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A structural equation modeling of supply chain strategies for artemisinin-based combination therapies in Uganda

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Abstract

Introduction: Malaria is a killer disease in the tropical environment; artemisinin-based combination therapies (ACTs) play a central role in treating malaria. Thus, the supply and presence of ACT drugs in hospitals are a key feature in the fight against malaria. Supply chain management literature has focused on the private sector, and less attention has been paid to the public sector, especially hospitals.

Aim: This study uses an interdisciplinary lens in investigating how to boost the supply and distribution of ACTs to save lives in low-income countries, specifically in Uganda.

Methodology: The study adopted a quantitative research design using a questionnaire as the data collection instrument. Of the 440-population size, 304 of the sample population participated in the study. The model was estimated using structural equation modeling (SEM) to establish the causal relationship among the variables.

Results: From the SEM analysis, all the hypotheses were significant at $p < 0.05$. The availability of ACTs is strongly affected by strategic dimensions (0.612), followed by operation dimensions (0.257); strategic determinants significantly affect operational determinants by a magnitude of 0.599. The indirect influence of the strategic determinants via operational determinants on the availability of ACTs is not significant. Overall, the factors explained 63.9% of the observed variance in the availability of ACTs, and the ACT availability can be predicted as follows: ACT availability = 0.612 × strategic determinants + 0.256 × operation determinants. Top management commitment and organizational responsiveness are among the items that positively affect the availability of ACTs.

Conclusion: Strategically, hospital management should invest in cheap technology and software to minimize the unavailability of medicines. Our research suggests that strategic and operational determinants should be integrated into the hospitals' core business and implemented by the top management. The article contributes to theoretical and policy direction in the public sector medicine supply chain, specifically in public hospitals.

Keywords

Malaria, supply chain coordination, mutual understanding, top management, logistics, public health, low-income countries

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What is already known about the topic?

- The effective supply chain is based on accurate information.
- Purchasing and supply organizations must match external and internal demands.
- Strategic and operational factors influence the supply chain network.

What this paper adds

- Both strategic and operational determinants explain 63.9% of the variance in the supply chain availability of artemisinin-based combination therapies (ACTs).
- In low-income countries, strategic determinants play a significant role in the availability of ACTs in hospitals.
- In critical supply chains, better top management commitments were associated with the high availability of ACTs.

Introduction

The availability of medicines is a necessary component under universal health coverage and is in line with Goal 3 of the United Nations' Sustainable Development Goals that aim to ensure the health and well-being of people of all age groups. Specifically, one of the targets is that by 2030, the population of all countries should have access to crucial, quality, safe, and affordable essential medicines and vaccines. Nonetheless, achieving this target is a formidable challenge for developing countries where supply chain coordination is wanting, and the solutions being brought forward to address this dilemma do not solve the problem.[1–4] The coordination dilemma has significant implications on the availability of artemisinin-based combination therapies (ACTs) that are used to treat malaria in several countries within sub-Saharan Africa.[5–7]

Presently, malaria ranks as one of the primary factors for disease and death in low-income countries,[8,9] even though there have been several efforts in the recent past that aimed to cut down the growing burden of malaria disease. While several interventions have focused on preventive (such as the provision of treated mosquito nets) and various therapeutic approaches, malaria has remained one of the oldest and deadliest diseases known to humankind.[10] Currently, international efforts are focused on malaria elimination through the rollout of new technologies, such as mobile health (m-health), financial pledges, and political commitment; however, even with such assurances, there will be an estimated 11 million malaria cases by 2050. To plummet the occurrence of malaria cases, especially in the right of progress stalling and limited funding, it is very important to look for efficiencies in the current context—particularly at strategic and operational levels.

This study adopted the coordination theory, while the conceptualization of both the strategic and operational determinants was built on the work of Mehralian et al.[11] and Singh.[12] As advanced by Malone and Crowston,[13] the coordination theory maintains that organizations that aspire for better effectiveness and efficiency should continually identify and assign tasks and identify the required linkages that can lead to better supply chain performance. The scholars Malone and Crowston premised the theory on the works of previous researchers in the field of the supply chain.[14–16] Although the findings of these studies overemphasized the principle of planned processes and structures, they did not articulate how environmental challenges or shocks would be managed contextually in the performance of tasks. Yet, the definition provided by Malone and Crowston[13] came off as quite unrealistic, given the way they perceived the modes of coordination. For example, they did not place much emphasis on how to manage unique strategic and operational factors. Ensuring coordination in seemingly complicated settings, such as hospitals, may require diverse outputs and specific inputs with strong interdependencies to manage unexpected changes and goal setting.

Our study extends the literature on supply chain coordination with the specific interest from a hospital perspective. Public and private hospitals are vital in treating malaria-affected patients. Nonetheless, some public health facilities in sub-Saharan Africa run out of stock of malaria medicines. In others, the medicines expire, leaving the majority of the impoverished populace desperate for treatment.[17] Therefore, the phenomenon of interest in our study revolves around how hospitals can coordinate their supply chain actors to achieve the desired outcomes. We focus here on the parameters that hospitals can directly influence, namely, their strategic and operational orientation in making ACTs available.

Hypothesis formulation

According to some earlier researchers on the subject, empirical shortcomings notwithstanding, the availability of ACTs has been impeded by the lack of a conclusive framework related to the major determining factors. The situation has been exacerbated by the absence of an effective strategy aimed toward better managing the intertwined connections between healthcare personnel and the kind of information that could aid the delivery of health services.[18] The situation has yielded a combination of undesirable outcomes.[19] This calls for more comprehensive studies on the subject to address the challenge of inadequate ACTs, especially in low-income countries.[7] Even then, as Patouillard et al.[20] argue, there is a considerable gap in the literature related to the supply and distribution chains of ACTs in sub-Saharan Africa.

