The Relationship Between Market Environment Dimensions and Availability of Malaria Pills in Uganda

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Abstract

Introduction: This study sought to examine the contribution of relationship building (in terms of collaboration, information sharing and supply chain interdependence) on the availability of malaria treatment pills in public hospitals in Sub-Saharan Africa using data from Uganda.

Methods: By means of a cross-sectional survey research design, the study used a questionnaire strategy to collect quantitative data. Out of the 320 questionnaires that were distributed in 40 public hospitals, 283 were answered and returned, which yielded an 88% response rate. Structural equation modelling (SEM) was used to establish the relationship between measured variables and latent constructs.

Results: Drawing on the survey results, the confirmatory factor analysis and the Structural Equation Modelling clearly demonstrate that relationship building (in terms of collaboration, information sharing and supply chain interdependence) significantly influences the availability of Artemisinin-based combination therapies in public general hospitals in Uganda.

Conclusion: Policy-makers should focus on developing cheaper information technology tools to exchange information regarding stock levels, forecasting, quantification, orders, and dispensing. This study developed a measurement model for an inter-hospital relationship, using relational view theory, and it employs dimensions in terms of information sharing and supply chain interdependence to predict and explain the availability of malaria pills in government hospitals.

Keywords
supply chain, collaboration partnerships, information sharing, public health, structural equation modeling, AMOS, malaria drug

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Introduction

Medicines are strategic products, and their availability is a necessity, despite the complexity involved in managing the various stakeholders such as regulatory authorities, ministries, medicine manufacturers, distributors, wholesalers, retailers, customers, and information service providers.1 Regrettably, there is a scarcity of research in the area of medicine supply chains.2 Therefore, coordinating the medicine supply chain is vital whether in developed, emerging, or underdeveloped economies, despite the lack of research on the topic.3 The availability of medicine is considered to be one of the activities with the most significant potential impact on human life; therefore, the need to coordinate it.4

Medicine supply chain coordination is defined as managing the interdependencies among the various actors internally and externally to the hospital to make health care delivery efficient and effective.5 In particular, the planning or forecasting, quantification, procurement, storage, and dispensing should be synchronized to reduce stock-outs or variabilities.6 Attempts to
ensure the availability of medicines can strengthen the overall health system’s responsiveness to the treatment of the patients. Unfortunately, the stock-out of Artemisin-based combination therapies (ACTs), which have been approved by the World Health Organization (WHO) to treat uncomplicated malaria in health facilities in developing countries, has put many lives at risk and has sometimes led to death.

In Kenya, several case studies have established that a mix of strategies was required to stabilize the artemisin (ACTs) market to avert death among children under five and pregnant women. Similarly, another study concluded that “the public health and private retail sector are important complementary sources of treatment in rural Tanzania for ACTs successful uptake”. The same recommendation was made in Ghana to control deaths as a result of complicated malaria. A case study on Uganda advised that the private sector should be included in healthcare provision and should be encouraged to subsidize ACTs. This may lead to a dramatic improvement in the availability and improved uptake, and reduced deaths. Also in Uganda, a study examined case studies of four rural districts in Uganda, and concluded that the failure of coordination was increasing the death burden on already pressured hospitals.

From the foregoing, it is clear that the frequent unabated unavailability of malarial drugs is of urgent global concern, as over 3.7 billion people are at risk of contracting malaria. In Africa alone, malaria is responsible for almost four deaths every five minutes. In 2019, 229 million cases led to 409,000 deaths; of these 67% (274,000) were children under 5 years. In Uganda, malaria is the leading human killer, especially among children under five years and expectant mothers. Several studies that have advanced a number of predictors of the availability of malaria treatment pills have found key enablers to include the use of cheaper information technologies. The management of medicine instead of individually. The management of medicine

Hypotheses Development

This study first adopted the conceptualization of collaborative relationships from Simatupang and Sridhuran. The study further adopted the conceptual framework developed by Nagitta and Mkansi from a qualitative study. However, this paper aimed at measuring and validating the model. This study, therefore, aimed to test and validate the initial qualitative findings from the above scholars using a survey. The conceptualization of the collaborative partnership was conceived to involve joint training with external partners such as the Uganda National Medical Stores (NMS), Drug Monitoring Unit, Ministry of Health, and Non-Governmental Organizations. Information sharing involved variables such as the timely sharing of information with other stakeholders, credibility of shared information, sharing of delivery schedules, and exchange of evaluation reviews with external stakeholders. Finally, the constructs of supply chain interdependence involved variables such as the pooling of resources, standardization of processes, joint planning and mutual adjustment. In developing the hypotheses, this section reviews the literature on collaborative partnerships, information sharing, and the management of supply chain interdependence, and thereafter, they are tested.

