The Role of Financial Information in Health Commodity Supply Chain Management in Developing Countries: A Case Study from Tanzania

A Study of Informational Needs and Considerations for the LMIS

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IV
Abstract

The Tanzanian health commodity supply chain has gradually improved since the decentralisation of the health information system began in 1999. As a part of the decentralisation process, the supply chain management has improved in terms of making information timelier available to decision-makers at lower-level health care units. Still, access and use of information are limited at some levels of the health hierarchy.

This thesis examines the role of financial information in health commodity procurement processes at the lower-level health care units in the public health system in Tanzania. It does so, by discussing different models of distributing health commodities to study the role of financial information in different supply chain contexts. Further, the thesis considers what the informational needs, within each distribution model, requires of the information system for logistic management to be accessed and used. This is done to define how logistic management information systems can promote the role of financial information in supply chain decision-making.

The research is based on a case study in Tanzania, where the supply chain is investigated. The case study involves interviews and observations of 45 participants from the public health system. The focus is to investigate the role of financial information at the lower health care units, to understand how to strengthen the role of financial information for supply chain decision-making at this level.

The results of the research show that the role of financial information is limited at the lower health care units in Tanzania. The information is by some means accessible, but not in a timely manner, and neither supported by the logistic management information system. The result is ineffective supplies of health commodities to the lower health care levels, where measures must be made to provide good quality health care services.

As a contribution to strengthening the supply chain management in developing countries, this thesis provides research that can be used to define informational needs in different supply chain contexts. These informational needs can be used as a guide for how to improve information systems for logistic management, to promote the role of these informational needs in the supply chain management.
Acknowledgement

First, I would like to thank my supervisor Petter Nielsen for advice, comments, criticism, guidance, and encouragement. In addition to Petter, I would like to thank Johan Ivar Sæbø, for guidance during the first field trip to Tanzania and feedback and discussions during the whole process. I would also thank the other team members traveling with me to Tanzania; Marit Kilde Mjelva and Bjørn-Ingar Bergum for support and collaboration. Next, I would like to thank the HISP team supporting us during our visits to Tanzania; Wilfred Senyoni, Ismail Yusuf Koleleni and Hassan Omary for exceptional guidance during the field visits. I would also like to thank Dr. Honest Christopher Kimaro for guiding my research during the time in Tanzania and reviewing field documents.

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Mathias Rove Olaussen

University of Oslo

May 2017
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The Push-based model

The Informed push model

The Vendor-Managed Inventory model

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Financial management in sparsely-populated areas

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The Logistic Management Information System

The eLMIS and procurement of health commodities

ILS Gateway

EPICOR9

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# Abbreviations

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<th>Description</th>
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<tbody>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
</tr>
<tr>
<td>ARV</td>
<td>Antiretroviral</td>
</tr>
<tr>
<td>CCIT</td>
<td>Cold Chain Inventory Tool</td>
</tr>
<tr>
<td>DHIS2</td>
<td>District Health Information System 2</td>
</tr>
<tr>
<td>DHMT</td>
<td>District Health Management Team</td>
</tr>
<tr>
<td>DIVO</td>
<td>District Immunisation and Vaccine Officer</td>
</tr>
<tr>
<td>DMO</td>
<td>District Medical Officer</td>
</tr>
<tr>
<td>DVDMT</td>
<td>District Vaccination Data Management Tool</td>
</tr>
<tr>
<td>eLMIS</td>
<td>electronic Logistic Management Information System</td>
</tr>
<tr>
<td>EPICOR9</td>
<td>EPICOR9 – ERP software from Epicor, 9th edition</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>HIS</td>
<td>Health Information System</td>
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<tr>
<td>HISP</td>
<td>Health Information System Program</td>
</tr>
<tr>
<td>HIV</td>
<td>Human Immunodeficiency Virus</td>
</tr>
<tr>
<td>HMIS</td>
<td>Health Management Information System</td>
</tr>
<tr>
<td>HMN</td>
<td>Health Metrics Network</td>
</tr>
<tr>
<td>II</td>
<td>Information Infrastructure</td>
</tr>
<tr>
<td>ILS</td>
<td>Integrated Logistic System</td>
</tr>
<tr>
<td>ILS Gateway</td>
<td>Integrated Logistic System Gateway</td>
</tr>
<tr>
<td>IS</td>
<td>Information System</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>IVD</td>
<td>Immunisation and Vaccine Development</td>
</tr>
<tr>
<td>JSI</td>
<td>John Snow Inc.</td>
</tr>
<tr>
<td>LMIS</td>
<td>Logistic Management Information System</td>
</tr>
<tr>
<td>MOHSW</td>
<td>Ministry of Health and Social Welfare</td>
</tr>
<tr>
<td>MoH</td>
<td>Ministry of Health, Community Development, Gender, Elderly and Children</td>
</tr>
<tr>
<td>MSD</td>
<td>Medical Store Department</td>
</tr>
<tr>
<td>NCRD</td>
<td>Norwegian Centre for Research Data</td>
</tr>
<tr>
<td>XVI</td>
<td></td>
</tr>
<tr>
<td>Acronym</td>
<td>Full Form</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-Governmental Organization</td>
</tr>
<tr>
<td>OI</td>
<td>Opportunistic Infections</td>
</tr>
<tr>
<td>PEPFAR</td>
<td>The United States President’s Emergency Plan for AIDS Relief</td>
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<tr>
<td>RHMT</td>
<td>Regional Health Management Team</td>
</tr>
<tr>
<td>RMO</td>
<td>Regional Medical Officer</td>
</tr>
<tr>
<td>R&amp;R</td>
<td>Report and Requisition</td>
</tr>
<tr>
<td>SMT</td>
<td>Stock Management Tool</td>
</tr>
<tr>
<td>TBA</td>
<td>Traditional Birth Attendant</td>
</tr>
<tr>
<td>TT</td>
<td>Tetanus</td>
</tr>
<tr>
<td>TNBS</td>
<td>Tanzanian National Bureau of Statistics</td>
</tr>
<tr>
<td>UIO</td>
<td>University of Oslo</td>
</tr>
<tr>
<td>VIMS</td>
<td>Vaccine Information Management System</td>
</tr>
<tr>
<td>VMI</td>
<td>Vendor-Managed Inventory</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
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<tr>
<td>USAID</td>
<td>United States Agency for International Development</td>
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1 Introduction

This thesis studies the supply chain of health commodities (hereby addressed as supply chain) in Tanzania, a developing country. The study investigates the informational needs in a supply chain. The informational needs are used as a background to study how logistic management information systems (LMIS) can support the informational needs in managerial activities. By studying different models of distributing health commodities in developing countries, the study focus on the role of financial information for procurement in different contexts within a supply chain.

1.1 Motivation

In public health, decision-makers are dependent on timely data that are presented, communicated, and disseminated to them which influences their understanding of needs and health issues (AbouZahr & Boerma, 2005; Health Metrics Network, 2008). To support the decisions-makers at making decisions that improve health outcomes, information must be available to all of the actors within a health network where it is needed for action (Mumford, 2006). By improving the role of information when making decisions about the supply chain management, the decision-makers will be knowledgeable of all possible choices (Braa & Sahay, 2012). By researching the supply chain in Tanzania, empirical findings indicate that limited access to certain information at the lower health care units has an impact on the outcome of the deliveries of health commodity supplies.

Without timely availability to information at the lower health levels in Tanzania, the health workers are unable to make decisions that are based on understandings of need and health issues. As a result, less attention is given to information use, when making decisions in the supply chain management. This leads to ineffective management of the supply chain.

By defining the informational needs in the Tanzanian supply chain management, one can define requirements to the LMIS to support greater use of information for decision-making in the supply chain management. This can contribute to establish considerations for how the LMIS can promote the role of financial information in the supply chain management.
1.2 Research Context

This research is a part of an ongoing project of strengthening the supply chain in Tanzania, supported by the Information Infrastructure group at the Institute of Informatics, University of Oslo. In addition to me, the research team consists of five researchers within the group. One other researcher is from the University of Dar es Salaam with good knowledge to the supply chain in Tanzania. Included are a senior engineer and a professor with knowledge about the supply chain in several developing countries.

The empirical study was conducted over two periods. The first during January-February 2016, and the second during August-September 2016. In total, we spent eight weeks in Tanzania. Two other researchers worked on similar research. In the first phase of the field studies, we were three researchers, the senior engineer, and the professor. During the second phase, we were two researchers collaborating in Tanzania. This will be further described in chapter 3.

1.3 Scope

The theme for this thesis is to research the supply chain in developing countries to strengthen the management of health commodity procurement. The role of financial information for procurement within supply chain management is chosen as a topic to address areas where the LMIS in the Tanzania supply chain can be improved. Looking at the role of information for procurement at the lower health care units, and the use of LMIS at this level, it can contribute to stress the importance of including the lower health care levels to use LMIS in the decision-making processes. Research from other developing countries, such as in Nigeria, has stated that the lack of information systems at middle, and lower levels of supply chain management are drastically affecting the effectiveness of the management (Mohammed, Magaji, Lawal, & Masoud, 2007).

1.4 Research Questions and Objectives

The purpose of this thesis is to investigate the role of financial information in supply chain management in Tanzania. In addition, to consider how LMIS can support the informational needs for decision-making at lower health care units. The research question that will be
addressed through this research consist of one overall question and two secondary questions, presented below.

**What is the role of financial information for procurement in the supply chain management at the lower health care levels in developing countries?**

a) **What considerations for the logistic management information systems should be made to promote the role of financial information in supply chain management?**

b) **What are the challenges with the existing situation, and the opportunities for improvement in the Tanzanian supply chain management?**

The main objectives, and the process of answering the research questions, for this thesis is to (1) identify the informational needs in different supply chain contexts, (2) assessing the use of information for decisions-making in supply chain management, (3) considering the use of LMIS, and (4) address challenges and derive improvements for further work.

### 1.5 Chapter Overview

**Chapter 2 – Background** provides a situation analysis of Tanzania, including geography and infrastructure, demography, the socio-economic status, the health status and an overview of the structure of the health system. Further, the chapter describes the HIS, HMIS, and LMIS in the country.

**Chapter 3 – Research Approach** introduces the research approach, which includes the philosophical assumptions for the thesis, the methodology, and methods used for conducting and analysing the research within the thesis. In addition, the chapter presents some ethical considerations for the research.

**Chapter 4 – Theoretical Background** presents the literature used as background for the thesis. The chapter is divided into five sections; information systems as socio-technical systems, health Information systems in developing countries, information systems and the health commodity supply chain, distribution models for health commodities, and a section defining informational needs for the different levels of the supply chain.

**Chapter 5 – Empirical Findings** presents the findings from the field studies in Tanzania.
Chapter 6 – Discussion compares the literature presented in chapter 4 and the empirical findings in chapter 5, and discusses the research question.

Chapter 7 - Conclusion summarises the discussion of the main research question. The chapter includes some reflections upon the research conducted and thoughts of future work.
2 Background

This chapter presents a situation analysis of Tanzania to provide the reader with an understanding of the research context. The analysis gives insight to the geography, demography and infrastructure of Tanzania, the socio-economic status and the health status. In addition, a brief overview of the health system structure is presented. An introduction to Health Information System (HIS), Health Management Information System (HMIS), and Logistic Management Information System (LMIS) is provided, and includes a description of the HMIS and LMIS in Tanzania. Finally, the chapter briefly presents the research programme in which this research is conducted (the Health Information System Programme - HISP).

2.1 Situation Analysis of Tanzania

Letting the reader get a grasp on the situation where the data originates from, the analysis consists of factors that directly, or indirectly, impacts the health care delivery and the logistic management of health commodities.

2.1.1 Geography, demography and infrastructure

Tanzania is an African country that borders Zambia, Mozambique, and Malawi in the South; The Democratic Republic of Congo, Burundi, and Rwanda in the West; and Uganda and Kenya in the North (Benjaminsen & Hem, 2016). It is the largest of the East-African countries and has an area of approximately 945,000 square kilometres. The country consists of 30 regions in total.

According to the Tanzania National Bureau of Statistics, the total population of Tanzania was estimated to approximately 45,000,000 people in 2012, including the population at the islands (Tanzania National Bureau of Statistics, 2013). In 2015, the estimate was 53,470,000 (World Health Organization, 2016). The country is sparsely populated with about 51 persons per square kilometres. They are mostly concentrated in the Dar es Salaam and the Mjini Magharibi regions with a density of respectively 3,111 and 2,581 people per square kilom
kilometres (Tanzania National Bureau of Statistics, 2013). Approximately one third of the population are living in urban areas (Central Intelligence Agency, 2016).

Tanzania has a typical developing country structure, where almost 50 percent of the total population is under the age of 18 (45 percent is under 15, 2013 estimate). The country’s youthful population – where two-thirds are under the age of 25 - are growing rapidly because of the high total fertility rate (Central Intelligence Agency, 2016; Tanzania National Bureau of Statistics, 2014; World Health Organization, 2015). The population over 65 years of age only constitutes 4 percent of the population (Kwesigabo, Mwangu, Kakoko, & Killewo, 2012a).

Considering the infrastructure of Tanzania, one of the main challenges they face is the lack of proper roads. Of 87,600 kilometres of road, less than five percent are paved, thus making the communication and transportation of goods challenging – especially in the rural areas. It is argued that a key factor to continue the rapid economic growth in Tanzania, which has taken

Figure 2: Map of Tanzania showing the 30 regions (Maps of World, n.d.)
place in the recent years, is their ability to continue to improving their road infrastructure (Clyde & Co, 2014). The substantial part of the national budgets for 2016/17 allocated for improving the infrastructure, reflects the government’s high priorities in this infrastructural development (The World Bank, 2016).

One of Tanzania’s most serious infrastructural challenges is maintaining a sufficient supply of electricity. Tanzania has a variety of natural energy resources, but much of this energy potential is unexploited. The gap between Tanzania’s power supply and demand is reflected in its low level of development and industrialization. The gap also poses a major challenge when providing health care services and managing logistics of health commodities. Most of the Tanzanian people do not have access to electricity, and only two percent of the rural population have access (94 percent use biomass) compared to 39 percent of the urban population (United Nation Development Programme, 2017).

2.1.2 Socio-economic status

In Tanzania, agriculture is the main source of employment, where around 80% labour force are occupied (2002 estimate) (Central Intelligence Agency, 2016). Tanzania is one of the poorest countries in the world in terms of income per capita, but has achieved a high growth rate due to their substantial natural resource wealth and tourism (Central Intelligence Agency, 2016). However, most of the economic growth have been concentrated in urban areas without benefitting the rural areas that much, which are still struggling (Mohammed, 2015). Figure 3 illustrates how most the poor are living in the rural areas. In these areas, 33,3 percent of the population are living below the basic need poverty line. The population below the basic need poverty line is 28,2 and in the urban areas 21,7 (2012 estimate) (Ministry of Finance and Planning, 2016). As of 2015, the global poverty line was updated from $1,25 to $1,90 (The World Bank, 2015).
The economic challenges that Tanzania are facing, especially in the rural areas, has some impacts concerning health care acquires and procuring health commodities. Without the adequate funding, these are areas where compromises must be made to fit the economic profile of the country. For instance, rationing of health commodities due occur because there are not enough economical resources available. More about this in chapter 5.

2.1.3 Health status

In 2010 it was estimated a hospital bed coverage of seven percent of the population (Central Intelligence Agency, 2016). The health expenditures were around 5.6 percent of the total GDP (Central Intelligence Agency, 2016).

Life expectancy at birth is 61 (approximately) for both sexes, while the healthy life expectancy at birth is 52 (World Health Organization, 2015). The under-five mortality rate is at 5.2 percent and the maternal mortality rate is at 0.41 percent (2012 estimate) compared to respectively 16.7 percent and 0.92 percent since 1990 (World Health Organization, 2015).

Figure 3: Tanzania’s Poor by Geographic Area (Mohammed, 2015)
The total expenditure on health per capita are illustrated in figure 4, spanning from 1995 – 2015, where the blue line is for Tanzania and the green line is for the World Health Organization region. The graph indicates that the expenditure has increased over the years, that people are spending more out of their own pocket to pay for their health services, but also that more people are able to access health services (World Health Organization, 2015).

53 percent of deliveries take place at home, most of them with traditional birth attendants (TBA) present (Kwesigabo et al., 2012b). The numbers of women delivering at facilities has decreased significantly, from 60 percent in 1984 to only 36 percent in 1999. These figures reflect the government policy of training TBAs at the community level to conduct safe delivery at home – also referred to as the TBA program (Ministry of Health Tanzania, 2003).

2.1.4 The structure of the health system in Tanzania

Health providers and the levels of health care

The Tanzanian health services are provided at three main levels; primary, secondary and tertiary. The health system is divided into five main levels; national-, zonal-, regional-, district-, and facility-level. The referral system is then divided into three levels; hospitals, dispensaries, and health centres (Ministry of Health Tanzania, 2003). When patients need higher level health care, they are referred from a dispensary or health centres to district and regional hospitals (Ministry of Health Tanzania, 2003). An overview of the organisation and management structure of the Health System in Tanzania is shown in table 1 (page 11).

The primary health care level is the main care service provider where care is provided both in private and public hospitals, health centres and dispensaries. They are offering outpatient services including reproductive services, child health services, and diagnostic services. Other
services at this level are health education, family planning, out-reach services and mobile clinics. At the secondary level, services are provided through regional hospitals. These hospitals provide the same health care services as at the ones at the district level, but with a higher level of expertise. The tertiary health care providers provides similar services as the secondary level through hospitals and training institutions, in addition to some specialized and consultative health care (Ministry of Health, 2003).

To meet the requirements of a rapid growing population, Tanzania have developed a multi-tiered decentralised health system. For instance, a major part of the Tanzanian people is living in rural areas. When they need medical attention, they seek the first local point of medical contact before they are possibly referred to a more specialised and central facility for further health care. The first part of medical contact is often traditional healers. In the National Health Policy report compiled by the Ministry of Health (now under the name Ministry of Health, Community Development, Gender, Elderly and Children - MoH) in Tanzania in 2003, they estimated that 60 percent of the population that availed care sought health services that depended on traditional healers or other alternative healing methods (Ministry of Health, 2003). Because many in Tanzania have access to different forms of health care services, such as services from traditional healers, about 80 percent of the population in Tanzania can access and obtain health services (Ministry of Health Tanzania, 2003).
<table>
<thead>
<tr>
<th>Health System Level</th>
<th>Organization/Health provider</th>
<th>Health responsibilities</th>
</tr>
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<tbody>
<tr>
<td>National</td>
<td>Ministry of Health, Community Development, Gender, Elderly and Children¹ (MoH)</td>
<td>Delivery of public health services, policy formulation, development of guidelines for policy implementation</td>
</tr>
<tr>
<td>Zone</td>
<td>Zonal Offices</td>
<td>Receives commodities: provision to the regions</td>
</tr>
<tr>
<td></td>
<td>Zonal Hospitals (five in the country)</td>
<td>Same task as regional hospitals. More skilled personnel, more specialised care. Provide training, oversee quality of treatment, establish health service referral systems</td>
</tr>
<tr>
<td>Regional</td>
<td>Regional Health Management Teams (RHMT)</td>
<td>Interpretation of policies, monitoring implementation in districts</td>
</tr>
<tr>
<td></td>
<td>Regional Medical Officer (RMO)</td>
<td>Heads the RHMT, reports to MoH: issues related to medical management, health administration and management</td>
</tr>
<tr>
<td>District</td>
<td>District Offices</td>
<td>Monitors and supervise the health clinics and dispensaries</td>
</tr>
<tr>
<td></td>
<td>District Health Management Team (DHMT)</td>
<td>Council health services: dispensaries, health centres and hospitals (in given district)</td>
</tr>
<tr>
<td></td>
<td>District Medical Officer (DMO)</td>
<td>Head of DHMT, accountable to the Council Director on administrative and managerial matters, responsible to the RMO on technical matters</td>
</tr>
<tr>
<td></td>
<td>Hospital</td>
<td>Same as dispensary and health centres, but with a higher expertise (higher level of clinical and nursing care capability and laboratory/radiology diagnostic capacity). In addition; surgical care</td>
</tr>
<tr>
<td></td>
<td>Facility</td>
<td>Preventative and curative outpatient services to the local communities</td>
</tr>
<tr>
<td></td>
<td>Dispensary</td>
<td>Cater for in- and outpatients, deliveries, receive referrals from dispensaries, conduct preventive service activities including outreach</td>
</tr>
</tbody>
</table>

1. Previously named Ministry of Health and Social Welfare. Ministry of Health previous to that.

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<thead>
<tr>
<th>2.2 Health Information System</th>
</tr>
</thead>
<tbody>
<tr>
<td>The goals of a Health Information System (HIS) is to improve health services management through optimal information support. They can be defined as a set of components and procedures that seek to generate information, which will improve health care management</td>
</tr>
</tbody>
</table>

Table 1: Organization and management structure of the National Health System (Ministry of Health, 2003; World Health Organization, 2004)
decisions on all levels of the health system (Braa & Sahay, 2012; Lippeveld, Sauerborn, & Bodart, 2000). According to Lippeveld et al. (2000), “The challenge for health systems is to optimize the management of service delivery in a way that minimizes losses of effectiveness” (p. 1). To optimise the management of service delivery, information must be used by all decision-makers at all points; from the periphery to the centre. This includes policymakers, managers, care providers, health technicians, and community health workers (Lippeveld et al., 2000).

