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**An investigation into supply chain risk
factors and their impact on performance of
humanitarian pharmaceutical supply chain
in Sub-Sahara Africa - A case study of the
supply chain system for UNICEF Tanzania**

Fredrick Sheshe

A thesis submitted in partial fulfilment of the
requirements of the
University of Northumbria at Newcastle
for the degree of
Doctor of Business Leadership

Newcastle Business School

March 2018

Declaration

I declare that the work contained in this thesis has not been submitted for any other award and that it is all my own work. I also confirm that this work fully acknowledges opinions, ideas and contributions from the work of others. The work was done in collaboration with Brown Consultants.

Any ethical clearance for the research presented in this thesis has been approved. Approval has been sought and granted by the Faculty Ethics Committee on 10th April 2017.

I declare that the Word Count of this Thesis is 49,134 words

Name: **Fredrick Sheshe**

Signature:

Date: **20th March 2018**

Abstract

This thesis investigated the presence of supply chain risk factors and their impact on performance of humanitarian health programs in Sub-Saharan Africa, particularly UNICEF Tanzania. Supply Chain Risk management (SCRM) approach has become a major contributor to supply chain performance and to program/business success. The aim of this study was to contribute to professional practice by suggesting risk management approach (prioritisation and mitigation) as the one possible solution to the criticism that; “*Supply chain management is our Achilles heel; we receive the most criticism for this*” (UNICEF 2014). This criticism triggered this research whose aim was to systematically identify, prioritise and mitigate critical risk factors that impact on supply chain performance metrics of time, cost and quality. To achieve this aim, this study addressed two key research questions of **risk prioritisation** and **risk treatment**. A number of Supply Chain Risk Management (SCRM) studies available in literature mainly identified risks factors without much focus on prioritisation using Failure Mode and Effect Analysis (FMEA) methodology. This enquiry was abductive in reasoning and mixed methods in approach using process FMEA to quantify and analyse process risks. Besides being industry relevant, the benefit of using FMEA for this investigation included an increased focus on most imminent risks, prioritisation of risks and development of effective risk mitigation strategies.

The research findings confirmed that poor risk management is the primary cause of poor supply chain performance. It also found a causal relationship between detection capability and likelihood of occurrence on a few of the risks, and a zero relationship on most risks tested. Overall, the research confirmed the proposition that effective supply chain risk management approach (prioritisation and mitigation/treatment) contributes to an improvement in supply chain performance of health programs in Sub Saharan Africa. The research findings matter in that the established risk profiles by performance metrics of delivery time, cost and quality (the SCRM Iceberg Model) can be used by supply chain managers to anticipate and proactively manage the potential risks found in their operations. The knowledge on the relationship between investment on risk detection capability and the reduction in risk occurrence challenges managers to re-assess the potential benefit of every investment on risk detection. The suggested context specific challenges and opportunities identified in this study, if applied rationally can help effectively manage supply chain risks for humanitarian operations in Sub-Saharan Africa and similar context globally.

Acknowledgement

“Now thanks be to God who always leads us in triumph in Christ, and through us diffuses the fragrance of His knowledge in every place” 2 Cor 2:14 (NKJV)

Embarking on a doctorate course is a long journey, intellectually and emotionally. But, I was never alone in this journey. The support to stand on the course despite all the challenges came from several people around me. In particular, I would like to express my sincere gratitude to:

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Chapter 1: Introduction

1.1. Background of the Research

1.1.1 Supply Chain Risk Management for Humanitarian Healthcare

Every humanitarian program the world over remains relevant and viable when it is able to reduce or alleviate human suffering and pain caused by disasters, natural or man-made.

Among the many humanitarian interventions is the health care program whose focus is to provide essential medicines and nutrition products. Other programs can also include the provision of education, water, sanitation, food, shelter, social protection and household items required to restore or provide basic human needs. By their nature, humanitarian programs involve the provision of supplies and as such it is no secret that their successful implementation depends heavily on the performance of their supply chains and yet supply chains are often taken for granted (Pettit and Taylor, 2007 cited in McClintock, 2009).

“The healthcare supply chain is frequently described as highly fragmented and relatively inefficient” (Schneller and Smeltzer, 2006, p.27). Therefore, to perform effectively and consistently, every global supply chain should be mitigated against the many risks that lays along the chain. Supply chain resilience has gained attention in recent years as a concept to respond to these disruptions in the supply chain. There is clearly more risk today in the supply chain than there was just 10 years ago and an extensive and complex global humanitarian relief community has developed, and it is still growing and evolving in complexity (Oloruntoba and Kovacs, 2015). It has become critical for every health program to ensure that their supply chains are efficient and effective or risk losing lives and or resources. Such an objective is always challenged by the various risks and dangers found in many of today’s supply chains. Giunipero L. C, et al (2004) recognized the presence of

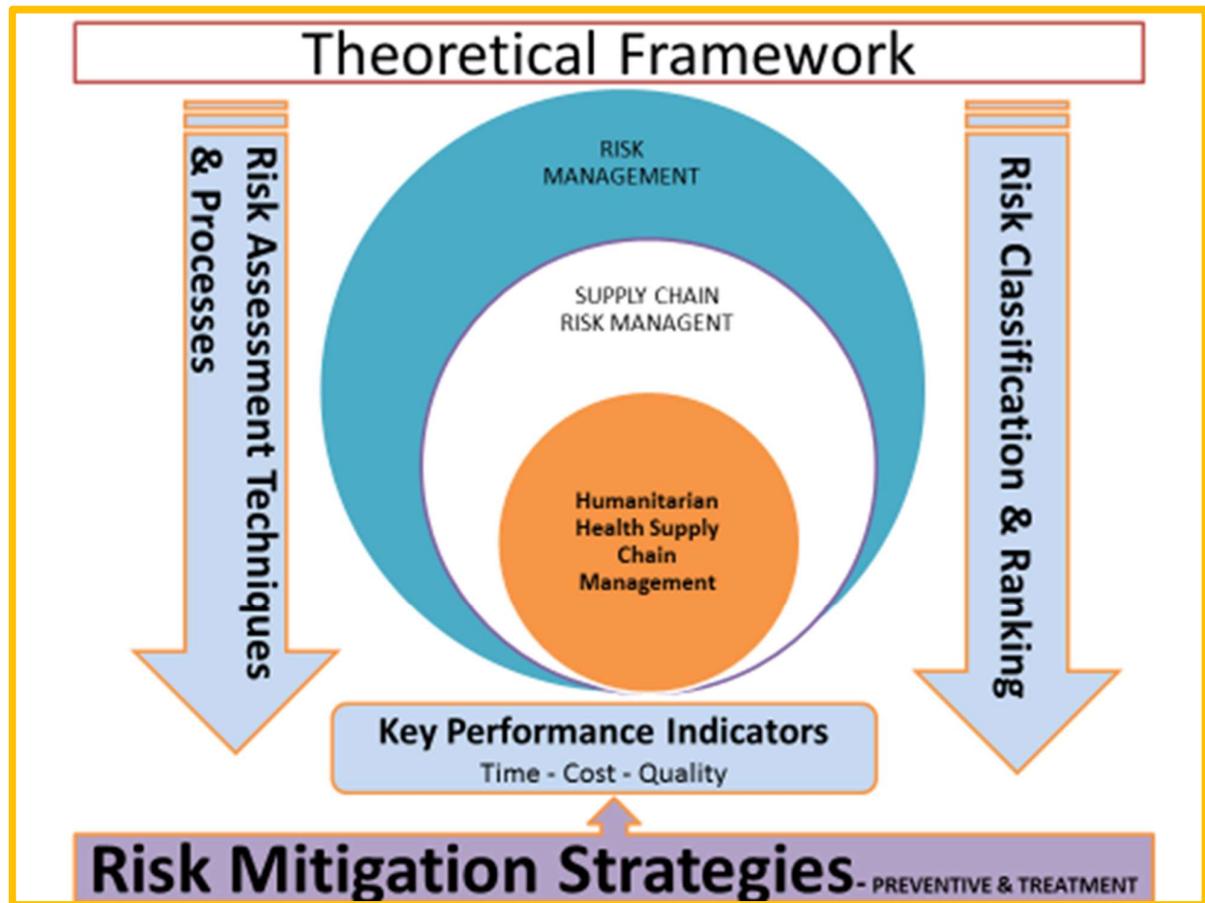
increasing tension, risks and dangers in the world environment today. Moreover, the use of offshore manufactures/suppliers for health and nutrition products means more uncertainties and risks through longer lead times and potential transportation disruptions that managers face in such global and complex supply chain (Sofyalioglu C, et al 2012; Manuj I et al 2008; Giunipero L. C, et al 2004). To remain effective and efficient, organizations such as UNICEF with operations in Tanzania must continuously evaluate and mitigate against these risks and dangers threatening their supply chains. Hence the need to undertake an investigation into the risk factors/elements in the health supply chains and their impact in overall organization performance.

While there is much research on supply chain risks in general, there is still a gap on academic and peer reviewed studies related to health supply chain risks in Sub-Saharan Africa. The increase in the emerging risks related to climate changes, natural disasters, terrorism, accidents, conflicts and government compliance in the Africa region is on its own adequate reason to carry out research to understand these risks and build mitigation strategies in the supply chain. The Supply Chain Risk Leadership Council also anticipated the rise of supply chain risk as a new supply chain challenge and concern (Supply Chain Risk Leadership Council, 2014). Such a rise in supply chain risks means high exposure that may lead to a direct decline in supply chain performance, if risks are not properly managed. The effect of poorly managed supply chain risks is supported by Wang (2018) who advanced that supply chain uncertainty and risk have negative impacts on logistics performance. Most health supplies, particularly vaccines are considered complicated products in terms of their demands in procurement, handling, transportation and storage. Focusing this study on the supply chains risks for health supplies would mean that any suggested management strategies and

model resulting from this research would be able to support the needs for most of the humanitarian chains.

SCRM in the health program means that the critically needed supplies and equipment are delivered efficiently and effectively. In the case of ARV drugs, stock-outs can lead to ART interruption for patients (Larson.C et al, 2014). When applied to the vaccines supply chain, Kaufmann et al (2011) pointed out that all personnel, systems, equipment and activities required to deliver vaccines from point of production to the person who needs the vaccines have minimum risk impact. For this reason, many organizations (mainly government and NGOs) should invest in risk management programs if they are to remain cost-effective and time efficient. The researcher proposes a theoretical framework that humanitarian health organisations can use to review and manage their supply chain risks. As detailed in Figure 1.1 below, the analysis should include zooming in from overall risk management to supply chain risk management and then to health supply chain risk management. The focus in this risk management process is to use available risk assessment techniques to classify and rank risks for prioritized treatment and mitigation or prevention. And for the purpose of this study, the main aim is how this process will help to improve on the performance of the three strategic performance objectives/metrics of time, cost and quality. Improving supply chain performance has become a challenge for companies aiming to sustain their competitive advantages (Cai et al, 2009; Estampe et al., 2013 cited in Vlachos, 2014).

Figure 1.1 Risk Management Theoretical Framework



Source: Author

Healthcare supply chains are generally complex in nature and can become even worse when implemented in fragile humanitarian operations. Ryan (2005) pointed out that the involvement and participation of government adds to the complexity of the humanitarian healthcare system. As for Aronsson, et al (2011), healthcare supply chain has distinguished characteristics such as:

- *Large extension of lead time uncertainties in individual functions due to difficulties to predict the time-ex: surgical procedure*

- *Organized in functions with lack of a systems view/overall strategy*
- *Lack of strategy for sub processes within each department*
- *Volumes are relatively low and variety is high*
- *Mix of highly standardized treatments and new experimental treatments with high variation in the degree of standardization between different treatments.*

Towill and Christopher (2005) added that healthcare policies and practices are influenced more by political governance and that statistics are usually distorted making it difficult to set up long term strategy improvements. This is very common characteristics for most supply chains in Sub-Saharan Africa where politics are heavily involved in the delivery of social services. These unique characteristics requires a unique approach in supply chain management, and effective SCRM can be just the one.

1.1.2 SCRM Overview of issues in the current system: The Case Study

The United Nations (UN) organisations, like many other humanitarian organisations, implement most of their programs in fragile and risky environments. Political insecurity, poor infrastructure, climatic conditions, inadequate economic conditions and malfunctioning legal systems are among the common factors that causes huge risks in the supply Sub-Saharan Africa. Like many other humanitarian players in this case study region, UNICEF continue to face challenges as they try and deliver health services. Despite this challenging context, the objective of supply chain in these operations is deliver the right supplies and services within a short time frame (Wassenhove, 2006). Hence, it becomes critical that risks are recognised and reduced or mitigated to an acceptable level (UNGM, 2006). Considering the hardship nature

of disaster affected locations, it is not surprising that high performing supply chains are those that manage their risks to optimal levels. Poor risk management results in high supply chain costs, reduced efficiency and at times loss of life which is something every organisation tries to avoid. The international standards recommend that “*organisations develop, implement and continuously improve a framework whose purpose is to integrate the process of managing risk into the organisation’s overall governance, strategy and planning, management, reporting processes, policies, values and culture*”. (ISO 31000:2009).

The 2014-2017 supply strategies for UNICEF globally includes service delivery, emergency, product innovation, strengthening supply chains, monitoring and influencing markets. Its enablers are supply community, optimization, partnerships and working together for results. The strategy about strengthening supply chains aimed at supporting activities to help reduce costs, stock-outs and/or wastage, improve performance and achieve results, in collaboration with government counterparts, suppliers, freight forwarders, implementing partners, Regional and Country Offices, and donors (UNICEF Intranet, 2013). UNICEF internal evaluations have reported an increase in losses to aid supplies mainly due to product expiration and also the increasing supply chain costs from long storage days and expensive transportation means. The criticism “*Supply chain management is our Achilles heel; we receive the most criticism for this*”, which appeared in one of UNICEF internal annual program reports triggered the researcher’s desire to dig deeper on why supply chain systems fail.

The health supply chain system under study has several risk factors, starting from port of origin to point of distribution/consumption, through an array of risks at supply hubs and

along supply routes. The supply chain pipeline is also divided into three phases, the *upstream* (from point of origin to port of entry), the *midstream* (from port of entry storages at national level) and the *downstream* (from national storage to point of distribution). Such classification of risks is appropriate for the supply chain under investigation as it analyses the risks associated with management of the upstream supply chain, operational / midstream risks, and the risks associated with management of the downstream supply chain (Spekman et al 2004; Christopher and Lee 2008; Juttner et al 2003). A number of SCRM studies mainly identified risks factors without much focus on prioritisation using FMEA methodology, particularly for humanitarian health supply chains in Sub-Saharan Africa. As such, this study will identify and analyse supply chain risk factors according to the three phases (upstream risks, midstream risks and downstream risks). An understanding of critical risks at each phase is critical for prioritization and designing the right mitigation strategies and for resource allocation.

Risk mapping was carried out for Sub-Saharan Africa with particular focus on Tanzania. Unpublished organisation program assessment and evaluation reports were the main source used to identify the potential risks for inclusion into the research questionnaire. UNICEF's Enterprise Risk Management framework was also used to provide some high-level risks which were included into the study (UNICEF Immunisation, 2014 and UNICEF Risk Management, 2015). In addition, academic journals were also used to provide selected general supply risks (Norman and Lindroth, 2004; Kovacs, 2009; Punniyamoorthy, M. et al, 2013), pharmaceutical supply risks (Ouabouch and Amri, 2013) and public health risks in developing countries (Jahre, M. et al, 2012; Noel, W. et al, 2013). The list of risks identified in these sources were further screened by the researcher based on context experience and

according to the stages within the supply chain. The final list had 10 upstream risks, 10 mid-stream risks and 10 downstream risks. These risks are presented in Table 1.1. The mapping was done through desk review of organisation reports and were later on used in the questionnaire. A graphic presentation of these mapped out risks are found in Figure 1.2, which also doubles as the supply chain network diagram for humanitarian system in Sub-Saharan Africa and Tanzania. The list (grouped into sub-categories), although non-exhaustive clearly shows that the system under study has many potential risks that require profiling, prioritisation and mitigation. The research process and results will help UNICEF to mitigate potential risks in Sub-Saharan Africa and globally, thereby supporting the realization of set objectives.

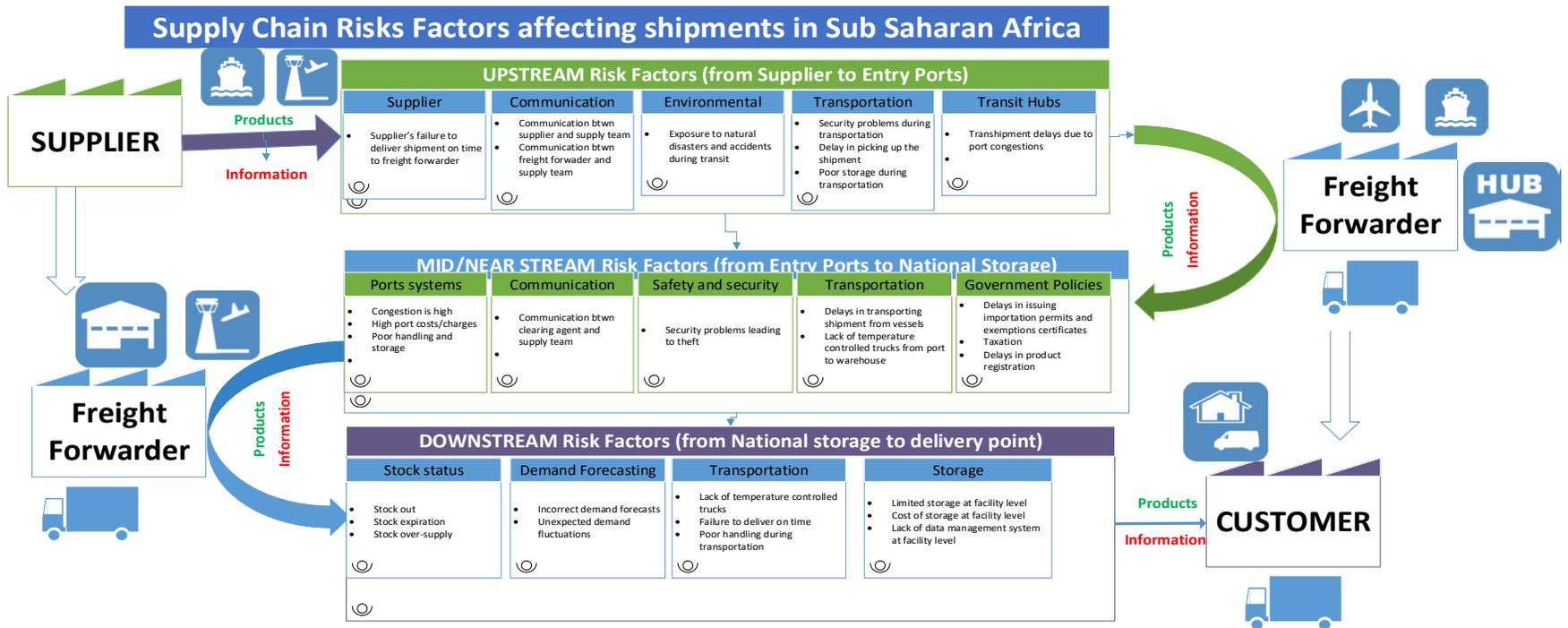
Table 1. 1: Risk Mapping - Pharmaceutical Supply Chain in Tanzania

Upstream Supply Chain (from supplier/port of origin to the port of entry)	
Code	Risk Factor
RIU1	Communication problems between suppliers and supply team in receiving country
RIU2	Communication problems between freight forwarders and supply team in receiving country
RIU3	Security problems during transit transportation including piracy and terrorism
RIU4	Exposure to natural disasters and accidents during transit
RIU5	Supplier's failure to meet agreed delivery time
RIU6	Supplier's failure to meet agreed product quality standards
RIU7	Freight forwarder's failure to collect and ship consignment at agreed time
RIU8	Freight forwarder's failure to keep consignment at agreed quality standards
RIU9	Trans-shipment delays at transit hubs due to congestion
RIU10	Pipeline visibility and tracking problems from port of origin to port of entry
Midstream Supply Chain (Entry port to national warehouse)	
Code	Risk Factor
RIN1	Communication problems between clearing agents and supply team in receiving country
RIN2	Port congestion leading to shipment delays (lack of capacity)
RIN3	Port charges/cost are too high on humanitarian shipments (handling and storage)
RIN4	Permits to import are taking long (too many bodies, documentation and registration)

Table 1.1. (continued)	
RIN5	Security problems at port storage leading to theft
RIN6	Quality problems due to poor handling and storage of shipments
RIN7	Storage spaces at national hubs is inadequate
RIN8	Lack of temperature controlled storage facilities at port/national hubs
RIN9	Manual order processing at port of entry leading to clearing delays
RIN10	Clearing agent's failure to perform customs clearance processes on time
Downstream Supply Chain (from national hubs to final warehouse)	
Code	Risk Factor
RID1	Communication problems between supply team and last mile recipient
RID2	Stock out
RID3	Stock expiration
RID4	Stock oversupply
RID5	Unexpected demand fluctuations
RID6	Incorrect forecasting
RID7	Quality problems due to poor handling and storage of shipments
RID8	Storage spaces at regional/destination hubs is inadequate
RID9	Limited cold chain trucks/refrigerated vehicles
RID10	Transporter's failure to deliver on agreed time

Source: Author (Risk factors drawn from Norman and Lindroth, 2004; Kovacs, 2009; Punniyamoorthy, M. etal, 2013; Ouabouch and Amri, 2013 and Jahre, M. etal, 2012; Noel, W. etal, 2013; UNICEF, 2014; UNICEF 2015;).

Figure 1. 1 Risk Mapping and Supply chain network for Sub Saharan Africa



Source: Author

The 30 risk factors listed on Table 1.1 and Fig 1.2 were used to design the questionnaire and the interview schedule for the field study. This was done to validate the presence of these risks and identify those to be prioritised for UNICEF Tanzania pharmaceutical supply chain as per the performance metrics they impact the most. The findings are illustrated in the form of an iceberg metaphor, described as the Supply Chain Risk Management Iceberg Model (SCRMIM) shown in Figure 5.1. The model reveals that the poorly performing indicators is the visible part of the iceberg and the supply chain risk factors represents the invisible part of the iceberg. The model provides a list of risks to be prioritised for UNICEF Tanzania supply chains. SCRM Iceberg Model illustrates how supply chain risk factors can be linked to supply chain performance metrics as per the research findings for UNICEF Tanzania case study. The model identifies the risk factors in terms of their position in the hierarchy of prioritisation. That is, high priority in treatment or mitigation of risks should be given to those risks closer to the top of the iceberg, while risks beneath the iceberg should be given low priority.

Firstly, the most critical risk factors affecting **cost metrics** are; high port charges, high storage at national hubs, high cost of importation permits and high communication charges at last mile. Secondly, **on-time delivery metrics** is mostly affected by delays in issuance of importation permits, freight forwarders' communication and delivery problems, supplier's delivery problems, delays due to congestion at entry ports and last mile transporter's delivery delays. Thirdly, **quality metrics** is mostly affected by risk factors such as stock expiration, inadequate cold chain systems, oversupply due to incorrect forecasting, poor handling and storage affecting quality standards and quality problems at production stage (manufacturer's factory).

The iceberg model helps supply managers to explore the root causes of poor performance, which is usually found in the numerous supply chain risk factors. Regardless of the position of the risk factor along the iceberg, their impact on the performance of the supply chain still matters. Thus, supply chain managers should endeavour to mitigate each of the risks listed in the iceberg.

1.1.3 Supply Chain performance and research gaps

SCRM is gaining increasing interest from researchers (Khan and Burnes, 2007; Sodhi et al., 2012). Program risk profiling and planning for humanitarian projects is usually of a less priority but yet when performed properly, its benefits are enormous. Noel. W et al (2013) highlighted some of the benefits as found while evaluating the USAID Deliver projects to include:

- Increase the likelihood of achieving the supply chain objectives
- Reduce costs and improve the overall efficiency of the supply chain operations
- Improve the governance and leadership of the supply chain
- Improve customer and stakeholder confidence and trust in the supply chain
- Focus the supply chain manager on proactively managing risk, not only reacting to unforeseen events

Risk management in health supply chain is very critical because risks from a supply chain are difficult to manage. They are difficult to identify, they can arise from every echelon of the supply chain and that fewer well-defined tools and techniques for SCRM exists. Furthermore, as with health supply chains, it can be further complicated by the too many product lines as well as the perishable nature of some such as vaccines. According to Jüttner (2005), a key feature of supply chain risk is that, by definition, it extends beyond the boundaries of the single firm, and moreover, the boundary spanning flows can become a source of supply risks. Thus, the need for management to focus on supply chain risk management if they are to achieve efficiency and effectiveness.

Generally, few researchers agree that there is only limited work on the effect of SCRM on business profitability and liquidity (Ritchie and Brindley, 2007) or supply chain performance (Thun and Hoenig, 2011; Mishra et al., 2016) or risk performance (Kern et al., 2012; Hallikas and Lintukangas, 2016). The literature has shown studies have been undertaken about supply chain risk management in general, to understand the link between risk types and the corresponding management and mitigation strategies (Manuj & Mentzer, 2008) and also to understand the link between strategies and performance (Wieland & Wallenburg, 2012). However, the research by Wieland and Wallenburg, (2012) addressed this link using private sector manufacturing companies. Thus, the researcher cannot agree more with Nooraie and Parast, (2016) who suggested further research in investigating the link between SCRM strategies and supply chain performance capabilities. Results from a recent systematic literature review of SCRM by Bak (2018) identified limited organized understanding of what constitutes holistic supply chain risk process and challenges in developing SCRM frameworks as some of the critical gaps that requires attention.

Thus, using FMEA to carry out a study in understanding the risk model relevant for humanitarian health supply chains and the link between risks and how they impact on performance metrics of cost, quality and delivery time will not only close the literature gap but will also pioneer studies for this concept in health supply chains in Sub-Saharan Africa.

1.2 Purpose/Rationale of the Research

1.2.1 Aim of the research

Humanitarian organisations in Sub-Saharan Africa continue to face challenges in managing their pharmaceutical supply chains. The possible reason behind the underperformance in the supply chain system may be due to the presence of many risk factors found along the supply process that most organisations, UNICEF included have been unable to properly assess, prioritize and mitigate.

The knowledge and understanding of risk factors that causes supply process failures, in a proactive way, can help supply managers to use the limited resources efficiently through risk prioritization and treatment. Thus, the author suggests that the answer to this criticism lies in a systematic and strategic supply chain risk management through prioritisation, treatment and mitigation. And for Faizal & Palaniappan (2014), understanding the types of risks and their probability of occurrence as well as the associated impacts is a starting point for companies to develop effective Risk Management strategies.

Maheshwari et al (2014) acknowledged the many tools and approaches in SCRM. A few of these approaches are the Supply Chain Operations Reference (SCOR) model developed by the Supply Chain Council (SCC); the bow-tie risk analysis, the Risk Maturity model by the Supply Chain Risk Leadership Council (SCRLC), the 5-step process, the Analytical Hierarchy Process (AHP) model and the Failure Mode and Effects Analysis (FMEA) tool. All these are popular decision making tools/models that managers can use to reach a decision regarding risk presence, impact, priority and treatment. Hallikas et al (2002) also argued that

prioritization of risks helps a company to focus the decision making and risk management effort on the most important risks.

Having reviewed and considered all the risk frameworks and methods available for managing supply chain risks, the FMEA methodology was chosen as the tool that forms the backbone of this study. The FMEA methodology was found most suitable for this study because it is one of a few among the techniques suggested by the ISO/EIC 31010:2009 standard which categorises and highly recommended for risk identification, analysis, prioritisation and treatment (Curkovic et al, 2013). FMEA is a method that prioritises risks by ranking them in order of Risk Priority Number (RPN) (Faizal & Palaniappan, 2014). RPN is calculated as *Risk Severity * Risk Occurrence * Risk Detection*. The higher the RPN, the higher the level of risk priority. This makes FMEA one of the well-documented and proven technique commonly used for evaluating risk failures in process designs. Hence, the selection of FMEA as the technique for enquiring about risk prioritisation and treatment for humanitarian health supply chain.

Furthermore, FMEA methodology is considered as a proactive tool developed to identify, evaluate and prevent product and/or process failures (Bluvband, 2009). Sinha *et al.* (2004) sees FMEA methodology as a developed prescriptive method to decrease risk occurrence and impact. The key features of FMEA are utilised in identifying supply chain risk sources, risks and mitigation strategies. Thus, the author proposes the use of FMEA methodology to carry out the investigation. It is important to mention hereon that many a times, the worst impact comes from unknown risk factors, and the use of FMEA helps to systematically assess the

occurrence and severity against potential process failures as described by The Department of Defense in the United States (Anleitner, 2010). The research by Curkovic et al (2013) revealed that those companies that properly and consistently used FMEA in risk assessment and evaluation achieved significant benefits. As such, FMEA methodology gained reputation as a tool to assessment and manage risk factors in a variety of industries including military logistics, healthcare, food services, manufacturing processing and software technologies among many others.

Thus, the aim of this research is twofold; firstly, to come up with a list of priority risks that impact on humanitarian health supply chain performance metrics of time, cost and quality. Secondly, to suggest risk mitigation measures or strategies that managers can use against the prioritised risks. Both the prioritised risks menu and the corresponding mitigation strategies suggested from this study are applicable to Sub-Saharan Africa and other developing countries globally that has supply chain characteristics similar to Tanzania (the case study country).

1.2.2 Objectives of the research

SCRM focuses on “the identification of potential sources of risk and implementation of appropriate strategies (Christopher et al., 2003). In line with this thinking, the two main objectives of the research are:

- 1) *To investigate the impact of risk factors on pharmaceutical supply chain performance, especially using FMEA as a tool for risk assessment and prioritization*
- 2) *To identify possible risk mitigation strategies that can be used to manage risks and improve on supply chain performance.*

Two broad questions are used to address these two research objectives.

1.2.3 Research Questions

Two lead questions are used to make the research enquiry. The study focuses on two broad themes, that is, *risk prioritisation and risk treatment or mitigation for humanitarian pharmaceutical supply chain system.*

RQ1: Select the critical risk factors to be prioritised and managed in health supply chain system in Sub-Saharan Africa?

This research question is associated with risk prioritisation through identification of risk occurrence, detection, impact analysis and ranking to determine critical risk factors for management. Sub questions for this enquiry are available in research methodology Chapter 3.

RQ2: How can an organisation effectively manage risk factors for a health supply chain system in Sub-Saharan Africa?

This research question aims at identifying appropriate risk mitigation strategies that can help reduce the impact of supply chain risk factors on supply chain delivery time, cost and material quality. This section also identifies the potential challenges and opportunities that can be found in the pharmaceutical supply chain system. Sub questions for this enquiry are available in research methodology Chapter 3.

1.2.4 Research Hypothesis

Upon prioritising the top nine risk factors, three for each supply chain performance indicator of delivery time, cost and material quality, the study will further enquire on the relationship between risk detection capability and the likelihood of risk occurrence. Investing in risk detection tools or systems is rare for humanitarian operations. Thus, the knowledge of the relationship of risk detection capability and risk occurrence becomes paramount. This part of the study will enquire on this relationship using the following hypothesis:

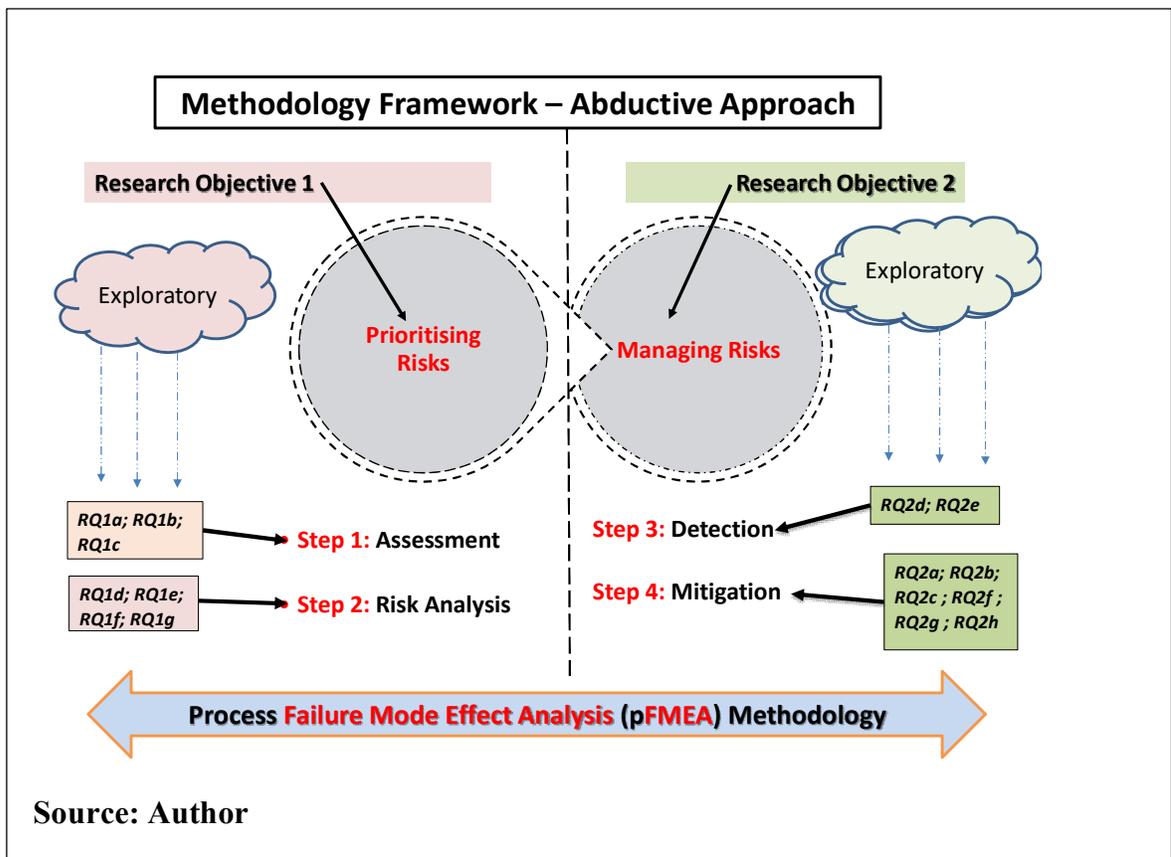
H0: If risk detection capability is increased and applied through use of FMEA model, then the risk likelihood in pharmaceutical supply chain will not be reduced

H1: If risk detection capability is increased and applied through use of FMEA model, then the risk likelihood in pharmaceutical supply chain will be reduced

The above hypothesis will be statistically tested and validated using regression analysis.

The process to obtain answers to both the research questions and the hypothesis will be conducted through multiple research methods appropriate to give best results. Figure 1.3 below presents the overview of the methodology framework the researcher is using for this enquiry. The bottom line is to provide new knowledge in the prioritisation and mitigation of pharmaceutical supply chain risks in a humanitarian context.

Figure 1. 2 Methodology Framework



1.3. Methodology / Thesis Approach

Traditionally, there are two views to research methodology, the quantitative approach and the qualitative approach. According to (Wheeldon and Ahlberg , 2012), quantitative approach uses deductive reasoning through top-down process that tests general premises through a series of steps to reach specific conclusions. On the contrary, qualitative approach applies inductive reasoning that develops general conclusions based on the exploration of how individuals experience and perceive the world around them. These two views lies each at the opposite extreme end of the continuum. This supports the traditional view that a researcher is either a strong positivist or a strong constructionist and nothing in between. But this has since been challenged by the third view, the pragmatic view (also known as mixed methods) that uses the abductive process in order to benefit from the merits of both qualitative and quantitative approaches.

This third view was born out the first two views' wrong assumptions that paradigms are always distinct and that there can be no overlaps. Typically, qualitative studies are seen as weak on generalisation and quantitative studies as weak at explaining why the observed results have been obtained (Smith et al, 2012). Pragmatic approach is an abductive process that values the expertise, experience and intuition of researchers themselves (Wheeldon and Ahlberg, 2012).

