authors declare that they do not have any known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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