ADDIS ABABA UNIVERSITY

SCHOOL OF COMMERCE

DEPARTMENT OF LOGISTIC AND SUPPLY CHAIN MANAGEMENT

ASSESSMENT OF LABORATORY COMMODITIES SUPPLY CHAIN PERFORMANCE IN AMANUEL SPECIALIZED MENTAL HOSPITAL, ADDIS ABABA, ETHIOPIA

BY

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Statement of Declaration

This is to certify that Banchirega Mekuria Gibe has carried out her research work on the topic entitled, Assessment of Laboratory Supply Chain Performance in Amanuel Specialized Mental Hospital, Addis Ababa, Ethiopia.

The work is original in nature and suitable for submission for the award of Masters of art in Logistic and Supply Chain Management (M.A in LSCM).

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List of abbreviation and acronym

AMSH	Amanuel Specialized Mental Hospital
FMOH	Federal Ministry of Health
KPI	key performance indicators
PFSA	Pharmaceutical Fund and Supply Agency
SCC	Supply Chain Council
SCM	Supply Chain Management
SCOR	Supply Chain Operation Reference
SCPM	Supply Chain Performance Measures
WHO	World Health Organization

Abstract

A Supply chain operation reference is a model that provides "a unique framework that links business process, metrics, best practices and technology into a unified structure to support communication among supply chain partners and to improve the effectiveness of supply chain management and related supply chain improvement activities. The aim of this study is to assess the performance of laboratory commodities supply chain of Amanuel Mental Specialized Hospital. The study focused on five supply chain performance attributes which are supply chain reliability, supply chain responsiveness, supply chain agility, supply chain operational cost and inventory management Practice. A case study design using SCOR model was used to conduct the study on laboratory supply chain performance in Amanuel Specialized mental hospital. The research used both qualitative and quantitative approach. The quantitative data was analyzed using excel for descriptive statistics and the qualitative data was used to further explain the findings of the quantitative data. All one year data of report and request form, intra facility report and request form model, model 19 and 22, inventory reports, stock out report form, bin cards and stock cards were used. Census is sample selection technique to study the quantitative variable. Data for each metrics were obtained from the process components that are used to drive the calculation according to the SCOR guide. Structured data collection format and interview guide were used to collect data. Decomposition analysis method was used to measure the performance gap and identify root cause. The study found out that perfect order fulfillment of laboratory commodities were 25%. The order fulfillment cycle time was 54.45. The asset turnover rate was 0.72. Some of the root causes mainly contributed for low performance was unavailability laboratory commodities with required kind and quantity at distributers and delay to authorize payment. Therefore strengthening collaborative planning, forecasting and replenishment between the hospital and suppliers, establishing long term supplier agreement between the private suppliers and Improving the authorization of payment timely are some of the recommended practices.

Key word: Laboratory commodities, supply chain performance supply chain operation reference

Chapter one

1. Introduction

1.1. Background

Amanuel Mental Specialized Hospital (AMSH) is one of oldest hospitals established in 1930 E.C. by Italian colonizers to serve the nations of Ethiopia unlike other the preceding Hospitals serving the white only. It is located in western part of Addis Ababa in Addis Ketema sub city kebele 08. The hospital established on an area of 15,660.6 km2 .The hospital is increasing the service to be the center of excellence for mental health services by providing treatment for those who have mental and general health problems, training mental health professional of different level of skill and knowledge, conducting research, and other administrative services; in order to integrate mental health services to the level of primary health care in Ethiopia.

The common mental & neurological disorder seen in 2016 in a descending frequency is schizophrenia, epilepsy, depression, acute psychotic disorder, mania and OPD disease respectively. Training master‘s program in psychiatry has been established in collaboration with Gondar & Jimma University by the year 2001 while BSc psychiatry training has been running in Gonder, Mekele, Jimma, Haromaya and Hawassa Univeristy. The hospital is giving technical support for the program. Since 2001 the Hospital managed to integrate the clinical services through facility renovation & expansion, HR development, leadership commitment, decentralization of mental health care & excelling the service (AMSH, 2016).

Lamb *et al*. (2014) define the supply chain as ―the connected chain of all business entities, both internal and external to the company, that perform or support the logistics function”. Supply chain management is concerned with coordination of the flow of the business process output of one actor to the input of another actor‘s processes. The main flows among supply chain business processes are products, orders, and demand and supply information (Heriberto *et al*, 2010).

The healthcare supply chain is vast, diverse, and complex which presents many challenges to effective management. In health care supply chains, the principal participants include manufacturers (drugs, medical equipment, and hospital medical supplies), distributors, medical

service provisions, medical groups, insurance companies, government agencies, employers, government regulators, and users of health care services (Burns & Lee, 2008).

The ultimate goal of the health care supply chain is to deliver materials and information in order for patients to receive quality care. An effective supply chain brings in the right materials and information at the right time, with the right quantities, to the right place. It is believed that opportunities exist to reduce costs and improve delivery of healthcare by improving the efficiency and quality of healthcare supply chain operations. This can have a direct, positive impact on patient care by reducing risk and errors, eliminating operating room waits and cancellations, and reducing the length of stay (Shumaker, 2006; Singh, 2006; Mantone, 2007).

The importance and influence of supply chain management can be seen clearly in the fact that firms expend up to 75 percent of their revenue on supply chain activities (Ellinger *et al*, 2014). Stevenson (2005) lists the benefits of effective supply chain management to be lower inventories, lower costs, higher productivity, greater agility, shorter lead times, higher profits, and greater customer loyalty. According to a research study presented to the Medical Device Supply Chain Council in 2011, 40-45% of the hospital operating expense is represented by supply chain and potential savings of 5-15% of supply chain cost can be realized with better supply chain management strategies (Global Healthcare Exchange, 2011).According to Kazemkhanlou *et al* (2014), the effective supply chain management (SCM) has been associated with a variety of advantages including increased customer value, increased profitability, reduced cycle times and average inventory levels and even better product design".

In order to understand how the supply chain performing; measuring the performance is important. Supply Chain Performance Measures (SCPM) serves as an indicator of how well the system is functioning (Kazemkhanlou *et al*, 2014). Performance measurement in supply chain is one of the challenges faced in managing supply chain (Storey *et al*,(2006).Traditional supply chain metrics have grown less relevant to today's business environments since they are too narrow inside scope to effectively tackle the broad ranges involving activities. More specifically, the original matrices don't capture exactly how well key business procedures have performed or provide understandings about how effectively the supply chain has met customer qualification. Thus, there exists a need for new metrics pertaining to efficiently managing the supply chain

performance. Supply Chain Operation Reference (SCOR) model is one of the most famous Business analytics metric that systematically and comprehensively determine the performance of the supply chain (Agami *et al*, 2012).

Despite the role of supply chain management as a competitive tool, the supply chain operational excellence in the laboratory commodities in Ethiopia is under researched and there is knowledge gap how well is the performance supply chain management practice in Ethiopia. Consequently, this thesis will focus on investigating the performance of supply chain management practice in the case Amanuel specialized mental hospital located in Addis Ababa in terms of supply chain reliability, responsiveness, agility and supply chain operational cost as well as asset utilization in supply chain management in the hospital with limited scope.

1.2. Statement of the problem

According to world health organization (WHO) one of the building block of health system is pharmaceuticals which accounting for 10-30% of health care costs (WHO, 2009). Early diagnosis and treatment of public health problems could be achieved through provision of adequate inputs of pharmaceuticals. Uninterrupted supply of safe, effective, quality pharmaceuticals at an affordable price, and rational use is crucial for the success of health program implementation (FMOH, 2010).

Well-organized pharmaceutical service ensures the continuous availability of all pharmaceuticals (FMOH, 2010). In opposite poor pharmaceutical supply management results in unreliable availability of pharmaceuticals that leads to stock out, shortage and treatment failure. It could also result in significant wastage of resources due to deterioration and expiration, which leads not only to the morbidity or mortality of a patient but also have socioeconomic impacts (USAID, 2011).

In Ethiopia lack of proper management of medical equipment has limited the capacity of health institution to deliver adequate health care (FMOH, 2010). Supply chain problems like weakness of inventory control, irrational forecasting, weakness of communication between store and outlets, wastage, stock out, delay in delivery, weak procurement strategy for lab reagents, weak

communication with facilities, poor quality supplies, inadequate involvement of biomedical unit in supply system negatively influence the health care delivery. A study done by the Federal Ministry of Health showed among 85 laboratory tests that should be available as per the national menu, availability was found to range from 40% to 80%. Patient surveys showed that only approximately half of patients received their full tests from the hospitals. This implies that many patients might be forced to go to private facilities (FMOH, 2016).

There are a number of reasons why health care industries needs to look at how they manage their supply chain (Bradley, 2000). The main reasons are cost and risk. Since the two reasons are critical for all members across the supply chain, performance measurement is important to understand how they are performing.

During my literature reviews, most of the researches on assessment of supply chain management performance were conducted on manufacturing companies in the developed countries. Researchers conducted on the supply chain performance of laboratory commodities were very rare especially in Ethiopia. As a result, there was little insight about the performance of supply chain management of these commodities. The intention of this research study is to measure the performance supply chain management of laboratory commodities in Amanuel Specialized Mental Hospital focusing on the responsiveness, reliability, agility, and cost and inventory management efficiency of the supply chain management practices as well as best practices based on SCOR model.

1.3. Research Question

What is the internal performance level of laboratory commodities supply chain in Amanuel hospital?

What are the root causes that affect laboratory commodities supply chain performance in Amanuel Hospital?

What are the best practices that help to improve identified performance gap in hospital laboratory supply chain?

1.4. Objective

1.5.1. General Objective

The general objective of this study is to assess laboratory commodities supply chain performance in Amanuel Specialized hospitals in Addis Ababa, Ethiopia.

1.5.2. Specific Objectives

To assess the internal performance of laboratory commodities supply chain practice in AMSH

To identify the root causes that affect the laboratory supply chain performance

To assess practices that will help to improve identified performance gap in hospital laboratory supply chain

1.5. Scope of the study

The geographic scope of this study is limited to only on one hospital laboratory commodities supply chain performance (Amanuel Specialized mental hospital) in Addis Ababa. The result from the study might not be representative of other hospitals. The study would not cover other member of supply chain therefore the full image of supply chain performance could not be addressed. Lastly the study used the two parts of SCOR model that are performance and practice. The performance measurement is restricted in scope attributes such as supply chain variables supply chain reliabilities, responsiveness, agility, cost and asset.