The theoretical coordination frameworks developed by Singh[12] and Mehralian et al.,[11] commonly presuppose that coordinating the supply chain is a critical element that ensures all activities are systematically glued together to achieve joint supply chain performance. The scholars conceptualized diverse coordination dimensions with common themes, but with a different emphasis on responsiveness, top management, information-sharing, organizational factors, mutual understanding, relationship management, and joint decision-making.[21] Notwithstanding the great foundation laid by previous studies, these scholars' definitive conceptualizations appear too optimistic, as the scholars considered the coordination modes according to process realignment. They did not highlight the question of combining different dimensions of coordination in a public health context and offer no empirical validation regarding the public hospitals in the healthcare sector. Policymakers often face the dilemma of designing appropriate decision-making models that balance the different supply chain players[22] without compromising quality standards. Thus, this study answers three main questions: (1) What are the strategic coordination determinants affecting medicine availability? (2) What are the operational supply chain coordination determinants affecting medicine availability? and (3) What is the contribution of strategic and operational level determinants toward the availability of ACTs?

Strategic determinants and availability

The term "strategic determinants" refers to top management's commitment to aligning the firm's competitive strategy with the functional strategy through coordinating resources, information flow, and products.[23] Top management is mandated to ascertain the staffing requirements and determine the structure needed to fulfill the company's goals and objectives.[24] The scholars also argue that top management is obliged to ensure the availability of the necessary financial and other resources required to establish an effective system to prioritize the implementation of supply chain management to make products available in terms of quality, delivery, and flexibility. However, prioritizing some capabilities may call for trade-offs concerning specific tasks.

Nonetheless, in the absence of effective governance mechanisms and openness among key stakeholders regarding information flow and medical concerns, it is unlikely that the much-needed outcomes in the medicines supply chain will be realized.[4] This situation calls for accountability from leaders and effective systems for performance measurement to enhance staff capacity, among other strategies. This is in agreement with the observation made by Tatambhotla et al.[25] that the leader of a supply chain should have excellent leadership skills, in combination with a mix of hands-on experience, a position to amass the support of many stakeholders, and the ability to rally political support. Moreover, the supply chain leader should be an agent of change, have a craving to seize fresh opportunities in the prevailing establishment when the need arises, and effect change within the operating legal framework.

Another strategic determinant is appreciating the relevant organizational factors,[26] which requires that the organizational structures be defined, whether vertically or horizontally. The vertical structures bear the characteristics of some chain of command and a particular establishment that bears the characteristics of hierarchical features (in the case of vertical ones) and knowledge and involvement (for the horizontal structures). The kind of structure in the organization is a determining factor for coordination.[27] As such, hierarchies are coordinated from top to bottom, and those with a horizontal structure capitalize on some form of specialization that may call for more flexible dimensions to increase the likelihood of using the newly acquired skills.[28] According to Banerjee and Srivastava,[29] culture influences the structure of the organization. Specifically, culture is entangled with the way innovation is managed or implemented in any organization. With more bureaucratic structures, the culture within the organization may not favor improvements, while systems with an established culture based on teamwork might be better aligned to improve quality.

The specific organizational determinants may include standardization, setting contracts, policies, rules, guidelines, and schedules. The study examined how these determinants manifest at the hospital level and their influence on supply chain coordination. From the theoretical background, it has been argued that the coordination dimensions are examined based on decision style, resource-sharing structure (strategic or tactical and operational), level of control and risk, and allocated rewards.[30] Malone et al.[31] underscore this approach by emphasizing two dimensions: information-sharing (how actors' proportion, understand, and interpret data) and how to make decisions. Overall, organizational factors are considered to have an essential impact on medical experts' uptake of the interventions that enhance their practices. In addition, operating factors at either the level of the functional unit or the level of the broader health system are worthy of examination.[32] For instance, many public sector organizations are subject to state regulations and supervision. However, Osifo[27] claims that regulations often endanger the implementation of feasible coordination that would have facilitated service delivery. Specifically, the study examined the influence of structural and operational factors on the coordination of tasks and standard operating procedures. Grafton et al.[33] empirically analyzed three hospital networks and found that supply chain performance differed in the health facility's ability and willingness to pursue effective coordination in light of external stakeholders. In turn, the hospital administrators designed systems incompatible with the organization's institutional mandate, making coordination impossible.

The concept of responsiveness is crucial in obtaining the products that consumers may need. A company adopts various strategies to fulfill the requirements of customers, or it considers demand and supply changes that might require an immediate response to remain competitive.[11,12] Being responsive to the requirements of customers is necessary across sectors.[34] From the literature, it is noteworthy that swift reaction is a key factor in ensuring any firm's effective performance.[35] From a strategic point of view, being responsive enables companies to compete based on the quality of services, timeliness, cost-effectiveness, and efficiency, among others. The implication is that the logistical aspects of transport and distribution in a hospital setting enable the introduction of other products and services, besides enhancing a hospital's ability to quickly obtain products and services. However, in the absence of information on supply and demand, the situation is likely to play out differently.[36]

Singh[12] shares the categorization of responsiveness as timely delivery, flexibility, ability to adopt process changes and service reliability. This may, however, prove to be an uphill task because any uncertainty at any one stage of the chain might affect the entire chain. Turkyilmaz et al.,[37] also add that health facilities at times neglect to focus on their responsiveness; and this amounts to unfulfilled promises, consequently affecting the intended health service delivery outcomes. Against this background, our model captures three strategic determinants: top management commitment, organizational factors, and responsiveness in making ACTs available, allowing possible linear combinations. Two hypotheses were formulated for the study:

H1a. Strategic determinants positively affect ACTs' availability

H1b. Strategic determinants positively affect operational determinants

Operational determinants and availability of products

Galaskiewicz[38] accentuates that in many cases, organizations carry out activities through a complex network of employees to manage how information, resources, and products flow, with the aid of systems that are enabled to disseminate information. As a result, this is how interorganizational networks are created, succeed, fail, or disintegrate. A key ingredient in supply chain networks is trust enabled by effective logistics information systems, which aim to improve the application of a well-organized system of information to accurately report on supply patterns, consumption and wastage. The system should be one that can facilitate data collection and analysis and ensure timely, accurate, and suitable data, such that the people making decisions can conduct an evaluation of the flow of supplies, ensure accountability for products, have a reduction in supply inconsistencies, and register improvement in productivity.[39]

The resultant effect would be the mutual interchange of information regarding the various aspects of the supply chain, which would assist members of the supply chain to timely and accurately plan for the delivery of products and improve responsiveness in the process. In addition, it helps to enhance the authenticity of information related to product demand and improves stock levels.[40–42] Yousefi and Alibabaei[43] admit that using ICT (information and communications technology) applications and the general Internet effectively facilitates information flow among supply chain partners. It is worth noting that the original cost of investing might be considered prohibitive in low-income countries that still have the minimal infrastructure to support information technologies.

