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# Assessing performance using maturity model: a multiple case study of public health supply chains in Nigeria

Ramatu Abdulkadir

School of Engineering, Liverpool John Moores University, Liverpool, UK and Department of Pharmacy, National Ear Care Centre Kaduna, Kaduna State, Nigeria, and

Dante Benjamin Matellini, Ian D. Jenkinson, Robyn Pyne and Trung Thanh Nguyen  
School of Engineering, Liverpool John Moores University, Liverpool, UK

## Abstract

**Purpose** – This study aims to determine the factors and dynamic systems behaviour of essential medicine stockout in public health-care supply chains. The authors examine the constraints and effects of mental models on medicine stockout to develop a dynamic theory of medicine availability towards saving patients' lives.

**Design/methodology/approach** – This study uses a mixed-method approach. Starting with a survey method, followed by in-depth interviews with stakeholders within five health-care supply chains to determine the dynamic feedback leading to stockout and conclude by developing a network mental model for medicines availability.

**Findings** – The authors identified five constraints and developed five case mental models. The authors develop a dynamic theory of medicine availability across cases and identify feedback loops and variables leading to medicine availability.

**Research limitations/implications** – The need to include mental models of stakeholders like manufacturers and distributors of medicines to understand the system completely. Group surveys are prone to power dynamics and bias from group thinking. This survey's quantitative output could minimize the bias.

**Originality/value** – This study uniquely uses a mixed-method of survey method and in-depth interviews of experts to assess the essential medicine stockout in Nigeria. To improve medicine availability, the authors develop a dynamic network mental model to understand the system structure, feedback and behaviour driving stockouts. This research will benefit public policymakers and hospital managers in designing policies that reduce medicine stockout.

**Keywords** Mixed method research, Mental models, Medicines stockout, Survey method, In-depth interviews, Systems thinking, System dynamics, Essential medicines, Causal loop diagrams, Nigeria

**Paper type** Research paper

## 1. Introduction

Essential medicines (EM) cater to the medical needs of most of a country's population. Hence, medicines stockout is the bane of achieving goal three of the United Nations Sustainable Development Goals (SDGs), which focuses on the global attainment of good health and well-being for citizens (WHO, 2019; Oluatase *et al.*, 2022). Nigeria is a developing country in West Africa that runs a federal political system with Abuja as the capital city. Nigeria has 36 states comprising of 774 Local Government Areas (LGAs) (Federal Ministry of Health, 2020). Health-care services in Nigeria are public sector driven (67%) in contrast to private health facilities, constituting only 33% of health facilities (Federal Ministry of Health, 2020). The public health sector has three levels of care, primary, secondary and tertiary care levels. Public Health-care Supply Chains

(PHSCs) provide EM for the citizens through clinics and hospitals at all levels under the supervision of authorities at LGAs, state and federal governments (Hafez, 2018). These PHSCs are mainly fragmented and vertical, with inadequate funding, infrastructure and coordination with ongoing efforts to integrate public health programmes at the national level (Byrnes, 2004; Federal Ministry of Health, 2016). Though the

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health sector is social and not profit-driven, the availability of EM is a priority for saving lives.

Kaduna State is in the northwestern part of Nigeria and operates the Drug Revolving Fund (DRF) model to deliver EM to patients. The DRF model is a brainchild of the Bamako initiative, introduced in 1987 to sub-Saharan African countries as a financing mechanism for the continuous availability of EM (Hardon, 1990). The DRF model provides medicines to patients at a subsidised rate, and the cash from sales is used to procure more medicines. Different versions of the model have evolved over the years while stakeholders still grapple with the implementation and sustainability of the DRF model (Tran et al., 2020; Oguniola et al., 2021). Success stories of the model abound from extant studies, but some studies have also questioned the inequities and rational use of medicines that arise in different implementation settings (Uzochukwu and Onwujekwe, 2004; Uzochukwu and Onwujekwe, 2005; Tran et al., 2021). The controversies surrounding different DRF models make it imperative for user countries to continue to research methods and strategies for ensuring equitable drug distribution models to save the lives of citizens and ensure economic development in line with the SDGs (WHO, 2019). Thus, measuring and improving the EM Supply Chains (SCs) is critical for developing countries to achieve the SDGs.

To improve the EM SC, Kaduna State launched a transformation initiative to save lives and promote the well-being of its citizens through an integrated, gold-standard SC management system. The transformation initiative seeks to foster a performance-driven and self-sustaining system to deliver quality and sustainable health supplies to end-users and minimise medicines stockout. Essential medicine stockout in hospitals leads to treatment failures and loss of lives. The health-care industry is complex, where different stakeholders have varying expectations and attempting to reform a particular aspect might have an unwanted effect on another (Paina and Peters, 2011; Bigdeli et al., 2012). Hence, the need to assess the effect of these reform initiatives on the availability of medicines in the DRF SC. Research on medicines performance measurement (PM) in health-care SCs are scarce, particularly in developing countries where health-care systems are weak and rely on government support (Dixit et al., 2020). This study aims to determine the essential medicine stockout factors and dynamic systems behaviour in revolving fund SCs. The specific objectives of this study are:

- 1 To determine the constraints leading to medicine stockout;
- 2 To examine whether mental models improve understanding of medicine availability (MA); and
- 3 To develop a dynamic theory for improving medicine availability performance (MAP).

This article attempts to answer the following research questions (RQ):

- RQ1. What are the constraints preventing medicine availability in essential medicines supply chains?
- RQ2. Did using a dynamic approach identify the structure, feedback and delays leading to medicine stockout in essential medicines supply chains?

- RQ3. How has a dynamic approach affected medicine availability in essential medicine supply chains?

Our theoretical proposition for this case study will show why MA only increases in organisations with a network systems perspective and not just internal and external organisational focus on increasing EM availability. This research will also show why staff monitoring of medicine stockout alone was insufficient to increase EM in the PHSCs.

### 1.1 Sequence of the research article

We arrange our article in the following sequence: firstly, we conduct a comprehensive review of the literature on EM stockout in health-care SCs to determine the research gaps and propose using system thinking and dynamics to fill the gaps. Secondly, we conduct the main study to measure MA and constraints with the Global Health Supply Chain Maturity Model (GHSCMM) tool and build on the process by determining key informants' perceptions and mental models using the dynamics approach. Thirdly, we provide a case-by-case causal loop diagram (CLD) of individual mental models, which leads to the developing of a cross-case network mental model. Fourthly, we develop the network mental model as a dynamic theory for improving MAP. Finally, we conclude by considering the benefits and limitations of this study and propose areas for future studies.

## 2. Literature review on medicine stockout in public health-care supply chains

There is a frequent stockout of medicines in health-care facilities across Africa, including Nigeria (Kuwawenaruwa et al., 2020), where local markets drive the prices of medicines (Russo and McPake, 2009). Medicines stockout in PHSCs prevents access to care, leading to increased cost of care in private hospitals and inequitable distribution of medicines (Fitzpatrick, 2022). Medicines must be available and affordable to improve the elimination of diseases such as malaria (Lussiana, 2015; Lee et al., 2017), diabetes (Gong et al., 2018) and the treatment of childhood diseases (Kiplagat et al., 2014). Strategies to reform ineffective health-care SCs have been investigated over the years to save costs, make medicines accessible (Fu et al., 2017; Orubu et al., 2019) and improve efficiency and performance (Geng et al., 2017). Lack of competent personnel to handle medicines and manual inventory management practices lead to medicine stockout (Zuma, 2022). Countries receiving medicines as donor support have also experienced stockout due to funding uncertainty and inadequate performance monitoring (Gallien et al., 2017). The multi-tiered structure of EM SCs, complex delivery channels and delayed information flow prevent access to medicines (Vledder et al., 2019). Table 1 below summarizes the factors responsible for medicine stockouts in health-care SCs.

### 2.1 Measuring medicine availability performance

To determine the efficiency of SCs, measurements of service, asset and speed performance metrics across functions and organisations support continuous improvement across extended networks (Hausman, 2004). Avelar-Sosa et al. (2019) define SC performance as the capacity of organisations to

Table 1 Factors responsible for medicines stockout in health-care SCs

Authors	Data collection approaches	Data analysis techniques	Factors responsible for medicine stockout
<a href="#">Aigbavboa and Mbohwa (2020)</a> <a href="#">Bate et al. (2010)</a>	Quantitative survey Sampling technique	Exploratory factor analysis Statistical analysis	Inadequate competent staff, lack of infrastructure and regulatory capacities Diversion of medicines from public to private health-care sector
<a href="#">Okoye et al. (2022)</a>	Survey, interviews, observation and document reviews	Statistical analysis	Lack of inventory management capacities, inadequate competent staff, inadequate funds and procurement delays from bureaucracy
<a href="#">Nditunze et al. (2015)</a>	Document reviews	Statistical analysis	Medicine campaigns, importation delays, personnel turnover, proliferation of medicine brands
<a href="#">Mikkelsen-Lopez et al. (2014)</a> <a href="#">Zakumumpa et al. (2019)</a>	Data reviews Interviews	Statistical analysis Thematic analysis	Inadequate medicine supplies and delivery delays Supply of short-dated medicines, deficient quantification leading to supply of inadequate or excess medicine inventory
<a href="#">Hwang et al. (2019)</a>	Survey	Statistical analysis	Inadequate visibility, monitoring and medicine transparency
<a href="#">Kuwawenaruwa et al. (2020)</a> <a href="#">Gils et al. (2018)</a>	Survey, interviews, observation and document reviews Document reviews, observation and interviews	Statistical analysis Statistical analysis	Inadequate forecasts, replenishment delays, upstream shortages Insufficient planning for stocking medicines
<a href="#">Koomen et al. (2019)</a>	Survey and data reviews	Regression analysis	Increase poverty which prevents patient access to medicines
<a href="#">Martei et al. (2018)</a> <a href="#">Kumar and Kumar (2018)</a> <a href="#">Bam et al. (2017)</a>	Data reviews and interviews Survey Data reviews	Statistical analysis System dynamics modelling and simulation System dynamics modelling and simulation	Inefficient procurement practices Inadequate safety stock Prolonged supplier lead times, excessive medicine inventory
<a href="#">Kefale and Shebo (2019)</a>	Survey	Statistical analysis	Lack of inventory management capacities

understand the needs of their customers and fulfil customer needs with sufficient inventory levels through product availability and on-time deliveries. Besides the use of online measurements to improve information sharing and time to order and deliver medicines ([Kasparis et al., 2021](#)), the use of PM, information and technology and other management practices is crucial to MA in government hospitals ([Dixit et al., 2019](#)). The use of digital technology platforms for PM reduces medicines stockout by tracking and enabling decision-making through enhanced information flows and reduced delays in order fulfilment ([Wang et al., 2022](#)). PHSCs are humanitarian with a focus on service and not profit-driven. A lack of robust PM systems in non-profit SCs, when compared to commercial businesses ([Adair et al., 2006](#)), can lead to medicines stockout ([Gallien et al., 2017](#)). Measuring health-care systems' performance guides the development of suitable policies ([Aristovnic, 2015](#)) and affirms the value creation process from multiple stakeholders ([Nuti et al., 2018](#)). Medicine stockout rate, a critical component of SC performance, decreases with information technology platforms ([Mwencha et al., 2017](#)). Poor inventory management performance, budget and funding constraints and oversupply of medicines with short shelf lives

contribute to medicine stockout ([Gurmu and Ibrahim, 2017](#); [Kebede and Tilahun, 2021](#)), leading to calls for strengthening demand forecasting capacities ([Leung et al., 2016](#)).

## 2.2 Identifying the research gaps

Most studies identified some of the causes of medicine stockout in PHSCs and proposed strategies to prevent stockout ([Table 2](#)). However, none of the studies explores the dynamic role of mental models of the system operators in improving MA. In contrast, system dynamics studies like [Bam et al. \(2017\)](#) and [Kumar and Kumar \(2018\)](#) use dynamic models to measure and prevent specific medicine stockouts. Hence, our research attempts to fill these gaps by using system dynamic methods to understand the structure, feedback and delays leading to medicines stockout and develop the mental models of system operators to build a dynamic theory for improving MA. This research will benefit from using multiple case study methods as essential medicine stockout in hospitals is a contemporary issue globally. We do not have control over the hospitals, which necessitates using the case study method ([Yin, 2015](#)). Using a multiple case study approach will allow

Table 2 Measurement of medicines stockout and improvement strategies in public health-care SCs

Type of supply chain	Measurement of medicines stockout	Medicine availability improvement strategies	Authors
Pharmaceuticals	Use of national data to track and prevent medicine shortages	Collaboration between national stakeholders	Bouy and Rotaru (2021)
	Public-private partnerships in hospitals	Effective contract management in direct purchasing from selected and reputable vendors	Kuwawenaruwa et al. (2021)
	Price differentials between local and international sourcing	Strategies to improve pricing of medicines locally	Nakambale and Bangalee (2022)
Cold chain	Sensory networking and computer hardware to improve cold chain logistics	Affordable warehouse cold chain systems	Schon and Streit-Juotsa (2015), Shafiq et al. (2019)
	Measures availability, stockout and storage conditions of vaccines	Intervention of top management, training and supervision of staff	Feyisa et al. (2021)
Generic medicines	Considers use of value stream map and ordering to from a supply chain wide perspective	Enhance the use of resources	Dixit et al. (2019)
Essential medicines	Dynamics of SC systems and policies that affect cost and availability of paediatric cancer medicines	Regional integration of forecasting and procurement	Boateng et al. (2021)
	Direct distribution of medicines through cross-docking to last mile	Working with political actors and stakeholders for the successful implementation of strategies	Vledder et al. (2019)
	Determine health outcomes derived from digitizing last mile medicine delivery	Deploy hospital logistics management information systems to hospitals to save children's lives	Fritz, Herrick and Gilbert (2021)
	Measures donor fund disbursement <i>vis-à-vis</i> medicine procurement	Managing timing risk in disbursing fund for procurement	Gallien et al. (2017)
	Impact of COVID-19 on prices of medicine and stockout	Increased funding from government and medicine exchange collaborative efforts between hospitals	Aljadeed et al. (2021)
	Weak systems of procuring medicines	Buying from local suppliers with improved production capacity and robust contract management with the state actors	Chebolu-Subramanian and Sundarraj (2021), Magadzire et al. (2017)
Sexual and reproductive medicines	Determine optimum inventory in hospitals	Build system dynamic model for prediction, measuring and improving the SC. Maintaining safety stock and reducing supplier lead times	Kumar and Kumar (2018), Bam et al. (2017)
	Barriers to sexual and reproductive care	Strategies to reduce medicine delivery delays	Ooms et al. (2022)

comparisons between cases and support building a dynamic theory for improving MA in hospitals using replication, pattern matching (Eisenhardt, 1989) and combining multiple mental models.

This study presents five case studies assessing medicine stockout from a system thinking and dynamics perspective. We use the GHSCMM tool to measure SCs operations and constraints leading to stockout (Association for Supply Chain Management, 2020). Furthermore, we use the interview protocol to explore the feedback mechanisms responsible for medicine stockouts, develop SC for the managers' mental models and propose a dynamic theory of MA. We build on the works of Kim and Andersen (2012), Turner et al. (2013) and Tomoia-Cotisel et al. (2022) that use only qualitative interviews for system dynamics model. In contrast, our study combines output from quantitative surveys and in-depth interviews to design and interpret CLDs in a mixed-method framework for building a systems dynamics model (Figure 1).