1.6. Significance of the study

This study makes the hospital to have a clear picture of how current processes and activities are carried out in the laboratory supply chain. This research also shed light on the need for hospital to enhance their decision making and supply chain process management. It may also become a reference point for future reference in the field of supply chain management.

1.7. Limitation of the Study

Due to lack of data the agility attribute of laboratory commodities supply chain performance in ASMH could not be performed.

1.8. Organization of the study

The study is organized into five chapters. Chapter one introduces the study by giving the background information on the research problems, objectives, and scope of the study. Chapter

two deal with the review of relevant literature. Chapter three discusses the research methodology adopted for the study with relevant justifications. It outlines the methodology for carrying out the data collections and how results were analyzed. Chapter four presented the finding on the supply chain performance of laboratory commodities in Amanuel specialized mental hospital. Chapter five presents the conclusions drawn from the research findings and recommendations to enhance organizational supply chain performance efficiency.

Chapter Two

2. Related literature Review

2.1. Supply Chain Management

2.1.1. Supply Chain

Stevenson (2005) defines the supply chain as ~~a~~ sequence of organizations – their facilities, functions, and activities – that are involved in producing and delivering a product or service".

Krajewski *et al* (2010) take a wider view and define supply chain as ~~th~~he interrelated series of processes within a firm and across different firms that produces a service or product to the satisfaction of customers" and specify the definition even further to be ~~a~~ network of service, material, monetary, and information flows that link a firm's customer relationship, order fulfillment, and supplier relationship processes to those of its suppliers and customers".

Rushton *et al* like to see the participants of the chain as an entity: ~~th~~he supply chain is viewed as a single entity rather than a series of fragmented elements such as procurement, manufacturing, distribution, etc. This is also how logistics is viewed in most forward looking companies. The real change is that both the suppliers and end users are included in the planning process, thus going outside the boundaries of a single organization in an attempt to plan for the supply chain as a whole".

Stevenson (2005) offers illustrations for typical (simplified) supply chains and points out that the number and type of organizations in a supply chain are determined by whether the supply chain is manufacturing or service oriented. Stevenson (2005) illustrated typical service oriented supply chain Figure 1.

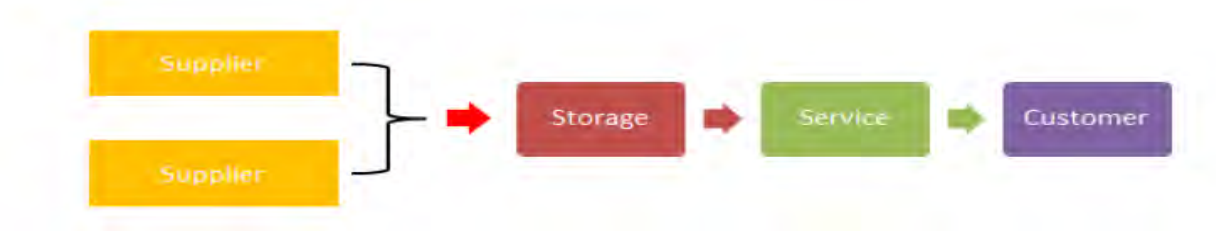

Figure 1: Typical service oriented supply chain adapted from Stevenson (2005)

Stevenson (2005) points out that not only physical activity take place: ―there are two kinds of movement in these systems: the physical movement of material, generally in the direction of the end of the chain, and exchange of information, which moves in both directions along the chain". Thus supply chain needs to be managed from many perspectives.

2.1.2. Internal Supply Chain

Internal supply chain refers to the chain of activities or functions within a company that result in providing a product to the customer. Integration of these functions involves the holistic performance of activities across departmental boundaries. A well-integrated internal supply chain should result in excellent customer service and company performance (Basnet, 2013).

Effective internal supply chain integrates the internal functions for example from marketing to logistics. Interdepartmental collaboration can bring departments together into a cohesive organization. Firm performance and, ultimately, supply chain performance depend on such collaboration (Chen *et al*, 2007). According to Gimenez *et al* (2005) ―internal integration has a positive effect on external integration because coordination among internal functions facilitates coordination among different companies".

2.1.3. Supply Chain Management

Rushton *et al* (2006) define the supply chain management as ―very much a strategic planning process, with a particular emphasis on strategic decision making rather than on the operational systems". According to Stevenson (2006) ―supply chain management involves coordinating activities across the supply chain. Central to this is taking customer demand and translating it into corresponding activities at each level of the supply chain". Krajewski *et al* (2010) define the supply chain management quite clearly as ―the synchronization of the firm's processes with those of its suppliers and customers to match the flow of materials, services and information with demand".

Lamb *et al* (2014) describe that ―the goal of supply chain management is to coordinate and integrate all of the activities performed by supply chain members into a seamless process, from the source to the point of consumption, ultimately giving the supply managers total visibility of the supply chain both inside and outside the firm".

2.1.4. Challenges of Supply Chain Management

Storey *et al* (2006) have identified three core enablers and inhibitors for supply chain management in their study: transparency of information and knowledge; supply chain behavior; and performance measurement. The use of key performance indicators was guided by top level business objectives or metrics pursued at functional level could at worst jeopardize the performance of the supply chain as a totality and the end customers‘ needs were forgotten.

2.2. Health Care Supply Chain Management

The healthcare industry is of significant importance in both economic development and social welfare in modern economies. Healthcare is traditionally defined as the delivery of treatment and services to people in need of medical attention. Healthcare supply chain management differs from other application in term of key elements as it tends to be high costs for healthcare providers and heavy dependence on third party. There are multitudes of factors to be considered so as to ensure on-time delivery, protection and product integrity from origin to destination. This is a highly sensitive supply chain that everything less than 100% customer service level is unacceptable as it directly influences the health and safety (USAID, 2011).

In any business, a supply chain needs to be designed with respect to the strategy and the nature of the company‘s business. Across hospitals, the strategy is consistent. To put it simply, a hospital‘s strategy is to maximize patient care. The hospital supply chain enables this strategy by: ensuring product availability, minimizing storage space, maximizing patient care space reduce material handling time and costs for all medical staff as well as minimizing non-liquid assets (inventory).

Hospital supply chains are complex. The hospital product line consists of high cost and low cost items as well as perishable and durable goods that are consumed in large and small volumes. In addition, there are highly critical and noncritical items. Hospital supply chains have to be constructed such that they can handle products with all combinations of these various traits (i.e. highly critical, low volume, high cost, perishable goods)(Valestin,2001).

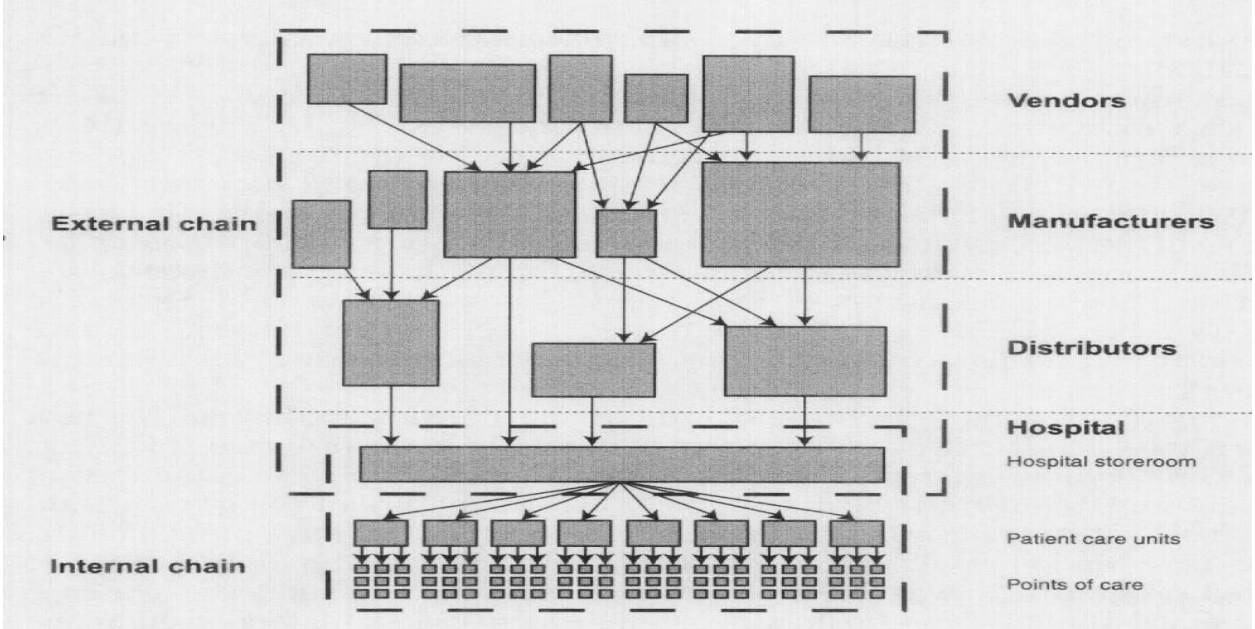

Figure 2: Typical Hospital Supply Chain. Source (Rivard Royer *et al*, 2002)

SCM in hospitals involves the internal chain, including patient care unit, hospital storage, patient, and etc., and the external chain, including vendors, manufacturers, distributors, and etc. Healthcare SCM processes have three types of flows: physical product flow, information flow, and financial flow. The physical product flow manages customized products and services for the treatment of patients and their needs. Information and financial flows are related to supply chain design decisions for effective product flow and improved organizational performance.

2.3. Supply Chain Performance Measurement

Kazemkhanlou *et al* (2014) conclude in their article that ~~"p~~erformance measurement is a power tool that assists firms or organizations to evaluate resource utilization so that they can strategically manage and continuously control to achieve their objectives and goals". By selecting the right measurements the organization can check its position, that it knows where it is and where it is going; communicate its position according to two perspectives, internal, i.e. organization internally communicates in order to thank or spur individuals and teams, and external, organization externally communicates in order to cope with legal requirements or market's needs; confirm priorities, since by measuring it can identify how far it is from its goal;

and compel progress that means it can use measurement as means of motivation and communicating priorities, and as a basis for reward.