One outstanding limitation in the supply chain, commonly known as the bullwhip effect, indicates the increasing upward variation in a chain of supplies, resulting in performance shortfalls. Information lopsidedness is a vital source of the bullwhip effect. Misrepresented information at both ends of the supply chain can result in incredible ineffectiveness.[44] Kembro et al.[45] suggest that partnerships within the supply chain can increase the flow of information, leading to more accuracy, and therefore, better supply chain performance. Unfortunately, the authenticity of the data related to supply and demand is often doubted, negatively impacting service quality and overall efficiency.[46] In the absence of authentic information, as Yadav[4] puts it, the supply chain's performance in the field of public health is negatively affected. Rassi et al.[47] further admit that although setting standards for the supply chain may reduce the stock-outs of medicines for malaria treatment, the issue of inaccurate data presents a huge limitation.

In another view, Koçoğlu et al.[48] maintain that the flow of information requires a clear understanding of how supply chain management is integrated. Nonetheless, Otchere et al.[49] argue that although incorporating up and downstream supply chains is preferred, implementing them should involve integrating internal organizational systems before considering external factors. As such, a shift to better coordinate the supply chain might require the investment in a health information management system (HMIS), which could revive chain activities.[46]

It is anticipated that participation in collaborative decision-making may lead to two positive consequences for employees: (1) augmented confidence among employees and (2) improved fundamental enthusiasm toward work.[50] In the case of Uganda, several scholars have conducted studies in supply chain collaboration from the perspective of small and medium enterprises.[51] However, while the highlighted scholars failed to mention the interrelationships between supply chain and medicine availability in public health facilities, this article examined those interrelationships. In another study conducted by Nyaga et al.,[52] the evidence showed that functions that include collaborative information-sharing, collective liaison effort, and unfaltering investments contribute to commitment and mutual trust, which eventually enhance satisfaction and performance.

Collective decision-making involves combined efforts in predicting demand and should be done to help cut costs, ensure timeliness in delivery, and ensure improved satisfaction in services.[53] Understanding the complex supply chain system should consider trust and information flow among its members.[54] However, one major bottleneck in the effective coordination of the supply chain is the inability to have frequent meetings for collaboration among supply chain partners, as better relationships will lead to better decisions being made at the planning level. For this article, there was interaction with government, donors, and health managers, as collaborative partners within the medicine supply chain to assess how they contribute to the accessibility of ACTs in public health facilities in Uganda. Empirically, an examination of strategy frameworks revealed that employees should not only gain an understanding of the goals but also how they could make a contribution to those goals. This article assumes that the availability of ACTs can be improved once there are shared assumptions, beliefs, and values among employees at all levels.

The available literature assumes that members of the supply chain have complete trust in one another,[55] and these scholars posit that trust enables a joint demand forecast. In such a case, it is easy to modify orders when the need arises and reduce stock-outs.[56] Although having a common understanding is a matter of necessity, it may not result in the performance that the supply chain actors desire, more so where there are no common goals. The literature, however, does not clearly illustrate how having a shared understanding of the micro-, market-, and macro-environments can be realized in such a manner that it can lead to product availability and contribute to a reduction in product stock-outs in public hospitals. This article draws from the hypothesis that if hospitals work toward leveraging operational determinants, there will be an improvement in the availability of ACTs. Therefore, the following hypothesis was formulated for the study:

> *H2*. Operational determinants positively affect the availability of ACTs

As shown in Figure 1, the model identifies a hospital's micro-supply chain coordination factors, categorized as strategic and operational determinants, as the two key determinants of ACTs.

Methodology

Research philosophy

This study aimed to establish the cardinal parameters that influence the availability of ACT supply in Uganda to enhance malaria drug availability. The pragmatism approach was employed to verify the relationship among the tested variables because of its practical and real strategy of resolving challenges.[57,58] The fundamental question in terms of this problem is how supply chain variables can enhance the availability of ACTs in developing economies, a case for Uganda. Pragmatism allowed quantitative approaches to scale the strength of variables/parameters that might impact ACT availability in the medical sector.

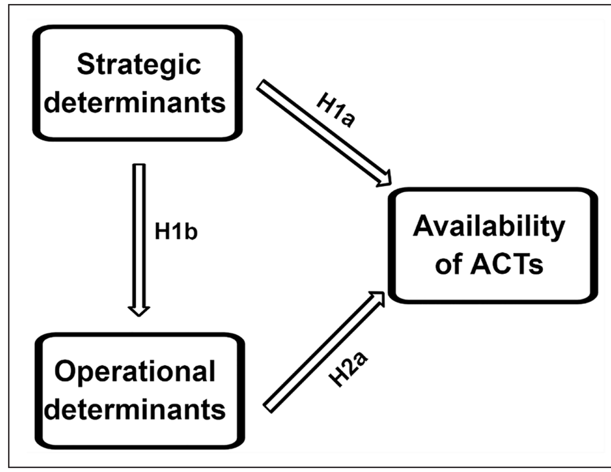

Figure 1. A conceptual model developed from the literature.