Regardless of the technique used, the designs for data collection must adhere to the two main considerations of sequencing (one method goes before the other) and dominance (one method

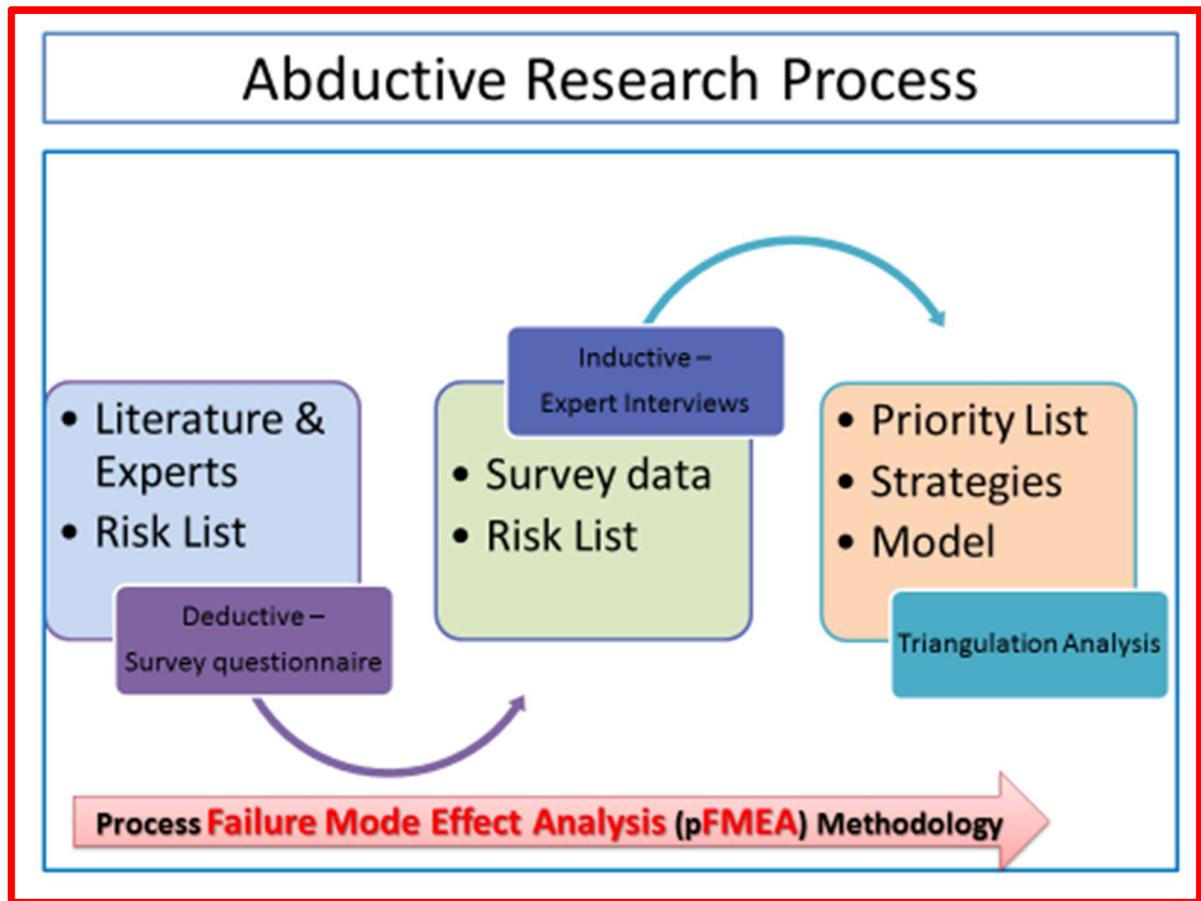
is more significant than the other or both are balanced). The application of the designs can either be in partnership (similar importance) or compensatory (where one makes up for the weakness of another). (Smith, et al, 2012).

This study is using the pragmatic approach (abductive reasoning/mixed methods) which the researcher finds most suitable for case study doctorate studies that combines empirical counts and researcher's lived experience. The use of mixed methods through the compensatory approach of using both methods (combination or triangulation) ensures that a weakness of one method is usually a strength of the other and would help to capture a more complete story (Jick, 1979; Aastrup & Halldorsson, 2008; Boyer & Swink, 2008 cited in Wieland and Wallenburg, 2012). Mixing strategies in mixed methods research provides three options to present results or findings in a mixed method (Wheeldon and Ahlberg, 2012). Data can be merged by transforming or integrating two data types together, one data type can be embedded within another or they can be presented separately and then connected to answer different aspects of the same or a similar research question (Cresswell and Plano Clark, 2007). Quantitative method was important in risk ranking. The qualitative part of the abductive logic helps the researcher to collect data from supply chain expertise on risk strategies available in practice and to design a new risk mitigation model based on opinions and reported practice, not on objective observations.

Abduction approach is found suitable for this study because, as supported by Dubois and Gadde (2002), both theoretical frameworks and fieldworks in the form of case study are simultaneously applied to reach conclusions. These strengths of mixed methods through

abductive reasoning makes it a most suitable method for this research. Figure 1.4 provides an overview of the abductive process that the author is using for this study.

Figure 1. 3 Abductive Research Process



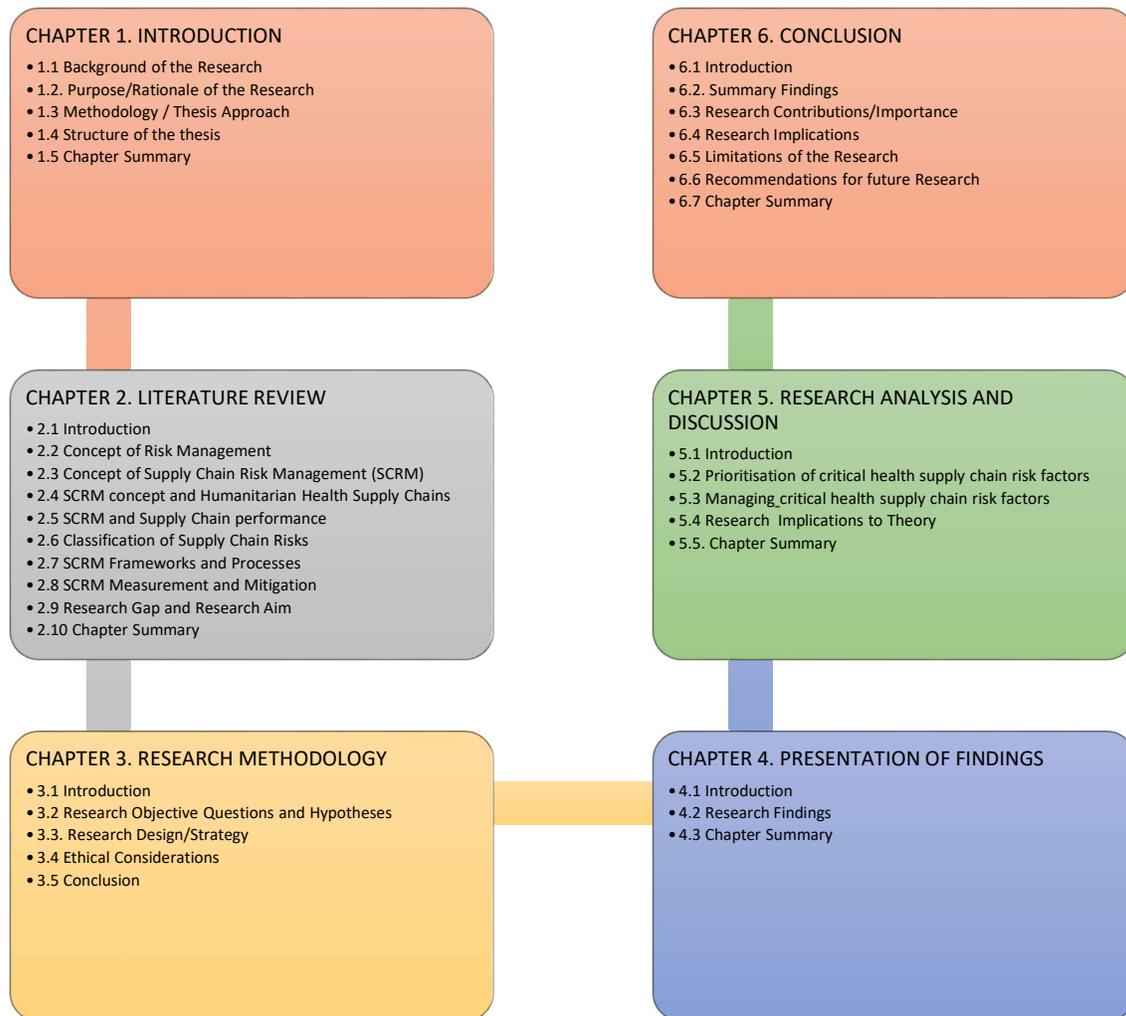
Source: Author

1.4 Thesis Structure

The structure of this thesis is outlined in Figure 1.5 below. It provides a review of all the chapters which includes; firstly, this introduction chapter, followed by review of literature to

identify research gap, thirdly is the methodology for enquiry, the findings and the discussion chapters and lastly, the conclusion.

Figure 1. 4 Thesis Structure



Source: Author

1.5 Chapter Summary

An understanding of critical risks at each phase is critical for prioritization and designing the right mitigation strategies and for resource allocation. Recent and relevant literature is used to predetermine potential risk factors that can be found in a typical pharmaceutical supply chain in developing world. A number of SCRM studies mainly identified risks factors without much focus on prioritisation using FMEA methodology, particularly for humanitarian pharmaceutical supply chains in Sub-Saharan Africa.

Chapter 2: Literature Review

2.0. Introduction

This chapter will provide a detailed review of related literature in risk management and supply management with the aim of identifying the gap and building a foundation for this study. The chapter will begin by looking at the concept of risk management in its broader sense, which includes the definition and perception of risk. The concepts of SCRM, pharmaceutical supply chains and supply chain performance are also discussed. This is followed by the detailed discussion on the classification of risks, risk measurement and mitigation and the FMEA methodology. The identified research gap from this review will be discussed and research questions are defined.

2.1. Concept of Risk Management

Risk can be described as exposure to objective and subjective uncertainty (Jereb, 2010 cited in Jereb et al 2012). According to Waters (2007 cited in Vilko and Ritala, 2014), risk in a supply chain is a threat that something might occur to disrupt normal activities and stop things happening as planned. A standard formula for (supply chain) risk is (Mitchell, 1995): $\text{Risk} = P (\text{Loss}) * I (\text{Loss})$, where risk is defined as the probability (P) of loss and its significance/impact (I).

Regardless of how risk is defined or perceived or classified, it is important to note that every risk factor has three main characteristics. That is, probability of occurrence, impact and criticality. Probability of occurrence looks at the likelihood of the risk factor taking place at a

given time, while impact focuses on the effect or severity or damage or loss suffered should the risk occurs. Criticality here refers to the intensity of the incident when it occurs. These three characteristics makes it possible to measure, rank and prioritise risks in their management. In support of this conceptual view, Manuj & Mentzer (2008a) found the presence of following three components in all conceptualisations of risk:

- probability (likelihood) of the occurrence of an event that leads to the realisation of a risk,
- potential losses once the risk is realised (criticality),
- significance of the consequences of losses (impact/severity)

Vatsa (2004) went on to define risk as the probability that a particular adverse event occurs during a stated period of time, or results from a particular challenge. It is about the uncertainty concerning the occurrence of a loss (Regda, 2007) or even a chance of injury, damage or loss (Vatsa, 2004). The uncertainty can pertain to the timing or the magnitude of the event (World Bank, 2001). The United Nations Disaster Relief Coordinator (UNDRO) provided an official definition of risk as “expected losses from a given hazard to a given element at risk over a specified period of time (Coburn et. al. 1994). Risk is the possibility that an event will occur or circumstance will arise that affects the achievement of objectives. Risk is the uncertainty of outcome and can be a threat to success or an opportunity to increased success. Such an adverse event may result in harm or loss or negative economic consequences (Paulson, 2005).

According to Lavastre et al (2012), risks influence negatively the achievement of organizations' goals. As a result, it is critically important that the cause(s) of any risk is identified and treated before risk does occur. This process is called risk management. Of course, the meaning of risk depends on how one sees and perceive it. Such perceptions of risk determine how people decide or react and technical experts and members of general public always disagree about the best course of action (Slovic and Weber, 2002). Risk management is the process of identifying and assessing risk, and establishing measures or controls to bring risks within the organizational risk tolerance. When applied to public pharmaceutical supply chains, risk management is viewed as a formal approach used to identify and mitigate the sources of disruption and dysfunction (Noel, et al 2013). Risk management includes activities to realize opportunities while mitigating the negative consequences of events (UNICEF, 2008). The United Nations Development Programme (UNDP) prepares a World Vulnerability Report which includes a Global Risk and Vulnerability Index at the national level. The index ranks countries in terms of their vulnerability to natural disaster losses. This helps countries to understand their risk exposure and the ways to mitigate against these.

The recent financial crisis meant that risk management has not found its rightful position even in its industries of origin, the insurance and financial sectors (Elahi, 2013). Thus, risk management has many definitions depending on how it is being perceived. Regda (2007) defines risk management as a process that identifies loss exposure faced by an organization and selects the most appropriate technique for treating such exposures. The two important elements in risk management is the identification of risks, usually done through assessments and the treatment of risks in order to avoid or reduce its impact. Understanding of risk(s) in a particular environment helps to establish the level of vulnerability or exposure to such risks

(Vatsa, 2004). As such, vulnerability has emerged as the most critical concept in disaster management studies. In order to adequately assess the exposure to risk and develop an appropriate response, a risk must be clearly stated in terms of the objective and cause and effect. This helps to develop resilience.

The United Nations International Strategy for Disaster Reduction defined resilience as the capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure (United Nations, 2005). Gunderson and Holling (2001 cited in Ponomarov and Holcomb, 2009) see resilience as the capacity of a system to experience disturbance and maintain its functions and controls. It is all about the system's ability to resist and absorb disruptions and changes, and if affected by these events, it is about its ability to swiftly recover to its original state (L'Hermitte C et al 2016). Resilience is important to ensure continuity of operations at the desired level. Thus, resilience in supply chains should be considered as one pillar of a resilient system, organisation, community or society.

Supply chain resilience has gained attention in recent years as a concept to respond to disruptions in the humanitarian and disaster supply chains. Disruptions can be of operational-technical nature or also include political instability, natural disasters, and complex emergencies. Humanitarian relief has therefore come to embrace the concept of supply chain resilience as well. Resilience in the disaster relief and development context refers to both the overall management of humanitarian supply chains, but also to the responsiveness to particular challenges these supply chains are exposed to. A humanitarian supply chain system is considered resilient if it has the ability to proactively plan and design the supply

chain network in a way that they anticipate unexpected disruptive (negative) events, can understand the financial impact, and respond adaptively to these disruptions whilst maintaining control over the process, desired outcomes and any legislative obligations in place (CIPS, 2018). Christopher (2005) adds that to be considered resilient, supply chain processes should be flexible and agile and are able to change quickly. In addition to these characteristics, Carpenter et al. (2001 cited in Ponomarov and Holcomb, 2009) concluded that resilience has three primary properties;

- The amount of change that a system can undergo while retaining the same controls on structure and function
- The degree to which the system is capable of organizing itself without disorganization or force from external factors.
- The degree to which a system develops the capacity to learn and adapt in response to disturbances.

Thus, a resilient humanitarian supply chain is one that can management shocks or emergency events through hazard mitigation, disaster preparedness (readiness), emergency response, and disaster recovery. Such resilience covers all risk factors in upstream, mid-stream and downstream. In other words, when disaster strikes, all the phases of supply chain should facilitate the efficient flow of aid from source to end user. A resilient supply chain is one that has alternatives of alternatives to back up the main system should a disruption occurs. Such disruptions can be in the form of a security incident, breakdown in transport system or cold chain system or port system, bad weather in the high seas and breakdown in communication networks among others. Resilience should deal with all these disruptions.

The role of risk management is to guide appropriate strategic solutions in the disruption settlements to mitigate severe effects. (Kurniawan, R. et al ,2017). Risk management typically addresses issues related to strategy, operations, economics and hazards (Andersen, 2008 cited in Henry L. et al ed Lemke, 2015). The origin of risk management as a concept can be traced back to 1950s in USA, then to United Kingdom in 1969 and was recognised as a profession in 1985. This led to the birth of The Institute of Risk Management (IRM) in 1986. According to Christopher, et al (2011), risk has been studied since the seventeenth century. Research on risk was first adapted to the business context in the 1950's and studied in areas of economics, finance, strategic management, international management. However, research on risk in the supply chain context has only started to develop in recent years (Harland et al., 2003; Christopher and Peck, 2004; Zsidisin et al., 2004, Manuj and Mentzer, 2008a; 2008b). In support of the view that supply chain risk management was a recent study, Vereecke et al (2010) postulates that risk management practices, techniques and tools have been used extensively in the financial community for years but only recently was applied to supply chain management.

The famous example of risk management in supply chain is between Erickson and Nokia on how each handled the information/threat on supply disruption by their main supplier, Royal Phillips Electronics when their factory caught fire on 17 March 2000. Nokia monitored the situation and quickly moved their orders to an alternative supplier. Erickson reported a loss of close to \$200m and yet Nokia's market share increased from 27% to 30% during the same period. The above endless list of risk attacks and their consequences or impact on business performance leave organisations with no option but to manage them strategically.

In concluding, the researcher defines risk as any potential or actual obstruction to business or project success. ***Risk is anything with potential to affect business or project's potential to success or achieve results.*** For humanitarian projects, this includes any element (actual or potential) that delays or disrupts the uninterrupted flow of goods and information from the point of origin (upstream) through transit hubs (midstream) to the final user / beneficiary (downstream). Managing these risks becomes very critical for project success. In the same context, ***risk management can be defined as the process of profiling all potential and actual risks and identifying their corresponding treatment or mitigation methods based on organisation priorities and capabilities.*** Such a process, when done well can guarantee project success.

2.2. Concept of Supply Chain Risk Management (SCRM)

The probability of an event happening and its severity given that an event occurs are considered the main characteristics of supply chain risk (Handfield et al., 2011). The knowledge of the main dimensions of supply chain risks are critical to the understanding of SCRM concept. The four key dimensions of supply chain risk as seen by Lee (2014) are; elements of loss, significance of loss, uncertainty associated with the loss and probability of loss. It is from this premises that the concept of SCRM is derived. Results from a recent systematic literature review of SCRM by Bak (2018) identified limited organized understanding of what constitutes holistic supply chain risk process and challenges in developing SCRM frameworks as some of the critical gaps that requires attention.

The concept of supply chain risk management (SCRM) is a sub-component of enterprise risk management (ERM). While the concept of risk management is quite known in areas such as finance, it is said to be still developing within the realm of supply chain management (Khan and Burnes, 2007). While ERM is about ‘holistic and enterprise / organisation wide’ approach covering corporate governance issues (Gaudensi and Borghesi, 2006), SCRM focuses on “the identification of potential sources of risk and implementation of appropriate strategies (Christopher et al., 2003). ERM looks at all loss exposures faced by the organisation and how they are treated (Regda, 2007) and also appears to be fragmented into areas such as insurance, safety, financial and non-financial (Gaudensi and Borghesi, 2006; Deloach, 2000). A well detailed definition of SCRM by Sofyalioglu and Kartal (2012) view it as a *process of risk mitigation achieved through collaboration, co-ordination and application of risk management tools among the partners, to ensure continuity coupled with long term profitability of the supply chain*. SCRM is a mere action plan specifying the potential risks and the ways of addressing them (Faisal, 2009).

This research will lean towards the definition by Faisal (2009) because of its simplicity and practicality. To this effect and in the context of humanitarian projects, ***supply chain risk management can be defined as the process of profiling all potential and actual supply chain risks and their corresponding treatment or mitigation methods based on organisation priorities and capabilities***. Common treatment methods or strategies used in humanitarian context are accept, avoid, transfer, share, reduce and mitigate/eliminate. This process can be summed up by two main phases; risk prioritisation and risk treatment or mitigation (Faisal, 2009). Managing risks in supply chain is all about coming up with a strategy or action plan on how risks will be identified and prioritised and how the prioritised risks will be treated or

mitigated. In line with this adopted definition, the researcher developed the two research questions from it. This ensured the validity of the research questions and how the findings can be used to address issues of SCRM for humanitarian pharmaceutical.

To better understand the concept of SCRM, it is important to first define what supply chain risk is. According to Maheshwari and Jain (2014) supply chain risk (also known by Tang 2006 as operational disruption risk) can be defined as an uncertainty or unpredictable event with negative influence to achieving business objectives (Foroughi et al. 2006; J. Chen et al. 2013). Tang et al. (2011) sees supply chain risk as events with small probability but may occur abruptly and can bring substantial negative consequences to the system. It can also be defined as an event with adverse effects on supply chain operations (Sofyalioglu and Kartal, 2012) or as a variation in the distribution of possible supply chain outcomes, their likelihood, and their subjective value (Juttner et al. 2003). The Supply Chain Risk Leadership Council (2011) defines “supply-chain risk” as the likelihood and consequence of events at any point in the end-to-end supply chain and “supply-chain risk management” as the coordination of activities to direct and control an enterprise’s end-to-end supply chain with regard to supply-chain risks.

This research will lean to the definition by The Supply Chain Risk Leadership Council (2011) which focuses on event likelihood and consequences along the supply chain. The researcher however will also add the element of detection capability when calculating the risk prioritisation numbers for ranking purposes. Thus, *supply chain risk can be defined as the likelihood of events taking place despite all possible detection capabilities applied and their ultimate consequence at any stage of a complete supply chain network.* The researcher

agrees that supply chain risk impedes the efficient flow of materials, products, services and information along the supply chain network. Supply chain risk is about uncertainty, unpredictability, negative influence, negative consequences, deviations, disruptions, variations and its abruptness. The effort to find solutions to the increasing impact of supply chain risks to business performance gave birth to the concept of supply chain risk management. This SCRM concept, according to White (1995) and most recently Waters (2007), has three interconnected phases or stages which are;

- **Risk Identification** that produces a list of the risks that are likely to affect the supply chain
- **Risk analysis**, whose aim is to give a prioritised list of risks that need positive attention, and the less significant ones that can be ignored
- **Risk response (mitigation)** which defines the most appropriate way of dealing with all risks to the supply chain.

The above three steps in SCRM will be adopted in this study as one that is most appropriate for the humanitarian pharmaceutical supply chains. The study will attempt to prioritise critical risks and then identify corresponding risk mitigation strategies.

In the context of humanitarian sector which this research will focus on, humanitarian supply chain entails working with an ad hoc team of organisations on extremely difficult and unpredictable circumstances (Overstreet, et al 2011). It is this difficult and unpredictable nature of relief supply chains that brings about the increase in risk levels. Any attempt to ignore such risks or dangers result in either the outright failure to implement the project or the high supply chain costs. None of these outcomes is desirable, hence the need to manage known and potential risks.

Any supply chain risk has an adverse effect on the desired performance measures like cost, chain-wide service levels and responsiveness (Tummala & Schoenherr, 2011 cited in Sofyalioglu C et al 2012). In this case, management of supply chain risks involves their assessment and identification of probability and consequences and selecting strategy to mitigate/treat the consequences (Manuj & Mentzer, 2008). Organisations with good visibility of its extended supply chain are aware of these risks and can build contingencies and react to disruptions in an informed way. *Visibility refers to the organisation or the system's ability to see (or put to open) all the flow pathways of their end to end supply chain.* Visibility capability is possible through the use of various tools or software, visual and non-visual.

Humanitarian organisations can acquire visibility through setting up pipeline tracking tools and software that can provides real-time information on the location and status of a consignment as it flows along the supply chain. For example, in relation to visibility of vaccines shipment, tracking Radio Frequency Identification (RFID) such as barcodes temperature monitoring devices are tagged on the products or shipment to provide real-time information on the exact location of the shipment and quality status of vaccines. Thus, throughout the shipping or delivery process, the supply chain manager will be able to see the location and condition of the consignment from his/her computer or dashboard. The use of RFID has a direct impact on supply chain risk management as noted by Vlachos (2013) who gave *better handling of unforeseen events*; reducing lead times in warehousing and inventory; improved quality control as some of its operational benefits. Thus, supply chain

managers can enhance their ability to manage risks (unforeseen events) by making their supply chain better visible from origin to final user.

Also, the use of SAP systems provides supply dashboards where information on order processing status can be accessed in real time and managers can use this to manage risks of delivery delays, cost and quality among others. SAP systems support external integration of the supply chain network, which is seen as one way of ensuring visibility of risks across supply chain partners and joint decision making for risk management (Chaudhuri, A, et al, 2018). Bak (2018) also echo the point that risk visibility and transparency can be achieved through systems integration. It is the desire to microscope the entire supply chain and mitigate against any potential risks that gave birth to the concept of supply chain risk management.

Supply chain management has to become SCRM oriented (Norrman and Jansson, 2004; Peck, 2006). The need to be responsive, lean and agile in the supply chain has increased supply chain complexity leading to a significant shift of attention towards risk (Micheli et al, 2008). Supply chain management is about efficient and effective ways of linking sources of supply (suppliers) to the owners of demand (end customers). This involves the movement or transferring of physical goods, services and information along the supply chain and the coordination of supply chain members. Hence its susceptibility to risks known as ‘supply chain risks’.

Risk is about the exposure to a premise of which the outcome is uncertain, (Rao and Goldsby, 2009) and supply chain risks is any risks for the information, material and product flows from original supplier to the delivery of these to the end user (Juttner, 2003). It is very paramount for an organisation to understand its supply chain risks in terms of their origin/source, their classification and the appropriate mitigation means. This is the concept of SCRM with its definition from a few authors summarised in Table 2.1 below:

Table 2. 1: Definitions of Supply Chain Risk Management	
Author	Definition of SCRM
Ju'ttner et al. (2003); Ju'ttner (2005) and Manuj and Mentzer (2008)	The identification of potential sources of risk and implementation of appropriate strategies through a coordinated approach among supply chain members, to reduce supply chain vulnerability.
Christopher et al., 2003	The identification of potential sources of risk and implementation of appropriate strategies through a coordinated approach among supply chain members, to reduce supply chain vulnerability
Tang, 2006	The management of supply chain risk through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity
Norrman and Lindroth (2004)	The collaborative application of risk management process tools for the purpose of dealing with uncertainties related to logistics activities.
Carter and Rogers (2008)	The ability of a firm to understand and manage its economic, environmental, and social risks in the supply chain
Faisal, 2009	An action plan specifying the potential risks and the ways of addressing them
Sofyalioglu C and Kartal B (2012)	The process of risk mitigation achieved through collaboration, co-ordination and application of risk management tools among the partners, to ensure continuity coupled with long term profitability of the supply chain

The definitions in table 2.1 above contain commonalities and differences about SCRM. Commonalities are found in that they all agree that SCRM is a process; they all talk about risk identification, risk mitigation, risk strategies and risk impact on business performance. Some authors went further to incorporate the “how” SCRM is achieved; that is through coordination and collaboration among others (Sofyalioglu and Kartal, 2012). Having taken all these ideas into account, the researcher proposes the following as a new definition for SCRM;

“The process of profiling all potential and actual supply chain risks and their corresponding treatment or mitigation methods based on organisation priorities and capabilities to best achieve supply chain performance objectives”

Regardless of how SCRM is defined, its main objective remains same, that is of protecting the organization from adverse effects and improve its performance. SCRM ensures that business objectives are met at optimal cost. If supply chain risks or disturbances are not properly managed, the cost of achieving the objectives of the organisation increases leading to a drop in its competitiveness. Beyond SCRM, the organisation aims to be more resilience, which is its ability to absorb or mitigate the impact of the risk/disturbance (Peck, 2006)

SCRM is not a completely new concept but one that has seen a lot of interest by many authors over the past two decades. However, its application to certain industries and business sectors is still at an infancy stage. Micheli, et al (2008) and Maheshwari et al (2014) provided a good account of literature that deals with SCRM as outlined in Table 2.2 below:

Table 2. 2 Literature dealing with SCRM	
Adopted from Micheli et al, (2008) and from Maheshwari et al (2014)	
Authors	Description of contents
Wilding (1998)	Three main causes of supply chain risks are proposed: demand amplifications, deterministic chaos, and parallel interactions
Ritchie and Brindley (2000)	The emergence of risk in the passage from supply chain to supply network is analysed
Harland et al. (2003)	A review of definitions and classifications of types of risk is provided and a useful tool to assess supply chain risks is proposed and tested
U. Juttner 2003	Supply chain risk management: outlining an agenda for future
Barry (2004)	The emergence of risk in supply chain is analysed, proposing some questions that a company must take into consideration when handling supply chain risks
Finch (2004)	A case studies analysis is presented that finds that large companies generally increase their exposure to risks by having SMEs (small- and medium-size enterprises) as partners
Giunipero and Eltantawy (2004)	Some factors are identified that should be taken into consideration When determining the level of risk in a supply chain. These factors are: degree of product technology, security needs, relative importance of the supplier, and purchasers prior experience with the situation
Norrman and Jansson (2004)	The SCRM approach implemented by Ericsson is presented and Discussed
Shi (2004)	The enterprise risk management practices in the context of supply chains are reviewed
Spekman and Davis (2004)	The importance of SCRM in extended enterprises is underlined
Ju'ttner (2005)	The business requirements for SCRM from a practitioner perspective are investigated
Peck (2005)	The possible sources of risk within a supply chain are identified
Towill (2005)	The bullwhip effect as being the main source of supply risk is Analysed

Table 2.2 continued	
Cucchiella and Gastaldi (2006)	The possible sources of supply risk in a supply chain are identified, and then a methodology based on real option to coverage the identified risks is presented
Faisal et al. (2006a)	Eleven factors that affect supply chain risk are identified that can be used to minimise it. Then, the relationships existing among these factors are established using interpretative structuring modelling
Faisal et al. (2006b)	Supply chain typologies (traditional, lean, agile, and le-agile) are classified on the basis of two dimensions: customer sensitivity and risk alleviation competencies
Gaudenzi and Borghesi (2006)	An analytical hierarchy process method is provided to evaluate supply chain risks, in order to meet the supply chain objectives
Peck (2006)	A review of the literature about supply chain management is presented, trying to analyse the link with risk and vulnerability. In particular, supply chain management is viewed as the management of risk
Tang (2006)	Four approaches that might be simultaneously used to manage risks in supply chains are proposed
A. Foroughi et al. 2006	Perspectives on Global Supply Chain Supply-Side Risk Management
Faisal et al. (2007)	A conceptual framework is presented that models various variables associated with risk mitigation environment (RME) along with their interdependencies (the same presented in Faisal et al., 2006a). Using graph theory and matrix methods, the RME is quantified and presented in the form of a single numerical index
Ritchie and Brindley (2007)	The relationships between risk management and performance in a supply chain is analysed
O. Tang et al. 2011	Identifying risk issues and research advancements in supply chain risk management
C. Colicchia et al. 2012	SCRM: a new methodology for a systematic literature review
Wieland and C.M Wallenburg (2012)	Dealing with supply chain risks: Linking risk management practices and strategies to performance

Table 2.2 continued	
J. Chen et al. 2013	Supply chain operational risk mitigation: a collaborative approach
C. F. Durach and F. Wiengarten, (2017)	Exploring the impact of geographical traits on the occurrence of supply chain failures
O. Bak (2018)	Utilized a systematic literature review (SLR) to explore the SCR research trends and gaps within the management literature

Table 2.2 above provides a summary of some of the research carried out in SCRM. There is a clear trend in this research showing the evolution of the subject. The first research before and until around 2005 looked a lot on the origin and evolution of risk management in supply chains (Ritchie and Brindley, 2000; Juttner, U. 2003), the causes of risks and the sources of risks (Wilding, 1998 and Peck, 2005), the classification of risks (Harland et al, 2003) and the importance of SCRM (Spekman and Davis, 2004).

The next generation of research on SCRM was around approaches and frameworks for SCRM (Gaudenzi and Borghesi, 2006; Faizal et al, 2009), benefits of SCRM by linking it to business performance (Ritchie and Brindley, 2007; Tang, O et al, 2011) and globalisation of risks (Foroughi, A et al, 2006). The current generation of research since 2012 is looking at methodologies of researching SCRM (Colicchia, C. et al, 2012), risk mitigation strategies (Chen J, et al, 2012), strategies to manage supply chain risks (Wieland, A and Wallenburg, C.M. 2012), impact of SCRM (Durach, C.F and F. Wiengarten, F, 2017) and on exploring research trends and gaps in SCRM (Bak, O, 2018). In his analysis, Bak (2018) went on to categorise supply chain risks into four themes; the design continuum, the process continuum, the relationship continuum and economic continuum. Much of the challenges in risk

management are found in the process continuum where products and information is exposed to the external environment as they flow from origin to destination.

This synthesis clearly shows that a lot of research was done in areas such as risk management approaches, risk classification, risk analysis, risk management tools and risk models. Few researchers looked at linking risk management to supply chain performance (Ritchie and Brindley, 2007; Wieland, A and Wallenburg, C.M. 2012). A closer look at these researches reveals that majority of these studies were done for commercial or private sector settings, thereby presenting the need for research that links risk management to performance in humanitarian/public sector pharmaceutical supply chains.

It is also important to note that the emergency of new risk sources and types calls for more analysis and new studies in supply chain risk management. According to Micheli et al (2008), a great portion of the literature has focused on the specific sources of supply risk and their groupings and another portion has analysed the methods, both qualitative and quantitative, used by companies to assess and manage supply risks. By applying commercially proven risk management approaches to humanitarian supply chains, the researcher aim to use the research findings to advance professional practices in this subject. The findings will contribute by revealing the risks to be prioritised in Sub-Saharan Africa and the corresponding mitigation strategies according to the critical performance metrics of time, cost and quality.

2.3. SCRM concept and Humanitarian Pharmaceutical Supply Chains

There are many definitions and descriptions on both logistics and supply chain management (SCM). For the purpose of this project, humanitarian supply chain management and logistics will be used interchangeably and would mean *“the process of planning, implementing, and controlling the efficient, cost-effective flow and storage of goods, and materials, as well as related information, from point of origin to the point of consumption for the purpose of alleviating the suffering of vulnerable people”* (Fritz Institute, 2015). According to McLachlin et al. (2009), humanitarian supply chains tend to be unstable, prone to political and military influence, and inefficient due to lack of joint planning and inter-organisational collaboration. Humanitarian supply chains are also seen as extensive and complex and still growing and evolving in complexity (Oloruntoba. R, and Kovács.G, 2015).

When referring to the health sector, supply chain is about the flow of products, and services in order to satisfy the needs of those who serve patients (Schneller and Smeltzer, 2006).

Whatever the definition, SCM’s goal remains the same, that of responding to multiple interventions, as quickly as possible and within a short time frame (Wassenhove, 2006). The main purpose of the healthcare supply chain is to deliver products in a timely manner, in order to fulfil the needs of those providing healthcare. This role becomes more delicate when it is about delivering health supplies and equipment to very remote locations affected by disaster. While the application of SCM practices in the healthcare sector includes the flow of patients (Beier, 1995 cited in de Vries.J and Huijsman. R, 2011), this research will only focus on its application to physical goods like vaccines, drugs, pharmaceuticals, medical devices and health aids.

A good understanding of the nature and characteristics of a humanitarian supply chain in the context of developing nations is critical foundation for any SCRM program. There are similarities and differences between humanitarian logistics and commercial logistics. Broadly speaking, humanitarian logistics is characterised by unpredictable demand, suddenness of its occurrence, the high stakes associated with the timeliness of deliveries, and a lack of resources (Beamon and Balcik, 2008). Knowledge of these characteristics helps risk managers to develop the right framework capable to mitigate against the numerous risks found in the pharmaceutical supply chain. Table 1.3 below summarises the similarities and difference between commercial and humanitarian supply chain. The application of an appropriate risk management plan is critical for business performance.

Table 2. 3 Comparison of Commercial and Humanitarian Supply Chain		
Topic	Business SCM	Humanitarian SCM
Main Objective	Maximize profit	Save lives and help beneficiaries
Demand Pattern	Fairly stable	Irregular
Supply pattern	Mostly predictable	Unsolicited donations and in-kind donation
Flow type	Commercial products	Resources like vehicles, shelters, food, drugs
Lead time	Mostly predetermined	Approximately zero lead time
Inventory control	Safety stocks	Challenging inventory control
Delivery network structure	Location of warehouses	DCs Ad hoc distribution facilities
Technology	Highly developed technology	Less technology is used
Performance measurement method	Based on standard supply chain metrics	Time to respond the disaster; meeting donor expectation, percentage of demand supplied
Source: Ertem et al. (2010)		

The performance objective of humanitarian supply chains is to save lives and help beneficiaries, yet commercial supply chains target profit maximisation. Commercial supply chains are mostly predictable and implemented in fairly stable while humanitarian chains are usually in very unstable and emergency context. This makes humanitarian chains difficult to managed as they usually managed without or with less technology. Thus, the two systems should be structured differently and rates the performance metrics differently. While humanitarian supply chains will prioritise on-time delivery in order to save lives, commercial chains are likely to prioritise the right cost. This makes the humanitarian supply chain very unique and hence, standard commercial supply chain strategies can only be contextualised rather than replicated.

Given the characteristics of humanitarian supply chains described above, it is important to note that the available resources, infrastructure and systems does not adequately supports these fragile environments. For example, the risk profile of Somalia as one such fragile country is given as *“inadequate planning, poor handling and storage, and weak management of warehouse may result in loss, damage and expired supplies as well as inventory issues”* (UNICEF, Risk Management, 2015). Such fragile state call for the need for a detailed supply chain risk analysis, leading to the development of a risk management plan to ensure support reaches the needy and timely.

Aronsson et al (2011) distinguishes healthcare supply chains from commercial supply chains indicating characteristics of healthcare supply chain as

- *Large extension of lead time uncertainties in individual functions due to difficulties to predict the time-ex: surgical procedure*
- *Organized in functions with lack of a systems view/overall strategy*
- *Lack of strategy for sub processes within each department*
- *Volumes are relatively low and variety is high*
- *Mix of highly standardized treatments and new experimental treatments with high variation in the degree of standardization between different treatments.*

In support of the uniqueness of pharmaceutical supply chains, Schneller and Smeltzer (2006) argued that in most cases, healthcare supply chains are highly fragmented and relatively inefficient. These unique characteristics of pharmaceutical supply chain calls for corresponding unique risk management models and strategies which can help promote coordination, collaboration and re-alignment of the system to make it deliver at its best. It is not a “one-size fits all” approach.

While SCM practices have been widely adopted in many sectors, the healthcare industry has not seen major improvements in the implementation of these practices (McKone-Sweet et al., 2005). Industry experts have estimated that supply chain management practices of the healthcare industry are 10 years behind such industries as retail and manufacturing (Burt, 2006). SCRM in the health program means that the critically needed supplies and equipment are delivered efficiently and effectively. In the case of ARV drugs, stock-outs can lead to ART interruption for patients (Larson.C et al, 2014). When applied to the vaccines supply chain, Kaufmann et al (2011) pointed out that all personnel, systems, equipment and activities

required to deliver vaccines from point of production to the person who needs the vaccines have minimum risk impact. For this reason, many organizations (mainly government and NGOs) should invest in risk management programs if they are to remain cost-effective and time efficient.

Every humanitarian program the world over remains relevant and viable when it is able to reduce or alleviate human suffering and pain caused by disasters, natural or man-made. Among the many humanitarian interventions is the health care program whose focus is to provide essential medicines and nutrition products. Other programs can also include the provision of education, water, sanitation, food, shelter, social protection and household items required to restore or provide basic human needs. By their nature, humanitarian programs involve the provision of supplies and as such it is no secret that their successful implementation depends heavily on the performance of their supply chains and yet supply chains are often taken for granted (Pettit and Taylor, 2007 cited in McClintock, 2009).