### 3. Methodology

#### 3.1 Rationale for using quantitative and qualitative methods

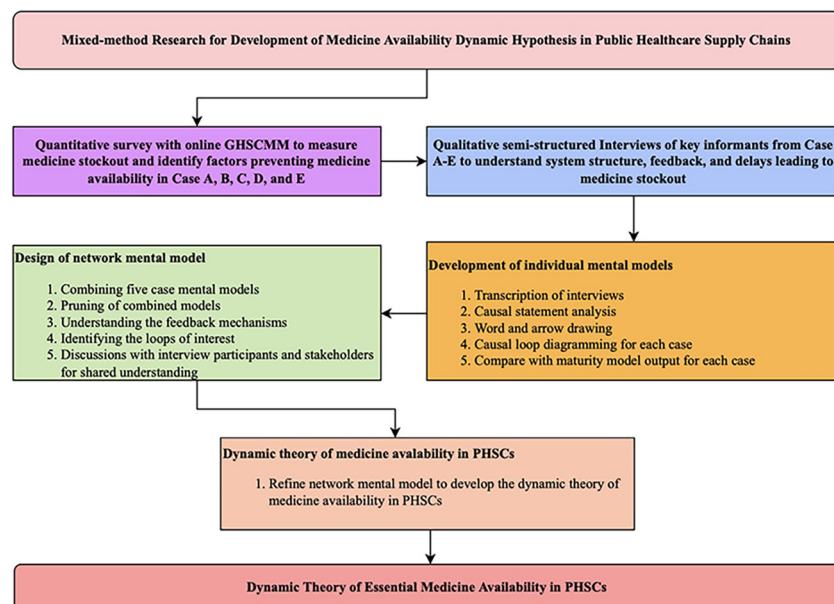
Firstly, we use the quantitative GHSCMM survey to measure MA and the constraints leading to medicine stockout. The survey helps address objective one by identifying the factors hindering MA and providing vital input into developing interview protocol to evoke the causal statements responsible for medicine stockout. Using statistical data analysis from the survey provides details of the pattern of responses across cases and identifies the SC operations constraints responsible for stockout. We collect data on all the processes of providing medicines, from procurement planning to customer fulfilment, to understand the end-to-end operations of the DRF programme and identify underperforming areas that lead to stockout. The questions are analysed using statistical analysis

on Qualtrics and viewed online with participants. Secondly, we collect interview data on participants' perceptions of managing the DRF SC to understand the challenges affecting the provision of medicines in conformance to objective two. The interview questions probe causal statements from stakeholders working in the SCs. We rigorously interpret, analyse and standardise quotations from interview transcripts into variables to draw words and arrow diagrams and CLDs (Tomoia-Cotisel et al., 2022). This grounded theory approach clarifies participants' mental models of how the systems operate within the identified constraints to provide medicines and deepens understanding of factors leading to medicine stockout. We analyse the standardised variables into categories of MAP that affect the organisations internally, externally, and at the network level to help address objective three by developing a dynamic theory of MA. The rationale for mixed methods supports data triangulation (Yin, 2015) by building scientifically sound and transferable results (Ivankova and Wingo, 2018) through the integration of findings into a general theory (Kopainsky and Luna-Reyes, 2008). See the methodology roadmap in Figure 2 below.

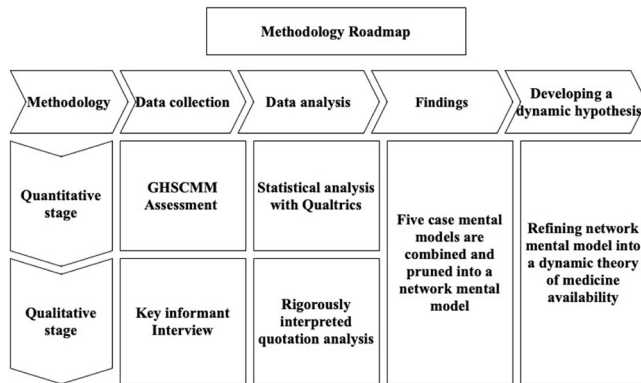
#### 3.2 Quantitative and qualitative pilot study

We test the GHSCMM online assessment questionnaire (Appendix 1) for reliability using test-retest and content validity in a pilot study (Polit and Beck, 2006). The insights gleaned from the qualitative study pilot (Appendix 2) led to the design of an in-depth interview protocol for the main study (Figure 3). The in-depth interview is necessary from the systems perspective to understand how the hospital network operates to provide medicines to patients. The pilot was important as this study started in 2020 at the beginning of the COVID-19 pandemic. Adjustments were required to minimise the risk of exposure to the disease, like changing face-to-face interviews into telephone sessions.

**Figure 1** Dynamic theory framework to improve medicine availability in PHSCs



**Figure 2** Methodology roadmap for developing a dynamic theory of MA



We use an explanatory multiple-case method with replication logic design (Yin, 2015) to explore medicine stockout performance in five PHSCs, as described in Table 3. Multiple case studies broaden the analysis of result and provide convincing proof of this study's robustness (Yin, 2015). The case study selection criteria include PHSCs in Kaduna State that operate a DRF programme (Figure 4). Ethical clearance was received from Liverpool John Moores University and the five case study organisations.

**Figure 3** Outline of in-depth interview questions derived from the pilot study

Questions for In-depth Interviews
1. How do inter-departmental teams (pharmacy, accounts, procurement etc) work together in the organization to make medicines available?
2. What should be done to improve how teams work together?
3. Can you describe how your inter-departmental teams work with your patients and suppliers to provide medicines?
4. Can you describe how the teams work with suppliers to make medicines available?
5. In your own perspective, how can inter-departmental teams improve working relationship with patients?
6. In your own opinion, how can inter-departmental teams improve working relationship with suppliers?
7. In your own opinion, how can inter-departmental teams improve working relationship with critical stakeholders (donor/partner, government/regulators/ CSOs etc)
8. Can you describe how you share information about medicines and other health supplies with patients, suppliers, and other critical stakeholders (donor/partner, government/regulators/ CSOs)?
9. Describe how you share logistic information (stock level, available medicines, expiries, expected medicines etc)?
10. In your opinion, what should be done to improve information-sharing with patients, suppliers, and other critical stakeholders (donor/partner, government/regulators/ CSOs)?
11. In your opinion, what do you think about the use of digital technology for making medicines available?
12. What type of digital technology do you have experience with in making medicine available?
13. In your opinion, explain how would you measure the performance of medicine availability in your organization?
14. In your opinion, describe how the inter-departmental teams can improve performance by working with patients, suppliers, and other critical stakeholders (donor/partner, government/regulators/ CSOs)?

### 3.3 Medicine availability performance measurement

We conduct a 4-h workshop from March to May 2021 in each of the five case study organisations using the ASCM GHSCMM version 8.0 (Association for Supply Chain Management, 2020) to determine five public health SC MAP (Appendix 1). We administered 72 questions to 78 respondents that were selected using criterion sampling (Miles and Huberman, 1994) from departments responsible for DRF operations with inclusion criteria in Figure 4. Case A had 15 respondents, Case B (9), Case C (19), Case D (20) and Case E (15) respondents, as shown in Table 4. The workshops were a combination of virtual for Case A and face-to-face for Cases B, C, D and E. COVID-19 protocols were strictly adhered to, including physical distancing and use of personal protective equipment during face-to-face workshop sessions. We compute the data electronically and analyse it with Qualtrics software (2021). At the end of each session, we review the results with the respondents.

### 3.4 Semi-structured key informant interview for the main study

We use in-depth interview questions to elicit responses from heads of pharmacy departments and SC managers selected based on the criteria in Figure 5. The interview provides detailed information about the operations of EM and challenges leading to stockouts. We conducted interviews with five purposively selected respondents from July to August 2021. Each interview

**Table 3** Descriptions of public health-care SCs with revolving fund distribution channels

Case study	Supply chain description	Ownership structure	Distribution channels	Location in Kaduna
Case Study A	A supply chain organisation that procures and distributes essential medicines to all clinics and hospitals at the primary, secondary and tertiary level of care	State Government	Primary health-care clinics (1051), Secondary health-care hospitals (35) and Tertiary health-care hospital (1)	Kaduna South LGA
Case Study B	A tertiary specialist hospital that provides essential medicines for the treatment of ear, nose and throat diseases	Federal Government	Active stores (3)	Kaduna North LGA
Case Study C	A tertiary teaching hospital that provides essential medicines for the treatment of diseases	Federal Government	Outstation pharmacy (3), Active stores (2)	Zaria LGA
Case Study D	A tertiary specialist hospital that provides essential medicines for the treatment of neuro-psychiatric disorders	Federal Government	Active stores (8)	Kaduna South LGA
Case Study E	A tertiary specialist hospital that provides essential medicines for the treatment of eye diseases	Federal Government	Active stores (2)	Kaduna South LGA

**Figure 4** Inclusion and exclusion criteria for selection of case study organisation

Inclusion Criteria	Exclusion Criteria
Public healthcare organisation	Less than 3-year experience in operations of the essential medicines revolving fund program
Operates the essential medicines revolving fund program	Refusal to give consent
Located in Kaduna State	
Owned by the Kaduna State government	
Owned by the Federal Government of Nigeria	
Responsible for the essential medicines supply chain operations	

session lasted 40–60 min and was recorded and transcribed with Otter software. The respondents included four pharmacists (PH) and one supply chain manager (SM). We use open-text analysis of the transcripts to identify cause and effect statements

and draw words and arrow diagrams which is combined and pruned into participants' mental models (Kim and Andersen, 2012; Turner *et al.*, 2013; Tomoia-Cotisel *et al.*, 2022). This article uses the Tomoia-Cotisel *et al.*, 2022 quotation analysis method to build the mental model of each manager in the system with Vensim PLE Plus 2022. The mental models allow us to visualise the system's structure and comprehend how the participants perceive their operations structure, feedback and delays leading to medicine stockout.

## 4. Results and discussion

### 4.1 Global health maturity model assessment output

The GHSCMM findings showed that Case A had previously measured the DRF SC operations once, while Case B, C, D and E have never measured their entire DRF operations. In total, 80% of the case study sites reported never measuring the SCs, while 20% reported measuring operations using the online GHSCMM version once. The average scores for the five SCs were Case A (75%), Case B (66%), Case C (61%), Case D (55%) and Case E (45%) across categories of SC operations.

**Table 4** List of maturity model assessment participants' department

Participants	Case A	Case B	Case C	Case D	Case E	Total
Pharmacy	0	2	15	14	7	38
Supply chain management	9	0	0	0	0	9
Administration and planning	4	2	0	0	2	8
Accountant	1	1	1	1	2	6
Store	0	2	1	1	3	7
Procurement	1	1	0	1	1	4
Quality control	0	0	2	0	0	2
Audit	0	1	0	1	0	2
Laboratory	0	0	0	1	0	1
Maintenance	0	0	0	1	0	1
<b>Total</b>	<b>15</b>	<b>9</b>	<b>19</b>	<b>20</b>	<b>15</b>	<b>78</b>



**Figure 5** Inclusion and exclusion criteria for key informant interview

Inclusion Criteria	Exclusion Criteria
Essential medicine Supply chain manager	Less than 3-years' experience in DRF program
Leads the operations of the DRF program	Refusal to give consent
Have complete understanding of the functional supply chain operations	
Full time staff of the institution	
Oversees the operations team responsible for providing essential medicines in the organisation	

The lowest category and constraint for Case A was infrastructure and assets (50%), fund and financial management was the lowest category and constraint for Case B (46.7%), Case C (40%), Case D (36%) and Case E (28.9%). The results showed that 80% of the case study sites (Case B, C, D and E) had funds and financial management as the constraint, while 20% (Case A) had infrastructure and assets (Table 5).

#### 4.1.1 Medicine stockout performance at case study sites

We identify the connection between the constraints from the MM assessment and medicine stockout performance. The availability of medicines was 50%–75% in Cases A, B, D and E. Cases A, B, D and E reported a 25%–50% medicine stockout. While Case C had availability of less than 50% of the product with a stockout greater than 50%. More than 70% of products were affordable, within the health facility budgets and could be acquired for patients in Cases A, B and C. In total, 30% to 50% of products were cost-prohibitive and above the health facility budget in Cases D and E.

**Table 5** MAP measurement output

Categories	Case A (%)	Case B (%)	Case C (%)	Case D (%)	Case E (%)
	Score obtained				
Service-delivery point (SDP)/health facility (HF) visibility	66.7	62.2	56.7	53.3	45.9
SDP/HF inventory management	90	80	75	72	66.7
SDP/HF order management	80	66.7	58.3	56	51.1
Warehouse/store visibility	86.7	77.8	70	65.3	56.3
Warehouse/store inventory management	90	80	75	70	62.2
Warehouse/store order management	80	75	62.5	54	41.7
Warehouse/store operations	93.3	91.1	73.3	64	47.4
Transportation	60	57.8	51.7	45.3	36.5
Expiry management	90	73.3	70	60	46.7
Procurement	73.3	64.4	60	57.3	51.9
Infrastructure and assets	50	50	52.5	46	37.8
Performance management	80	66.7	60	53.3	41.5
Analysis and evaluation	100	80	75	64	44.4
Demand planning	70	70	67.5	58	42.2
Supply planning	80	73.3	70	60	42.2
Fund management	60	46.7	40	36	28.9
Financial management	60	46.7	40	36	28.9
Governance	60	53.3	47.5	42	32.2
Staff training/development	70	53.3	50	44	33.3
Patient-focused performance	60	60	56.7	54.7	52.6
Average score	75	66	61	55	45

## 4.2 Case-by-case quotation analysis of interview transcript

System dynamics methods help us explore the structure and feedback driving the dynamics of the DRF system (Sternan, 2000). We use open-text analysis and systems dynamics methods of interpreting quotations from in-depth interviews with participants to draw words and arrow diagrams for each quotation (Kim and Andersen, 2012; Tomoiaia-Cotisel et al., 2022). We use the words and arrow diagram to draw CLDs, which represent the mental model of each participant as the hospitals try to provide EM for the treatment of diseases and the perception of DRF operations in meeting the needs of patients.

### 4.2.1 Case A interview quotation analysis

Case A is experiencing problems in delivering medicines to patients, as observed by the response of the SC manager (SM01). For example, when asked about teamwork and getting medicines to patients:

[...] They should communicate information, get information together to get work done to achieve our goals as an organisation. [...] The procurement [team] will need to know what the budget looks like, before they start quantifying or forecasting on what they will [...] procure for the organisation. The data visibility [team] will have to come up with the data. [...] The warehousing will have to inform the team [...] to keep all the commodities that are needed to be procured. There has to be information sharing and communication among teams. It can be in form of [...] sharing of reports [...] or having data so that everybody could see or [...] use the data to create a dashboard that every team can see and interpret what is going on in the organisation.

From this response, we can see that time delay in getting information across teams affects MA. When teams do not get information on time, it reduces the effectiveness of the process and leads to stockout. Information sharing delays affect medicine

production by manufacturers. Teamwork and aligning processes increase the ability of cross-functional teams to get medicines to patients and minimises competition among functional units. The MM constraint of infrastructure and assets could be information and technology systems to provide visibility, as shown in the visibility loop where an increase in information sharing increases the production of medicine by the manufacturer. The mental model of SM01 and interpretation captures the feedback and delays in Figure 6. Full details of the quotation analysis for SM01 is shown in Appendix 3.

4.2.2 Case B interview quotation analysis

We observe fund leakages and disharmony between the treasury single account policies and the DRF, which connects to the financial constraint that prevents access to funds for the procurement of medicines. Inadequate staff inventory and procurement management capacity hinder the provision of medicines and information to patients and SC partners, as noted by the pharmacist (PH01):

[...] Only the head of department that has direct communication with the suppliers, no other person is expected to communicate with suppliers regarding any medication or drugs supply, [...] the pharmacist communicates with the head of department [...] when the stock gets too low. [...] usually the restocking is quarterly, due to procurement bureaucracy, It usually goes into like six months before drugs get replenished.

This statement and the mental model in Figure 7 show that bureaucracy and system’s structure delay information sharing leading to extended periods of stockout. Full details of the quotation analysis are in Appendix 4.

4.2.3 Case C interview quotation analysis

Quantification of medicines for procurement depends on available funds. Using digital platforms to share information with SC partners increases trust, which improves the ability to deliver medicines to the hospital. Transparency and accountability with digital tools increase sales and cash flow in the DRF programme and reduce patient wait time by increasing fill rate as indicated by PH02 statement:

Working together means, we should have a transparent policy, transparent in the sense that what goes on in pharmacy should be open to accounts at any time. [...] transparency can be enhanced maybe through electronic data collection. [...] when we digitalize or computerise the whole process, everybody will see what is happening at one point or the other. So, there should be no hidden agenda. [...] that can only be done when all processes are computerised.

This statement shows that a lack of trust in the system and the perception of a “hidden agenda” affects the procurement process in a reinforcing loop and links to the fund and financial management constraint as shown in Figure 8. See full details of quotation analysis in Appendix 5.