Sample size selection

There are 45 public general hospitals in Uganda. Using Krejcie and Morgan's[59] table at 95% confidence, the sample population was 40 hospitals. By applying simple random selection, five hospitals were eliminated. On average, there are 11 officers in the supply department of public hospitals—giving a total population of 440. Using the Krejcie and Morgan table, the sample population was 205. Assuming 100% participation, the sample population of 205 was low to meet the structural equation modeling (SEM) requirements. Thus, eight people were selected from each hospital to overcome this challenge, making a total sample population of 320. The eligible participants were invited to complete the questionnaire after they agreed to participate. The study protocol was approved by the ethics committee, Ministry of Health, Uganda, and the University of South Africa, South Africa (Ref#: 2017_CEM_ESTTL_005). The Drug Therapeutic Management Committee members provided written consent to participate in the study.

Pilot study and data collection

Upon establishing the research variables, a research questionnaire was designed to test the hypotheses of the study, as formulated in section "Hypothesis formulation." The research tool was based on the 5-point Likert-type scale; the scale was created such that "5" elicits an outstanding variable, while "1" elicits an insignificant variable. Before rolling out the research tool, a preliminary study was conducted with five logistics experts and three medical managers from the medical sector. After piloting, the research tool was corrected for mistakes, clarity, language, and the proposed model's coherent flow. Data on the constructs were collected through an in-person questionnaire.

Data evaluation and reliability analysis

SEM was used to test the model above; missing data and outliers were tested before subjecting the data to SEM.[60] Of the 320 questionnaires, 304 questionnaires were completed and returned. In total, 11 out of 304 were rejected on the grounds of being incomplete—more than 10% missing data. In questionnaires with less than 10% missing data, the median of the nearby point was used to replace missing data. Seven responses were eliminated due to disengaged responses, as each variable registered the same response. Outliers can significantly impact the correlation and regression among variables, based on the Mahalanobis analysis of outliers, and three research tools were debarred.[61]

The symmetry (skewness, S) and tailing (kurtosis, K) of the data were also tested; all variables were in the allowable range of $-2 \leqslant S, T \leqslant +2$, which elicits good normality of the data. Cronbach's alpha (CA) was employed to estimate the internal consistency (IC) and determine how closely the measuring variables contributed to their respective latent variables. CA values range from 0.0 to 1.0; $CA > 0.70$ elicits unacceptable consistency, $0.7 \leqslant CA \leqslant 0.8$ elicits acceptable levels, while $CA > 0.8$ shows good IC.[5,62] To improve CA, items with a CA greater than the overall CA were deleted to ameliorate the IC. Using this approach, one item under the Availability category was deleted; the CA for the group soared from 0.897 to 0.908. The overall CA for the tested variables in this study was 0.926, with no individual group eliciting $CA < 0.800$, as shown in Table 1. Thus, the proposed hypothetical model elicits good IC and reliability.

Table 1. Reliability test based on 283 respondents and listwise deletion, based on all variables in the procedure.

Group	CA[a]	No. of items
Strategic determinants	0.817	10
Operation determinants	0.897	11
Availability of ACTs[b]	0.908	6

CA: Cronbach's alpha.
[a]Overall CA = 0.926.
[b]Six items remained after deleting one item.

Results and discussions

Demographics

The respondents comprised 52.3% females and 47.7% males. The qualifications of the respondents were as follows: 3.2% hold secondary school certificates, 24.0% are diploma holders, 50.2% had bachelor's degrees, 18.4% had master's degrees, while 4.2% had PhDs as the highest qualification. A total of 7.1% of the respondents had experience of more than 10 years, while only nine respondents had less than 1 year of experience in the medical industry. Overall, the demographics elicited a diverse dataset, as summarized in Table 2.

Table 2. Demographical nature of the respondents.

Variable	Category	*N*	%
Gender	Male	135	47.7
	Female	148	52.3
Age	20–29	67	23.7
	30–39	102	36.0
	40–49	76	26.9
	50+	38	13.4
Education	Certificate	9	3.2
	Diploma	68	24.0
	Degree	142	50.2
	Master	52	18.4
	PhD	12	4.2
Supply chain training	Yes	83	29.3
	No	196	69.3
Position	Senior manager	32	11.3
	Middle manager	60	21.2
	Supervisor	51	18.0
	Officer	140	49.5
Experience	<1	9	3.2
	1–3	105	37.1
	4–6	116	41.0
	7–9	33	11.7
	10+	20	7.1

Confirmatory factor analysis and validity analysis

Confirmatory factor analysis (CFA) was used to assess the convergent validity of the hypothetical model. All the retained variables after CA were subjected to CFA, and IBM® SPSS® Amos (V.21) graphic software was applied in this analysis. For a proposed model to pass CFA and validity analysis, the average variance explained (AVE) and composite reliability (CR) should be ⩾0.50 and 0.70, respectively. The maximum shared variance (MSV) should be less than the average shared variance (ASV), and the square root of AVE should be higher than inter-construct correlations.[63]

The initial values of the hypothetical model are summarized in Table 3. The results shown in the table elicit the abysmal levels of the initial proposed model. To improve the model outputs, suggestions based on AMOS yield were

Table 3. Validity and factor correlation matrix with the square root of AVE on the diagonal.

Proposed model	CR	AVE	MSV	Operation	Strategy	Availability
Operational	0.880	0.425	0.450	0.652		
Strategic	0.788	0.297	0.527	0.671	*0.545*	
Availability	0.910	0.629	0.527	0.630	0.726	**0.793**
Adjusted model	CR	AVE	MSV	Operation	Strategy	Availability
Operational	0.891	0.523	0.391	**0.723**		
Strategic	0.794	0.520	0.505	0.625	**0.648**	
Availability	0.910	0.629	0.552	0.622	0.643	**0.793**

AVE: average variance explained; CR: composite reliability; MSV: maximum shared variance.
Common method bias based on the percentage of variance = 63.90%. It was conducted by running maximum likelihood with Promax rotation.

followed. Besides, items with a residual covariance >|2.0| were eliminated.[64] Based on these recommendations, items like R03, IS01, and IS02 were eliminated from the model. It should be noted that some items that carried heavy weights based on the qualitative approach were also deleted. For instance, "Institutional structures (OF02)" and "Flexible ordering system (R02)" carry a sturdy capability construct; however, their elimination secured acceptable levels of reliability and validity for the model. The removal of such items suggests the heterogeneous nature of ACT availability. Removing such items plummeted measurement error, which revved reliability among the retained items, thus ameliorating model validity. Table 3 elicits the validity and factor correlation matrix before and after modification. The common method bias was 63.90%, which elicited acceptable levels of biases in the data. Figure 2 shows the CFA measurement after adjustment.