An HIS cannot exist by itself, but is functional as an entity within a framework of a comprehensive health system. The HIS are supposed to generate information for rational decision-making at all the levels of the health system (Lippeveld et al., 2000). Within the framework, a variety of components are existing, such as Health Management Information Systems (HMIS) and Logistic Management Information Systems (LMIS). These systems can be seen as sub-systems of the overall health information system (HIS), and will be further explained (Lippeveld et al., 2000).

### 2.3 The Health Management Information System

The main goal of HMIS is to assist the management and planning of health programs and services, and can be seen as a system for decision-making (Braa & Sahay, 2012). The purpose with an HMIS is to collect and report health data to different instances of the health care system. This information can be incidences of diseases, client and patient information, and health services rendered (Mendoza & Chong, 2004). HMIS are dealing with aggregated data about everyday provision of health services (Braa & Sahay, 2012). The processes where HMIS are included are for data collection, -reporting, -processing, and in the use of information to improve health service effectiveness and efficiency through better management (Lippeveld et al., 2000).

#### 2.3.1 HMIS in Tanzania: DHIS2

HMIS was introduced nationwide in Tanzania between 1994 and 1997, with an attempt of expanding the old systems that did not meet the requirements of integrating the existing health systems. These existing systems were used for management in the independent vertical health programmes and were initially developed to suit the independent needs of each health
programme. However, specific programmes such as disease-specific programmes, does still exist which process program-specific information. Even though they still exist, most of this information are now integrated into the national HMIS (African Health Observatory, 2014).

In Tanzania, DHIS2 (hereby referred to as DHIS) is the national HMIS. DHIS is a free and open source HMIS that emphasizes the use of information for action and improved health services (Braa & Sahay, 2012). It is a platform for management of routine health information with a focus on health statistics (Sahay, Sæbø, & Braa, 2013). It is designed to support health workers at all administrative levels through a balance between flexibility and standardisation (HISP, n.d.). It is organized by the Health Information System Program (HISP) network and developed by the University of Oslo. The software is currently being used in more than 40 countries around the world, by national governments and some international organisations (HISP, n.d.; Sahay et al., 2013).

The application database of DHIS is designed ground-up with flexibility in mind so that the system can be adapted to a multitude of locale contexts and use-cases (Braa & Sahay, 2012). This means that it makes it possible to serve as a management systems for domains such as logistics and finance (Braa & Sahay, 2012). Now, DHIS is only used for health management in Tanzania. Within logistic management, the electronic logistic management information system (eLMIS) is the system that is currently implemented for managing the logistic of health commodities. The eLMIS will be further elaborated in the section 2.4 and sub-section 2.4.1.

The flexibility in DHIS shows for instance by the ability of its web portal to consume data from more than one Web API. If available, it can consume data from a logistic system for tracking and managing various commodities such as Antiretroviral (ARV) medicines, or retrieve information from finance systems for managing payments to health facilities (Braa & Sahay, 2012).

DHIS is being used in all the levels of the health system in Tanzania to various degrees. At the facility-level, the health data is processed on paper and/or electronically. This varies from facility to facility largely depending on the infrastructure, such as access to electricity, computers, and the Internet. The facilities that are reporting both on paper and electronically are often doing this because they want the paper records for themselves and the reporting into DHIS are conducted to provide information to the higher levels.
All the districts in Tanzania are using DHIS. The employees at the district offices are transferring data into DHIS that are collected from or provided to them from the lower level health care units. The data are entered DHIS by district office staff only when the facilities are not reporting directly into DHIS themselves – but on paper-based systems where the information must be entered DHIS manually from paper forms. In cases where the lower level health care units are entering data in DHIS themselves, the data are controlled checked by the staff at the district offices before submitted to the national database. This is done to improve data quality, so that decision-makers are making decisions based on reliable data. Where there are some uncertainties about the data provided by the facilities, the district office staff contacts the facility and make sure that the inaccurate data are corrected. The data reported, are used by the levels above the district-level to manage health care services based on informed decisions. In total, each month 1.5 million data entries from the facilities are reported into the National Data Warehouse (DHIS2, n.d., p. 2).

The main goal of the research is to investigate the LMIS in Tanzania. They are often closely linked to the use of HMIS. For instance, both are being used at most of the district offices in Tanzania which is an indication that an integration of the functionalities of the systems into one platform could be beneficial to minimise fragmentation of systems (Braa & Sahay, 2012). Now, there are several vertical programs that collects information individually, independent on other programs. I will not go into details about integration, but integration is highly discussed considering HIS in developing countries (Braa & Sahay, 2012; Health Metrics Network, 2008; Monteiro, 2003). Fragmentation of HIS will be further elaborated in chapter 4.

### 2.4 Logistic Management Information System

LMIS is a system of records and reports, whether paper-based or electronically, that is being used to collect, organise, and present logistic data gathered from all levels of a health system. It is used to aggregate, analyse, validate, and display data that can be used to make logistic decisions and manage the health commodity supply chain (hereby addressed as supply chain) and improve customer service (USAID | DELIVER PROJECT, Task Order 1, 2011). An LMIS collects data about health products, stock on hand, losses, adjustments, consumption, demand, issues, shipment, status, and information about the cost of commodities managed in the system (Abdullah et al., 2014). The information that is being used to improve management decisions
can, for instance, be information about the number of health commodities consumed which ultimately would contribute to improve forecasting procedures.

In a supply chain of health commodities, the LMIS is operating as a linkage between the health system levels. It is important that each of the levels of the supply chain understand how they link to the other levels in the system. Each activity in the chain are all steps in an interconnected process (John Snow, Inc., 2012).

### 2.4.1 LMIS in Tanzania: the eLMIS

The Health Information System (HIS) in Tanzania were decentralised in the 1990s. Before the decentralisation process, the health commodities were distributed by pushing kits to the customers on a regular basis. After the decentralisation, they shifted to having a system where the customers where ordering health commodities based on their own needs. The responsibility of ordering health commodities was transferred from the central-level of the HIS to the lower levels of the health system. The decentralisation was motioned to address the inherent problems with the kits; shortages for some products and overstock of others (USAID | DELIVER PROJECT, Task Order 4, 2011). The shift introduced the need for the development of information systems (IS) for logistic management.

The national LMIS that is implemented in Tanzania today is the eLMIS. It is an implementation of OpenLMIS by the USAID | DELIVER PROJECT in Tanzania and Zambia which is designed to meet the LMIS needs of the two countries. OpenLMIS is a collaboration of “domain experts in logistics and supply chains, eHealth information systems, software development for low-resource settings, and process improvement.” (USAID | DELIVER PROJECT, 2008, p. 1). The intention is to ensure that “OpenLMIS becomes the place for sharing information about LMIS planning, requirements and system design, promoting interoperability between systems” (USAID | DELIVER PROJECT, 2008, p. 1).

Since 2004, and long before the introduction of the eLMIS, the Medical Store Department\(^2\) (MSD) fulfilled paper-based orders that were received. Several IS emerged in the years to come, such as the Integrated Logistic System (ILS) Gateway. The ILS Gateway is an SMS-based monitoring and reporting system. It was introduced in 2010 in a pilot project and was aimed at

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\(^2\) The MSD is the main supplier of health commodities in Tanzania
supporting the already existing ILS and improve the logistic data for a set of tracer products. The ILS itself was introduced in 2005 and merged the management of health commodities for the essential drug programme, malaria, reproductive and child health, sexually transmitted infections, and family planning into one ordering and reporting system. Final completion of roll-out were in 2009 (USAID | DELIVER PROJECT, Task Order 4, USAID | DELIVER PROJECT, Task Order 7, & Supply Chain Management System, 2016). The ILS Gateway will be further explained in sub-section 5.3.2.

Despite the introduction of the ILS Gateway, and other IS for logistic management, Tanzania needed a more robust LMIS that is web-based which can handle health facility R&R forms. To meet this need, the eLMIS was launched in November 2013. During December the same year, both Tanzania and Zambia, went live with the web-based eLMIS solution (USAID | DELIVER PROJECT, 2008). The eLMIS were early in 2015 completely rolled out to all of the districts of Tanzania (USAID | DELIVER PROJECT, Task Order 4 et al., 2016).

The eLMIS is part of the supply chain in Tanzania, operating as a management system. It is being used at the facility-level, but only in one district in Tanzania (per August 2016), at the district-level and at the regional and national level. At facility-level where the eLMIS are implemented, the health workers trained in LMIS places orders that are sent to the district offices. They control-check the data before they are sent to the regional or central supply store of health commodities. Some facilities do only use paper-based systems. In this case, the district offices are processing the data into eLMIS before it is being sent to the regional or central stores. This process will be further elaborated in the chapter 5.

2.5 Health Information System Program

This research is a part of the Health Information System Programme (HISP) project at the University of Oslo. A group of researchers, consisting of seven master students and two supervisors, are especially focusing on LMIS in developing countries. Two of the researchers are focusing on conducting research about LMIS in Tanzania, three in Uganda, one in Zambia and one that does a comparative study between the Uganda and Tanzania countries.

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3 A set of pre-selected health commodities
HISP UiO is designing, implementing, and sustaining Health Information Systems in developing countries. “The overall goals of HISP is to enable and support countries to strengthen their health systems and their capacity to govern their Health Information Systems in a sustainable way to improve the management and delivery of health services.” (‘The Health Information Systems Programme (HISP) - Department of Informatics’, n.d.).

HISP UiO and partners are collectively responsible for the development of the DHIS2 software, and support the implementation of it in collaboration with ministries of health (Sahay et al., 2013). The HISP network consists of several implementing partners located in developing countries. Other institutions involved are the WHO, PEPFAR, and The Global Fund (Sahay et al., 2013).

As a contribution to the program, this research is investigating HIS in Tanzania with a focus on information systems for logistic management. The research considers the supply chain in Tanzanian to understand the involved activities and procedures. This includes investigating how information is flowing between the actors in the network, the information available to the decision-makers, and how it is being used in managerial activities. These are fundamental aspects of this research which will consider the logistic management of health commodities in Tanzania. The research especially focuses on the role of financial information related to health commodities. Who has access to it, how is it being used, and what kinds of information systems are used when processing information about funding for health commodities? As a contribution to the HISP network, this research will bring knowledge about an area of logistic management of health commodities that has not received a broad focus within existing literature and research.
3 Research Approach

The purpose of this chapter is to introduce the research approach. First, the chapter presents the philosophical assumptions behind the research approach. The chapter continues by presenting the methodology framework, including the approach for the methodology. In addition, a description of the methods used for data collection and the methods for data analysis are provided. Finally, a presentation of ethical considerations related to the research.

3.1 Philosophical Assumptions

All research is based on assumptions about what constitutes valid research and which research methods that are appropriate (Myers, 1997). What do we see as research that has reason to foresee, and what kind of methods should we use to foresee it? To conduct research, it is important to know what one is looking for, how one is going to look for it, and why one is looking for it. When conducting research, the researcher must take a certain position regarding their own perception of how things really are and how they really work. It is not enough to believe that things are as you believe they are in the real world. Researchers also have to know how to create knowledge, and how to acquire and communicate it (Scotland, 2012). To do so, understanding people’s meanings that are assigned to you, are important. They are necessary to understand the different contexts researched, and how these contexts are influencing the data.

I have interpreted the data that I have collected in this study. Based on this, one can say that this study lies within the interpretive paradigm. In this paradigm, reality is given “through social construction such as language, consciousness and shared meanings” (Myers, 1997). The intersubjectivity is important in this paradigm where reality, as we know it, is constructed intersubjective through the shared meanings and understandings developed socially and experimentally (Walsham, 2006). The interpretive research approach is heavily relying on naturalistic approaches such as interviews, observations as well as analysis of relevant literature (Myers, 1997). These types of methods enable the necessary communication between the researcher and the key participants in the study to establish a meaningful reality to the research (Robert Wood Johnson Foundation, 2008).
Being an outsider that had little or no knowledge prior to the data collection, it was important to enter the research with an open mind. My intention was to investigate a new and unknown field to me, where the interpretations provided by the participants in the research are important to obtaining their subjective view.

3.2 Research Methodology: Case Study

The Methodological framework used for this thesis is a case study. A case study is a research method that investigates a contemporary phenomenon within its real life context, and especially where the boundaries between the context and the phenomenon are not evident (Myers, 1997). The case in this research has been to investigate the LMIS within the health commodity supply chain (hereby addressed as supply chain) in Tanzania. The focus has especially been geared towards addressing the role of financial information at all the levels of the supply chain, and what role it plays in managerial activities. In this case, the phenomenon is the role of financial information in a supply chain. The phenomenon itself are quite clear and well-defined, hence what considering its role in the supply chain, but it is more difficult to determine the boundaries between the phenomenon and how it is in real life and how to investigate it. How are the actual access, use, and flow of financial information and what does it have to say for its role in the supply chain management? Are there any differences from context to context, and at the different health levels, etc? What factors that play certain roles, is difficult to pre-determine without investigating it in the real world. Use-patterns, and what role the information plays in certain activities, may vary from context to context. A case study methodology has therefore been the most suitable approach for the research.

Case studies are the most common used methodology in information system research. The methodology is especially useful for in-depth-studies, where the aim is to narrow down a broad field of research to a searchable topic. Because case studies usually are used to investigate a phenomenon within its real-life context, a case study is a suitable methodology for this particular research (Myers, 1997). One of the advantages of case studies is that one can gain knowledge from experts that operate based on intimate knowledge of several thousand concrete cases in their areas of expertise. In this manner, the participants are working every day with LMIS and most of them are experts when it comes to everyday use patterns and situations. This type of information is important to understand the LMIS and its use contexts in Tanzania. Referring to Flyvbjerg (2006), context-dependent knowledge is the centre of the case study:
Context-dependent knowledge and experience are at the very heart of expert activity. Such knowledge and expertise also lie at the center of the case study as a research and teaching method or to put it more generally still, as a method of learning (p. 222).

For me, being able to move from being a beginner to being an ‘expert’ within the field, a case study was, therefore, the most suitable methodology for this research. Another important reason for choosing this particular methodology is that the aim of a case study is not necessarily to prove something, but to learn something (Flyvbjerg, 2006). Considering this, a case study is suitable because I did not gather data in Tanzania necessarily to prove something, but mainly to learn as well as contribute with research to the field. Based on the learning processes that take place in a case study, one can build hypothesis of how things could be, should be, and should not be.

In interpretive studies, setting up and carry out fieldwork are the fundamental basis of the research (Walsham, 2006). Fieldwork is context-dependent, that is, choices of involvement, access, and working in a different country are all aspect that has to be thought through when collecting data from the field (Walsham, 2006). In the next sub-section, I describe the case study approach and the fieldwork conducted in Tanzania.

### 3.2.1 Case study approach

The case span of two field trips to Tanzania. The first trip was in January and February 2016 and the second in August and September 2016. A total of eight weeks was spent collecting data in Tanzania, mostly in Dar es Salaam and the surrounding areas, including a weekend trip to Zanzibar where I visited the Ministry of Health and Social Welfare (MoHSW). The overall focus of the case was the same during the whole data collection process. During the second trip, the data collection was more directed to a more specific part of the supply chain; the role of financial information for procurement within the supply chain management.

Before the trip to Tanzania in January/February 2016, my supervisor, my fellow students, and I had several discussions about the scope of the project as well as what to look for when visiting Tanzania for the first time. It was necessary for me to get to know the research field as much as possible during the time before the first trip. Since the project started in August 2015, I have
focused on reviewing as much documentation as possible to get basic knowledge. Before the first field trip, things were a bit unclear. However, bits were starting to fall into place when I started collecting data. The documentation that was reviewed before the trip gave more meaning as the collection of data gained momentum.

Both in January/February and August/September, I travelled to Dar es Salaam with my fellow student. In January/February, our supervisor was also with us. Another fellow student, that does a comparative study of the LMIS between two East-African countries, was also travelling with his supervisor. My travel companion and I were conducting the same research during the first trip in January/February but diverted our focuses into different parts of the supply chain after analysing the data from the first field trip. Despite this, we travelled together the second time as well, and went together to all the field visits in August/September. Our research topic had a different goal, but it was useful for us to travel together and visit the same places. In that way, we could learn from each other as well as get a second opinion on how to proceed the research based on the data collected so far. It was especially helpful for me to get another perspective, to show different angles of the research. It was also useful to have a fellow student travelling with me so we could support each other when doing research in another country that I had not experienced before. Discussions about how to act, how to get involved, and how we were going to proceed forward were useful to do with someone familiar.

During the eight weeks of collecting data in Tanzania, we conducted 15 interviews and observations with 45 participants at facility-, district-, and the national level as well as with Non-Governmental Organizations (NGO).

Table 2 shows an overview of the interviews and observations that were held during the two trips to Tanzania. Included are the roles of the participants, and at what level of the health system we conducted the interviews and observations. At some visits, we talked with more participants than presented in the table. These participants were not considered relevant for the research, and are not included, because they were not considered as the primary participant(s). They were present during some of the field visits, but was not the main participant. However, all the information provided during the visits are analysed and processed to obtain as much knowledge as possible. At some of the district offices we visited during our stay in Tanzania, we talked to some participants that also showed us around at some facilities in the district. These participants from the districts are only included in the district-rows in table 2 and not in the facility-rows. However, the participants from the districts did provide us with information when
visiting the facilities as well. They supplied information, in addition to the information provided by the participants at the facilities.

*The health workers consist of several participants we interviewed. These can for instance be nurses, doctors or other health workers that did not have a specific title.