Figure 6 Case A participant mental model and interpretation of findings

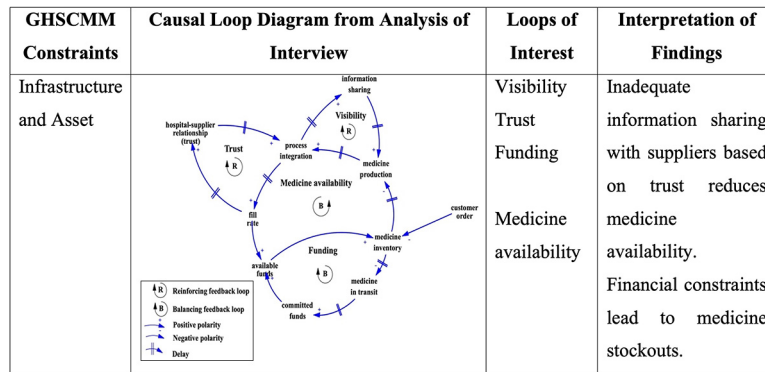


Figure 7 Case B participant mental model and interpretation of findings

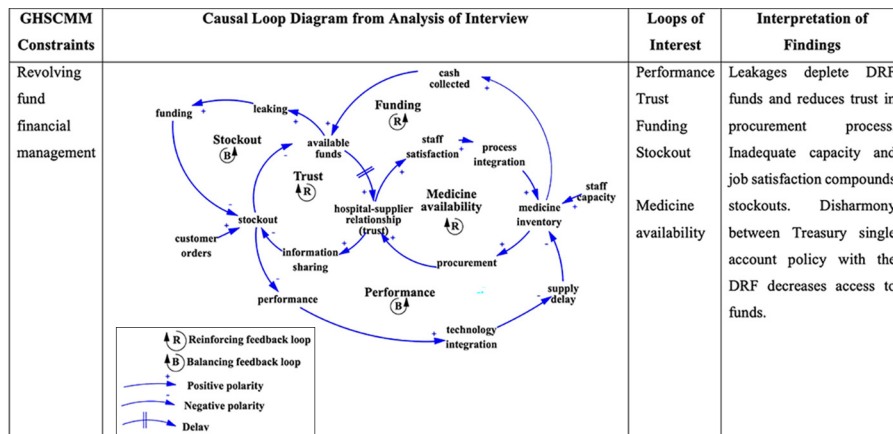
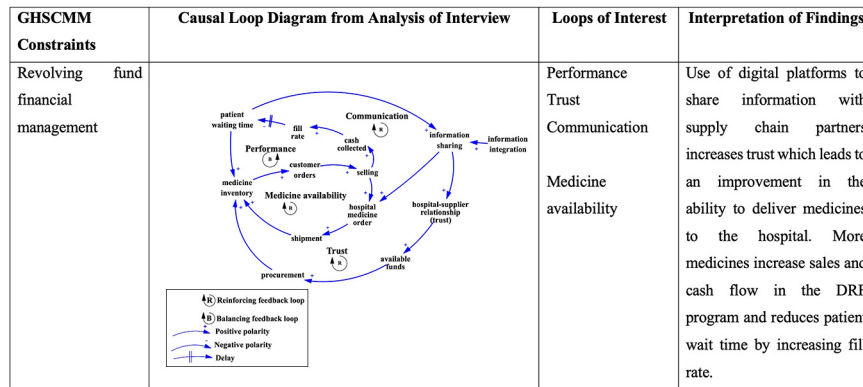


Figure 8 Case C participant mental model and interpretation of findings



4.2.4 Case D interview quotation analysis

Improving staff procurement capacity and deploying technology platforms ensures on-time ordering before stockout. Supply delays reduce with increasing payment of outstanding invoices, as stated by PH03:

For patients, we make sure there's constant supply of drugs. [...] sustainability of medicines so that patients can have access to the drugs it's important to reduce lead times during order to be able to meet customer needs. Make sure we prepare list of medicines that are about to be exhausted on time. [...] timely submission of data for procurement. There should be prompt payment of suppliers whenever they deliver medicine.

Delays from manual processes and minimal alignment of the DRF programme lead to a reinforcing stockout loop impervious to the balancing loops of initiating procurement and sending multiple orders (Figure 9). Shrinking inventory due to pilferages and expiries links to MM constraints of financial management, which affect the procurement planning process due to inaccurate inventory records (Appendix 6).

4.2.5 Case E interview quotation analysis

Delays in medicine shipment led to medicine stockout in a reinforcing loop, while external government funding will increase MA through procurement and better customer

satisfaction. Procurement is hampered by bureaucracy as stated by PH04:

[...] The collaboration can be better, if the pharmacist is given more to operate like sometimes, because before a major decision is taken, every part of this team [...] has to be carried along, or when [...] purchases are made, the approval has to come from somewhere, this can affect how often we get drug into the facility. I think that if the pharmacists are given more free room to operate and we get drug into the facility, [...] people can see the need that we don't have to wait for bureaucracy for drugs to be brought in [...].

Delays due to an increase in lead times decrease MA of the DRF programme and increase medicine stockout (Figure 10). Measuring performance and working hard, as seen in the performance balancing loop does not prevent stockout as delays in shipment continue to deplete medicine inventory. The inability to pay suppliers on time due to financial constraints and the subsequent reluctance of suppliers to deliver orders traps the system in a vicious cycle (Appendix 7). See the sample quotation analysis of PH04 in Figure 11.

4.3 Dynamic hypothesis across cases

We combine and prune the CLDs from Cases A, B, C, D and E (Kim and Andersen, 2012; Tomoia-Cotisel, 2018) to draw the network mental model of medicines stockout in public health-care DRF SCs. The reinforcing feedback loops of

Figure 9 Case D participant mental model and interpretation of findings

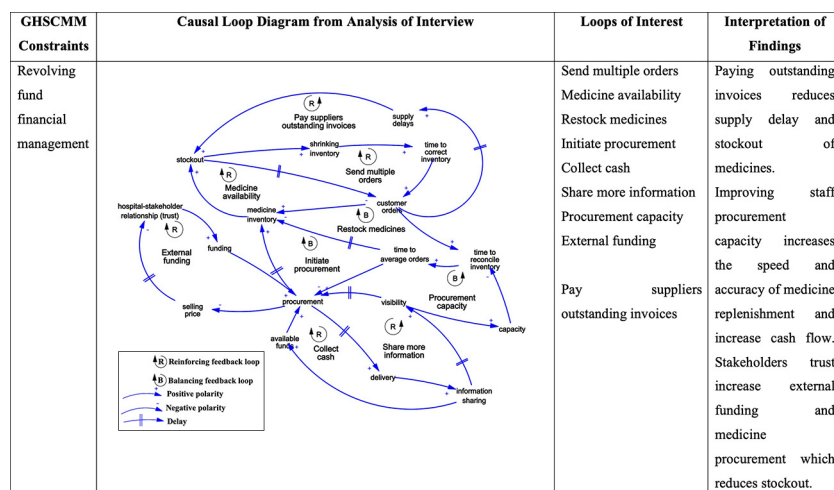


Figure 10 Case E participant mental model and interpretation of findings

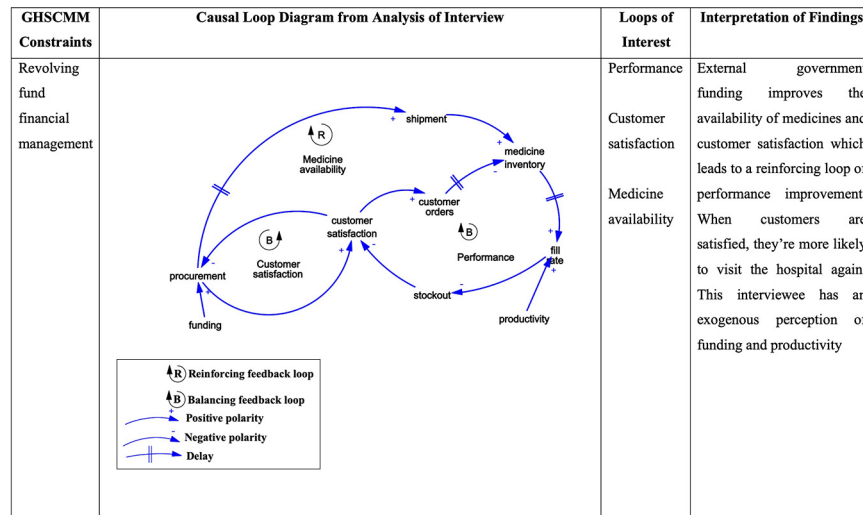


Figure 11 Sample quotation analysis for participant (PH04)

Participant Number-Quote number " - variables in Phrase(s)" (word count in variables/total word count in causal statement)	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, - =causal link with delay, +/-positive or negative polarity)	Comments
PH04-01 "There's an EDRF committee... Essential Drug Revolving Fund which is a team of professionals, which includes the medical doctor, includes the account, the pharmacy, and then the stores. we all work together to make sure that drugs are readily available from time-to-time meetings are held, to see how the EDRF functions and whether we're making progress or if there's areas that need to that we need to improve upon." (70 /91)	- from time-to-time - to make sure that drugs are readily available - whether we're making progress	Time delay Medicine availability Fill rate	Medicine inventory- = →+ Fill rate	Even though the teams work together there is delay in getting the required medicine for the patient.
PH04-02 "...the collaboration can be better, if the pharmacist is given more to operate like, sometimes because before a major decision is taken, every part of this team ... has to be carried along, or when purchases are made, the approval has to come from somewhere, this can affect how often we get drug into the facility. I think that if the pharmacists are given more free room to operate and we get drug into the facility, ...people can see the need that we don't have to wait for bureaucracy for drugs to be brought in..." (96/101)	- has to be carried along - can affect how often - and take decisions instantly - have to wait - given more free room to operate - when ... purchases are made - we get drug into the facility	Time delay Process integration Procurement shipment	Process integration- = →+ Procurement- = →+ shipment	Bottlenecks are preventing the teams from seamless operations.
PH04-03 "...And depending on the volume of patients we have in particular times like there are certain seasons, that we have a higher turnover than others. ... we make sure that we always have drugs readily to meet the particular needs of patients ... particular clinic days to make sure that those drugs they'll be needed in clinics...very available. ... during the rainy season we see a spike in allergies. For this season we make sure that we do not run out of anti-allergic agents and we get the accounts department to make sure that when this drugs are supplied payments are made in good time. so that when we call upon the suppliers for more supplies or other supplies, they will not be reluctant to supply." (126/208)	- volume of patients - we see a spike in allergies - turnover - needs of patients - those drugs they'll be needed in clinics...very available - payments are made in good time - reluctant to supply	Customer orders Cash collected Fill rate Medicine inventory Available funds Supply delay	Customer orders→+Cash collected- = →+ Available funds- = →+Supply delay→- Medicine inventory- = →+Fill rate	High number of orders depletes inventory which cannot be replenished when suppliers are not paid on time.

sending multiple orders and paying suppliers outstanding invoices increase stockout as shrinkage and associated leakage of funds makes stockout worst. The staff need visibility of the cash collected from patients and available for procurement. Suppliers continue receiving orders for replenishment but cannot deliver the products leading to supply delays as they demand outstanding payments from the hospitals. The staff selling the medicines presuppose that the accounts staff have collected all cash from customer sales. The accounts department cannot pay suppliers for previous deliveries, and suppliers are not delivering medicines fast enough leading to continuous medicine stockout. The balancing loops of initiating procurement and replenishment do not prevent stockout as the suppliers do not get paid on time to enable the delivery of new orders, as shown in Figure 12 below. The dynamic hypothesis of MA proposes the consideration of four

internal medicines availability loops, which includes sending multiple orders, restocking medicines, procurement capacity and MA. The five external MA loops of interest include paying suppliers, initiating procurement, trust, increased collaboration and performance. The two network medicines availability loops of collecting cash and sharing information with stakeholders complete the 11 loops driving MA.

A cross-case analysis of mental model variables shows that Case A is gravitating towards network MA performance compared to Cases B, C, D and E, which are more internally focused. Case A considers collaboration, medicine production and equity as critical factors in making medicines available at the network level. We observe that supplier and stakeholder trust is a big issue at the level of external MA performance for all cases. Cases C and E note the influence of government and partner trust on external supplier and customer performance.



Table 6 Cross-case mental model variable analysis to improve MA

Performance level	Case A variables	Case B variables	Case C variables	Case D variables	Case E variables
<b>Internal medicine availability performance</b>	Process integration Information sharing Internal integration Internal performance Fill rate Data analysis Data-driven decisions Committed funds Available funds Customer order Internal performance Time delay Medicine inventory	Available funds Process integration Procurement Staff satisfaction Staff capacity Information sharing Stockout Procurement Staff capacity Information sharing Time delay Supply delay Cash collected Medicine inventory Performance Customer orders Fill rate Leakage	Internal integration Time delay Hospital medicine order Available funds Procurement Internal trust Customer orders Cash collected Selling Shipment Supply delay Procurement Medicine inventory Information sharing Medicine order Process integration Internal performance Fill rate	Procurement Delivery Information sharing Available funds Time delay Medicine inventory Time delay Customer order Time to reconcile inventory Time to average orders Selling price Information sharing Stockout Capacity Stockout Customer orders Supply delay Time to correct inventory Shrinking inventory	Time delay Medicine availability Fill rate Process integration Procurement Shipment Customer orders Cash collected Medicine inventory Available funds Stockout Productivity Information sharing Staff satisfaction Performance Medicine inventory Staff attrition
<b>External medicine availability performance</b>	Supplier integration Process integration Technology integration Customer integration Hospital-supplier relationship (trust) Contract management Transactional relationship Collaboration Non-alignment Communication Information sharing Price visibility Medicine in transit	Information sharing Technology integration Funding Hospital-stakeholder relationship (trust) Hospital-supplier relationship (trust) Transactional relationship Collaboration Non-alignment Communication Information sharing Price visibility Medicine in transit	Communication Shipment Supply delay Information integration Information sharing Patient waiting time Supplier performance Supplier integration Medicine in transit Technology integration Hospital-supplier relationship (trust) Hospital-government relationship (trust) Visibility	Information sharing Funding Hospital-stakeholders relationship (trust)	Supply delay Customer satisfaction Technology integration Funding Partner satisfaction Hospital-partner relationship (trust)
<b>Network medicine availability performance</b>	Visibility Collaboration Production Medicine equity		Visibility	Visibility	Visibility

the only organisation with staff attrition which could explain its poor performance during the MM assessment. Staff attrition limits the capacity to deliver the needed services even when funds are available to procure medicines. Overworked staff will make mistakes in the customer fulfilment process and increase lead times, further reinforcing staff dissatisfaction and reducing internal MA performance.

## 5. Conclusions

Our study identifies the dynamic variables driving medicine stockout in PHSCs. The dynamic network mental model shifts the perceptions and understanding of health-care SC practitioners away from internal to a network systems orientation of increasing MAP. The network model serves as a dynamic theory of MA and a learning tool for advocacy to stakeholders. The model helps users reflect on their roles and stakeholders towards improving MAP by working on the structure, feedback and delays in the DRF system. We recommend that Cases B, C, D and E collaborate and leverage the SC capacity of Case A to reduce capacity gaps. Knowledge sharing across the SCs will improve the network's MAP since they all share the same suppliers, customers and other stakeholders as reference hospitals. The five cases can explore other areas of synergy like pooled procurement, sharing technologies and best inventory management practices to increase the availability of EM to serve patients.

Our study bridges the gap between practice and theory by proposing a dynamic theory of MAP in PHSCs. We contribute to the systems thinking and dynamics body of knowledge by fusing five PHSCs mental models into a network model. This study helps SC managers see the mental models of medicine stockout and the dynamic complexity of increasing MA building on Tomoia-Cotisel et al. (2022) study. We develop a dynamic theory of MA in revolving fund SCs to bridge the gap between theory and practice and support our theoretical proposition that MA only increases in organisations with a network systems perspective and not internal and external organisational focus to increasing EM availability.

Healthy citizens contribute positively to societies and the economic development of nations. This research will benefit public policymakers and hospital managers as they strive to improve MA by providing a dynamic systems perspective of health-care SCs to address the challenges towards achieving goal three of SDGs. Hospital managers and policymakers will design sustainable policies with an increased understanding of system feedback and behaviours to improve essential MA and save lives, as noted in Aristovnic's, 2015 study. The findings from this study can be generalised to revolving fund PHSCs in other African countries and can help increase MA in other donor-supported programme SCs.

The limitations of this study include the need to expand the model boundary to gain insights from other stakeholders like medicine manufacturers and suppliers, which we will be addressing in subsequent studies. The dynamic theory will be tested and validated in subsequent studies. We also need to build a stock and flow model for simulating and testing policies to improve the availability of medicines in the PHSCs. Finally, we will expand this study by modelling and simulating policies to reduce medicine stockout and improve availability in the DRF network.

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### Corresponding author

**Ramatu Abdulkadir** can be contacted at: [R.Abdulkadir@2020.ljmu.ac.uk](mailto:R.Abdulkadir@2020.ljmu.ac.uk)

## Appendix 1. Global health supply chain maturity model v8.0

Please complete questions in all 20 Maturity Model categories. Each category appears on a separate page. As you complete a category, your responses will automatically be saved in the event you inadvertently exit the assessment website or lose your internet connection.

To save a copy of your responses, please follow the instructions on the last page of the questionnaire.

### Assessment Profile

1. Please include the following information:

Country and Region/State/Country: (required) \_\_\_\_\_

District/Organization/Other: (optional) \_\_\_\_\_

Date of Completion: \_\_\_\_\_

Names of Individuals or Team Completing the Evaluation: \_\_\_\_\_

Type of Organization (Private, Public, or NGO) \_\_\_\_\_

Is this assessment supported by a donor organization?

- No  
 Yes (please name donor)

Registration: (choose one) — If you wish to enter both an email address and a Registration code, please record the Registration code in the *District/Organization/Other* field above.

- Registration code: \_\_\_\_\_  
 Self-assessment: (For self-assessment, you must provide an email address below)

2. Please indicate the commodity type for which the assessment is being completed. (choose one) — If you are completing an assessment for COVID-19, please select *Other* and write in *COVID-19*.