Desirable characteristics of SCPM include inclusiveness (measurement of all pertinent aspects) ,universality (allow for comparison under various operating conditions) ,measurability (data required are measurable) and consistency (measures consistent with organization goals) (Kazemkhanlou *et al*, 2014) .The main goal of SCPM models and frameworks is to support management by measuring business performance as well as analyzing and improving business operational efficiency.

Kazemkhanlou *et al* (2014) present 16 well-known supply chain performance measurement models Key supply chain performance measurement models will be dealt in this section.

1. **Activity-Based Costing:** It has been created in the1980s. It aims to analyze costs and margin, but goes beyond the simple calculation of return costs. It necessitates a deep knowledge of the company. It groups activities by their process logic and interweaves accounting data into this concept.
2. **Framework for Logistics Research:** It has been developed in the 1990s. It describes dependency between the level of performance achieved, logistics organization and competitive strategy. It can be applied at organizational and strategic level. It structures logistics function into several dimensions (centralization, formalization, integration and areas of control).
3. **Balanced Score Card**: It has been developed in the 1990s. It seeks balanced measures to but-tress company strategy. This principle proposes four analytical axes: customers, finance, internal processes and innovation-growth and it incorporate a human dimension for the performance measurement. It is specifically geared towards general management and can be applied from the strategic through the organizational level. It aims to establish causalities be-tween the performance of each analytical axis.
4. **Supply Chain Operation Reference** model: It has been developed in 1996 by the Supply Chain Council (SCC).It aims to analyses four dimensions: reliability of commercial performance, flexibility/ responsiveness, cost of supply chain and turnover of committed capital. It can be applied to all industrial and service sector companies, at tactical and

operational level for an implementation of decisions relating to the company‘s strategic planning. Its indicators‘ definitions are explained using calculation modes and giving association of indicators for each process.

5. **Global Supply Chain Frame work**: It has been created by Ohio State University in 1994. It describes three levels (strategic, tactical and operational) and highlights links between supply chain process and structure. It focuses on seven processes: customer relationship management, customer service management, demand management, order fulfillment, manufacturing flow management, supplier relationship management, product development and commercialization, and returns management.
6. **ASLOG audit:** It has been created in1997 by ASLOG, based on models used in the automobile sector. It assesses logistics procedures by analyzing strengths and weaknesses. It is a transversal tool, which aims to implement good practice dedicated to companies with low or medium levels of maturity. It analyses the following areas: management, strategy and planning, design and projects, sourcing, production, transportation, stocks, sales, returns and after sales, piloting and permanent progress indicator.
7. **Strategic Audit Supply Chain:** It has been developed in 1999. It analyzes supply chain in terms of processes, information technologies and organization at an organizational level. Its principle is to break logistics chain down into six competencies: customer orientation, distribution, sales planning, lean production, supplier partnerships and integrated management of chain and to link competencies to information technology and organization of chain.
8. **Global EVALOG (Global MMOG/LE):** It has been created in 1999 with Odette International Limited and Automobile Industry Action Group. It assesses partner site processes and performance, pursues continuous improvement approach. Although it has been developed for an automobile industry, it can be used for associated sectors (metal works, chemicals). It is structured in to six areas: strategy and improvement, work organization, production planning, customer interface, process control and supplier interface.
9. **World Class Logistics model:** It has been developed by Michigan State University in the 1990s. It evaluates the company‘s performance in terms of its ability to account for inter organizational relationships through a model comprised of 68 questions. It can be applied at

strategic and organizational level. It revolves around four areas of competency: positioning, integration, agility and performance measurement.

10. **AFNOR FDX50-605:** It has been developed in 2008.It offers general framework for strategic reflection and defines different logistics processes. It identifies performance levers associated with each process. Its model features six areas: identification of needs and setting of objectives, logistics system design and development, production, sales and distribution, logistics support and control over global logistics process.
11. **SCM/SME**: It has been developed in 2007 within an SME context. It is composed by a questionnaire featuring 25 modules: corporate strategy, organization and logistic competencies development, performance processes and measurements, information system. Its targets are mainly industrial SMEs in fast moving consumer goods sector. It is structured around demand management, distribution, import/export flows, stocks, production, sourcing, returns, after sales support and traceability.
12. **APICS:** It has been developed by professional association APICS in 2000. It analyzes innovation and customer service management, efficiency drivers, agility, risk control and sustainability. It mainly applies to industrial firms. Its processes are structured via model that is mainly geared towards production planning.
13. **Efficient Customer Response**: It has been created in 1994 by an ECR Association of manufacturers and retailers. It evaluates good inter organizational practices and uses maturity based evaluation tool: global mapping. It focuses on collaboration between industrialists and distributors in fast moving consumer goods sector. It establishes common language based on joint evaluation of performance by act or sin the chain. It is based on 45 criteria structured into four areas: consumer demand management, supply chain management, technological platforms and integration.
14. **EFQM: Excellence model:** It has been in traduced in 1992. It starts by a questionnaire with 50 questions; respondents positioned along the scale of excellence. It covers areas relating to process efficiency, continuous improvement in products and services, personnel management and progression. It is suitable for all types of companies. It is based on eight principles: customer focus, leadership, definition of objectives, process-based management, staff involvement, continuous innovation process, development of partnerships and civic responsibility.

15. **Supply Chain Advisor Level Evaluation:** It has been created in the early 2000s by the Institute for Supply Chain Excellence (ISLI) for all sectors of activity. It revolves around questionnaire that assesses strategic and tactical dimensions, elements of value creation. It is based on 58 processes classified into seven categories of activities: definition of strategic objectives, establishment of procedures, needs planning, coordination of phases, performance evaluation and monitoring and supply chain optimization.
16. **Strategic Profit Model**: It has been created in 2002, derived from the DuPont model. It displays existing interactions between strategic and operational levels by means of financial ratios. It proposes strategic and financial implementation based on cost drivers using returns on asset or returns on net value measurements.

The SCOR model is chosen as one of the best models to assess the performance of laboratory supply chain performance. It provides a unique framework that links business process, metrics, best practices and technology into a unified structure to support communication among supply chain partners and to improve the effectiveness of supply chain management and related supply chain improvement activities. It is compressive model to assess the performance of supply chain process based on the core process categories of plan, source, make, deliver, return and enable. In addition to this SCOR provides set of practices, benchmarks and measurement tools for staff competency that will help to take pragmatic solutions.

The hospital can sustain the implementation of the SCOR project with the technical support to available staff because the tool does not require complex skill of statistical analysis or in depth research technique. The SCOR implementation can easily be adapted to the hospital local context and other tools such as lean, six sigma or Balanced Score Card can be added in the next steps in the future.

2.4 Supply Chain Operations Reference (SCOR)

According to Supply Chain Council (2012) the Supply Chain Operations Reference model (SCOR®) was established for evaluating and comparing supply chain activities and performance and it provides ~~a~~ unique framework that links business process, metrics, best practices and technology into a unified structure to support communication among supply chain partners and to improve the effectiveness of supply chain management and related supply chain improvement

activities" (SCC, 2012). The SCOR model has several sections and six primary management processes of Plan, Source, Make, and Deliver, Return and Enable as seen on the following image (Figure 3):

Figure 3 SCOR is organized around six major management processes (SCC, 2012)

These process building blocks can be used in describing the supply chains that are very simple or very complex using a common set of definitions and according to the SCC (2012) the model spans ~~a~~ll customer interactions (order entry through paid invoice), all physical material transactions (supplier's supplier to customer's customer, including equipment, supplies, spare parts, bulk product, software, etc.) and all market interactions (from the understanding of aggregate demand to the fulfillment of each order)". However, ~~t~~he model does not address: sales and marketing (demand generation), product development, research and development, and some elements of post-delivery customer support".

The SCOR model is focused on the top three industry neutral process levels and the organization that implement supply chain improvements with the SCOR model has to extend the model, at least to Level-4 (industry-, organization- and/or location-specific processes, systems, and practices) (SCC, 2012). The illustration of the SCOR as a hierarchical process model can be seen in the following image (Figure 4):

	Level		Examples	Comments
	#	Description		
Within scope of SCOR	1 	Process Types (Scope)	Plan, Source, Make, Deliver, Return and Enable	Level-1 defines scope and content of a supply chain. At level-1 the basis-of-competition performance targets for a supply chain are set.
	2 	Process Categories (Configuration)	Make-to-Stock, Make-to-Order, Engineer-to-Order Defective Products, MRO Products, Excess Products	Level-2 defines the operations strategy. At level-2 the process capabilities for a supply chain are set. (Make-to-Stock, Make-to-Order)
	3 	Process Elements (Steps)	• Schedule Deliveries • Receive Product • Verify Product • Transfer Product • Authorize Payment	Level-3 defines the configuration of individual processes. At level-3 the ability to execute is set. At level-3 the focus is on the right: • Processes • Inputs and Outputs • Process performance • Practices • Technology capabilities • Skills of staff
Not in scope	4 	Activities (Implementation)	Industry-, company-, location- and/or technology specific steps	Level-4 describes the activities performed within the supply chain. Companies implement industry-, company-, and/or location-specific processes and practices to achieve required performance

Figure 4: SCOR is a hierarchical process model (SCC, 2012)

The SCOR reference model consists of 4 major sections: **performance** (standard metrics to describe process performance and define strategic goals); **processes** (standard descriptions of management processes and process relationships); **practices** (management practices that produce significant better process performance) and **people** (standard definitions for skills required to perform supply chain processes). (SCC, 2012)

The first SCOR section of Performance/Metrics focuses on Performance Attributes and Metrics. SCOR recognizes 5 performance attributes:

Reliability: The Reliability attribute addresses the ability to perform tasks as required. Reliability focuses on the predictability of the outcome of a process. Typical metrics for the reliability attribute include: On-time, the right quantity, the right quality. The SCOR key performance indicator (level-1 metric) is Perfect Order Fulfillment. Reliability is a customer focused attribute.