Structural equation model

SEM was applied to analyze the multivariate relationship between the measuring variables. AMOS software was used to study the relationship. Maximum likelihood (ML) was employed in the model evaluation since there was no problem with univariate normality, and the data were normally distributed.[62,63,65] The goodness-of-fit indices (GOFIs) were tested using the different parameters, as outlined in Table 4.[66–68] The majority of the GOFIs failed to pass the minimum requirement.

To improve the model fit in covariance and causal relationships were established among the model variables and error terms. AMOS modification indices were used as a baseline to build the interrelationships among the measured parameters.[67,69] As a way of modifying the model, covariance relations were established, as illustrated in Figure 3 (see also Figure 4, Appendix 2). For example, the relationship in the error parameters of "Supplier relationship, (RM04)" with "Joint decision (RM03)" and "Staff relationship (RM02)" makes theoretical sense. This creates a conceptual sense, as improved staff relationships mean an easy joint decision that fosters supplier relationships. The covariance between "Frequent feedback (TM01)" and "Supplier relationship (RM04)" also makes sense in the way the feedback facilitates communication, thus a strong partnership. Table 4 summarizes the GOFIs of the final model after several refinements—all the minimum requirements were satisfied. For instance, GFI = 0.906; thus, the model outcomes are well explained by the collected data; RMSEA = 0.054, which elicits high confidence levels among variables.

Table 5 presents the standard regression coefficient of each retained item in the model. All the path coefficients are positive and significant at $p < 0.05$. The three hypotheses, H1a, H1b, and H2, are supported based on the data collected from the survey. The indirect effect of "strategy" through "operation" or mediation effect was determined by multiplying both effects, strategy → operation × operation → availability ($0.612 \times 0.257 = 0.156$). The p of this effect was determined by running bootstrapping at 2000 and a bias-corrected confidence interval of 90. The results elicited no indirect effect of strategic supply chain decisions through the operation. These results suggest that the vital supply chain coordination determinants for ACTs can be enthused through organizations' vital determinants, such as top management (TM), organizational factors (OFs) and responsiveness (R). In contrast, operational determinants include mutual understanding (MU) and relationship management (RM)—which are cardinal parameters of promoting ACTs' availability at the micro-level.

From the strategic determinants, our results show that hospitals pursuing a strategy of making ACTs available should pursue top management commitment in tandem with aligning the organizational structure. The results from the relationships between the hospital's strategic determinants and operational outcomes suggest a significantly higher tendency to increase availability. It is interesting to note that top management's commitment, responsiveness, and organizational determinants positively affect the availability outcomes, and provide empirical support for the notion that strategic determinants are critical in enhancing capabilities,[11] a requisite