- Family Planning  
 Reproductive Health  
 Essential Medicines  
 Vaccines  
 HIV  
 Malaria  
 Tuberculosis  
 Integrated Commodities (please describe the commodities): \_\_\_\_\_  
 Other (please specify): \_\_\_\_\_

3. Which supply-chain stakeholders are represented in the assessment? (choose all that apply)

- National (identify by name): \_\_\_\_\_  
 State (identify by name): \_\_\_\_\_  
 County (identify by name): \_\_\_\_\_  
 Sub-county/Community (identify by name): \_\_\_\_\_  
 Site (identify by name): \_\_\_\_\_  
 Other (please specify): \_\_\_\_\_

4. How many assessments have been conducted previously with this same scope and supply chain? (choose one)

- 0  
 1  
 2  
 3  
 4  
 5  
 More than 5  
 Don't know

5. What is the primary source of the information for this assessment? (choose one)

- First-hand experience  
 First-hand experience and second-hand information (from another person or information system)  
 Second-hand information (from another person or information system)

### Service Delivery Point (SDP)/Health Facility (HF)

#### I. SDP/HF Visibility

Service Delivery Points/Health Facilities generate data regarding the inventory levels and consumption of product on site. As maturity increases, the supply chain increasingly receives real-time data from SDPs/HFs that feeds into a broader supply-chain digital platform.

Objective: Improve the visibility and tracking of inventory at the SDP/HF.

(continued)

6. Please describe the visibility of inventory and consumption from the facility(ies): (choose one)
- Limited visibility to inventory and consumption at facilities (quarterly)
  - Some visibility to inventory and consumption at some facilities, monthly (minimum of 80% of facilities)
  - Visibility to inventory and consumption at most facilities, twice per month (minimum of 80% of facilities)
  - Some digital visibility (near real time; 1 week or faster) to inventory and consumption at most facilities (minimum of 90% of facilities)
  - Digital visibility (near real time) to inventory and consumption at all facilities (100% of facilities)
  - Not applicable
  - Don't know
7. Please describe the visibility of upstream supply-chain inventory information to the facility(ies): (choose one)
- No visibility of upstream supply-chain inventory information
  - Upstream supply-chain information is rarely available and only if requested
  - Some upstream supply-chain information provided to facilities (about warehouse/store inventory, upcoming shipments, health programs)
  - Upstream supply-chain information provided to all facilities
  - Automated upstream supply-chain information process connects to supply-chain digital platform
  - Not applicable
  - Don't know
8. How is inventory information within the facility(ies) shared with supply-chain partners?(choose one)
- Inventory information is not shared with supply-chain partners
  - Some inventory information is shared verbally, manually, or handwritten with supply-chain partners
  - Inventory information is shared electronically with supply-chain partners
  - Data connected to larger supply-chain digital platform or national logistics management information system
  - Data connected to larger supply-chain digital platform or national logistics management information system with real-time dashboards for decision-making
  - Not applicable
  - Don't know
9. Which of the following are constraints that prevent improvement of inventory visibility at facilities? (choose all that apply)
- Human resources
  - Improvement-process knowledge
  - Enabling technologies
  - Leadership/guidance
  - National guidelines
  - Funding
  - Infrastructure
  - Government support
  - No public/private collaboration
  - Other (please specify): \_\_\_\_\_
  - No constraints
  - Not applicable
  - Don't know

Comments/notes for this category:

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## II. SDP/HF Inventory Management

**Inventory in the facilities is segmented into simple product categories to improve data (e.g., quantities, expiration dates, stockouts) and provide a clearer sense of what products are needed. As maturity increases, regular audits are conducted to ensure accurate product levels and adherence to policies to maintain appropriate stock levels.**

***Objective: Standardize inventory-handling practices at SDP/HF to ensure that optimal levels of inventory are always available.***

10. How are inventory levels within the facility(ies) established?(choose one)
- No process to establish inventory levels
  - Staff react to depleted inventory and stockouts
  - Policy/guidelines are in place to inform how much inventory should be kept in the facility(ies)
  - Inventory segmentation used to calculate stocking levels (monthly)
  - Dynamic segmentation used to calculate stocking levels (daily)
  - Not applicable
  - Don't know

(continued)

11. How frequently are physical stock counts conducted within the facility(ies)? (choose one)
- No physical stock counts
  - Random physical stock counts
  - Regular physical stock counts conducted (at least quarterly)
  - Regular physical stock counts conducted (monthly)
  - Frequency of physical counts dynamically determined by inventory control system
  - Not applicable
  - Don't know
12. Which of the following are constraints that prevent improvement of inventory management at facilities? (choose all that apply)
- Human resources
  - Improvement-process knowledge
  - Enabling technologies
  - Leadership/guidance
  - National guidelines
  - Funding
  - Infrastructure
  - Government support
  - No public/private collaboration
  - Other (please specify): \_\_\_\_\_
  - No constraints
  - Not applicable
  - Don't know

Comments/notes for this category:

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### III. SDP/HF Order Management

The facility can determine the need to order more inventory, identify that an order is based on inventory policies, and execute the order in a timely manner. As maturity increases, orders are created within a broader supply-chain digital platform on demand.

**Objective: Execute order management at the SDP/HF in relation to inbound orders, outbound inventory, real-time demand, and SDP/HF budget.**

13. How do/does the facility(ies) determine the need to order inventory? (choose one)
- No process to determine the need to order inventory
  - Manual/visual process used to determine the need to order inventory
  - Ordering of inventory is based on inventory policies, guidelines, and/or SOPs
  - Digital order management process is in place, or a process to digitize within 1 day exists
  - Orders are created on demand through consumption or demand calculated by an electronic inventory management system
  - Not applicable
  - Don't know
14. How is the order quantity for the facility(ies) determined? (choose one)
- No process to determine order quantity
  - Visual review of inventory determines order quantity for the facility(ies)
  - Automated ordering for the facility(ies) based on inventory management strategy
  - Automated ordering that accounts for orders already placed, but not received
  - Order management is connected to the supply-chain digital platform that recommends resupply based on demand and consumption
  - Not applicable
  - Don't know
15. How are orders checked against the budget of the facility(ies) for the order? (choose one)
- Orders are not checked against the budget
  - Budget constraints are sometimes recognized and can affect ordering
  - Order amount authorized by those with budget information
  - Order amount considers the facility's (ies') budget
  - Order amount electronically checked in real time against the facility's (ies') budget
  - Not applicable
  - Don't know

(continued)

16. Which of the following are constraints that prevent improvement of order management at facilities? (choose all that apply)

- Human resources
- Improvement-process knowledge
- Enabling technologies
- Leadership/guidance
- National guidelines
- Funding
- Infrastructure
- Government support
- No public/private collaboration
- Other (please specify): \_\_\_\_\_
- No constraints
- Not applicable
- Don't know

Comments/notes for this category:

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## Warehouse/Store

### IV. Warehouse/Store Visibility

**Within supply-chain warehouse(s)/store(s), all products, inventory levels, and orders can be identified whether they are on the shelf, inbound, or outbound. As maturity increases, the supply chain has a Warehouse Management System (WMS) that is connected to a broader supply-chain platform, which allows the warehouse/store to define specific inventory level rules.**

*Objective: Improve the visibility and tracking of inventory within the warehouse(s)/store(s).*

17. How is product located at the warehouse(s)/store(s)? (choose one)

- Difficult and time-consuming to locate specific product within warehouse(s)/store(s)
- Warehouse(s)/store(s) is arranged to ease identifying the location of specific product
- Manual tools available to track product in warehouse(s)/store(s)
- Electronic WMS with batch and bin tracking used to track product in warehouse(s)/store(s)
- Real-time tracking and visibility of product in warehouse(s)/store(s)
- Not applicable
- Don't know

18. Describe the ability to identify order status within the warehouse(s)/store(s)? (choose one)

- Not able to identify order status
- Difficult to identify order status
- Ability to track order status
- Visibility to incoming and outgoing inventory (past and future)
- Visibility to incoming and outgoing inventory (past and future) through an inventory management system with real-time, event-driven decision-making or real-time dashboards
- Not applicable
- Don't know

19. How is inventory information in the warehouse(s)/store(s) shared with others in the supply chain? (choose one)

- Inventory information is not shared with the supply chain
- Some inventory information shared upon request
- Inventory information sent to supply chain periodically
- WMS connected to supply-chain digital platform/LMIS (logistics management and information system)
- WMS connected to supply-chain digital platform with what-if analysis and real-time, event-driven decision-making
- Not applicable
- Don't know

*(continued)*

20. Which of the following currently are constraints that prevent improvement of visibility at warehouse(s)/store(s)? (choose all that apply)

- Human resources
- Improvement-process knowledge
- Enabling technologies
- Leadership/guidance
- National guidelines
- Funding
- Infrastructure
- Government support
- No public/private collaboration
- Other (please specify): \_\_\_\_\_
- No constraints
- Not applicable
- Don't know

Comments/notes for this category:

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#### V. Warehouse/Store Inventory Management

**At the warehouse/store level, there is a defined amount of inventory of each product that should be maintained, based on demand. These levels are not fixed and should be updated on a regular basis. As maturity increases, regular audits are conducted to ensure accurate product levels and adherence to policies to maintain appropriate stocking levels.**

***Objective: Standardize inventory-handling practices at the warehouse(s)/store(s) to ensure optimal levels of inventory are available.***

21. How does/do the warehouse(s)/store(s) define the optimum level of inventory to maintain? (choose one)

- No method to define the optimum level of inventory
- Manual inventory management based on frequency of replenishment, stockouts, etc.
- Dynamic policy on how much inventory should be maintained at the warehouse(s)/store(s) with defined min/max levels
- Inventory segmentation used (reviewed quarterly)
- Dynamic segmentation determined electronically by WMS or inventory management system
- Not applicable
- Don't know

22. How is the current physical count of inventory in the warehouse(s)/store(s) determined? (choose one)

- No method to determine inventory physical count
- Random audits to determine inventory physical count
- Inventory policy used to determine inventory physical count
- Regular (at least quarterly) inventory physical count
- Frequency of inventory physical count dynamically determined by WMS
- Not applicable
- Don't know

23. Which of the following currently are constraints that prevent improvement of inventory management at warehouse(s)/store(s)? (choose all that apply)

- Human resources
- Improvement-process knowledge
- Enabling technologies
- Leadership/guidance
- National guidelines
- Funding
- Infrastructure
- Government support
- No public/private collaboration
- Other (please specify): \_\_\_\_\_
- No constraints
- Not applicable
- Don't know

Comments/notes for this category:

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(continued)

## VI. Warehouse/Store Order Management

Supply-chain warehouses/stores can determine that the location needs to order more inventory, that the order is based on inventory policies, and then execute the order. As maturity increases, orders are created within a broader supply-chain digital platform as needed.

*Objective: Coordinate order management at the warehouse(s)/store(s) with real-time demand from SDP/HFs and other warehouses/stores.*

24. How are facility orders processed at the warehouse(s)/store(s)? (choose one)
- Difficult to process facility orders
  - Ability to get facility orders to warehouse(s)/store(s)
  - Established frequency to review and process orders
  - Visual replenishment system (e.g., two-bin system) signals the need to process orders
  - Orders are created and processed immediately upon request for product from SDP(s)/HF(s) or other warehouse(s)/store(s)
  - Not applicable
  - Don't know
25. What is the typical order ship-date request from the warehouse(s)/store(s) to SDP(s)/HF(s)? (choose one)
- No order ship-date requests provided
  - Orders have extensive ship-date requests (more than two weeks of order)
  - Orders have moderate ship-date requests (one to two weeks of order)
  - Orders have short ship-date requests (within one week of order)
  - Order management is connected to the supply-chain digital platform, enabling ship-date requests of one day of order or SDP(s)/HF(s) preferred date
  - Not applicable
  - Don't know
26. How are open orders in the warehouse(s)/store(s) identified and resolved? (choose one)
- No process to identify and resolve open orders
  - Communication from SDP(s)/HF(s) triggers investigation into open order
  - Open orders occasionally reviewed and resolved if problematic
  - Open orders are reviewed weekly and actively resolved
  - Open orders are actively managed and resolved via WMS and visible via supply-chain digital platform
  - Not applicable
  - Don't know
27. What is the complete-and-on-time delivery rate of warehouses/stores to SDPs/HFs? (choose one)
- Delivery rate is not tracked
  - Less than 80%
  - 80% to 90%
  - 90% to 95%
  - Greater than 95%
  - Not applicable
  - Don't know
28. Which of the following currently are constraints that prevent improvement of order management at warehouse(s)/store(s)? (choose all that apply)
- Human resources
  - Improvement-process knowledge
  - Enabling technologies
  - Leadership/guidance
  - National guidelines
  - Funding
  - Infrastructure
  - Government support
  - No public/private collaboration
  - Other (please specify): \_\_\_\_\_
  - No constraints
  - Not applicable
  - Don't know

(continued)



Comments/notes for this category:

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#### VII. Warehouse/Store Operations

Each warehouse/store can promptly receive, prepare, and ship inventory as required. As maturity increases, orders are picked accurately and moved efficiently to transportation provider(s).

**Objective: Standardize warehouse/store stocking, picking, handling, and staging processes and eliminate wasteful steps to ensure product quality and increase process speed.**

29. How are orders prepared for shipment? (choose one)
- No process to determine when orders are shipped from warehouse(s)/store(s)
  - Ability to prepare inventory for shipment in less than one week from order receipt
  - Service level agreements (SLAs) for receiving and shipping within a specified time period are met
  - Orders are picked and staged ahead of transport arrival
  - Orders are picked and staged with pick path/routing determined by WMS
  - Not applicable
  - Don't know
30. What is the inventory accuracy of the warehouse(s)/store(s)? (choose one)
- Inventory accuracy not regularly tracked
  - Less than 80%
  - 80%-90%
  - 90%-97%
  - Greater than 97%
  - Not applicable
  - Don't know
31. What method of quality control is used in warehouse(s)/store(s) to ensure product integrity? (choose one)
- No quality control method
  - Quality defects randomly identified
  - A quality inspection process is performed during receipt (i.e. quantity, damage, sample testing)
  - A quality inspection process is performed during receipt and stocking
  - A quality inspection process is performed during all phases of operation (e.g., receipt, stocking, picking, staging)
  - Not applicable
  - Don't know
32. Which of the following currently are constraints that prevent improvement of operations at warehouse(s)/store(s)? (choose all that apply)
- Human resources
  - Improvement-process knowledge
  - Enabling technologies
  - Leadership/guidance
  - National guidelines
  - Funding
  - Infrastructure
  - Government support
  - No public/private collaboration
  - Other (please specify): \_\_\_\_\_
  - No constraints
  - Not applicable
  - Don't know

Comments/notes for this category:

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(continued)

## Supply-Chain Components

## VIII. Transportation

The supply chain can deliver product to service delivery points. Each location is documented, has a delivery schedule, knows what the delivery schedule is, and has a Proof of Delivery (POD) system in place. As maturity increases, route planning is conducted, appointments are defined, and product-delivery timing is measured and tracked.

*Objective: Improve accuracy, timeliness, and efficiency of inventory transportation.*

33. How is the movement of goods throughout the supply chain determined? (choose one)
- No standard method to schedule transportation
  - Schedules set ad hoc
  - Basic scheduled delivery mechanism
  - Transport arrives on time for warehouse/store appointments with defined service level agreements (SLAs) that are measured and managed
  - Transport arrives on time for warehouse/store appointments, SLAs are measured and managed, and real-time delivery tracking is visible via supply-chain digital platform.
  - Not applicable
  - Don't know
34. How are product deliveries communicated to facilities? (choose one)
- No communication with facilities regarding deliveries
  - Facilities are informed of scheduled deliveries if they inquire about them
  - Facilities are informed of scheduled deliveries by upstream parties
  - Facilities can access delivery schedules; transport delivers on time to facility with defined service level agreements (SLAs) that are measured and managed
  - Transport delivers on time to facility, defined SLAs are measured and managed, and real-time delivery tracking is visible via supply-chain platform
  - Not applicable
  - Don't know
35. How is the receipt of product at facilities verified? (choose one)
- No process to verify receipt of product at facilities
  - Random proof of delivery (POD) by transporters
  - Completed POD is returned to warehouse(s)/store(s)
  - Electronic POD sent to warehouse(s)/store(s)
  - Embedded devices (e.g., RFID tags) provide POD to warehouse management system
  - Not applicable
  - Don't know
36. Which of the following currently are constraints that prevent improvement of transportation of product throughout the supply chain? (choose all that apply)
- Human resources
  - Improvement-process knowledge
  - Enabling technologies
  - Leadership/guidance
  - National guidelines
  - Funding
  - Infrastructure
  - Government support
  - No public/private collaboration
  - Other (please specify): \_\_\_\_\_
  - No constraints
  - Not applicable
  - Don't know

Comments/notes for this category:

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## IX. Expiry Management

Both warehouses/stores and service delivery points have policies to handle expired product. As maturity increases, quarantine areas are maintained and a "first- expired, first-out" (FEFO) policy is systematic and maintained.