To perform effectively and consistently, every global supply chain should mitigate against the many risks/disruptions that lay along the chain. Supply chain resilience has gained attention in recent years as a concept to respond to these disruptions in the supply chain. There is clearly more risk today in the supply chain than there was just 10 years ago. It has become critical for every health program to ensure that their supply chains are efficient and effective or there is a serious risk of losing lives and or resources. Such an objective is always challenged by the various risks and dangers found in many of today's supply chains. Giunipero et al (2004) recognized the presence of increasing tension, risks and dangers in the world environment today. Moreover, the use of offshore manufacturers/suppliers for health

products such as vaccines and ready-to-use therapeutic food (RUTF) means more uncertainties and risks through longer lead times and potential transportation disruptions that managers face in such global and complex supply chains (Sofyalioglu et al 2012; Manuj et al 2008; Giunipero, et al 2004). To remain effective and efficient, humanitarian organizations operating in developing villages must continuously evaluate and mitigate against these risks and dangers threatening their supply chains. Hence the need to undertake both a practical and theoretical investigation into the risk factors/elements in the pharmaceutical supply chains and better understand their impact related to overall organization performance.

Avoiding freezing or heating damage is also identified as a supply chain risk that can lead to vaccines losing their potency (Matthias et al, 2007), and the heat adversely affects nutrition products such as the Ready to Use Therapeutic Food (RUTF) as well. Thus, one can easily conclude that pharmaceutical supply chains are subject to both qualitative and quantitative risks which require assessment and mitigation. Recent research (Kaufmann et al, 2011; WHO, 2014 and UNICEF, 2014) also noted the high supply chain risks resulting from the introduction of new vaccines and emerging dangers such as climate change. Lack of effective and functioning national regulatory authority to guarantee quality and safety of health supplies both in producing and consuming countries is a great supply chain risk.

The above analysis shows that there has been significant research in supply chain concepts, models and practices in the industrial/commercial sector and that the healthcare services can benefit from the lessons learnt (de Vries et al, 2011). The analysis also shows that few academic and peer-reviewed studies exist in areas related to models and strategies to better

manage pharmaceutical supply chain risks in developing countries. The increase in the emerging risks related to climate changes, natural disasters, terrorism, accidents, conflicts and government compliance in Sub-Saharan Africa is on its own adequate reason to carry out research to understand these risks and build resilience in the supply chain. The Supply Chain Risk Leadership Council also anticipated the rise of supply chain risk as a new supply chain 'pain point' (Supply Chain Risk Leadership Council, 2014). Supply chain risks regularly affect supply-demand equilibrium that managers attempt to maintain throughout the supply chain (Riley, J.M. et al, 2016), and supply chain managers continue to face a challenge to reduce the complexity of transactions along the supply chain (Pietro Cunha Dolci et al, 2017). Such complexity is seen in health supplies, particularly vaccines in terms of their demands in procurement, handling, transportation and storage. Focusing this study on the supply chains risks for these pharmaceutical products would mean that any suggested management model resulting from this research would be able to support the needs for most types of humanitarian products.

2.4. SCRM and Supply Chain performance

This section will look at the importance of SCRM and how it contributes to supply chain performance metrics of quality, cost and delivery time. Supply chain risk adversely affects the desired performance measures such as cost, responsiveness and service levels (Tummala and Schoenherr, 2011 cited in Sofyalioglu C et al 2012). Supply chain uncertainty and risk have negative impacts on logistics performance - such as delays, damage and loss (Sanchez-Rodrigues et al., 2010 cited Michael Wang, 2018). To mitigate against these adverse effects, supply chain managers are to ensure that risk mitigation measures and strategies in the form

of a SCRM plan are put in place. According to Wieland, A et al (2012) SCRM can be used as a management tool to help supply chains cope with vulnerabilities which have great influence on the supply chain's customer value and performance. In other words, the implementation of technically designed supply chain risk mitigation strategies reduces the vulnerability of global supply chains.

In support of the adverse effects of supply chain disruptions, Ponomarov and Holcomb (2009), argued that disruptions of any form, be it loss of a critical supplier, fire at a plant or act of terrorism does leads to loss of revenue and comes at a cost. In commercial terms, such supply chain disruption can lead to lost sales, lost market share and increase in logistics costs to meet expedited services. Hence some of the key benefits of a viable SCRM as echoed by Horvath (2001) are lowered inventory risks and costs, accelerated delivery times, along with reduction in warehousing, distribution and transportation costs. The impact of timely delivery of goods and services on program or business performance need no further emphasis than given by Kouvelis and Li, (2008) who postulated of its increasing criticality, with failure to deliver on time resulting in high penalties of lost sales, obsolete inventories and expediting costs. It is then true to say that a well-designed supply chain strategy which includes a SCRM plan can effectively coordinates performance, eliminate redundancies and uncertainties, and maximize efficiencies in terms of costs and speed (Tomasini & Van Wassenhove, 2009; Oloruntoba, 2007).

A good understanding of the potential risks and how they can be treated has a positive impact on the performance of any supply chain. Looking at healthcare services, it is crystal clear that

their supply chains are complex and fragmented but critical for saving lives. The application of SCRM in the pharmaceutical supply chains becomes a priority for any humanitarian program as it deals with risks which adversely affect their capacity to efficiently serve the final customers (Ouabouch.L, et al, 2013). If left unattended, supply chain risks can interrupt the performance of every business. Allianz Risk Barometer 2014 found that 43% of insurance experts are worried about business interruptions and supply chain risks among others such as natural catastrophes, fire or explosions (Supply management, 2014). Globalization too has also increased supply chain risk level when supply managers are expected to deal with complexities in projects monitoring and control brought by global trends such as outsourcing, global sourcing and off-shoring (Vereecke et al, 2010).

Program risk profiling and planning for humanitarian projects is usually of a less priority but yet when performed properly, its benefits are enormously. Some of these benefits as highlighted by Noel. W et al (2013) when evaluating the USAID Deliver projects include:

- Increase the likelihood of achieving the supply chain objectives
- Reduce costs and improve the overall efficiency of the supply chain operations
- Improve the governance and leadership of the supply chain
- Improve customer and stakeholder confidence and trust in the supply chain
- Focus the supply chain manager on proactively managing risk, not only reacting to unforeseen events

Risk management in pharmaceutical supply chain is very critical because risks from a supply chain are difficult to manage. They are difficult to identify, they can arise from every echelon of the supply chain and that fewer well-defined tools and techniques for SCRM exists.

Furthermore, as with pharmaceutical supply chains, it can be further complicated by the too many product lines as well as the perishable nature of some such as vaccines. According to Jüttner (2005), a key feature of supply chain risk is that, by definition, it extends beyond the boundaries of the single firm, and moreover, the boundary spanning flows can become a source of supply risks. Thus, the need for management to focus on supply chain risk management if they are to achieve efficiency and effectiveness.

Van Wassenhove, (2006) argued that ‘unlike logisticians in the private sector, humanitarian workers are always faced with the unknown: when, where, what, how much, where from, and how many times; in short, the basic parameters needed for an efficient supply chain setup are highly uncertain’. Humanitarian supply chains as described by Balcik and Beamon (2008 cited in Kovacs 2009) consist of the:

- (a) unpredictability of demand, in terms of timing, location, type, and size;
- (b) suddenness of the occurrence of demand in large amounts but with short lead times for a wide variety of supplies;
- (c) high stakes associated with the timeliness of deliveries; and
- (d) Lack of resources in terms of supply, people, technology, transportation capacity, and money.

The above description of humanitarian supply chains resonates very well with humanitarian pharmaceutical supply chain situations in the Sub Saharan Africa. Emergency operations (natural or man-made) always begins on a small scale with the expectation that it will end. But experience in several countries has proven that most emergencies start small and then grow bigger and bigger in size and locations, making demand very unpredictable. The sudden

occurrence of emergencies such as floods, earthquakes and tsunamis always requires pharmaceutical and food aid supplies to feed the hungry and to heal the sick and injured. Such operations to ensure that all possible steps are taken alleviate human suffering (Haavisto, I and Goentzel, J., 2015), hence the need for short lead-time delivery of supplies. Thus, on-time delivery objective will be given the highest preference compared to cost factors, although the resources limitation still requires humanitarian supply chains to be cost effective.

It is also important to note that due to the complexity of humanitarian pharmaceutical supply chains, their performance measurements seem to be more complicated as well. To be successful while operating in such a complex humanitarian context, supply managers are required to implement SCRM programs. Failure to have such risk management plan is a recipe for failure to deliver to the promise. That is why the results from a recent study by Chen D. Q et al. (2013) involving 117 supply chain executives in US hospitals found out that improving hospital supply chain performance has become increasingly important as healthcare organizations strive to improve operational efficiency and to reduce cost. The effective management of supply chain risks can contribute heavily to effective supply chain management as a whole (Manuj & Mentzer, 2008). Attempting to manage complexity in humanitarian supply chains in an unsystematic, piecemeal, and non-strategic manner can result in sub-optimal outcomes, waste of resources, and loss of lives (Oloruntoba, 2007).

To be relevant in today's volatile environment, management needs to clearly understand the risks associated with their supply chains and the possible mitigation strategies/mechanism. As

seen in the manufacturing context, properly managed supply chains provide the capability to continuously lower operational cost and increasing service to achieve differentiation (Davis, 1993; Morgan, 1997 cited in Tracey et al, 2005). Further on, well managed supply chains (including risk management) has a positive impact on business performance through better quality of products and services (Johnson and Templar, 2011). Understanding the nature of risks and the ability to build mitigation pillars around the supply chain will remain critical to sustainable supply chains. If managers fail to deal with supply chain risks, their impact on the chains have huge consequences.

The literature has shown studies have been undertaken about supply chain risk management in general, to understand the link between risk types and the corresponding management and mitigation strategies (Manuj & Mentzer, 2008) and also to understand the link between strategies and performance (Wieland & Wallenburg, 2012). However, the research by Wieland and Wallenburg, (2012) addressed this link using private sector manufacturing companies. There is a well-established link between supply chain risk disruptions and poor performance. Disruptions adversely impact on the free flow of materials and information within the supply chain. Since each supply chain system is different, the knowledge of available risks and how these causes shift in performance barometer is critical for a successful project delivery.

Thus, the researcher is of the opinion that by carrying out a study in understanding the risk prioritisation and mitigation strategies relevant for humanitarian pharmaceutical supply chains and the link between risks and how they impact on performance metrics of cost,

quality and delivery time will not only contribute to professional practice but will also pioneer studies for this concept in pharmaceutical supply chains in Sub-Saharan Africa.

2.5. Classification of Supply Chain Risks

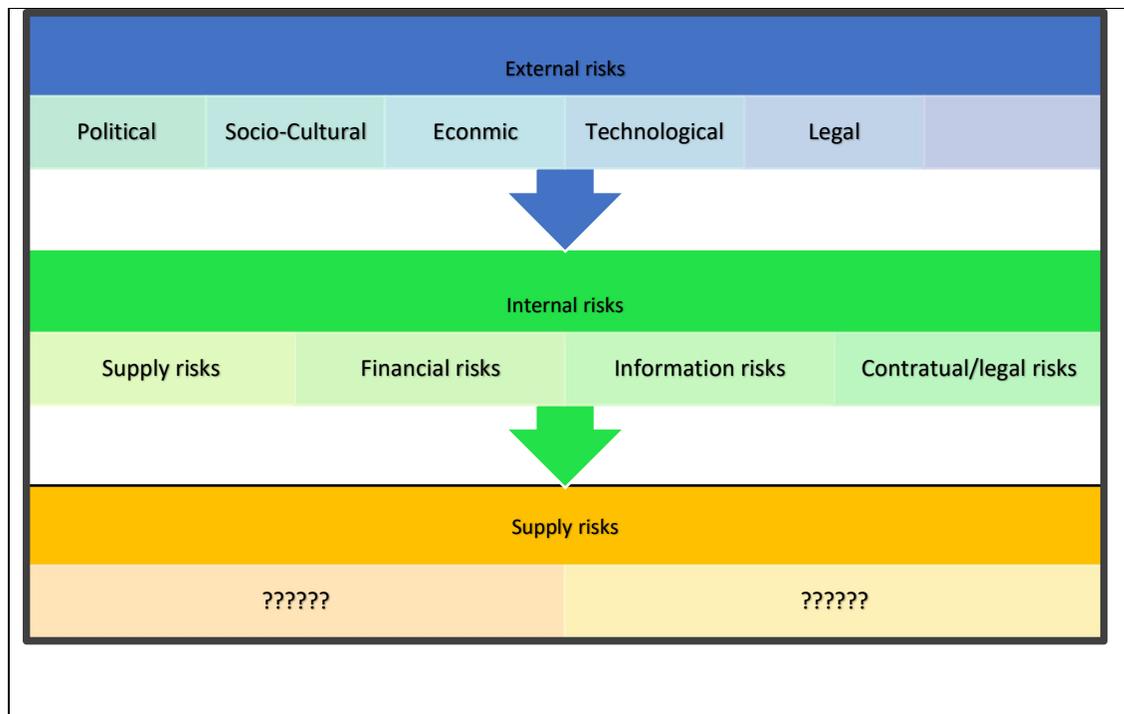
Identifying risk sources is considered as the first important issue of supply chain risk management (Zhu. Q. et al, 2017). Identification of risks is followed by their classification. Regardless of how these risks are classified, it is important to note that every risk factor has three main characteristics of occurrence probability, impact and criticality. Probability of occurrence looks at the likelihood of the risk factor taking place at a given time, while impact focuses on the effect or severity or damage or loss suffered should the risk occurs. Criticality here refers to the intensity of the incident when it occurs.

The complexity of many supply chains tells how complicated it is to try and classify the various supply chain risks that exist in the supply networks. There are commercial supply chains and public supply chains. Each of these chains have different types of risks which requires a specific form of classification. Within the public-sector chains, there are also development chains and humanitarian chains. This even further complicates the classification of these public-sector risks. According to Husdal.com (2011), supply chain risks exist on different levels of the chain, some within and some outside. For this reason, classification of supply chain risks even for a single chain becomes complicated.

The most common and maybe the easiest way of classifying supply chain risks is between internal and external as shown in Figure 2.1 below. Internal risks (endogenous) are those

risks that originates from within the organisation’s supply chain function and its suppliers, including information risks, legal or contractual risks and financial risks. On the other hand, external risks (exogenous) goes beyond specific organisation to cover the entire sourcing market and all indirect network partners. External risks examples are socio-cultural, technological, legal, political and economic risks. Similarly, Juttner et al (2003) defined these classes in terms of risk sources including environmental risk sources, network risk sources, and organizational risk sources. These are very broad classification of risks. While the organisation will have some level of control over internal risks, it may not be in a position to control or manage external risks.

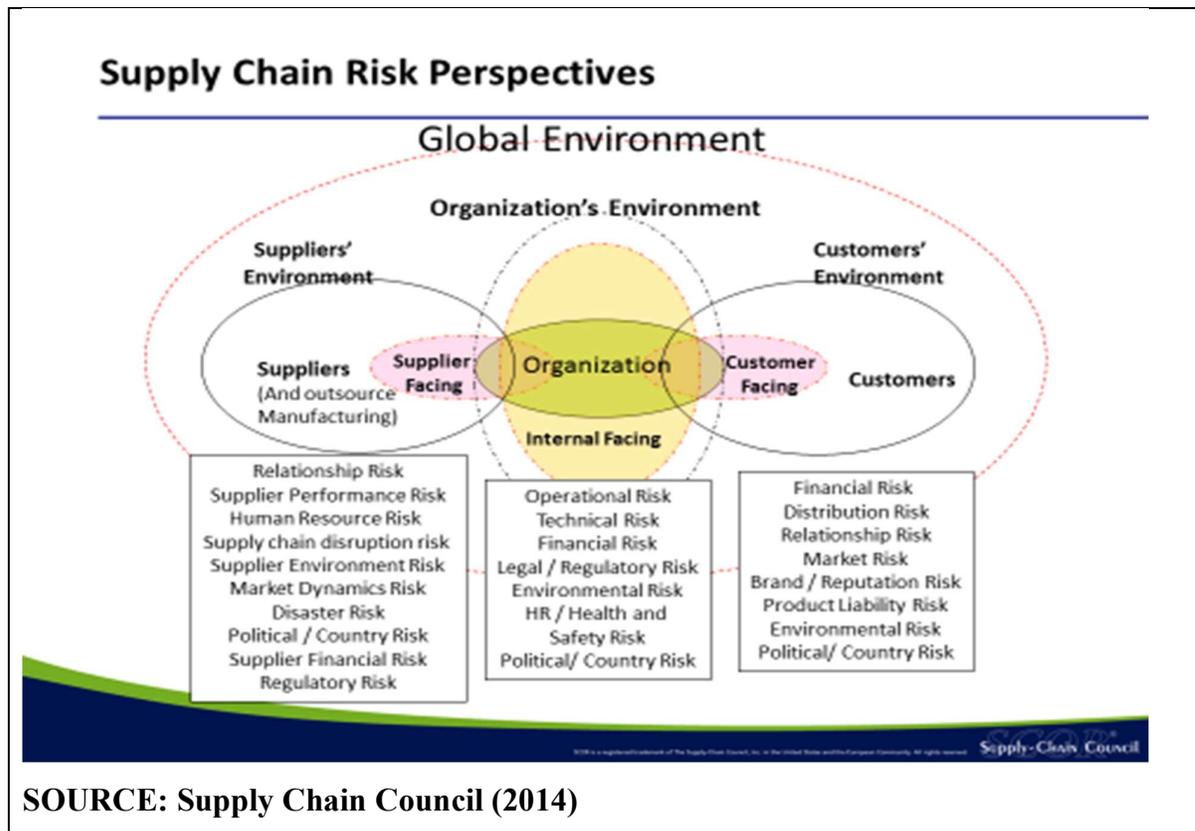
Figure 2. 1: Classification of supply chain risks: Internal vs External



Christopher et al (2011) presents a classification of risks covering four categories: supply risk, process and control risks, environmental and sustainability risks, and demand risks. Risks can also be classified into supply side risks, manufacturing side risks, demand side risks, logistics side risks, information risks and environment risks (Punniyamoorthy et al 2013). Manuj & Mentzer (2008) classified supply chain risks as qualitative or quantitative. Examples of quantitative risks are stock-outs, overstocking, obsolescence and discounts, while qualitative ones include lack of accuracy and reliability among others. Regardless of what classification is done for the identified risks and their sources, supply managers should be able to know what impact each of them have on the supply chain, rank the level of impact and come up with mitigation strategies to eliminate or reduce the occurrence and impact.

The Supply Chain Council supported a similar form of classifying supply chain risks but using what they call 'supply chain risk perspective'. It provides a detailed connection between the organisation's supply chain and its environment, internal (within organisation) and external (with supplier and customer). The council went on to classify these risks into supplier facing; internal facing and customer facing as detailed in Figure 2.2 below: The most important here is that each supply chain risk can either be internal or external. Internal is within the organisation while external is either on the supplier side or the customer side.

Figure 2. 2 Supply Chain Risk Perspectives



The classification by the Supply Chain Council is very useful and appropriate to several industries and sectors as it try to analyse the risks associated with management of the upstream supply chain (relations with suppliers), operational risks (internal to the company), and the risks associated with management of the downstream supply chain (customer relationships). However, the type of risks and their likelihood vary from organisation to organisation. And so is the level of resilience and impact.

Previous research (Ouabouch et al, 2013; Jüttner, et al, 2003; Christopher, et al 2008; Spekman et al 2004) shows that complex supply chains classify and analyse risks into three

families, that is, the risks associated with management of the upstream supply chain (relations with suppliers), mid-stream/operational risks (internal to the company), and the risks associated with management of the downstream supply chain (customer relationships). This is probably the closest way to classify supply chain risks for complex pharmaceutical supply chains in developing world as it reflects well the configuration of these supply chains.

Summary of classification by various authors is provided in Table 2.4 below: This classification borrowed heavily from the article by Husdal.com (2011) which was found to be a very useful classification of supply chain risks

Table 2. 4 Classification of Supply Chain Risks	
Supply chain risk classification (types and sources)	Author(s)
externally-driven (environmental), internally-driven (process), decision-driven (information)	Deloach (2000)
exogenous, endogenous	Ritchie and Brindley (2000)
external to the supply chain, internal to the supply chain, network related	Jüttner et al. (2002)
operational disturbance, tactical disruption, strategic uncertainty	Paulsson and Norrman (2003)
supply-demand co-ordination, disruption	Kleindorfer and Wassenhove (2003)
Environmental, network-related, organizational	Jüttner et al. (2003)
Based on five sub-chains/networks as risk sources, (1) physical, (2) financial, (3) informational, (4) relational, and (5) innovational	Cavinato (2004)
operational accidents, operational catastrophes, strategic uncertainty	Norrman and Lindroth (2004)
process, control, demand, supply, environmental	Christopher and Peck (2004)

Table 2.4. (continued)	
disruptions, delays, systems, forecast, intellectual property, procurement, receivables, inventory, capacity	Chopra and Sodhi (2004)
flow of goods, flow of information, flow of money, security, opportunistic behaviour, corporate social responsibility	Spekman and Davis (2004)
supply, demand, environmental	Jüttner (2005)
Based on the sources and vulnerabilities of risks, (1) operational contingencies, (2) natural hazards, and (3) terrorism and political instability	Kleindorfer and Saad (2005)
internal uncontrollable, external controllable, external partially controllable, external uncontrollable	Wu et al. (2006)
operational, disruption	Tang (2006)
demand-side, supply-side, catastrophic	Wagner and Bode (2006)
strategic, tactical, operational	Ritchie and Brindley (2007)
organizational, network level, industry level, environmental level	Gaonkar and Viswanadham (2007)
Categorize supply chain risks as (1) supply risks; (2) process risks; (3) demand risks; and (4) control risks	Bogataj and Bogataj (2007)
Categorize supply chain risks in the consumer electronics industry broadly as those requiring strategic decisions and those requiring operational decisions, in three categories: (1) supply, (2) demand, and (3) contextual risks	Sodhi and Lee (2007)
Categorize supply chain risks as (1) supply, (2) process, and (3) demand risks, (4) intellectual property risks, (5) behavioral risks, and (6) political/social risks	Tang and Tomlin (2008)
demand side; supply side; regulatory, legal and bureaucratic; infrastructure; catastrophic	Wagner and Bode (2008)
Categorize supply chain risks as (1) supply, (2) operations, (3) demand, and (4) other risks including security and currency risks	Manuj and Mentzer (2008a)

Table 2.4. (continued)	
for another categorization: (1) supply, (2) operational, (3) demand, (4) security, (5) macro, (6) policy, (7) competitive, and (8) resource risks	Manuj and Mentzer (2008b)
Consider low-impact high-frequency and high-impact low-frequency risks in three major categories: (1) supply, (2) demand, and miscellaneous risks in the retail sector	Oke and Gopalakrishnan (2009)
Categorize supply chain risks as (1) framework and (2) problem specific, and (3) decision making risk	Rao and Goldsby (2009)
supply, process, demand, rare-but-severe disruption, other (intellectual property, behavioral , political and social)	Tang and Tomlin (2009)
Supply risk, process and control risks, environmental and sustainability risks, and demand risks.	Christopher et al (2011)
demand, delay, disruption, inventory, manufacturing (process) breakdown, physical plant (capacity), supply (procurement), system, sovereign, transportation	Tummala and Schoenherr (2011)
supply side, manufacturing side, demand side, logistics side, information, environment	Punniyamoorthy et al. (2013)
Upstream supply chain (relations with suppliers), operational risks (internal to the company), and the risks associated with management of the downstream supply chain (customer relationships).	(Ouabouch L and Amri M, 2013)
SOURCE: Husdal.com (2011) - modified by Author	

The table above (Table 2.4) give an account of the various classes of supply chain risks. The classification varies widely based on the focus of each and every research. Most authors classify risks by supply chain phases (demand side versus supply side) or (upstream, operational and downstream); by geographical scope (internal versus external); by supply chain processes (manufacturing, logistics, transportation, storage and handling); by scope (organisational, industry, network and environmental); by

sources and vulnerabilities (operational contingencies, natural hazards, terrorism and political instability) and by managerial aspects (strategic, tactical and operational) among others.

The variety of classes of risks is a sure indication of the variety of supply chain scope and configurations that varies by industry, sector, organisation and phase/stage within the supply chain network. The researcher adopted the classification by Ouabouch and Amri (2013) which categorised risks into upstream, operational/midstream and downstream. This classification is in line with the phases of humanitarian supply chain (from supplier to user) and in accordance to what is being used by the case study organisation and other similar humanitarian organisations. The researcher will use this classification in designing research questions and in data analysis and conclusions.

2.6. SCRM Frameworks and Processes

Managing risks is about detecting or identifying potential pitfalls or hurdles and design ways to eliminate them or reduce their probability and or their impact these risks may cause to the business performance. Risk management strategy is about proactive prevention and risk mitigation. It involves plans or ways on how to deal with potential unexpected losses caused by an unexpected event (Manuj & Mentzer, 2008a). The market dynamics in the global economy makes it even harder for businesses to survive without paying attention to supply chain risks. Sofyalioglu and Kartal (2012) are of the opinion that the effect of globalization is forcing companies to design SCRM plans that manage their supply chain effectively. Besides globalization, the increase in natural and man-made disasters has also made supply chains uncertain and understanding the nature of these risks is critical to determine the appropriate mitigation measures (Vatsa, 2004)

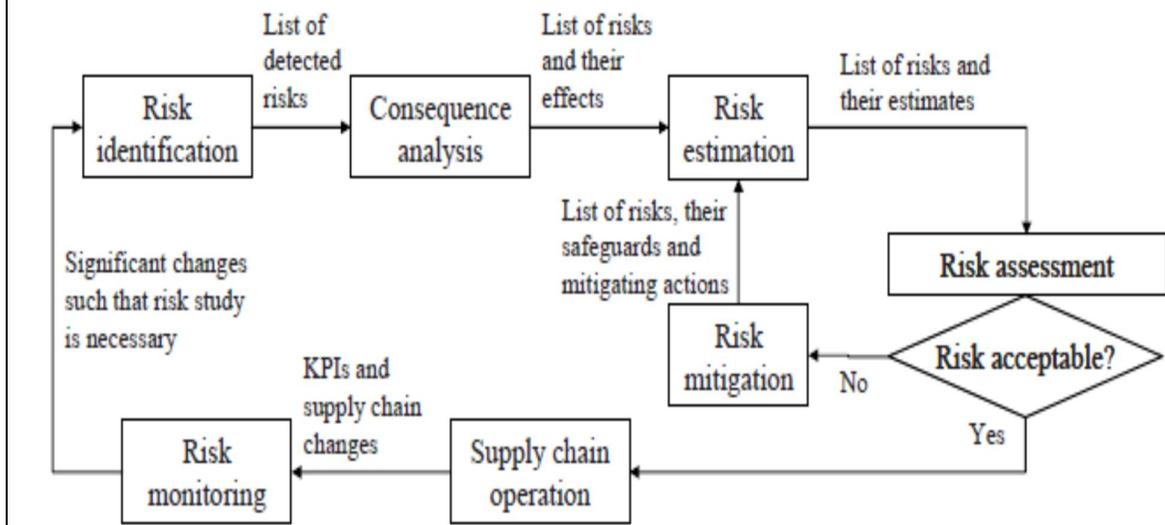
The element of designing means that the process has to follow a systematic approach. While there are several processes to deal with risk management for supply chains, there is general consensus among risk management experts that any effective process should include risk identification, assessment and mitigation or treatment. SCRM process, thus, includes risk identification, risk assessment, risk treatment, and risk monitoring represent the four main stages of the SCRM process (Zsidisin et al., 2005; Hachicha and Elmsalmi, 2014 cited in Fan and Stevenson, 2018). SCRM approach is now used by many as a tool to identify threats, assess them, and determine actions needed to manage these threats (Foroughi et al, 2006). A well designed SCRM plan brings about resilience which helps organisations to absorb or mitigate the impact of the disturbance (Peck, 2006). It is also important at this point to note that in spite of every mitigation effort an organisation takes, risk cannot be completely eliminated (Fisher, 1997 cited in Micheli, et al, 2008).

While Table 2.5 below will provide a summary of the different processes of SCRM initiatives as given by various experts, a brief explanation of these steps is paramount. Jüttner et al. (2003) considers four steps of assessing risk sources; identifying risk concept by defining its consequences; tracking risk drivers from the strategies and mitigating risks (avoidance, control, cooperation and flexibility). SCRM can also take five steps which includes identification, root cause analysis, assessment, monitoring and evaluations (Collins, 2008). Manuj and Mentzer (2008) also proposed a 5-step process covering elements of identification, assessment, selection, implementation and mitigation. As shown in Figure 2.3 below, Adhitya et al. (2008) added more steps and ended with 7-steps including risk

identification, consequence analysis, risk estimation, risk assessment, risk mitigation and risk monitoring.

The 7-steps described in Figure 2.3. were adopted in the methodology framework (Figure 1.3) in a summarised form. The methodology framework used risk assessment as a multi-steps phase covering risk identification, consequence analysis and risk estimation. Thus, when undertaking risk assessment, the assessors must ensure that all the sub-steps of identification, analysis and estimation forms part of the risk assessment exercise. Upon assessment, risks are either confirmed as acceptable or unacceptable. Risk mitigation strategies are then applied against all risks that are assessed and marked as unacceptable. However, where risk is acceptable, risk managers are expected to do nothing other than continue to monitor these risks during project implementation. Thus, ensuring that a risk management framework is in place for every critical project is important to improve on supply chain performance.

Figure 2. 3 The 7 –Steps Framework for Supply Chain Risk Management



SOURCE: Adhitya et al. (2008)

In some of the recent studies on SCRM process, The Supply Chain Risk Leadership Council (2011) underscored that an effective risk management should follow a simple process of risk identification, risk assessment, and risk treatment. As for Bandaly et al. (2012) any effective SCRM framework should incorporates risk taxonomy, assessment, prioritization, mitigation and evaluation. In their evaluation of a USAID Deliver’s supply chain project, Noel et al (2013) used a process of identification, assessment, treatment, performance monitoring and risk handling (Figure 2.4).

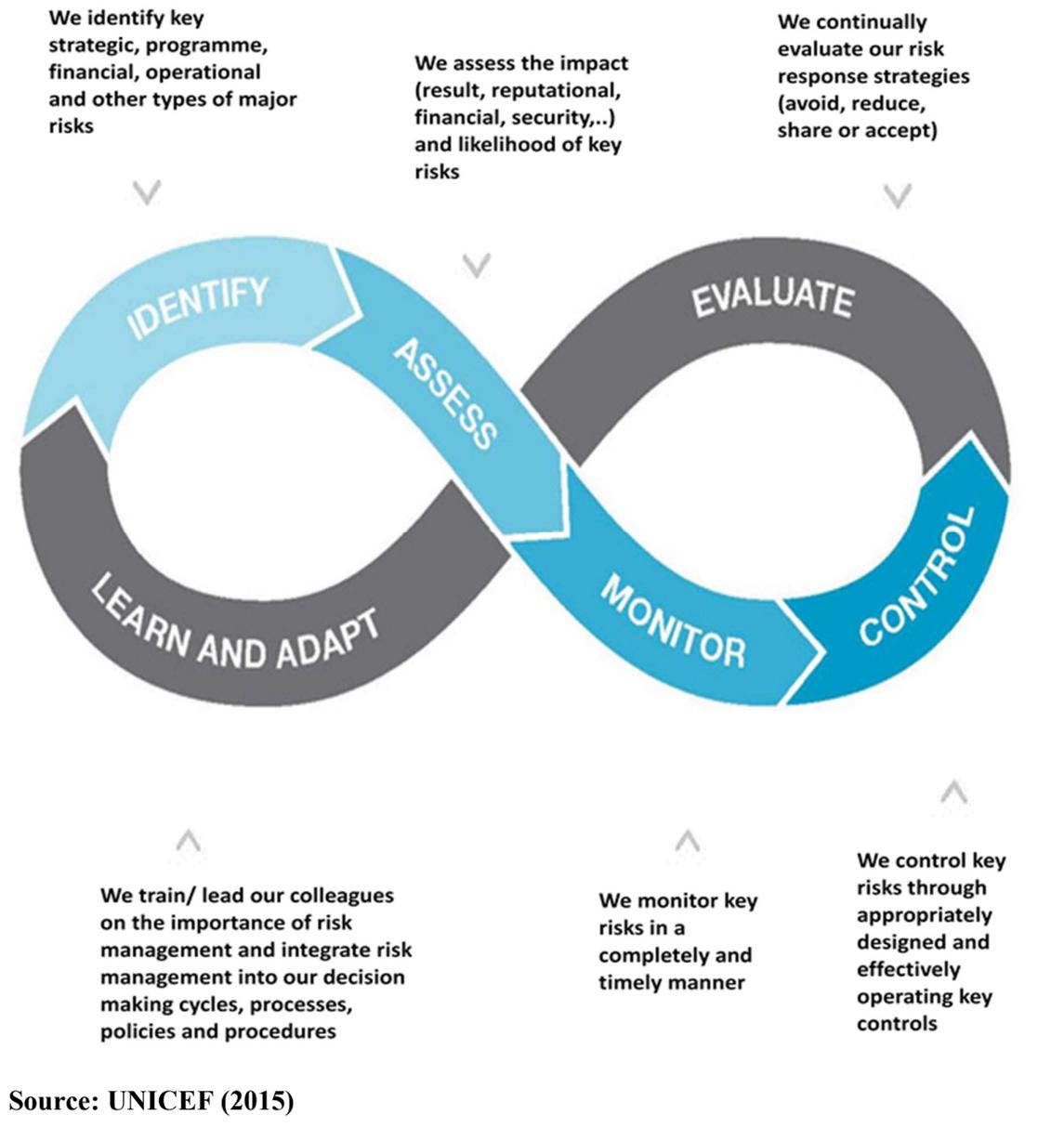
Figure 2. 4 Risk Management Process



Source: Noel. W et al (2013) – modified by Author

UNICEF (2015) has also included six-steps in their risk management process, that is identify, assess, monitor, control, evaluate and learn and adapt as shown in Figure 2.5 below.

Figure 2. 5. Risk Management Process



And lastly, Maheshwari et al (2014) acknowledged the many approaches in SCRM and then went on to summarise these approaches into what he calls three critical stages of risk identification, risk analysis and risk evaluation/mitigation.

After having reviewed the many steps or stages in SCRM process, one can conclude that there is no one right process for the many supply chain risks. The different operating environment and difference in size and complexity of projects calls for this diversity in approaches. However, whatever the number of steps or the wording, any effective SCRM should include risk profiling, risk ranking/prioritisation (due to limited resources and time), risk mitigation and risk monitoring and evaluation. Table 2.5 below provides a summary of the different SCRM process as put forward by different researchers.

Table 2. 5: Summary of SCRM Process (steps/stages by authors)					
SCRM steps/stages					Authors
1	2	3	4	5	
Assessment	Identification	Tracing	Mitigation	-	Jüttner et al. (2003)
Identification	Assessment	-	Mitigation	-	Foroughi et al. (2006)
Identification	Analysis	Assessment	Monitoring	Evaluation	Collins (2008)
Identification	Analysis	Estimation	Mitigation	Monitoring	Adhitya et al. (2008)
Identification	Assessment / Evaluation	Selection of strategy	Implementation of strategy	Mitigation	Manuj and Mentzer (2008)
Identification	Assessment	-	Treatment	-	SCRLC (2011)
Taxonomy	Assessment	Analysis	Mitigation	Evaluation	Bandaly et al. (2012)
Identification	Assessment	Treatment	Monitoring	Handling	Noel. W et al (2013)
Identification	Analysis		Evaluation		Maheshwari et al (2014)
Identification	Assessment	Treatment	Monitoring		Fan and Stevenson, 2018
Source: Author					

2.7. Supply Chain Risk Management: Measurement and Mitigation

2.7.1. Risk Profiling Techniques: Identification, assessment and analysis

The literature review has revealed the multiple risks and dangers that can be found in global supply chains including in those managing the delivery of humanitarian aid. As such, there is need to refer to some of the existing commercial risk management techniques which may be seen as a more mature subject discipline. The SCRM frameworks are used to perform risk profiling and select appropriate treatment strategies.

Risk profiling is considered the most important step in risk management. This is supported by Ouabouch et al, (2013) who advanced that in the process of the supply chain risk analysis, risk identification is often regarded as paramount. It is at this stage that all risks are identified, assessed and measured leading to matching these with response strategies. Here, the constructs of risk identification are risk drivers (*what causes?*), risk sources (*where are risks found?*) and risk consequences (*what impact/effect?*). Thus, it is important that a common set of assessment and measurement criteria is developed and used to evaluate the risks across the entire supply chain.

One of the most popular tool or framework that risk managers use for risk profiling is the supply chain operations reference (SCOR) model developed by the Supply Chain Council (SCC). SCOR is a widely-accepted industry reference model for SC operations that was introduced to assist organizations in mapping, developing and referencing SC operations, and

assessing and monitoring levels of SC performance (Rotaru, K et al, 2014). The SCOR model evaluates and compare supply chain activities and their performance using the four perspectives of internal-facing, customer-facing, supply-facing and environment-facing. Rotaru, K et al, (2014) records that from the supply chain process perspective, SCOR is organized around five strategic supply chain process types, namely Plan, Source, Make, Deliver and Return. At the strategic level SCOR represents each supply chain as interconnected sets of Source-Make-Deliver execution processes, which transform/transport materials and/or products. Planning allows management of cross-organizational customer-supplier links, while Return accounts for raw material returns and receipt of finished goods.