Responsiveness: The Responsiveness attribute describes the speed at which tasks are performed. Responsiveness addresses repeated speed of doing business. Example Responsiveness metrics

are cycle time metrics. The SCOR key performance indicator for Responsiveness is Order Fulfillment Cycle Time. Responsiveness is a customer focused attribute.

Agility: The Agility attribute describes the ability to respond to external influences; the ability to and speed of change. External influences include: None forecast able increases or decreases in demand, suppliers or partners going out of business, natural disasters, acts of (cyber) terrorism, availability of financial resources, labor issues. The SCOR key performance indicators include Flexibility, Adaptability and Value-at-Risk. Agility is a customer focused attribute.

Cost: The Cost attribute describes the cost of operating the process. Typical costs include labor cost, material cost, transportation cost. The SCOR key performance indicators for Cost are Total Cost to Serve. Cost is an internal focused attribute.

Assets: The Asset Management Efficiency (_Assets‘) attribute describes the ability to efficiently utilize assets. Asset management strategies in supply chain include inventory reduction and in-source vs. outsource. Example metrics include: Inventory days of supply, capacity utilization. The SCOR key performance indicators include: Cash-to-Cash Cycle Time, Return on Fixed Assets. Asset Management Efficiency is an internal focused attribute (SCC, 2012).

There are three levels of metrics in SCOR model:

Level-1 metrics: are diagnostics for the overall health of the supply chain. These metrics are also known as strategic metrics and key performance indicators (KPI). Benchmarking level-1 metrics helps establishing realistic targets to support the strategic directions.

Level-2 metrics: serve as diagnostics for the level-1 metrics. The diagnostic relationship helps to identify the root cause or causes of a performance gap for a level-1 metric.

Level-3 metrics: serve as diagnostics for level-2 metrics

The level 1 metrics for the performance attributes as follows (Table 1):

Table 1: Ten strategic level-1 metrics (SCC, 2012)

Attribute	Level 1 metric
Reliability	Perfect Order Fulfillment
Responsiveness	Order Fulfillment Cycle Time
Agility	Upside Flexibility, Upside Adaptability, Downside Adaptability, Overall Value at Risk
Cost	Total Cost to Serve
Asset Management Efficiency	Cash to Cash Cycle Time, Return on Fixed Assets Return on Working Capital

Each level-1 metric expand to level-2 and level-3. In all, there are over 200 metrics.

In the second SCOR section of processes the six major processes (level-1 processes) are each explained in detail, the main objectives of the processes are as follows:

Plan

The Plan processes describe the activities associated with developing plans to operate the supply chain. The Plan processes include the gathering of requirements, gathering of information on available resources, balancing requirements and resources to determine planned capabilities and gaps in demand or resources and identify actions to correct these gaps.

Source: The Source processes describe the ordering (or scheduling of deliveries) and receipt of goods and services. The Source process embodies the issuance of purchase orders or scheduling deliveries, receiving, validation and storage of goods and accepting the invoice from the supplier.

Make: The Make processes describe the activities associated with the conversion of materials or creation of the content for services. Conversion of materials is used rather than _production' or _manufacturing' as make represents all types of material conversions: Assembly, Chemical processing, Maintenance, Repair, Overhaul, Recycling, Refurbishment, Remanufacturing and other common names for material conversion processes. As a general guideline: These processes are recognized by the fact that 1 or more item numbers go in and 1 or more different item numbers come out of this process.

Deliver: The Deliver processes describe the activities associated with the creation, maintenance and fulfillment of customer orders. The Deliver process embodies the receipt, validation and

creation of customer orders, scheduling order delivery, pick, pack and shipment and invoicing the customer.

Return: The Return processes describe the activities associated with the reverse flow of goods. The Return process embodies the identification of the need to return, the disposition decision making, the scheduling of the return and the shipment and receipt of the returned goods. Repair, recycling, refurbishment and remanufacturing processes are not described using Return process elements.

Enable

The Enable processes describe the associated with the management of the supply chain. Enable processes include management of business rules, performance management, data management, resource management, facilities management, contract management, supply chain network management, managing regulatory compliance and risk management. (SCC, 2012)

In the third SCOR section of Practices the SCC has listed the best practices based on input from practitioners and experts from a diverse range of industries. According to SCC the ―practices listed in SCOR are for identification purposes only. Further research and analysis is generally required to fully understand how to implement a practice" (SCC, 2012).

In the fourth SCOR section of People the standards for managing talent in the supply chain are introduced. The key elements of the People section are Skills, Experiences, Aptitudes and Trainings:

Skill: Skill is the capacity to deliver pre-determined results with minimal input of time and energy. Skills are further defined by Experiences, Aptitudes, Trainings and Competency levels. Examples of supply chain skills include: Master Scheduling, Import/Export Regulations, Production Planning, and Risk Mitigation.

Experience: Experience is the knowledge or ability acquired by observation or active participation. Experience is obtained by doing the work in a real life environment and undergoing different situations that require different actions. Example experiences include: Cycle Counting, Cross Docking, and Hazardous Materials Handling.

Aptitude: Aptitude is a natural, acquired, learned or developed ability to perform a certain kind of work at a certain level. Example aptitudes include: Accuracy, Analytical, and Natural leadership.

Training: Training develops a skill or type of behavior through instruction. Examples of training include formal trainings such as SCOR-S certification, but also include courses and on-the-job training. (SCC, 2012). The fifth section of Green SCOR is proposing a set of strategic environmental metrics that can be added to the SCOR Model.

2.5. Empirical Studies

From the perspective of specific metrics, the method which involves broad strategic aspirations and raises reflections on the performance measurement of all the processes in the supply chain is the % of perfect order delivery from the point of view of the final consumer. A perfect order is an order which meets all of the following conditions: delivery of the right product, in the correct quantity and quality, from the correct source, to the correct destination, in perfect condition, at the agreed time and with appropriate documentation. To be able to offer a high standard in this regard, it is necessary to meet several conditions, such as for example: validity of the data in systems, availability of all ordered items, having a flexible distribution system in place, accuracy of order completion, complete documentation, orders delivered on time and in perfect condition, error-free invoices and faultless payment process (Morgan, 2004).

Perfect order fulfillment requires, therefore, coordination across multiple processes and close cooperation of all involved links. Only few supply chains can boast high achievements in this field. As Bowersox and Closs wrote in 1996, the best organizations achieved approximately 50-55% of the perfect order fulfillment level at that time, while for a great majority of companies this indicator stood at less than 20%. The study conducted by Hofman shows a positive correlation between a high level of perfect order fulfillment and the growth in sale revenue, profits and ROA (Hofman, 2004).

The Pharmaceutical Supply Chain is very complicated and greatly responsible to ensure that the appropriate drug, reaches the right people at the right time and in the right situation to fight against sickness and sufferings. This is a highly sensitive supply chain that everything less than 100% customer service level is unacceptable as it directly influence the health and safety. The solution that a lot of Pharmaceutical industries adopt is to bear a vast inventory in the supply chain to ensure close to 100 percent fill rate. However, it is a great war to ensure product

availability at an optimum cost unless supply chain processes are streamlined towards customer requirements and demands (Chandrasekaran and Kumar, 2003). However, the perceived order fill rate—the percentage of items that are filled, based on the ordered quantities with the correct products—for both program (37 percent) and revolving drug fund (RDF) (14 percent) products was low. Likewise, for most products assessed, the percentage of facilities filled with the quantities ordered was about 60 percent at both the hospital- and health center–level. Note that there are many reasons why a facility may not be supplied with the quantity ordered. Shortage is one, but it is also possible that facilities were ordering more or less than the required or correct quantity (PFSA, 2015).

Supply chain delivery performance is the average percentage of orders for the supply chain members that are filled on or before the requested delivery date. In the top-performing supply chains, delivery dates are being met from 94 to 100 per cent of the time. For average firms, delivery performance is approximately 70 to 80 per cent. Updating customers on the expected delivery dates of orders is becoming a common e-service for many supply chains, (Joel et al., 2009). A study conducted in Ethiopia show that, regardless of the type of product, more than 80 percent of both hospitals and health centers usually receive products requested within one month or less((PFSA,2015).

A perfect order – as an evaluation method of supply chain performance – should not be approached too idealistically or uncritically. Obviously, this is a reliable tool to measure the adaptation capacity of the supply chain. Unfortunately, it does not answer questions related to the performance achieved inside the chain. Yet, performance is very important because what counts is not only to what extent the customer expectations are met, but also how much it costs. The order may be fulfilled by all means but when this involves very high costs related to non-standard procedures it is no longer so desirable. Lapide argues that the fulfillment level of an efficient perfect order is a much more reliable indicator. Perfect order is not an ideal measurement tool in conducting non-standard operations that result in additional costs related, for example, to correcting errors or taking steps in order to avoid delays in order fulfillment. Through such actions, which are not reported, the true picture of the situation in the supply chain is very often blurred. Then it is impossible to make precise plans or analyze causes of problems, which in turn prevents continuous improvement Lapide, (2007).

In this context, implementation and use of an efficient perfect order seems to be an interesting solution. In addition to the analysis of meeting customer expectations, also an assessment is introduced of how often operations which do not appear in the standard process are carried out and what additional costs are thus generated. Such set of metrics and indicators analyses both the supply chain from the customer's point of view, as well as internal processes in cost terms.

Also other criteria are applied, by means of which performance of supply chains is evaluated from the perspective of the entire system: sale revenue of the last link of the supply chain, Inventory idle time; Customer satisfaction level; benchmarking; Cash to cash cycle. If sales at the end-customer level are visible throughout the supply chain, it is possible for each link to adapt the inventory to real needs. This reduces costs in the entire system and positively affects the customer service level. Inventory idle time, defined as the ratio of inactive days to active days in the supply chain, is a performance evaluation indicator. The aim is to utilize the capital employed as efficiently as possible. Obviously, it is impossible to eliminate all inactive days due to inspections and buffering against fluctuations of demand, however, reduced time in which inventory is used leads to a more efficient use of resources and reduced costs (Bowersox et al., 1999).