*Objective: Identify product in SDP/HFs and warehouse(s)/store(s) near expiration, minimize expired product, and prevent unsafe release of expired product.*

(continued)

37. What policies, guidance, and/or SOPs are in place at the SDP/HF and warehouse/store levels to identify and manage expired product? (choose one)
- No policies or processes
  - Staff attempt to identify expired product on a regular basis
  - Policy, guidance, and/or SOPs for expiration management at facility is in place
  - FEFO picking policy for expiration is followed and audited
  - Standardized FEFO picking process is followed and audited and problems-solving occurs regularly to minimize potential for expired product
  - Not applicable
  - Don't know
38. What practices are in place at SDP/HF and warehouse/store levels to dispose of expired product? (choose one)
- No practices to dispose of expired product
  - Staff are able to identify expired product
  - Staff actively track and document expired product
  - Staff actively track and document expired product and pull it from storage
  - Staff actively track and document expired product, pull it from storage, and dispose of it at designated sites according to policy/guidance/SOPs
  - Not applicable
  - Don't know
39. Which of the following currently are constraints that prevent improvement of expiry management? (choose all that apply)
- Human resources
  - Improvement-process knowledge
  - Enabling technologies
  - Leadership/guidance
  - National guidelines
  - Funding
  - Infrastructure
  - Government support
  - No public/private collaboration
  - Other (please specify): \_\_\_\_\_
  - No constraints
  - Not applicable
  - Don't know

Comments/notes for this category:

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#### X. Procurement

The procurement process for product can be executed in a reasonable time frame. Within this maturity model, procurement is defined as the issuance of a purchase order to a previously established supplier, the approval of said purchase order by the vendor(s), shipment of goods, and receipt of goods. As maturity increases, the speed of the procurement process increases, levels are based on demand, and prices are competitive with national standards.

*Objective: Rapidly procure the optimal amount of appropriately priced inventory to satisfy real-time demand.*

40. How long does it take to procure product (purchase order under an existing contract)? (choose one)
- Procurement takes more than one month
  - Procurement can be executed in less than one month
  - Procurement can be executed in less than 2 weeks
  - Procurement can be executed in less than 1 week
  - Procurement can be executed in less than 1 week, with a process in place to compare supply-chain prices to national average at time of purchase
  - Not applicable
  - Don't know
41. How is the procurement quantity determined? (choose one)
- No standard process to determine procurement quantity
  - Procurement quantity is based on count of existing supply and/or stockouts
  - Procurement quantity is based on beneficiary consumption
  - Procurement quantity is based on supply plan
  - Procurement quantity is based on current system inventory levels and real-time demand forecasts
  - Not applicable
  - Don't know

(continued)

42. What is the typical frequency for the procurement of product?

- Semiannually or less frequently
- Quarterly
- Monthly
- Weekly
- As needed
- Not applicable
- Don't know

43. Which of the following currently are constraints that prevent improvement of procurement processes? (choose all that apply)

- Human resources
- Improvement-process knowledge
- Enabling technologies
- Leadership/guidance
- National guidelines
- Funding
- Infrastructure
- Government support
- No public/private collaboration
- Other (please specify): \_\_\_\_\_
- No constraints
- Not applicable
- Don't know

Comments/notes for this category:

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#### XI. Infrastructure and Assets

The buildings in the supply chain are appropriate for storing and managing products in sound condition. As maturity increases, internet access is prevalent at all locations and facility risks are identified and managed.

**Objective: Establish buildings for product and personnel that are safe, secure, and technology-enabled.**

44. How are products maintained in secure and sound condition at facilities? (choose one)

- No standard process to keep products in secure and sound condition
- Facilities have policies/guidance/SOPs to keep product dry
- Conditions at all sites keep product dry
- Conditions at all sites keep product dry, secure, and accessible only by authorized personnel
- All sites keep product dry, secure, accessible only by authorized personnel, and in optimal environmental conditions specific to product type
- Not applicable
- Don't know

45. To what extent is internet access available at facilities? (choose one)

- Few facilities have internet available
- Internet is available at 50-80% of facilities
- Internet is available at 80% of facilities
- Internet is available at 100% of facilities
- Internet available at a 100% of facilities and among those transporting product
- Not applicable
- Don't know

46. Which of the following currently are constraints that prevent improvement of supply-chain infrastructure and assets? (choose all that apply)

- Human resources
- Improvement-process knowledge
- Enabling technologies
- Leadership/guidance
- National guidelines
- Funding
- Infrastructure
- Government support
- No public/private collaboration
- Other (please specify): \_\_\_\_\_
- No constraints
- Not applicable
- Don't know

(continued)

Comments/notes for this category:

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### XII. Performance Management

Each process in the supply chain has a defined set of performance indicators that are managed, and effort is made to improve them over time. Decision-making processes are driven by supply-chain data that populates scorecards. As maturity increases, data analytics are used in determining and improving supply-chain and staff performance.

**Objective: Establish a system to align and continuously improve performance at all sites consistent with overall supply-chain goals.**

47. How are problems and opportunities for improvement identified? (choose one)
- No process to identify problems and opportunities
  - Problems identified as they occur
  - Measurement of basic key performance indicators (KPIs)
  - Decision-making processes are built upon reliable data inputs
  - Analytics drive gap analysis
  - Not applicable
  - Don't know
48. Describe the skill level of staff in identifying and solving problems? (choose one)
- Staff have no problem-solving skills
  - Some staff have awareness of problem-solving skills (e.g., root-cause analysis)
  - Staff trained in basic problem-solving skills and lean tools (e.g., process-mapping, standardized work, 5 Whys)
  - Regular scorecard/dashboard reviews are conducted
  - Regular scorecard/dashboard reviews are conducted, with gap analysis driving problem-solving initiatives
  - Not applicable
  - Don't know
49. To what extent are teams empowered to solve problems independently? (choose one)
- Teams are not empowered to solve problems independently
  - Teams are encouraged to suggest solutions to problems
  - Teams are able to take action on some KPIs (less than 50%) prior to scheduled scorecard/dashboard reviews
  - Teams are able to take action on most KPIs (50% to 80%) prior to scheduled scorecard/dashboard reviews
  - Teams are able to take action on all KPIs prior to scheduled scorecard/dashboard reviews
  - Not applicable
  - Don't know
50. Which of the following currently are constraints that prevent improvement of performance management? (choose all that apply)
- Human resources
  - Improvement-process knowledge
  - Enabling technologies
  - Leadership/guidance
  - National guidelines
  - Funding
  - Infrastructure
  - Government support
  - No public/private collaboration
  - Other (please specify): \_\_\_\_\_
  - No constraints
  - Not applicable
  - Don't know

Comments/notes for this category:

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(continued)

## XIII. Analysis and Evaluation

The supply chain uses data to understand properly functioning processes and to identify deviations from the norm. Data from orders, shipments, receipts, and other supply-chain events are tracked to monitor process flow. As maturity increases, regular team reviews of supply-chain data and analytics identify areas for improvement.

*Objective: Establish capabilities whereby data alerts sites and the overall supply chain to problems and opportunities for improvement.*

51. How does data analysis and evaluation occur? (choose one)
- No data analysis and evaluation
  - Data analyzed when a problem occurs
  - Data analyzed for process deviation (e.g., missing orders, delays) to prevent problems
  - Dedicated team for ongoing analysis and evaluation
  - End-to-end supply-chain data analyzed to find areas for improvement
  - Not applicable
  - Don't know
52. How frequently are analysis findings reviewed? (choose one)
- No review of analysis findings
  - Reviews occur at random
  - Reviews of analysis findings occur at a regular frequency (quarterly or less often)
  - Reviews of analysis findings occur at a regular frequency (at least monthly)
  - Supply chain visibility and analytics network (VAN) provides data to make operational and strategic decisions, data is regularly reviewed, and actions taken to improve performance on an ongoing basis
  - Not applicable
  - Don't know
53. Which of the following currently are constraints that prevent improvement of analysis and evaluation processes? (choose all that apply)
- Human resources
  - Improvement-process knowledge
  - Enabling technologies
  - Leadership/guidance
  - National guidelines
  - Funding
  - Infrastructure
  - Government support
  - No public/private collaboration
  - Other (please specify): \_\_\_\_\_
  - No constraints
  - Not applicable
  - Don't know

Comments/notes for this category:

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## XIV. Demand Planning/Management

The supply chain quantifies consumption and creates a forecast for future commodity requirements based on multiple factors (historical usage, known fluctuations, etc.). As maturity increases, the demand assumptions and plan are held in the broader supply-chain digital platform to influence decision-making.

*Objective: Improve the accuracy of demand forecasting and eventually automate forecasting capabilities.*

54. How is the demand plan created? (choose one)
- There is no demand plan
  - Demand plan is being developed
  - Demand plan has been created (based on previous-year plan)
  - Demand plan has been created (based on actual consumption)
  - Demand plan has been created (based on actual consumption, external variables, etc.) and integrated into supply-chain digital platform
  - Not applicable
  - Don't know

(continued)

55. How frequently is the demand plan checked for accuracy? (choose one)
- Demand plan is not checked for accuracy
  - Demand plan can be tracked for accuracy (biannual — twice a year)
  - Demand plan can be tracked for accuracy (monthly or quarterly)
  - Demand plan can be tracked for accuracy (at least weekly)
  - Automated and dynamic demand plan tracking
  - Not applicable
  - Don't know

56. Which of the following currently are constraints that prevent improvement of demand planning/management? (choose all that apply)

- Human resources
- Improvement-process knowledge
- Enabling technologies
- Leadership/guidance
- National guidelines
- Funding
- Infrastructure
- Government support
- No public/private collaboration
- Other (please specify): \_\_\_\_\_
- No constraints
- Not applicable
- Don't know

Comments/notes for this category:

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#### XV. Supply Planning/Management

**A strategy is in place for how the supply chain will maintain appropriate levels of each commodity. As maturity increases, the supply plan is based on demand and inventory, and is tracked in the broader supply-chain digital platform.**

**Objective: Plan and tightly coordinate supply-chain actions and inventories with the demand plan.**

57. How is the supply plan created? (choose one)

- There is no supply plan
- Supply plan is being developed
- Supply plan has been created (from demand plan)
- Supply plan has been created (based on inventory policies)
- Supply plan has been created (based on inventory policies, sourcing variables, etc.) and is included in supply-chain digital platform
- Not applicable
- Don't know

58. Which of the following currently are constraints that prevent improvement of supply planning/management? (choose all that apply)

- Human resources
- Improvement-process knowledge
- Enabling technologies
- Leadership/guidance
- National guidelines
- Funding
- Infrastructure
- Government support
- No public/private collaboration
- Other (please specify): \_\_\_\_\_
- No constraints
- Not applicable
- Don't know

Comments/notes for this category:

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(continued)

## XVI. Fund Management

The sources of funds available to the supply chain are known, and commitments are documented and tracked. As maturity increases, funding needs are identified and managed actively in a broader supply-chain digital platform.

*Objective: Improve accuracy and timeliness of fund-tracking in order to proactively pursue new funds to address emerging needs.*

59. How are funding sources and commitments tracked and monitored? (choose one)
- Overall fund amount/budget is not known and funds are not regularly released
  - Overall fund amount/budget is known and funds are released
  - Funding commitments are tracked and documented
  - Gaps in funding are identified based on analysis and actively managed
  - Budget and funding schedule are connected to the supply-chain digital platform
  - Not applicable
  - Don't know
60. Which of the following currently are constraints that prevent improvement of fund management? (choose all that apply)
- Human resources
  - Improvement-process knowledge
  - Enabling technologies
  - Leadership/guidance
  - National guidelines
  - Funding
  - Infrastructure
  - Government support
  - No public/private collaboration
  - Other (please specify): \_\_\_\_\_
  - No constraints
  - Not applicable
  - Don't know

Comments/notes for this category:

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## XVII. Financial Management and Costing

Supply-chain costs incurred from procurement to receipt by the beneficiary are documented. As maturity increases, the supply chain establishes budgets based on known costs for each function at each facility, actively manages deviations, and has full visibility to the financials at each level.

*Objective: Improve accuracy and timeliness of financial tracking across the supply chain to ensure optimal use of funds and establish appropriate budgets for the sites/overall supply chain.*

61. How are supply-chain costs tracked? (choose one)
- Little or no tracking of supply chain costs
  - Cost baseline completed
  - Ability to track supply-chain costs monthly
  - Financial deviations from target are actively managed
  - Full visibility to financials connected to the supply-chain digital platform
  - Not applicable
  - Don't know
62. Which of the following currently are constraints that prevent improvement of financial management and costing? (choose all that apply)
- Human resources
  - Improvement-process knowledge
  - Enabling technologies
  - Leadership/guidance
  - National guidelines
  - Funding
  - Infrastructure
  - Government support
  - No public/private collaboration
  - Other (please specify): \_\_\_\_\_
  - No constraints
  - Not applicable
  - Don't know

(continued)



Comments/notes for this category:

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#### XVIII. Governance

**Appropriate structure is established to define roles and responsibilities for teams, individuals, and change agents within the supply chain. Teams have established goals and performance-management structures. As maturity increases, all processes are documented.**

**Objective: Roles for individuals, teams, and sites are clearly documented and understood, creating opportunities for collaboration, empowerment, and knowledge development.**

63. To what extent are team roles and responsibilities within the supply chain understood? (choose one)
- Team roles and responsibilities are not entirely clear
  - Team roles and responsibilities are clearly documented (RACI matrix — Responsible, Accountable, Consulted, and Informed — or similar completed)
  - Team goals are defined, tracked, and actively managed on a regular frequency (rhythm of business)
  - Processes between functional teams are understood and working
  - End-to-end team processes and performances are documented
  - Not applicable
  - Don't know
64. How would you describe leadership roles within the supply chain? (choose one)
- Leadership roles are not fully staffed
  - Leadership roles are fully staffed
  - Leadership roles are fully staffed, with ongoing development of leadership capability
  - Leadership roles are fully staffed, with ongoing development of leadership capability; leaders facilitate stakeholder collaboration across the supply chain
  - Leadership roles are fully staffed, with ongoing development of leadership capability; leaders facilitate stakeholder collaboration across the supply chain and foster knowledge transfer from mature regions to regions that require improvement
  - Not applicable
  - Don't know
65. Which of the following currently are constraints that prevent improvement of governance processes? (choose all that apply)
- Human resources
  - Improvement-process knowledge
  - Enabling technologies
  - Leadership/guidance
  - National guidelines
  - Funding
  - Infrastructure
  - Government support
  - No public/private collaboration
  - Other (please specify): \_\_\_\_\_
  - No constraints
  - Not applicable
  - Don't know

Comments/notes for this category:

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#### XIX. Staff Training/Development

**Staff have the skills to perform well in their positions. As maturity increases, staff have access to certifications, training and cross-training, and tools that will support their continued development.**

**Objective: Engage, educate/develop, and empower staff across the supply chain, improving their abilities to identify and solve supply-chain problems.**

66. How knowledgeable are staff regarding supply-chain management processes, practices, and tools? (choose one)
- Staff lack basic supply-chain knowledge
  - Staff have basic supply-chain knowledge (inventory management, logistics, etc.)
  - Staff are cross-trained and provided options for development
  - Staff are encouraged to pursue additional supply-chain related certifications
  - Staff collaborate closely with industry to keep the training/programs refreshed with latest trends/tools in supply-chain management.
  - Not applicable
  - Don't know

(continued)

67. What expertise do staff have in supply-chain improvements? (choose one)
- Most staff have little or no experience with supply-chain improvements
  - Some staff have experience with supply-chain improvements
  - Most staff have experience with supply-chain improvements and basic skills required to be effective in their roles
  - All staff have experience with supply-chain improvements and expertise in the skills required to be effective in their roles
  - All staff have experience with supply-chain improvements, expertise in the skills required to be effective in their roles, and most are able to train other staff
  - Not applicable
  - Don't know

68. Which of the following currently are constraints that prevent improvement of staff training and development? (choose all that apply)

- Human resources
- Improvement-process knowledge
- Enabling technologies
- Leadership/guidance
- National guidelines
- Funding
- Infrastructure
- Government support
- No public/private collaboration
- Other (please specify): \_\_\_\_\_
- No constraints
- Not applicable
- Don't know

Comments/notes for this category:

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#### XX Patient-Focused Performance

The supply chain and all parties within it measure last-mile product/medicine access, availability, and affordability, and collaboratively work to eliminate problems that impact product/medicine access, availability, and affordability.