Through integrating these components SCOR aims to increase visibility and enhance performance for all members of a SC network (SCC, 2010). The internal logic driving the risk management process is reflected within SCOR's best practices, rather than as sub-processes integral to SCOR. Within SCOR, SCRM has been reflected at Level 3 as a set of "Enable" type process elements, that is, Plan Risk, Make Risk, Source Risk, Deliver Risk and Return Risk. But, as seen by Rotaru, K et al, (2014), SCOR's Process component does not reflect decomposition of risk management processes into sub-processes such as risk identification, risk analysis, risk treatment and risk monitoring as commonly recommended in risk management standards and frameworks. For this reason, the researcher will not use it for this study.

The bow-tie risk analysis is also another method that can be used to understand nature of risk, rate of likelihood and the consequences. The risk maturity model is also seen as one tool

supply managers can use to identify, assess and treat potential risks in order to suggest mitigation strategies. The maturity model allows a self-assessment of supply chain risk management (SCRM) capabilities across five categories (Leadership, Planning, Implementation, Evaluation, and Improvement), assessing each on a five-stage rating scale (Reactive, Aware, Proactive, Integrated, Resilient) (Supply Chain Risk Leadership Council, 2014). The other relevant risk assessment, management and mitigation models include the 5-step process (Manuj & Mentzer, 2008) and the Analytical Hierarchy Process (AHP) model.

All these are popular decision making tools/models that managers can use to reach a decision regarding risk presence, impact and priority. Hallikas et al (2002) also argued that prioritization of risks helps a company to focus the decision making and risk management effort on the most important risks. Table 2.6 below summarize the various frameworks or techniques available for risk measurement and analysis.

Table 2. 6 SCRM frameworks and techniques		
Framework / Tool	Purpose	Author
Failure Mode and Effect Analysis (FMEA)	Prioritises risks by ranking them in order of Risk Priority Number (RPN). RPN is calculated as <i>Risk Severity X Risk Occurrence X Risk Detection</i> . The higher the RPN, the higher the level of risk priority.	Faizal & Palaniappan, (2014)
Maturity Model	Self-assessment of supply chain risk management (SCRM) capabilities across five categories (Leadership, Planning, Implementation, Evaluation, and Improvement), assessing each on a five-stage rating scale (Reactive, Aware, Proactive, Integrated, Resilient)	SCRLC (2014)
Probability-Impact Matrix	uses the combination of probability and impact scores of individual risks and ranks/ prioritizes them for easy handling of the risks	Ouabouch L and Amri M (2013)
Five- Step process	Uses 5-steps of risk identification, evaluation, selection, implementation and mitigation	Manuj and Mentzer (2008)
Analytical Hierarchy Process (AHP)	the decision making techniques is used to estimate the weights of the risk factors in a supply chain. The importance of each of the risk mitigation strategies is also estimated accordingly.	Saaty (1996)
Fuzzy Analytical Hierarchy Process (FAHP)	a synthetic extension of the classical AHP method by taking into account the fuzziness of decision maker	Gaudenzi and Borghesi (2006)
SCOR Model	evaluates and compare supply chain activities and their performance using the four perspectives of internal-facing, customer-facing, supply-facing and environment-facing.	Supply Chain Council
Bow-Tie Risk Analysis	Identify, analyse and demonstrate causal relationships in high risk scenarios (causes and measures) and provides visual presentation	Alizadeh and Moshashaei (2015)

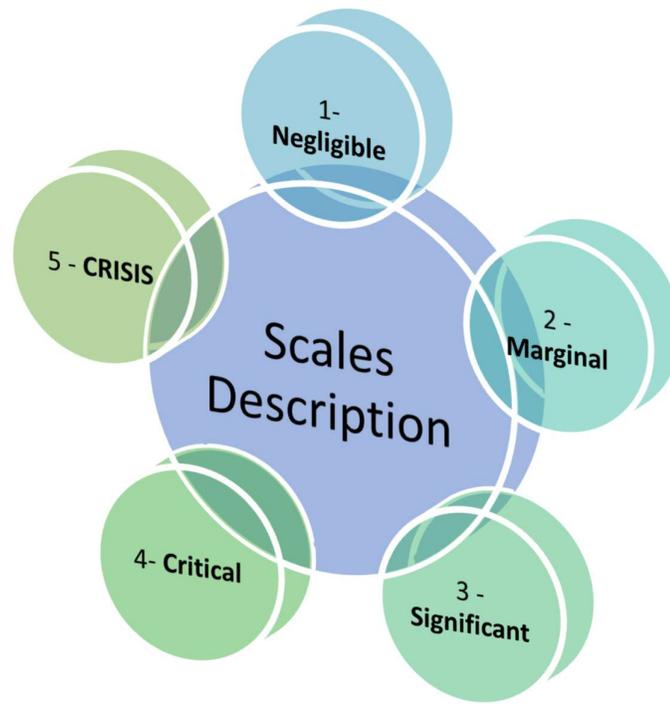
Whatever framework or tool is used, it must focus on three most common criteria for risk measurement or assessment which are LIKELIHOOD, IMPACT and DETECTION. When

likelihood and impact only are under consideration, the criteria is commonly known as probability-impact approach (Manuj and Mentzer, 2008). According to Christopher (2005), there are six steps for mapping the risk profile and developing strategies:

- Prioritize earnings drivers
- Identify critical infrastructure that affect the earnings drivers
- Locate vulnerabilities in the critical infrastructure
- Model scenarios for the vulnerabilities
- Develop responses to the scenarios
- Monitor, detect and respond to potential disruptions as soon as possible

When assessing the likelihood of a risk occurring, one has to look at the possibility/probability that such a given event will take place. Likelihood can be expressed using qualitative terms such as FREQUENT, LIKELY, POSSIBLE, UNLIKELY and RARE. Once the likelihood is known, the next step is to measure the potential impact should that risk takes place. The impact is assessed using a five-point scale of NEGLIBLE, MARGINAL, SIGNIFICANT, CRITICAL and CRISIS as shown in Figure 2.6.

Figure 2. 6 Risk Impact Measurement Scale



The combination of both likelihood and impact ratios is what brings about risk profiling and prioritization. The outcome of this measurement process is a risk matrix which allocates risk levels to all potential risks along the supply network using levels such as VERY HIGH; HIGH; MEDIUM; LOW; VERY LOW (UNICEF, 2015).

Thus, each identified risk level will require an appropriate risk response strategy. Normally, for very low and low risks, the acceptance strategy is employed while avoidance, reduction and transfer is applied to medium to very high risks. Whatever strategy is used, its objective is to decrease either the likelihood or the impact. Understanding the risk drivers (through root

cause analysis) can help managers to select the appropriate risk responses/strategies. Thus, the process of risk profiling should take into account the identification of risk drivers.

Having reviewed and considered all the risk frameworks and methods available for managing supply chain risks, the FMEA methodology was chosen as the tool that forms the backbone of this study. FMEA is a method that prioritises risks by ranking them in order of Risk Priority Number (RPN) (Faizal & Palaniappan, 2014). RPN is calculated as *Risk Severity * Risk Occurrence * Risk Detection*. The higher the RPN, the higher the level of risk priority. The key features of FMEA are utilised in identifying supply chain risk sources, risks and mitigation strategies. The FMEA methodology was found most suitable for this study because it is one of a few among the techniques suggested by the ISO/EIC 31010:2009 standard which categorises and highly recommended for risk identification, analysis, prioritisation and treatment (Curkovic et al, 2013). This makes FMEA one of the well-documented and proven technique commonly used for evaluating risk failures in process designs. The research by Curkovic et al (2013) revealed that those companies that properly and consistently used FMEA in risk assessment and evaluation achieved significant benefits. *“Understanding the types of risks and their probability of occurrence as well as the associated impacts is a starting point for companies to develop effective Risk Management strategies”* Faizal & Palaniappan (2014). Hence, the choice of this tool in designing tools for enquiring about risk prioritisation and treatment for humanitarian pharmaceutical supply chain.

FMEA can be found in two types, the Product FMEA and the Process FMEA. This study will investigate supply chain risks throughout the supply chain processes, hence, a Process FMEA will be the appropriate tool to use. The clearest FMEA process this study will borrow a lot

from in order to investigate risk factors and ways to mitigate them is one by Welborn (2007) and Faizal and Palaniappan (2014) which includes the following stages/steps:

1. Identify risk categories.
2. Identify potential risks.
3. Rate the opportunity, probability, and severity for each risk.
4. Calculate the risk priority number (RPN) for each risk.
5. Analyse risks by RPN using a Pareto distribution.
6. Develop actions to mitigate risks with high RPN.
7. Reassess risks with another cycle of failure mode effect analysis

Having reviewed and considered all the risk frameworks and methods available for managing supply chain risks, the FMEA methodology was chosen as the tool that forms the backbone of this study. The FMEA methodology was found most suitable for this study because it is one of a few among the techniques suggested by the ISO/EIC 31010:2009 standard which categorises and highly recommended for risk identification, analysis, prioritisation and treatment (Curkovic et al, 2013). FMEA is a method that prioritises risks by ranking them in order of Risk Priority Number (RPN) (Faizal & Palaniappan, 2014). RPN is calculated as *Risk Severity * Risk Occurrence * Risk Detection*. The higher the RPN, the higher the level of risk priority. This makes FMEA one of the well-documented and proven technique commonly used for evaluating risk failures in process designs. Hence, the selection of FMEA as the technique for enquiring about risk prioritisation and treatment for humanitarian health supply chain.

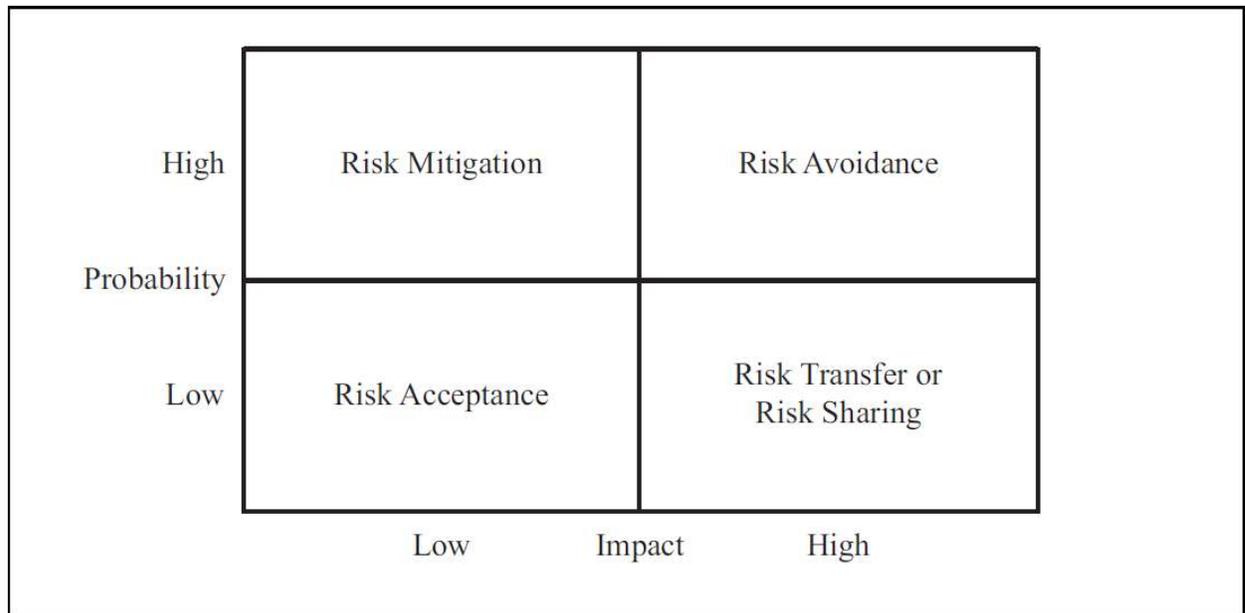
2.7.2. Risk Mitigation Strategies

Mitigation is one of the risk treatment approaches. Mitigation seeks to actively reduce risk to an acceptable level (Fan and Stevenson, 2018). Considered as the last and major step in risk management, mitigation is about developing and implementing ways or strategies that help to reduce either the likelihood and or the impact of key risks so that they do not significantly affect the achievement of an organization's objectives. Hence, understanding the nature of risks is critical in recommending the appropriate treatment measures and building resilience (Vatsa et al, 2004; Peck, 2006). The selection of a risk mitigation strategy also depends on the risk type and the organisation's budget (Tummala and Schoenherr, 2011); and organisations should carefully evaluate the acceptance, avoidance, sharing, and transfer options before selecting a mitigation strategy (Fan and Severson, 2018).

Treatment method depends on type of risk, occurrence of risk and impact of risk, and is usually done through risk acceptance, risk avoidance, risk transfer/share and risk mitigation (Fan and Stevenson, 2018). Mitigation strategies are typically suitable for operational risks with a high probability and low impact (Aqlan and Lam, 2015). The selection of a risk mitigation strategy also depends on the risk type and the organisation's budget (Tummala and Schoenherr, 2011), and organisations should carefully evaluate the acceptance, avoidance, sharing, and transfer options before selecting a mitigation strategy (Fan and Stevenson, 2018). As summarised in Figure 2.7 below, (Fan and Stevenson, 2018) went further on to explain that investing in risk avoidance seems necessary for high probability, high impact risks to reduce their likelihood of occurrence, whereas risk acceptance may be permitted for low probability, low impact risks. Risk mitigation appears most suitable for high probability, low

impact risks while risk transfer/sharing seems most appropriate for disruption risks with a low probability and high impact, such as natural disasters and terrorist attacks.

Figure 2. 7: Risk Treatment strategies based on probability and Impact

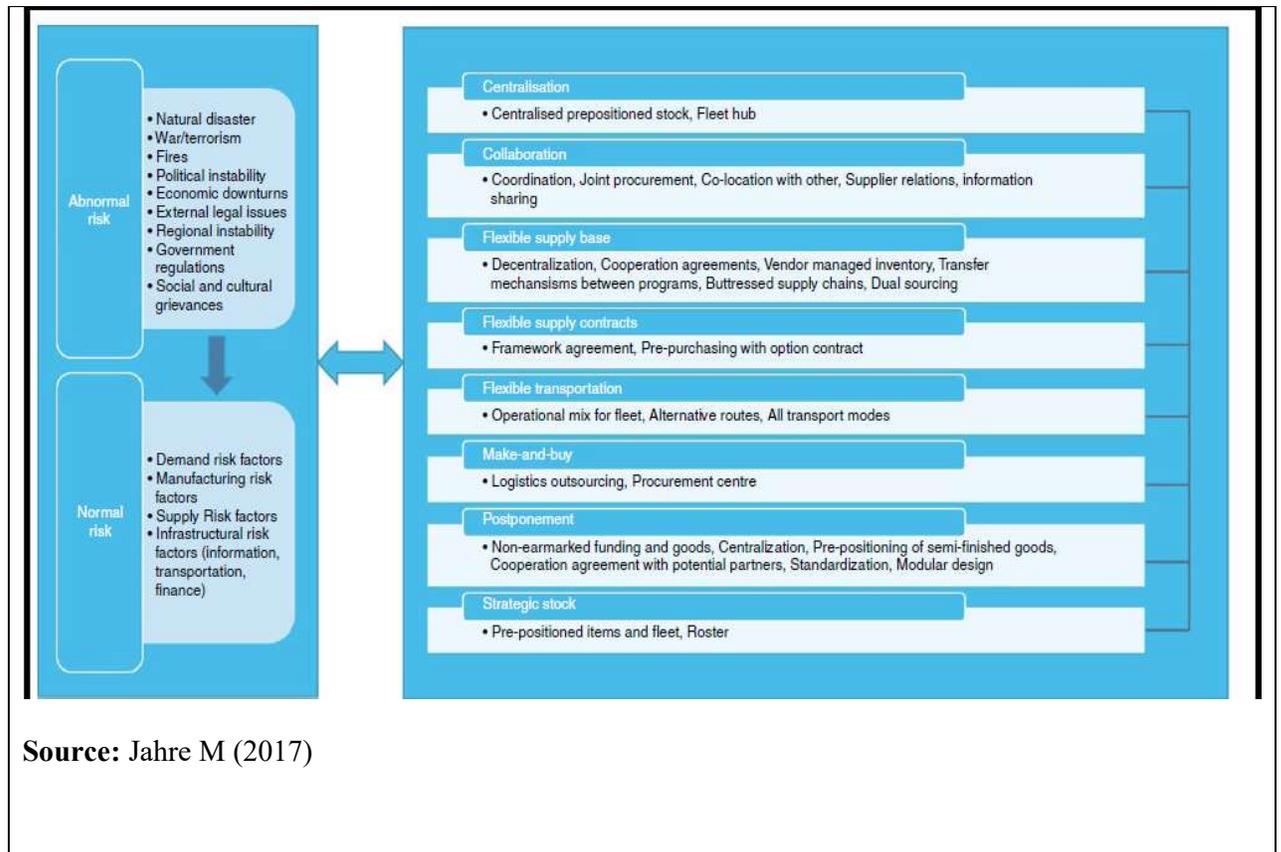


Source: Fan, Y and Stevenson, M (2018)

There are many techniques or strategies of managing risks and these vary by nature of risk and context of the operating environment. Thus, the right strategy is a result of the correct risk profiling process. Tang (2006) classifies four basic approaches to mitigate the impact of such supply chain risks. These includes the management of demand (downstream); product (material flow); information (sharing information) and supply (upstream). These approaches points to the fact that while risk profiling, managers must ensure that all stages in the supply chain network are covered, that is from up-stream to downstream through the mid-stream.

Kleindorfer and Saad, 2005 (cited in Sofyalioglu and Kartal, 2012) gave some of the risk mitigation strategies in the form of a set of 10 principles which includes; putting company's house in order; applying portfolio theory in sourcing options, logistics, and operational modes; focusing on prevention rather than cure; establishing backup systems, contingency plans, and maintaining reasonable slack; collaborative sharing of information and practices among supply chain partners and applying TQM principles like Six-Sigma Approach. To be more precise, Manuj and Mentzer (2008) in their five-step process method suggested risk management strategies such as postponement, speculation, hedging, transfer/share, security and avoidance. When applied to humanitarian supply chain, Jahre, M (2017), gave risk mitigation strategies which includes; centralization, collaboration, flexible supply base, flexible supply contracts, flexible transportation information sharing, postponement, make or buy, speculation and strategic stock prepositioning. These humanitarian mitigation strategies are more relevant to the case under investigation and are described in Figure 2.8. According to Christopher et al, (2011) risks managers can implement network re-engineering, collaboration and agility in dealing with global sourcing risks.

Figure 2. 8: Humanitarian Supply Chain Risk Mitigation Strategies



Postponement is about delaying the actual commitment of resources to maintain flexibility and delay incurring costs, whereas speculation is the opposite of postponement; also, called as selective risk taking. Postponement for humanitarian supply chains can benefit concepts such as non-earmarked funding and goods, centralization, pre-positioning of semi-finished goods, cooperation agreement with potential partners, standardization, operations reversal and modular designing (Tang, 2006; Jahre, M, 2017). **Speculation** (the opposite of postponement; also, called as selective risk taking). According to Sofyalioglu and Kartal, (2012), speculation strategy, referring to early commitment of resources and forward action in the supply chain in order to reduce marketing costs, is the best alternative for the following

situations: Excessive demand of consumers requiring more goods to be supplied and suppliers being late to submit documents to banks, and finally problems of port capacity and congestion. All these risks threaten timely production and delivery of products and speculation may be the cure.

Centralisation is when the organisation set up central supply chain hubs for easy processing and management of supply chain resources and processes such as procurement, fleet hubs and prepositioned stock. **Collaboration** is a strategy which covers aspects such as coordination, joint procurement, co-location with others, supplier relations and information sharing. This strategy has become so relevant in current humanitarian responses where resources are limited and cost effectiveness is considered critical. Collaborative partnerships support visibility across the supply chain, development of supply chain flexibility, relationships between supply chain members and efficiency of inventory costs (Faisal et al., 2006).

Strategic stocking, also known as **prepositioning** is one key risk mitigation strategy as part of emergency preparedness. This refers to an arrangement whereby an advance investment is done to procure and deliver humanitarian supplies and equipment closer to potential risk prone locations. This strategy also involves prequalification of humanitarian response personnel into rosters ready to be deployed when an emergency strikes.

Flexible supply base is another important strategy whereby long term supply framework agreements are established for all strategic supplies and equipment. Such agreements are triggered as soon as an emergency happens and will enable supplies to be ordered and delivery in a very short lead-time. Similarly, **flexible transportation** strategy where an

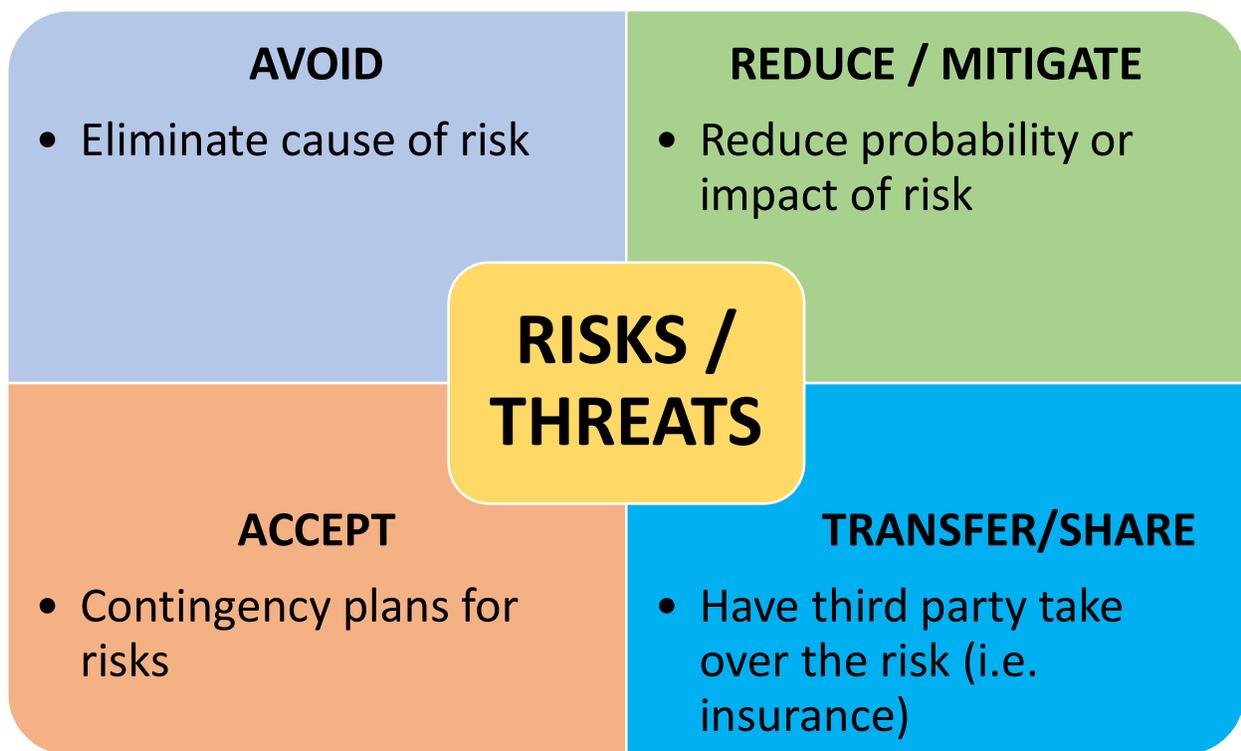
operational mix for fleet is established, covering alternative routes and for all transport modes.

In their study of a supply chain system for ARVs (shown is Table 2.7 below), Larson. C, et al (2014) argued that in order to improve the delivery performance due to production or shipping delays, the program can use four strategies which are multiple-source procurement; pooled procurement; stock piling and flexible specifications for presentation of ARVs (appearance of packaging, quantities per package, instructions printed in multiple languages) to facilitate common product use across multiple countries.

Table 2. 7 ARV Supply Chain Risks and Corresponding Risk Mitigation Strategies		
Risk Category	ARV Supply Chain Risks	Risk Mitigation Strategies
Supply	<ul style="list-style-type: none"> • Production delays • Shipping delays 	<ul style="list-style-type: none"> • Multiple-source procurement • Pooled procurement • Use of regional distribution centres (RDC) • Flexible product specification
Demand	Expanding treatment program	Frequent update and review of supply plans
	<ul style="list-style-type: none"> • Inaccurate or /and delayed demand forecasting and supply planning • Burdensome procurement procedures 	<ul style="list-style-type: none"> • Regional aggregation of country forecasts and supply plans for pooled procurement • Restocking of RDCs based on likely demand
Cost	<ul style="list-style-type: none"> • High per unit product cost • High shipping cost 	<ul style="list-style-type: none"> • Pooled procurement based on aggregate demand plan • Freight consolidation and ocean shipping
Source: Larson.C, Burn.R, Minnick-Sakal.A, Douglas. M.O and Kuritsky J (2014)		

Taking this further, the results from the evaluation of the USAID Deliver projects by Noel, et al (2013) revealed that the most common risk treatment strategies and their responses are acceptance (develop contingency plans); avoidance (reduce likelihood); reduction (reduce impact) and hedging (reduce impact). For UNICEF (2015), the four basic risk treatment strategies to key organizational risks are avoid, accept, transfer/share and reduce/mitigate (as presented in Figure 2.9 below)

Figure 2. 9: Risk Response Strategies



Source: UNICEF (2015)

Sofyalioglu and Kartal, (2012) concludes by arguing that the right strategy differs from firm to firm and is also based on manager's subjective evaluation of the current position in the

market and its characteristics. Supply chain visibility, supply chain flexibility, supplier development and inventory control are critical ingredients to choosing the right risk mitigation strategies (Kurniawan, R, et al, 2017). Thus, identifying the right mitigation strategies for the pharmaceutical supply chain is critical to ensure business performance.

2.8. Research gap and Research Aim

Most researchers agree that the interest in studying SCRM is on the rise (Khan and Burnes, 2007; Sodhi et al., 2012; Colicchia & Strozzi, 2012) and that the field of SCRM is still developing (Khan and Burnes, 2007; Ghadge et al., 2012; Sodhi et al., 2012). So far, most of these studies focused on setting out concepts and frameworks (Tang, 2006, Faisal et al 2007 and Chen et al. 2013). While these frameworks and concept are very important in providing foundational base, their application to some industries and context such as humanitarian sector in Tanzania still remain under-researched. While a few studies have been much on risk identification and treatment, very few has been able to link these risks to supply chain performance measures (Ritchie and Brindley, 2007), especially for humanitarian health programs in general and Tanzania in particular. The implementation challenges that programs face has been largely attributed to poor performance of the supply chain system and understanding their impact is the starting point for excellence (Faizal & Palaniappan, 2014). Understanding of risk(s) in a particular environment helps to establish the level of vulnerability or exposure to such risks (Vatsa, 2004), thereby reducing the impact of risks on supply chain performance.

While exposure to risks impacts on several performance measures, this study will focus on measures of on time delivery, cost and quality. The other performance measures include product quantity, accountability and sustainability, thus making prioritisation of which risk

elements to deal with much more difficult. According to Haavisto, I and Goentzel, J, (2015), when efficiency is defined as cost or time efficiency, it can directly support an overall organizational goal such as program effectiveness and financial continuity. Supply chain risk adversely affects the desired performance measures such as cost, responsiveness and service levels (Tummala and Schoenherr, 2011 cited in Sofyalioglu C et al 2012). The impact of timely delivery of goods and services on program or business performance need no further emphasis than given by Kouvelis and Li, (2008) who postulated of its increasing criticality, with failure to deliver on time resulting in high penalties of lost sales, obsolete inventories and expediting costs. For humanitarian supply chains, failure to deliver critically needed supplies results in loss of lives.

In an effort to close contextual gap, this study has a twofold outcome. That is, using FMEA methodology to establish a list of *prioritised risks* and propose list of appropriate *mitigation strategies* that can be applied to humanitarian pharmaceutical supply chains in Sub-Saharan Africa and other developing states globally with similar supply chain characteristics. The strategic model should contain critical risk factors and the recommended risk mitigation strategies that supply managers can use to improve on the performance of their humanitarian health supply chain. Literature search has not been able to provide evidence of any such research in terms of aim, methodology and location. Thus, the aim of this research is *firstly to come up with a list of priority risks that impact on humanitarian pharmaceutical supply chain performance metrics of time, cost and quality. Secondly, to suggest risk mitigation measures or strategies that managers can use against the prioritised risks.*

This enquiry used 2 research questions through both quantitative and qualitative means:

RQ1: What are the critical risk factors to be prioritised and managed in pharmaceutical supply chain system in Sub-Saharan Africa?

RQ2: How can an organisation effectively manage risk factors for a pharmaceutical supply chain system in Sub-Saharan Africa?

2.9. Chapter Summary

In this chapter, the researcher used various sources and articles (largely published between 2000 and 2017) to provide the analytical review of literature available on risk management. This looked at the concept of risk management in terms of its definition and how it is perceived both in supply chain industry in general, and humanitarian pharmaceuticals in particular. A comparative analysis per industry sector and country supply chains helped to understand the scope and impact of risks on supply chain performance metrics or indicators. The various approaches and frameworks to classify and profile supply chain risks and the respective treatment approaches were also discussed in terms of the respective steps, stages and processes. In conclusion, the contextual gap was identified leading to the construction of the research aim for this study.

Chapter 3: The research methodology

3.0. Introduction:

The preceding chapter on the review of literature pointed out to the research gaps in the area of supply chain risk management. This study made an investigation into the prioritization and management of humanitarian pharmaceutical supply chain risk factors and their impact on project performance in Sub-Saharan Africa context. To investigate this contextual gap and build on previous research, two research questions were established; the first on risk prioritization and the second on risk mitigation. The presentation of the research hypotheses (derived from the research questions) is included in this chapter.

This chapter starts by explaining the research design; that is the philosophical background and theoretical perspective and the research approaches/methodology and its limitations. The characteristics of the research paradigms and approaches are explained to arrive at the preferred pragmatic philosophy that is enquired through an abductive approach (theory testing and theory generation).

Further on, the chapter explains how this exploratory study used mixed methods on a compensatory approach using the FMEA methodology to enquire on the case study. FMEA is a risk management research technique that uses RPN values to rank risks and prioritize them for treatment. The data collection techniques are outlined. While both questionnaire survey and interviews enquires on risks to be prioritized; interviews further enquire on risk mitigation strategies and techniques. The questionnaire survey was designed and completed on Qualtrics tool and analyzed through SPSS's descriptive statistics and regression analysis,

FMEA tool and Pareto Distribution analysis. Interviews (face to face and Skype) were conducted and data was analyzed through Nvivo software and content analysis. Data collection tools were taken for a pilot study as a way of ensuring their suitability for needs and purpose of this study.

3.1. Research Objective, Questions and Hypotheses

After reviewing the literature on risk management in humanitarian pharmaceutical supply chains in developing countries, most of it in project reports, presentations and company websites, there is a gap relating to academic studies published in peer reviewed journals in this area particularly with reference to the Sub-Saharan Africa region and Tanzania. Thus, the aim of the research is to examine risk factors that affects humanitarian supply chains and their impact on performance metrics of quality, delivery time and cost. Research findings will contribute towards a better understanding of the critical risk factors and how reducing or eliminating their impact of supply chain system can contribute to systems strengthening and resilience through delivery time reduction, cost efficiency and quality assurance.

This research aims to answer the what, why and how questions. According to Kvale and Flick (2007, p.35), *“the why and what of the investigation should be clarified before the question of how-mode is poised”*. For this reason, the objectives of the study are designed systematically to ensure that all the “what and why” questions are addressed first and the “how” questions second. This formula is also observed even in the designing of data collection tools. The objectives of the study is to deliver research that:

- (a) Evaluate the concepts and theories about critical risk factors that exists in humanitarian pharmaceutical supply chains and their impact on supply chain performance, including the identification of key performance indicators (KPIs).
- (b) Investigates supply routes and hubs to identify and rank supply chain critical risks and vulnerabilities and the corresponding performance objectives/indicators that they impact (KPI risk matrix)
- (c) Explores the possible corresponding mitigation strategies against each of the risk factors
- (d) Investigate the causal relationship between risk detection and risk occurrence

To clearly answer the four objectives above, the researcher carefully selected the appropriate research methods for collecting data for each objective as presented in Table 3.1 below.

Table 3. 1: Research Objectives and Research Tools

Research Objective	Research Tools/Methods
Evaluate the concepts and theories about critical risk factors that exists in humanitarian pharmaceutical supply chains and their impact on supply chain performance	<ul style="list-style-type: none"> • Academic journals • Academic books • Conference papers • Organisation documents
Investigates supply routes and hubs to identify and rank supply chain critical risks and vulnerabilities and the corresponding performance objectives/indicators that they impact (KPI risk matrix)	<ul style="list-style-type: none"> • Questionnaire survey (closed questions) • Observations (systems at hubs) • Public or/and organisation documents

Table 3.1. (continued)	
Explores the possible corresponding mitigation strategies against each of the risk factors	<ul style="list-style-type: none"> • Questionnaire survey (closed and open-ended questions) • Interviews (semi-structured) • Public or/and organisation documents
Investigate the causal relationship between risk detection and risk occurrence	<ul style="list-style-type: none"> • Questionnaire survey (closed and open-ended questions) • Public or/and organisation documents

Key Performance Indicators (KPIs), also known as performance measures or metrics are the milestones that confirms whether or not the system has achieved its intent or objectives.

There are several performance metrics important in the effective management of humanitarian pharmaceutical supply chain. According to Yang and Geunes (2007), certain customers place a high premium on shorter order lead times, while others may be willing to trade a longer lead time for a lower price. Wagner and Bode (2008) suggested order fill capacity, delivery dependability, customer satisfaction and delivery speed as important aspects of customer value. High product quality and reduced cost as also considered critical elements that brings customer value (Wieland and Wallenburg , 2012). There is general consensus that delivery time, delivery times, speed, quality, cost and capacity are the metrics that can be used to measure the contribution of a supply chain system towards customer satisfaction.

When applied to pharmaceutical programs, Hult et al. (2006) gave quality, speed, cost and flexibility as the key hospital supply chain performance metrics. One of the key indicator of an effective pharmaceutical supply chain as recorded by The Sphere Project (2011) is that no health facility is out of stock of selected essential medicines and tracer products for more than

one week. Thus, to ensure zero stock outs, every supply chain system should maintain stock availability at optimum level. This can be achieved by focusing on measures of on time delivery (OTD) on quality products at the right cost. While most of these metrics are found in the system under study, the most important three metrics that are mostly affected by the risk factors are on time delivery (herein referred to as delivery time), product quality and cost of delivery. Thus, this study will investigate the impact of risk factors on the three (3) performance metrics of on-time delivery, product quality and cost of delivery. The research objectives and questions were formulated around efforts to identify the risk factors that impact on these three metrics and the corresponding mitigation strategies.

In line with the research objective and research gaps, this study established the below two research questions against which questionnaire and interview schedule were designed. Sub questions are also used to provide an in-depth investigation.

RQ1: What are the critical risk factors to be prioritised and managed in pharmaceutical supply chain system in Sub-Saharan Africa?

RQ1a. What are the upstream risk factors in pharmaceutical supply chain system?

RQ1b. What are the midstream risk factors in pharmaceutical supply chain system?

RQ1c. What are the downstream risk factors in pharmaceutical supply chain system?

RQ1d. What are the critical risk factors affecting supply chain delivery time?

RQ1e. What are the critical risk factors affecting supply chain cost?

RQ1f. What are the critical risk factors affecting supply chain material quality?

RQ1g. What risk factors should be prioritised for treatment?

RQ2: How can an organisation **effectively manage** risk factors for a pharmaceutical supply chain system in Sub-Saharan Africa?

RQ2a. What risk mitigation strategies minimise the impact/severity of risk factors on supply chain delivery time?

RQ2b. What risk mitigation strategies minimise the impact/severity of risk factors on supply chain cost?

RQ2c. What risk mitigation strategies minimise the impact/severity of risk factors on supply chain performance material quality?

RQ2d. What risk factors have weak detection capability?

RQ2e. How important is early detection in eliminating or minimising risk occurrence and impact/severity?

RQ2f. What factors impede implementation of risk mitigation strategies?

RQ2g. What risk management opportunities exist in Sub-Saharan Africa region?

In answering RQ2e (causal relationship between risk detection and occurrence), the study will look at the following broad hypothesis:

H0: *If risk detection capability is increased and applied through use of FMEA model, then the risk likelihood in pharmaceutical supply chain **will not be** reduced*

H1: *If risk detection capability is increased and applied through use of FMEA model, then the risk likelihood in pharmaceutical supply chain **will be** reduced*

Risk detection is the ability to foresee risk events before they occur. Risk detection can lead to risk prevention, however, building risk detection capability in humanitarian context is

expensive. The increased costs for monitoring suppliers can lead to decreased overall transaction costs, **as early detection of supply chain risks can enable risk mitigation**, and hence lower overall transaction costs by reducing the likelihood of supply chain disruptions (Blome and Schoenherr, 2011). Hence, the need to carry out this hypothesis to identify the significance level of the relationship between risk detection and risk occurrence.

Sodhi & Tang, (2009) defines detection time as the elapsed time between the occurrence of an event and the moment a firm recognises the occurrence of – or the initial impact of – the event. Effective risk detection tools or systems should always ensure that the detection time is one that leads to prevention. Speed detection allows quick adjustments of supply and demand levels so as to address disruption consequences (Riley, J.M et al 2016). Risk detection, according to Bak (2018) is important as it provides causal and hierarchical structure in which the “causal interrelationships between risk sub-factors, risk factors and risk events. Detecting operations risks such as internal or supplier monitoring, inspection, and tracking are critical elements of risk management (Sinha et al. 2004, Zsidisin et al. 2004, Manuj and Mentzer, 2008). Warning capabilities such as detection serve as an antecedent to recovery (Price, 2004). Managers can lessen the severity of a threat by detecting and disseminating information quickly to supply chain partners. Riley, J.M et al (2016) suggest that information derived from warning activities also bolsters recovery capability, since managers might use new knowledge as they reconfigure existing systems so as to mitigate the impact of a supply chain risk that has created an imbalance. Thus, the researcher found it value adding to study the causal relationship between risk detection and occurrence.