Collaborative Partnerships and Availability of ACTs

The term ‘collaborative partnership’ refers to organizations working with each other towards a common goal instead of individually. The management of medicine
supply chains necessitates partners’ capability to disclose, account, and scrutinize information flow. Therefore, in performing such actions, the collaboration with committed suppliers and other stakeholders of products and services should reduce stock-outs or deliver the needed medical supplies. Without focused collaboration and information sharing, it may be difficult for individual hospitals to make medical supplies available.12,28 However, chain partners often opportunistically misuse their powers rather than creating better overall value, therefore, this calls for proposals to explain the interplay of power and trust mechanisms in collaborative interactions.29 Nevertheless, supply chain entities must integrate and act on similar terms to improve the flow of services and products, including financial information and overall economic impacts.30

Collaboration is characterized by a higher-level interest, representing an affective, volitional, shared interest process.31 Other scholars32 stress the importance of the shared interest by including the term “unity of effort.” There must be some form of investment in the relationship that provides for mutual understanding, a shared vision, shared resources, and the achievement of collective goals.33 Collaboration between firms is a powerful competitive advantage source, calling for the effective management of relationships in the supply chain. This includes the development and maintenance of capabilities to ensure the effective delivery of medical products and services.34

Following the reviewed literature, it is hypothesized that:

\[ H_1: \text{There is a relationship between collaborations and availability of ACTs} \]

**Information Sharing and Availability of ACTs**

Information sharing synchronizes the supply chain members’ knowledge and expertise to increase the ability to serve downstream customers efficiently. The coordinated information includes, among others, changes in market demand and customer preferences, and helps to coordinate transaction-related activities.35 Coordinated information is characterized by multiple dimensions, including timeliness, accuracy, adequacy, completeness, and information credibility.36 The supply chain intervention’s primary goals are to improve stocking levels of essential medicines, to and reduce the incidence and duration of pharmaceutical stock-outs.37 Therefore, an effective supply chain plays a critical role in improving the health system performance regarding the general behavioral aspects of the health system.7

However, sometimes firms are reluctant to share information because of a lack of trust, leading to uncoordinated activities within the functional units.38 The information helps to link the point of production seamlessly with the point of delivery or purchase. It allows planning, tracking, and estimating the lead times based on real-time data. Sharing of the information between the supply chain members is very important for effective coordination in the supply chain.39 According to Kabra et al.,40 the sharing of information between supply chain members helps to substitute information with inventory and lead time, reduces the supply chain costs, reduces the demand variability, enhances responsiveness, and improves the service level. Available empiricism, as investigated by Prajogo et al.41 found out that information technology capabilities, particularly, have significant positive effects on integrated supply and distribution systems. The same study demonstrates that long-term supplier relationships have direct effects on logistics integration. However, sharing supply information among the general hospitals and donors remain a challenge in Sub-Saharan Africa.42 The effective exchange of information with external suppliers is crucial for the supply chain delivery of health products.41

Following the reviewed literature, it is hypothesized that:

\[ H_2: \text{There is a relationship between information sharing and the availability of ACTs} \]