**Objective: Patients have efficient access to SDPs/HFs, and product/medicines are readily available and affordable.**

69. Please rate patients' access to facilities and services. (choose one)
- Patient access to services is extremely challenging and/or patients experience excessive wait times at facilities
  - Patients access to services is difficult and/or patients experience moderate to long wait times at facilities
  - Patients access to services is reasonable and/or patients may experience some wait times at facilities
  - Patients access to services is good and patients experience minimum wait times at facilities
  - Patients access to services is excellent — including out-of-facility delivery options — and patients experience no wait times
  - Not applicable
  - Don't know
70. Please rate the availability of product/medicines at the facility(ies). (choose one)
- Less than 50% of products/medicines are available
  - 50-75% of products/medicines are available
  - 76-90% of products/medicines are available
  - 91-99% of products/medicines are available
  - 100% of products/medicines are available
  - Not applicable
  - Don't know
71. How do facility procurement prices for products/medicines impact patients? (choose one)
- Most prices (>70%) are cost-prohibitive and well above facility budgets — most products/medicines cannot be acquired for patients
  - Many prices (50-70%) are cost-prohibitive and above facility budgets — many products/medicines cannot be acquired for patients
  - Some prices (30-50%) are cost-prohibitive and above facility budgets — some products/medicines cannot be acquired for patients
  - Most prices (>70%) are affordable and within facility budgets — most products/medicines can be acquired for patients
  - All prices are affordable and within facility budgets — all products/medicines can be acquired for patients
  - Not applicable
  - Don't know

(continued)

72. Which of the following currently are constraints that prevent improvement of access, availability, and affordability? (choose all that apply)

- Human resources
- Improvement-process knowledge
- Enabling technologies
- Leadership/guidance
- National guidelines
- Funding
- Infrastructure
- Government support
- No public/private collaboration
- Wait times at facilities
- Other (please specify): \_\_\_\_\_
- No constraints
- Not applicable
- Don't know

Comments/notes for this category:

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When you submit your assessment, you will be given an opportunity to review your answers and save a copy of your responses:

1. Click on "Submit your assessment" below.
2. You will then be presented with your entire questionnaire as a single, scrollable page. At the top of the page is a "Download PDF" option.
3. Review your answers.
  1. If you ARE satisfied with your answers:
    1. Scroll to the bottom of the page and click on "Submit your assessment."  
You will automatically access the data visualization website and your Assessment Output.
  2. If you ARE NOT satisfied with your answers:
    1. Click on "Previous category" and revise your answers as necessary. When you are finished, proceed to the end of the assessment questionnaire and repeat the submission process (Steps 1, 2, and 3.1).

## Appendix 2. Pilot study interview protocol

### Stage 1 – Pilot key informant interview questions

- 1 How does the organisation carry out demand forecasting of medicines?
- 2 How does the organisation carry out procurement of medicines?
- 3 How does the organisation carry out warehousing of medicines?
- 4 How does the organisation carry out inventory management of medicines?
- 5 How does the organisation carry out delivery of medicines to patients?
- 6 Which departments/units are responsible for making medicines available to end-users?
- 7 Has the organisation experienced stock out of medicines?
- 8 How do you manage stockout of essential medicines?

### Stage 2 – Revised in-depth interview questions derived from pilot study to be used for the main study

- 1 How do inter-departmental teams (pharmacy, accounts, procurement, etc.) work together in the organisation to make medicines available?
- 2 What should be done to improve how teams work together?
- 3 Can you describe how your inter-departmental teams work with your patients and suppliers to provide medicines?
- 4 Can you describe how the teams work with suppliers to make medicines available?

- 5 In your own perspective, how can inter-departmental teams improve working relationship with patients?
- 6 In your own opinion, how can inter-departmental teams improve working relationship with suppliers?
- 7 In your own opinion, how can inter-departmental teams improve working relationship with critical stakeholders (donor/partner, government/regulators/civil society organisations (CSOs), etc.)?
- 8 Can you describe how you share information about medicines and other health supplies with patients, suppliers and other critical stakeholders (donor/partner, government/regulators/CSOs)?
- 9 Describe how you share logistic information (stock level, available medicines, expiries, expected medicines, etc.)?
- 10 In your opinion, what should be done to improve information-sharing with patients, suppliers and other critical stakeholders (donor/partner, government/regulators/CSOs)?
- 11 In your opinion, what do you think about the use of digital technology for making medicines available?
- 12 What type of digital technology do you have experience with in making medicine available?
- 13 In your opinion, explain how would you measure the performance of medicine availability in your organisation?
- 14 In your opinion, describe how the inter-departmental teams can improve performance by working with patients, suppliers and other critical stakeholders (donor/partner, government/regulators/CSOs)?

## Appendix 3

Table A1 Interview quotation analysis for supply chain manager (SM01)

	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, -  →=causal link with delay, +/−=positive or negative polarity)	Comments
<i>ParticipantNumber-Quote number</i> "... variables in Phrase(s)" (word count in variables/total word count in causal statement)				
<i>SM01-01</i> "... They communicate information, get information together to get work done to achieve our goals as an organisation. ... The procurement will need to know what the budget looks like, before they start quantifying or forecasting on what will ... procured for the organisation. The data visibility will have to come up with the data. ... The warehousing will have to inform the team ... to keep all the commodities that are needed to be procure. There has to be information sharing and communication among teams. It can be in form of ... sharing of reports ... or having data so that everybody could see or ... use the data to create a dashboard that every team can see and interpret what is going on in the organisation." (123/186)	<ul style="list-style-type: none"> <li>- get information together to get work done</li> <li>- will need to know</li> <li>- will have to come up with</li> <li>- will have to inform the team</li> <li>- before they start quantifying or forecasting</li> <li>- create a dashboard that every team can see</li> <li>- There has to be information sharing and communication among teams</li> <li>- having data so that everybody could see</li> </ul>	<ul style="list-style-type: none"> <li>Time delay</li> <li>Process integration</li> <li>Information sharing</li> <li>Visibility</li> </ul>	<ul style="list-style-type: none"> <li>Process integration-  →+</li> <li>Information sharing-  →+</li> <li>Visibility</li> </ul>	The time delay in getting information across teams affects medicine availability. When teams do not get information at the same time reduces process integration
<i>SM01-02</i> "... The teams will have to first understand that they need each other to be successful, it's not a competition. ... it needs to be an integration and a collaboration within the team. Then secondly based on how the operation of that organisation flow, ... will have to look at their process and pinpoint the best way to communicate, communication is key, so if they are good in technology, that'll be fine." (69/133)	<ul style="list-style-type: none"> <li>- it needs to be an integration and a collaboration</li> <li>- based on how the operation of that organisation flow</li> <li>- will have to look</li> <li>- if they are good in technology</li> </ul>	<ul style="list-style-type: none"> <li>Internal integration</li> <li>Time delay</li> <li>Process integration</li> <li>Technology integration</li> </ul>	<ul style="list-style-type: none"> <li>Internal integration-  →+</li> <li>Process integration→+ Technology integration</li> </ul>	Teamwork increases internal integration, and the need to align processes and increase flow of information can be achieved with technology
<i>SM01-03</i> "... communication with patients is providing the needed commodities that the patient needs as our clients, ... transcribe to getting the	<ul style="list-style-type: none"> <li>- providing the needed commodities</li> <li>- quantify what we need</li> <li>- we don't share data with</li> </ul>	<ul style="list-style-type: none"> <li>Customer orders</li> <li>Medicine inventory</li> <li>Time delay</li> <li>Supplier integration</li> </ul>	<ul style="list-style-type: none"> <li>Customer order-  →+ Medicine inventory Supplier integration→+ Internal</li> </ul>	Increasing communication with suppliers leads to availability of more medicines, but also a reduced interaction with (continued)

Table A1

	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, -  →=causal link with delay, +/- =positive or negative polarity)	Comments
ParticipantNumber-Quote number" . . . variables in Phrase(s)" (word count in variables/total word count in causal statement)				
records of what was given to the patient directly. This consumption is used to quantify what we need. . . . we communicate with suppliers is . . . we don't share data with them. . . . we only tell them what we need, and how much of it we need. We also communicate with the suppliers on our processes for them to understand the organization's goal. So we can work better . . . when it comes to performance on the supplies needed by the organisation, I will say that the communication with the patients are minimal." (109/186)	them - communicate with the suppliers on our processes - when it comes to performance - communication with the patients are minimal	Internal performance Customer integration	performance-  →-Customer integration	patients prevents them from stocking what the patients' needs
SM01-04) "I would say by doing their best to ensure that the patient gets their medicines when they need it, . . . everybody will seek to ensure that happens to improve communication with patients." (31/49)	- ensure that the patient gets their medicine - improve communication with patients	Fill rate Customer integration	Fill rate→+Customer integration	Better communication with patients enables stocking of the right medicines
SM01-05) " . . . improve our working relationship with the suppliers by sharing information. . . . i think that is lacking. Currently, there's no information sharing especially data. . . . sharing information with the suppliers, that can help the suppliers to serve us better. Then also improving communication with the suppliers on contract terms and reviewing contracts so that it will not be just . . . selling and buying kind of relationship." (63/90)	- improve our working relationship with the suppliers - no information sharing, especially data - improving communication with the suppliers on contract terms - it will not be just . . . selling and buying kind of relationship	Hospital-supplier relationship (Trust) Time delay Contract management Transactional relationship	Hospital-supplier relationship (trust)-  →+Contract management→-Transactional relationship	Building closer ties with suppliers is hindered by the delay in building trust, which leads to transactions with suppliers and prevents optimal stocking of medicines
SM01-06) "The best way to improve . . . is to collaborate with stakeholders by engaging them in whatever we are doing. Always ready with . . . our . . .	- collaborate with stakeholders - Always ready with . . . our . . . plans - don't have partners doing	Collaboration Time delay Non-alignment communication	Partner collaboration-  →-Non-alignment of partners→+Communication	Partners working independently is caused by delay in collaboration and

(continued)

Table A1

Participant/Number-Quote number) "... variables in Phrase(s)" (word count in variables/total word count in causal statement)	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, -  →=causal link with delay, +/- =positive or negative polarity)	Comments
plans so that we don't have partners doing their own plans or activity on the organisation. And we will support them as they also support us in achieving our goals. I also think that the information sharing with other partners include sharing achievements of the organisation. Sharing the plans of the organisation to help with better collaboration." (81/137)	their own plans or activity - information sharing with other partners			shared vision which is improved with communication
SM01-07) "... for patients we share limited information ... What we share currently is the prices, the unified selling prices of the medicines we have at the facility, i.e. giving the patient's visibility for them to know the cost of the medicines they're using, thereby improving relationships with patients and improving visibility as a way of the patient to trust in government in hospitals. With higher stakeholders we share information on summary report of the basic performance including performance on medicine availability at the facility which translates to whether patients got medicines when they visited those facilities." (95/165)	- for them to know the cost of the medicines they are using - improving relationships with patients - medicine availability	Price visibility Customer integration Fill rate	Price visibility → + Customer integration → + Fill rate	Customers can access more medicines when there's transparency in pricing
SM01-08) "I love technology. However, I know that basically we've not gone far on technology. However, if wishes were horses we can ride, I'll prefer that we have a platform like a dashboard and all the stakeholders depending on the level can have access to the data and information. They can view them and readily accessible. However, ... we	- we have not gone far on technology - have access to the data and information - should be part of the culture of the organisation	Technology integration	Technology integration → + Access to information → + Information sharing culture	Information sharing culture is improved with technology and access to information

(continued)

Table A1

	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, -  →=causal link with delay, +/- =positive or negative polarity)	Comments
ParticipantNumber-Quote number) "... variables in Phrase(s)" (word count in variables/total word count in causal statement)				
can have newsletter, maybe quarterly report sharing whether hardcopy or e-copy, a summary of supply chain performance at different levels. Information sharing should be part of the culture of the organisation."				
(88/134)				
SM01-09) "The ... dashboard is used to analyse and ... we use to make decisions, good ... from all the data we're getting from operations."	- dashboard is used to analyse - use to make decisions	Data analysis Data-driven decisions	Data analysis→+Data-driven decisions	Analysing data enhance decision-making
(23/79)				
SM01-10) "... we can only improve performance by using the real consumption data to drive our activities and operations. The data should be available and visible for use to everyone. The information should be shared with the suppliers to collaborate better to understand ... our consumption rate to plan for production of needed medicines."	- real consumption data - data should be available and visible - to collaborate better to understand ... our consumption rate - plan for production of needed medicines	Time delay Information sharing Collaboration Production	Information sharing-   →+Supplier collaboration-   →+Medicine production	Collaboration is delayed by information sharing, which also delays production of medicines
(50/96)				
SM01-11) "It will help the donor to know what is already available so that they don't duplication effort by doing what the organization is already doing. ... help government by encouraging accountability and lead to more support from the government... the government can go ahead to support more because Government wants to see accountability of whatever resources that have been allocated to any organisation. for the Civil Society	- what is already available - duplication effort - encouraging accountability - can go ahead to - allocated to any organisation - create demand - increase economy of scale	Medicine inventory Medicine in transit Committed funds Time delay Available funds Customer order Medicine inventory	Medicine inventory-   →+Medicine in transit-   →+Committed funds→+Available funds Customer order-  →Medicine inventory	When receiving medicines is delayed from the supplier, available funds for procurement of medicines is depleted and customer orders cannot be fulfilled

(continued)



Table A1

Participant/Number-Quote number) "... variables in Phrase(s)" (word count in variables/total word count in causal statement)	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, -  →=causal link with delay, +/- =positive or negative polarity)	Comments
Organizations ... visibility will help them work with the community to get people to patronize hospital and create demand that will increase the population of people attending the hospitals and the volume of demand will increase economy of scale and trust at the community." (110/130)	- incentive for the organisations to do better - on-shelf availability - which will lead - turnover - reduce out of pocket expenses	Internal performance Medicine inventory Time delay Available funds Medicine equity	Performance-  →+ Medicine inventory-  →+ Available funds-  →+ Medicine equity	The subsidised medicines from government will increase equity after time delays
SM01-12) "Yes, because it means that the organization is achieving its goals ... and it's an incentive for the organisations to do better. There is increased demand and on-shelf availability of products which will lead to higher turnover for the drug revolving fund even though it is a government organisation ... is not for profit. However, it will reduce out of pocket expenses for the patients." (64/66)	- incentive for the organisations to do better - on-shelf availability - which will lead - turnover - reduce out of pocket expenses	Internal performance Medicine inventory Time delay Available funds Medicine equity	Performance-  →+ Medicine inventory-  →+ Available funds-  →+ Medicine equity	The subsidised medicines from government will increase equity after time delays

## Appendix 4

Table A2 Interview quotation analysis for pharmacist (PH01)

Participant/Number-Quote number " . . . variables in Phrase(s)" (word count in variables/total word count in causal statement)	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, -  →=causal link with delay, +/-→=positive or negative polarity)	Comments
PH01-01 " . . . if you identify such companies and pay them when due, that means you developed a good relationship with the supplier. if you have expired items or they're about to expire, you can call on their attention to come and retrieve those medications or if you have any other formulation preferences, they can be called upon to replenish your stock. When you establish a pattern for purchase or replenishment where interests are considered . . . this system tries to delay the supply of medication, so we go into out of stock." (88/144)	<ul style="list-style-type: none"> <li>- when due</li> <li>- pay them</li> <li>- relationship with the supplier</li> <li>- where interests are considered</li> <li>- call on their attention</li> <li>- out of stock</li> </ul>	Time delay Available funds Hospital-supplier relationship (trust) Information sharing Stockout	Available funds-  →+ Hospital-supplier relationship (trust)→+ Information sharing→- Stockout	Payment of suppliers and information delays lead to stockout of medicines. Conflict of interest during procurement disrupts leads distrust and medicine stockout
PH01-02 " . . . let's have a team that works together all through the process and ensures that at the end of day the patient gets what he needs." (25/36)	<ul style="list-style-type: none"> <li>- works together all through the process</li> <li>- patient gets what he needs</li> </ul>	Process integration Medicine inventory	Process integration→+ Medicine inventory	Alignment of internal processes improves medicine availability
PH01-03 "we give them specifications of drug names, that's all, we don't recommend. They are registered companies already, so those companies key into the bidding. I think having laid down rules and everyone takes his own responsibilities stating it legally or officially will go a long way in improving such relationship with the . . . drugs should not be treated as general commodities." (61/199)	<ul style="list-style-type: none"> <li>- specifications of drug names</li> <li>- key into the bidding</li> <li>- improving such relationship</li> <li>- drugs should not be treated</li> </ul>	Medicine inventory Procurement Hospital-supplier relationship (trust) Staff satisfaction	Medicine inventory→+ Procurement→+ Hospital-supplier relationship (trust)→+ IS satisfaction	Pharmacists are happy when medicines are prioritised during procurement
PH01-04 " . . . all committee members should undergo training on . . . logistics so that they will know what they ought to do and how they will improve on the quality of services rendered to the patient. They should establish good relationship with the stakeholders." (41/60)	<ul style="list-style-type: none"> <li>- undergo training</li> <li>- quality of services</li> <li>- good relationship with the stakeholders</li> </ul>	Staff capacity Medicine inventory Hospital-stakeholder relationship (trust)	Staff capacity→+ Medicine inventory→+ Hospital-stakeholder relationship (trust)	Developing competency in staff will improve the image of the hospital

(continued)