<table>
<thead>
<tr>
<th>Health System Level</th>
<th>Number of Participants</th>
<th>Role of Participants</th>
<th>Methods used</th>
</tr>
</thead>
<tbody>
<tr>
<td>District</td>
<td>6</td>
<td>HMIS workers, District pharmacists, pharmacist, health workers*</td>
<td>Unstructured interview, Observation</td>
</tr>
<tr>
<td>District</td>
<td>4</td>
<td>HMIS workers, LMIS Workers, District pharmacist</td>
<td>Unstructured interview, Observation</td>
</tr>
<tr>
<td>District</td>
<td>3</td>
<td>HMIS workers, DIVO</td>
<td>Semi-structured interviews, Observation</td>
</tr>
<tr>
<td>District</td>
<td>3</td>
<td>DIVO, HMIS worker, LMIS worker</td>
<td>Semi-structured interviews, Observation</td>
</tr>
<tr>
<td>District</td>
<td>5</td>
<td>DIVO, HMIS worker, Health workers*</td>
<td>Semi-structured interviews, Observation</td>
</tr>
<tr>
<td>Facility</td>
<td>1</td>
<td>Clinical Officer</td>
<td>Unstructured interview, Observation</td>
</tr>
<tr>
<td>Facility</td>
<td>4</td>
<td>Health workers</td>
<td>Semi-structured interviews, Observations</td>
</tr>
<tr>
<td>Facility</td>
<td>2</td>
<td>LMIS worker, Health worker*</td>
<td>Semi-structured interviews, Observations</td>
</tr>
<tr>
<td>Facility</td>
<td>1</td>
<td>Health worker*</td>
<td>Unstructured interview, Observation</td>
</tr>
<tr>
<td>Facility</td>
<td>1</td>
<td>Health worker*</td>
<td>Semi-structured interviews, Observations</td>
</tr>
<tr>
<td>National</td>
<td>3</td>
<td>Pharmacists</td>
<td>Semi-structured interview</td>
</tr>
<tr>
<td>National</td>
<td>4</td>
<td>LMIS workers, HMIS worker, Drug storage manager</td>
<td>Semi-structured interview, Observation</td>
</tr>
<tr>
<td>National</td>
<td>2</td>
<td>Manager, System developer</td>
<td>Semi-structured interview</td>
</tr>
<tr>
<td>NGO</td>
<td>4</td>
<td>Pharmacist, HMIS Manager, System developers</td>
<td>Semi-structured Interviews</td>
</tr>
<tr>
<td>NGO</td>
<td>2</td>
<td>System Developers</td>
<td>Semi-structures Interview, Observation</td>
</tr>
</tbody>
</table>

Table 2: Overview of the participants involved in the research

During the first trip to Tanzania in January/February 2016, I investigated broadly the HMIS and LMIS in use. I interviewed and observed several different actors in the supply chain to get an overview of the situation. The aim with the first trip was to establish knowledge about the Tanzanian supply chain and its management as well as the information systems involved. It was especially important to establish a focus area for the further research. After analysing the data back in Oslo, I narrowed down the research area and started focusing on the financial information for procurement of health commodities in the Tanzanian supply chain. In the next phase of the data collection in August/September 2016, I focused more specific on this area of the supply chain. During the second trip, I talked more with participants that had a stronger
relation to procurement processes for health commodities, such as immunisation officers and pharmacists as well as relevant facility-staff. I also managed to understand, in greater detail, how the various information systems within the supply chain works as well as the processes of using them in the supply chain management.

3.3 Data Collection

In this section, the framework for the data collection is presented. It included a description of the research goals, the participants involved, and the methods used for the data collection.

3.3.1 Research goals

The fieldwork conducted in this research, were developed based on a set of goals. Some were determined before the first field trip and some emerged after the first trip, as well as during the second field trip. The goal of the research during the first trip to Tanzania was to obtain a preliminary overview of the supply chain and its management as well as the information systems used for the supply chain management. The next goal was to gain an understanding of how the information flows between the organisations, the health levels, and actors involved in the supply chain. After the first trip to Tanzania, another research goal was drawn up; focusing on the role of financial information in the supply chain management. The final goals were to analyse the findings and consider the role of financial information in the supply chain management at the lower health care units, and how it can be promoted by the LMIS. In addition, consider the challenges and possibilities of improvements.

The goals of this research changed after analysing the data from the first field trip. I found a focus area that I thought of as relevant and interesting, and that seemed to could benefit from being researched. When I returned to Oslo after the first trip to Tanzania, I discovered some issues considering the role flow of financial information for procurement at the lower health levels. The overall goals, and its process of change, are summarised in table 3.
Table 3: The overall goals of the research

<table>
<thead>
<tr>
<th>January 2016/February 2016</th>
<th>August/September 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary overview of the supply chain and related</td>
<td>More focus on the flow of information between the levels of the supply chain and its management</td>
</tr>
<tr>
<td>information systems</td>
<td></td>
</tr>
<tr>
<td>Gain understanding of the supply chain management in Tanzania</td>
<td>Investigate the role of financial information in the supply chain management. Focusing on the access, use, and flow of financial information</td>
</tr>
<tr>
<td>Get insight into the flow of information in the supply chain</td>
<td>Analyse data and consider the role of financial information in the supply chain management, and how it can be promoted by the LMIS. In addition,</td>
</tr>
<tr>
<td>management</td>
<td>consider the challenges and possibilities of improvements.</td>
</tr>
</tbody>
</table>

3.3.2 Participants

The participants included in this study represent the use of LMIS, and HMIS, on all the levels of the supply chain, hence from the national-, district- and facility-level. The selection of participants is important to answer the research question and can map the use of these information systems and how the logistics management are conducted by different users. Other participants that are not first-hand users were also included in the study, such as developers of the information systems.

Who to include as participants in the study were determined in collaboration with my supervisor and the HISP team in Tanzania. I stated my wishes and requests and they supported me and provided access to the participants we found relevant to the research. Because I visited Tanzania together with my fellow student, we tried to find participants that could suit both of our researches.

3.3.3 Data collection methods

Document analysis

Document analysis is a method where relevant documents are examined and interpreted to give meaning, gain empirical knowledge, and to gain understanding about a specific topic (Bowen, 2009).
It has been a continuous effort throughout my research to analyse relevant documents to strengthen my knowledge about the supply chain and its management. The documents analysed themes that address distribution models of health commodities, information technology (IT) related to health (supply chain IT and IS, overall HIS in developing countries, etc.), financial management of health commodities in developing countries, etc. The documents that are relevant to this thesis is used as a theoretical background, and to underpin the empirical findings from the field trips to Tanzania, and in the discussion.

**Interview**

Interviews range from being *structured, semi-structured, focus groups, and unstructured*. These interview techniques are used in various forms of research. In this research, *semi-structured* interviews were mostly used. This is an interview approach where the researcher and the participant(s) have a set of pre-defined topics to discuss and explore in some depth, where new questions can emerge as new information is discovered during the interview (Bourgeault, Dingwall, & De Vries, 2010; Crang & Cook, 2007). Follow-up questions are important in terms of guiding the interview towards topics of interest, and to fully cover the intended topic (Bourgeault et al., 2010). This interview form seeks open-ended responses and is especially useful where little research has previously been done. There is not a substantial body of literature on the topic the role of financial information for procurement processes in the supply chain in Tanzania, which makes the semi-structure interview approach suitable for this research (Bourgeault et al., 2010). Transcribing and decoding data from interviews like this, often results in new and useful information, but may also often time-consuming (Sharp, Rogers, & Preece, 2011).

*Unstructured* interviews are often more exploratory in nature and they are more like regular conversations around a certain topic. Following this approach, a researcher must get the balance between making sure that the answers provided by the participant are relevant to the questions, while at the same time being prepared to follow up the unanticipated aspects that emerge (Sharp et al., 2011). Doing so, rich data is often generated. Unstructured interviews were sometimes used during the field trips, mostly in cases where we were going to interview people we did not know much about beforehand or if we met someone during the field visits that we had not planned to meet. There were also some other occasions where unstructured interviews where held where we just presented our topics of interest and the participant started talking about it – just like a normal conversation. These interviews were mostly planned as semi-structured, but
turned out to be quite unstructured, because the participant provided us with the information we wanted at that time without much interaction from us besides participating in the conversation. Before the field trip, I did not think of unstructured interviews as a suitable approach, because the approach requires great interviewing skills. If the researcher does not manage to coordinate the interview properly, poor data may be obtained – something I did not want to risk.

Another approach, the focus group, has similar characteristics to the semi-structured interview form. In addition to these characteristics, focus groups usually consist of three to 10 participants (Sharp et al., 2011). The participants are selected to get a representative sample of the target population. The benefit of this approach is that they allow for diverse or sensitive topics to be discussed, that otherwise might be missed. Individuals are making opinions within a social context when talking to others in a supportive environment (Sharp et al., 2011). The approach supports a flexibility for the interviewer to follow up unanticipated issues as they are raised. Focus groups were rarely used within this research, but groups of people were participating in discussions in some of the field visits. These focus groups were not planned, but emerged as a combination of semi-structured interview and focus group because several unanticipated participants were included in the conversations. This was mostly useful as we gained more momentum in the discussion and could enlighten the topics from different viewpoints. However, the focus group approach is not considered as one of the main data collection methods in this research, and are therefore not included in the overview in table 2.

The last interview approach, one that I did not use, is structured interviews. They are more predetermined compared to the other approaches and look more like a questionnaire (Sharp et al., 2011). The approach is useful when the goals are clearly understood in advance and the questions can be set based on these goals (Sharp et al., 2011). In this research, the goals were not clearly understood before the field trips. Developing full and final interview guides in advance was therefore not possible. Questions in structured interviews are also often short and concise, which is not the case for the questions I asked during the interviews in Tanzania. My questions were more detailed to make sure that the participants fully understood what the research was about. There were neither a set of predetermined alternatives of answers to the questions I wanted to ask, which often is a characteristic with closed questions in structured interviews (Sharp et al., 2011).
Observation

Observation is a useful method to understand the users’ context, tasks, and goals (Sharp et al., 2011). During the field trips, we observed the participants on several occasions to improve our understanding, especially of the use of the information systems for supply chain management. The observations primarily happened in the participants’ natural settings, where they used the different information systems. In most of the field visits, we observed the participants performing some key tasks using some of the key functionalities of the information systems. Observations were frequently used in combination with interviews. This combination can help filling in the details and nuances which are not elicited from the interview themselves. In this research, it was especially useful during the analysis where observations could clarify ambiguities that emerged from the interviews. To give an example, some of the participants gave the impression that it was challenging to talk about the access, use, and flow of financial information for procurement in the supply chain management. At some occasions, they mentioned that they did not have any knowledge about the topic. When I later observed the participant using the eLMIS, I saw that information about financial information were not available in the information system. However, interviewing the participants in addition to observing them, it was sometimes easier to explain and ask questions about certain topics. The information emerging from these situations would perhaps not have been discovered if I did not observe in combination with interviewing the participants. The results emerging from the data collection are further elaborated in chapter 5.

When observing, we wrote down a detailed description of what we were observing. At most of the observations, we were two (or more at some occasions) that wrote down notes. Afterward, we went through the observation notes, and then compared and combined them with the notes from the interviews. The observation notes were mostly used to supplement, or fill the missing gaps that occurred from the interviews.

Most of the observations conducted during the field trips to Tanzania were not planned in detail. They often emerged as the interview went along; when a participant wanted to show us something, for instance in the eLMIS, in addition, to give an explanation. This could, for example, be the functionalities of an information system they were using or a process of registering data on stock balances etc. Being able as a researcher to adapt to this dynamic data collection processes in each research setting is important to gather as much qualitative data as possible. It is a challenging skill to be able to adapt to each research setting, but the skill evolves
and develops with experience. When observing, there is a particular careful balance between being guided by certain goals and being open to modifying, shaping and refocusing the study as you interpret the situations (Sharp et al., 2011). This was particularly important in this data collection process as we conducted field work in new and unfamiliar contexts.

### 3.4 Data Analysis

There are several approaches to choose when analysing data. Some are choosing to use well-defined theories such as grounded theory, actor-network theory, or a thematic analysis to mention a few. I have chosen to have a looser approach in the analysis process. To generate raw data from the field trip into new knowledge, I was engaged in data analysis throughout the process. I have written down impressions and thoughts during the research, such as after an interview or observation. The next was to look for themes, patterns, and issues that I could associate the data with (Walsham, 2006). In that way, I could look for specific challenges and issues that I would like to know more about. What I learned from each field visit were taken into consideration in the next visits, and so forth. In that way, the further investigation was driven in a certain direction based on the analysis of the data so far in the process. The process itself was quite unplanned. In my case, this was a useful approach as one know what the next step of the research should be. If another approach was chosen, for instance by analysing all the data when returning to Norway, the data analysis would have been quite demanding. Missing information about certain topics could also be a result, because the data collection would not have been guided by the continuous analysis process.

The process of analysis after a field visit in Tanzania are summarised in table 4.

<table>
<thead>
<tr>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Immediate after a field visit: writing the field notes down structurally in a document</td>
</tr>
<tr>
<td>2  Going through the data, looking for themes, patterns, and issues</td>
</tr>
<tr>
<td>3  Summarise the data in collaboration with my fellow research student</td>
</tr>
<tr>
<td>4  Discussion of further plans for the investigation (both of our cases)</td>
</tr>
<tr>
<td>5  Individual planning of further plans for the research</td>
</tr>
<tr>
<td>6  Modification of interview questions to fit with the new requirements that are set from the analysed data</td>
</tr>
</tbody>
</table>

*Table 4: Summary of the analysis process in Tanzania*
The data that we collected in Tanzania, are also reviewed in Oslo in several iterations. This is done to fill missing gaps that have occurred, and supplement them with other data that I have found relevant to the research. It has also been a continuous effort to keep a dialogue with our colleagues from the HISP network in Tanzania and Oslo. In addition to supervision from my supervisor, discussions with my fellow students have been useful to get feedback on my research and to learn from their experiences.

In addition to the analytical processes mentioned above, I also made a table in collaboration with my fellow research student where we listed up information about the field visits. The table contains information of who we talked to, where and when we talked to them, as well as on what level the participants are operating in. In addition, we also listed up what data collection methods we used. The reason for making the list was to have some hooks to ‘hang’ the data. It is easier afterward to process the data if you know when, where and from whom collected. Information may become more meaningful to you if you remember who it was that provided it to you. It may also be easier to memorise it. The table is not included in this thesis, due to privacy concerns as the table contains the occupation of the participant combined with the place of employment.

3.5 Ethical Considerations

Before conducting research in Tanzania, I had to apply for a research concession in Norway through the Norwegian centre for research data (NCRD). The process consists of applying electronically through a survey online. When completing the survey, I got an immediate answer informing that I did not need to apply for a research approval and could continue the research. The result of the application can be viewed in appendix A.

This research considers different ethical considerations throughout the fieldwork. For instance, the participants included in the research were briefed about our aim with the study as well as how the information are going to be processed and used. We did not establish an informed consent before the field visits, but chose to inform the participants orally about anonymity and how we would make sure that it will not be possible to trace the answers they provide back to them (Sharp et al., 2011). This was done because it seemed to be more effective at the time. An oral presentation of the research and data collection seemed more appropriate than providing it by paper. Many of the participants have probably not been exposed with informed consent.
letters before, and after consultation with our research colleagues in Tanzania, we thought that an oral presentation of a consent form was a suitable approach. Some of the interviews were recorded, and the participants were informed about this in beforehand. After transcription, they were deleted. We also took some photos during the field trips which always were taken after consent from the participants. In this thesis, no names or occupations of the participants are mentioned. Names of an organisation may be mentioned, but never in combination with the occupation of the participant. This is carefully thought through to minimise the risk of identifying any of the participants.

Conveying the information with the most pragmatic approach, was another ethical consideration when collecting data. Talking to the participants in a way that they felt included, was important to create positive outcomes. It is also important to clarify what I am eager to learn and understand. To achieve this, it is necessary to know the participants’ level of knowledge about the topic to discuss. I usually began the interviews with some basic questions to plan the further interview accordingly. The initial questions were context-dependent and established after knowing where we were going to visit and whom we were going to interview. It was also important to be polite and thankful that the participants graciously spent their precious time to meet with us.

Another consideration when conducting field work in unknown and unfamiliar contexts, is always to consider language as an ethical challenge. In this research, where I conducted field work in Tanzania, it was important to speak in a way that the participants understood what I tried to convey. It was crucial to talk in a way that the participants felt included in the conversations. In some of the interviews we held, I recognised that the language skills were varied. If we interviewed multiple participants at the same time, I adapted the language to accommodate all the participants. As English is not the native language in Tanzania, neither mine, this was an important ethical consideration to think through.

As a researcher from the ‘developed part of the world’, it is essential to be aware of one’s position as a researcher in a context where one is a visitor. As Crang & Cook (2007) says; “many people would not tolerate the white stranger snooping around were it not that he [sic] belongs, as far as they are concerned, to the powerful white society which they hesitate to brush with” (p. 27). My intentions as a researcher must, therefore, be considered conducting this research, and what my intentions are when representing the participants in this thesis. What do I want to achieve, how do I want to achieve it, and where do I want to achieve it? These are all
important questions to ask in that manner. It is also important to consider what one’s intention are when representing the participants. Is the content of this research representative for the information provided by the participants? Will the participants be able to read the thesis and understand what the research is about and what it is for? How will the information from this research be circulated and what impact might it have on the lives of the researched in the future? These are all factors that I had to consider, both prior and after, my data collection and study (Crang & Cook, 2007). It is important to work ‘with’ the people and not ‘on’ people and take our diversity into consideration when collecting data.
4 Theoretical Background

The intent of this chapter is to introduce the literature used as theoretical background for the thesis. The most relevant part of the theoretical background for the thesis, constitutes theory of distribution models for health commodities within developing countries. To understand this in coalition with information systems (IS) and information infrastructures (II), an introduction to relevant IS and II theory is provided for the reader to understand what IS and II is about. Drawing on theory, a framework for informational needs in the supply chain management are developed. This framework will be further used to discuss the research question in chapter 6.

In addition, as health information systems (HIS) in developing countries often tends to come in a variety of forms, often with overlapping or similar functionalities, a section describing fragmentation of HIS are also provided. Before describing four distribution models within health commodity supply chains (hereby addressed as supply chain(s)) in developing countries, a short description of HIS in developing countries and an introduction of what the supply chain is about is provided.

4.1 Information Systems

Theory related to information systems is relevant for this thesis for understanding what information systems is about, and how IS are used in the distribution models presented in section 4.4. In addition, understanding what information systems is about are relevant considering how IS can promote the role of financial information for procurement in supply chains.

The distribution models, the financial information for procurement, and the overall supply chain management are all representing aspects within the Tanzanian management IS for the supply chain that influence how the IS operates, exist, and are being used. As distribution models of health commodities varies, each of them has different requirements of an IS. Understanding IS is therefore important to see what role financial information can play for the distribution models of health commodities, and how it can be promoted by using IS in supply chain management. IS theory is also relevant to understand how IS can contribute to enhance the supply chain. Considering a further development of the IS, it is important to know the actors and components of the process.
Theory covering IS as socio-technical systems, are also provided in this section. IS are constituting of several components and actors. Seeing IS as socio-technical systems is therefore important to recognise these components in relation to each other. IS are often shared through a variety of actors. The combination of actors, both human and nonhuman, in the network are often referred to as information infrastructures (II) that constitutes of several systems, actors, and components. HIS can be one such II. HIS are often substantial, including a high number of actors with individual interest and with individual IS. This is often the situation in developing countries, making the II heavily fragmented.

4.1.1 Information systems as socio-technical systems

Information systems (IS) constitutes of hardware, software, people, techniques, etc. They are more than pure technological components. They do also consist of socio-technical components (Hanseth, 2000). The components can be both human and nonhuman components, and together they shape the IS, for instance when developing or using them. Seeing IS as socio-technical systems is therefore important to understand how contexts plays an important role for the IS. Viewing IS as social systems are presented here to establish an understanding of how varying contexts have an impact on the use of IS, such as how the use of the Logistic Management Information Systems (LMIS) differs depending on the use-context in Tanzania (as presented in sub-section 2.4.1).