Cash to cash cycle is one of the new metrics of supply chains performance. It is calculated using the following formula: quantity of inventory in days waiting period for receivables liabilities payment period. It is effective to such an extent as to allow performance measurement of multiple processes: starting from purchasing, through production, delivery and ending with management of financial flows in the organization. Importance of this aspect in international supply chains is enormous, for example due to tax issues. Coordination of financial flows is currently one of the major challenges to the management of integrated supply chains. Cash to cash cycle is perceived as a metric which determines operational and financial efficiency in companies and entire supply chains, because it provides an answer to the question how fast the capital employed in components is converted through operations in the supply chain into cash received from the customer. Research shows that there is a tendency to reduce the cash to cash

cycle in subsequent links of the supply chain, and there are significant differences between industries (Banomyong, 2005).

In special cases, such as in sales networks, this cycle can be negative, because the companies receive immediate payment from customers, do not maintain large quantities of inventory, and their period of liabilities payment is extremely long. Recently, other criteria have been taken into account, which are used to evaluate the performance of supply chains as a whole. In this respect, such issues are pointed out as the extent of mutual trust in the relationship with cooperators, level of inventory and its rotation in the entire supply chain or the entire supply chain's ability to adapt to the changing needs of customers (Chen and Paulraj, 2004).

Until appropriate tools to measure the performance of the entire process are introduced, starting from purchasing through production, delivery, customer service, sales, and ending with finance, and many other functional areas, efforts to improve the performance of supply chains have little chance of success. It is impossible to improve supply chain performance to reach the level achieved by world business leaders, such as Wal- Mart (which was able to reduce the prices of finished products by 5-10% by implementing integrated measurement in the supply chain and continuous monitoring of inventory levels and operational efficiency) or Coca Cola, HP, Siemens, Intel, and BASF, which use the SCOR model to monitor health and management of extended supply chains which they are a part of. The research conducted by the Supply Chain Council shows that the application of the SCOR model contributes to positive results, including: reduced fulfillment time of orders by 30-50%, increased forecast accuracy by 25-80%, reduced costs of supply chain management by 25-50%, and, as a consequence, increased value (Stephens, 2000).

2.6 Summary and Research Gaps

This chapter reviews the various theories that are relevant to the study. In addition, the empirical literature brings out the fact that supply chain performance is the key, in ensuring organizational efficiency and effectiveness. A number of studies have been conducted on supply chain performance by many scholars. Many of these scholars propose the need to review PMS and suggest SCOR model techniques for such review. However, none has been done about Laboratory supply chain performance in hospitals using SCOR model. In addition, many of the

studies available have been carried out in developed countries. The study available about Ethiopia was carried out on manufacturing industries.

During the course of the article selection stage for the literature review, the search on Google Scholar of the terms ―medical laboratory supply chain in hospitals in Ethiopia" or ―laboratory supply chain in Ethiopia" did not deliver any relevant articles to be incorporated to the literature review. This suggests that the laboratory supply chain is being understudied. In addition in the ministry of health website and databases there is no comprehensive study on performance of laboratory supply chain. Hence there is need to carry out a research on the supply chain performance of laboratory supply chain performance in hospital using SCOR model in the Ethiopian context.

Although SCOR model originate manufacturing industries; it also apply in the health care industries (Hubner, 2008). Despite this fact in Ethiopia hospitals supply chain particularly for laboratory supply are not measured comprehensively. Beside most studies were done to measure the perceived performance of supply chain or only focused on the theoretical application of the SCOR model. Only indicators such as availability of test, samples referred to another facility, and average turnaround time per type of test are indicated for performance measurement in Ethiopian Hospital Reform Guideline (FMOH, 2010). Therefore the researcher interested to empirically measure the performance in more comprehensive and deeper way. This will further help the hospital administrators and other stakeholders to devise improvement strategies in order to improve their performance and take informed actions for better health care delivery.

2.7. Definition of terms

Supply chain as ―a sequence of organizations – their facilities, functions, and activities – that are involved in producing and delivering a product or service" (Stevenson 2005).

Internal supply chain refers to the chain of activities or functions within a company that result in providing a product to the customer. Integration of these functions involves the holistic performance of activities across departmental boundaries. A well-integrated internal supply chain should result in excellent customer service and company performance (Basnet, 2013).

Supply chain management defined as ~~"th~~e synchronization of the firm's processes with those of its suppliers and customers to match the flow of materials, services and information with demand". (Krajewski *et al*, 2010).

Performance measurement is defined as a metric to quantify the efficiency and effectiveness of operations (Kazemkhanlou *et al*, 2014).

Performance measurement System (PMS) can be defined as ~~"a~~ balanced and dynamic system that enables support of decision-making processes by gathering, elaborating and analyzing information" (Kazemkhanlou *et al*, 2014).

Supply Chain Operations Reference model (SCOR) is ~~"a~~ unique framework that links business process, metrics, best practices and technology into a unified structure to support communication among supply chain partners and to improve the effectiveness of supply chain management and related supply chain improvement activities" (SCC, 2012).

2.8. Conceptual framework of this study

The researcher focused mainly on the SCOR model framework for this study as discussed below. Globally SCC has over 800 Member Organizations employing SCOR model. Countries like North America and Europe take the line share of the member distributions. Other member countries include China, Australia, South Africa, Latin America, Southeast Asia and Japan also employs the SCOR model of SCC in their organizations. The researcher assessed the performance of supply chain management practices in terms of Reliability, Responsiveness, Agility, Costs, and Supply Chain Asset Management Efficiency and SCOR best practices as shown in the diagram below.

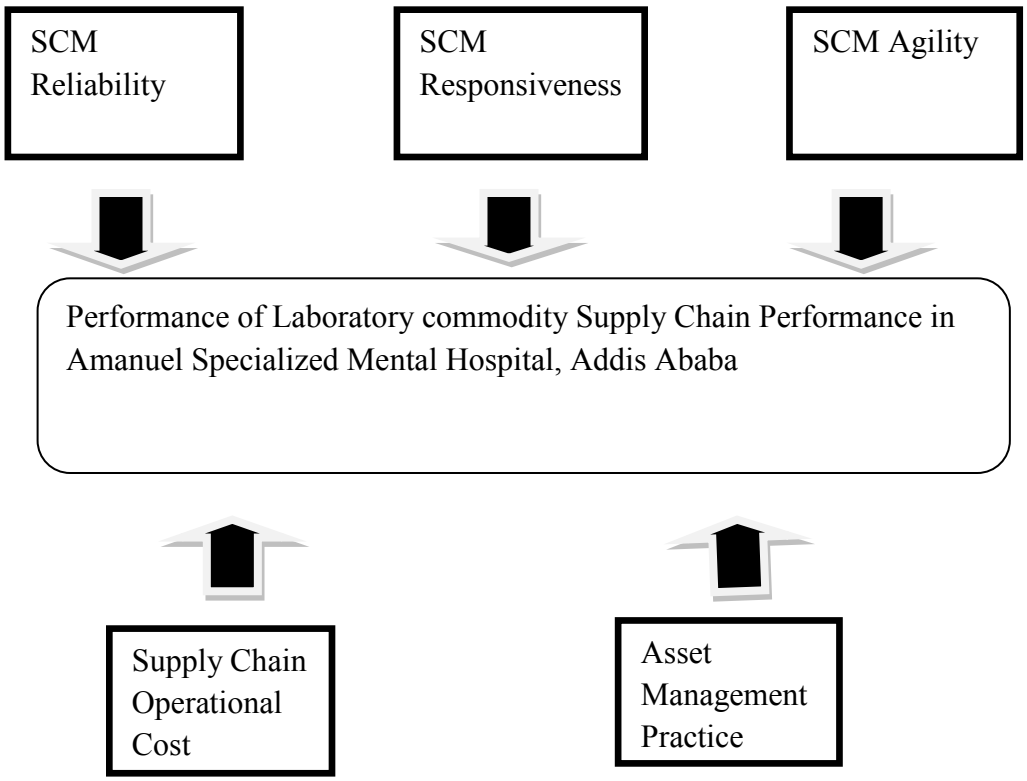

Figure 5: A conceptual framework of supply chain performance indicators of this study (SCC, 2012).

Chapter Three

3. Methodology of the study

3.1. Study design

A case study design using SCOR model was used to conduct the study on laboratory supply chain performance in Amanuel Specialized mental hospital. The case study gave detail analysis of the performance and root cause of the laboratory supply chain process. The study would look for the performance and best practice in laboratory commodities supply chain. Quantitative to measure the performance of supply chain. The SCOR consists of two types of elements: Performance Attributes and Metrics. A performance attribute is a grouping of metrics used to express a strategy. An attribute itself cannot be measured; it is used to set strategic direction. Metrics measure the ability of a supply chain to achieve these strategic attributes.

This study measures five performance attributes: reliability, responsiveness, agility, cost and asset. The Reliability attribute addresses the ability to perform tasks as expected. It focuses on the predictability of the outcome of a process. The Responsiveness attribute describes the speed at which tasks are performed. The Agility attribute describes the ability to respond to external influences. The Cost attribute describes the cost of operating the process. The Asset Management Efficiency (‗Assets') attribute describes the ability to efficiently utilize assets.

Metric

A metric is a standard for measurement of the performance of a process. SCOR metrics are diagnostic metrics. SCOR recognizes three levels of pre-defined metrics: Level 1 metrics are diagnostics for the overall health of the supply chain. These metrics are also known as strategic metrics and key performance indicators (KPI). Level 2 metrics serve as diagnostics for the level 1 metrics. The diagnostic relationship helps to identify the root cause or causes of a performance gap for a level 1 metric. Level 3 metrics serve as diagnostics for level 2 metrics. Five level 1 metrics for performance attributes will be included in the study. Each attribute will have one key performance indicator (level 1 metric).

Table 2: Attributes and selected metrics to assess laboratory supply chain performance in Amanuel specialized mental hospital

Attribute	Level 1 metric
Reliability	Perfect Order Fulfillment
Responsiveness	Order Fulfillment Cycle Time
Agility	Upside Flexibility
Cost	Total Cost to Serve
Asset Management Efficiency	Inventory turnover rate

SCOR Model Version.11 (2012)

3.2. Description of the study area

The study was undertaken in Amanuel Specialized Mental Hospital. The hospital was established in 1930 and found in Addis Ketema Sub City. The hospital provides mental health referral service for patients from all over the country. The hospital has 600 beds with an annual patient attendance rate of 110,000 in 2016. The annual budget for the year 2016 was 206, 000,000 ETB of which 30,900,000 (15%) was allocated for pharmaceuticals supply chain.