This enquiry wanted to establish if there is any relationship between the level of risk detection and the rate of occurrence against the fourteen (14) risk factors found to be critical in the supply chain based on FMEA methodology and the 80-20 Pareto rule. This is important because it can inform organisations whether or not to invest in expensive risk detection tools knowing their level of contribution in reducing risk occurrence and impact.

To address this, fourteen (14) hypothesis were derived from the prioritised risk factors with the highest impact (RPN) and those that contributed to 80% of occurrence and impact, and tested using SPSS's regression analysis. The minimum recommended value of significance is 0.05 (5%). Any value more than 0.05 is not significant.

- *H1: The capability to detect unexpected port charges on humanitarian shipments reduces its rate of occurrence*
- *H2: Advance detection of stock expiration reduces the risk of actual stock expiry*
- *H3: Advance detection of causes of permits processing delays reduces rate of its occurrence*
- *H4: The capability to detect communication problems with freight forwarders reduces the rate of its occurrence*
- *H5: Advance detection of supplier delivery problems reduces its rate of occurrence*
- *H6: The capability to detect delivery problems by freight forwarder reduces on the rate of its occurrence*

- *H7: Advance detection of last mile transporters' problems improves on the timely delivery of shipments*
- *H8: Advance detection of shortage of temperature controlled storage facilities at port reduces the rate of its occurrence)*
- *H9: The capability to detect causes of incorrect product forecasting reduces the rate of its occurrence*
- *H10: The capability to detect causes of poor handling and storage reduces the rate of its occurrence*
- *H11: The capability to detect potential shortage of refrigerated vehicles reduces the rate of its occurrence*
- *H12: The capability to detect causes of product quality failures by suppliers reduces the rate of its occurrence*
- *H13: The capability to detect causes of communication problems with end user reduces the rate of its occurrence*
- *H14: The capability to detect quality failures by freight forwarders can reduces rate of its occurrence*

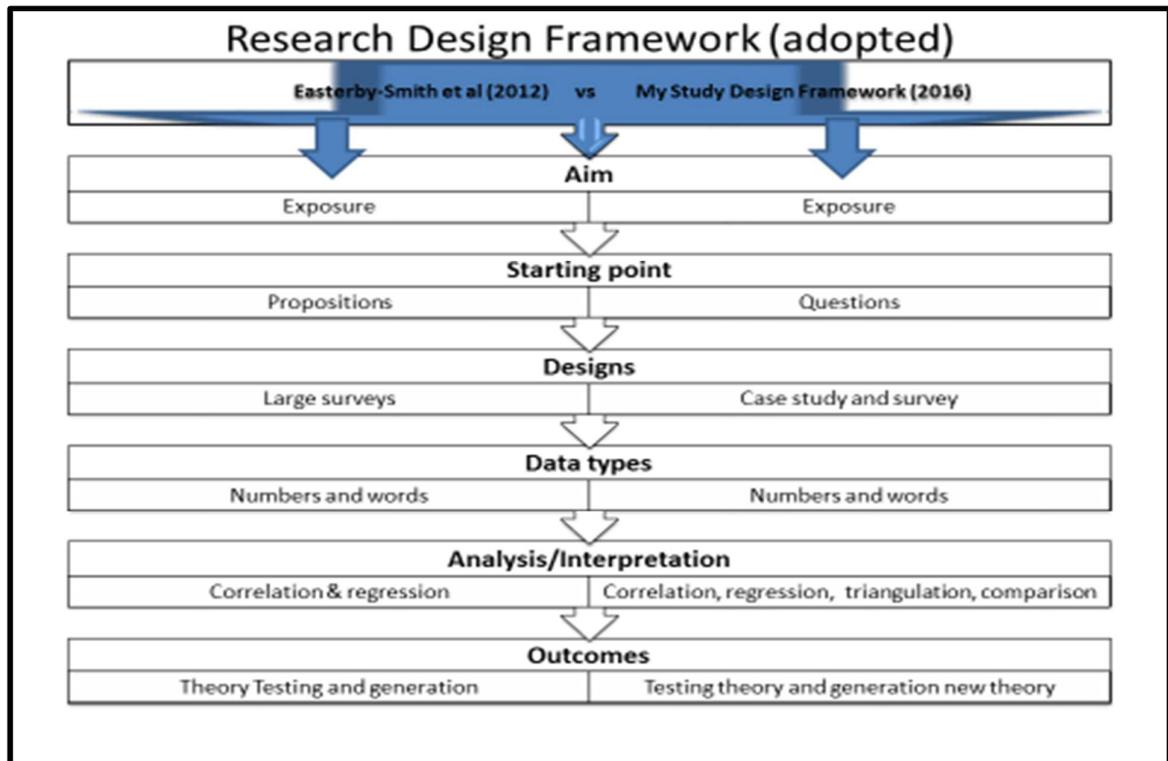
3.2. Research Design / Strategy

The outcome of the research is as good as its strategy. A research strategy provides a clear overall plan of how the research will address the research question in line with the philosophical framework and researcher's epistemological position (Saunders et al. 2009).

Drawing from the research paradigm which is pragmatic in philosophy, this study is mainly deductive in nature, with some aspects of inductive approach in order to generate new theory.

For this reason, the study will use a mixed-methods approach to answer the pre-set research questions. Adapting from the Smith et al (2012), the design framework for this study will comprise of the elements of ontology, epistemology, methodology and methods and techniques as shown in Figure 3.1 below. In applying the suggested research design framework, the study will also use the research steps as suggested by Sarantakos (2005) and presented in Figure 3.2.

Figure 3. 1 Research Design Framework



Source: Author

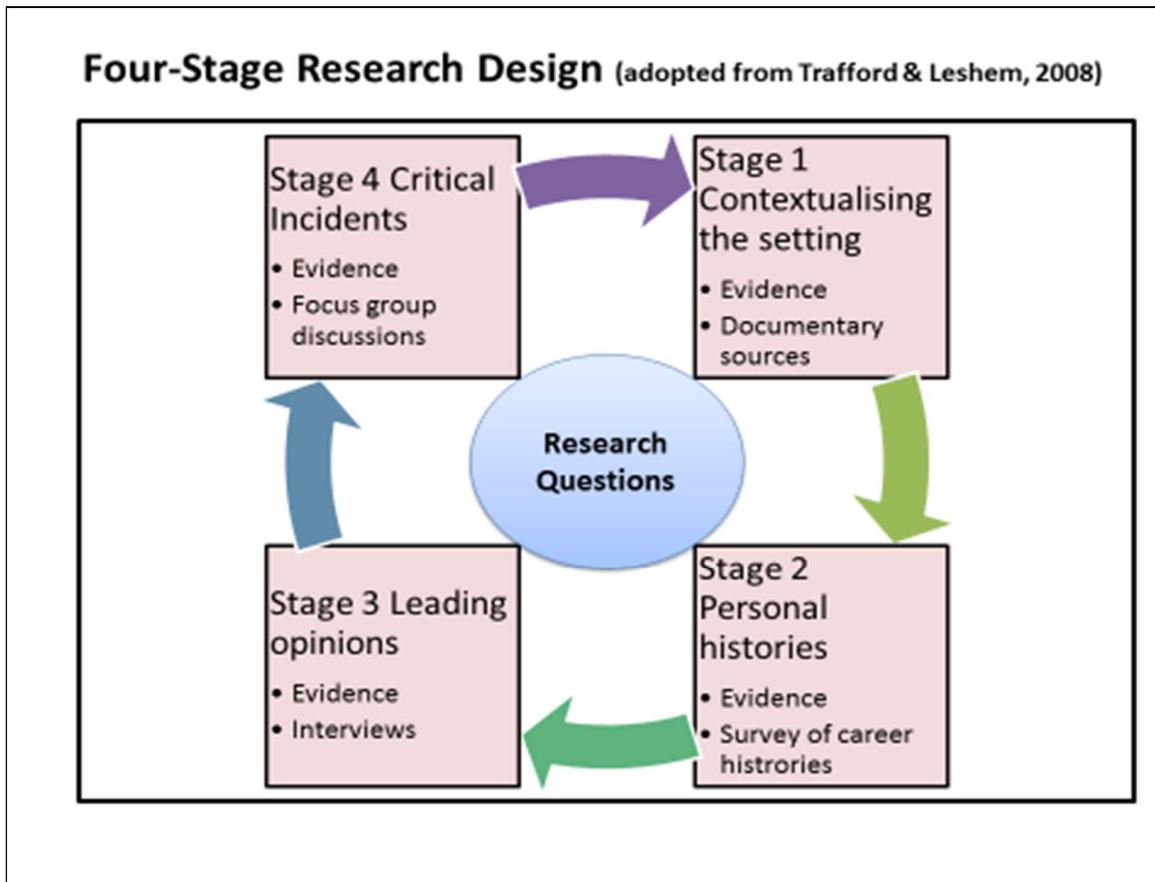
Figure 3. 2 Steps of the Research Design



Source: Sarantakos (2005)

In the event of combining both deductive and inductive approaches (which is the case in my Trafford & Leshem (2008) suggested a four-stage research design involving sequential fieldwork as shown in Figure 3.3 below. And each approach and stage will be designed to answer specific research questions and the conclusions from each stage will feed evidence in the subsequent stage in a triangulation way.

Figure 3.3 Four Stage Research Design



3.3. Research Philosophical Paradigms

Research paradigm is a perspective that is based on a set of presuppositions, concepts and values (Johnson & Christensen, 2008). That is why social science researchers are required to consider an inherent philosophical preference, stemming from post-positivist to post-constructionist. It is extremely important to understand philosophical assumptions underlying a research process as, *“The way we think the world is (ontology) influences: what we think can be known about it (epistemology); how we think it can be investigated (methodology*

and research techniques); the kind of theories we think can be constructed about it; and the political and policy stances we are prepared to take" (Fleetwood, 2005, p. 197).

Research is undertaken for two broad reasons; *to test existing theory* (positivism) or *to develop new theory* (anti-positivism/social constructionism). According to Denzin & Lincoln (2011, p.13), research is influenced by the set of beliefs and feelings that the researcher has regarding the world and how it should be understood and studied. Such set of beliefs guides how the researcher should act, and this is also known as paradigm (Guba, 1990.p.17).

Paradigms represent ways of seeing the world through a 'definition of the field and the idea that shared paradigms result in commitment to the same rules and standards for scientific practice. (Kuhn, 1996 cited in Trafford & Leshem, 2008).

The belief and feelings are the determinants of the researcher's philosophical position, which in turn underlie the designs of management research. Failure to have a philosophical position can seriously affect the quality of management research (Smith, Thorpe & Jackson, 2012.p.17). According to Smith et al (2012.p.17), understanding of philosophical issues is very useful for three reason: "*to clarify research designs; to recognize which designs will work and which will not; to identify and even create designs that maybe outside his or her past experience*".

Thus, a good researcher must take a philosophical stand concerning matters of *ontology* (assumptions on how reality looks like or beliefs about REALITY) and *epistemology* (assumptions on how to measure or enquire about this reality). The differences in the

philosophical position results in the difference in the methodologies, methods and techniques used in conducting research. It is paramount for a researcher to be clear and precise on philosophies and paradigms which helps to shape up the research design framework (Crotty, 1998; Burrell & Morgan, 1979).

When thinking about carrying out a research, one has to consider the design framework which basically looks at scope, levels of thinking and terminology to be adopted. In this regard, Crotty (1998) talks of epistemology, theoretical perspective, methodology and methods. On the other hand, Trafford and Leshem (2008) gave the choices in design which includes paradigms, approaches, methodology and methods. Lastly in this analysis is the thinking by Smith, Thorpe and Jackson (2012.p.18) who advanced that the choices in research design should look at “*the essence of ontology, epistemology, methodology and methods and techniques*”. This research will adopt the design and terminology by Smith, Thorpe & Jackson (2012) as described in Table 3.2 below.

Terminology	Meaning
<i>Ontology</i>	Philosophical assumptions about the nature of the reality
<i>Epistemology</i>	A general set of assumptions about ways of inquiring into the nature of the world (how research is conducted)
<i>Methodology</i>	A combination of techniques used to inquire into the specific situation
<i>Methods and Techniques</i>	Individual techniques for data collection and analysis

Source: Adopted from Smith, Thorpe & Jackson, (2012)

Smith et al (2012) went on to explain these terminologies by giving the different forms and types.

- **Ontology** has four different types which are realism, internal realism, relativism and nominalism. Here, the debate is between realism (single truth) and relativism (no truths). In **realism**, there is a belief that truth can be discovered using objective measurements. Its characteristics of realism are; one truth exists and it does not changes, objective measurements and can be generalised. On the other hand, **relativism** is directly the opposite of realism. Relativists believe in multiple truth/realities, subjective measurements, shaped by context, truth evolves and changes depending on experiences and cannot be generalised but can only be transferred to similar context.

- **Epistemology** is about what relationship the researcher has with the research. It is about how researchers get knowledge or discover new things. It has two main positions, that of positivism (*also known as epic/outside epistemology*) and social constructionism (*also known as etim/inside epistemology*). Positivism believes the social world exists externally and must be measured objectively while constructionism believes that reality is socially constructed and is subjective as it is given meaning by people.
- **Methodology** is about how knowledge is gathered and analysed in a systematic way. It refers to philosophies that guides data gathering. The two main forms are deductive (quantitative) and inductive (qualitative).
- **Methods and techniques** are several and includes survey questionnaires, case studies, experiments, interviews, observations, document reviews and focus groups among others.

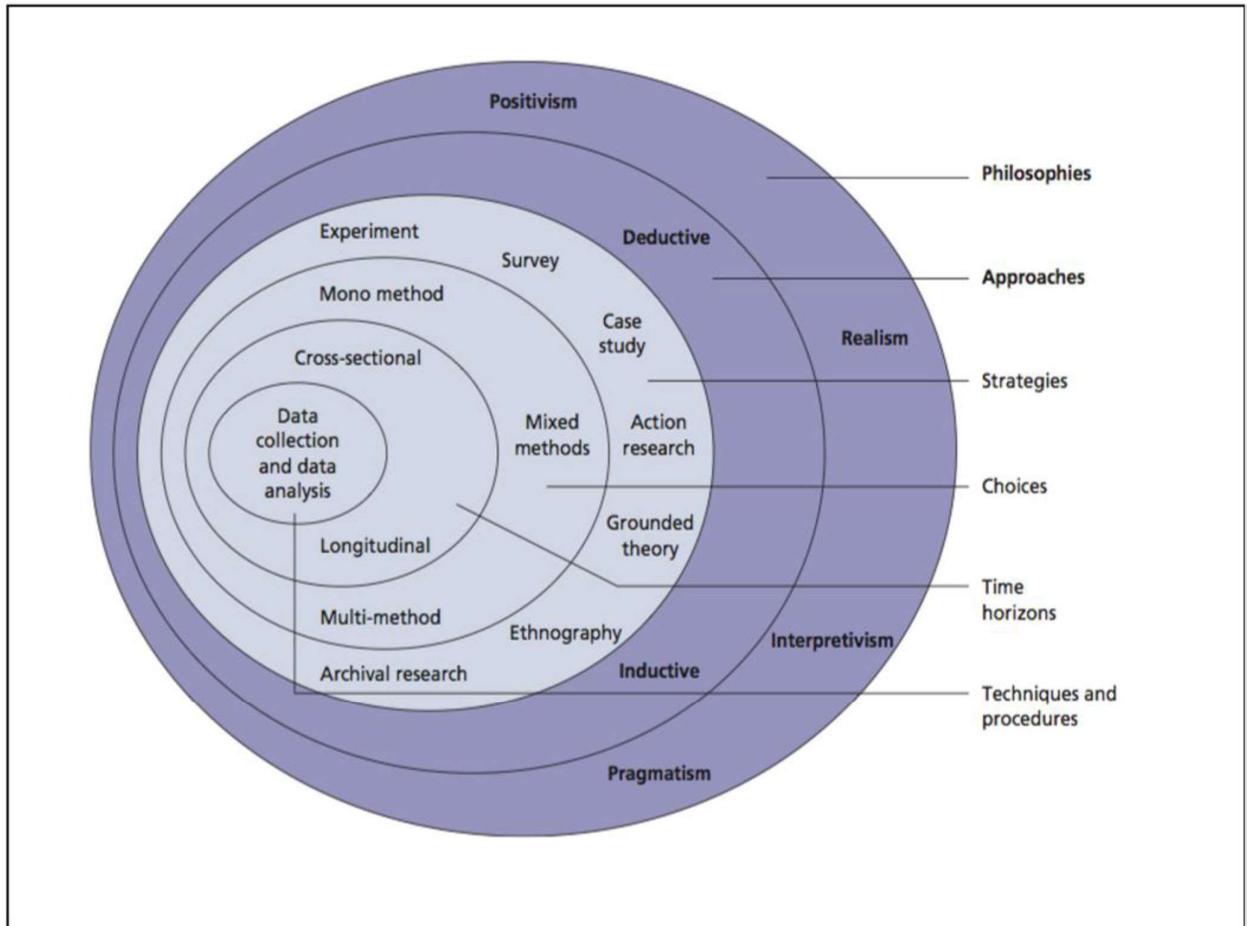
The concept of research design was explained by Saunders et al (2007) in what they called ‘research onion’ as shown in figure 3.4. This metaphor provides clarity on the links between philosophies, approaches, strategies, choices and techniques and procedures, which are all important for effective enquiry. Smith et al (2012) further explained the link between ontology, epistemology and methodology which has help to guide my study and is summarised in Table 3.3 below. They (Smith et al) stated that positivism fits with realist ontologies while constructionism fits with nominalism. The philosophical preferences of the researcher determines the design, approach, methods and analysis of the study. The selection

of such paradigm usually starts with the purpose or outcome of the research, which is either theory testing or theory generation. This research will use the research onion ideology by Saunders et al (2007) to guide the research design process.

Table 3. 3 Methodological implications of different epistemologies				
Ontologies	Realism	Internal Realism	Relativism	Nominalism
Epistemology	Strong	Positivism	Constructionism	Strong
Methodology	Positivism			Constructionism
Aims	Discovery	Exposure	Convergence	Invention
Starting points	Hypotheses	Propositions	Questions	Critique
Designs	Experiment	Large surveys; multi-cases	Cases and surveys	Engagement and reflexivity
Data types	Numbers and facts	Numbers and words	Words and numbers	Discourse and experiences
Analysis / interpretation	Verification / falsification	Correlation and regression	Triangulation and comparison	Sense-making; understanding
Outcomes	Confirmation of theories	Theory testing and generation	Theory generation	New insights and actions

Source: Adapted from Smith, et al, (2012)

Figure 3. 4. Research Onion



Source: Saunders et al. (2007)

Managing risks is dynamic and so is its research. Thus, SCRM researchers consider supply chain risks as true reality and based on assumption of objectivism and measurability.

However, there is also the social constructivist perspective, which considers the influence of social, political and historical factors of those involved in managing risks (Khan and Burnes, 2007). Hussey and Hussey (1997) criticises strong positivist paradigm on the basis that it assumes separation of people from their social context; it relies on highly structured and inflexible designs; it is not objective and it captures complex phenomenon in a single

measure, which is misleading. It is for these reasons that this study adopted a mixed method to compensate on these weaknesses.

After analysed the four philosophical preferences as detailed in Table 3.3 and Figure 3.4 above, this study will take a pragmatic approach and an abductive logic, focusing on generating theory through testing of existing theory. The pragmatic approach offers an effective means for both theory testing and theory generation which helps to advance the understanding of theory thereby closing the knowledge gap and also contributing to professional practice. Abductive reasoning mainly focuses on empirical observation, which is “theory matching” or “systematic combining” (Dubois and Gadde, 2002). This study used a mixed-methods to collect data simultaneously and analyse through a “back and forth” direction between theory and empirical study (Dubois and Gadde, 2002 cited in Kovac and Spens, 2005) leading the conclusion on how the strategic performance metric approach is used to prioritise supply chain risks and the corresponding mitigation strategies.

3.3.1. Research Approaches / methodology

This section outlines the research approaches and the rationale for the choice made by the researcher in identifying the appropriate approach for this investigation. There are many but three most known classes or groups of research approaches; which are: the *inductive* approach, the *deductive* approach and the *abductive* approach. The *retroductive* is the fourth approach that was suggested by Blaikie (2007). *Induction* looks for patterns and associations derived from observations of the world; *deduction* generates propositions and hypotheses theoretically through a logically derived process. *Abductive* is when both deduction and

induction are involved at different stages of the research process. Lastly, the *retroductive* involves the researcher identifying the structures or mechanisms that may have produced patterns in the data, trying different models for ‘fit’.

The majority of research in logistics and supply chain management is mainly positivist as many researchers seek to fill the knowledge gap. Deductive (Quantitative) approaches are used as the primary research methods, but there are also calls for more use of qualitative methods to complement these studies. This movement (mixed methods, also known as the *abductive* approach) has gained ground in the recent past (Mangan et al., 2004; Frankel et al., 2005 cited in Wieland & Wallenburg, 2012).

As such, this study will use the abductive (mixed-methods) approach, combining quantitative and qualitative research strategies (Bryman and Bell, 2011 cited in Jahre, et al, 2012:56). Mixed-methods was also seen by Naslund (2002) as the best way to develop and advance logistics research.

3.3.1.1. Deductive approach

Deductive approach is about arriving at a conclusion (new knowledge) by testing of theoretical propositions or hypothesis through an experiment. The purpose of a deductive enquiry is adopting a theory that is opened to rigorous testing and prediction of occurrence (Collis and Hussey, 2003; Saunders, 2009). Through its top-down process of enquiry, the

deductive research focuses on agreeing (prove) or disagreeing (discard) on the existing propositions and hypotheses on the subject of enquiry (Ritchie et al, 2014).

According to his suggestion, Robson (2002), deductive approach involves five stages:

- Deducing a hypothesis from the theory
- Expressing the hypothesis in operational terms
- Testing this operational hypothesis
- Examining the specific outcome of the inquiry
- Modifying the theory in the light of the findings

The deductive reasoning is usually associated with *quantitative* research and uses the top-down process that test general premises to reach at specific conclusions, which is the new knowledge (Wieland & Wallenburg, 2012).

One major weakness in deductive reasoning is the reliance on the initial premise being correct (Shuttleworth, 2008). By relying heavily on initial premise, the reliability of the study outcome conducted through deductive reasoning is as good as its premise. A wrong premise can easily lead to an unreliable research outcome. Shuttleworth, (2008) further argued that if one or more premises are incorrect, the argument is invalid and necessarily unsound. There is very limited known and peer reviewed research on supply chain risks with links to performance measurement for humanitarian pharmaceutical supply chain for UNICEF Tanzania. This is the research gap that this study has identified. The use of deductive reasoning alone may not provide adequate conclusions for this study.

3.3.1.2. Inductive approach

In contrast to deductive reasoning explained in the preceding section, inductive approach uses inductive reasoning (theory-developing) to address identified research questions. This inductive reasoning is associated with *qualitative* enquiry and develops general conclusions based on individual experiences and perceptions (Wieland & Wallenburg, 2012). The inductive approach is known to be a theory-developing process which begins with the observations of individual instances and then establishes generalisations about the phenomenon under investigation and mostly using the end results to derive a theory (Easterby-Smith et al., 2008; Saunders et al., 2009). Inductive process identifies patterns within the available data sets to create propositions, hypotheses and theories that can be investigated qualitatively. In other words, data is collected in a subjective manner by recognising participants and their surrounding environment (Ritchie et al, 2014). Thus, inductive approach is almost the opposite of deductive and researchers adopt inductive reasoning in their enquiry because according to Easterby-Smith et al. (2008):

- It allows the researcher to make more affirmed decisions in regards to the research design, which is as important as data collection and analysis
- It creates an environment in which the researcher thinks of various research strategies and decisions that will enhance the research outcomes
- It assists the researcher in adopting the research design to consider for constraints

3.3.1.3. Abductive approach

“The abductive approach stems from the insight that most great advances in science neither followed the pattern of pure deduction nor of pure induction” (Kirkeby, 1990; Taylor et al., 2002 cited in Kovacs and Spens, 2005, p 135). Thus, it can be considered as a blend of deductive and inductive as it seeks to bring the best elements of the two continuums in a practical process, with a special focus on empirical observation, which is “theory matching” or “systematic combining” (Dubois and Gadde, 2002). It can be understood as a process that values both deductive and inductive approaches (Bryman and Bell, 2011 cited in Jahre, et al, 2012:56), but relies principally on the expertise, experience, and intuition of researchers (Wieland and Wallenburg, 2012). Abductive reasoning offers an important and new way to conceive research and produce more robust findings. Adductive researchers escape the trap of being forced to be of either a deductive or an inductive mind-set.

The abductive process values the expertise, experience and intuition of researchers themselves (Wheeldon s and Ahlberg, 2012). By using abductive reasoning, researchers can get a better understanding of a phenomenon by combining *the reliability of empirical counts with the validity of lived experience*. The choice of a mixed methods on a social science study also face criticism that sees it unwise to combine different paradigms within same study because of different underlying assumptions of the approaches and that it can often lead to contradictory results (Smith, Thorpe and Jackson, 2012).

The use of mixed methods through the compensatory approach of using both methods (combination or triangulation) ensures that a weakness of one method is usually a strength of the other and would help to capture a more complete story (Jick, 1979; Aastrup &

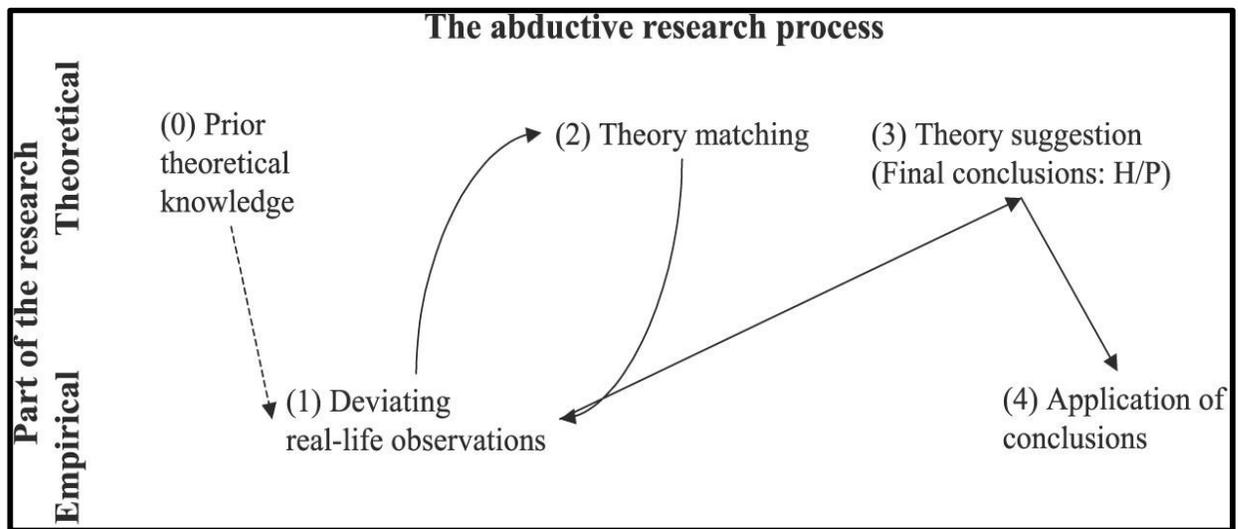
Halldorsson, 2008; Boyer & Swink, 2008 cited in Wieland and Wallenburg, 2012). However, Smith, Thorpe & Jackson (2012) also felt that the ontologies of the two methods are different which can result in philosophical problems. Mixed methods can give contradictory results with no way of resolving the confusion. In order to eliminate this contradiction, these methods will be used in sequence in a compensatory approach. Naslund (2002) argues that it is necessary to use both quantitative and qualitative methods if we really want to develop and advance logistics research.

The way mixed methods findings are presented depends, to a large extent, on the type of mixed methods design that was used and or how the data were mixed (Teddlie and Tashakkori, 2009). Mixing strategies in mixed methods research provides three options to present results or findings in a mixed method (Wheeldon and Ahlberg, 2012). Data can be merged by transforming or integrating two data types together, one data type can be embedded within another or they can be presented separately and then connected to answer different aspects of the same or a similar research question (Cresswell and Plano Clark, 2007). For this research, different options will be used in line with how data was collected for each research question.

The strength of abductive reasoning as outlined above qualifies the logic of this study to be abductive, which will use a mixed-methods approach, combining quantitative and qualitative research strategies (Naslund, 2002) as the best way to develop and advance logistics research. The use of abductive reasoning requires the study to be divided into two phases and ensure that the two approaches complement each other. Kovacs and Spens (2005) summarised the

abduction process in 5 stages (Figure 3.5 including analysis of theoretical knowledge, observations, theory matching, theory suggestion and application of conclusions. Thus, the research process should cover both empirical and theoretical aspects of research before reaching at conclusions.

Figure 3. 5 The Abduction Research Process



Source: Kovacs and Spens (2005)

The process of abduction reasoning, its application and strength makes it the best fit for this research. Abduction approach is found suitable for this study because, as supported by Dubois and Gadde (2002), both theoretical frameworks and fieldworks in the form of case study are simultaneously applied to reach conclusions. As described in Figure 3.3, an abduction research can start with a real-life observation and then match it with theory. This research also started with a real-life situation where supply chain is regarded as a weak link in

program delivery. It is for this reason that abduction reasoning is considered most suitable for this study. Mixed methods through abduction calls for triangulation of analysis and interpretation and suits very well for case study research methods (Dubois and Gadde, 2002). This is important characteristics and is used in this study in order to arrive at research conclusions.

3.3.2. Research Strategy, Methods and Techniques

3.3.2.1. Research strategy

Several research strategies (designs) exist for researchers to choose from. Notable strategies commonly used for social science studies includes; experimental research, action research, survey research, archival research, ethnography, case study and grounded theory among others (Easterby-smith et al., 2008). This study uses the exploratory case study strategy of UNICEF Tanzania whose path begins with the review of literature and followed by the careful and thoughtful posing of research questions or objectives (Yin, 2009). Case study looks in depth at experiences of one or small number of individuals / organisations and events, generally over time. This line of thinking is supported by Dubois and Gadde (2002) who felt that the interaction between a phenomenon and its context is best understood through in-depth case studies. Voss et al., (2002) made the recognition of case study as one of the effective methods in operations management, and as a common method in many scientific and social science disciplines (Dubois and Gadde, 2002).

Thus, considering that supply chain is a sub-division of operations and a social science subject, this study largely uses the *case study* strategy /design by focusing on in depth investigation into the risk management of pharmaceutical supply chain system for UNICEF Tanzania. As an exploratory case study of UNICEF Tanzania, this enquiry seeks to find new insights by asking the what, how and why questions for describing phenomenon and developing or testing theory (Robson, 2002; Yin, 2013). This makes case study strategy a perfect fit for this study. The justification for choosing UNICEF as the case study is provided on pages 5-6 in Chapter 1.

United Nations Children's Fund (UNICEF) is a United Nations agency that focuses of children rights, protection and welfare. For 70 years, UNICEF has been working on the ground in 190 countries and territories to promote children's survival, protection and development. The world's largest provider of vaccines for developing countries, UNICEF supports child health and nutrition, good water and sanitation, quality basic education for all boys and girls, and the protection of children from violence, exploitation, and AIDS. UNICEF is funded entirely by the voluntary contributions of individuals, businesses, foundations and governments (UNICEF, 2015)

UNICEF Tanzania, one of the 190 countries, is moving steadily towards middle-income status. UNICEF Tanzania is currently implementing a five-year programme, from 2016–2021, that focuses on practical ways to realize the rights of children. Achieving programme results for children and women is driven by several implementation strategies. These include developing the capacity of families and communities to care for children and demand quality

services; strengthening national capacity to deliver quality and equitable social services; and generating data and evidence to bolster child-centred policy development and leveraging more resources for children (UNICEF Website, 2018). Supply chain systems strengthening is one key element to ensure quality and timely services. Thus, the research will help to address supply chain risk factors that can hinder program delivery and also recommends ways to mitigate these risks.

UNICEF procures and supplies over 5,000 products to address the needs of children. Ensuring the global availability of essential supplies through influencing markets for lifesaving commodities such as vaccines, essential medicines and health products, and implementing a range of supply chain models to ensure these supplies are delivered to children, are two overarching focuses. The UNICEF Supply Chain involves working with industry to develop more effective formulations of medicines and products for children whilst keeping prices at affordable and quality at international standards. Every link of the supply chain is essential in ensuring vital supplies reach children. The UNICEF Supply Chain covers three main phases, that is **upstream** (definition of need; budgeting & planning; procurement), **mid-stream** (delivery and clearance, inspection, warehousing) and **downstream** (distribution and reorder, utilisation by end-user and monitoring and evaluation) (UNICEF Website, 2018). This study mapped supply chain risks across these steps and propose the mitigation strategies that can prevent risk occurrence or minimise risk impact in order to enhance program performance.

The literature reveals that there are numerous studies in supply chain and logistics research that use a case study approach (Smeltzer and Siferd, 1998; Zsidisin, 2003a; Sachan and Datta,

2005; Craighead et al. 2007; Ellegaard, 2008; Foerstl et al., 2010). Such case study approaches are considered the preferred approach in answering the how and why questions (Eisenhardt, 1989; Ellram, 1996 cited in Blome and Schoenherr 2011; Yin, 2009). Case study is considered most suitable for this study because of its suitability for more complex phenomenon which surveys would find too complex (Yin 2009) and also its suitability for subjects that are at exploratory stage (emerging) and targeted respondents are enthusiastic to report about the subject under investigation (Blome and Schoenherr, 2011). These characteristics fit into the study in supply chain risk management for humanitarian pharmaceutical programs.

The use of case study is not safeguarded from criticism. Easton (1995 cited in Dubois and Gadde, 2009) see reliance on self-conclusions, limited data to support theories and frameworks (quasi-deductive theory testing) and reliance on some notion of statistical generalisation as some of the key weaknesses of case study approach. Yin (2009) points to the rigorousness, biasedness and unsuitability for scientific studies as some of the main drawbacks of case study strategy. It is also important to note that case studies that are done over time may take too long to complete and may result in massive documents and complex data analysis. However, the benefits of case study strategy outlined above in comparison to other strategies made the researcher to select the case study as the best option for carrying out the investigation and especially that the researcher is the current employee of the case study organisation. This makes access to key information about the case study easier and can also easily facilitates the implementation of the research recommendations.

Thus, an exploratory case study is used for this investigation and UNICEF is selected as the primary research case study organization and the particular focus will be on humanitarian pharmaceutical supply chains in Tanzania. Close reference will also be made to other major humanitarian organizations and government institutions implementing health and food chains in Tanzania and the Sub-Saharan Region.

3.3.2.2. Data Collection Tools

This study is abductive and uses both quantitative and qualitative tools to gather the primary data. The enquiry gathered data through an online questionnaire and interviews as the main data collection methods in a case study investigation (Drever, 1995; Dubois and Gadde, 2002; Bryman and Bell, 2011; Saunders et al., 2012). According to Yin (2013), identified both questionnaire survey and interviews as one of the sources of information that can be used the case study enquiry. Blome and Schoenherr, (2011) supports the use of questionnaires and semi-structured interviews as a reliable tool/method to investigate supply chain risk management. Thus, the questionnaire and the semi-structured interview schedule were signed to support this enquiry.

The survey questions for both questionnaire and interviews were carefully designed in line with the study's research questions. All questions were designed in English language and all responses were gathered or received in English language. The collection tools were both designed using the Failure Mode Effect Analysis (FMEA) methodology. FMEA is a method that prioritises risks by ranking them in order of Risk Priority Number (RPN) (Faizal & Palaniappan, 2014). RPN is calculated as *Risk Severity X Risk Occurrence X Risk Detection*.

The higher the RPN, the higher the level of risk priority. Additional information that was included into the both questionnaire and interview schedule was gathered from other assessment tools such as the Supply Chain Council's maturity model (SCRLC, 2014), 5-Steps Process model (Manuj and Mentzer 2008) and the Analytical Hierarchy Process (AHP) model (Saaty (1996; Gaudenzi and Borghesi, 2006). These four additional tools are very useful in risk identification, assessment, ranking, prioritisation and analysis. These tools were used to design a modified (hybrid) tool to cover type of risks, occurrence and impact of risks, treatment/mitigation measure, strategies, challenges and opportunities. Research tools covers all the research questions for this study.

The FMEA methodology was found most suitable for this study because it is one of a few among the techniques suggested by the ISO/EIC 31010:2009 standard which categorises and highly recommended for risk identification, analysis, prioritisation and treatment (Curkovic et al, 2013). This makes FMEA one of the well-documented and proven technique commonly used for evaluating risk failures in process designs. The research by Curkovic et al (2013) revealed that those companies that properly and consistently used FMEA in risk assessment and evaluation achieved significant benefits. *“Understanding the types of risks and their probability of occurrence as well as the associated impacts is a starting point for companies to develop effective Risk Management strategies”* Faizal and Palaniappan (2014). Hence, the choice of this tool in designing tools for enquiring about risk prioritisation and treatment for humanitarian pharmaceutical supply chain.