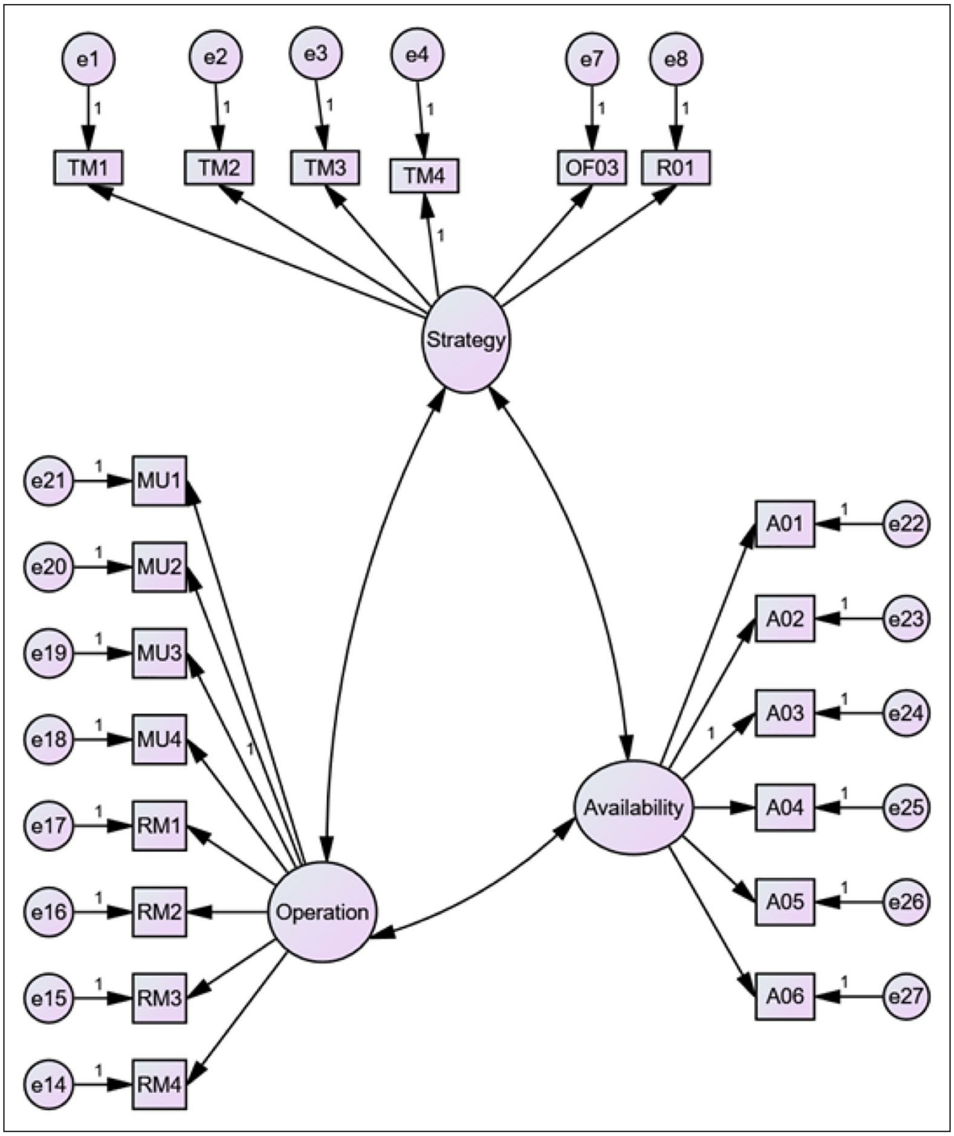

Figure 2. CFA model.e_n: error in n^{th} univariate variable; other variables are defined in Table 6.

Table 4. Results of GOFI measures.

Goodness-of-fit measure	Acceptable threshold	Hypothetical model	Revised model
RMSEA	<0.08	0.126	0.054
GFI	>0.90	0.718	0.906
AGFI	>0.90	0.645	0.874
CFI	>0.90	0.807	0.966
NFI	>0.90	0.774	0.929
TLI	>0.90	0.780	0.959
PCFI	>0.50	0.709	0.798
PNFI	>0.50	0.681	0.768

RMSEA: root mean square error of approximation; GFI: goodness of fit index; AGFI: adjusted goodness of fit index; CFI: comparative fit index; NFI: normed fit index; TLI: Tucker–Lewis index; PCFI: parsimony comparative fit index; PNFI: parsimony normed fit index.

requirement for all sectors.[34] However, prioritizing some capabilities may call for tradeoffs with specific tasks. Hence, taking the trio of determinants into account, this suggests that in the long run (when attempting to realize investments), the trade-offs between hospital size and responsiveness become evident as all have hypothesized similar effects.

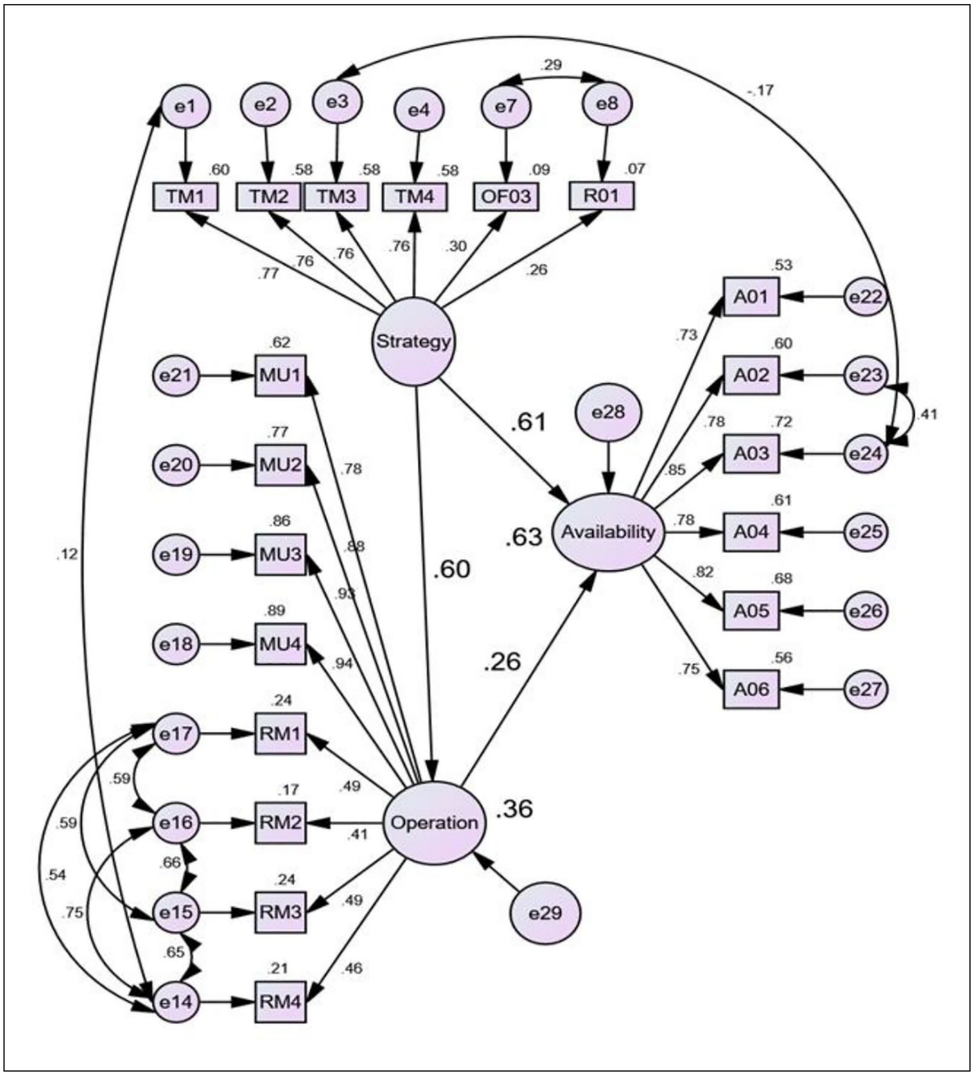

Figure 3. Path coefficients of the predictor model.