**Management of Supply-Chain Interdependence and Availability of ACTs**

The past decade has been characterized by pulling data together using different strategies towards an integrated supply chain from both suppliers and customers.43,44 notes that managing supply-chain interdependence is a critical factor for organisations in various industries. It has potential benefits for firms’ performance, resulting from the interdependencies of supplier business relationships.45 Research on Kenya’s Public Health Sector46 found that the effective management of the health sector requires the efficient integration of the hospital processes using information technology tools so that products are provided adequately at the right time and delivered at the right places. This minimizes system-wide
Studies have shown that partners can easily adjust or vary fixed contractual terms, such as cost or budget pressures and volume adjustments, among others, when supply chain processes are integrated. By this very fact, a high level of total interdependence, like the one in Uganda between NMS and health facilities, might indicate a strong, cooperative, long-term relationship. Both parties have invested time, effort, and money. These scholars demonstrate that supply-chain interdependence ensures that medicines do not expire in any health facility, while there are either public or private outlets that do not have stocks. Therefore, we hypothesized that:

H₃: There is a relationship between supply-chain interdependence and the availability of ACTs

### Methods

**Research Philosophy and Approach**

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

**Data Collection Method and Pilot Study**

The study adopted a cross-sectional survey design, and collected data through the use of a standardised questionnaire, which enabled us to draw inferences through the measurement of casual relations between the variables at a particular point in time. Upon establishing the research variables, a research questionnaire was designed to test the hypotheses of the study. The research tool was based on the five-point Likert 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 market experts and three medical practitioners. After piloting, the research tool was corrected for mistakes, clarity, language, and the proposed model’s coherent flow. Data related to the constructs were collected via a web-based and in-person questionnaire.

**Survey Population, Sample Size, and Technique**

The unit of analysis was hospitals and Drug Therapeutic Management Committee (DTMC) members in each hospital who handle the medicine supply chain. Out of the 45 general hospitals (GHS), 40 were selected based on Krejcie and Morgan. This assumed 95% statistical significance testing level (confidence level). The population proportion of 0.5% or margin of error/degree of accuracy (5%) was expressed as a proportion (.05). From the 40 GHS, a population of 440 DTMC members were identified, out of which, 320 were selected using simple random technique (eight from each hospital). The members were able to offer insights from which we built supply chain coordination understanding from a public hospital perspective. Hence giving equal chance to estimate statistically the characteristics of the population from the sample. In addition, the respondents are responsible for planning and forecasting quantifying, procuring, storing and dispensing medicines. In total, 283 questionnaires were returned, giving a response rate of 88.4%. The sample was considered adequate because for factor analysis to be run, a sample size of at least 100 respondents is recommended, even though the number of variables is less than 20, or at least 10 cases for each item in the instrument.

**Operationalization of Variables**

Availability refers to the physical presence of the medicine at the service delivery point, in good quality and in the right quantities, to treat ailments and diseases; timely delivery of drugs, stock-out frequency and improved stock levels. Collaborative partnerships. This variable entails hospitals working together in aspects of joint training with either the supplier, donors or Ministry of Health.

Information sharing. This refers to the extent to which critical and proprietary information is communicated to a supply chain partner. It involves the aspects of accuracy, timeliness, adequacy and credibility of exchanged information. The information shared could be inventory and order levels, delivery schedules, customer demand and sales trends.

Supply-chain interdependence. Interdependency relates to how the different functions or units within an organization connect with each other, given the interdependence among their internal and external operations through mutual adjustment, standardization of processes and joint planning. The rest of the variables, as used in the study, are listed in Table 1.
Data Evaluation and Reliability Analysis

Structural Equation Modelling (SEM) was used to test the model. SEM is a multivariate statistical analysis technique that is used to analyze structural relationships. This technique is the combination of factor analysis and multiple regression analysis, and it can be used to analyze the fundamental relationship between measured variables and latent constructs. Missing and outliers were tested before subjecting the data to SEM.57 Overall, 304 questionnaires were completed and returned. A total of 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. Ten (10) 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. The symmetry (skewness, $S$) and tailing (kurtosis, $K$) of the data were also tested; all variables were in the allowable range of $-2 \leq S, T \leq +2$, which elicits good normality of the data. Cronbach Alpha (CA) was employed to estimate the internal consistency (IC), and to determine how closely the measuring variables were contributing to their respective latent variables. CA values range from 0.0 to 1.0; CA $< 0.70$ elicits unacceptable consistency, 0.7 $\leq$ CA $\leq 0.8$ elicits acceptable levels, while CA $> 0.8$ shows good IC.58 To improve CA, items with a CA greater than the overall CA were deleted. Using this approach, one item under the supply chain interdependence with suppliers (SCI) category was deleted; and the CA for the group soared from 0.699 to 0.760. The overall CA for the tested variables in this study was 0.838, with no individual group eliciting CA $< 0.700$, as shown in Table 2. Thus, the proposed hypothetical model elicits a good IC and reliability.