Thus, this study will follow the below steps in analysing the supply chain system leading to the proposed risk mitigation model;

- a) *Step 1 = Identify the risk points within the supply chain (hubs and routes for health products)*
- b) *Step 2 = Identify and group the risk events across the supply chain*
- c) *Step 3 = Determine likelihood, impact and detection for each risk event*
- d) *Step 4 = Calculate the Risk Priority Numbers (RPN) for each risk event*
- e) *Step 5 = Recommend correct action/mitigation strategies/challenges and opportunities*

The researcher used the hub and route process for mapping the pharmaceutical supply chain under investigation. In this study, hubs will refer to all places where shipment is kept in storage/station pending delivery, and routes refers to the spaces between the hubs where shipments are in motion. This method is chosen because it provides an opportunity to the researcher to identify all factors available in the supply chain. This will help to identify the various risk factors and their categories which will be used in designing the data collection techniques

Quantitatively, the Statistical Package for the Social Sciences (SPSS) statistical analysis package is used to analyze the data. The descriptive statistics is used to calculate the MEAN values for each risk factor. Calculating MEAN value or averaging is applicable in analysing Likert Scales whenever more than two (2) participants/candidates are used. This allows qualitative data to be analysed quantitatively. The MEAN values were found meaningful for this context-specific study firstly because the aim of the study was to measure individual

opinions or perceptions or behaviours on Likert scale either way from the neutral point, and secondly MEAN is considered the best measure of central tendency where Likert data is being analysed as interval data. The REGRESSION ANALYSIS procedure is used to further analyse this ordinary averages/MEANS of Likert Scale data. These MEAN values are used to calculate RPN. Once the RPN values are identified through the FMEA tool, the Pareto Distribution is used to prioritise risks that constitute 80% of the impact (using the Pareto's 80-20 rule). The 80:20 rule says that 20% of the work can gain 80% of all the benefits that can be obtained (Faizal & Palaniappan, 2014). Thus, managing 20% of the risks that caused 80% of the impact on performance is considered critical. The regression analysis is used to test the identified hypothesis to measure the significance level of the relationship between risk detection and risk occurrence. The qualitative approach used interviews to collect the data. The interview transcripts were coded and uploaded into NVivo software for analysis. NVivo is considered a reliable tool to store and structure relevant information and supplemental material (Blome and Schoenherr, 2011). Thematic analysis was also used in the interpretation of interviews. Thematic analysis has three approaches of conventional, directed, or summative. Summative approach was used in this study and involves counting and comparisons, usually of keywords or content, followed by the interpretation of the underlying context (Hsieh and Shannon, 2005). The researcher used summative thematic analysis to systematically evaluate texts and audio from interview transcript in order to establish data themes as well as converted qualitative data into quantitative data for graphic presentation. The findings from both questionnaire survey and interviews are triangularly analysed in order to make research recommendations.

3.3.2.3. Pilot Study

The designed questionnaire was distributed to 10 supply chain experts for piloting (N=10) on 2nd December 2016. Snowballing was used to identify 10 respondents from the group of participants of the Global Health Supply Chain Conference held in Tanzania. The selected 10 participants were from across the various categories of government institutions (N=3), United Nations agencies (N=3), Non-Governmental Organisations (N=2) and Third party logistics agents (N=2). A 60% response rate was achieved (N=6), which was good enough to provide the required feedback on the appropriateness of the questionnaire.

According to Bell (2005 cited in Saunders et al. 2007), pilot study is done to ensure that participants understand the instructions correctly and provide the following information:

- How long the questionnaire took to complete;
- The clarity of instructions;
- Which, if any, questions were unclear or ambiguous;
- Which, if any, questions the respondent felt uneasy about answering;
- Whether in their opinion there were any major topic omissions;
- Whether the layout was clear and attractive; and
- Any other comments

The researcher included an email explanation on the purpose of the research and requesting feedback on the questionnaire structure, format and duration of completion. The pilot specifically requested feedback on:

- *Structure of questionnaire. Is the questionnaire easy to read and follow?*
- *Clarity of questions. Are questions easy to understand?*
- *Is the length of the questions appropriate?*
- *Record the time that is needed to complete this survey*

The feedback was received and loose ends clarified through interview before the final questionnaire was reviewed, amended and designed accordingly for use for this study.

In order to achieve consistency in quality and time efficiency, the interview schedule was also shared with the same 6 supply chain experts for review (N=6), those who had responded to the questionnaire. The reviewed interview questions were then piloted with 3 of the 6 supply chain experts, two by face to face and one by Skype call (N=3). The 3 participants were selected each from government institutions, United Nations agencies and third party logistics. The pilot on interviews sought similar feedback on:

- *Structure of interview schedules in terms of the flow of ideas*
- *Clarity of questions. Are questions easy to understand?*
- *Is the length of the questions appropriate?*
- *What is the appropriate time needed to complete this interview?*
- *Connectivity strength and clarity of voices in the case of Skype calls*

The received feedback was used to improve on the quality of the interview schedule prior to actual interviews for this research study.

3.3.2.4 Data Collection techniques

Like any mixed method approach, this study used both quantitative means (questionnaire) and qualitative means (interviews). According to Patton (2005), the use of both qualitative and quantitative data in mixed method is useful if one is to adequately address the objectives and the research questions under study. The two processes were carried out simultaneously during the period of March to June 2017.

3.3.2.4.1. Questionnaire Survey

A questionnaire was prepared using the FMEA methodology as outlined above and in line with the study research questions and hypothesis. The researcher received guidance from literature, research advisors and supply chain experts from pilot study. The questionnaire had three themes in line with the FMEA formula. That is, risk severity, risk occurrence and risk detection (Vatsa et al, 2004; Peck, 2006; Pillay and Wang, 2007; Welborn, 2007; Blome and Schoenherr, 2011; Faizal & Palaniappan, 2014). Relevant literature and researcher experience were used to select 30 supply chain risk factors according to the three phases of the supply pipeline (upstream, midstream and downstream).

The 30 risk factors were selected through a risk mapping process that was carried out for Sub-Saharan Africa with particular focus on Tanzania. Unpublished organisation program assessment and evaluation reports were the main source used to identify the potential risks for inclusion into the research questionnaire. UNICEF's Enterprise Risk Management framework was also used to provide some high-level risks which were included into the study (UNICEF

Immunisation, 2014 and UNICEF Risk Management, 2015). In addition, academic journals were also used to provide selected general supply risks (Norman and Lindroth, 2004; Kovacs, 2009; Punniyamoorthy, M. et al, 2013), pharmaceutical supply risks (Ouabouch and Amri, 2013) and public health risks in developing countries (Jahre, M. et al, 2012; Noel, W. et al, 2013).

The list of risks identified in these sources were further screened by the researcher based on context experience and according to the stages within the supply chain. The final list had 10 upstream risks (from point of origin to port of entry), 10 mid-stream risks (from port of entry to receiving at national warehouse) and 10 downstream risks (from national warehouse to final destination/end user). These risks are presented in Table 1.1 and Figure 1.2. The mapping was done through desk review of organisation reports and were later on used in the questionnaire. The list (grouped into sub-categories), although non-exhaustive clearly shows that the system under study has many potential risks that require profiling, prioritisation and mitigation.

The FMEA tool uses 10-point scale in rating risks. Converting from 10-point scale to 5-point scale did not had any effect in the outcome since the purpose was about ranking the risks.

Using the 10-points/item scale would have required more time to complete and hence discourage respondents. The use of a 5-point Likert Scale was seen as a more practical tool as responses could easily be doubled to align with FMEA rating scale. The doubling of the numbers to the 10-point scale for normalisation had no effect since the numbers could be the same, as the ranking remained the same. Thus, the pre-selected risk factors were plotted on a 5-point Likert Scale questionnaire described as follows:

- Very Likely to Occur (5)
- Will Likely Occur (4)
- Equal chance of occurring or not (3)
- Unlikely to Occur (2)
- Very Unlikely to occur (1)

The questionnaire sought participants' perception on the level of likelihood, impact and detection of the given risk factors in relation to their supply chains. The questionnaire was uploaded into the Qualtrics, an online survey tool recommended and licensed by Northumbria University. The questionnaire survey was locked to prevent invalidation of collected responses. A password code was also provided to access the survey. These measures were put in place to ensure reliability, validity and confidentiality aspects of the research study. A cover letter was included into the front page of the questionnaire providing participants with information on the purpose of the study, the duration of the questionnaire, the submission deadline, confidentiality guarantees and contact details of researcher, research supervisor and the ethics office of Northumbria University. The questionnaire duration was 30 minutes, with the initial submission deadline of 15 April 2017 since 20 March 2017. The submission deadline was later on extended to 15 May 2017. The questionnaire is attached as **Appendix A**

Once the questionnaire was ready, it was shared through email to participants who were selected through systematic random sampling. The credibility of the research study is as good as its source of data. Thus, the primary objective for the researcher is to remove sampling bias through random sampling of the sample (Cooligan, 1999). The study required prior

knowledge and expertise in supply chain management, hence the used of systematic random sampling. Systematic random sampling is used where a database of target participants exists (Easterby-smith et al. 2008). In the case of this study, databases of employees and subscribed members was used. Participants were systematically selected from case study organisation and its development and logistics partners (150 participants targeted) and from the Association of Public Health Logisticians (APHL) whose membership is estimated to be approximately 4,000 globally. Participants had a wide range of experience in supply chain management in the humanitarian health industry. Participation was voluntary and none of the participants received compensation or favour in return for their responses. Receiving the executive summary of the research study was promised as motivation to participate and to complete as accurate as possible. The target response from questionnaire survey was 250 responses as advised by the research supervisor.

The first window of questionnaire completion was 20 March to 15 April 2017. By 11 April 2018, the number of responses received was 120 (48% of the target) and a reminder was send to the same sample, with an extension of submission date to 15 May 2017. By the submission deadline, a total of 202 valid and complete responses were received (81.6% of the target). The response rate of 81.6% was found adequate and data cleaning and analysis started.

3.3.2.4.1.1. Questionnaire Respondents composition

The 202 valid responses from the questionnaire survey came from a wide range of expertise and industry. The composition of the respondents is distributed by industry (Figure 3.6); by years of experience in supply chain issues (Figure 3.7) and by job level or title (Figure 3.8). The classification “OTHER” is used to refer to those respondents whose industry and job title were not in the given classification, but relevant to participate in the survey. The responses from the humanitarian and public sector which was the focus for this study was 81.7% (with government at 31.7%; the United Nations at 30.7% and NGOs at 19.3%) and the rest at 18.3%. This high response rate from humanitarian and public sector (81.7%) provides some level of validity of the findings in line with the study focus. In terms of years of experience in supply chain and health systems, 81.2 % of the respondents have at more than 5 years of work experience in general supply chain and 68.3% in specialised pharmaceutical supply chain system. In addition to the high level of experience, most of the respondents (66.8%) are at director and manager/specialist level. Again, this also provides belief that the findings are very strategic issues that affect supply chain.

Figure 3. 6 Distribution of responses by industry

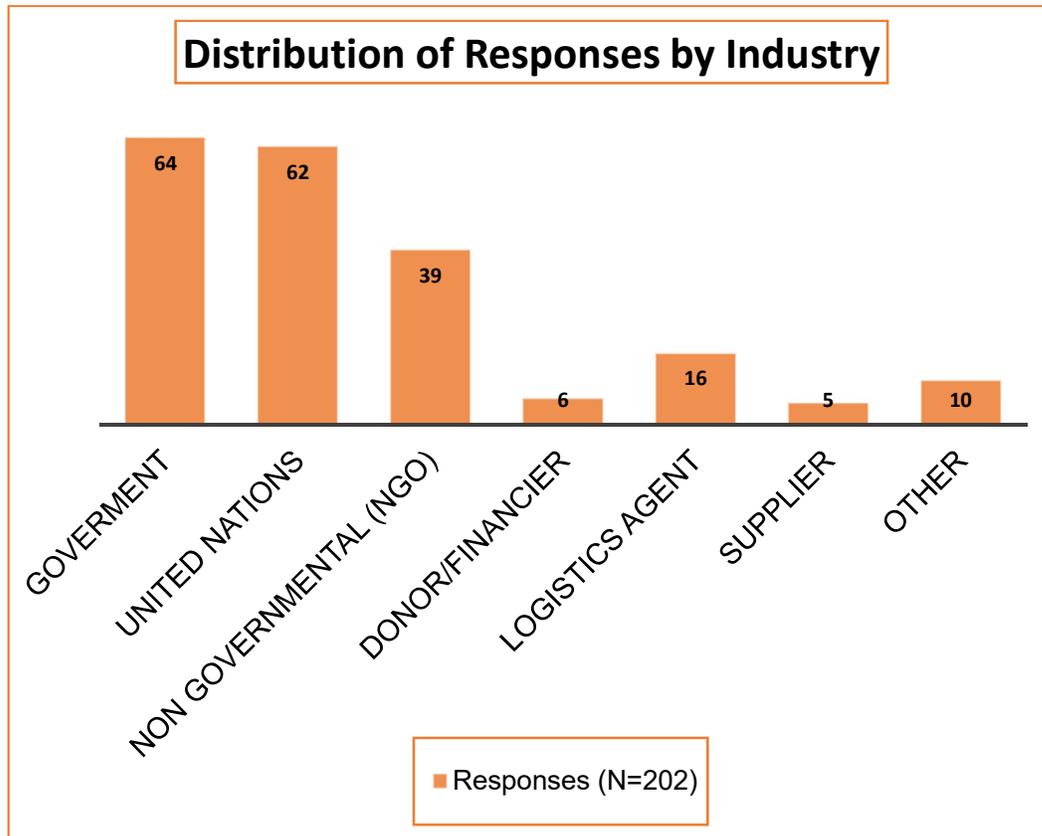


Figure 3. 7 Distribution of responses by work experience

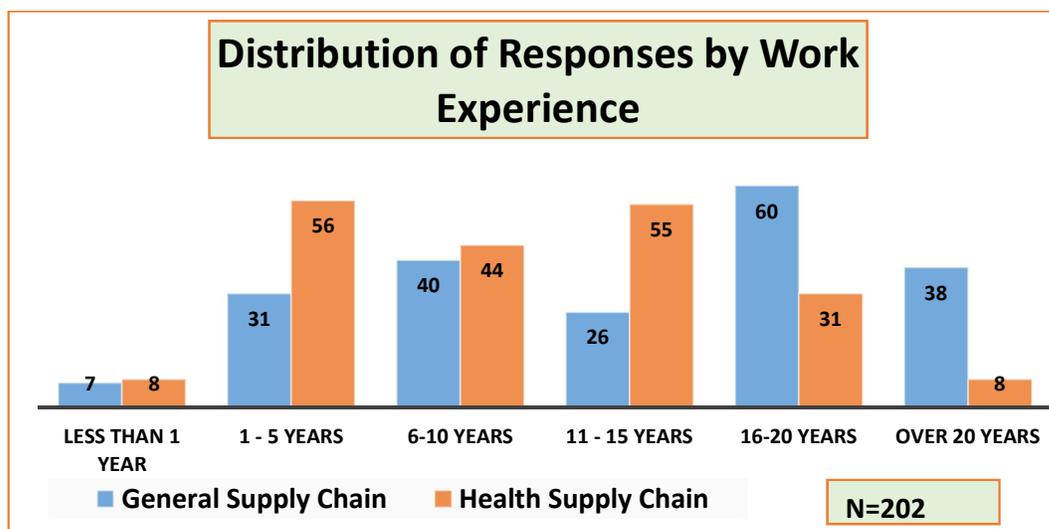
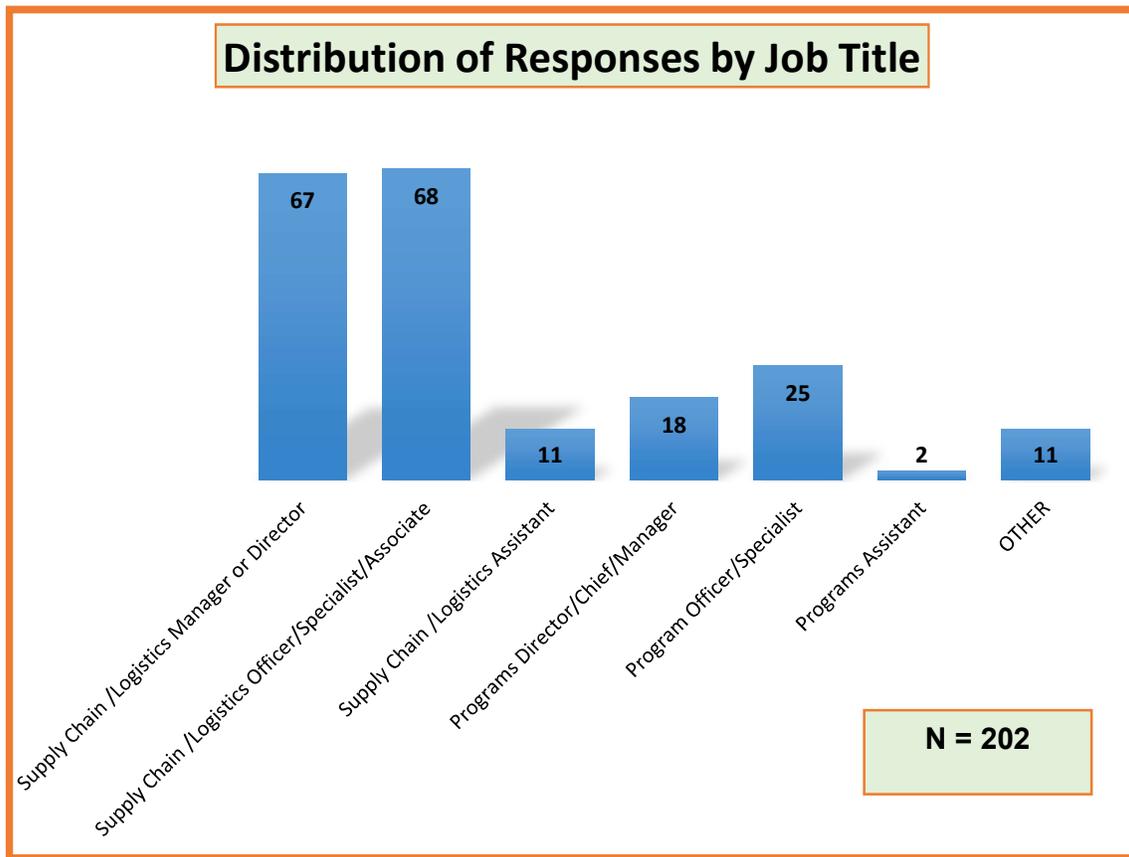


Figure 3. 8 Distribution of responses by Job Title



3.3.2.4.1.2. Data analysis – Questionnaire

FMEA methodology uses ordinal data, which is analysed using a number of descriptive statistics. Ordinal data requires non-parametric statistics (Cooligan, 1999; Singh, 2006). The nature of data was taken into account in the selection of the most appropriate statistical testing. The Statistical Package for the Social Sciences (SPSS) statistical analysis package is used to analyze the data. The descriptive statistics is used to calculate the MEAN values for each risk factor. These MEAN values were multiplied by 2 (doubled) in order to align with FMEA format are uses 10-point Likert Scale. The new MEAN values were then used to

calculate RPN. Once the RPN values are identified through the FMEA tool, the Pareto Distribution is used to prioritise risks that constitute 80% of the impact (using the Pareto's 80-20 rule). The 80:20 rule says that 20% of the work can gain 80% of all the benefits that can be obtained (Faizal & Palaniappan, 2014). Thus, managing 20% of the risks that caused 80% of the impact on performance is considered critical. The REGRESSION ANALYSIS is used to test the identified hypothesis to measure the significance level of the relationship between risk detection and risk occurrence. The significance level adopted for this research is at 5% ($p \leq 0.05$). Subsequently the null hypothesis will be rejected when the probability of it being true drops below 0.05.

3.3.2.4.2. Interview Technique

The second part of the abductive approach was conducting semi-structured interviews, through face to face and telephone call. The other type of interviews that can be used are in-depth, focused and structured and survey interview (Yin, 2013). Interviews are a common and most important form of data gathering for case study research. The major advantage of face-to-face interview is the 'richness' of the communication that is possible (Gillham, 2000). Rubin and Rubin (1995) view interviews as guided conversations rather than structured enquiries. Hence, they help the conversation to remain focused to the topic as well as maintaining insightfulness by providing perceived causal inferences. Bias is considered the major disadvantage of interviews, which the researcher managed by remaining ethical, objective and professional. For Easterby-smith et al. (2008), interviews are an important tool to gain insights into social and organisational realities. And this is exactly what the research

was looking for, organisational realities on how the manage supply chain risks for health programs.

As was with questionnaire design, the FMEA methodology was used to design the interview schedule. The schedule covered risk severity, risk occurrence, risk detection, mitigation strategies, risk management tools, risk challenges and opportunities. These themes were designed using Kvale (1996) style for exploratory interview questions as follows:

- Introducing questions.
- Follow up questions.
- Probing questions.
- Specifying questions.

- Direct questions.

- Indirect questions.

- Structuring questions

- Silence
- Interpreting questions.

The above style was adopted and found very useful in gathering adequate and accurate data. If designed and conducted well, interviews can gather deeper level of information than questionnaires through detailed discussions and can also provide a way of comparing responses to make (Drever, 1995). The researcher was consistent in following the sequencing of the questions as a way of building the argument as well as diminishing biasedness and increase reliability and validity of the findings.

The interview schedule/Questions used for this study is attached as **Appendix B**

The interview participants were selected through snowballing process ((Noy, 2008; Sadler et al., 2010), particularly targeting senior supply chain managers and experts with experience in pharmaceutical supply chains in Sub Saharan Africa and Tanzania. These high-level managers and experts selected had direct responsibility in SCRM (Blome and Schoenherr, 2011), making them most suitable respondents. As supported by Foerstl et al. (2010) and Reuter et al. (2010), the researcher used his experience in selecting and interviewing participants having successfully used a similar technique and process in carrying out a postgraduate research in supply chain strategy development. A total of fifteen interviews were conducted for this study, considering that a questionnaire survey was also gathering similar data and also for time and cost reasons (Gillham, 2000). It was expected that such a sample would provide “an informative-rich case study” (Saunders et al., 2012, p. 283) that answers the research questions under investigation and as complementary to the questionnaire survey. The distribution of respondents is as follows;

- Case study organisation and United Nations (11 candidates)
- Logistics Companies (2 candidates)
- Governmental entities (1 candidate)
- Independent logistics consultant (1 candidate)

The qualifications and work experience of the respondents are shown in Table 3.4 below.

Table 3. 4 Profiles of Interview Respondents

Cand Code	Interview Date	Industry / Organisation	Job Title	Highest Qualification	Interview method
001	24-Mar	United Nations	Supply Manager	Master's Degree	Face to Face
002	28-Mar	United Nations	Logistics Manager	Master's Degree	Skype
003	29- Mar	Logistics Company	Country Manager	Undisclosed	Face to Face
004	31 Mar	United Nations	Operations Manager	Master's Degree	Skype
005	1-Apr	Logistics Consultant	Logistics Consultant	Master's Degree	Skype
006	01-June	United Nations	Logistics Officer	First Degree	Face to Face
007	17-May	United Nations	Supply Assistant	First Degree	Face to Face
008	17-May	United Nations	Supply Officer	Master's Degree	Face to Face
009	07-June	United Nations	Chief of Operations	Master's Degree	Face to Face
010	24-May	United Nations	Logistics Specialist	Master's Degree	Skype
011	20-May	Government	Logistics	First Degree	Face to Face
012	26-April	United Nations	Program Specialist	First Degree	Face to Face
013	26-April	INGO	Chief of Party	Master's Degree	Face to Face
014	09-June	United Nations	Supply Specialist	First degree	Skype
015	08-June	United Nations	Chief of Program	Doctorate degree	Face to Face

The interview meeting schedules were arranged with all the 15 candidates, considering candidate preferences in terms of date, time and venue. The interviews were conducted from 24 March to 9 June 2017. Face to face meetings were preferred to Skype calls. Candidates were requested to read and voluntarily sign (if in agreement) the ethics form on participant informed consent (sample attached as **Appendix C**). During the actual interview process and with the permission of the respondents, the researcher took notes on the pre-designed

interviews schedules as well as recording on voice recorder (face to face) or Skype audio recording. This was done so as to obviate the chance of misrepresentation and loss of data. The researcher also assured anonymous of the responses, confidentiality and purposeful use of data. With these measures, participants felt comfortable to express their opinions, feelings and perceptions. All interviews recordings and transcripts were typed up and validated before for uploading into Nvivo for analysis.

3.3.2.4.2.1 Data analysis – Interviews

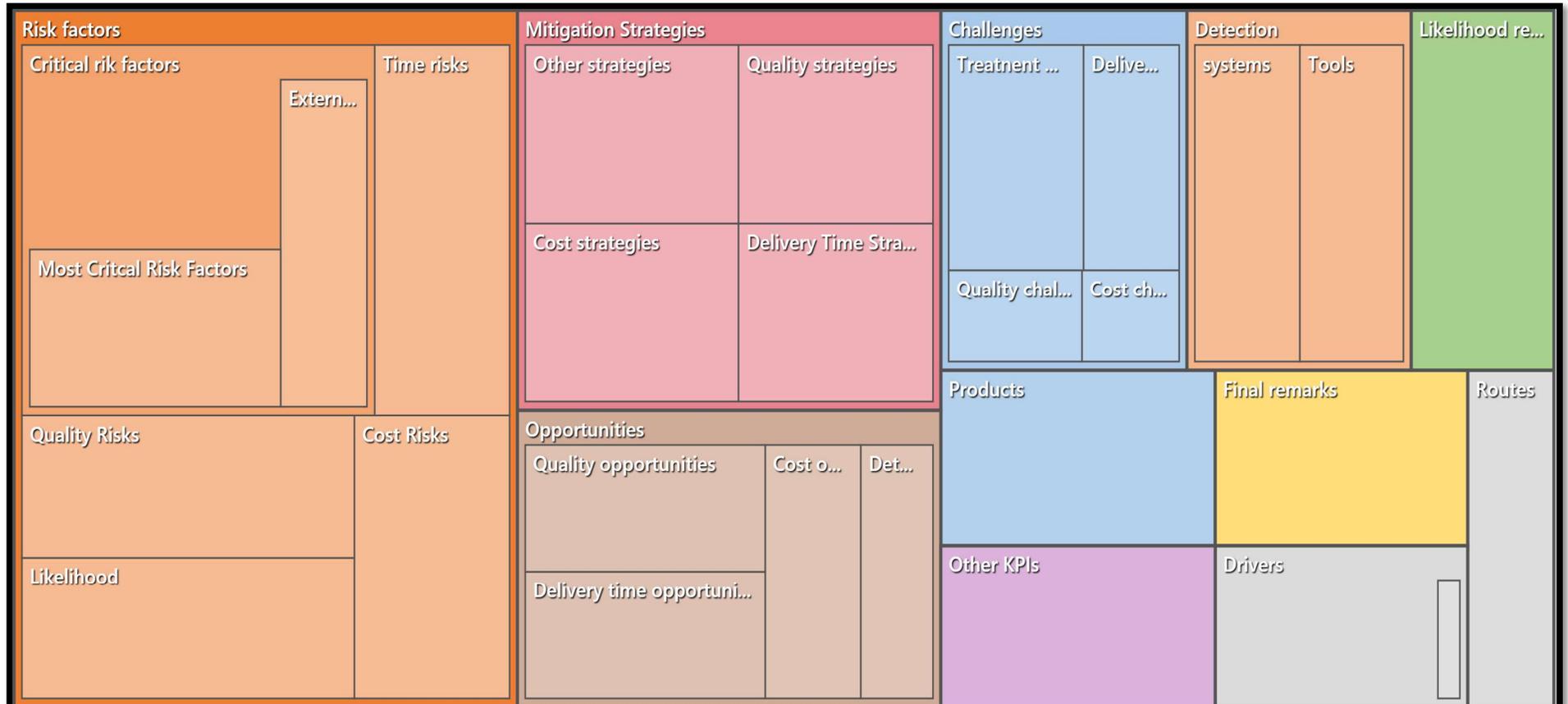
A combination of NVIVO and Template /Thematic Analysis are used to analyse the interview data. The term ‘template analysis’ refers to a process of thematically analysing qualitative data, where a coding ‘template’ is developed, which summarises themes identified by the researcher(s) as important in a data set, and organises them in a meaningful and useful manner. Template analysis uses a hierarchical list of codes and themes. Some codes and themes may be pre-determined from the literature (known as a priori) and others are derived from the data. Template analysis was selected for analyzing NVIVO data in order to enable comparative analysis of themes between qualitative results and quantitative results.

The first step in data analysis process was data transcription, which involved developing Word format transcripts from both written interview notes and audio-recorded interviews of the 15 participants, so that they could be imported into NVivo 10.0 software for data coding. The NVivo software was recorded by the supervision team and was obtained using the free access key provided by Northumbria University. NVivo has the capability to undertake analysis of qualitative data much quickly and present it into various forms such as graphs,

charts and frequencies (Gibbs, 2007). NVivo is also considered a reliable tool to store and structure relevant information and supplemental material (Blome and Schoenherr, 2011).

Audio-recorded interviews were transcribed word for word (verbatim) into Word format transcripts. To supplement this coding process, a summative content analysis approach was also adopted. Summative content analysis involves counting and comparisons, usually of keywords or content, followed by the interpretation of the underlying context (Hsieh and Shannon, 2005). Udawatta et al. (2015) suggested that summative content analysis helps to reduce data and identify main concept and themes per candidate according to how they presented their responses to specific interview questions. Adding to the purpose of content analysis, Gillham (2000) talked of its ability to identify substantive statements that really say something. The transcribing process helped the researcher to familiarize with the data and resulted in 15 files, one for each participant with details of their responses to the interview questions. Cross verification was done between written interview notes and audio recordings. Discrepancies were found in 4 files and the respective participants were approached and requested to verify. The NVivo software was used to generate themes and codes and the final output from this software is the descriptive statistics data (frequencies and percentages) used to provide answers to the two research questions. Inside Nvivo software, themes were coded into nodes (groups/families) in line with research questions (main and sub-questions) as shown in Figure 3.9 below.

Figure 3. 9 Tree Map of NVivo Codes



Following the development of data into nodes as per Figure 3.9 above, Nvivo was used to generate data outputs through word frequency, text search query and tree maps. The data outputs, in the form of retrievable graphs, charts and tables helped the researcher to identify and rank critical risk factors, mitigation strategies, challenges and opportunities as given by the participants. In an effort to get intimate with the material for accurate analysis, the researcher read and reread the material and categorised data into several codes, as per suggestion by Marshall and Rossman (2011). The details of these outputs are presented in Chapter 4 and discussed in Chapter 5.

3.4. Ethical Considerations

All the activities related to the production of the final report of this project and its publication will be done in accordance with the University's ethics policy which provides guidance on the minimum principles of undertaking academic research. The ethical request form (**Appendix D**) was used to apply for ethical clearance and was approved by the University (see **Appendix E**). The basic principle of do no harm will form the base foundation of all the activities of this project including referencing of literature, selection of literature sources, selection of case study organization, selection of participants and reporting. All confidential information provided will be safeguarded according to the guidelines of the University policy as well as those of the case study organizations and all other participants.

In accordance with the University ethics policy, participation was on the basis of informed consent, anonymous and voluntary basis. Prior to the interview meeting, all 15 candidates read and voluntarily agreed to sign the participant's informed consent forms. This was

important to confirm that candidates were not forced or coerced to participate in the research study. In addition, all selected participants were given the opportunity to withdraw at any point in the research process as the wish. The researcher ensured that all information provided by participants and gathered from existing body of knowledge is used solely for this specific academic purpose.

The survey questionnaire was completed online using Qualtrics survey tool. The anonymous survey questionnaire responses were received and stored within the secured and password protected student account in Qualtrics. The analysis of data was done using SPSS copy owned by Northumbria University and access was password protected. Face to face interview sessions were recorded and stored into a voice recorder owned by the student, Skype videos recorded in personal laptop and written scripts were done on interview questionnaire templates and notepad which were kept under lock and key by the researcher. Basically, all the material gathered by various means and tools was kept in a secure environment and will be destroyed safely after use.

To achieve a high-quality research culture, the Northumbria University's Research Ethics and Governance Handbook, 2013-2014 provided the following key elements which the researcher adhered to:

- Respect for the dignity, rights, safety and well-being of participants and researchers
- Valuing diversity in society
- Personal and scientific integrity
- Leadership

- Honesty
- Accountability
- Openness
- Clear and supportive management

3.5. Chapter Summary

The methodological approach for this research study on the prioritisation and impact analysis of supply chain risk factors on humanitarian pharmaceutical supply chains in Sub-Saharan Africa was abductive in approach and case study in design and strategy. This chapter outlined the philosophical position of the study, its approach, strategy and the data collection techniques (process and analysis) used to conduct this investigation. The systematic application of the appropriate research methodology and its processes and tools were essential ingredients for reliable and valid research findings presented in the next chapter.

Chapter 4. Presentation of Findings

4.0. Introduction

This section is dedicated to present the finding against the research questions on risk identification and likelihood, risk severity/impact and risk detection and mitigation for pharmaceutical supply chain system in Sub-Saharan Africa. It aims to identify and analyse the risks, specifically focusing on prioritisation and the causal relationship between risk detection and risk occurrence. With this purpose in mind, a mixed method approach through questionnaire survey and case study interviews is adopted not just to produce a list of risks and risk likelihood and impact, but also to prioritise them and to understand the available preventive measures and mitigation strategies and opportunities.

The findings are presented in themes as follows:

- a) Critical risks factors available in the Upstream, Midstream and Downstream
- b) Critical risk factors that impact on supply chain delivery time, cost and material quality
- c) Risk mitigation strategies for supply chain delivery time, cost and material quality
- d) Risk detection tools/mechanism
- e) Factors that impede implementation of risk mitigation strategies
- f) Risk management opportunities in Sub-Saharan Africa

4.1. Research Findings

4.1.1. Critical Risk Factors – Upstream

RQ1a. What are the upstream risk factors in pharmaceutical supply chain system?

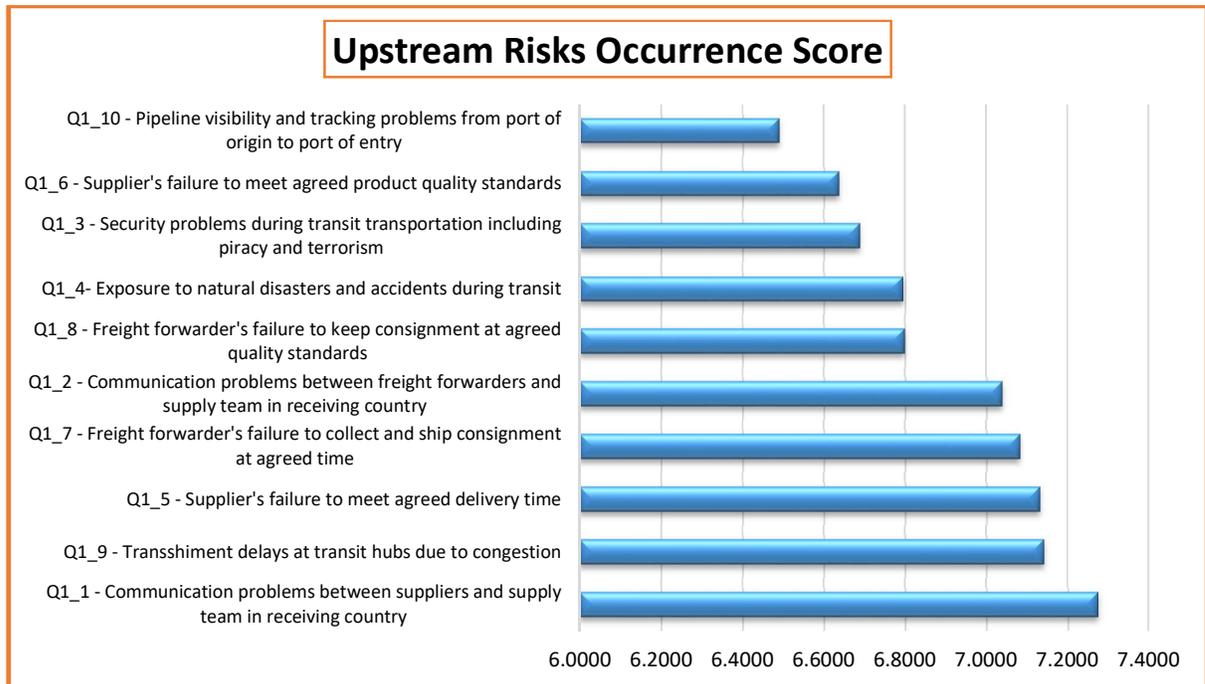
In responding to RQ1a above, 202 participants scored on the likelihood of each risk occurrence in a single shipment on a Likert scale of 1-5.

The author doubles each score to align with the risk rating scale of the FMEA methodology.

As presented in Figure 4.1 below, the top three critical risks available in the upstream are:

- **Communication problems** between suppliers and supply team in receiving country (score of 7.28 out of 10)
- **Trans-shipment delays** at transit hubs due to congestion (score of 7.14 out of 10)
- Supplier's failure to meet agreed **delivery time** (score of 7.13 out of 10)

Figure 4. 1 Occurrence of Upstream Risks



4.1.2. Critical Risk Factors – Midstream

RQ1b. What are the midstream risk factors in pharmaceutical supply chain system?