Table A2

Participant/Number-Quote number) "... variables in Phrase(s)" (word count in variables/total word count in causal statement)	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, -  →=causal link with delay, +/-=-positive or negative polarity)	Comments
<i>PH01-05</i> "... only the head of department that has direct communication with the suppliers, no other person is expected to communicate with suppliers regarding any medication or drugs supply, ... the pharmacist communicates with the head of department... when the stock gets too low. ... usually the restocking is quarterly, due to procurement bureaucracy. It usually goes into like six months before drugs get replenished." (61/118)	- direct communication - stock gets too low - procurement bureaucracy - six months - drugs get replenished	Information sharing Stockout Time delay Procurement	Information sharing → + Procurement-    → - Stockout	Delay in information sharing with suppliers and supply chain partners increase stockouts
<i>PH01-06</i> "... training and retraining of staff in the pharmacy. Having them knowing so much about the work on the drugs so that they will have enough knowledge to disseminate to the patients' during dispensing is very important." (36/69)	- training and retraining of staff - disseminate to the patients	Staff capacity Information sharing	Staff capacity → + Information sharing	Increased capacity enhances knowledge sharing in the hospital
<i>PH01-07</i> "... online platforms for purchasing commodities if such platforms could be used for drugs, we'll get prompt supply of medications and easy payment because mostly you have to pay then get your commodities or pay on delivery such things will improve the availability of medication. So it makes the ... supply time shorter, and you get to have drugs, whenever you need them." (62/134)	- online platforms for purchasing commodities - prompt supply - supply time shorter - easy payment - availability of medication	Technology integration Time delay Supply delay Cash collected Medicine inventory	Technology integration-   → - Supply delay → - Medicine inventory → + Cash collected	Improving visibility with technology improves medicine availability and cash management
<i>PH01-08</i> "... if i dispense good number of drugs and prescription without having an out of stock. ... that is a yard stick for measuring performance. ... the account, I expect them to make a smooth payment to suppliers." (1/56)	- out of stock - measuring performance - smooth payment to suppliers	Stockout Performance Available funds	Available funds → - Stockout → - Performance	When suppliers are not paid, they do not supply medicines to the hospital, which increases stockout rate

(continued)

Table A2

Participant/Number-Quote number " . . . variables in Phrase(s)" (word count in variables/total word count in causal statement)	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables ( $\rightarrow$ =causal link, $\parallel$ $\rightarrow$ =causal link with delay, $+/-$ =positive or negative polarity)	Comments
PH01-09 " . . . the pharmacist, makes sure that he raises request when due, he doesn't go out of stock before raising a request he has . . . a timeframe to have that stock. . . . the procurement people should make sure the right supplier supplies the medication at the right amount considering the best quality." (48/77)	-raises request when due - out of stock - a timeframe - supplies the medication at the right amount	Customer orders Stockout Time delay Procurement	Customer orders- $\parallel$ $\rightarrow$ + Stockout $\rightarrow$ + Procurement	The pharmacist should not wait to go out of stock before restocking. Knowing when to restock is important to prevent stockout
PH01-10 "if I had the power, I would want government to look at the purpose of setting up a drug revolving fund. Because having a drug revolving fund means the drug, the proceed from the sales of drugs is what you use to replenish the drug and you're expected to be revolving the fund. . . . the government has defied those rules by merging all accounts into Treasury Single Account and it makes the DRF not to access the funds directly, it brings about a delay in the whole procurement process to at the end of the day, you go out of stock for a very long time due to inaccessibility of funds, and mostly they don't give priority to buying drugs. . . . instead, they go on other projects with the proceeds from DRF." (130/159)	- I had the power - purpose of setting up a drug revolving fund - sales of drugs - replenish the drug - access the funds directly - a delay - a very long time - out of stock - don't give priority to buying drugs - they go on other projects with the proceeds from DRF	Staff satisfaction Fill rate Cash collected Procurement Available funds Time delay Stockout Funding Leakage	Staff satisfaction- $\parallel$ $\rightarrow$ + Fill rate $\rightarrow$ $\parallel$ $\rightarrow$ + Procurement $\rightarrow$ + Cash collected $\rightarrow$ + Available funds- $\parallel$ $\rightarrow$ + Leakage- $\parallel$ $\rightarrow$ + Funding- $\parallel$ $\rightarrow$ - Stockout	Government and hospital management do not prioritise medicine procurement. The Treasury Single Account policy prevents access to DRF funds. Lack of access to funds leads to stockout of medicines for extended periods of time

## Appendix 5

Table A3 Interview quotation analysis for pharmacist (PH02)

ParticipantNumber-Quote number" . . . variables in Phrase(s)" (word count in variables/total word count in causal statement)	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, -  →=causal link with delay, +/-=-positive or negative polarity)	Comments
PH02-01) "The way we work together in specifically, pharmacy, accounts, procurement is that during tendering process, . . . normally we make purchases through tender. . . the pharmacy department will go around to all the clinical department and collect their needs. . . so the pharmacy departments initiate the quantification process for whatever is going to be procured. . . the accounts department will now inform the pharmacy department of the available funds in the accounts for procuring the needed medicines. . . the account is ready with the money then we can go ahead and do tender to award the medicines to the suppliers." (99/176)	- we work together - will go around to all the clinical department - for whatever is going to be procured - available funds - award the medicines to the suppliers	Internal integration Time delay Hospital medicine order Available funds Procurement	Internal integration-  →+ Hospital medicine order→+ Available funds-  →+ Procurement	Working across departments takes time which delays procurement of medicines
PH02-02) "Working together means we should have a transparent policy, transparent in the sense that what goes on in pharmacy should be open to accounts at any time. . . transparency can be enhanced maybe through electronic data collection. . . when we digitalize or computerise the whole process, everybody will see what is happening at one point or the other. So there should be no hidden agenda. . . that can only be done when all processes are computerised." (75/185)	- Working together - when we digitalise - everybody will see what is happening - no hidden agenda	Internal integration Time delay Visibility Internal trust	Internal integration-  →+ Visibility-  →+ Internal trust	Delay in working together and lack of data openness breeds distrust
PH02-03) ". . . with patients, what we normally do is . . . verify the prescription. . . everything that the patient needs is actually in the prescription. . . a pharmacist does a thorough verification. . . the accounting department are now the ones. . . that will collect the cash from the patient. . . the prescription comes back to the pharmacist to dispense the drugs. . . the way we make medicines available through the suppliers is that when quantifications are done and when tender process is done, the pharmacy department will issue out a local purchase order (LPO) to the supplier to make the drugs available. within a certain time, maybe one week or two weeks as stated on the LPO." (114/276)	- everything that the patient needs - does a thorough verification - collect the cash from the patient - to dispense the drugs - will issue out a local purchase order - to make the drugs available - maybe one week or two weeks	Customer orders Time delay Cash collected Selling Hospital medicine order Shipment Supply delay	Customer orders-  →+ Cash collected→+ Selling→+ Hospital medicine order-  →_ Shipment	Delay in delivering supplies affect the level of medicines available to serve customers
PH02-04) ". . . we do what we call an emergency purchase . . . before tender process is ready. . . to buy any out-of-stock drug. There's another process called a standing order. A particular company is being given a standing order because we feel that the medicines that they are supplying as something that is all is available and it's always needed in the hospital, because it's always needed like infusion, it should be readily available in the hospital. As the medicines are about to finish. . . or at the reorder	- emergency purchase - to buy any out-of-stock drug - it should be readily available - not necessarily waiting	Procurement Medicine inventory Time delay Time delay	Procurement-  →+ Medicine inventory	Buying medicines hurriedly leads to further delay in the procurement cycle

(continued)

Table A3

ParticipantNumber-Quote number) "... variables in Phrase(s)" (word count in variables/total word count in causal statement)	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, -  →=causal link with delay, +/-=-positive or negative polarity)	Comments
level, the supplier is informed to supply another batch of products and not necessarily waiting for the tender process." (103/213) <i>PH02-05)</i> "... pharmacist can see what the physician has prescribed for the patient immediately even before the patient appear in the pharmacy department, the pharmacist can go ahead to immediately prepare for the patient. In that way, waiting time will be reduced by the time the patient ... appears in the pharmacy department. ... an electronic system. ... the only way ... teams could improve working with patients is by computerising, making everything electronic from the physician. ... to the pharmacist to the accounting department." (83172)	- can see - patient waiting time - an electronic system - by computerising	Visibility Patient waiting time Information integration Information sharing	Visibility-  →+ Information integration→+ Information sharing-  →- Patient waiting time	Sharing information is facilitated digitally with electronic systems, which is affected when there's delay in implementation
<i>PH02-06)</i> "After quantification and medicine selection, we ask suppliers to quote for drugs before, sending it to us, we improve the process by putting the list of medications in a flash drive and sharing with suppliers. I envisage a process in which there will be an interface with the organisation and the supplier. An interface that allows suppliers to key into the system from their end automatically. All wasted time (1-2 weeks) in the current system will be saved and improve working relationship with the suppliers. Lack of immediate payment for supplies delivered to the hospital ... hinders working relationship with the suppliers." (102/142)	- before sending it to us - all wasted time - interface with the organisation and the supplier - improve working relationship with the suppliers - lack of immediate payment	Time delay Time delay Supplier integration Hospital-supplier relationship Available funds	Supplier integration-  →+ Hospital-supplier relationship (trust)→+ Available funds	Improving relationship with suppliers will increase trust and level of inventory making more funds available to procure medicines
<i>PH02-07)</i> "The only way that we can improve working relationship with all these critical stakeholders is by letting them realise what our situation is, what our needs are. ... to improve services..." (31/96)	- improve working relationship - by letting them realise what our situation is	Hospital-supplier relationship (trust) Visibility	Hospital-supplier relationship (trust)→+ Visibility	Increasing access to information will improve services
<i>PH02-08)</i> "we give information to patients verbally and some patients also call through our phones to get information to ask if we have a particular drug. ... For suppliers, we collate list of medicines in a computer and share the list in a flash drive or on a printed paper. When critical stakeholders sometimes ask for information, especially for the donor/partner as we do in our chemotherapy access partnership, we send information through emails ... and send via email. ... usually, drugs availability and quantity of drugs needed." (87/154)	- to get information - ask if we have a particular drug - we send information through emails	Information sharing Medicine inventory Technology integration	Technology integration→+ Information sharing→+ Medicine inventory	Sharing information improves levels of medicine inventory

(continued)

Table A3

ParticipantNumber-Quote number" . . . variables in Phrase(s)" (word count in variables/total word count in causal statement)	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, → =causal link with delay, +/−=positive or negative polarity)	Comments
PH02-09) "The supplier, for example . . . I need to tell these companies the stock levels of . . . for them to be able to know my reorder level so that they can actually supply me more. I share this information through email, WhatsApp messages. So I give all these logistics information to my supplier for a specific drug that . . . have to supply. Sometimes the suppliers give information (feedback) about available medicines and expected drugs that will be available in the country." (78/166)	- I need to tell - reorder level - supply me more - through email, WhatsApp messages - to supply - expected drugs that will be available	Information sharing Medicine order Medicine inventory Technology integration Medicine in transit Supply delay	Technology integration → + Information sharing inventory → + Medicine order → + Medicine → + Medicine in transit	Sharing information with suppliers increase inventory levels and reduces supply delay
PH02-10) "When we digitalize and computerise every . . . processes, it makes . . . information sharing easy for patients, suppliers and all critical stakeholders." (20/106)	- digitalize and computerise every . . . processes - information sharing easy	Process integration Information sharing	Process integration → + Information sharing	Sharing information Improves with digitalisation
PH02-11) ". . . information sharing and communications should be across all the levels. . . immediately everybody will know that this drug is at reorder level and escalate the information to the supplier. . . a process where suppliers are connected to the organization and can see that a particular drug is at reorder level in a particular hospital and make resupply immediately. . . ." (57/207)	- information sharing and communications - reorder level - suppliers are connected to the organisation - resupply immediately	Communication Medicine order Supplier integration Shipment	Communication → + Medicine order → + Supplier integration → + Shipment	Information sharing and communication with suppliers improves delivery of medicines
PH02-12) "It is only . . . that I have used but I know there are . . . technology out there. . . connected to some units that are important for now due to lack of funds." (32/35)	- it is only x, that I have used - lack of funds	Technology integration Available funds	Technology integration → + Available funds	Technology improves medicine inventory and increases funds
PH02-13) "The way we measure the performance of medicine availability in my organisation . . . and the supplier supplies seven out of 10. . . the supplier has scored 70%. It is possible that the medicine is out of stock at the time of supply. . . if we're able to make the 200 items available, then we will say our performance is 100% but if we're not able to, we count the number of available medicines and say maybe 75% performance. . . we believe we will satisfy our customers, . . . when prepare our list of medicines and we see that at least . . . we make available 75% or 80% or 90% of the stock." (109/247)	- the supplier has scored 70% - our performance is 100% - satisfy our customers	Supplier performance Internal performance Fill rate	Supplier performance → + Internal performance → + Fill rate	When patients get all their medicine, and the suppliers and hospital are performing optimally
PH02-14) ". . . we can improve performance by achieving patient satisfaction by providing the drug needs of the patients. . . we can improve the . . . by making patient drugs available at all times . . . and then by reducing the patient waiting time when they come to access these drugs in the pharmacy." (49/52)	- patient satisfaction - waiting time - access these drugs	Fill rate Patient waiting time Medicine inventory	Fill rate → + Patient waiting time → - Medicine inventory	Available medicines increase fill rate and reduce wait times

(continued)

Table A3

Participant/Number-Quote number) "... Variables in Phrase(s)" (word count in variables/total word count in causal statement)	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, -  →=causal link with delay, +/-=-positive or negative polarity)	Comments
<i>PH02-15</i> ) "For the suppliers, we can improve performance by making sure that the suppliers get payment for the supply to the institution as soon as possible. Computerising and digitalising all processes makes it easier for you to inform the supplier, immediately that a drug is at reorder level. ... this information can be shared with the supplier to make medicines available. ... we pay suppliers and ... improve performance for all critical stakeholders." (71/119)	<ul style="list-style-type: none"> <li>- as soon as possible</li> <li>- inform the supplier</li> <li>- medicines available</li> <li>- we pay suppliers and ... improve performance for all critical stakeholders</li> </ul>	<ul style="list-style-type: none"> <li>Time delay</li> <li>Information sharing</li> <li>Medicine inventory</li> </ul>	Information sharing-  →+ Medicine inventory	Network partners benefit from information sharing, and the patient gets medicines
<i>PH02-16</i> ) "With government, I think the only way we can improve is to remove ... bottlenecks. ... The only way to remove bottlenecks is ... government ... to give funds, ... directly to the hospitals for certain activities. The hospitals should strictly use the funds for the intended purpose and not divert funds ... funds allocated for drugs should not be used to fund building or other capital projects in the hospital. ... government can strengthen institutions through ... improving communication. ... through digitalization. There should be transparency and accountability in use of funds at the hospital." (158)	<ul style="list-style-type: none"> <li>- remove ... bottlenecks</li> <li>- not divert funds</li> <li>- improving communication</li> <li>- transparency and accountability</li> </ul>	<ul style="list-style-type: none"> <li>Time delays</li> <li>Hospital-government relationship (trust)</li> <li>Communication</li> <li>Visibility</li> </ul>	Hospital-government relationship (trust)→+ Communication→+Visibility	Reduced trust and communication decreases transparency



## Appendix 6

Table A4 Interview quotation analysis for pharmacist (PH03)

	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, -  →=causal link with delay, +/-=-positive or negative polarity)	Comments
<i>PH03-01</i> "...pharmacy department provide data and forward to procurement unit to work on it to send order to the suppliers. pharmacy makes sales of drugs dispensed to patients and send sales to accounts departments/finance unit. the money is used to pay for suppliers after delivery of products by suppliers. we share information, when there's need for any medicine, we work on it and send it to procurement unit to place order for the purchase of medicines. After management approval, the account s will pay for the drugs and we give the drug to patients." (93/97)	<ul style="list-style-type: none"> <li>- to send order to the suppliers</li> <li>- delivery of products</li> <li>- share information</li> <li>- pay for the drugs</li> </ul>	<ul style="list-style-type: none"> <li>Procurement</li> <li>Delivery</li> <li>Information sharing</li> <li>Available funds</li> </ul>	<ul style="list-style-type: none"> <li>Procurement → + Delivery</li> <li>→ + Information sharing → + Available funds</li> </ul>	Information sharing is only shared when there's need for products which hamper planning on the part of the suppliers
<i>PH03-02</i> "we share information with our patient's. some patients make request through phone calls to find out about drugs that are not readily available e.g. xxx. . . we display our drugs prices list publicly so that patients can know the prices of medicines. we interact with suppliers by keeping stock inventory of the patients. . . purchase drugs directly from them or through contracts. for management, we periodically send them reports quarterly on all activities." (72/82)	<ul style="list-style-type: none"> <li>- share information</li> <li>- can know the prices</li> <li>- purchase drugs directly</li> <li>- periodically</li> </ul>	<ul style="list-style-type: none"> <li>Information sharing</li> <li>Visibility</li> <li>Procurement</li> <li>Time delay</li> </ul>	<ul style="list-style-type: none"> <li>Information sharing → + Visibility -/ -</li> <li>→ + Procurement</li> </ul>	Information sharing is not real time for all stakeholders
<i>PH03-03</i> "for patients, we make sure there's constant supply of drugs. . . sustainability of medicines so that patients can have access to the drugs it's important to reduce lead times during order to be able to meet customer needs. Make sure we prepare list of medicines that are about to be exhausted on time. . . timely submission of data for	<ul style="list-style-type: none"> <li>- constant supply of drugs</li> <li>- reduce lead times</li> <li>- on time</li> <li>- should be prompt</li> <li>- customer needs</li> <li>- prepare list of medicines that are about to be exhausted</li> <li>- timely submission of data for procurement</li> </ul>	<ul style="list-style-type: none"> <li>Medicine inventory</li> <li>Time delay</li> <li>Customer order</li> <li>Time to reconcile inventory</li> <li>Time to average orders</li> </ul>	<ul style="list-style-type: none"> <li>Medicine inventory -/ -</li> <li>→ + Customer order -/ -</li> <li>→ + Time to reconcile inventory -/ - → + Time to average orders</li> </ul>	Delayed payment of suppliers affects the delivery of medicines to the hospital