Results and Discussions

Demographics

The respondents comprised of 52.3% females and 47.7% males. The respondents’ qualifications were as follows: 3.2% held secondary school certificates, 24.0% were diploma holders, 50.2% had bachelor’s degrees, and 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 ten years, while only nine respondents had less than one year of experience in the medical industry. Overall, the demographics elicited a diverse dataset.
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. 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) < average shared variance (ASV), and the square root of AVE should be higher than inter-construct correlations.59

The initial values of the hypothetical model are summarized in Table 3. The results shown in the table elicit abysmal levels of the initial proposed model. To improve the model outputs, suggestions based on the AMOS yield were followed. In addition, items with a residual covariance > 2.0 were eliminated.60 Based on these recommendations, items SCI01, SCI02, and ISS03 were eliminated from the model. Their elimination secured acceptable levels of reliability and validity for the model. The removal of such items suggests the heterogeneous nature of ACT availability, and plummets 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. Figure 1 shows the CFA measurement after adjustment.

Structural Equation Model

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 was normally distributed.58,59,61 The goodness of fit indices (GOFIs) was tested using the different parameters, as outlined in Table 4.62 The majority of the GOFIs failed to pass the minimum requirement. To improve the model fit, covariances and causal relationships were established among the model variables and error terms. AMOS modification indices were used as a baseline to build the interrelationships amongst the measured parameters.63 As a way of modifying the model in this regard, covariance relations were established, as illustrated in Figure 2. For example, the relationship in the error parameters of “evaluation meetings (SCI06)” with “routine monitoring (SCI05)” and

![Figure 1: Hypothetical Model Measurement Using CFA. ISS: Information sharing with suppliers; CP: Collaborative partnerships for training; SCI: Supply chain interdependence with suppliers; AV: Availability; en: error in nth univariate variable; other variables are defined in Table 1.]

| Proposed Model | CR  | AVE | MSV | SCI | CP  | ISS  | AV  |
|----------------|-----|-----|-----|-----|-----|------|-----|
| SCI            | 0.757 | 0.424 | 0.360 | 0.651 |     |      |     |
| CP             | 0.818 | 0.531 | 0.001 | 0.017 | 0.729 |      |     |
| ISS            | 0.812 | 0.538 | 0.100 | 0.316 | 0.006 | 0.733 |     |
| AV             | 0.910 | 0.562 | 0.360 | 0.600 | 0.027 | 0.307 | 0.749 |
| Adjusted model | CR  | AVE | MSV | SCI | CP  | ISS  | AV  |
| SCI            | 0.919 | 0.740 | 0.361 | 0.860 |     |      |     |
| CP             | 0.818 | 0.531 | 0.001 | 0.015 | 0.729 |      |     |
| ISS            | 0.889 | 0.670 | 0.100 | 0.317 | 0.001 | 0.819 |     |
| AV             | 0.910 | 0.562 | 0.361 | 0.601 | 0.027 | 0.306 | 0.749 |

AVE: average variance explained, CR: composite reliability, MSV: maximum shared variance, ASV: average shared variance, ISS: Information sharing with suppliers, CP: Collaborative partnerships for training, SCI: Supply chain interdependence with suppliers, AV: Availability.
“timely delivery (A01)” makes theoretical sense. This creates conceptual sense, as increased evaluation meetings mean revved routine monitoring, which fosters timely delivery.

Table 4 summarizes the GOFIs of the final model after several refinements, and all the minimum requirements were satisfied. For instance, GFI = 0.926, thus the model outcomes are well explained by the collected data; RMSEA = 0.042, which elicits high confidence levels amongst variables.