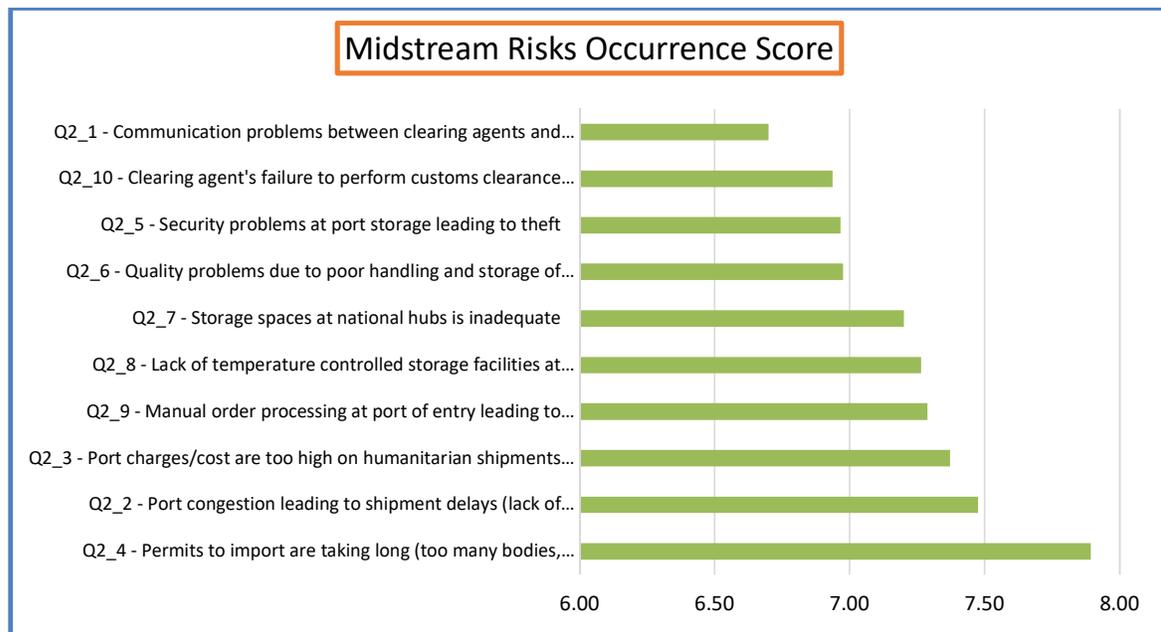
In responding to RQ1b above, 202 participants scored on the likelihood of each risk occurrence in a single shipment on a Likert scale of 1-5.

The author doubles each score to align with the risk rating scale of the FMEA methodology. As presented in Figure 4.2 below, the top three critical risks available in the midstream are:

- **Permits to import** are taking long (too many bodies, documentation and registration) (score of 7.89 out of 10)

- **Port congestion** leading to shipment delays (lack of capacity) (score of 7.48 out of 10)
- **Port charges/cost** are too high on humanitarian shipments (handling and storage) (score of 7.37 out of 10)

Figure 4. 2 Occurrence of Midstream Risks



4.1.3. Critical Risk Factors – Downstream

RQ1c. What are the downstream risk factors in pharmaceutical supply chain system?

In responding to RQ1c above, 202 participants scored on the likelihood of each risk occurrence in a single shipment on a Likert scale of 1-5.

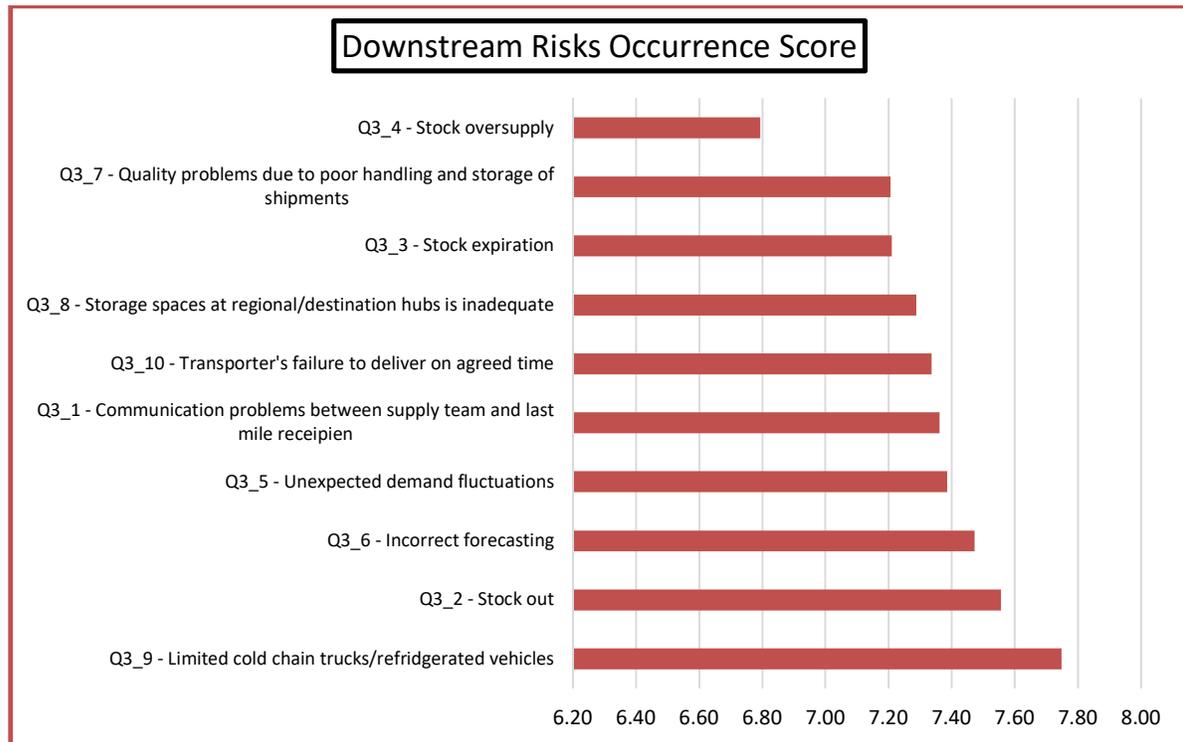
The author doubles each score to align with the risk rating scale of the FMEA methodology.

As presented in Figure 4.3 below, the top three critical risks available in the downstream are:

- **Limited cold chain trucks/refrigerated vehicles** (score of 7.75 out of 10)
- **Stock out** (score of 7.56 out of 10)

- **Incorrect forecasting** (score of 7.47 out of 10)

Figure 4. 3 Occurrence of Downstream Risks



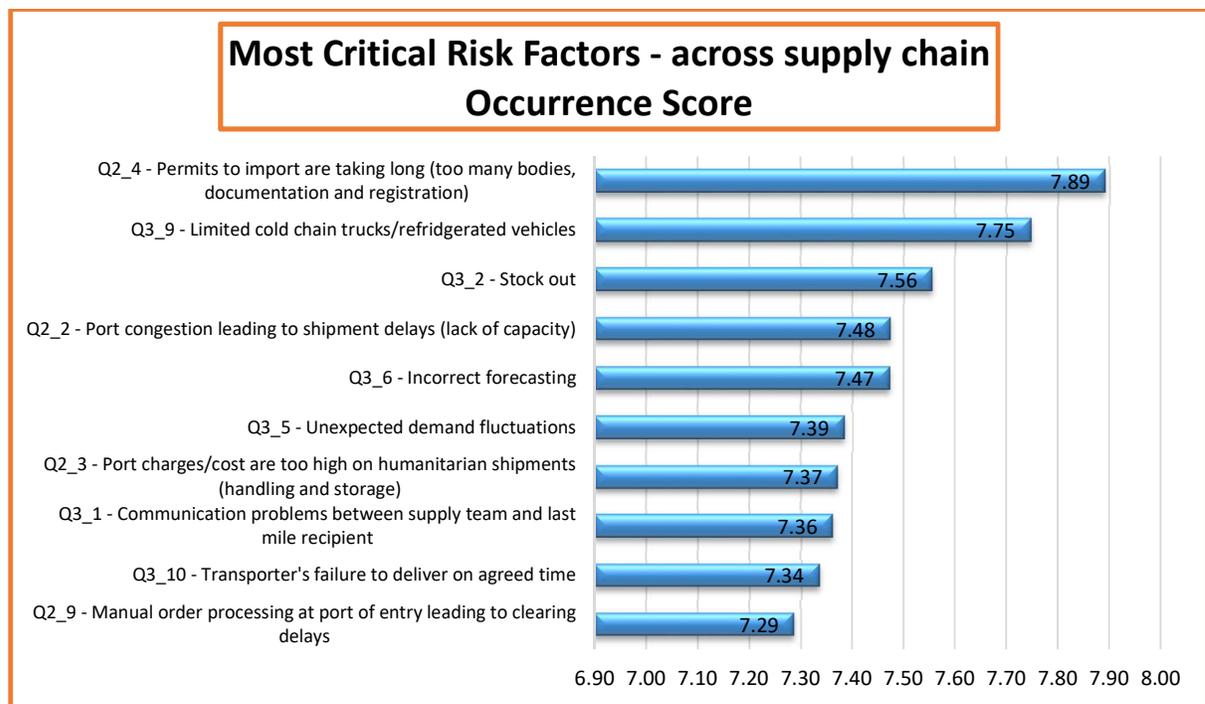
4.1.4. Risk factors with most likelihood of occurrence

To sum up in terms of risk occurrence as per quantitative enquiry, the below are the **top 10 risk factors** found across the supply chain are recorded in Figures 4.4 (in order of occurrence rate).

- *Permits to import are taking long (too many bodies, documentation and registration)*
- *Limited cold chain trucks/refrigerated vehicles*
- *Stock out*
- *Port congestion leading to shipment delays (lack of capacity)*

- *Incorrect forecasting*
- *Unexpected demand fluctuations*
- *Port charges/cost are too high on humanitarian shipments (handling and storage)*
- *Communication problems between supply team and last mile recipient*
- *Manual order processing at port of entry leading to clearing delays*

Figure 4. 4 Occurrence of risks across Supply Chain



This part of the enquiry was also conducted through qualitative methodology. The data from qualitative enquiry through interviews is analysed through NVivo 11 software. Figure 4.5 below shows a list of top 100 most frequently mentioned risk factors. These risks factors were further reduced to top 10 through Nvivo software.

- *Security*
- *Communication Problems*

Figure 4. 6 Most Critical risk factors from interviews

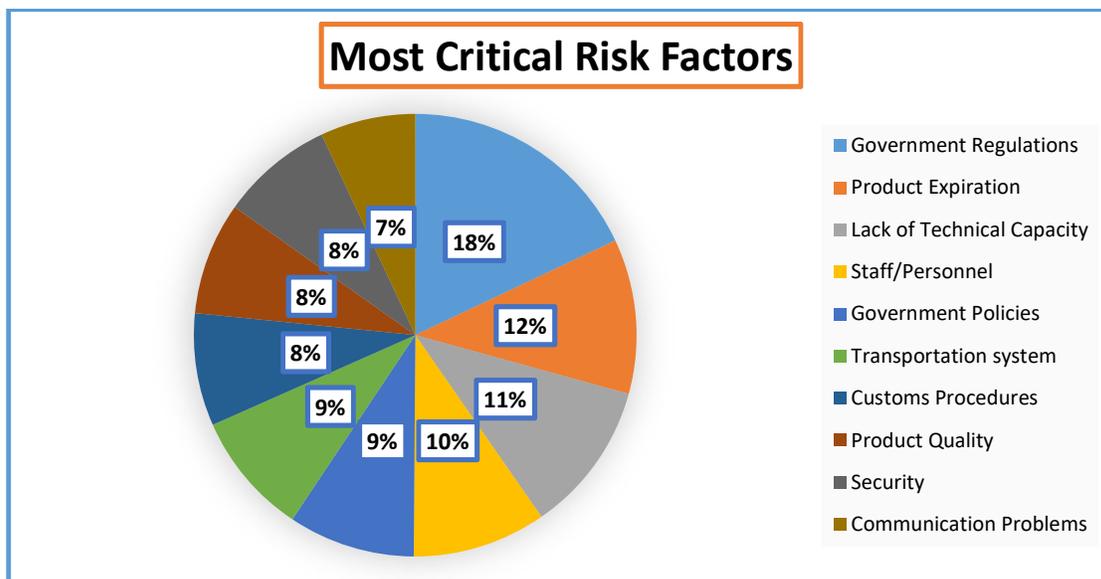


Figure 4. 7 Most risk factors from interviews



4.1.5. Risk Detection Capability

RQ2d. What risk factors have weak detection capability?

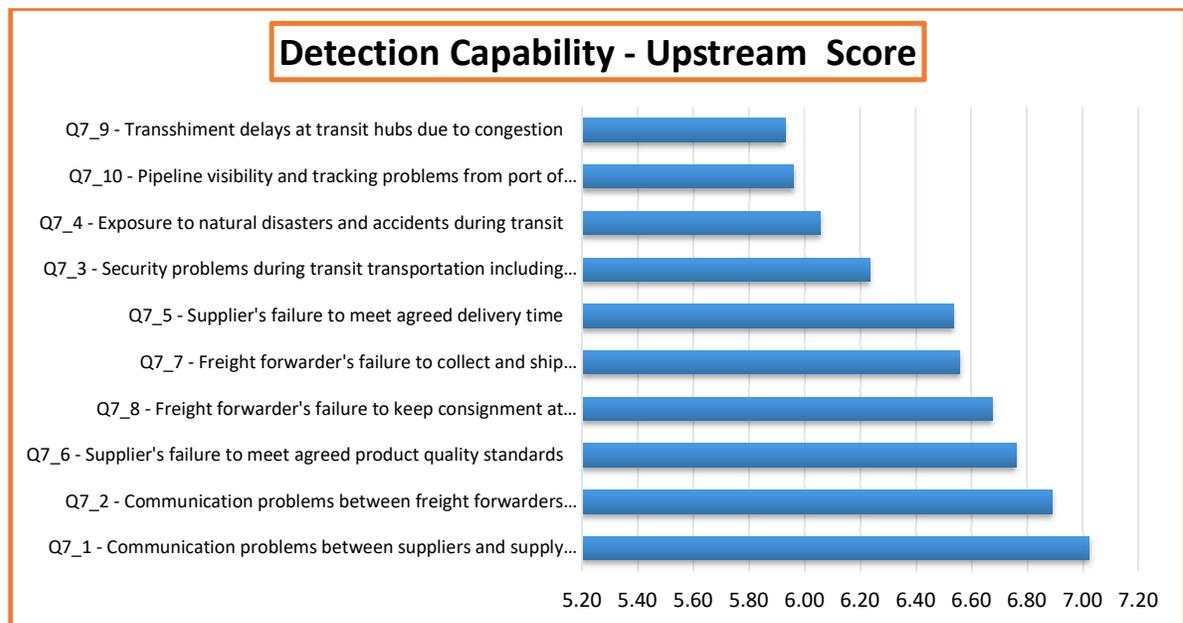
202 participants were responded on their organisations' capacity to detect upstream risk factors before they happen on a Likert scale of 1-5.

The author doubles each score to align with the risk rating scale of the FMEA methodology.

The responses are shown in Figure 4.8 below. The top 3 upstream risk factors where organisations have weak detection capability are:

- **Trans-shipment delays** at transit hubs due to congestion (score of 5.93 out of 10)
- **Pipeline visibility and tracking problems** from port of origin to port of entry (score of 5.96 out of 10)
- **Exposure to natural disasters and accidents** during transit (score of 6.06 out of 10)

Figure 4. 8 Detection capability – Upstream Risk Factors



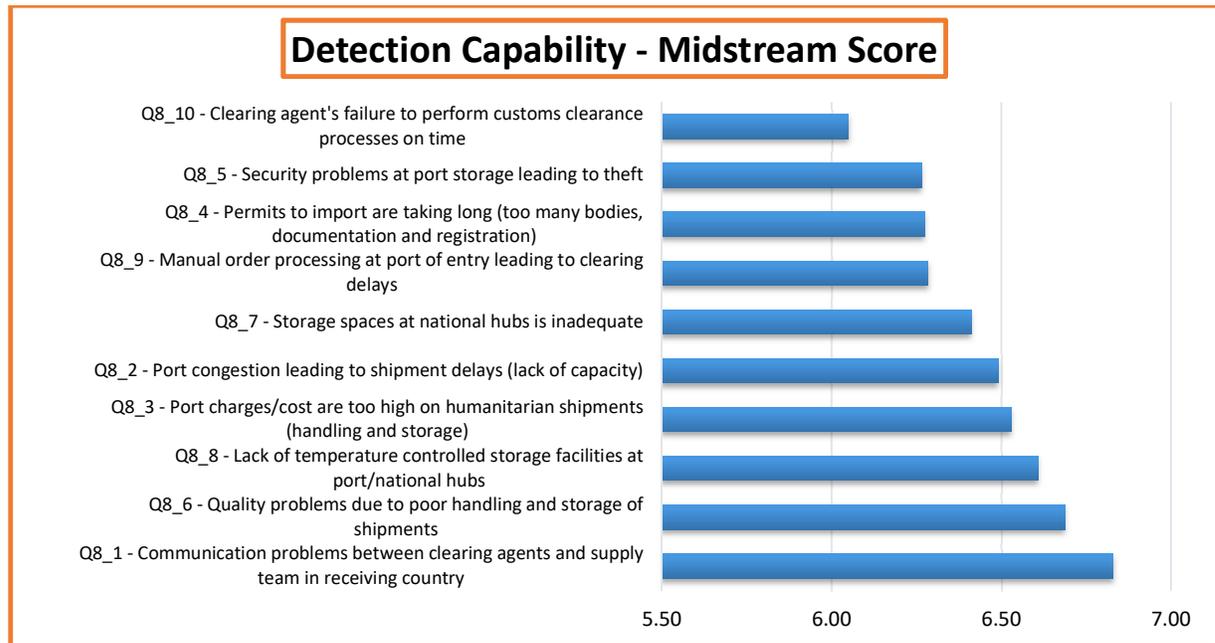
In the midstream risk factors, 202 participants responded to the questionnaire on a Likert scale of 1-5 on the organisation’s capability to detect risks and their responses are summarised in Figure 4.9.

The author doubles each score to align with the risk rating scale of the FMEA methodology.

The top 3 midstream risk factors where organisations have weak detection capability are:

- Clearing agent's failure to perform customs clearance processes on time (score of 6.05 out of 10)
- Security problems at port storage leading to theft (score of 6.26 out of 10)
- Permits to import are taking long (too many bodies, documentation and registration) (score of 6.27 out of 10)

Figure 4. 9 Detection capability – Midstream Risk Factors



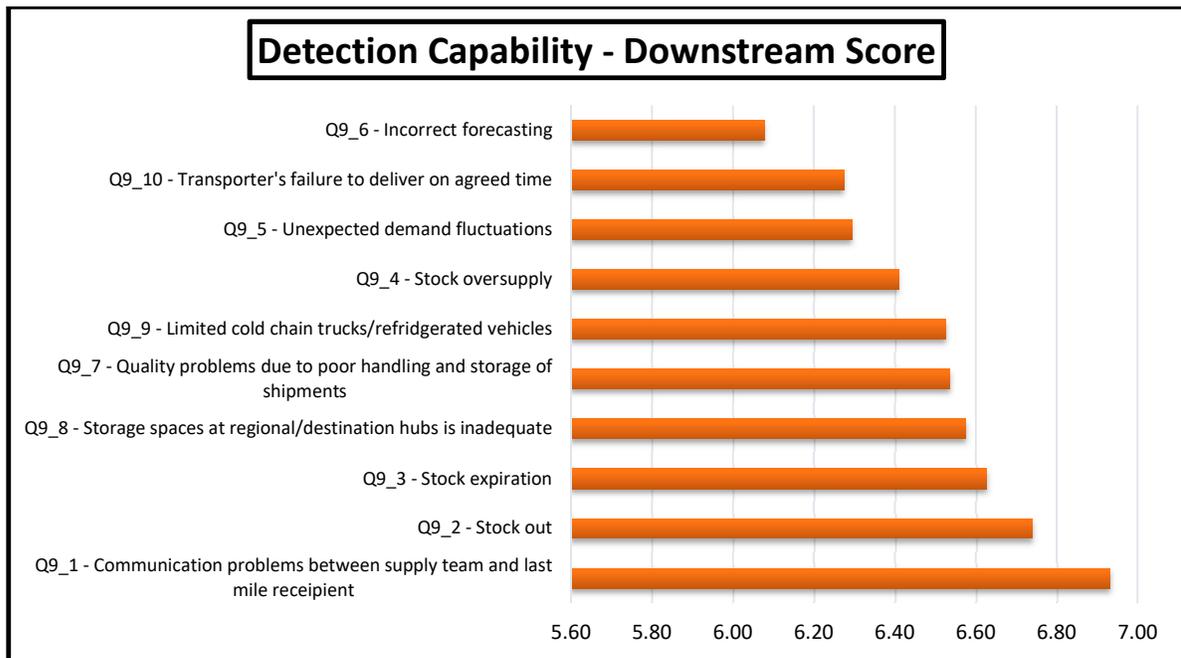
In the downstream risk factors, 202 participants responded to the questionnaire on a Likert scale of 1-5 on the organisation’s capability to detect risks and their responses are summarised in Figure 4.10.

The author doubles each score to align with the risk rating scale of the FMEA methodology.

The top 3 downstream risk factors where organisations have weak detection capability are:

- Incorrect ***forecasting*** (score of 6.08 out of 10)
- Transporter's failure to deliver on agreed ***delivery time*** (score of 6.27 out of 10)
- Unexpected ***demand fluctuations*** (score of 6.29 out of 10)

Figure 4. 10 Detection capability – Downstream Risk Factors

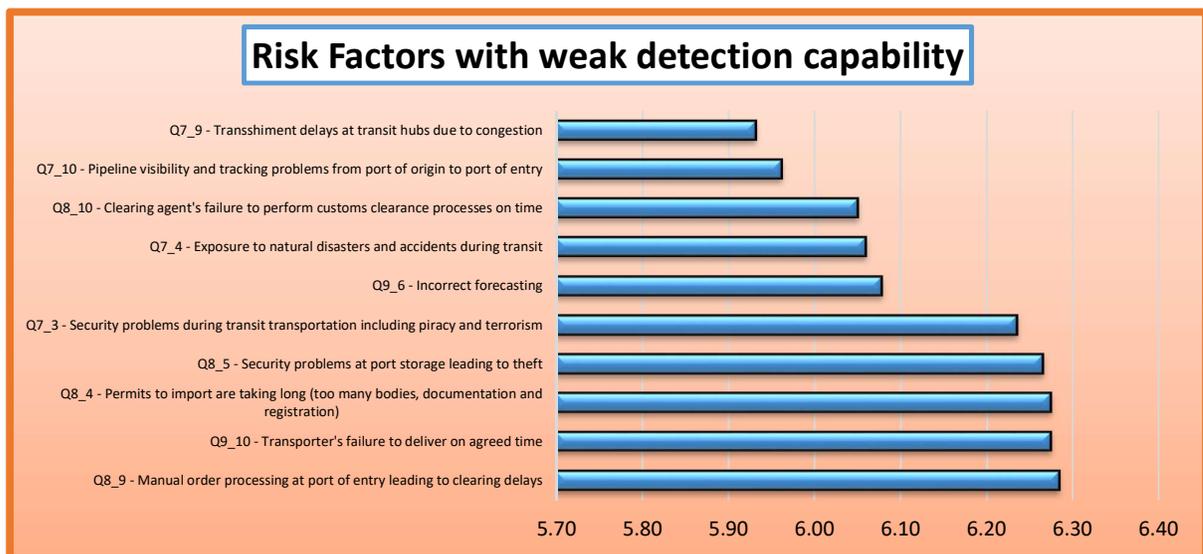


In summary, the following 10 risk factors are top priority in building risk detection tools which are currently reflected as weak across the supply chain in order of priority (up-mid-down streams) as shown in Figure 4.11.

- *Trans-shipment delays at transit hubs due to congestion*
- *Pipeline visibility and tracking problems from port of origin to port of entry*

- *Clearing agent's failure to perform customs clearance processes on time*
- *Exposure to natural disasters and accidents during transit*
- *Incorrect forecasting*
- *Security problems during transit transportation including piracy and terrorism*
- *Security problems at port storage leading to theft*
- *Permits to import are taking long (too many bodies, documentation and registration)*
- *Transporter's failure to deliver on agreed time*
- *Manual order processing at port of entry leading to clearing delays*

Figure 4. 11 Risk Factors with weak detection across supply chain

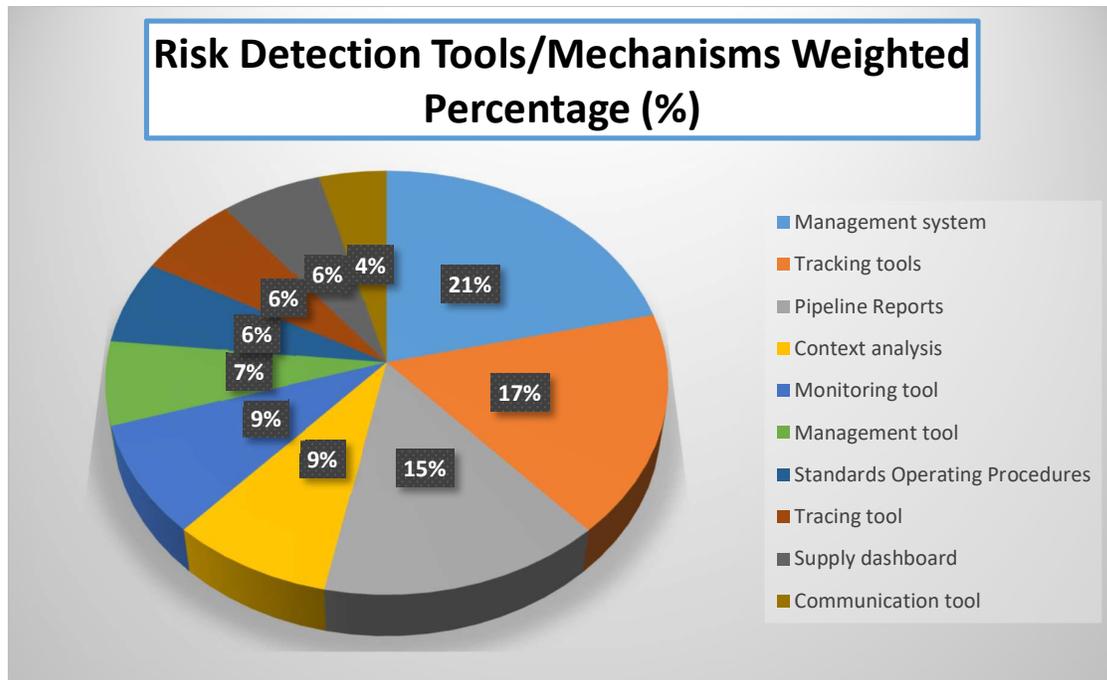


4.1.6. Risk Detection Tools/mechanisms

The author interviewed 15 participants, who are supply chain expected to gather information on what they see as some of the tools currently available for detecting supply chain risk factors. Figure 4.12 shows a list of these tools or mechanisms that organisations can or is using to detect risk factors. The list of tools was processed through Nvivo by selecting tools

that interviewees gave as commonly used or most appropriate. Content analysis was also done by author to confirm the details of tools as given by the interviewed participants.

Figure 4. 12 Risk detection tools/mechanisms



4.1.7. Critical Risk Factors affecting supply chain delivery time

The severity or criticality of risk factors on on-time delivery is determined by the RPN number of each factor. RPN is calculated using the formula:

$$RPN = \textit{Severity} * \textit{Occurrence} * \textit{Detection}.$$

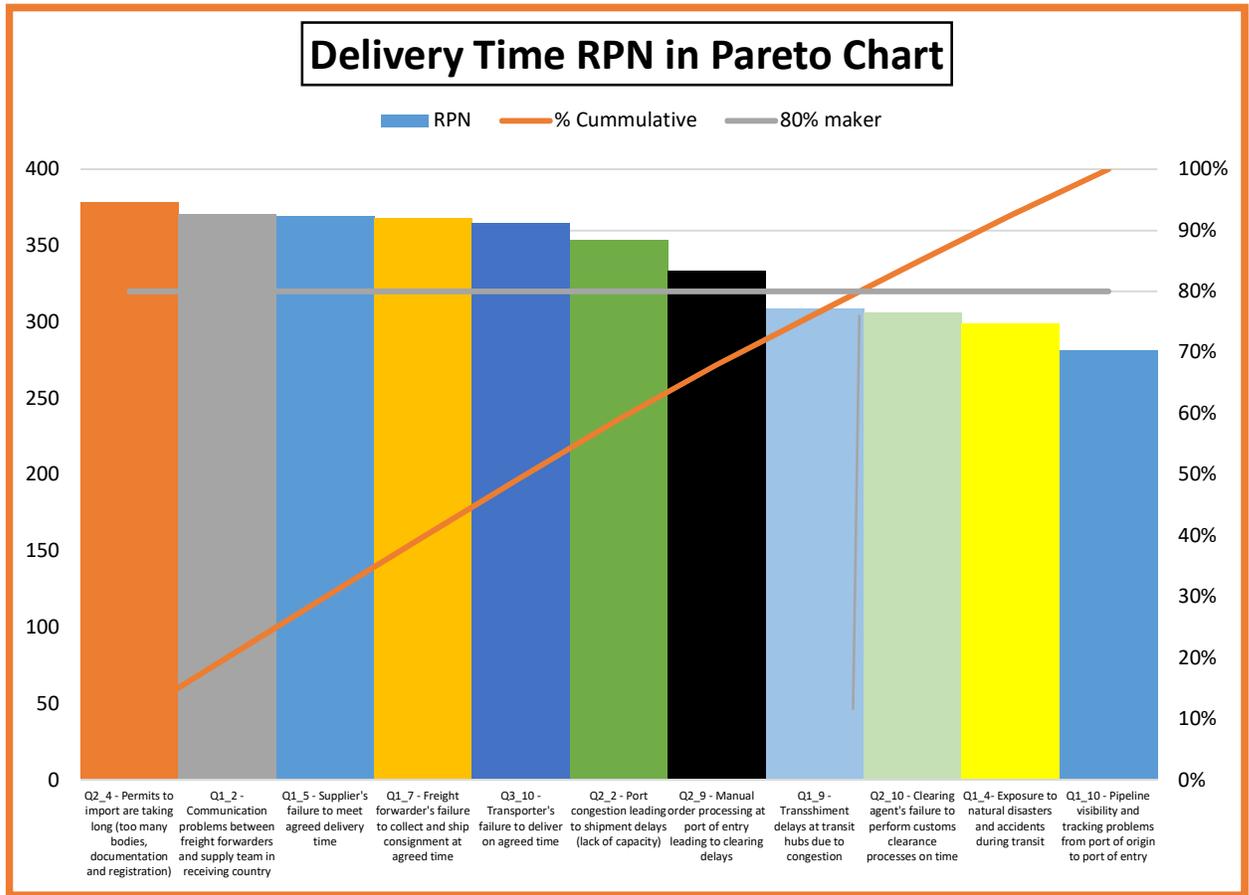
Using the above formula, RPN is calculated for each risk factor affecting the delivery time as shown in Table 4.1 and Figure 4.13 below. The calculated RPNs were put on a Pareto Distribution Chart to determine the risk factors with the most impact/effect on delivery time using the 80-20 Pareto rule. The following factors are considered critical (in order of value of RPN):

- *Permits to import are taking long (too many bodies, documentation and registration)*
- *Communication problems between freight forwarders and supply team in receiving country*
- *Supplier's failure to meet agreed delivery time*
- *Freight forwarder's failure to collect and ship consignment at agreed time*
- *Transporter's failure to deliver on agreed time*
- *Port congestion leading to shipment delays (lack of capacity)*
- *Manual order processing at port of entry leading to clearing delays*
- *Trans-shipment delays at transit hubs due to congestion*

Table 4. 1: Critical Risk Factors affecting deliver time

Delivery Time					
Risk Factors	Severity Score	Occurrence Score	Detection Score	RPN	% Cumulative
Q2_4 - Permits to import are taking long (too many bodies, documentation and registration)	7.64	7.89	6.27	378	10%
Q1_2 - Communication problems between freight forwarders and supply team in receiving country	7.64	7.04	6.89	371	20%
Q1_5 - Supplier's failure to meet agreed delivery time	7.92	7.13	6.54	369	30%
Q1_7 - Freight forwarder's failure to collect and ship consignment at agreed time	7.92	7.08	6.56	368	40%
Q3_10 - Transporter's failure to deliver on agreed time	7.92	7.34	6.27	365	50%
Q2_2 - Port congestion leading to shipment delays (lack of capacity)	7.29	7.48	6.49	354	59%
Q2_9 - Manual order processing at port of entry leading to clearing delays	7.28	7.29	6.28	333	68%
Q1_9 – Trans-shipment delays at transit hubs due to congestion	7.28	7.14	5.93	308	76%
Q2_10 - Clearing agent's failure to perform customs clearance processes on time	7.29	6.94	6.05	306	84%
Q1_4- Exposure to natural disasters and accidents during transit	7.26	6.80	6.06	299	92%
Q1_10 - Pipeline visibility and tracking problems from port of origin to port of entry	7.26	6.49	5.96	281	100%
				3732	

Figure 4. 13 Critical Risk Factors affecting deliver time



4.1.8. Critical Risk Factors affecting supply chain cost

The severity or criticality of risk factors on delivery time is determined by the RPN number of each factor. RPN is calculated using the formula:

$$RPN = Severity * Occurrence * Detection.$$

Using the above formula, RPN is calculated for each risk factor affecting the supply chain cost as shown in Table 4.2 and Figure 4.14 below. The calculated RPNs were put on a Pareto Distribution Chart to determine the risk factors with the most impact/effect on supply chain

cost using the 80-20 Pareto rule. The following factors are considered critical (in order of value of RPN):

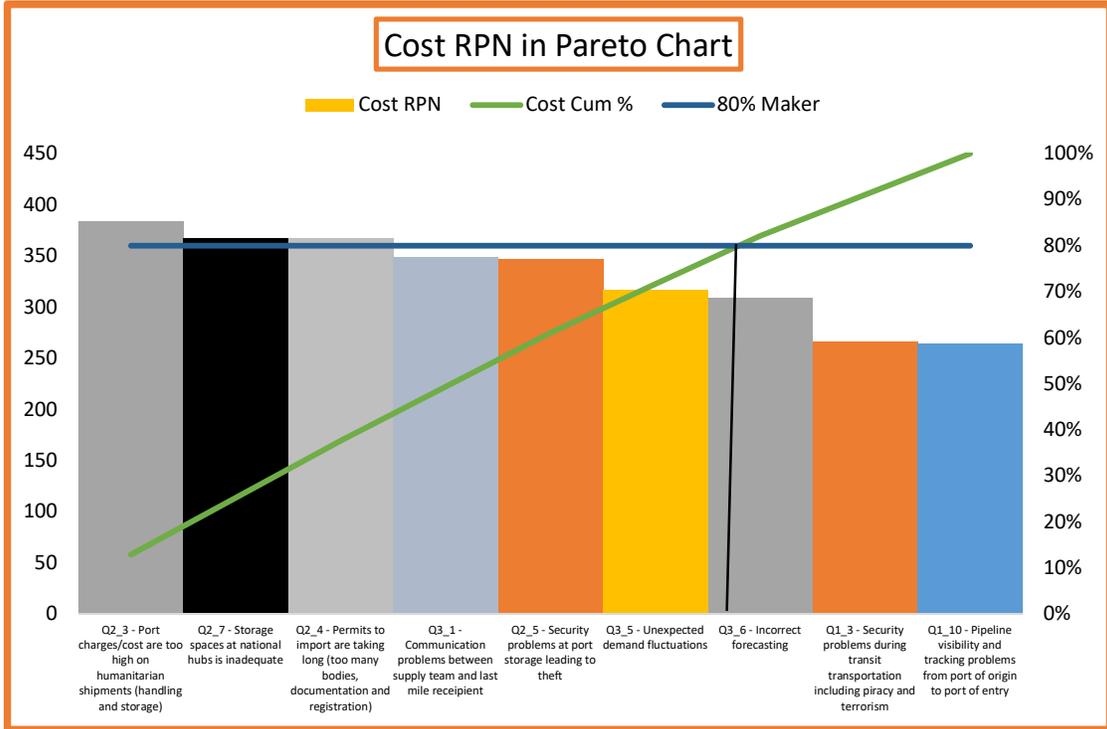
- *Port charges/cost are too high on humanitarian shipments (handling and storage)*
- *Storage spaces at national hubs is inadequate*
- *Permits to import are taking long (too many bodies, documentation and registration)*
- *Communication problems between supply team and last mile recipient*
- *Security problems at port storage leading to theft*
- *Unexpected demand fluctuations*
- *Incorrect forecasting*

Table 4. 2: Critical Risk Factors affecting supply chain cost

Cost					
Risk Factor	Severity Score	Occurrence Score	Detection Score	RPN	Cum %
Q2_3 - Port charges/cost are too high on humanitarian shipments (handling and storage)	7.96	7.37	6.53	383	13%
Q2_7 - Storage spaces at national hubs is inadequate	7.96	7.20	6.41	368	25%
Q2_4 - Permits to import are taking long (too many bodies, documentation and registration)	7.41	7.89	6.27	367	38%
Q3_1 - Communication problems between supply team and last mile recipient	6.83	7.36	6.93	349	49%
Q2_5 - Security problems at port storage leading to theft	7.96	6.97	6.26	347	61%

Table 4.2. (continued)					
Q3_5 - Unexpected demand fluctuations	6.81	7.39	6.29	316	72%
Q3_6 - Incorrect forecasting	6.81	7.47	6.08	309	82%
Q1_3 - Security problems during transit transportation including piracy and terrorism	6.38	6.69	6.24	266	91%
Q1_10 - Pipeline visibility and tracking problems from port of origin to port of entry	6.83	6.49	5.96	264	100%
				2970	

Figure 4. 14 Critical Risk Factors affecting supply chain cost



4.1.9. Critical Risk Factors affecting material quality

The severity or criticality of risk factors on delivery time is determined by the RPN number of each factor. RPN is calculated using the formula:

$$RPN = Severity * Occurrence * Detection.$$

Using the above formula, RPN is calculated for each risk factor affecting the material quality as shown in Table 4.3 and Figure 4.15 below the calculated RPNs were put on a Pareto Distribution Chart to determine the risk factors with the most impact/effect on supply chain cost using the 80-20 Pareto rule. The following factors are considered critical (in order of value of RPN):

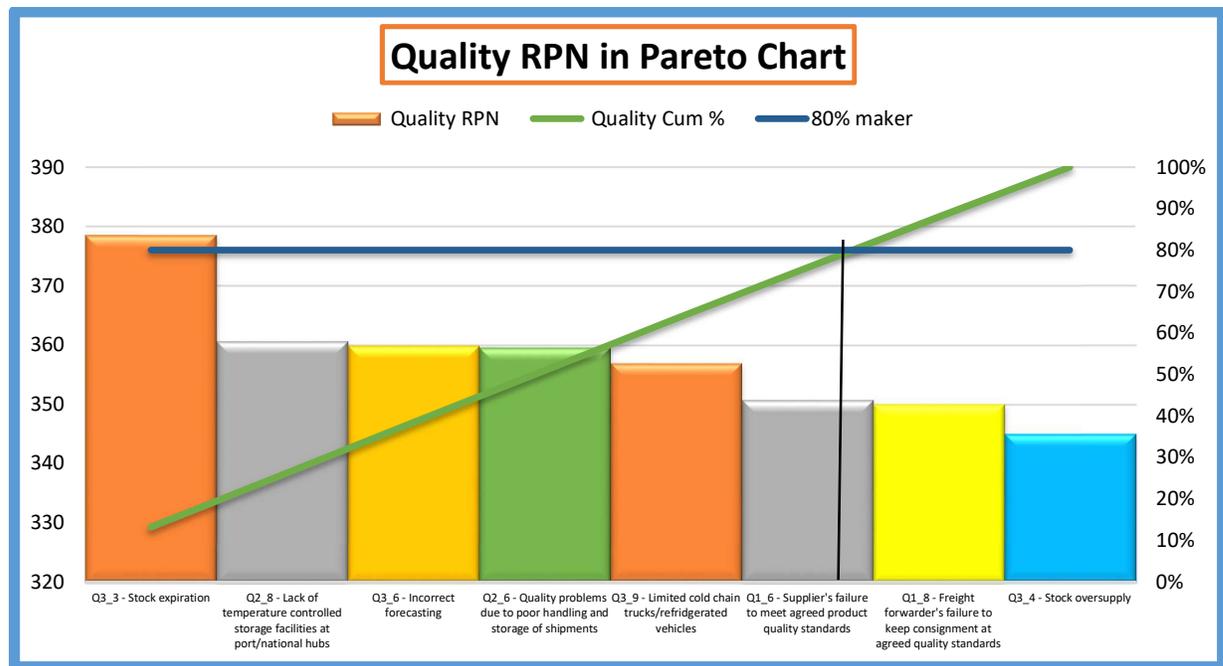
- *Stock expiration*
- *Lack of temperature controlled storage facilities at port/national hubs*
- *Incorrect forecasting*
- *Quality problems due to poor handling and storage of shipments*
- *Limited cold chain trucks/refrigerated vehicles*
- *Supplier's failure to meet agreed product quality standards*

Table 4. 3: Critical Risk Factors affecting material quality

Quality					
Risk Factor	Severity Score	Occurrence Score	Detection Score	RPN	Cum %
Q3_3 - Stock expiration	7.92	7.21	6.63	379	13%
Q2_8 - Lack of temperature controlled storage facilities at port/national hubs	7.51	7.26	6.61	361	26%
Q3_6 - Incorrect forecasting	7.92	7.47	6.08	360	38%
Q2_6 - Quality problems due to poor handling and storage of shipments	7.71	6.98	6.69	360	51%
Q3_9 - Limited cold chain trucks/refrigerated vehicles	7.06	7.75	6.53	357	63%

Table 4.3. (continued)					
Q1_6 - Supplier's failure to meet agreed product quality standards	7.82	6.64	6.76	351	76%
Q1_8 - Freight forwarder's failure to keep consignment at agreed quality standards	7.71	6.80	6.68	350	88%
Q3_4 - Stock oversupply	7.92	6.79	6.41	345	100%
				2861	

Figure 4. 15 Critical Risk Factors affecting material quality



4.1.10. Most Critical Risk Factors on supply chain performance

RQ1g. What risk factors should be prioritised for treatment?