3.3. Sampling and Sampling Technique

All one year data of report and request form, intra facility report and request form model, model 19 and 22, inventory reports, stock out report form, bin cards and stock cards were used. Each metrics in the supply chain performance assessment needs data source according to the SCOR guidance.

3.4. Ethical consideration

Approvals of ethical clearance were taken from School of commerce, Addis Ababa University. Informed verbal consent was obtained from study participants, following an explanation about the purpose of the study and what to expect from them. Finally the participants were assured about confidentiality.

3.5. Data collection instrument

Data for each metrics were obtained from the process components that are used to drive the calculation according to the SCOR guide. Structured data collection format were developed for each metrics. The tools were reviewed by the hospital experts who have experience related to

supply chain. The researcher was technical assistance from supply chain council on knowledge and practical application of SCOR model. For an interview with the participants a guide was developed.

Documents Reviews: Documents related to finance, procurement, and stock records available at the hospital for one year were reviewed to gather information on relevant metrics. Registers, vouchers, requisition/procurement forms, and bin/stock cards were also reviewed. This document was searched from pharmacy, laboratory and finance department.

Observation: Direct observation were also be made following the process of laboratory supply chain. Particularly laboratory stores would be observed. Observation check list were developed.

3.6. Data collection procedure

The implementation of SCOR involves several stakeholders. The following procedure shows the data collection procedure to measure the performance of laboratory supply chain using SCOR.
Step 1: Communicate the ethical clearance obtained from Addis Ababa University to Emanuel hospital. In this step the investigator got to know with the hospital higher officials. The investigator presented brief description on the SCOR model, its benefit and the project plan. In this meeting the hospital provided information on the priority areas. Here, SCOR implementation team was established from the hospital side and consent were obtained from all participants.

Step 2: Metrics selection: The researcher provided orientation on the SCOR model, proposed metrics, and procedures to the team from the hospital that were key to laboratory supply chain management. The team discussed and selects level one metrics for the study. In this step the researcher got relevant documents related to supply chain management and performance report from the hospital.

Step 3: Process mapping: The principal investigator developed process map for the actual practice of supply chain management with the hospital staffs. Data abstraction formats were reviewed and staffs were instructed to provide relevant data for the research. Here the team agreed on detail schedule of data collection and interview.

Step 4: The researcher collected data and conduct observation. The data were collected from March 2017 to April 2017. Parallel with the data collection the investigator conducted aggregation and decomposition analysis to measure level 1 to level 2 to level 3 metrics.

Step 5: The investigator surf best practices from the supply chain council standards and other related data based to benchmark and improve the existing process.

Step 6: Brainstorming: The investigator presented preliminary finding to the team for interpretation and iteratively collect if there is any data need to be collected.

Step 7: Presentation: The researcher presented the finding to key stakeholders and the hospital management.

3.7. Reliability and validity of the data

Reliability

Reliability is the level at which an assessment tool can produce the same result consistently (Mora, 2011). The SCOR is a standard model that could be comparable across companies or settings. The tool was developed based on the metrics selected from SCOR guide. Orientation was given on the tool for easy understanding. Participants were advised to consult the researcher during data collection and document review.

Validity

Greene *et al* (2011) describe validity as the extent to which data measures the intended purpose. In this research to improve validity, the SCOR guide were used to develop the tool, which is reference tool accepted by supply chain council. In addition the participants for the study team were selected purposively that have knowledge on supply chain management.

3.8. Data entry and analysis

Data were analyzed using excel spreadsheet. Simple descriptive analysis such as percentage, proportion and average, were computed. Tables were used to present summary result.

Decomposition analysis method was used to measure the performance gap and identify root cause. Metrics decomposition: For each problem metric identify the diagnostic metrics and collect the data to calculate these diagnostic metrics. It determines the problem metric or metrics. Repeat this process until no more diagnostic metrics can be identified. Zero is given for the metrics that did not meet the criteria and one is given for the metrics that fulfill the criteria. To calculate the level two metrics score of each level three metrics under the respective level two

metrics were computed. If the order considered perfect it will score one otherwise the score will be zero.

Figure 6 shows hierarchical metric structure of decomposition analysis.

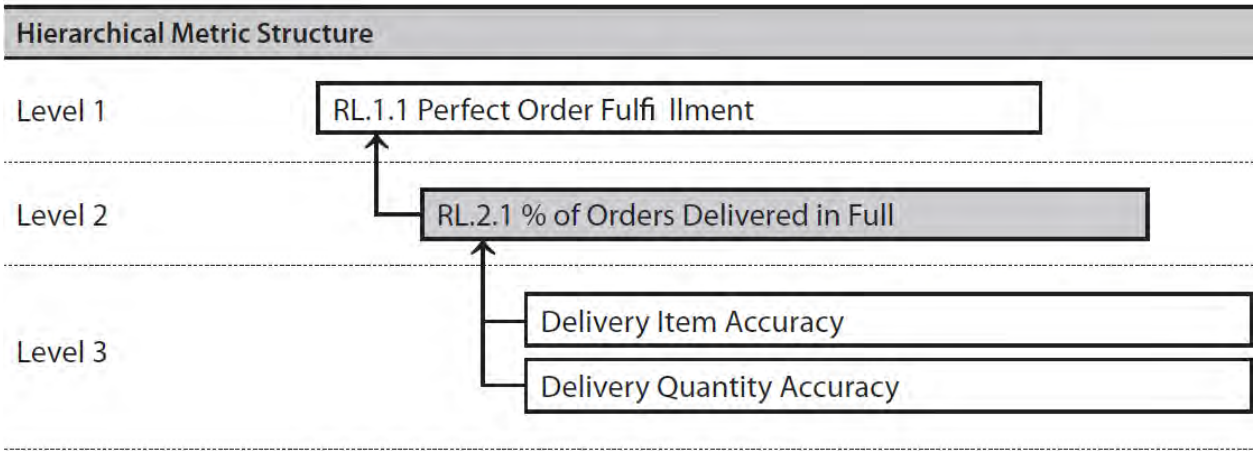

Figure 6: Decomposition analysis of level 1, level 2 and level 3 metrics

The qualitative analysis was involving an intensive reading through the data in order to identify key themes. Themes were identified manually. The qualitative analysis would help for process problem discovery: For all diagnostic metrics, the associated processes were determined. The analysis identified how the process operates, who performs the work, sources of relevant information to perform the work, rules and regulations that apply, and tools supporting the process. In addition the quantitative and qualitative analyses were complemented to group relevant observed process and performance problems together and determine how they impact the overall problem.

Chapter four

4. Result, Discussion and Interpretation

During the process of data collection for the quantitative part; it was noted that there were 20 orders sent for both public and private suppliers to acquire laboratory reagents, equipment and supplies.

4.1 Reliability

Level 1 metrics R1: Perfect Order Fulfillment

Calculation

[Number of perfect order]/ [Total number of orders] **5/20*100=25%**

The finding of the study showed that the reliability of supply chain performance is 25%. This result is mainly due to the fact that order delivered is less than order requested as shown in table 4. Due to this the laboratory service might not be able to serve the intended service to the customer. This will further cost customer additional money and energy to find other laboratory service especially if the customer select the private laboratory for the service. Ultimately this will definitely decreases the customer satisfaction on the hospital laboratory service.

According to Bowersox and Closs wrote in 1996, the best organizations achieved approximately 50-55% of the perfect order fulfillment level at that time, while for a great majority of companies this indicator stood at less than 20%. The result from the study showed that the perfect order fulfillment is relatively low as seen in most of companies in literature. The study conducted by Hofman shows a positive correlation between a high level of perfect order fulfillment and the growth in sale revenue, profits and ROA (Hofman, 2004). Since pharmaceutical supply chain system is highly sensitive and everything less than 100% customer service level is unacceptable as it directly influence the health and safety of its customers; there is a need to improvement on the performance indicator.

Table 3: Performance of level 2 metrics of reliability for laboratory commodity supply chain, in ASMH, 2017

Level 2 metrics for reliability	Orders that fulfill level 2(A)	Orders that do not fulfill level 2	%(A/A+B*100)
Orders delivered in full	6	14	30
Delivery performance to customers commit date	15	5	75
Documentation accuracy	18	2	90
Perfect condition	20	0	100

Calculation of reliability level 2 metrics of reliability

RL 2.1 % orders delivered in full

Calculation

[Total number of orders delivered in full] / [Total number of orders]*100=**6/20*100=30%**

RL 2.2 Delivery performances to customer commit date

Calculation

[Total number of orders delivered on the original commitment date] / [Total number of orders]*100 =15/20*100=75%

RL 2.3 Documentation Accuracy

Calculation

[Total number of orders delivered with accurate documentation] / [Total number of orders delivered]* 100%=**18/20*100=90%**

RL 2.4 Perfect Condition

Calculation

[Number of orders delivered in Perfect Condition] / [Number of orders delivered] * 100% **=20/20*100= 100%**

As can be seen in table 5, from level three metrics the lowest score was for delivery item accuracy is relatively low (50%) than other parameters. Requested items were not supplied fully from the hospital suppliers (both pharmaceutical fund and supply agency and private suppliers). The other gap seen was on the delivery quantity accuracy. The result showed that only 70% of the requested quantity be supplied. This implies that there will be both stocks out and over stock items. If the products are stock out there could be service interruption and if the products are over stock there will be a risk of expiry.

According to Chandrasekaran and Kumar, 2003pharmaceutical supply chain must ensure close to 100 percent fill rate. However, the perceived order fill rate ranges from 14 % to 60 % according to the study done by PFSA, 2015. Note that there are many reasons why a facility may not be supplied with the quantity ordered. Shortage is one, but it is also possible that facilities were ordering more or less than the required or correct quantity (PFSA, 2015). Therefore there is a need to replenish what has been reported and requested.

Delivery performances to customer commit date for the laboratory commodities in AMSH is 75%. In the top-performing supply chains, delivery dates are being met from 94 to 100 per cent of the time. For average firms, delivery performance is approximately 70 to 80 per cent. Updating customers on the expected delivery dates of orders is becoming a common e-service for many supply chains, (Joel et al., 2009). When comparing with the study done by Joel et al the performance is categorized with average performing companies.