(continued)

Table A4

Participant Number-Quote number" . . . variables in Phrase(s)" (word count in variables/total word count in causal statement)	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, -  →=causal link with delay, + /- =positive or negative polarity)	Comments
procurement, there should be prompt payment of suppliers whenever they deliver medicine." (69/79)				
PH03-04) "we have friends of hospital where management reach out to people that are ready to assist the less privilege because our patients cannot take care of themselves. . . . hospital reach out to people that can . . . help financially to the treatment of some of the less privilege patients that cannot afford their medication." (53/78)	- friends of hospital - assist the less privilege - cannot afford their medication	Hospital-stakeholders relationship (trust) funding Selling price	Hospital-stakeholders relationship (trust)-   → - funding → + Selling price	External funding from stakeholders supports the provision of medicines to indigent patients
PH03-05) "We share information through reports, for patients, everything is done manually, we display our list of drugs pricing for patients to know how much, it costs to take their medicines. we also keep manual documentation." (35)	- share information - done manually - to know how much, it costs	Information sharing Time delay Visibility	Information sharing-   → + Visibility	Communication with patients is through physical display of price list
PH03-06) ". . .we make phone calls if there are problems or if there's any urgent need for some drugs. . . .they come to the hospital for us to discuss what the problem is and how to resolve it. For CSOs and government, we document manually." (42/58)	- urgent - there are problems - and how to resolve it	Time delay Stockout Medicine inventory	Stockout-  →- Medicine inventory	Even though the suppliers can reach the staff by phone, constraints are resolved at the hospital manually
PH03 - 07) ". . .Use of digital technology, internet, computers is faster, more reliable. The whole process will be more efficient. it can be used to analyse or reproduce any information. . . . we don't have digital tools. whatever request can be done electronically. it is the best." (43/47)	- is faster - reproduce any information - don't have digital tools	Time delay Information sharing Visibility	Information sharing-   → + Visibility	The staff long for the use of technology to ease difficulty in information management

(continued)

Table A4

Participant Number-Quote number" . . . variables in Phrase(s)" (word count in variables/total word count in causal statement)	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, -  →=causal link with delay, +/-→=positive or negative polarity)	Comments
<i>PH03-08</i> ". . . makes the whole process faster and it also eliminates interruption or disruption. . . meet the target you set for the patients, reliable, easy to use. . . can be used to analyse data or reproduce data which is not possible manually especially if you're looking for an information that takes a length of time to reproduce, you will not finish on time. by clicking a button or two, you get all information you need." (71/73)	<ul style="list-style-type: none"> <li>- makes the whole process faster</li> <li>- takes a length of time</li> <li>- not finish on time</li> <li>- target you set for the patients</li> <li>- looking for an information</li> </ul>	Time delay Medicine inventory Information sharing	Information sharing-   → + Medicine inventory	The staff experience delay in replenishment of medicines which is attributed to manual inventory management techniques
<i>PH03-09</i> ". . . We use computers for our stock balances on monthly basis, we keep record of issuance and the stock available at the end of every month. . . some places provide computerized provider order systems. . . also learned about radio-frequency identification technology (RFID). I don't have any idea about it." (55/94)	<ul style="list-style-type: none"> <li>- our stock balances</li> <li>- issuance and the stock available</li> <li>- computerized provider order systems</li> <li>- radio-frequency identification technology</li> <li>- I don't have any idea about it</li> </ul>	Time to reconcile inventory Time to average orders Information sharing Visibility Capacity	Information sharing → + Visibility → + Capacity → - Time to reconcile inventory → + Time to average orders	The staff are curious to the perceived gains from the use of digital technology for inventory management
<i>PH03-10</i> ". . . we use maximum and minimum inventory management system. we use visual method to determine stock levels. we know the drugs that are available, and we know the drugs that are about to be exhausted. the method is not effective 100%, depending on a particular period . . . you may not have many cases or patients. . . we run into problems when prescribing patterns changes which affects us. when new drugs are introduced to the system, you start seeing prescriptions on it. then all of a sudden demand decreases for the new drug." (90/125)	<ul style="list-style-type: none"> <li>- to determine stock levels</li> <li>- about to be exhausted</li> <li>- period</li> <li>- all of a sudden</li> <li>- many cases</li> <li>- we run into problems when prescribing patterns changes</li> </ul>	Medicine inventory Stockout Time delay Customer orders Supply delay	Medicine inventory-   → - Stockout → - Customer orders -   → - Supply delay	Sudden changes in prescribing patterns and demand of customers lead to stockout of medicines and delays in supply

(continued)

Table A4

Participant/Number-Quote number) "... variables in Phrase(s)" (word count in variables/total word count in causal statement)	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, -  →=causal link with delay, +/-=-positive or negative polarity)	Comments
PH03-11) "... we keep adequate record so that when we need drugs we can order quickly. inventory accuracy improve the supplies and minimising wastages through pilferages, theft, damages and expiries increases availability of drugs. for patients, by keeping accurate records, ... don't allow drugs to finish before requesting for more keeps drugs readily available." (/58)	<ul style="list-style-type: none"> <li>- adequate record</li> <li>- order quickly</li> <li>- inventory accuracy</li> <li>- wastages through pilferages, theft, damages and expiries</li> <li>- availability of drugs</li> <li>- allow drugs to finish</li> </ul>	<ul style="list-style-type: none"> <li>Time to average orders</li> <li>Medicine procurement</li> <li>Time to correct inventory</li> <li>Shrinking inventory</li> <li>Medicine inventory</li> <li>Stockout</li> </ul>	<ul style="list-style-type: none"> <li>Time to average orders → - Medicine procurement → + Medicine inventory → - Stockout → + Shrinking inventory → + Time to correct inventory</li> </ul>	Shrinking inventory plays a huge role in stockout of medicines by distorting the accuracy of medicine records and delaying replenishment
PH03-11) "I think supply chain knowledge is very good. ... if we can encourage stakeholders to take it serious and key into the drug revolving fund. it will motivate people to work better." (31/46)	<ul style="list-style-type: none"> <li>- supply chain knowledge</li> <li>- motivate people to work better</li> </ul>	<ul style="list-style-type: none"> <li>Capacity</li> <li>Medicine inventory</li> </ul>	Capacity → + Medicine inventory	Building capacity will make the staff happy and increase productivity

## Appendix 7

Table A5 Interview quotation analysis for pharmacist (PH04)

Participant/Number-Quote number" . . . variables in Phrase(s)" (word count in variables/ total word count in causal statement)	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, -  →=causal link with delay, +/-=-positive or negative polarity)	Comments
PH04-01) "There's an EDRF committee. . . Essential Drug Revolving Fund which is a team of professionals, which includes the medical doctor, includes the account, the pharmacy, and then the stores. we all work together to make sure that drugs are readily available from time-to-time meetings are held, to see how the EDRF functions and whether we're making progress or if there're areas that need to that we need to improve upon." (70/91)	- from time-to-time - to make sure that drugs are readily available - whether we're making progress	Time delay Medicine availability Fill rate	Medicine inventory-  →→+Fill rate	Even though the teams work together, there is delay in getting the required medicine for the patient
PH04-02) ". . . the collaboration can be better, if the pharmacist is given more to operate like, sometimes because before a major decision is taken, every part of this team . . . has to be carried along, or when . . . purchases are made, the approval has to come from somewhere, this can affect how often we get drug into the facility. I think that if the pharmacists are given more free room to operate and we get drug into the facility. . . people can see the need that we don't have to wait for bureaucracy for drugs to be brought in. . ." (96/101)	- has to be carried along - can affect how often - and take decisions instantly - have to wait - given more free room to operate - when . . . purchases are made - we get drug into the facility	Time delay Process integration Procurement Shipment	Process integration-  →→+Procurement-  →→+Shipment	Bottlenecks are preventing the teams from seamless operations
PH04-03) ". . . And depending on the volume of patients we have in particular times like there are certain seasons, that we have a higher turnover than others. . . we make sure that we always have drugs readily to meet the particular needs of patients . . . particular clinic days to make sure that those drugs they'll be needed in clinics. . . very available, . . . during the rainy season we see a spike in allergies. For this season we make sure that we do not run out of anti-allergic agents and we get the accounts department to make sure that when this drugs are supplied payments are made in good time. so that when we call upon the suppliers for more supplies or other supplies, they will not be reluctant to supply." (126/208)	- volume of patients - we see a spike in allergies - turnover - needs of patients - those drugs they'll be needed in clinics. . . very available - payments are made in good time - reluctant to supply	Customer orders Cash collected Fill rate Medicine inventory Available funds Supply delay	Customer orders→+Cash collected-  →→+Available funds-  →→+Supply delay→→+Medicine inventory-  →→+Fill rate	High number of orders depletes inventory, which cannot be replenished when suppliers are not paid on time
PH04-04) "When a patient comes to the hospital, . . . making drugs readily available for them is uppermost in our mind . . . so we make sure that drugs are always readily available for our patients, when they come to the pharmacy, which keeps them happy. A lot of times, when patients come and they're told that certain drugs are not available, they are not always happy. . . we always have this consciousness, we are always working hard to make sure that drugs are available because that is what pleases our customers, our patients." (89/196)	- making drugs readily available - which keeps them happy - they are not always happy - certain drugs are not available - we are always working hard - a lot of times	Fill rate Customer satisfaction Stockout Productivity Time delay	Productivity-  →→+Fill rate→→+Stockout-  →→+Customer satisfaction	The staff work hard to fill prescriptions, but sometimes the drugs are not available

(continued)

Table A5

Participant/Quote-Number" . . . . . variables in Phrase(s)" (word count in variables/ total word count in causal statement)	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (->=causal link, -  ->=causal link with delay, +/-=-positive or negative polarity)	Comments
<b>PH04-05</b> ". . . we can make it better by making sure that suppliers . . . paid even more promptly. I know that we're trying but it can be better. . . . the processes involved in getting the payment done, everybody that's involved in that chain, should take up their responsibility and do it as quickly as possible." (52/135)	- making sure that suppliers . . . paid promptly - as quickly as possible - everybody that's involved in that chain	Available funds Time delay Process integration	Process integration-  ->+Available funds	Alignment of processes will get suppliers paid at the right time
<b>PH04-06</b> "we can improve our working relationships with them when we are very transparent about everything that we do for donor partners when drugs have been donated, we should be open to let them know how these drugs have been utilised. I think it will make them happy to see that the drug finally gets to the people that they were meant for and every other person involved . . . transparency is key." (70/89)	- improve our working relationships - we should be open - transparency is key - make them happy	Hospital-partner relationship (trust) Visibility Partner satisfaction	Visibility->+Hospital-Partner relationship (trust)->+Partner satisfaction	Transparency builds trust and ensures every partner achieves their goals
<b>PH04-07</b> "for patients during . . . during dispensing and counseling . . . we make sure that this information is made available to the patient. . . . we listen to the patient. . . . we get a lot of questions during fasting, whether eye drops can break their fast or interrupt the fasting. . . . we answer their question in a way to assure them that they can still carry on their religious obligations while they use their medication." (69/188)	- information is made available - use their medication	Information sharing Customer orders	Information sharing->+Customer orders	Sharing information enables customers to get the best of their orders
<b>PH04-08</b> "Everything we do is documented most of this information is . . . documented, . . . written maybe not in soft copies, some already on soft copies most are in hard copies. . . . whenever . . . need this information if they're requested for, they are always readily available." (40/45)	- maybe not in soft copies - readily available	Technology integration Visibility	Technology integration->+Visibility	Technology makes information available
<b>PH04-09</b> ". . . we review the prescriptions, the ones that are available, we let them know immediately, the ones that are not available. . . . we tell them and give them specific periods within which it will be available. . . . we let them know that we do not have these drugs, . . . may have to get it elsewhere. . . . The best we can tell . . . is make sure you go to a reputable pharmacy to get your drug, that's what we do with the patients." (75/157)	- we review the prescriptions - the ones that are available - the ones that are not available - specific periods within which it will be available - may have to get it elsewhere	Customer orders Medicine inventory Stockout Shipment Customer satisfaction	Customer orders->+Medicine inventory->+Stockout->+Shipment->+Customer satisfaction	Customers are unhappy when medicines are out of stock
<b>PH04-10</b> ". . . technology. . . is the way to go. . . . it can make things to make things easier. But there are challenges that are associated with that. . . . because the network was very poor. . . . it will impact on going digital. . . . (71/32)	- technology. . . is the way to go - because the network was very poor - impact on going digital	Technology integration Visibility	Technology integration->+Visibility	Technology use is hindered by network connectivity

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Table A5

Participant/Number-Quote number) "... variables in Phrase(s)" (word count in variables/total word count in causal statement)	Phrase(s) from participant quote denoting model variables	Interpreted model variables	Causal link between model variables (→=causal link, -  →=causal link with delay, +/-=-positive or negative polarity)	Comments
<i>PH04-11</i> "... what we have now is the electronic medical record, ... yes, I like it very well, it helps a lot, it makes the work easier. And then it's has taken away a lot of writing." (34/99)	- electronic medical record - yes, I like it very well	Technology integration Staff satisfaction	Technology integration → + Staff satisfaction	Using technology reduces manual effort of dealing with prescriptions
<i>PH04-12</i> "... will measure performance by the number of out of stock. As a dispensing pharmacist, so I'm always in touch with the patient. And my goal is to make sure that the patient that whatever number of drugs are on the patient's prescription, the patient's gets all of them. ... I measure performance by the out of stock or the availability of drugs. The more drugs are available... the higher I will rate our performance."	- number of out of stock - always in touch - number of drugs - the patient's gets all of them - availability of drugs - rate our performance	Stockout Information sharing Medicine inventory Fill rate Fill rate Performance	Information sharing → + Medicine inventory → + Fill rate → - Stockout → - Performance	Performance is measured by availability of medicine and out of stock
<i>PH04-13</i> "... everybody doing their own bit at the right time as quickly as possible. If everybody does that, drugs will be more readily available to the patient. Sometimes when drugs are out of stock there's not much that the pharmacist can do after he has done their roles and informed the necessary authorities that drugs are out of stock the list has to be taken to someone who will approve if the approval doesn't come on time, there's nothing you can do about that, when the approval comes and the order needs to be written out and given to the suppliers immediately. So whoever needs to do that should do it promptly. ... when the order gets to the supplier, the supplier should do it promptly too, when everybody has done their parts as soon as possible, then drugs will be readily available to the patient." (144/147)	- as quickly as possible - come on time - should do it promptly - drugs will be more readily available - there's not much that the pharmacist can do - should do it promptly too	Time delay Medicine inventory Stockout Productivity Shipment	Stockout → - Medicine inventory -    → + Productivity -    → + Shipment	Staff productivity decreases with more stockout
<i>PH04-14</i> "By letting the suppliers know that whatever order is given to them needs to be acted upon immediately. Because those drugs need to get to the end users as soon as possible. ... whatever order they get should be acted on within a timeframe to make it available for the patient." (50/54)	- acted upon immediately - as soon as possible - whatever order - to make it available	Time delay Customer orders Medicine inventory	Customer orders -    → + Medicine inventory	The is some frustration on the part of the pharmacist with the delay in sending orders to the suppliers and supply delay to the hospital
<i>PH04-15</i> "... government can help by engaging more hands on ground to do the work, then ... making funds available, lack of manpower is our main challenge for now, human resource is a challenge."	- engaging more hands - lack of manpower - making funds available	Staff attrition Funding	Funding → - Staff attrition	The hospital does not have autonomy to employ staff. Staff attrition and lack of funds reduces productivity