Contribution

Theoretical implications

Our conceptualization of the coordination dimensions extends supply chain coordination frameworks by examining the influence of structural and operational factors on the coordination of tasks and standard operating procedures, including the trade-offs required and their linear combinations. In more specific terms, the study contributes to the extension of coordination frameworks. Second, seen from the operational determinants, the model initially showed adverse effects on the availability of ACTs. These results suggest that the hospitals might first seek to develop trust among their employees, build relationships, and perform joint decision-making among supply chain actors. However, as the hospitals engage in a proactive and direct development approach, they should invest in the connections to establish a collaborative relationship and leverage the new capabilities. For this reason, the concept of mutual understanding must be emphasized to include joint planning, and an agreement should be reached on the dimensions of bringing services and products closer to the consumers,[70] apart from building trust in the exceedingly inter-reliant supply chains.[71] Our findings further point to the trade-offs required by capturing three strategic determinants: top management commitment, organizational factors, and responsiveness in making ACTs available, and its linear combination of pursuing top management commitment in tandem with aligning the organizational structure.

The results offer new insights into how general public hospitals influence medicine supply and distribution to the patients and highlights the implications for Drug Management Committee members regarding how they can benefit from the two tested models that explain how hospitals' strategic and operational determinants affect medicine availability. Hospitals should become directly involved in the above development activities to produce a more cooperative and long-lasting relationship among key

Table 5. Standardized regression weights and hypothesis test.

Path			Estimate	p	Path			Estimate	p
TM1	<---	Strategy	0.774	***	MU4	<---	Operation	0.943	***
TM2	<---	Strategy	0.764	***	MU3	<---	Operation	0.929	***
TM3	<---	Strategy	0.764	***	MU2	<---	Operation	0.876	***
TM4	<---	Strategy	0.759	***	MU1	<---	Operation	0.784	***
OF03	<---	Strategy	0.301	***	A01	<---	Availability	0.727	***
R01	<---	Strategy	0.265	***	A02	<---	Availability	0.776	***
RM4	<---	Operation	0.456	***	A03	<---	Availability	0.851	***
RM3	<---	Operation	0.494	***	A04	<---	Availability	0.78	***
RM2	<---	Operation	0.414	***	A05	<---	Availability	0.825	***
RM1	<---	Operation	0.486	***	A06	<---	Availability	0.747	***
Hypotheses		Path			Effect		p	Results	
H1a		Strategy→Availability			0.612		***	Supported	
H1b		Strategy→Operation			0.599		***	Supported	
H2		Operation→Availability			0.257		***	Supported	
Indirect effect		Strategy→Operation→Availability			0.156		0.056	Not supported	

TM: top management; MU: mutual understanding; OF: organizational factor; A: ACT (artemisinin-based combination therapy); R: responsiveness; RM: relationship management.
***$p < 0.001$.

partners to leverage medicine availability through increased information flow and a reduction in uncertainty.[45] An increased lack of reliable data may escalate the weak supply chain performance in public health services. Failure to pay attention to strategic and operational dimensions when assessing supply chain coordination creates loopholes that, when closed, could improve the availability of ACTs, thereby leading to a significant reduction in unavailability and even decreasing malaria-related deaths. Whereas the initial conceptualization of both the strategic and operational determinants was built on the work by Singh[12] and Mehralian et al.,[11] whose studies were in the Small and Medium Enterprises, this study significantly contributes to the body of literature in the field of healthcare supply chain, more specifically in developing countries like Uganda.

Managerial implications

Based on the study results and findings, top management must develop efficient feedback systems, such as having regular meetings for quick information and feedback sharing. It is equally essential for top management to enhance the redistribution strategy for ACTs, both within and outwardly, to ensure medicines are available for patients at all health centers. While the provision of transport to address emergencies received the least scores, it is equally necessary to make changes in the national medical and pharmaceutical policies to direct managerial strategies toward enhancements in the strategic and operational mechanisms to broaden the information flow with various stakeholders. Henceforth, the approach may augment the balanced use of medicines, making them available to those who need them most.

The unavailability of instantaneous point of consumption data causes bullwhip effects along the hospital supply chains, especially in Uganda, where the logistics function responsible for replenishment and procurement (national stores or government department) is further away from the demand (healthcare centers or hospitals). Further away is the logistics concepts from the demand, and the larger responses to demand changes occur through inventory orders. The moderating factor is the restriction and/or permission on the information shared between supply chain partners. Hence, most big retailers invest in retail link systems for accurate information sharing necessary to manage the bullwhip effect.[72] Taking push and pull production system as default comparison, a push is further away to demand than pull logistics concepts; hence the sensitivity to bullwhip effect is high for push than it is for pull logistics concepts. Therefore, top management must share supply and distribution information with relevant users and suppliers for suitable information synchronization in the supply chain. Equally important, top management must devise approaches to commit resources toward cheaper and affordable information technologies and expedite their implementation in general hospitals. In addition, the strategy may improve both internal and external relationships (specified by loyalty, shared vision, and increased trust). It is to be expected that significant cost-cutting may be realized during product selection, ordering, and dispensing. Such tools may aid managers to make timely and effective decisions, which result in better mutual understanding, thereby optimizing the supply chain goal. In the absence of a mutual understanding among the chain players, the management of interdependencies may remain just an illusion. The implication of the findings is that to improve conjoint understanding, mutual confidence, shared vision, and goals should be enhanced to conduct procurement and accurate forecasts collectively. Therefore, the Ministry of Health and other stakeholders could consider the option of investing in the m-health solutions used in other developing countries.

Policy implications

It is paramount to strengthen the building blocks for an effective health system, such as policy, infrastructure, human resources, and information systems. This will call for efforts to phase out manual information systems in favor of automated ones. To effect this, a well laid-out policy toward the provision of computers in all general hospitals in the country is necessary, in addition to extensive staff training and sensitization on the use of ICT. Finally, the government needs to ensure a reliable power supply, especially in the rural areas, including exploring solar-powered systems, to facilitate timely information sharing among significant stakeholders.