The social relations constituting IS are characterised by fundamentally being in relation (Star & Ruhleder, 1996). The evolution of IS are largely formed by the interdependencies between these socio-technical components of human and nonhuman character (Henfridsson & Bygstad, 2013). Further, IS are often embedded in an environment which affect the way it behaves, and evidently how it evolve (Mumford, 2006). Mumford (2006) argues that systems can eventually evolve and settle for a steady state and accommodate change without disruption. However, this is questioned, and it is argued that they can become increasingly chaotic as they progress from one state to another, which makes evolution of systems challenging (Mumford, 2006).

The term information system should be used to refer to the interaction between technology, people, processes, and data (Braa & Sahay, 2012). A perspective where IS are viewed as socio-technical systems is particularly useful for understanding IS that are related to health in developing countries. These IS constitutes of, and evolve, in complex webs of social, political, institutional, and cultural relations which arise from the involvement of technology and a
variety of actors (Braa & Sahay, 2012). Drawing on the collection of complex web of relations forming IS, Kling & Scacchi (1982) stresses the repercussions of new technology. They state the consequences of new technology as translation of technical attributes into social attributes in these complex relations, and mentions that faster data flows mean faster and better decisions. This supports the idea of making information available to the lower health levels for making better informed decisions (see section 2.2). However, some suggest that IS will increase the amount of data that decisions makers must contend with, while others suggest that they will ensure the decision makers with support by the selective ability of IS to manage mounds of data (Kling & Scacchi, 1982).

4.1.2 Information infrastructures

This sub-section provides an overview of the capabilities of an information infrastructure (II) and some of the challenges they are facing, followed by a description of how they evolve. Understanding how II operate, how they evolve, and what capabilities they may have, are useful to get a grasp of what to have in mind when developing IS for health that operates within a health II. II theory is also useful to understand what the HIS in developing countries constitutes of, and useful when drawing lines to the IS in the supply chain in Tanzania. In addition, understanding health II can contribute to understand how it may support the supply chain management with access to information for decision-making.

An information infrastructure can be defined as “shared, open (and unbounded), heterogeneous and evolving socio-technical system (which we call installed base) consisting of a set of IT capabilities and their users, operations and design communities” (Hanseth & Lyytinen, 2010, p. 4).

II are shared by multiple communities by using the same object in many unexpected ways, and has a supporting or enabling function (Hanseth, 2000). They are designed to support a wide range of activities and are not tailored to one (Hanseth, 2000). II unveils unbounded openness by letting new components to be added and integrated in unexpected ways and contexts, having a unlimited set of users, stakeholders, developers, components, vendors, etc. (Hanseth, 2000; Hanseth & Lyytinen, 2010). The components of an II can consist of both human and nonhuman actors and the boundaries between who can use it, develop it or where it can be used are not clearly defined (Hanseth & Lyytinen, 2010).
As Hanseth & Henningson (n.d.) mention; infrastructures do not have any life cycle, they are always present. In II this is only applicable for some; many II has existed for a long time making them ever present and evolving – such as the Internet. Because there are many already existing II, many II must adapt to already existing installed bases. This is also applicable for HIS in many developing countries. They are often reliable on installed bases and the successful rate depends on how it is able to adapt (Hanseth, 2000).

As II are defined as open (and unbounded), they can be characterised with a lifetime with increased technical and social diversity as well as heterogeneity. They become more heterogeneous as more components are added. The components are usually of varying technologies, but can also be of other natures; user communities, design communities, operators, standardisation and governance bodies, etc. (Hanseth & Lyytinen, 2010). Heterogeneity in II can be explained, according to Hanseth (2000, p. 59), in two ways; as *socio-technical networks* and *ecologies of infrastructures*. The socio-technicality refers to the variety of actors involved in an II (described above) and the ecologies of infrastructures means that II are connected and interrelated with each other (Hanseth, 2000).

**Evolving information infrastructures**

II are shared, open and highly heterogeneous, and will therefore evolve *ad infinitum* as Hanseth & Lyytinen (2010, p. 4) addresses. Evolution of infrastructures is a process where heterogeneous and autonomous human, or organisational, actors seek to use information technology in their adaption to each other and their external environments (Henfridsson & Bygstad, 2013). It can also be formed by the interest translated and transcribed by humans into the technologies, creating an evolving network of human and nonhuman actors (Henfridsson & Bygstad, 2013). Studying the evolution of II are useful to understand how the variety of actors and factors that are involved contributes to shape them. Drawing a line to LMIS, and other sub-HIS, it is necessary to understand how they have evolved over time and how they will continue to evolve. This is useful in a way that we, as researchers, can influence its evolution by studying them. The decisions about further development, will hopefully be taken on well documented information.

Evolution of II are both constrained and enabled by their installed base. A requirement of horizontal and backwards compatibility with existing components are setting up constraints for its evolution. When developing new components within an II, it is important having other
components in the II in mind. Introducing new components within an II without considering others, could have a negatively effect on the success rate of the component. Within HIS in developing countries, this can mean complete failure or success based on the components ability to adapt to the already existing installed base.

Managing the evolution of II are also about managing networks effects and path dependencies (Monteiro, Pollock, Hanseth, & Williams, 2013). Network effects emerge because II are a shared resource among a large network of users. The more user, the more attractive it gets for others to use it as well. To achieve such network effects, it is important to “bring the network into existence and to make it grow” (Monteiro et al., 2013. p. 600). Bootstrapping the II is therefore important to make it valuable for other users to implement as well (Hanseth & Lytytinen, 2010; Monteiro et al., 2013). Seeing the processes described above in the light of HIS, it is important to develop information technology that can be implemented by a variety of actors within the health sector. Increasing the user base for the HIS, will make it more attractive for other actors to use as well.

As II continues to grow, other challenges emerge; their complexity increase, and they become more difficult to change. The path dependencies in II is increasing as it is being shaped by it neighbouring II, components, existing information technology (IT) capabilities, etc. The evolution of II are often path dependent, because in large and complex II there are several networks involved that are intersected (Monteiro et al., 2013). When one network is changing, the rest of the other ones have to change to be able to be connected to the network that initially changed (Hanseth, 2000; Hanseth & Henningson, n.d.). Side-effects emerge that generates new changes and so on. The II can therefore change in unpredictable ways (Hanseth & Henningson, n.d.; Monteiro, 2000).

An II that is always present, will continue to grow and evolve continuously. It grows into a complex net of element, relations, components, actors, etc. A challenge that often occurs in some IIIs are fragmentation. In developing countries, fragmentation is a serious issue within HIS. The concept of fragmentation of HIS will be described in the following sub-section.

### 4.1.3 Fragmentation of health information systems

According to (Braa & Sahay, 2012), HIS are usually fragmented. This, however, have resulted in a larger focus in strengthening HIS in developing countries. It has become a substantial part
of health restructuring policies in developing countries. Given contextual diversity, HIS has become to mean different things to different people. The variety of meanings about what an HIS is, has resulted in a multiplicity and diversity of systems. The largest challenge in HIS strengthening policies has therefore become: “how can we have these different systems to communicate to each other to get more integrated information?” (Braa & Sahay, 2012, p. 9).

Fragmentation of HIS is, by many researchers and managers, identified as a major problem shaping their utility and use. In many countries, the variety of health programs, health services, projects or initiatives tend to develop their own HIS to suit their own needs. It is also often done oblivious of existing systems or programmes that may collect the same, or similar, information (Braa & Sahay, 2012). In most developing countries, the health systems consist of several ‘vertical’ programmes. In many cases, each programme collect information for their own needs independent of other programmes, without contributing to the overall HIS (Braa & Sahay, 2012; Management Sciences for Health, 2012c). These vertical programmes, and their programme-specific HIS, constitutes an essential factor of the fragmentation of overall HIS. They generate excessive data with overlaps to each other.

Fragmentation of HIS has, for instance, rapidly occurred because of the quick development of mobile technology and the Internet. Technology has become more accessible to more people, which has led to the development of an increasingly number of HIS. The opportunities that these HIS provide comes with the challenge of managing them all, often leading to a variety of IS and a fragmented set of IS (Braa & Sahay, 2012). An example of a fragmented HIS can be drawn from Zanzibar where the Ministry of Health said:

> When I need to get an overview of the situation across different diseases and services areas, nowhere is that information available. I have to ask for information from a large number of programme offices – Malaria, HIV/AIDS, EPI, hospitals, and so forth. The resulting information is not easy to comprehend, compile and analyse, as each office tend to structure their information differently, and it is difficult to get exactly the information I need. […] What I need is to have all the important data from all offices available at one point, in one office, so that I can get it here on my desk – on my computer. By the press of a button (Braa & Sahay, 2012, p. 33).

Fragmentation of HIS is also shown in Tanzania, where several different actors has developed and implemented HIS based on their own interest only. For instance, DHIS2 are used to collect
health information data and generate aggregated data for decision-making. Another sub-HIS, the VIMS, are currently being implemented as another system for immunisation management (including logistics), while eLMIS are used for logistics management of other health commodities. DHIS2 for instance, could be used or modified for many of the purposes these three systems represents. However, the different actors have chosen to develop and implement separate system based on different standards, technologies and frameworks. The challenges that occurs due to fragmentation, enhance the complexity of the HIS which makes it hard for the health authorities to plan forward (Braa & Sahay, 2012). To grasp with this challenge, an architecture is needed to understand how the components of the HIS should work together and evolve in a flexible structure. Managing this enables the HIS to incorporate new changes seamlessly (Braa & Sahay, 2012). However, developing architectures should not be seen as a solution to any problem, but an approach for managing complexity (Braa & Sahay, 2012).

4.2 Health Information Systems in Developing Countries

The previous section shows that HIS in not necessarily primarily about technology, but rather a collection of varying components consisting of human and nonhuman actors. The collection of components aim at improving the service delivery and health outcomes. However, it is important to recognise what role the technology can play. The technologies are introduced to collect, report, and analyse health data to take better, and informed decisions. In public health, decision-makers are dependent on the timely availability to sound data that are presented, communicated, and disseminated to them which changes their understanding of health issues and needs (AbouZahr & Boerma, 2005; Health Metrics Network, 2008). Information must therefore flow to where it is needed for action (Mumford, 2006). Better information contributes to make better decisions, which makes the decision-makers knowledgeable about all possible choices (Braa & Sahay, 2012).

Information may be used in a variety of ways within a dynamic social context (Braa & Sahay, 2012). To make informed decisions, relevant information must be collected; many HIS of today are collecting a substantial amount of data, where more data are reported than would be regarded as needed (Braa & Sahay, 2012). However, the main goal is to report enough sound data so that HIS are able to generate, analyse, and disseminate this data to support the decision-making processes (AbouZahr & Boerma, 2005). Many HIS in developing countries tend to be
“data-rich” but “information poor” (Health Metrics Network, 2008, p. 42). This is often a consequence of the belief that raw data can be used directly to make decisions without making it accessible for users to generate information for decision-making; “High-quality data stored in a well-structures repository is of little value if it cannot be accessed by users to generate information for decision-making” (Health Metrics Network, 2008, p. 43). A well developed, and structured, technology is therefore necessary for users to access, and generate, information for decision-making.

4.3 The Health Commodity Supply Chain

Per Village Reach’s study from 2012, existing systems for health commodity distribution is struggling with meeting the demand of medical supplies. As the anticipated future are requiring more medical supplies, improving these systems is important to improve the supply chain in public health (VillageReach, 2012).

A typical distribution model for medical supplies in developing countries are characterised by a structure where the distribution is organised by one source to many locations. Strengthening the supply chain often comes from the top of the chain, where the commodities are in ‘bulks’ at a limited number of locations where few personnel are involved. Inventory is broken into smaller parts the further it goes down the supply chain, and managed by more personnel at several locations (VillageReach, 2012).

Over the years, various models for distribution of health commodities are developed. In the next section, I will describe four models that are practiced in developing countries.

4.4 Distribution Models for Health Commodities

There are several ways of distributing health commodities in a supply chain. The choice of distribution is usually determined by Ministries of Health, and is often context-dependent. There may be several distribution models practiced at the same time within a health structure or system.
4.4.1 The Pull-based model

One common distribution model is the pull-based model. According to Management Sciences for Health (2012b), a pull-based distribution model is in which each facility “determines the medicines quantities to be requisitioned from the procurement unit or warehouse.” (p. 22.16).

The process in the model is that the consumers, such as health centres, dispensaries, and facilities, are ordering the health commodities themselves based on needs. The order is sent from the facility, electronically or on paper, to the suppliers. In some situations, the order is bypassing a district office for further control before it is being sent to the suppliers. The order is proceeded by the supplier, and in most cases, delivered by them to their respective recipient.

In a pull-based model, each level of the health system determines what types and quantities are that are needed. They are then placing orders to the supply source. The system is also referred to as an independent demand or a requisition system (Management Sciences for Health, 2012b). When following a pull-based model, the managers of facilities are supposed to work out their own demands estimates and buffer stocks. Figure 5 show the overall processes in a pull-based model. The flow of the orders is going upstream, and the supplies downstream. The orders are managed electronically from the district-level and up, and either electronically or by paper from the facility-level.

Distributing commodities in a pull-based model is, according to (Management Sciences for Health, 2012b), favourable when;

a) The lower staff are competent in managing inventory and estimating needs
b) When there are sufficient supplies at the supply sources
c) A large range of products is being handled
d) Field staff members are regularly supervised, and performance is monitored
e) Good data are available to decision makers
Otherwise, if accurate information about needs exists or cannot be obtained, other distribution models should be considered.

### 4.4.2 The Push-based model

The push-based system is a distribution model where commodities are pushed to facilities on pre-determined terms. The terms are set by the higher levels of a health systems, such as an organisation (usually a governmental organisation, hereby referred to as supply sources). The Management Sciences for Health (2012b) describes the push-based distribution model “in which the procurement unit or warehouse determines what medicine quantities to be issued to the facilities.” (p. 22.16).

The push-based model can be useful in situations for disaster relief and when the pipelines for supplies does not function throughout the levels of the health system. In some situation, countries are practicing both a push- and a pull-based model, where primary health commodities are issued routinely, while district and regional hospitals are managing their own needs (Management Sciences for Health, 2012b). Changing from a push-based model to a pull-based model seems to be ideal, but is not always an easy task. It often requires complex changes in inventory management, warehouse operations, and distribution (Management Sciences for Health, 2012b). Figure 6 displays the overall processes in the push-based model where the flow of supply is downstream without any flow of orders, as displayed in figure 5 and the pull-based model.

![Figure 6: The overall processes in the push-based distribution model](image-url)
A typical push-based model, and the most known example in health commodity supply, is the ration kit system (Management Sciences for Health, 2012b). The pharmaceutical kits contain selected medicines and medical supplies, also referred to as tracer products (Management Sciences for Health, 2012a). The purpose of the kits, the quantity, and the range varies according to the situation (Management Sciences for Health, 2012a). Issuing kits are usually done in emergency situations, for example in a disease outbreak, but also in some situations for regular supply. In Kenya, for instance, they have since the early 1980s distributed kits to facilities as a part of its regular health commodity distribution model. However, the kit system has led to poor inventory control systems, and additional medicine orders that are issued may not be based on real consumption data, but on educated guesses and estimates (Management Sciences for Health, 2012a). Differing in distribution between districts in Kenya has therefore lead to overstock at some facilities, that should in theory be redistributed to other facilities that experience stock-outs. Weak infrastructure and transportation challenges made the redistribution difficult (Management Sciences for Health, 2012a). The kit systems still have some potential advantages; simplified budgeting (pre-determined kits with standard costs), procurement, storage and supply management; scheduled delivery intervals leading to more secure delivery to rural facilities, etc. (Management Sciences for Health, 2012a).

As pharmaceutical supply conditions are improving, shifting from a push-based model to other, more flexible, distribution models may be possible. More information about health is available now compared to what was available when, for instance, the kit distribution model was introduced in Kenya in the 1980s. However, shifting to another more flexible distribution model requires that financial and managerial capacities exist to maintain sufficient flow of health commodities to fill the individual orders (Management Sciences for Health, 2012a). A shift in distribution model also requires a reliable and complete information system. The information system should, at a minimum, monitor the number of patients treated, medicine consumption, and morbidity patterns. This is data that can help to determine whether there is sufficient management capacity to change to a pull-based model, or if a more advances push-based model should be considered (Management Sciences for Health, 2012a). A more advanced push-based model, the informed push model, are described in the next sub-section.
According to (Management Sciences for Health, 2012b), a push-based system is favourable when:

a) Lower level staff at health facilities etc. are not competent in inventory management

b) Where accurate information about needs does not exists, and cannot be obtained

c) When demand is exceeding supply, making rationing necessary

d) A limited number of products are being handled

e) When disaster relief are necessary, or when the situation calls for an immediate short-term supply through pre-packed kits
4.4.3 The Informed push model

The informed push model is a model adapted from the commercial sector. It uses trained staff and drivers that monitor and restock commodity inventory at health service delivery points and in low, or middle, income countries (Reproductive Health Supplies Coalition, 2014). The commodities are distributed on a pre-determined schedule without an order from the lower levels of the supply chain (SIAPS, 2014). The distribution is based on information from the lower levels, such as health facilities, that are collected from the trained staff or drivers.

The informed push model allows for greater visibility into the consumption of commodities. The data is reported upstream, who are using it to make further managerial decisions for the supply chain. The informed push model has proven effective in many countries for capturing data from the facilities. It is shown in results of reduced stock-outs for a range of products and that health workers can devote more of their time to clinical care (Reproductive Health Supplies Coalition, 2014). The overall processes of the informed push model are illustrated in figure 7, showing the stream of consumer information, orders, and the supplies.

The informed push model is, for instance, implemented in Senegal. Here, drivers are visiting sales points on a regular basis, topping up the storages. At the same time, they are collecting data about quantities sold and what products and sites that are most popular. In that way the warehouse can ensure sufficient stock and keep up with the demand and reduce the risks of stock-outs (Reproductive Health Supplies Coalition, 2014).

The advantages with the informed push model is that it relies on trained delivery teams to collect data about consumption and stock-levels. It does not require health facility staff to be trained or supervised in the same degree as when practicing other distribution models. The informed push model has also been proven more cost-effective through costing studies than other distribution models as well. This is despite the large amount of investments in vehicles, drivers...
and technical staff required and the ongoing costs such as fuel, maintenance, and ongoing training of delivery teams (SIAPS, 2014).

An informed push model should be considered when there are a limited number of commodities that have a relatively steady demand, and where adequate stock is available. Commodities with an unsteady demand are less conductive to a system with predetermined minimum and maximum stock levels. In situations where there is not sufficient supply to meet the demand, and rations must be made, the informed push model may not be a suitable approach (SIAPS, 2014).