Table 5 elicits the standard regression coefficient of each retained item in the model. All the path coefficients are positive and significant at $\rho < 0.05$. The two hypotheses, $H_2$ and $H_3$ are supported, based on the data collected from the survey. However, $H_1$ is not supported by the data. These results suggest that ACTs’ vital supply chain coordination determinants can be enthused through information sharing with suppliers and supply chain interdependence with suppliers. From the foregoing results, collaborative partnerships were surprisingly not supported. Yet partners need to leverage on each other’s strength to reduce stock-outs. This is because public hospitals by policy only receive medicine supplies supplied by National Medical Stores (NMS) or Joint Medical Stores. Enhancing collaborative partnerships may require a fundamental shift in policy, which will necessitate ethical considerations to deter partners from opportunistically misusing their powers. These findings contradict the findings of previous studies that revealed that collaborative partnerships were a significant predictor of medicine availability. Nonetheless, without close working relationships with committed suppliers (donors, Non-Governmental Organizations, and other stakeholders), collaborative training and joint supervision of medicine usage may be difficult.

Information sharing emerged as a critical theme in fostering the availability of ACTs to the populace. The finding is supported by Mbugua and Namada, who assert that information sharing is effective through information technology tools that lessen system-wide
cost implications, while satisfying service requirements. This then implies that all the stakeholders, particularly the beneficiaries of malaria drugs, should get the necessary information from government hospitals on where to obtain the drugs with ease and almost no effort.\textsuperscript{36,37} Therefore, the hospital must have in place mechanisms for sharing information in real-time with suppliers and other external stakeholders.\textsuperscript{38} The implication is an investment of resources in procuring appropriate information technology that will enable the integration of functions and systems within the hospitals and with external partners.\textsuperscript{40}

Supply chain interdependency is the most significant predictor of medicine availability. The result denotes that decisions between the general hospitals and NMS should be synchronized to boost the availability of ACTs. With integrated systems, decision synchronization involving joint decisions in planning could be possible (SCI\textsubscript{02} = 0.92 and SCI\textsubscript{06} = 0.71). Pooled and reciprocal interdependence were among the univariate variables that were retained under supply chain (SCI\textsubscript{04} = 0.97, and SCI\textsubscript{05} = 0.78). Pooled interdependence is vital to the efficiency of any kind of operation, since this form of interdependence has to do with the joint utilization of resources. By utilizing common resources, economies of scale can be achieved in the performance of individual activities that belong to different supply chains.

Where activities are subject to counterpart-specific interdependence, and hence, are closely complementary, it is necessary to include reciprocal interdependence in the supply chains. This interaction may include adjustments of resources used in, or refined by, the activities subject to coordination to improve resource utilization or the means by which the activities are coordinated.\textsuperscript{64} National Medical stores could work closely with the general hospitals when deciding to decouple or coordinate the inbound and outbound flows of inventories to reduce the ordering and channel inventory costs. The local government or Ministry of Health may have to invest in developing logistic infrastructure to significantly reduce the supply chain hurdles.

Conclusions and Implications

Based on the modified SEM model, the findings generally stick to the assertion that information sharing and interdependency improvements are significant predictors of the availability of ACTs. Therefore, it is essential for DTMC members in hospitals to enhance affordable information sharing, and manage the interdependency so as to make medicine available to the end-user. The implication for hospital management is to develop affordable information technologies which will be able to facilitate the information flow between different stakeholders. By so doing, the hospitals may minimize manual processes that sometimes are inaccurate and do not provide the much needed visibility. Taking note of the interdependence among supply chains partners implies that that hospitals need to share resources to the extent that is possible. This may require hospitals to rethink how to mutually adjust work plans the pooling of resources, and standardization of processes. This may in turn lead to the improved availability of medicines, to the neediest population, quality of service delivery, timeliness and reduced costs, which are key facets of good supply chain performance.

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Author Contributions

Oluka Pross Nagitta and George William Kajjumba designed the initial draft, wrote the manuscript, and did the literature review, while Marcia Mkansi edited the final revisions.

Availability of Data and Materials

The datasets supporting the conclusions of this article are available on reasonable request from the authors.

Consent for publication

All co-authors agree to a joint publication.

Declaration of Conflicting Interests

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