As can be seen from the table 5 performance of perfect condition for laboratory commodities were 100%. These have indication that ordered commodities received, delivered and installed damage free or faultlessly. This will further save the hospital money and time from maintenance cost. And it will increase the quality of laboratory services.

Table 4: Performance of level 3 metrics of reliability for laboratory commodity supply chain, in ASMH, 2017

Orders delivered in full	Order deliver in full(A)	Order not deliver in full(B)	%(A/A+B*100)
Delivery item accuracy	10	10	50
Delivery quantity accuracy	14	6	70
Delivery performances to customer commit date	Orders that meet customer commit date	Orders out of customer commit date	
Customer Commit Date Achievement Time Customer Receiving	15	5	75
Delivery Location Accuracy	20	0	100
Documentation Accuracy	Orders with accurate documentation	Orders without accurate documentation	
Compliance Documentation Accuracy	20	0	100
Other Required Documentation Accuracy	20	0	100
Payment Documentation Accuracy	18	2	90
Shipping Documentation Accuracy	20	0	100
Perfect condition	Orders with perfect condition	Orders without perfect condition	
Orders/lines received damage free	20	0	100
Orders Delivered Damage Free Conformance	20	0	100
Orders Delivered Defect Free Conformance	20	0	100

4.2 Responsiveness

The average actual cycle time consistently achieved to fulfill customer orders. For each individual orders, this cycle time starts from order receipt date to and ends with customers' acceptance of the order. The make cycle time is not applicable for this study because sourcing of laboratory products is possible only from Pharmaceutical fund and supply agency or private whole sellers.

R.S.1.1. Order Fulfillment Cycle Time

Calculation

Sum actual cycle times for all orders delivered / total number of orders delivered in days= 1089/20= 54.45

As depicted in table 6 the order fulfillment cycle time is 54.45 days. This was further decomposed to level two metrics source cycle time (19.45) and deliver cycle time (35). The fact that there is no manufacture in the country for most laboratory commodities, everything has to be imported from abroad those might create delay in availing the products with the required kind and quantity. There is a delay in delivery cycle time than source cycle time due to late authorize Supplier Payment Cycle Time. This is due to the fact that late release of finance from finance and economy bureau. The cycle time could be reduced by improving internal processes like arranging transport, automate laboratory transaction system.

Table 5: Performance of Order Fulfillment Cycle Time level 2 metrics for laboratory commodities supply chain in AMSH, 2017

Metrics (level 2)	Sum of days to fulfill all orders	Sum of cycle time/ total order
Source cycle time	389	19.45
Deliver cycle time	700	35
Total	1089	54.45

R.S.2.1: Source cycle time

The average time associated with Source Processes.

Calculation

Source Cycle Time - (Identify Sources of Supply Cycle Time + Select Supplier and Negotiate Cycle Time) + Schedule Product Deliveries Cycle Time + Receive Product Cycle Time + Verify Product Cycle Time + Transfer Product Cycle Time + Authorize Supplier Payment Cycle Time).

N.B For this study Identify Sources of Supply Cycle Time + Select Supplier and Negotiate Cycle Time) + Schedule Product Deliveries Cycle Time are processes that are equivalent to the process from preparing report and request form to sending report and request form to the supplier. At the same time; Receive Product Cycle Time + Verify Product Cycle Time is equivalent to number of cycle times to finish all activities to acquire the commodities. Lastly transfer Product Cycle Time is similar to receive product cycle time. Since the hospital purchases commodities by credit Authorize Supplier Payment Cycle Time is not applicable

The source cycle time for the laboratory commodities in ASMH is 19.45 days mostly due to internal processes like unable to schedule transportation timely; manual preparation of report and requisition format. Also if the products were not available at the public supplier (PFSA); there is a need to source, select, negotiate, schedule private supplier. This also increase the source cycle time.

Table 6: Performance of Source cycle time level 3 indicators for laboratory supply chain in AMSH, 2017

Metrics (level 3)	Sum of days to fulfill all orders	Sum of cycle time/ total order
(Identify Sources of Supply Cycle Time+ Select Supplier and Negotiate Cycle Time+ Schedule Product Deliveries Cycle Time)	214	10.7
(Receive Product Cycle Time +Verify Product Cycle Time)	136	6.8
Transfer Product Cycle Time	39	1.95
Total	389	19.45

RS.2.3 Delivery Cycle Time

The average time associated with Deliver Processes. In this case in authorize supplier payment cycle time there were relatively high delay. For some of the orders it took around two month to process the payment.

Table 7: Delivery cycle time level 3 indicators for Laboratory supply chain in AMSH, 2017

Metrics (level 3)	Sum of days to fulfill all orders	Sum of cycle time/ total order
Receive, Configure, Enter & Validate Order Cycle Time+ Reserve Resources & Determine delivery Date Cycle Time +Pack Product Cycle Time/ Pick Product Cycle Time / deliver Product Cycle Time+ Install Product Cycle Time+ Receive & Verify Product Cycle Time	25	1.25
Authorize Supplier Payment Cycle Time	675	33.75
Total	700	35

4.3 Cost

Total cost to serve

The Cost attribute describes the cost of operating the process. Typical costs include labor cost, Material cost, transportation cost. The SCOR key performance indicators for Cost are Total Cost to Serve. Cost is an internal focused attribute.

Table 8: Cost of operating laboratory supply chain in ASMH,2017

Type of activity	Cost in a year
Labor cost(pharmacy, laboratory, labor and other)	156151.25
Material cost (reagent, supplies and equipment)	495,440.82
Transportation cost	9650
Spare part cost	22,000
Maintenance cost	15,000
Other costs (miscellaneous)	30,000
Total cost	**718592.08**

4.4 Asset Management

Inventory turnover rate

Inventory turnover rate is calculated using data on value of commodity movement for the year 2008EFY. Table 5 shows inventory turnover rate of laboratory reagents and supplies from date July 1,2007EFY to June 30, 2008EFY. The finding shows that the average inventory rate was 0.72.

Table 9: Inventory turnover rate of laboratory reagents and supplies, in ASMH, 2017

Type of cost	Total amount (birr)
Laboratory reagent cost sold within 365 days	391,355.5
Average daily inventory balance	541,666.7
Inventory turnover rate	0.72

Inventory turnover rate is a metrics selected to measure the asset management efficiency attribute that describes the ability to efficiently utilize assets. Inventory turns, referred to as average annual inventory turns, measures the degree to which inventory held by AMSH to fulfill customer orders is appropriately sized to buffer for uncertain demand. The indicator assesses cost-effectiveness by evaluating the degree to which inventoried laboratory commodities are not stocking for too long in AMSH controlled inventory stocks. The finding showed that the laboratory inventory turnover rate of 0.72. It tells inventory was not moving in the supply chain. This implies that there a risk of expiry.

5. Conclusion

Supply chain management excellence in terms of cost reduction, responsiveness, reliability, integration and collaboration with supply chain partners, inventory management effectiveness, efficiency, flexibility and customer service creates a competitive advantage to companies in the competitive business environment. The study found that perfect order fulfillment of laboratory commodities were 25%. The root cause mainly contributed for low reliability was products were not available with required kind and quantity at distributers. The order fulfillment cycle time was 54.45 days. The main delay come from delivery cycle time which further decomposed to authorize payment cycle time which is 33.75. The total cost to serve laboratory supply chain management in ASMH was 718,592.08 and the asset turnover rate was 0.72. In summery the supply chain performance of laboratory commodities in AMSH was not satisfactory.

6. Recommendation

Based on the finding the following recommendations were forwarded.

- Strengthening collaborative planning, forecasting and replenishment between the hospital and suppliers.
- There is a need for long term supplier agreement between the private suppliers and the hospital.
- Improving transportation management system that was allocated to pharmaceutical supply chain of the hospital.
- Improving the authorization of payment timely by working with finance and economy minister.
- Further research must be undertaken in order to understand the agility attribute of supply chain performance in ASMH.

References

Agami, N., Saleh ,M. and Rasmy, M.(2012).Supply Chain Performance Measurement Approaches: Review and Classification. Journal of Organizational Management Studies; available at http://www.ibimapublishing.com/journals/JOMS/joms.html

AMSH(2016). Annual report of pharmacy department.(unpublished)

Banomyong, R., 2005. Measuring the time conversion cycle in an international supply chain. Annual Logistics Research Network Conference Proceedings, Sept. 2005, Plymouth, UK, available at: http://www.bus.tu.ac.th

Basnet, C(2013) .The measurement of internal supply chain integration, Management Research Review36.(2)pp.153-172.

Bradley,P (2000). Taking on the health care supply chain.MSI:50

Bowersox, D.J., Closs, D. and Stank, T.P., 1999. –21st century logistics: making supply chain integration a reality". Council of Logistics Management, Michigan State University, East Lansing.

Burns et al (2008). Hospital purchasing alliances: Utilization, service, and performance. Health Care Management Review,33(3),pp.203–215.

Chandrasekaran, N. and S. Mohan Kumar, 2003. Pharmaceutical Supply Chain Challenges and Best Practices, (working paper, CII – Institute of Logistics, 20 December. 20).

Chen, I.J. and Paulraj, A., 2004. Understanding supply chain management: critical research and a theoretical framework. International Journal of Production Research 42 (1), pp. 131-163.

Ellinger, A.E. & Ellinger, A.D.(2014) .Leveraging human resource development expertise to improve supply chain managers' skills and competencies, European Journal of Training and Development, 38, (1), pp.118-135.

FMoH(2010). Ethiopian hospital reform implementation guideline, volume I chapter four, Addis Ababa, Ethiopia.

FMoH(2010). Ethiopian Hospital Reform Implementation Guidelines Volume 2, Addis Ababa, Ethiopia.

FMoH(2016). Health governance watch, Addis Ababa, Ethiopia

Global Healthcare Exchange (2011). A Look inside your customer‘s world” Medical device supply chain council.Availableat www.medsupplychain.org/pdfs/GHXConway.