### 4.4.4 The Vendor-Managed Inventory model

The Vendor-Managed Inventory (VMI) model is an approach that has been developed for the commercial sector and has been extensively used here (Reproductive Health Supplies Coalition, 2014). The principles from the VMI models is also practiced in public health settings, for instance in Zimbabwe (Reproductive Health Supplies Coalition, 2014). Where the VMI system is practiced in public health, there are usually three parties connected to each other; the VMI partner, the customer and the custodians. The customer is the custodian of the inventory. The custodian may include central medical stores, regional warehouses, and health service delivery points and clinics (USAID | DELIVER PROJECT, 2012). The custodian is the ones receiving physical possession of stock from the VMI partner. They are responsible for the storage, disbursement, and stock receipt. The customer is the agency that enters into a contractual relationship with the VMI partner, and has the oversight over the custodian facilities or as the agency responsible for funding the health commodities. Often, in public health, the customer includes Ministries of health (country government), health department, or funder. The VMI partner is the one responsible for managing the stock at the custodians’ location, and is an external third party to the customer (USAID | DELIVER PROJECT, 2012). The VMI partner monitors and maintains the quantity of commodities at the custodian location and decides the timing and amount of stock to be replenished.
The VMI model works as opposed to the pull-based model, where the custodian themselves are placing orders and determines its size and timing (USAID | DELIVER PROJECT, 2012). One of the benefits of the VMI model, is that the VMI partner has the responsibility of supplying commodities to the custodian. The custodian provides the VMI partner with information about the inventory needs and consumption rates, as well as further plans for changes in the health services. This is particularly important because the last mile of distribution is the first mile of information, meaning that the lower levels of the health systems are the last mile of distribution but where the information about consumption, stock-balance etc. are collected from – in other words the first mile of information (VillageReach, 2012). To illustrate the actors in the VMI model, figure 8 is provided.

![Figure 8: The parties in the VMI distribution model and their roles in the supply chain](image)

The lack of infrastructure at the last mile of distribution makes the VMI system a favourable approach. Infrastructural challenges limit the availability and quality of information about the needed medical supply at the lower health system levels. Instead of managing this at the lower levels, they provide the VMI-partner with the information and shift the responsibilities of health commodity management to them. The vendor has more time and options to estimate needs of medical supplies, and to fill up the storages at the lower health service levels (USAID | DELIVER PROJECT, 2012). Discrepancies in inventory can also be identified earlier when giving the vendor more responsibilities (USAID | DELIVER PROJECT, 2012). For instance, the VMI partner can manage the stock, based on the custodian information, so that none of them experience any serious stock outs.
In supply chains where the case has been the opposite, where the vendor receives orders from the custodians, some challenges have emerged. For some, it has resulted in a crisis for the vendor and the entire supply chain (USAID | DELIVER PROJECT, 2012). In situations where the vendors have received orders from the custodians, the custodians were already having shortages. In supply chains where distribution models opposites to the VMI model are practiced, the vendor has little or no visibility into the custodians’ need. They are then unable to keep up with the demand. The effects of practicing the VMI model are explained in figure 9.

![Figure 9: Effects of the VMI distribution model (USAID | DELIVER PROJECT, 2012)](image)

Drawing links to the expenditures related to procurement, practicing a VMI system of health commodity distribution has some advantages; the custodian enables the vendor to plan their operations better, making the vendor more aware of the custodians’ needs. This contributes to driving the costs of commodities down. The vendor no longer has to use more resources on managerial activities than absolutely necessary (USAID | DELIVER PROJECT, 2012).

The processes of the VMI model has proven successful in several public health settings, referring to the Zimbabwe case (USAID | DELIVER PROJECT, 2012). It has also proven successful in public health settings where the VMI partner was a central medical store. A summary of the benefits of the VMI model is shown in figure 10. The improved visibility into the stock and consumption patterns in the lower levels contributes making the vendors take proactive measures, instead of reactive steps to address the issues (USAID | DELIVER PROJECT, 2012). Lower tier facilities have a poorer infrastructure and less personnel than higher level partners. It is, therefore, harder to establish sufficient stock management skills at the lower levels. Shifting the responsibility from the facilities to the higher level, and to more resourceful partners, should produce more accurate and timely replenishment. The broad outcome; greater health care delivery at the lower tier facilities, because the health workers can...
devote more of their time to health care services.

Figure 10: Expected benefits of the VMI distribution model (USAID | DELIVER PROJECT, 2012)

4.5 A framework for Informational Needs for the Different Levels of the Supply Chain

The distribution models presented above sets certain requirement for the need of information when making decisions about health commodity procurement. To get an overview of these informational needs in each distribution model at each health level, this chapter provides a framework that describes these informational needs.

The framework is developed with the aim of answering the research question in the discussion. In addition, the framework can be used in contexts such as developing countries, to distinguish where and when information is needed in different supply chain contexts. Furthermore, the results of using the framework in analysis can also contribute to determining requirements for the information systems for supply chain management, as the information systems often provide, or should provide, these informational needs to the actors in a supply chain.

Furthermore, the results of using the framework to define informational needs, is also useful when investigating if the information systems for logistic management are enabled or constrained by the information infrastructure they situate in. As presented, many health information systems are fragmented in developing countries. This may be a result that a variety of such information systems are implemented to suit the informational needs within health. One reason for this is that the information infrastructure is putting constrains at the development and implementation of the information systems for health management. The information systems may, therefore, struggle to provide the informational needs in a supply chain.
Table 5, at the next page, displays the framework developed, where the informational needs are presented for each combination. The framework can be outline as follow: Information needs in the;

1. The pull-based model at facility, district, and national-level.

2. The Informed push model at facility-, district-, and national-level.

3. The push-based model at facility-, district-, and national-level.

4. The Vendor-Managed Inventory model at facility-, district-, and national-level.

The informational needs may not be applicable in all the distribution models and health levels. Only two of the distribution models where discovered in Tanzania. However, informational needs are outlined for all four distribution models by making assumption based on the theory of distribution models.

The framework is divided into the health hierarchies facility-, district-, and national-level. The reason for this is that in a supply chain, each of them has certain informational needs when managing the supply chain. Especially when procuring health commodities.
<table>
<thead>
<tr>
<th></th>
<th>Facility-level</th>
<th>District-level</th>
<th>National-level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pull-Based Model</strong></td>
<td>Consumption, stock balances and capacity, population data, and information about finance provided from the national-level.</td>
<td>Information from the facilities about procurement. From national-level; financial information for procurement.</td>
<td>Facility-, and district-information about procurement</td>
</tr>
<tr>
<td><strong>Informed Push Model</strong></td>
<td>Consumption, stock balance and capacity (minimum and maximum)</td>
<td>Information from the facilities, financial information for procurement from the national-level. Population data to estimate the size of the orders.</td>
<td>Procurement information from the districts, financial information for procurement</td>
</tr>
<tr>
<td><strong>Push-Based Model</strong></td>
<td>Unaware of information needs at this level.</td>
<td>Unaware of information needs at this level.</td>
<td>Size of the kits to distribute. Information of disease surveillance</td>
</tr>
<tr>
<td><strong>Vendor-Managed Inventory Model</strong></td>
<td>Consumption over time and stock on hand, overview of further changes in health services</td>
<td>Consumption over time and stock on hand, overview of further changes in health services</td>
<td>Consumption over time and stock on hand, overview of further changes in health services (for the supply store). Funding information.</td>
</tr>
</tbody>
</table>

*Table 5: The framework of informational needs for the different health levels in a supply chain, considering what distribution model practiced*
5 Empirical Findings

The purpose of this chapter is to present the empirical findings from the field trips to Tanzania, and the information provided in this chapter are mostly originates from the interviews and observations conducted. We were a group of researchers that travelled to, and gathered data, from densely and sparsely-populated areas of Tanzania. The sparsely-populated areas we visited were about 60 km from the city centre of Dar es Salaam. The data presented below may not be representative of all rural areas, but gives an indication of how the Health Commodity Supply Chain (hereby addressed as supply chain) management situation are in areas where people are less densely-populated than in the urban, and more densely-populated areas.

First, the chapter present a section describing the financial information of health commodities in Tanzania. Included are two sub-sections describing two different settings of in financial management; financial management of health commodities in the densely-populated areas of Tanzania, and then in the sparsely-populated areas. Furthermore, the next section provides the empirical findings related to how population data are used in the supply chain management in Tanzania. The following sections presents the LMIS of Tanzania, which is followed by a section describing the HMIS in Tanzania. In addition, a section describing how the stock are managed in the Tanzanian supply chain are provided before the next section presents some findings related to the infrastructure in Tanzania.

5.1 Financial Management of Health Commodities

During the field trips to Tanzania, I discovered that the management of finance related to procurement of health commodities is not equal at all the facilities and district offices. I quickly understood that understanding the financial management for procurement of health commodities are difficult, and obtaining an overview was challenging. There seemed to be misunderstandings or limited knowledge about it. In some situations, the participants gave an impression that access to financial information about procurement of health commodities at facilities are not present, nor used in managerial activities.

Despite this, there were some participants that mentioned situations where the supplies of health commodities are smaller compared to what initially ordered. This happens mainly because of

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4 Includes health centres, hospitals, dispensaries
inadequate funding. One factor that increases the risk of this to happen is the limited, or no, use of financial information related to procurement in the logistics management. Thus, there seems to be an overall understanding that this is how it is sometimes. If it happens, one simply must deal with it in some way.

Shortly described, these situations occur when the facilities are placing an order via the eLMIS through their respective funds deposited at the Medical Store Department (MSD), or via R&R forms, to the MSD. The information in the order is control-checked by the district office and then sent to the MSD. Usually, when a facility is placing an order of health commodities, they are unaware of the status of the budget for procurement. These budgets are managed and monitored by the MSD, and available at the district offices for managerial purposes. The district office can reduce the order to fit the current budget for the facility, based on the information provided to them by the MSD. The MSD can do the same. The challenge is that the facilities are not notified if the order of health commodities is reduced. This comes to their attention when the supply of health commodities is delivered at the facility. Along with the supplies, there is a distribution information notice which informs the facility about the status of their current budget for procurement. However, some of the participants at the facilities said that this information is rarely, or ever, used for any further decision-making.

The facilities must deal with the challenges that emerge in these situations. A smaller delivery of health commodities compared to what originally ordered, may result in a lack of some health commodities when providing health services. To cover the missing health commodities, some facilities use financial assets from other sources; some facilities are following the cost-sharing principle. This principle is about using funds collected from patient fees to cover the rest of the needed health commodities. At some facilities, the patients are paying a deductible for certain kinds of treatment or medicines. The funds are sometimes used to cover the cost of so-called
emergency orders that are placed to fill up the storage with the rest of the needed health commodities. The emergency orders are placed whenever they see a need for it.

Another interesting finding is that vaccines are managed differently compared to other health commodities. How finance is managed for procurement of health commodities varies depending on the type of commodity. Commodities included in the eLMIS are all dealt with similarly when managing finance for procurement. Other health commodities that are not in eLMIS may be managed differently. The vaccines are not in eLMIS and managed in other systems with different financial management procedures (described in sub-sections 5.3.4 and 5.3.5). The funds for procurement of vaccines are governed and managed by the Ministry of Health, Community Development, Gender, Elderly and Children (hereby addressed as Ministry of Health - MoH). The budgets are calculated and directed by them using target population\(^5\) for

\(^5\) See section 5.2 for more about the use of target population in management processes
each district. Based on the empirical findings, there is an impression of inaccuracy in these budgets; more people consult healthcare to get vaccinated than the target population suggests. This may be an indication that the population data are outdated.

The next two sub-sections provide an explanation of the financial management for densely and sparsely-populated areas, and for all the health system levels in Tanzanian. I discovered that the financial management of health commodities differs depending on what type of distribution model that are practiced. I came across two models; one practiced in densely-populated areas and another in sparsely-populated areas. In the densely-populated areas, they practice a pull-based distribution model, where they in sparsely-populated areas practice an informed push distribution model. The De facto procedure is that all facilities in Tanzania are supposed to follow the pull-based distribution model for health commodities and follow the same procedures when managing finances for health commodity procurement. However, this is not the case, meaning that the financial management of health commodities are ambiguous.

In Tanzania, it is mainly a pull-based distribution model for health commodities where the facilities are ordering health commodities based on demand. This model is supposed to be an approach that is practiced nation-wide. However, as I also came across the use of the informed push model in some areas, a nation-wide approach is not the case. We visited some sparsely-populated areas, where the facilities are substantially smaller than the ones in the more densely-populated areas we had visited earlier. At the facilities, they are counting the current stock balance of their health commodities, and the minimum and maximum stock balance in their storage. The district office receives this information and uses it in the process of ordering health commodities for the facilities via eLMIS. The district offices receive the health commodities and distribute them to the facilities. In areas of Tanzania where the informed push distribution model is practiced, the district offices receive supplies every third month from the MSD. In addition to the information gathered from the facilities, the district offices use target population data to determine the amount of health commodities to order.

5.1.1 Financial management in densely-populated areas

This sub-section describes the financial management of health commodities in the densely-populated areas of Tanzania. The sub-section is divided into two parts presenting the data for the national-level, and for the district- and facility-level.
Financial management at the National-level

At the national-level, the MSD operates as the main supplier of health commodities. They use EPICOR9 (E9) to process health commodity orders from the facilities. The system monitors and manages the funds for procurement per facility, where each of the facilities has their respected budget for procurement of health commodities. The budgets are directed by the MoH and provided to the MSD. The MoH calculates the budgets for each facility based on data about target population and data from procurement of previous year. It is in E9 at the MSD the main management of the budgets for the facilities is controlled.

The MSD experience that many facilities are in debt to them. For example, a facility budget may be at $100 when they place an order valued at $30. Then the current budget is at $70. The next order placed is then valued at $80, when they only have $70 left. When this happens, commodities with a value of $70 are distributed to the facility and the budget has then reached $0. A notification to the respective facility about the reduction of the order is not given. The facility gets to know the reduction when the order is delivered to them. When the next order of health commodities is received by the MSD, the entire value of the order is debited, making the facility in debt to the MSD. If the debt is too large, the MSD stops sending the orders to the facilities. However, the facilities are monitored by the MSD so that they always have a list of prioritised health commodities available. This list of health commodities is funded by governmental assets.

Health commodities that are managed by separate health programmes in Tanzania (at the national-level), are distributed by the MSD to the facilities without any cost for the facilities. These health commodities are then funded by the health programme.

Financial management at the district- and facility-level

At the district offices located in densely-populated areas, they quality-check the data received in the eLMIS from the facilities (for the facilities using the eLMIS) or types in data from R&R forms into the eLMIS. This process will be further elaborated in sub-section 5.3.1.

When managing orders in the eLMIS, the district offices are provided with updated budget information from the MSD. This is done on a regular basis, but the district offices are not allowed to manage it in any way. The budget is received independently of the eLMIS, which

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9 Enterprise Resource Planner system used at the Medical Store Department in Tanzania
originally was developed with a finance module. This module is not in use for managing and sharing the financial information for procurement of health commodities between the users of the eLMIS. The information about the budgets is used in the management, such as for reducing, or increasing if necessary, an order of health commodities received from a facility before it is sent to the MSD. If an order is reduced, or increased, the facility is not notified about it until the order are received by them. A distribution information notice, inform them about their current financial status, and are delivered along with a health commodity delivery.

At the facility-level, financial information for health commodity procurement is not widely used for decision-making processes. Many of the facilities are in debt to the MSD, and they are seemingly not using the already existing and available financial information for managerial purposes when ordering health commodities. The result is orders of health commodities that are being reduced by the district offices or the MSD. The facility must deal with these situations, either by reducing the treatment rate or manage to procure the missing health commodities one way or another. One way of dealing with it is via the cost-sharing principle, described in section 5.1.

Using funding from patient fees, or from other sources, the facilities can procure health commodities from other suppliers than from the MSD. However, this is only allowed when the MSD are out of stock for some reason. Prior to this governmental law, they could order from wherever they desired. This raised an issue where many facilities paid more than necessary for health commodities compared to what they would have done if procuring from the MSD.

5.1.2 Financial management in sparsely-populated areas

This sub-section describes the financial management of health commodities in the sparsely-populated areas of Tanzania. The sub-section is divided into two parts presenting the data for the national-level, and for the district- and facility-level.

Financial management at the national-level

Without any further empirical findings of financial management at the national-level for the sparsely-populated areas, it is supposed to be managed similarly as for the densely-populated areas. However, the financial management of health commodity procurement at the lower levels are different in sparsely-populated areas compared to densely-populated areas. The sparsely-
populated districts we visited were practicing an informed push distribution model, where the flow of financial information for logistic from the national-level stops at the districts. Drawing on this information, it is reasonable to believe that the MSD are managing the budgets for health commodity procurement per district for sparsely-populated areas, and not per facility as in densely-populated areas.

Financial management at the district- and facility-level
The district offices in sparsely-populated areas are the ones that hold the responsibility of health commodity procurement for the facilities in the district. They use the eLMIS, and use information collected from the facilities in combination with target population data. What information that is used is explained in sub-section 5.3.1. When comparing to the procedures for managing financial information in densely-populated areas, the district offices in sparsely-populated areas are managing the health commodity budget entirely for the district. The facilities do not have their own allocated budgets. The financial information flows only down to the district-level.

At the district office, they are like in the densely-populated areas, regularly provided with the status of their current budget for procurement from the MSD. This is not shared via eLMIS, but outside the information system. Some of the districts we visited that practices an informed push distribution model, are usually not ordering more health commodities that they can afford at any given time. However, there was never an issue with a lack of funding in these areas, and they could always order the quantity needed or desired.

The facilities in sparsely-populated areas are simply counting their stock and consumption of health commodities before providing it, along with maximum and minimum stock capacity, to the district office. This information is not used for any managerial activities at the facilities. In fact, managerial activities for logistics are limited at these facilities except updating the number about the stock on hand etc. and when redistribution between the facilities (which is conducted by communicating via phone).

5.2 Population Data and Forecasting
Population data is used for several purposes in the logistic management of health commodities in Tanzania. The MoH use it when calculating the budgets for procurement of health
commodities for the facilities. Each of the facilities in Tanzania has their own allocated budget when ordering of health commodities. Population data is also being used for forecasting at the MSD and at the district offices for determining the number of commodities to order.

The population data is calculated by the Tanzania National Bureau of Statistics (TNBS). They are calculated based on the location of a facility or a district, as well as its surroundings. Census data from the TNBS are available from 1978, -88, 2002, and -12 (Tanzania National Bureau of Statistics, 2017; USAID | DELIVER PROJECT, 2011). There are no census data for later than 2012, which indicates that the population data for 2017 may be significantly higher compared to data from 2012.

In one district we visited, they were using population data when distributing vaccines to the facilities. Because vaccines are managed differently to other health commodities (see section 5.1), they are distributed from the district to the facilities. When distributing, they calculate the number of vaccines to distribute to each facility based on each facility target population data. A participant in charge of the procurement and distribution of vaccines informed us that the population data often seem to be incorrect; it frequently occurs that more patients are coming to get vaccinated compared to what the target population indicates. Thus, the facility will not have enough vaccines to vaccinate all their patients. There is no specific strategic plan to handle these situations, but they try to handle them when they happen. The long-term effects of this are unclear.

5.3 The Logistic Management Information System

There are several information systems for logistic management of health commodities in Tanzania. The information systems are usually developed based on different interests or for different purposes, but do often have similar or overlapping functionalities (Nielsen & Sæbø, 2016). The common factor is that their main function is to manage the logistic of health commodities. One of these information systems is the eLMIS. This is the most commonly used information system within the LMIS in Tanzania.

5.3.1 The eLMIS and procurement of health commodities

One of the nation-wide LMIS of Tanzania, the eLMIS, are developed by John Snow Inc. It is used at the facility-, district-, and the national-level in different aspects. This sub-section
presents the use of the eLMIS at all health levels in Tanzania. In addition, it describes the overall process of health commodity procurement to provide an overview of the flow of information within the supply chain management and in the eLMIS.

As mentioned in the previous section, we discovered two distribution models for health commodities in Tanzania. The use of the eLMIS, and the overall ordering process of health commodities, differs depending on the type of distribution model practiced. Procedures in the two models discovered will be elaborated.

It is only a selected set of health commodities that are managed in the eLMIS. Other health commodities can be program-specific health commodities or essential commodities managed outside the eLMIS. If not explicitly stated otherwise, this sub-section addresses health commodities managed in the eLMIS.