Limitations and future research directions

This study portrays several factors that may provide prospects for future studies in medicine supply chain coordination. We only considered supply chain coordination from the notion of Drug Therapeutic Management Committee participants in public general hospitals, leaving out other members of the supply chain. In the future, research can consider chain coordination from the multi-degree beliefs of other chain members. Or a comparative study can be carried out to compare coordination determinants between public and private (non-profit hospitals). Another predicament is that the survey is based only on the ACT that treats parasite-confirmed malaria—the study can be extended to other medicines. The indirect effect of operational factors on availability could not be supported. Therefore, other variables can be taken into consideration to expound the influence of medical policies and regulations and supply chain management competencies, among others, to enlighten the extent to which they affect the availability of medicines in Uganda.

Conclusion

ACTs are vital in treating malaria-affected patients. Health facilities in sub-Saharan Africa run out of stock of malaria medicines, while sometimes ACTs expire, leaving most of the impoverished populace desperate for treatment. This study explores how public hospitals can coordinate their supply chain actors to achieve the desired outcomes by focusing on strategic and operational orientation. To ameliorate ACT availability by a unit, the strategic variable must be enhanced by 0.612, and the operation variables must be improved by 0.256. These can be achieved by strengthening top management commitment and responsiveness of the hospitals. Improving ACT availability will contribute to progress in the elimination of malaria in sub-Saharan Africa.

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Ethics Statement

The study protocol was approved by the ethics committee, Ministry of Health, Uganda, and the University of South Africa, South Africa (Ref#: 2017_CEM_ESTTL_005). The Drug Therapeutic Management Committee members provided written consent to participate in the study.

Availability of data and materials

The questionnaire and datasets used and/or analyzed during this study are available from the authors on reasonable request.

Declaration of conflicting interests

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Appendix 1

Table 6. Nomenclature of the item.

OF03	Existence of the Drug Therapeutic Committee
R01	Adherence of timelines by stores to other units
MU01	Staff awareness
MU02	Staff coherence
MU03	Mutual trust among staff
MU04	Shared vision
RM02	Relationships
RM03	Joint decision on procurement planning
RM04	Good relationship with suppliers
TM01	Frequent feedback on stock status
TM02	Support for online ordering
TM03	Transport emergencies
TM04	Guidelines
A01	Timely delivery
A02	Flexible ordering
A03	Right quantities
A04	Right quality standards
A05	Orders met by the supplier
A06	Improved stock levels

Appendix 2

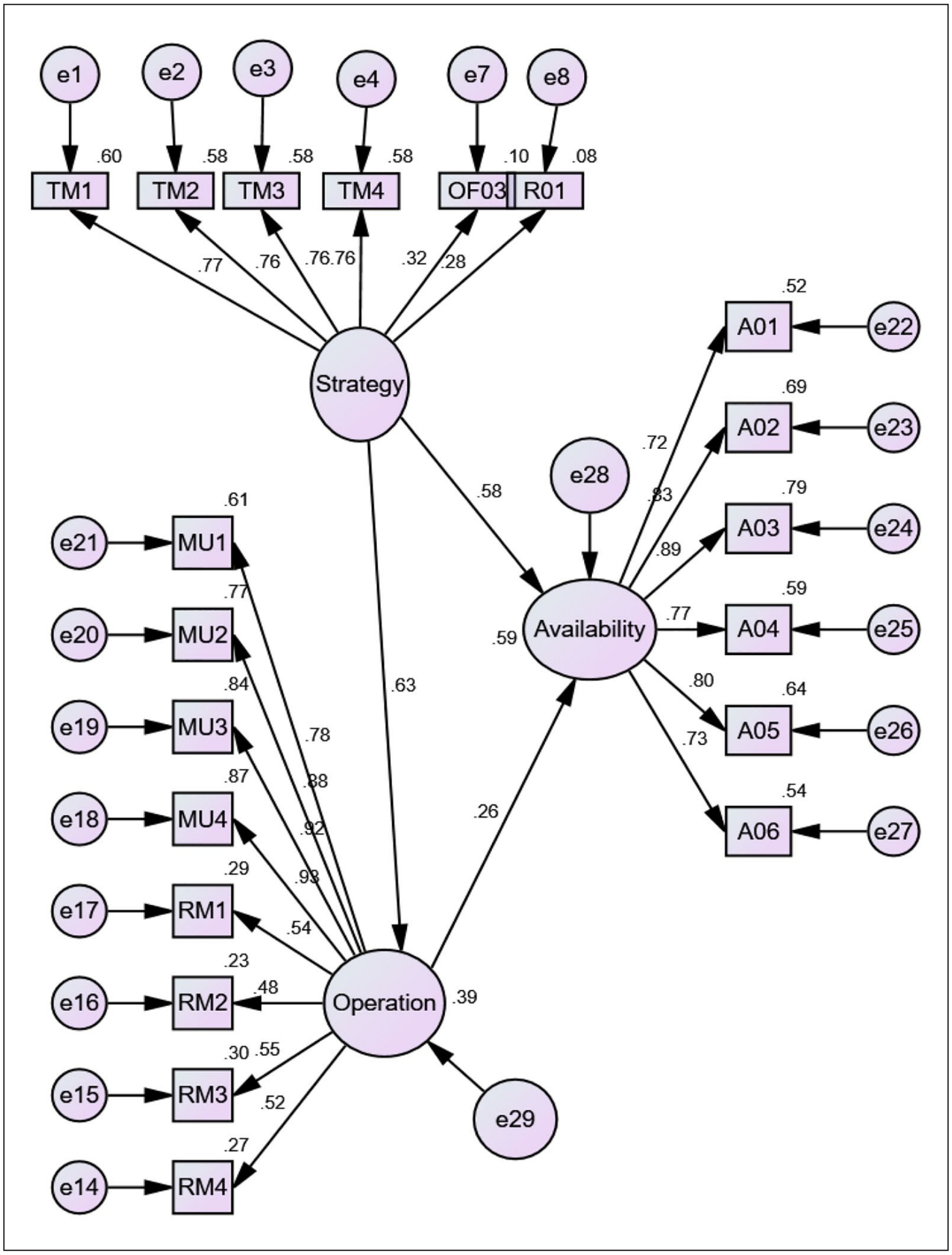

Figure 4. Initial SEM model.