Greene, S., Baldwin, L., Dolor, R., Thompson, E. and Neale, A. (2011). Streamlining Research by Using Existing Tools. Clinical and Translational Science, 4(4), pp.266-267.

Heriberto, Garcia Reyes, Ronald, Giachetti, (2010).Using experts to develop a supply chain maturity model in Mexico, Supply Chain Management: An International Journal,15(6), pp.415 – 424.

Hofman, D., 2004. The hierarchy of supply chain metrics (performance). Supply Chain Management Review, available at: http://www.highbeam.com/doc/1G1-122408969.html

Hubner.U(2008): eBusiness in Healthcare, Springer, London ,England.

Joel, D.W, Keong, L., and Keah-Choon T., (2009) Principles of Supply Chain Management: A Balanced Approach, 431-449.

Kazemkhanlou, Hamid; Ahadi, Hamid Reza(2014). Study of Performance Measurement Practices in Supply Chain Management, Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management Bali, Indonesia: 273-285.

Krajewski, L. J.; Ritzman, L.P. and Malhotra, M.K.(2010). Operations Management: Processes and Supply Chains 9th edition

Lamb, Charles W.; Hair J.R.., Joseph F.; and McDaniel, Carl, (2014) .MKTG8

Lapide, L., 2007. Not-so-perfect order. Supply Chain Management Review, July-August, pp. 7-8.

Mantone,J. (2007). The next game of tag. Modern Healthcare, 37(4), 18–20.
Mora, M. (2011). Validity and Reliability in Surveys. URL: Relevantinsights.com. URL: http://www.relevantinsights.com/validity-and-reliability.

Morgan, C., 2004. Structure, speed and salience: performance management in the supply chain. Business Process Management Journal 10 (5), pp. 522-536.

PFSA. 2015. Ethiopia: National Survey of the Integrated Pharmaceutical Logistics System. Arlington, Va.: USAID | DELIVER PROJECT, Task Order 4, and Pharmaceuticals Fund and Supply Agency (PFSA).

Pittsburg.van Weele, A., 2014. ―Purchasing and supply chain management", 6th edition. Cengage Learning, Andover, UK.

Stevenson T, William J., (2005).Operations Management 8th edition

Stephens, S., 2000. ―Supply Chain Council and Supply Chain Operations Reference Model overview". Supply Chain Council, Pittsburg.

Shumaker.T, (2006). Understanding the supply chain as a component of patient care. Materials Management in Health Care, 72.

Singh, M. (2006). Transforming the global health care supply chain. Cambridge, MA: MIT Center for Transportation and Logistics (CTL).

Supply Chain Council (2012). SCOR (Supply Chain Operations Reference Model) Revision 11.0, http://docs.huihoo.com/scm/supply-chain-operations-reference-model-r11.0.pdf

USAID (2011).The Logistics Handbook. A Practical Guide for the Supply Chain Management of Health Commodities. Second edition. Arlington, USA

WHO(2009). System thinking for health system strengthening. Switzerland,Geneva.

Annexes

Annex 1

Data abstraction format

Date of data collection._____

Performance Attribute: Reliability

Level 1 metric R1: Perfect Order Fulfillment

Table: Perfect order fulfillment level 2 metrics

Metrics (level 2)	Order 1 (Yes=1, N=0	Order 2 (Yes=1, N=0	Order 3 (Yes=1, N=0	Order 4 (Yes=1, N=0	Order 5 (Yes=1, N=0	Order N (Yes=1, N=0	Total
% of orders delivered in full							
Delivery performance to customers commit date							
Documentation accuracy							
Perfect condition							
Total							

Level 2: metrics RL 2.1 % orders delivered in full

Table :Perfect order fulfillment level 3 metrics

level 3 metrics	Order 1 (Yes=1, N=0	Order 2 (Yes=1, N=0	Order 3 (Yes=1, N=0	Order 4 (Yes=1, N=0	Order 5 (Yes=1, N=0	Order N (Yes=1, N=0	Total
Delivery item accuracy							
Delivery quantity accuracy							
Total							

Table: Perfect order fulfillment level 3 metrics

A. Delivery item accuracy

Order #	# items ordered	# items delivered	Items not ordered which are delivered	Reason if there is gap	Recommended process improvement	Remark
Order 1						
Order 2						
Order 3						

Delivery quantity accuracy

Order #	# items ordered	# items delivered	Items delivered similar to quantity ordered	Reason if there is gap	Recommended process improvement	Remark
Order 1						
Order 2						
Order 3						

Level 2: metrics RL 2.2 Delivery performances to customer commit date

Table: Perfect order fulfillment level 3 metrics

Indicator level 3	Order 1 (Yes=1, N=0	Order 2 (Yes=1, N=0	Order 3 (Yes=1, N=0	Order 4 (Yes=1, N=0	Order 5 (Yes=1, N=0	Order N (Yes=1, N=0	Total
Customer Commit Date Achievement Time Customer Receiving							
Delivery Location Accuracy							
Total							

Table: Perfect order fulfillment level 3 metrics

Level 3: Customer Commit Date Achievement Time Customer Receiving

Order #	# items ordered	# items delivered on commit date	Commit date	Actual delivery date	# items delivered within 5 days	Delivery location accurate (Yes 1, No 0)	Reason if there is gap	Recommended process improvement
Order 1								
Order 2								

Level 2: metrics RL 2.3 Documentation Accuracy

Table: Perfect order fulfillment level 3 metrics

Indicator level 3	Order 1 (Yes=1, N=0	Order 2 (Yes=1, N=0	Order 3 (Yes=1, N=0	Order 4 (Yes=1, N=0	Order 5 (Yes=1, N=0	Order N (Yes=1, N=0	Total
Compliance Documentation Accuracy							
Other Required Documentation Accuracy							
Payment Documentation Accuracy							
Shipping Documentation Accuracy							
Total							

Level 3: Shipping Documentation Accuracy

Order #	Are the documents complete	Are the documents correct	Are the documents delivered on time	Reason if there is gap	Recommended process improvement
Order 1					
Order 2					

Level 2: metrics RL 2.4 Perfect Condition

Table: Perfect order fulfillment level 3 metrics

Indicator level 3	Order 1 (Yes=1, N=0	Order 2 (Yes=1, N=0	Order 3 (Yes=1, N=0	Order 4 (Yes=1, N=0	Order 5 (Yes=1, N=0	Order N (Yes=1, N=0	Total
% Of Faultless Installations							
% Orders/lines received damage free							
Orders Delivered Damage Free Conformance							
Orders Delivered Defect Free Conformance							
Warranty and Returns							
Total							

Responsiveness

Level 1 metric R.S.1.1. Order Fulfillment Cycle Time

Table: Order Fulfillment Cycle Time level 2 indicators

Metrics (level 2)	Order 1 (days)	Order 2 (days)	Order 3 (days)	Order 4 (days)	Order 5 (days)	Order N (days)	Sum/N
Source cycle time							
Make cycle time							
Deliver cycle time							
Total							

Level 2 metrics R.S.2.1: Source cycle time

Table: Order Fulfillment Cycle Time level 3 indicators

Metrics (level 3)	Order 1 (days)	Order 2	Order 3	Order 4 (days)	Order 5 (days)	Sum/N
Identify Sources of Supply Cycle Time						
Select Supplier and Negotiate Cycle Time						
Schedule Product Deliveries Cycle Time						
Receive Product Cycle Time						
Verify Product Cycle Time						
Indicator 1-5 can be considered as sending request and RRF to PFSA cycle time.						
Transfer Product Cycle Time (receive product cycle time)						
Authorize Supplier Payment Cycle Time						
Total						

Level 2 metrics RS.2.3 Delivery Cycle Time

Table: Order Fulfillment Cycle Time level 3 indicators

Metrics (level 3)	Order 1 (days)	order.2(days)	order 3(days)	Order 4 (days)	Order 5 (days)	Sum/N
Receive, Configure, Enter & Validate Order Cycle Time						
Reserve Resources & Determine delivery Date Cycle Time (notify Emanuel cycle time)						
Pack Product Cycle Time/ Pick Product Cycle Time / deliver Product Cycle Time						
Install Product Cycle Time						
Receive & Verify Product Cycle Time						
Authorize Supplier Payment Cycle Time						
Total						

Level 2 metrics RS.2.4 Delivery Retail Cycle Time

Table: Order Fulfillment Cycle Time level 3 indicators

Metrics (level 3)	Order 1 (days)	Order 2 (days)	Order N (days)	Sum/N
Generate Stocking Schedule Cycle Time				
Receive Product Cycle Time				
Pick Product Cycle Time				
Stock Shelf Cycle Time				
Install Cycle Time				
Checkout Cycle Time				
Fill Shopping Cart Cycle Time				
Total				

Agility

Adaptability and flexibility measures

Table: Stock Movement in facility (bin card duplicate)

Item: _____, Date of data collection (DD/MM/ YY): _____

2008EFY average monthly consumption: _____ , 2008EFY tests performed using that product _____

T. No	Beginning balance (Hamle 1)	Received	Issued	Loss and adjustment	Stock on hand	Unit price	Manufacturing date	Expiry date

Level 2: Value at risk (VAR)

Indicator for value at risk (agility indicator)

Product at risk percentage (Average percentage shelf life remaining)

Table 1: Shelf life and quantity of products at the beginning, and ending balance

S. No	Item	Unit price	Manufacturing date	Expiry date	Item received date	Received quantity	Date of data collection	Remaining balance

Cost

Table 1: Cost of operating laboratory supply chain, 2008EFY

Type of activity	Cost in a year	Remark
Labor cost		
Pharmacy		
Laboratory		
Labor and others		
Material cost		
Supply		
Reagent		
Equipment		
Transportation cost		
Spare part cost		
Maintenance cost		
Storage cost		
Other costs (miscellaneous)		
Total cost		

Assets

Table: Inventory turnover rate of laboratory reagents and supplies, year 2008EFY

Time	Laboratory inventory cost in Birr (in the quarter)	Laboratory cost sold in birr (in the quarter)
Quarter 1		
Supplies		
Reagents		
Total		
Quarter 1I		
Supplies		
Reagents		
Total		
Quarter 1II		
Supplies		
Reagents		
Total		
Quarter 1V		
Supplies		
Reagents		
Total		