The facility-level
Only selected facilities⁷ are using the eLMIS because of infrastructural challenges such as an unsteady power supply or no Internet connection (even though it can function offline⁸). The eLMIS are only used at the facility-level where there is a pull-based distribution model, because facilities are ordering health commodities based on need and complete the order themselves.

The facilities that not use the eLMIS for health commodity procurement, but still practice the pull-based distribution model, are filling out the so-called R&R forms. This is a paper-based system that is used to report and require health commodities. The forms are filled out every quarter, and distributed or collected by the district offices for further processing.

In areas where there is practiced an informed push distribution model, the eLMIS are used down to the district-level. The facilities are not using any information system for ordering health commodities, because the process is managed by the district office. This approach eliminates the procedure of filling out R&R forms, or procuring in the eLMIS, at the facilities. These facilities are reporting information about inventory to their respective district office that manages the procurement.

The district-level

⁷ The eLMIS are only used at facility-level in one district in Dar es Salaam, Tanzania
⁸ Only needs Internet connection to send the data to the health commodity supplier
All the district offices in Tanzania are using the eLMIS for reporting and requiring health commodities. Dedicated workers at the offices, such as district pharmacists, are typing data collected or retrieved from the facilities into the eLMIS (except the facilities using eLMIS themselves). The data reported are the data from the R&R forms filled out by facility-staff. This process is conducted every quarter. If the facilities within the district are using the eLMIS for reporting and requisition themselves, the district offices are only supervising and control checking the data instead of typing it in themselves. This control check is seen through to improve data quality. The district staff compares the data in the forms to previous data reported at the facilities and checks if it is some irregularities or misunderstandings that must be clarified before they are typed into the eLMIS. For instance, some data can be rather different compared to previous data reported by the same facility from other reporting periods.

After the control check, the data from the R&R forms are reported into the eLMIS. When completed, the order of health commodities is automatically sent to the MSD for further processing. When reporting and requiring in the eLMIS, the district office staff first choose the facility, then select if the order is a regular order or an emergency order, and finally selecting the date of the order. The data form in the eLMIS contains a start balance for the health commodities, the number of health commodities received, losses, and expired commodities (or if they are redistributed to other facilities). The closing balance is also included in the form. These data are the data that constitutes the reporting part of the report and requisition process.

In areas where an informed push distribution model is practiced, the use of eLMIS is a bit different at the district-level compared to the processes described above. The district offices use information gathered from the facilities, in combination with target population for each facility, to determine the size of a health commodity order. The order placed by the district office are calculated to cover the facilities in the entire district. The order is sent to the MSD, which distributes the health commodities to the district office, which manages the distribution to the facilities.

**The national-level**

When an order is received by the MSD, it is manually processed into their LMIS, the EPICOR9 (E9). In one of the MSD located in the region of Dar es Salaam (per empirical findings January 2016), it is since 2014 tested an interface that supports automatically forwarding of orders from
the eLMIS into E9. Otherwise, staff at the MSD must type in data from the eLMIS manually into E9 by printing out R&R forms from the eLMIS and copy the data into E9.

To make the process more effective, the MSD in Dar es Salaam were provided with an interface from the government with the aim of automatically forwarding the information from the eLMIS into E9. However, the interface was too slow to function effectively; it took 5 days to process about 200 orders. Thus, they developed their own interface. The interface has since its first pilot in November 2014 met the requirements set. The interface is only supporting one-way communication, from the eLMIS to the E9. In the future, they want an interface that supports two-way communication between the information systems. This is particularly useful for comparison of data, such as stock data etc. The reason why the implementation of a two-way interface is not in place now, is mainly because of time and funding constraints.

When an order is processed by the MSD, and the health commodities are ready to be distributed, they send them out directly to the facilities using their own transportation vehicles. This is only applicable for areas with a pull-based distribution model. Where there is an informed push model, the health commodities are distributed to the district offices for further distribution to the facilities.

To manage to distribute the health commodities to all the 6,000 facilities in Tanzania, it is developed a staggered reporting structure for the facilities in eLMIS (Supply Chain Technical Resource Team & UN Commission on Life-Saving Commodities, 2016). The MSD are not able to process all the orders at once every quarter without this structure. To manage it, the facilities are divided into three groups; A, B, and C. Each group are submitting a quarterly report and requisition that covers the three months prior to the group’s reporting month. For instance, group A reports in January, B in February, C in March, and so forth. In that way, one-third of the health facilities are reporting every three months. By practicing this reporting structure, the MSD can process all the health commodity orders from the health facilities at any given time, and distribute them to the facilities. The staggered reporting structure minimises the risk of delays.

Figure 12 shows the procurement process for health commodities in areas where there are a pull-based model and an informed push distribution model practiced. The processes in the pull-based model include that the facilities place an order in the eLMIS or via the R&R forms. This is done quarterly. If they use the eLMIS, the order is directly forwarded to the supplier, and is
only viewed for control-checking of the data at the district office. If they use the paper based R&R forms they are sent to, or picked up by, the district office, control checked, and then typed into the eLMIS by staff at the district offices. The order is then processed by the supplier and distributed to the facilities by the supplier.

The processes in the informed push model include that the facility first manages their stock; They count the stock balance, the consumption, and the maximum and minimum stock capacity. This information is provided to the district office which uses it, with target population data for the facility, to place an order via the eLMIS. The order is sent to the MSD for further processing and distributed by them back to the district office. The district office is then distributing the health commodities to the facilities.

**Report & Requisition forms**

Besides technological information systems, the facilities are also using a paper-based system; the R&R forms. An R&R form is a paper form that the facilities, which are not using the eLMIS or other digital information systems, use when reporting and requiring health commodities. The R&R forms are distributed to the facilities respective district office. They control-check the
data in the R&R forms, usually conducted by a district pharmacist, to check if there are any mismatches or errors. Possible issues are sorted through with the facilities, often via phone. When the data are verified, they are typed into the eLMIS which processes the data to the suppliers. Figure 13 shows an example of an R&R form for Antiretroviral and Opportunistic infections.

![Example of an R&R form for Antiretroviral and Opportunistic Infections that is printed out from the eLMIS](image)

**Figure 13:** Example of an R&R form of medicines for Antiretroviral and Opportunistic Infections that is printed out from the eLMIS

### 5.3.2 ILS Gateway

In addition to the eLMIS, the ILS Gateway is implemented in the country. The ILS Gateway is a mobile reporting and requisition service. It was launched in 2010, and first included six family planning commodities. It later expanded to 10 commodities, and consists today of 20 health commodities. The information system is SMS-based; it functions as an alert system for 4,616 facilities in Tanzania (per 2016) by reminding health care workers to submit their report and requisition forms (R&R). The ILS Gateway also provides district managers with visibility into their supply chain performance, which includes the status of the stock of health commodities at the facilities they are supervising (USAID | DELIVER PROJECT, Task Order 4 et al., 2016).
5.3.3 EPICOR9

As mentioned in the sub-section 5.3.1, the MSD are using an ERP information systems named EPICOR9 (E9). The orders are received via the eLMIS and the MSD staff prints out R&R forms and types the data manually into the E9. At one region in Tanzania, the Dar es Salaam region, it is developed a ‘one-way’ interface between eLMIS and E9 for the information to flow automatically from eLMIS to E9. However, a backward interface is not in place, meaning that transferring information from E9 to eLMIS is not possible. During our visit at the MSD, they informed us that a new interface was under development and testing in the same region using the current ‘one-way’ interface. The purpose of the interface is to support a both-way information sharing between eLMIS and E9.

5.3.4 Managing logistic for the cold chain

The logistic management for medicines that needs to be kept cool, the so-called cold chain, uses specific information systems developed for this specific purpose. The cold chain management in Tanzania are using three information systems for the management; the District Vaccination Data Management Tool (DVDMT), the Stock Management Tool (SMT), and the Cold Chain Inventory Tool (CCIT). The DVDMT is a Microsoft Excel-based reporting tool for the use of vaccines at facilities, and is used at the district-level. At the facility-level, they are typing the data into a paper-based information system that further are typed into DVDMT by staff at the district offices. The SMT is a web-based system that initially was a Microsoft Excel-based system that, in 2014, was developed into a web-based solution. The SMT has two components; one that manages the stock of vaccines and another that has the functionality of managing the equipment for the cold chain. The overall functionalities of the SMT are the ordering of vaccines, showing the status of the cold chain equipment, forecasting the demand, adjustment functionality, and other logistic operations. However, a separate system for cold chain inventory does also exists. The CCIT is an information system that monitors the status of the equipment for the cold chain storages. We did not come to a district office or facility, or other organisations, that used the CCIT. We were only informed that it exists; participants at the national-level said that it is introduced in all regions for monitoring the cold chain equipment at the facilities.

9 Possible if they have population data
5.3.5 The Immunisation Programme

The Immunisation Programme in Tanzania is involved in delivering safe vaccines for vaccine-preventable diseases such as measles, polio, tetanus, and tuberculosis. Considering LMIS, the Immunisation Programme introduced us to a new system for logistic management of vaccines. The information system, the Vaccine Information Management System (VIMS), is developed by John Snow Inc., with the aim of combining the functionalities of the DVDMT, SMT, and CCIT into one information system. It is built on the same platform as eLMIS, the open source framework openLMIS\textsuperscript{10}, but with added functionalities for cold chain logistic management. When visiting the Immunisation Programme in January 2016, the VIMS was planned and under development. The first implementation was expected in the first quarter of 2016. The information systems used for cold chain logistic management today are developed, and unique, to the Immunisation Programme needs. None of them are in use in other health programmes or supply chains, even though the data needs and use are similar to other information systems (John Snow, Inc. & JSI Research & Training Institute, Inc., 2017). For instance, the eLMIS was also designed with vaccines in mind. However, it is not used for vaccine supply management. The VIMS are a module within the eLMIS architecture, but with the functionalities that deliver the full requirement from the Immunisation and Vaccine Development (IVD) in Tanzania. Both the VIMS and the eLMIS are designed with APIs required to exchange data with the national HMIS in Tanzania, DHIS2.

5.4 The Health Management Information System

During the field trips to Tanzania, we discovered several different information systems at the different health levels. Some of them with the purpose of managing health information, the so-called HMIS. The DHIS2 is one of these systems, which operates as the national HMIS of Tanzania. We did not study the actual use of DHIS2 in detail, because researching the information systems for logistic management were the one of the main goals in these field trips. However, understanding some of the use of DHIS2 was relevant, related to where it is being used and by whom to understand its role in health management. The usage of DHIS2 will be further elaborated in the next sub-section.

\textsuperscript{10} See section 2.4.1 LMIS in Tanzania: the eLMIS
5.4.1 Usage of DHIS2

DHIS2 are in use in all the districts in Tanzania. It is the main national HMIS in coalition with some paper-based reporting forms where DHIS2 is not used. It is used by District Office Managers at the district offices, and other workers dedicated for entering data into DHIS2 at the district offices.

Reporting into DHIS2 is monthly where data from the facilities are entered by workers at the district offices. The facilities and dispensaries are using paper-based systems for health data reporting. The data are delivered by the facilities and dispensaries, or collected by workers from the district offices. The data are then typed in DHIS2 at the district office, which is stores it in a national database warehouse. If there are some issues with the data, the district office contacts the facility in question to clarify. This is an important process to minimise the risk of reporting data of poor quality. Irregularities can, for instance, be large differences in incidences compared to the previous month, such as an abnormal number of malaria incidences than usual for a certain month.

5.5 The Health Commodity Stock

This section provides the empirical findings related to the stock of health commodities. The section briefly describes the stock management, the status of wastage of health commodities, and finally a sub-section addressing stock-outs in Tanzania.

5.5.1 Stock management

Health commodities are counted by facility-staff every month to keep an updated record of usage. This is especially important in the sparsely-populated areas that practice an informed distribution model. In these areas, the district offices are reliable of timely and reliable data to order the proper number of health commodities for the facilities.

Some hospitals are also counting the stock every quarter and register the information in tally cards. The expiration date for the health commodities is checked as well to avoid providing poor-quality health commodities. If a facility has an overstock of a certain health commodity, it is sometimes usual to redistribute to other facilities that need them. At the MSD, they count the stock perpetually and annually. The numbers are registered in their ERP system.
Vaccines must be stored in cold temperatures, and should not be kept in warm temperatures for more than a short period. There are set a maximum level for how long each of the units at the health levels can store vaccines. The MSD can have six months of stock, the region (or zonal stores) and the districts can have four months of stock, and the facilities six weeks of stock. The stock count is usually manually, where the smaller facilities are counting the stock of vaccines at the end of every day. The counting includes the number of used vaccines, remaining vaccines, and possible wastage. This is registered in a stock information ledger.

**5.5.2 Wastage of health commodities**

Wastage of vaccines and other health commodities do happen in Tanzania. For instance, there are situations where BCG vaccines are discarded because it has a short expiration date. Some also report wastage of measles vaccines. Wastage of other vaccines and regular health commodities seems to be rare, but still happen from time to time. The information about wastage at a facility is registered in the eLMIS when ordering health commodities.

A District Immunisation and Vaccine Officer (DIVO) are responsible for monitoring, and making sure, that the wastage of vaccines is at a minimum in the respective district and its facilities. Based on the empirical findings, they are not registering data about wastage in any information system for vaccines. However, as the VIMS are under development, they are including a function for registering data about wastage. This will be sent to the regional-level and then to the national-level.
5.5.3 Stock-outs

Stock-outs do occur in Tanzania. However, they seem to not be caused locally at the facilities, but from when higher levels of the health system experience stock-outs. Some factors that cause stock-outs can, for instance, be if a certain health programme is running a campaign. This can, for example, be a campaign for immunising for measles. Measles vaccines may, therefore, run out after some time. However, it is not a large issue; if they remember to order more vaccines prior to the campaign than a usual order they can avoid a potential stock-out situation. Stock-outs of vaccines are mainly happening at the facilities (different from regular health commodities), and are rare at the higher levels. If it is a stock-out at the higher levels, there is usually a global stock out. If it is a stock-out at the higher levels, the facilities may not take affect from it, because they probably have filled up their stores with vaccines (which may be the cause of a stock-out at the higher level).

If there is a stock-out for health commodities or vaccines at the higher levels of the health sector, they are managed by the MoH. The district-level and facility-level often manage the stock-out situations themselves if they can and have access to other resources. Redistribution is one mechanism they frequently use to distribute the available health commodities (within a district, etc.). If the stock-out happens at a facility, they inform their respective district office about the situation, which tries to manage it in a best possible way. Informing the district offices are important, especially when there is a stock-out of vaccines, because they must be registered formally. The number of stock-outs is currently going down, with only 5% stock-out at facility-level. During one of our visits to Tanzania, we were informed about a stock-out situation of TT vaccines (tetanus) which was a national stock-out. There were also reported on stock-outs of medicines for opportunistic infections (OI).

The higher health levels, mainly the MSD, are struggling with some serious stock-outs from time to time. They sometime seem to not have a strategic plan in hand because of financial constraints; “How do you handle stock-outs, if you don’t have any money?” – Manager for Data Centre Development at the MSD. The stock-outs may be caused by forecasting issues. The ministry of health at Zanzibar, a part of the Republic of Tanzania, reported that stock-outs at facilities are mainly because of financial problems.

In relation to the information systems used for logistic management, there are reports of stock-outs that are directly caused by information system-related challenges. Because there are
several information systems for health commodity procurement in Tanzania, there is reported of situations where facilities and districts experiencing stock-outs because they ‘thought’ that they had ordered the specific commodity. However, because of misunderstanding about the ordering procedure, the specific health commodity was not ordered at all.

5.6 Infrastructure

The quality of the infrastructure in Tanzania varies depending on the places we were visiting and what season we were in. The term infrastructure can mean several things. In this matter, it includes the quality of roads, the presence and quality of electricity, general standard at the facilities, etc.

Road quality

The infrastructure in Tanzania is quite vulnerable during the rainy seasons. When the heavy storms and rain sets in, nature compromises the infrastructure which impacts the supply chain.

For instance, heavy rain main deform some of the many dirt roads which make transportation of health commodities costlier and time-consuming. Poor road quality is also taking a strain on the trucks delivering health commodities. The poor road quality increases the need for repairs and maintenance of the trucks. Many roads are unpaved and bumpy, as shown in figure 15 and 16.

Figure 15 and 16: Example of poor roads in a sparsely-populated area
The main roads passing through several rural villages in Tanzania is often used as transportation routes for larger trucks, because of the locally poor road quality at other alternative routes (and possibly shorter). Because there is often only one proper road connecting cities in Tanzania, a congestion of trucks and private cars often forms large queues on these roads. This may slow the transportation of health commodities significantly.

Generally, the infrastructure of Tanzania is of poor quality, especially comparing it with more developed countries. However, it is evident that it is under significant improvement due to new governmental priorities. In Dar es Salaam, road work was visible several places. For instance, outside the University of Dar es Salaam they started working on improving one of the main roads during our first stay in Tanzania in January 2016. When returning in August, it was finished and the road was improved significantly.

**Electricity**

39 percent of the urban population, and two percent of the rural population in Tanzania, has access to electricity (United Nation Development Programme, 2017). However, the power supply is not stable enough to keep a steady supply throughout the year. Power outs occur frequently. Most of them are usually only for a short period, but some may last for hours. The heavy rain, and storms, that occurs during the rainy seasons has a large impact on the frequency of power outs. The power grid is not good enough to cope with it. When visiting health centres etc., we noticed the constraints these power outs constitutes for the health workers as some tasks may be interrupted. For instance, at one district office visited, the power supply went down during the visit. Most of the workers at the offices used laptops and could continue their work with no problems. Most of the district offices also had mobile Internet routers that also can run on batteries for a certain period during power outs. Short power outs are therefore often not a large challenge, because their work are not disrupted. However, it constrains work when the power is out several hours. When this is the case, the work will eventually stop if they do not have a generator to supply them with electricity.

**Access to the Internet**

There were some concerns about the Internet access at some of the district offices we visited in Tanzania. Their concern was mainly about the reporting deadline for the delivery of the health commodity orders. The deadline is the 21st every quarter. If the Internet access were not
functioning for some reason, they are unable to deliver the order via the eLMIS. It is not a major problem, but happened from time to time.

Besides the reporting and requisition deadline for health commodities in the eLMIS, the Internet access does not necessarily always need to be operable to use the information systems. Both the DHIS2 and the eLMIS are automatically storing the session the workers are in, meaning that the work is not lost or in vain if the Internet access stops working. When it is operable again, the session is pushed to the servers.

All the district offices in Tanzania are (supposed to) have access to the Internet. Most of the time it is via the mobile network using mobile routers that run on batteries. Mobile connectivity to the Internet is often favourable simply because they are mobile, and does not always need to be plugged into the power outlet.
6 Discussion

In this chapter, the empirical findings and the literature presented will be discussed in light of the research question. The research question consists of one overall question, with two sub-questions:

*What is the role of financial information for procurement in the supply chain management at the lower health care levels in developing countries?*

  a) *What considerations for the logistic management information systems should be made to promote the role of financial information in supply chain management?*

  b) *What are the challenges with the existing situation, and the opportunities for improvement in the Tanzanian supply chain management?*

The discussion is based on the theoretical background presented in this thesis. The present research was designed to study the information systems for logistic management, the distribution models of health commodities, and the role of financial information when managing procurement of health commodities at facilities\(^{11}\).

The discussion addresses the research question in four sections. The first section discusses the informational needs of financial information for procurement, and especially focus on the informational needs at the lower health care levels. To address the informational needs, the discussions draws on theory and the empirical findings. The section discusses the needs in two distribution models discovered in the Tanzanian supply chain by using the framework described in section 4.5. Two other distribution models are also covered to discuss the role of financial information in other supply chain contexts that practice other distribution models than in Tanzania. The first sub-section in the first section covers the distribution models discovered in Tanzania, and the second two the other distribution models. The next section discusses the logistic management information systems and what considerations that should be made to enhance support of making these informational needs accessible to the decision-makers, and how they can promote the role of financial information. This is discussed to address the challenges and possibilities of improvements to the information systems for logistic management to strengthen the supply chain management in Tanzania. The third section

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\(^{11}\) Includes health centres, hospitals, dispensaries
summarises the discussion from section one and two, by defining the role of the financial information in the Tanzanian supply chain. Finally, the fourth section discusses the health information infrastructure in Tanzania, and how this is supporting the actors in the supply chain to have access to the informational needs for decision-making. It includes a discussion of how the components and actors in the information infrastructure affect each other in supporting access to information.

6.1 Defining Informational Needs in the Health Commodity Supply Chain Management

In section 2.2, an important condition for optimising the management of service delivery are presented: information must be used by all decision-makers at all points. The points include all actors from the facilities to the centre of the management. Included are policymakers, managers, care providers, health technicians, and community health workers (Lippeveld et al., 2000). Having access to information, and using it for making decisions makes the decision-makers knowledgeable of all possible choices, and able to understand health issues and needs (Braa & Sahay, 2012). In a supply chain that supports informed decisions to be made by all actors, the information should flow all the way down to the facilities. Evidently, this is increasing the informational needs and its roles, in the supply chain management at the lower health levels.

Having access to information, and if used by the decision-makers, they can easier see the importance of using it when the results of the decisions often are desirable. As the desirable outcomes increase, the informational needs increase accordingly as the decision-makers see the benefits of having access to relevant information. This process can contribute to strengthen the supply chain management, and promote accountability and transparency. To support greater access to information, and increase information flow to the lower levels, it is necessary with a continuous focus on strengthening the HIS and the supply chain management. This often comes from the top of the supply chain and the strengthening processes often starts here (VillageReach, 2012).

An interesting result of the analysis is that the informational needs varies substantially depending on what distribution model practiced, and at what level in the health hierarchy the decisions are made. There is also inconsistency in managerial processes in the supply chain, that also has an impact on the informational needs. In Tanzania, an important factor for these
variations in managerial processes and informational needs, are the different practices of distributing health commodities.

Further, the discussion will elaborate distribution models for health commodities and the needs of financial information in procurement processes at the different health levels. A particular focus is on the informational needs at the facilities. The considerations of distribution models and needs of financial information for procurement are outlined. Discussing the informational needs, is also useful to see how transparency and accountability can be promoted in the Tanzanian supply chain.

6.1.1 Considering distribution models in Tanzania and the needs of information

As presented in section 4.4, there are established a variety of models for how to distribute health commodities. The main goal for all models is that they aim at making the deliveries of health commodities as effective as possible depending on the context. The choice of distribution is usually determined by Ministries of Health. There may be several distribution models practiced at the same time within a supply chain.

In many developing countries, a typical distribution model is characterised by a ‘one source to many locations’-structure. Therefore, strengthening the supply chain often comes from the top of the health hierarchy – namely the national-level that often consists of governmental organisations, suppliers, etc. At this level, the health commodities are organised in bulks at a limited number of locations with few personnel involved. The inventory is broken down into smaller parts as further down it goes the supply chain, and managed by more personnel at several locations (VillageReach, 2012).

The pull-based distribution model

One distribution model developed, and described in chapter 4, is the pull-based model (see sub-section 4.4.1). The main characteristics in this model is that the lower health care units are procuring based on own calculated needs and demands.

In Tanzania, most facilities are procuring health commodities themselves and base the orders on own calculated needs. These needs are estimated based on consumption, stock balances, stock status, stock capacity, commodities received, losses, and previously requested.
Considering the research question, the financial information for procurement of health commodities are not used when making decisions about procurement at the facilities. However, the role of financial information in these processes should be considered as important to improve the outcome of the health commodity deliveries. The outcomes could for instance be more reliable deliveries, in the sense that they are not reduced in numbers, etc.

By not using the financial information when procuring health commodities, the findings shows that it has implications for the deliverance. Supplies of health commodity are frequently not delivered in full compared to the initially number of health commodities ordered. This happens because the facilities have ordered more than their current budgets can cower. To cope with the reduced orders, the facilities sometimes must place emergency orders to cover the missing health commodities. This finding is particularly interesting considering the research question, because it indicates that the role of financial information is significantly weaker than it should be. If the information need of financial information for procurement was acknowledged and transparency was ensured, the decision-makers at the facilities would potentially have known that their budgets are not covering the entire order. Knowing the issue, they can take measures to try to cope with the situation. For instance, measurements such as supplementing the budgets with assets from the cost sharing, described in section 5.1, could ensure that the order are delivered in full. This would have contributed to reduce the risk of situations where placing emergency orders to cover missing health commodities are necessary to continue to provide health services to the patients and promote accountability.

Considering the information needs outlined in the framework mentioned in section 4.5, it is certainly an informational need of financial information for procuring health commodities at the facilities. However, according to the findings and the discussion above, the financial information is rarely used when making these decisions. The information is available to some extent as it is being provided to the facilities from the MSD in a distribution information notice. Because health commodities are delivered every quarter, they receive this notice accordingly. Updated budgets may therefore not always be available, which decreases the transparency. The role of the financial information for procurement should be promoted when making these decisions to improve the provision of health services. Considering health outcomes at the facilities, it would possibly improve with more reliable deliveries of health commodities, which will improve by meeting the informational needs when procuring.
The role of financial information is also relevant at other health levels. The district and the national-level are also in need of financial information for supply chain management. They are also the ones that are accountable of sharing the information down to the lower health care levels. Data of financial information must transmit from these levels down to the facilities, and the need of financial information at each level must be considered to understand how information can be shared amongst them. In Tanzania, the district offices are the ones procuring from the MSD in the eLMIS for facilities procuring via the R&R form to the district offices. For facilities using the eLMIS themselves, the data entered the information system is controlled checked at the district office, before being sent to the MSD. As the budgets for procurement are calculated and monitored at the national-level, they must ensure that this data is flowing downstream to the districts and facilities. If not foreseen, this data will not be used when making decisions about procurement at the lower levels.

Based on this discussion above, and from the framework described in section 4.5, table 6 shows a summary of the informational needs considering the role of financial information for procurement in a supply chain practicing the pull-based distribution model.

<table>
<thead>
<tr>
<th>Pull-based model</th>
<th>Facility</th>
<th>District</th>
<th>National</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Informational needs considering the role of financial information for procurement</strong></td>
<td><strong>Facility</strong></td>
<td><strong>District</strong></td>
<td><strong>National</strong></td>
</tr>
<tr>
<td>Access to, and use of, financial information is beneficial when making decisions about procurement to improve the reliability of the deliveries.</td>
<td>For the district offices that process orders from the facilities, the need of timely availability to financial information is useful when making decisions</td>
<td>The national-level are the ones managing the budgets. They should foresee that financial information are provided to the lower levels</td>
<td></td>
</tr>
<tr>
<td>To improve the supply chain management, information should be available when making the decisions. This will enhance transparency and accountability.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 6: The role of financial information, and the requirement of the information systems within the pull-based model*

Considering the case of Tanzania, and the role of financial information in the supply chain management, the table can give an indication of its role when practicing a pull-based distribution model. The framework, and the discussion, shows that the role of financial information is relevant in all the health levels of the supply chain management. The framework also gives an indication that transparency and accountability may be enhanced in this distribution model, by making sure that financial information is transmitted down from the
national-level to the lower levels. This information will contribute to improve decisions about procurement as the decisions-makers at the facilities, and at the district offices, know what they can afford to procure. This is particularly useful because measures can be made to manage the situation; they can if possible, supplement the finances with other sources than the sources provided form the government. This, to hopefully cover the entire cost of an order if the initial funding is inadequate.

The informed push distribution model

Another distribution model outlined in chapter 4, is the informed push model (see sub-section 4.4.3). Like the pull-based model, this model is also used in the Tanzanian supply chain. In this model, information is flowing upstream, which uses it for further management of the supply chain.

Considering the informational needs for supply chain management in this distribution model, it differs compared to the pull-based model. The informational needs at the facilities is not as comprehensive as in the pull-based model, because facilities following an informed push model are not in charge of procurement. They only provide the higher levels, that manages procurement and distribution, with stock information and consumption. The higher levels have accordingly more substantial information needs.

These levels oversee procuring of health commodities, and has other informational needs compared to the facilities. They need the same information as the facilities including information such as population data and budgets for procurement.

Relating to the findings from Tanzania, where some areas are practicing the informed push model, the informational needs must be lined according to the requirements of information outlined in the framework described in section 4.5. Each level should obtain this information to promote transparency and accountability. The facilities in Tanzania are only entailed to managed stock management and provide the district office with this information. This data has to be regularly updated so that they are timely available to the district offices when they need them. The district offices are using this information, in addition to the information needed at this level, when procuring health commodities.

Considering the role of financial information at the lower health levels, the facilities in these areas are not in need of this kind of information at any stages. They can devote their time to
clinical care and leave the supply chain management to the higher levels. To understand how information can be used effectively for supply chain management and the decisions that are involved, looking at the role of financial information at the district level is more appropriate in this distribution model. However, because Tanzania are practicing two different distribution models, comparing the informational needs and how the management of the supply chain are organised in the two models, are interesting to consider mapping the challenges that following two models impose.

When studying these challenges, they can be a direct cause of how the role of financial information are in the two distribution models. One of these challenges is that the role of financial information is irrelevant at the facilities following the informed push model; they are not procuring themselves. Further, the districts are the ones procuring by using financial information for procurement calculated by the MoH. This data is based on, according to the findings, by some means inaccurate population data. This impose that the budgets for procurement may be incorrectly calculated. The result is that the district offices, which also use the same population data, may face the risk of overfilling some of the facilities with health commodities. The funds used to cover the orders may therefore not be used effectively. Considering the role of financial information in the supply chain, this challenges shows that the role of financial information is not sufficient in this supply chain context.

The limited informational needs at the facilities also does not promote accountability in the supply chain management. This may make the health workers unaware of how they could have made an impact on their health care provision. This is especially visible when comparing the role this information has at the facilities in areas that practice a pull-based model. In these areas, the informational needs are greater at the facilities which enhance accountability.

The informational needs of financial information for procurement in a supply chain in the informed push model are shown in table 7. The table draws on information from the framework described in section 4.5, and represents the needs at each level of the health hierarchy.
Table 7: The role of financial information, and the requirement of the information systems within the informed push model

<table>
<thead>
<tr>
<th>Informed push model</th>
<th>Facility</th>
<th>District</th>
<th>National</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Informational needs considering the role of financial information for procurement</strong></td>
<td>No use, access, or flow of financial information to this level. The facilities receive supplies from the district offices. They provide the districts with information about stock, consumption, etc.</td>
<td>The district use financial information for procurement when procuring for the facilities within the district. In Tanzania, this information is received by the national-level.</td>
<td>In Tanzania, the national-level determine the size of the financial assets. These budgets are scaled for an entire district.</td>
</tr>
</tbody>
</table>

Besides the role of financial information for procurement in the informed-push mode, it is interesting to discuss if it is a suitable approach for the Tanzanian supply chain. One interesting finding is that the participants included in this research informed about little occurrence of stock-outs at the facilities following the informed push model. This implies that the model works well, without taking the situations of stock-outs at facilities following the pull-based model into consideration; another discussion that would be interesting, but outside the scope of this research, is to compare the stock-outs at facilities following the informed push – and pull-based model. The results could indicate if the availability to health commodities are unequally distributed. Considering the role of financial information, it could give an indication of the role it has in the different models and if the available funds are used as effective as possible.

Another interesting topics relating to informational needs in this distribution model at the facility level, is that the model should be considered when there is a relatively steady demand of health commodities (SIAPS, 2014). In Tanzania, the flow of people in and out of the sparsely-populated areas, where the informed push model is followed, are high. People tend to move into larger cities where opportunities for work are better. This can indicate that the demand of health commodities is not steady for these areas. Thus, because the districts are procuring and distributing health commodities to the facilities based on target population, they may face risking overstock at some facilities and understock at others. The budgets for procurement may accordingly also be calculated incorrectly, because they are based on poor population data.
6.1.2 Considering other distribution models and the needs of information

The distribution models discussed above were discovered during the field trips in Tanzania. However, other distribution models are also developed for distributing health commodities in developing countries. In this sub-section, the push-based distribution model and the Vendor-Managed Inventory model (VMI), will be discussed by considering the role of financial information when practicing these models. Considering the role of financial information in these distribution models contributes to provide other perspectives to its role in supply chains practicing other models than discovered in Tanzania.

The push-based distribution model

Considering informational needs in the push-based distribution model, and the role of financial information for procurement in the supply chain, the model is considerably different comparing the other models discussed above. Most of the informational needs lies at the national-level in this model, and the district- and facility-levels does not require much information considering the supply chain management (besides local stock management). In the push-based model, the health commodities are often pushed in certain pre-determined kits regularly to the facilities, often without considering the actual needs at the facilities. The terms for distribution are set by the national-level, and includes the quantity to distribute. In some developing countries, they may follow the push-based model in addition to the pull-based model. In these situations, primary health commodities are distributed regularly, and hospital at district and regional/national level are managing their own needs (as in the pull-based model) (Management Sciences for Health, 2012b). In these situations, the informational needs are as discussed in the pull-based models, and only relevant for health commodities that are not assumed as primary health commodities.

In the pull-based mode, the role of financial information is only relevant at the national-level. The national-level are procuring health commodities from the suppliers according to the pre-determined terms, and does this regularly. When procuring, they procure for all the lower health levels. The lower levels only require information about personal stock management and other information only relevant to local needs that does not necessarily have to be shared or used by other actors in the supply chain. Each of the health levels has their own separate informational needs that only are useful to them. Relating to the informational needs and the role of financial...
information in this model, transparency or accountability is not promoted, as the flow of information between the levels are not stressed and that the national-level are accountable to foresee that health commodities are delivered to the lower health care units.

**The Vendor-Managed Inventory distribution model**

The processes in the VMI model set certain requirements to the informational needs. Considering the role of financial information, it plays a role for the customer and the VMI partner. The customer is the main funder of the health commodities, and must calculate the assets for procurement for an entire country. This is like in the other distribution models, as ministries of health often are the responsible for providing funds for procurement (besides other international organisations). The VMI partner are provided with the financial information for procurement from the customer, and must manage to procure the health commodities required at the custodian locations as effective as possible.

The reason for including this model in this thesis, is to view the role of financial information for procurement from several angles. However, the VMI model implies some of the same informational needs as the push and informed push model. This is more visible when drawing lines to the findings from Tanzania; comparing to the processes in the informed push model here, and if one would follow the VMI model in Tanzania, the VMI partner would be the MSD, and are the ones managing the financial information provided by the customer (the MoH). On the contrary to the informed push model, the VMI partner are not managing the inventory at only the district offices, but at the custodians in general (which may include district hospitals, dispensaries, and facilities, etc). Different to the informed push models, considering the role of financial information, is that the role is only significant for the VMI partner and the customer at the national-level. The role of financial information at facility- and district-level are, therefore, not relevant in the VMI model.

### 6.2 The LMIS and How They Can Support the Informational Needs

The informational needs presented in the previous section are dependent of what distribution model practiced. Considering the overall research question, the role of financial information is highly dependent on the supply chain context and is only needed in certain supply chain contexts.
As mentioned in the theoretical background, several reports show that existing systems for health commodity distribution are struggling with meeting the demand of medical supplies. It is therefore important to improve these systems to enhance the overall supply chain, as the anticipated future are requiring more medical supplies (VillageReach, 2012). Defining information system requirements for different supply chain management settings, can contribute to improve these systems to support meeting the demand of medical supplies.

In supply chain contexts, a variety of information systems are used for logistic management. To improve the supply chain management, LMIS in supply chain contexts should promote the role of financial information in making decisions about health commodity procurement. For the LMIS to promote its role in the supply chain management, certain considerations to support this should be made. This section discusses these considerations, and especially draws attention to the LMIS in the Tanzanian supply chain.

Considerations for the LMIS to support the informational needs in supply chain management, and more specifically promote the role of financial information, are discussed for each distribution model described in this thesis. The following discussion is, therefore, provided under four headlines representing the LMIS in each distribution model.

**The pull-based distribution model**

The many similar informational needs in the health levels in a supply chain that practice the pull-based model, indicate that information systems that promotes transparency and accountability between the levels are needed. Information must flow upstream and downstream, making it accessible to all decision-makers at each health level. Such information systems also promote accountability as the decision-makers becomes aware of their own abilities to impact the supply management by using information that are relevant to them.

Having an information system that support the upstream and downstream flow of information, is especially important when following this distribution model. This, because it supports the idea of all the actors in the health network to base their decisions on shared information and agreements. Unexpected outcomes of the supply chain management are therefore decreasing, as all the actors in the health levels are considerate about other decisions and agreements.

An information system that supports an increased flow of information, also may improve the roles for some information when making decisions about procurement. Relating to the findings
from Tanzania, financial information is rarely used when making decisions about procurement. The decision-makers at the lower health care units are having, by some means, access to this information – but the flow of this information is not supported by the information systems in use. In fact, the financial information is provided to these levels outside any information system used for logistic management. This is particularly decreasing the role of financial information for procurement processes. Improving the information systems for logistic management to support greater flow of this information, could therefore enhance the role of it in decision-making processes. To do so, the improvement must start at the national-level. They should develop guidelines for how the logistic management information system are going to be improved to increase the flow of all relevant information for procurement, and down to the lower health care levels.

As mentioned in the empirical findings, one of these improvements are already in motion. The MSD are working on developing an interface that can share information, such as financial information for procurement, from their ERP system EPICOR9 into the national logistic management information system (the eLMIS). If seen through, this would considerably contribute to increase the role of financial information within the supply chain management at the lower health care levels in Tanzania. However, as the findings indicate, the eLMIS are not currently being used at the facility-level besides in one district of Tanzania. For the improvement to be relevant for the facilities, it should be a greater focus on implementing the eLMIS at more facilities. This would evidently increase the role of financial information when procuring, and increase the reliability of the deliveries of health commodities as financial assets are used more effectively.

Another challenge with the Tanzanian supply chain management is that vaccines are managed differently compared to other health commodities. The vaccines are managed using other information systems than the eLMIS. Considering the role of financial information for procurement, this information is not relevant for the facilities as they do not procure vaccines. This is done at the district-level. The role of financial information is important at this level, but are not flowing further down the supply chain. According to findings, the eLMIS were initially developed to manage the logistics of vaccines as well. If the system was used for procuring vaccines, the role of financial information for procuring the vaccines would also be relevant at the facilities. The management of procuring vaccines could then be shifted to the facilities. They would then be included in making decisions about procuring vaccines and base it on own
demands, and evidently have larger impact on this part of the supply chain management. This would also support the characteristics of the pull-based models, where lower health care units are ordering themselves based on own calculated needs. The process would also enhance transparency, because information is flowing all the way down to the facilities. This would make the lower health care units more aware of their health issues and needs, as more timely available data that are presented, communicated, and disseminated to the decision-makers (AbouZahr & Boerma, 2005).

Table 8 show a summary of the requirements that are relevant for the information systems for managing logistics in Tanzania when using the pull-based model. The table gives an indication of the role of financial information for procurement in each of the levels of the health hierarchy. When practicing the pull-based distribution model, the information systems should promote transparency and accountability to improve the role of using information when making decisions, and especially in this case – the role of financial information.

<table>
<thead>
<tr>
<th>Considerations for the Information systems</th>
<th>Facility</th>
<th>District</th>
<th>National</th>
</tr>
</thead>
<tbody>
<tr>
<td>The information systems should support upstream and downstream flow of information, so that all decisions-makers in the supply chain base their decisions on the same data</td>
<td>Similar requirements as at the facilities (both using the eLMIS for reporting and procuring health commodities)</td>
<td>Similar requirements as at the district and facilities. In addition, relevant data in EPICOR9 should be shared with the eLMIS, making it accessible for the lower levels</td>
<td></td>
</tr>
</tbody>
</table>

Table 8: Summary of the considerations for the LMIS in the Tanzanian supply chain practicing the pull-based model

**The Informed push distribution model**

The informational needs when practicing the informed push distribution models implies other considerations for the LMIS compared to, for instance, in the pull-based model.

In this model, the informational needs imply that the model could benefit from an information system that enhance flow of information upstream from the lower health care level, and up- and downstream between the district- and national level. The facilities, however, could potentially need an information system that contribute to improve the local management of the inventory. This information system should also support upstream flow of this information. This could
improve the supply chain management by effectively report the stock data, within an information system where it can easily be accessed at the district-level for further management. Considering the lack in needs of financial information at the facility-level, the information systems at this level do not necessarily have to have functionalities that manages this aspect of the supply chain management. That would be irrelevant as the facilities are not procuring health commodities themselves when following this distribution model.

At the district level they are, however, in need of an information systems that meet the requirements of managing the entire supply chain activities. As the role of financial information is significantly higher at this level, the flow of this information from the national-level should be promoted to make this information timely available to the decision-makers when procuring.

Considering the requirements to an information system for logistic management at the national-level, they need a system that supports provision of the necessary information down to the district-level. In addition, it should support the local managerial activities. The role of financial information should be significant at this level, as both the actors at the national-level and the decision-makers at the district-level could benefit from using it to make informed decisions.

In Tanzania, some areas are following the informed push distribution model. Relating to the information system requirements mentioned above, and the informational needs for financial information, one can suggest that the current situation are not considering the importance of the role of financial information when procuring. Now, this information is shared with the district-level, but the flow of it from one level to another are not supported in the existing information systems. To improve accountability and transparency, sharing this type of information more effectively should be given more attention when developing the LMIS further. One improvement could be the already mentions of sharing more data about finance, that exist in the MSD’s EPICOR9, with the eLMIS and make it timelier accessible for the district offices.

Table 9 shows a summary of the considerations that should be made for the information systems for logistic management in Tanzania, in areas that practice an informed push model.
Table 9: Summary of the considerations for the LMIS in the Tanzanian supply chain practicing the informed push model

<table>
<thead>
<tr>
<th>Considerations for the Information Systems</th>
<th>Facility</th>
<th>District</th>
<th>National</th>
</tr>
</thead>
<tbody>
<tr>
<td>Could benefit from an information system that supports management of stock (tracking consumption data, stock capacity, etc). This information should be available to higher levels to enhance transparency (upstream flow)</td>
<td>This level requires an information system that supports transparency of information (mostly upstream, but also downstream from the national-level) for optimal information sharing. The information system should support access to financial information for procurement, and make it timely available.</td>
<td>The information system for logistic management should support information flow of financial information to the LMIS at the district level. It must have the ability to send and receive information, such as financial data, as well as other relevant procurement data.</td>
<td></td>
</tr>
</tbody>
</table>

The push-based distribution model

The processes of distributing health commodities, when following a push-based model, are characterised by a ‘simple’ and pre-determined distribution scheme. As presented in the previous section, the needs of information for logistic management are therefore limited; especially at the levels below the national-level. The requirements to the functionalities in an LMIS within this distribution model, are therefore only drawn from the national-level where decisions about procurement are being made. The requirements of an information systems for the lower levels are mostly drawn to local management of their inventory and does not have to support information flow particularly. Considering that the role of financial information is only relevant to the national-level, they can manage it as they require without considering making sure it is flowing downstream.

The Vendor-Managed Inventory model

The requirements of the information systems for logistic management in supply chains that practise the VMI model, are by some means like the requirements outlined for the informed push model. The main difference is that the information systems at the national-level does not have to support downstream flow of financial information. The role of financial information is
only relevant at the national-level. The information system at national-level should also be able to receive and process the information of stock received from the lower levels.

6.3 What Is the Role of Financial Information In the Supply Chain Management?

The discussion has addressed the research question using the empirical findings in combination with existing theory. By referring to the framework developed in section 4.5, the informational needs within the distribution models practiced in the Tanzanian supply chain are used to describe the role of financial information in the supply chain management. In addition, two other distribution models are also discussed to enlighten the role of financial information in other supply chain contexts. Furthermore, the discussion of informational needs of finances in addition to considering its role in supply chain management, can be useful to develop certain considerations that should be made for the LMIS. The results address some challenges with the Tanzanian LMIS, and some opportunities of improvements.

Discussing the case of Tanzania and relating to the theoretical background of this chapter, the results indicate that the role of the financial information in decision-making processes are limited at the lower levels of the health hierarchy. This is especially visible at the facilities where the informed push model is practiced. The role of this information is significantly higher in areas where they practice the pull-based model. One common factor for both the supply chain contexts it that the role of financial information in decision-making processes are, by some means, constrained by the lack of support of flow of this information between the health levels. Neither are the role or flow of it promoted by any LMIS. The transparency and accountability are being constrained by these limitations to the LMIS.

To promote the role of financial information in the Tanzanian supply chain management, some improvements to the LMIS should be considered. The ongoing project of supporting greater flow of financial information from the LMIS at the national-level into the LMIS used at lower levels would significantly improve the role of the financial information when procuring health commodities at the lower health care levels. If seen through, financial information can be more extensively used by at this level, when making decisions in procurement. However, as many lower health care units still not use these LMIS, but rather paper-based systems, increasing the role of financial information is by some means constrained by this situation.
For the Tanzanian supply chain, focusing on improving the information systems to support greater use of financial information for procurement, could potentially improve the overall procurement and distribution process. Current situation is that health commodity deliveries are often shortened compared to what was initially ordered by the lower health levels. The findings indicate that one of the reasons for this to happen is the lack of using financial information when making the decisions about procurement. By promoting transparency and accountability, and focusing on greater support by the information system to share information between the health levels, the overall reliability in health commodity procurement and distribution could improve. Making the lower levels to be more aware of their current financial status for procurement they can, for instance, cover missing funds by supplementing with other funding sources such as funds received from patient fees etc. Today, this is difficult as the role of financial information for procurement are by some means limited at the lower health care levels.

To broadly summarise the discussion so far, table 10 illustrate in what distribution models and at what level the role of financial information is relevant in the Tanzanian supply chain. The table can function as an indicator for where the Tanzanian supply chain should consider promoting the LMIS to support greater use of financial information in procurement processes. For instance, by reading the table, one can see that for the areas practicing the pull-based model, the role of financial information is relevant all the way down to facility-level.

Table 11 shows the same information as in table 10, but for other supply chain contexts that practice other distribution models than to the ones in Tanzania.
6.4 The Health Information Infrastructure and Its Abilities to Enhance Access to Information Within the Supply Chain

An area addressed in the theoretical background is about information infrastructures. Relating to the discussion above about the informational needs in each distribution model, and the considerations of the information systems to support these needs, it is interesting to draw attention to the health information infrastructure. As a health information infrastructure include a variety of components and actors, it is interesting to consider how they interact and what impact they have on each other. These considerations can have enabling, or constraining, impacts on the supply chain management and the information systems included. The transparency and accountability for the role of financial information for procurement can also be affected by these impacts.

A health information infrastructure usually consists of multiple communities using the same objects in many, and unexpected, ways. Health information infrastructures has a supporting or
enabling function, because they are designed to support a wide range of activities and are not tailored to one. The components of the information infrastructure consist of both human and nonhuman actors that creates a complex and large web of interrelationships where the boundaries of where it can be used, or by whom, are not clearly defined. They unveils unbounded openness by letting new components to be added and integrated in unexpected ways and contexts, having unlimited set of users, stakeholders, developers, components, vendors, and etc. (Hanseth, 2000; Hanseth & Lyytinen, 2010). The large web of interrelationships that constitutes of a large set of components also create network effects in an information infrastructure. As the components of an health information infrastructure are a shared resource amongst the large network of user, the network effects and path dependencies increase (Monteiro et al., 2013). Making the components of a health infrastructures valuable to use for the users are important to create positive network effects.

To enable the information systems for logistic management to enhance the role of financial information for procurement, it is important to consider these webs of complex relationships and how they affect the information systems. Making sure that the informational needs are met, to all actors in the network, by the functionalities and capabilities of the information systems is important. Considering the overall health information infrastructure is, therefore, important when developing information systems for logistic management. The functionalities of the information systems in a health information infrastructure must be valuable to the users. For instance, by making access to financial information in the health information infrastructure valuable to the users, the role of it in procurement processes can be promoted in a supply chain.

The health information infrastructure in Tanzania could demonstrate some of the characteristic of an information infrastructure described above, and others not so well. For instance, the Tanzanian health information infrastructure includes a substantial number of both human and nonhuman actors. The empirical findings indicate that a substantial amount of people is included in the health information infrastructure, as well as a numerous information systems. There are district pharmacists, health workers at the facilities, representatives at the MSD, and actors at the MoH. In addition, the information infrastructure includes information systems such as the EPICOR9, the eLMIS, and others, as well as information systems for managing the cold chain. These findings further support that the actors in the information infrastructure has adapted to it differently, mostly to make its functionalities useful to them. The information systems in the information infrastructure are often implemented and developed to fit the need
of a certain community. To give an example, the R&R forms and the eLMIS are developed to support a supply chain where a pull-based distribution system are practiced. However, based on the interesting finding that some areas of Tanzania are practicing the informed push distribution model, it indicates that the information infrastructure allowed these areas to practice another distribution model than the national pull-based model by using the same components. Drawing lines to the role of financial information for procurement in the Tanzanian supply chain, it entails some implications; financial information is not used for any managerial activities at the facilities in these areas, and the district-level are the lowest level to access and use this information in the supply chain management. The role of financial information is substantially higher in areas the pull-based model is followed. Improvements, and a larger focus on increasing the role of financial information in the supply chain management should, therefore, be seen through to make the use of it more valuable to more users in the health information infrastructure.
7 Conclusion and Reflections

The purpose of this chapter is to conclude the work in this thesis according to the research question. In addition, the chapter provide some reflections upon the research conducted, which includes limitations of the research. Finally, a section presenting thoughts of future work.

7.1 Concluding Remarks

The research question that is discussed in this thesis, and that will be concluded in this section is;

What is the role of financial information for procurement in the supply chain management at the lower health care levels in developing countries?

a) What considerations for the logistic management information systems should be made to promote the role of financial information in supply chain management?

b) What are the challenges with the existing situation, and the opportunities for improvement in the Tanzanian supply chain management?

The research has considered the role of financial information for procurement in different supply chain contexts. The main result of the research is an increased understanding of the role of this information in the supply chain management at the lower health care units in Tanzania, a developing country. In addition, this research has provided insights into the LMIS in Tanzania, and how they can contribute to promoting the role of financial information in supply chain management. These insights contribute to outlining challenges with the current situation that further has led to thoughts of opportunities of improvements to be suggested.

The thesis has used the framework described in section 4.5 to address the need for financial information at all the health levels in the Tanzanian supply chain, and to address its role in the supply chain management. The main results of the study indicate that the role of financial information for procurement at the lower health care units in developing countries, are dependent on a variety of factors.

First, the role of financial information is only relevant for supply chain chains that practice a pull-based distribution model. This is because the lower health care units are managing their
own procurement, and thus need financial information when managing the procurement process. For optimal management, the decision-makers at these lower health care units should use financial information to plan procurements better.

The levels of relevance to the role of financial information at lower health care units, were especially visible in the Tanzanian supply chain management. The case from Tanzania showed implications of not acknowledging the role of financial information in the supply chain management at the lower health care units. The decision-makers at the lower health care levels were not using information about finances when procuring health commodities, which resulted in deliveries of health commodities that were significantly smaller in size than what was initially ordered. The main reason for this to happen is that the facilities are not able to make measures to cope with the fact that they possibly may have inadequate funding sources to cover an entire order. If the role of financial information was stressed at this health level, they could have used this information to make proactive measures. These measures could, for instance, be by covering missing funds with other available resources.

Secondly, the role of financial information may, or may not, be promoted and supported by the LMIS within a supply chain. When developing and improving LMIS for supply chain management, some considerations for supporting the informational needs should be thought through. In Tanzania, the LMIS at the lower health care levels is not supportive of promoting the role of financial information in the supply chain management. Financial information about procurement are currently not included in this the LMIS they use, the eLMIS, and neither made accessible for the decision-makers at the lower health care units. The financial information is only currently in the information system used at the supply store (the MSD) at national-level (the EPICOR9). For further development, transparency and accountability should be promoted. The overall LMIS should consider including the financial information for procurement to be used for the supply chain management. In doing so, the LMIS will contribute to strengthening the role of financial information in the supply chain management at the lower health care units.

In addition, the limited use of the eLMIS at facility-level in Tanzania should be given more attention. Unless, developing the LMIS further to promote the role of financial information, would not be useful for this health level.

Besides the Tanzanian supply chain management, other supply chain contexts could also benefit from developing and implementing LMIS further by having the role of financial information in
mind. By drawing lines to the case of Tanzania, one could use the results of this research to promote the role of financial information for procurement in other supply chain contexts in developing countries.

7.2 Reflections Upon the Research Conducted

7.2.1 The research team

In a research with several agendas it is important to stay objective when conducting interviews and observations to avoid influencing the participants. This is, however, not always been the case during the empirical studies. At some of the visits in Tanzania we tagged along with representatives from the Tanzanian health sector. The participants might have felt the need to present their situations more positively due to the presence of these representatives. Issues related to the management of the health commodity supply chain may have been excluded in the conversations with us. However, having these representatives with us also led us to access facilities and district offices and to relevant participants because they knew most of them. The empirical findings are therefore more thorough, but it is important to have in mind possible bias in some of these data.

Support from the research team

Starting this research without any prior knowledge to health information systems in developing countries, health related issues, and logistics management information systems, it was sometimes challenging to know how to approach the participants and to plan the work forward. It was very helpful to work with our colleagues at the Health Information System Programme at the University of Dar es Salaam, Tanzania, which could explain issues and aspects that I had difficulties with understanding. The help from the HISP team in Tanzania helped me make the most out of my field trips and has had a substantial impact on the content of the empirical studies.

Despite having a foreign background with limited prior knowledge, it also provided an objectivity to the field trips, and it was possibly easier to stay objective throughout the interviews and observations. Without much prior knowledge, I could obtain information about many aspects of the supply chain that were both complex and less complex.
7.2.2 Research approach

Based on the research context (see section 1.2) and the timeframe (field trip over eight weeks in two phases) the fieldwork was conducted in an opportunistic manner. The first trip to Tanzania in January/February 2016 were not planned, and we took advantage of opportunities as they arose. The second trip was somewhat planned in beforehand, but consisted of wishes of what we would like to know. Further planning, and taking advantage of situations as the arose, were also the case for the second phase of the field trip. This was a suitable approach for me, because it is difficult to plan everything in advance in new and unfamiliar research contexts.

The aim of the research was to obtain knowledge about the management of health commodities in the supply chain in Tanzania. The participants included in the study provided insights into the use contexts at all the levels of the supply chain, and I believe that the selection of participants was representative for this research.

The research methodology use for this research is a case study (see section 3.2). The case study elapsed over two phases in Tanzania. The data collection was conducted in several iterations, with continuously analysing the data to lead the further research in a desirable direction. By providing information to a field within the Tanzanian supply chain that has not received much attention, I have established a research that can contribute for further research.

The research has benefitted substantially of gathering data over two periods. In the second field trip, I could follow up the missing threads and uncertainties that I was not able to clear up in the first round of data collection. However, the research could have benefitted from finding the research area already during the first field trip. I was not able to analyse the data during the first field trip in preferably speed, because it was a substantial amount new data to analyse. It took some time to get to know all the processes discovered in the HCSC. The research area was first established when returning to Norway after the first trip to Tanzania. If I had even greater knowledge about the use, access, and flow of financial information before the second field trip, I could have planned it in even greater detail and possibly gather more useful data.

The same challenge was present in the second field trip, where it was challenging to analyse all of the gathered data during the field trip. This resulted in unanalysed data when returning to Norway and there was some information that needed clarification in correspondence with the HISP team in Tanzania and the participants. This seemed to be difficult due to varying
responses. However, based on the results of this study, I believe that it set the ground for even further research within the field and could contribute to enhance the LMIS of Tanzania.

7.2.3 Limitations

A limitation considering this research relates to the empirical findings. When conducting research in Tanzania, I only concentrated on collecting data from Dar es Salaam, and some selected sparsely-populated areas surrounding Dar es Salaam. The empirical findings may therefore not be applicable for all areas of Tanzania. However, the findings still give an indication of how the supply chain management are in the country.

Another limitation is about the time spent in Tanzania. A total of eight weeks was spent collecting data. Considering the timeframe, it is difficult to cover all the fields of the supply chain management relevant to this thesis. The timeframe was also a constraint for the previous mentioned limitation. If more time was spent in Tanzania, we could possibly have collected data from even more remote areas.

Furthermore, the research could have benefitted from greater focus on researching decisions that are based on financial information for the supply chain management. In addition, the research could also have benefitted from researching the actual outcomes of stock-outs of health commodities at facilities, and what implications this has for the provision of health care. This could have contributed to gain understanding of what the actual impacts of these stock-outs has for the patients.

7.3 Further Work

First, further research could be to investigate some of the limitations mentioned in the previous sub-section. This contributes to enhance the research and continue the work even further, and to discover several areas of the Tanzanian supply chain management that could benefit from being researched.

Second, researching distribution models in other developing countries could be beneficial to discover the informational needs in supply chains. These informational needs can be used to draw attention to what the information system for logistic management should support in terms of supply chain management.
Third, the research can be used to draw attention to similar research for other LMIS that operates in other developing countries. For instance, the DHIS2 mentioned in this thesis is also developed to support logistic management. By using the framework from section 4.5, one can study what informational needs the DHIS2 should support in different supply chain contexts. This may also be applicable for other LMIS in developing countries. Further work to strengthen supply chain management in developing countries are a continuous process, and should continue to receive attention within research.
References


USAID. Retrieved from
http://deliver.jsi.com/dlvr_content/resources/allpubs/guidelines/LogiHand.pdf
Appendix

Appendix A: Norwegian center for research data application letter

Result of Notification Test: Not Subject to Notification

You have indicated that neither directly or indirectly identifiable personal data will be registered in the project.

If no personal data is to be registered, the project will not be subject to notification, and you will not have to submit a notification form.

Please note that this is a guidance based on information that you have given in the notification test and not a formal confirmation.

For your information: In order for a project not to be subject to notification, we presuppose that all information processed using electronic equipment in the project remains anonymous.

Anonymous information is defined as information that cannot identify individuals in the data set in any of the following ways:
- directly, through uniquely identifiable characteristic (such as name, social security number, email address, etc.)
- indirectly, through a combination of background variables (such as residence/institution, gender, age, etc.)
- through a list of names referring to an encryption formula or code, or
- through recognizable faces on photographs or video recordings.

Furthermore, we presuppose that names/consent forms are not linked to sensitive personal data.

Kind regards,
NSD Data Protection