RQ1g provides the overall answer to the first research objective and first research question of the study, to understand most critical risk factors to be prioritised for treatment and mitigation. The results are responses of 202 participants who responded to the questionnaire and ranking is done using the calculated RPN (FMEA methodology) and then determined by Pareto analysis. The most critical risk factors are distributed by supply chain performance indicators of delivery time, cost and material quality. Table 4.4 and Figure 4.16 shows the risks plotted on Pareto distribution according to their RPN. Delivery time and cost related risks have the highest RPN average of 367 each and material quality at 361. The most critical risks that constitute 80% of the impact as per Pareto rule are:

- ***Delivery time risks***
 - ✓ Permits to import are taking long (too many bodies, documentation and registration) - *Midstream*
 - ✓ Communication problems between freight forwarders and supply team in receiving country - *Upstream*
 - ✓ Supplier's failure to meet agreed delivery time - *Upstream*
 - ✓ Freight forwarder's failure to collect and ship consignment at agreed time - *Upstream*
 - ✓ Transporter's failure to deliver on agreed time - *Downstream*
 - ✓ Port congestion leading to shipment delays (lack of capacity) - *Downstream*

- ***Cost risks***
 - ✓ Port charges/cost are too high on humanitarian shipments (handling and storage) - *Midstream*

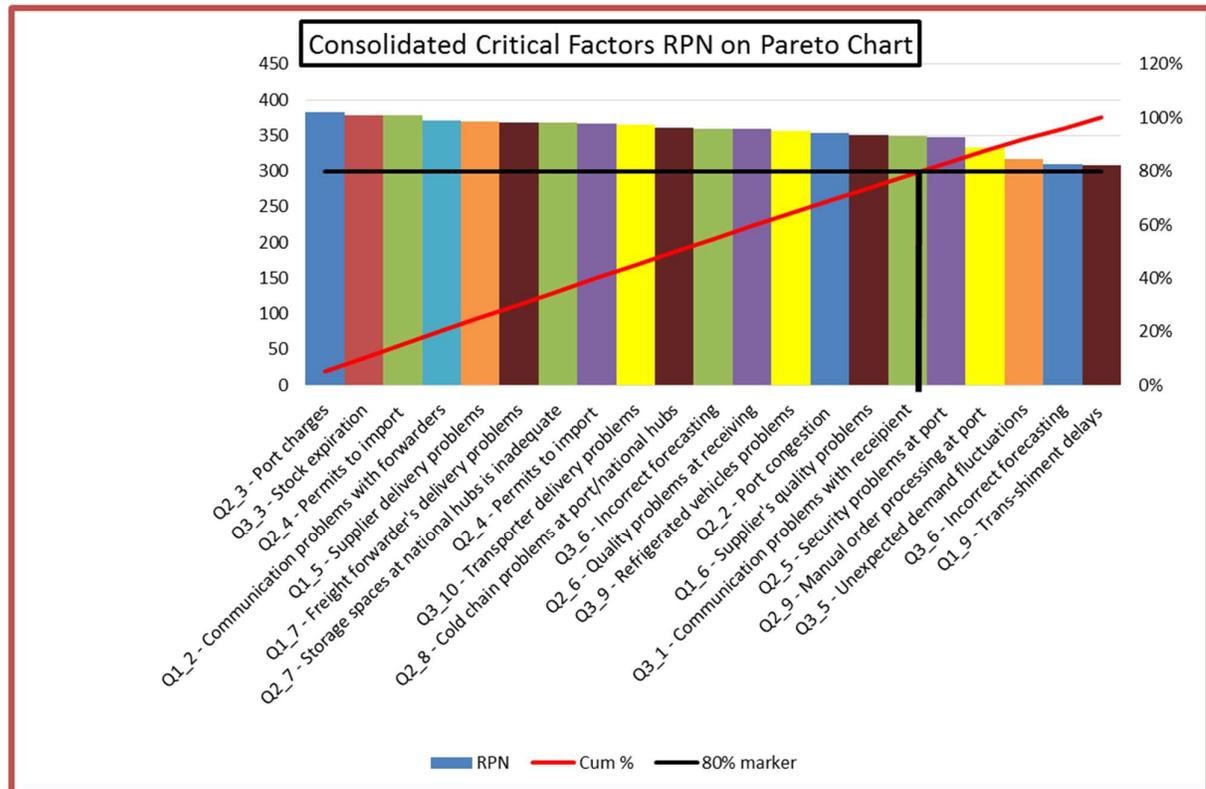
- ✓ Storage spaces at national hubs is inadequate - *Midstream*
- ✓ Permits to import are taking long (too many bodies, documentation and registration)
- *Midstream*
- ✓ Communication problems between supply team and last mile recipient -
Downstream

- ***Material quality risks***
 - ✓ Q3_3 - Stock expiration - *Downstream*
 - ✓ Q2_8 - Lack of temperature controlled storage facilities at port/national hubs -
Midstream
 - ✓ Q3_6 - Incorrect forecasting - *Downstream*
 - ✓ Q2_6 - Quality problems due to poor handling and storage of shipments -
Midstream
 - ✓ Q3_9 - Limited cold chain trucks/refrigerated vehicles - *Downstream*
 - ✓ Q1_6 - Supplier's failure to meet agreed product quality standards – *Upstream*

Table 4. 4: Critical Risk Factors affecting supply chain performance

Most Critical Risk Factors by Performance Indicators			
KPI	Risk Factors	RPN	Cum %
Cost	Q2_3 - Port charges/cost are too high on humanitarian shipments (handling and storage)	383	5%
Quality	Q3_3 - Stock expiration	379	10%
Delivery Time	Q2_4 - Permits to import are taking long (too many bodies, documentation and registration)	378	15%
Delivery Time	Q1_2 - Communication problems between freight forwarders and supply team in receiving country	371	20%
Delivery Time	Q1_5 - Supplier's failure to meet agreed delivery time	369	25%
Delivery Time	Q1_7 - Freight forwarder's failure to collect and ship consignment at agreed time	368	30%
Cost	Q2_7 - Storage spaces at national hubs is inadequate	368	35%
Cost	Q2_4 - Permits to import are taking long (too many bodies, documentation and registration)	367	40%
Delivery Time	Q3_10 - Transporter's failure to deliver on agreed time	365	45%
Quality	Q2_8 - Lack of temperature controlled storage facilities at port/national hubs	361	50%
Quality	Q3_6 - Incorrect forecasting	360	55%
Quality	Q2_6 - Quality problems due to poor handling and storage of shipments	360	59%
Quality	Q3_9 - Limited cold chain trucks/refrigerated vehicles	357	64%
Delivery Time	Q2_2 - Port congestion leading to shipment delays (lack of capacity)	354	69%
Quality	Q1_6 - Supplier's failure to meet agreed product quality standards	351	74%
Cost	Q3_1 - Communication problems between supply team and last mile recipient	349	78%
Cost	Q2_5 - Security problems at port storage leading to theft	347	83%
Delivery Time	Q2_9 - Manual order processing at port of entry leading to clearing delays	333	87%
Cost	Q3_5 - Unexpected demand fluctuations	316	92%
Cost	Q3_6 - Incorrect forecasting	309	96%
Delivery Time	Q1_9 – Trans-shipment delays at transit hubs due to congestion	308	100%
		7452	

Figure 4. 16 Critical Risk Factors affecting supply chain performance



The enquiry on RQ1g (risk prioritisation) was also carried out through interviews. The results of the 15 interviews is analysed through Nvivo and template/thematic analysis presented in Figures 4.17 and 4.18. The top 10 risk factors affecting the performance of the supply chain system as per interviews are (in order of weighted average):

- *Government Regulations*
- *Product Expiration*
- *Lack of Technical Capacity*
- *Staff/Personnel*
- *Government Policies*
- *Transportation system*
- *Customs Procedures*
- *Product Quality*

- *Security*
- *Communication Problems*

Figure 4. 17 Most Critical Risk Factors from interviews

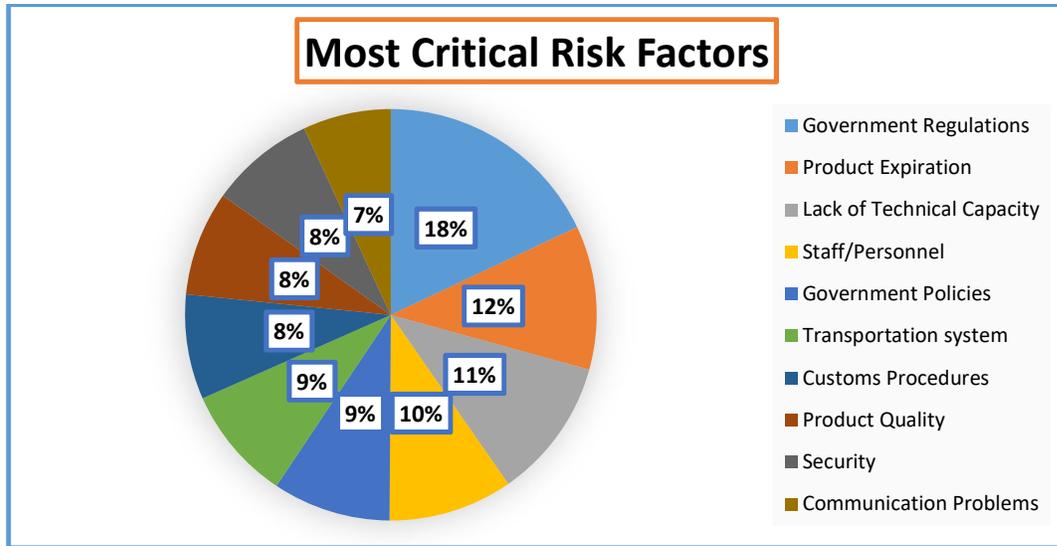
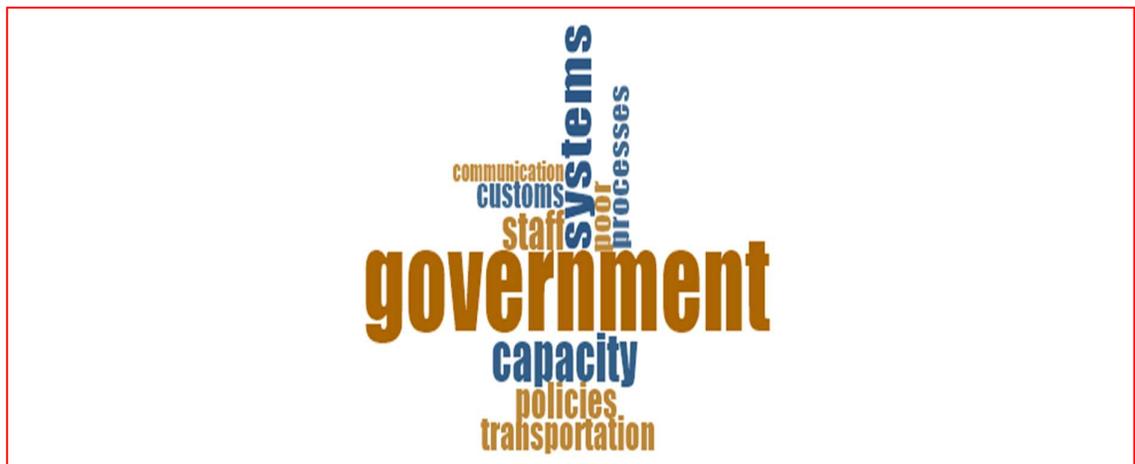


Figure 4. 18 Most Critical Risk Factors from interviews



4.3. Statistical Testing of Hypotheses

RQ2e. How important is early detection in eliminating or minimising risk occurrence and impact/severity?

This enquiry also wanted to establish if there is any relationship between the level of risk detection and the rate of occurrence against the fourteen (14) risks factors found to be critical in the supply chain based on FMEA methodology and the 80-20 Pareto rule. This is important because it can inform organisations whether or not to invest in expensive risk detection tools knowing their level of contribution to risk occurrence and impact. To address this, fourteen (14) hypothesis were derived from the 14 prioritised risk factors with the highest impact (RPN) and those that contributed to 80% of occurrence and impact, and tested using SPSS's correlation and regression analysis. This was important to know whether or not a relationship exist between advance detection and rate of occurrence, and if it does, then determine the level of significance.

Pearson Correlation Coefficient analysis was carried to measure the linear relationship or otherwise between risk detection and risk occurrence against all the 14 prioritised risks. In this measurement, the outcome has a value between +1 and -1, where 1 is total positive linear correlation, 0 is no linear correlation, and -1 is total negative linear correlation. Table 4.5 below shows the correlation values between advance detection of risks and their corresponding rate of occurrence. The table shows a positive relationship on 4 variables/risks whose rate of occurrence can be reduced by an increase in advance detection capability. The 4 variables/risks are;

- Permits to import are taking too long to process

- Supplier's failure to meet agreed delivery time
- Limited cold chain trucks / refrigerated vehicles
- Supplier's failure to meet agreed product quality standards

The remaining 10 variables/risks were found to have either zero relationship or negative relationship. Hence may not require any investment in risk detection capability.

Table 4. 5: Pearson's Correlation Table: Risk Occurrence and Risk Detection

Pearson's Correlation Table: Risk Occurrence and Risk Detection				
SN	Risk Occurrence (Dependent Variable)	Risk Detection (Independent Variable)	Correlation Coefficient	Notes
1	Rate of occurrence of high port charges	Advance detection of high port charges	-0.021	Negative Correlation
2	Rate of occurrence of stock expiration	Advance detection of stock expiration	0.018	Zero Correlation
3	Rate of occurrence of long lead-time for permits	Advance detection of delays in permits issuance	0.169	Positive Correlation
4	Rate of occurrence of communication problems between freight forwarders and supply team in receiving country	Advance detection of communication problems between freight forwarders and supply team in receiving country	0.021	Zero Correlation
5	Rate of occurrence of supplier's delivery problems	Advance detection of supplier's delivery problems	0.154	Positive Correlation
6	Rate of occurrence of freight forwarder's delivery problems	Rate of occurrence of freight forwarder's delivery problems	0.053	Zero Correlation
7	Rate of occurrence of transporter's failure to deliver on agreed time	Advance detection of transporter's failure to deliver on agreed time	0.091	Zero Correlation
8	Advance detection of temperature problems at port storage	Rate of occurrence of temperature problems at port storage	-0.001	Negative Correlation
9	Rate of occurrence of incorrect forecasting	Advance detection of incorrect forecasting	0.075	Zero Correlation
10	Rate of occurrence of quality problems due to poor handling	Advance detection of quality problems due to poor handling	0.106	Positive Correlation
11	Advance detection of limited cold chain trucks/refrigerated vehicles	Rate of occurrence of limited cold chain trucks/refrigerated vehicles	0.136	Positive Correlation
12	Rate of occurrence of supplier's product quality problems	Advance detection of supplier's product quality problems	-0.177	Negative Correlation

13	Advance detection of communication problems with last mile recipient	Rate of occurrence of communication problems with last mile recipient	0.052	Zero Correlation
14	Advance detection of freight forwarder's failure to keep consignment at agreed quality standards	Rate of occurrence of freight forwarder's failure to keep consignment at agreed quality standards	-0.090	Negative Correlation

Tables 4.6 to 4.19 provides Coefficient details with the significance values for each hypothesis tested as derived from the Regression Analysis procedure. The minimum recommended value of level of significance (sig) is 0.05 (5%). Any value more than 0.05 is not significant.

Hypothesis 1

H1: The capability to detect unexpected port charges on humanitarian shipments reduces its rate of occurrence

Table 4. 6: Coefficient–H1: Port charges/cost are too high on humanitarian shipments (handling and storage)

Coefficients^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.527	0.550		13.693	0.000
	Q8_3 – Advance detection of port charges/cost are too high on humanitarian shipments (handling and storage)	-0.024	0.081	-0.021	-0.292	0.771

a. Dependent Variable: Q2_3 – Rate of occurrence of port charges/cost are too high on humanitarian shipments (handling and storage)

Hypothesis 2

H2: Advance detection of stock expiration reduces the risk of actual stock expiry

Table 4. 7: Coefficient – H2: Stock Expiration detection

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.067	0.552		12.793	0.000
	Q9_3 – Advance detection of stock expiration	0.020	0.080	0.018	0.253	0.801

a. Dependent Variable: Q3_3 – Rate of occurrence of stock expiration

Hypothesis 3

H3: Advance detection of causes of permits processing delays reduces rate of its occurrence

Table 4. 8: Coefficient – H3: Permits to import are taking long

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.827	0.452		15.096	0.000
	Q8_4 – Advance detection of delays in permits issuance	0.168	0.069	0.169	2.443	0.015

a. Dependent Variable: Q2_4 – Rate of occurrence of long lead time for permits issuance

Hypothesis 4

H4: The capability to detect communication problems with freight forwarders reduces the rate of its occurrence

Table 4. 9: Coefficient – H4: Communication problems between freight forwarders and supply team in receiving country

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.857	0.567		12.087	0.000
	Q7_2 – Advance detection of communication problems between freight forwarders and supply team in receiving country	0.024	0.080	0.021	0.296	0.768

a. Dependent Variable: Q1_2 – Rate of occurrence of communication problems between freight forwarders and supply team in receiving country

Hypothesis 5

H5: Advance detection of supplier delivery problems reduces its rate of occurrence

Table 4. 10: Coefficient – H5: Supplier's failure to meet agreed delivery time

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.119	0.466		13.121	0.000
	Q7_5 – Advance detection of supplier's failure to meet agreed delivery time	0.152	0.069	0.154	2.222	0.027

a. Dependent Variable: Q1_5 – Rate of occurrence of supplier's failure to meet agreed delivery time

Hypothesis 6

H6: The capability to detect delivery problems by freight forwarder reduces on the rate of its occurrence

Table 4. 11: Coefficient – H6: Freight forwarder's failure to collect and ship consignment at agreed time

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.707	0.510		13.156	0.000
	Q7_7 – Advance detection of freight forwarder's delivery problems	0.057	0.075	0.053	0.759	0.449

a. Dependent Variable: Q1_7 – Rate of occurrence of freight forwarder's delivery problems

Hypothesis 7

H7: Advance detection of last mile transporter’s delivery problems improves on rate of timely delivery

Table 4. 12: Coefficient – H7: Transporter's failure to deliver on agreed time

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.696	0.508		13.179	0.000
	Q9_10 – Advance detection of transporter's failure to deliver on agreed time	0.101	0.078	0.091	1.297	0.196

a. Dependent Variable: Q3_10 – Rate of occurrence of transporter's failure to deliver on agreed time

Hypothesis 8

H8: Advance detection of shortage of temperature controlled storage facilities at port reduces the rate of its occurrence

Table 4. 13: Coefficient – H8: Lack of temperature controlled storage facilities at port/national hubs

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.275	0.473		15.393	0.000
	Q8_8 – Advance detection of temperature problems at port storage	-0.001	0.069	-0.001	-0.010	0.992

a. Dependent Variable: Q2_8 – Rate of occurrence of temperature problems at port storage

Hypothesis 9

H9: The capability to detect causes of incorrect product forecasting reduces the rate of its occurrence

Table 4. 14: Coefficient – H9: Incorrect forecasting

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.998	0.452		15.474	0.000
	Q9_6 - Incorrect forecasting	0.076	0.071	0.075	1.075	0.284

a. Dependent Variable: Q3_6 - Incorrect forecasting

Hypothesis 10

H10: The capability to detect causes of poor handling and storage reduces the rate of its occurrence

Table 4. 15: Coefficient – H10: Quality problems due to poor handling and storage of shipments

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.168	0.555		11.110	0.000
	Q8_6 – Advance detection of quality problems due to poor handling	0.122	0.080	0.106	1.515	0.131

a. Dependent Variable: Q2_6 – Rate of occurrence of quality problems due to poor handling and storage of shipments

Hypothesis 11

H11: The capability to detect potential shortage of refrigerated vehicles reduces the rate of its occurrence

Table 4. 16: Coefficient – H11: Limited cold chain trucks/refrigerated vehicles

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.932	0.430		16.114	0.000
	Q9_9 – Advance detection of limited refrigerated vehicles	0.123	0.063	0.136	1.959	0.051

a. Dependent Variable: Q3_9 – Rate of occurrence of limited refrigerated vehicles

Hypothesis 12

H12: The capability to detect causes of product quality failures by suppliers reduces the rate of its occurrence

Table 4. 17: Coefficient – H12: Supplier's failure to meet agreed product quality standards

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.847	0.498		15.745	0.000
	Q7_6 – Advance detection of supplier's product quality problems	-0.180	0.071	-0.177	-2.544	0.012

a. Dependent Variable: Q1_6 – Rate of occurrence of supplier's product quality problems

Hypothesis 13

H13: The capability to detect causes of communication problems with end user reduces the rate of its occurrence

Table 4. 18: Coefficient – H13: Communication problems with last mile recipient

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.977	0.540		12.909	0.000
	Q9_1 – Advance detection of communication problems between supply team and last mile recipient	0.056	0.075	0.052	0.737	0.462

a. Dependent Variable: Q3_1 – Rate of occurrence of communication problems between supply team and last mile recipient

Hypothesis 14

H14: The capability to detect quality failures by freight forwarders can reduce rate of its occurrence

Table 4. 19: Coefficient – H14: Freight forwarder's failure to keep consignment at agreed quality standards

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.858	0.210		13.600	0.000
	Q7_8 – Advance detection of freight forwarder's failure to keep consignment at agreed quality standards	-0.096	0.074	-0.090	-1.287	0.200

a. Dependent Variable: Q1_8 – Rate of occurrence of freight forwarder's failure to keep consignment at agreed quality standards

The data from both correlation and regression analysis shows that only 4 risk factors have linear relationship between detection and occurrence. The minimum recommended value of sig is 0.05 (5%). Any value more than 0.05 is not significant. Table 4.20 below provides a summary of all risk factors and their corresponding significant values derived from the Coefficient tables.

Table 4. 20: Regression Summary– Hypothesis Testing

Regression Summary Table - Level of Significance			
SN	Risk Detection Capability versus Risk Occurrence rate	Sig	Notes
1	Port charges/cost are too high on humanitarian shipments (handling and storage)	0.771 ^b	Not Significant
2	Stock expiration	0.801 ^b	Not Significant
3	Permits to import are taking long (too many bodies, documentation and registration)	0.015 ^b	Significant
4	Communication problems between freight forwarders and supply team in receiving country	0.768 ^b	Not Significant
5	Supplier's failure to meet agreed delivery time	0.027 ^b	Significant
6	Freight forwarder's failure to collect and ship consignment at agreed time	0.449 ^b	Not Significant
7	Transporter's failure to deliver on agreed time	0.196 ^b	Not Significant
8	Lack of temperature controlled storage facilities at port/national hubs	0.992 ^b	Not Significant
9	Incorrect forecasting	0.284 ^b	Not Significant
10	Quality problems due to poor handling and storage of shipments	0.131 ^b	Not Significant

Table 4.20 (continued)			
11	Limited cold chain trucks/refrigerated vehicles	0.051 ^b	Significant
12	Supplier's failure to meet agreed product quality standards	0.012 ^b	Significant
13	Communication problems between supply team and last mile recipient	0.462 ^b	Not Significant
14	Freight forwarder's failure to keep consignment at agreed quality standards	0.200 ^b	Not Significant

The overall results of the hypothesis testing show that only four (4) risk factors have a significant relationship between its detection capacity and its occurrence. This is shown by their significant values that are 0.05 (5%) and below.

- ***H3: Advance detection of causes of permits processing delays reduces rate of its occurrence (Sig = 0.015)***

The shows that there is a positive relationship between advance detection in delays in permits processing and the rate of occurrence of this risk. In other words, supply managers can invest in advance detection if they want to see a reduction in rate of occurrence for this risk. The values for this relationship are given in Table 4.21.

- ***H5: Advance detection of supplier delivery problems reduces its rate of occurrence (Sig =0.027)***

This shows a positive relationship exists between advance detection of supplier delivery problems and its rate of occurrence. The rate of occurrence of this risk can be

reduced by an increase in the detection of supplier delivery problems. The actual values of this relationship are provided in the models given in Table 4.21.

- *H11: The capability to detect potential shortage of refrigerated vehicles reduces the rate of its occurrence (Sig = 0.051)*

Results shows that a positive or meaningful relationship exists between advance detection of possible shortage of refrigerated vehicles and its occurrence. In this case, supply managers can reduce the rate of risk occurrence by increasing on the advance detection capability.

- *H12: The capability to detect causes of product quality failures by suppliers reduces the rate of its occurrence (Sig =0.012)*

This hypothesis confirms that there is a significant or positive relationship between advance detection of supplier quality problems and its rate of occurrence. This means that supply managers can invest in detection capability in their effort to reduce on risk occurrence. The values for this model are provided in Table 4.5.

Thus, regression models were developed for the 4 risks where a relationship between detection and occurrence was found exist and significant. These regression models are presented in Table 4.21 below.

Table 4. 21: Regression Models – Risk Occurrence and Risk Detection

Regression Analysis Models						
Model 1. Import permits are taking too long to obtain						
Coefficients^a						
		Unstandardized Coefficients		Standardized Coefficients		
			Std. Error		T	Sig.
Model		B		Beta		
1	(Constant)	6.827	0.452		15.096	0.000
	Q8_4 - Permits to import are taking long (too many bodies, documentation and registration)	0.168	0.069	0.169	2.443	0.015
a. Dependent Variable: Q2_4 - Permits to import are taking long (too many bodies, documentation and registration)						
Model: Occurrence = a + bDetection		Occurrence = 6.827 + 0.168 Detection				
Model 2. Supplier's failure to meet agreed delivery time						
Coefficients^a						
		Unstandardized Coefficients		Standardized Coefficients		
			Std. Error		T	Sig.
Model		B		Beta		
1	(Constant)	6.119	0.466		13.121	0.000
	Q7_5 - Supplier's failure to meet agreed delivery time	0.152	0.069	0.154	2.222	0.027
Model: Occurrence = a + bDetection		Occurrence = 6.119 + 0.152 Detection				

Table 4.21 (continued)						
Model 3. Limited cold chain trucks/refrigerated vehicles						
Coefficients ^a						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	T	Sig.
1	(Constant)	6.932	0.430		16.114	0.000
	Q9_9 - Limited cold chain trucks/refrigerated vehicles	0.123	0.063	0.136	1.959	0.051
a. Dependent Variable: Q3_9 - Limited cold chain trucks/refrigerated vehicles						
Model:		Occurrence = a + bDetection		Occurrence = 6.932 + 0.123 Detection		
Model 4. Supplier's failure to meet agreed product quality standards						
Coefficients ^a						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	T	Sig.
1	(Constant)	7.847	0.498		15.745	0.000
	Q7_6 - Supplier's failure to meet agreed product quality standards	-0.180	0.071	-0.177	-2.544	0.012
a. Dependent Variable: Q1_6 - Supplier's failure to meet agreed product quality standards						
Model :		Occurrence = a + bDetection		Occurrence = 7.847 + (0.180)Detection		

The other 10 hypothesis shows no correlation and no significance. That is to say, no relationship exists between detection and occurrence for the following risk factors.

- *H1: The capability to detect unexpected port charges on humanitarian shipments reduces its rate of occurrence (Sig = 0.771)*

- *H2: Advance detection of stock expiration reduces the risk of actual stock expiry (Sig = 0.801)*
- *H4: The capability to detect communication problems with freight forwarders reduces the rate of its occurrence (Sig = 0.768)*
- *H6: The capability to detect delivery problems by freight forwarder reduces on the rate of its occurrence (Sig = 0.449)*
- *H7: Advance detection of product quality problems by supplier improves on the quality of delivered products (Sig = 0.196)*
- *H8: Advance detection of shortage of temperature controlled storage facilities at port reduces the rate of its occurrence (Sig = 0.992)*
- *H9: The capability to detect causes of incorrect product forecasting reduces the rate of its occurrence (Sig = 0.284)*
- *H10: The capability to detect causes of poor handling and storage reduces the rate of its occurrence (Sig = 0.131)*
- *H13: The capability to detect causes of communication problems with end user reduces the rate of its occurrence (Sig = 0.462)*
- *H14: The capability to detect quality failures by freight forwarders can reduces rate of its occurrence (Sig =0.200)*

4.4. Risk Mitigation Strategies

*RQ2: How can an organisation **effectively manage** risk factors for a pharmaceutical supply chain system in Sub-Saharan Africa?*

The second research question is addressing the second objective of the enquiry that looks at identifying the strategies that promotes the effective management of prioritised risk factors.

The enquiry was conducted qualitatively through interviews method. Data was gathered on the mitigation strategies per each of the supply chain performance indicators of delivery time, cost and material quality. Participants also provided additional strategies that can be used for other supply chain performance indicators such as material availability, environmental impact and organizational reputation.

The results of this enquiry are presented in four categories of delivery time, cost, material quality and other indicators. This was done by running a word frequency query in Nvivo to list the most frequently occurring words or concepts from the interview scripts. The word frequency query was run to identify possible themes and their frequencies so as to determine and rank the most critical factors according to the weighted percentages. Weighted Percentage is the frequency of the word relative to the total words counted. The weighted percentage assigns a portion of the word's frequency to each group so that the overall total does not exceed 100%.

4.4.1. Risk Mitigation Strategies on delivery time

RQ2a. *What risk mitigation strategies minimise the impact/severity of risk factors on supply chain delivery time?*

Interviews were conducted to answer RQ2a on the mitigation strategies suitable for minimising the occurrence and impact of delivery time risk factors. The data is processed through Nvivo tool to show the 10 most recommended strategies as presented in Figures 4.19 and 4.20 below. The following are the top 10 delivery time related strategies with their weighted percentage rating.

- *Supply Planning tool (4.30%)*
- *Staff Capacity enhancement (3.23%)*
- *Communication efficiency (3.23%)*
- *Advance and Correct Documentation (3.23%)*
- *Pipeline Monitoring tool (3.23%)*
- *Customs Systems efficiency (3.23)*
- *Freight Forwarders efficiency (2.15%)*
- *Private Sector partnerships (2.15%)*
- *Prequalification of Suppliers (2.15%)*
- *Tracking & Tracing tool (2.15%)*

Figure 4. 19 Most recommended delivery time mitigation strategies

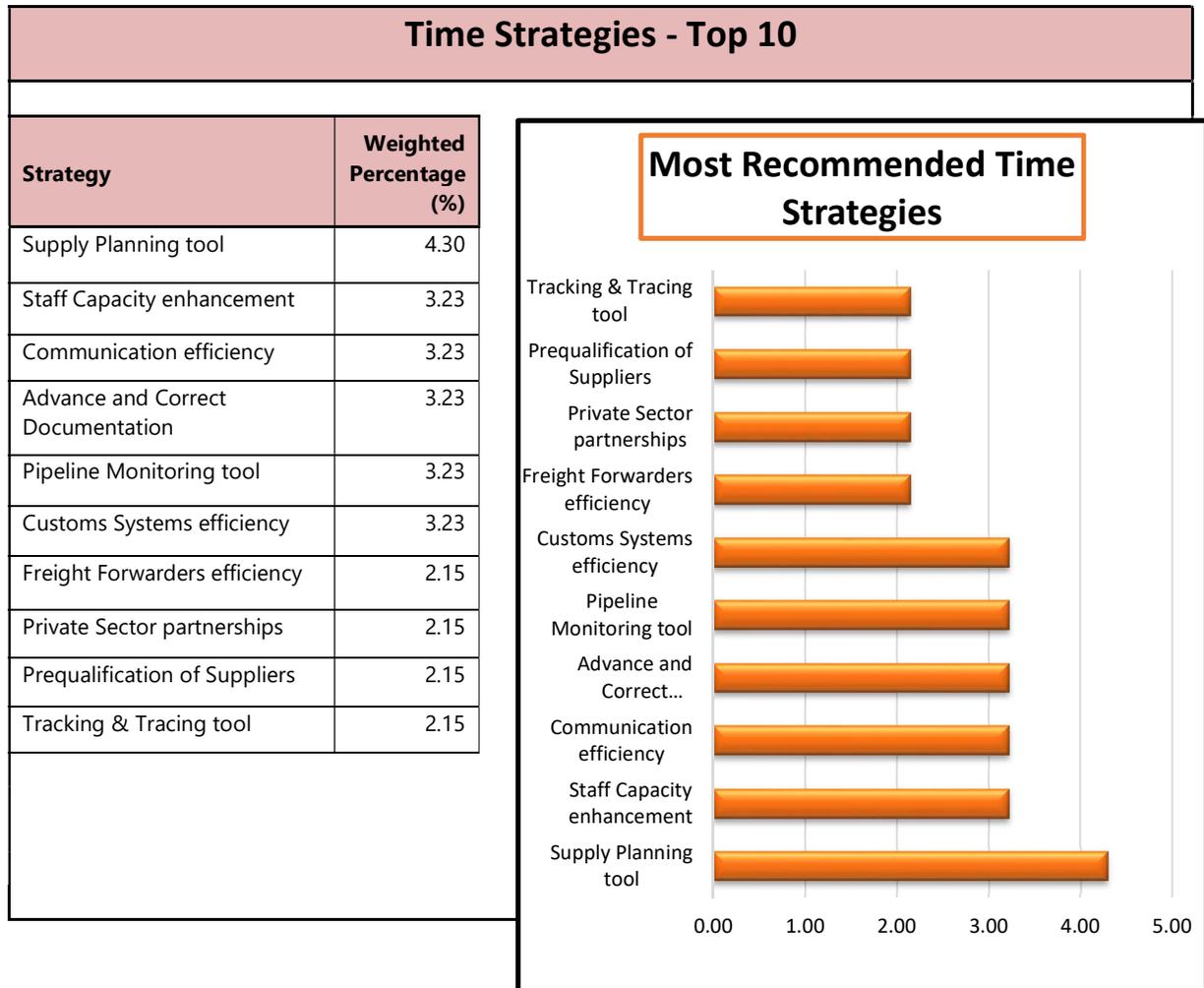
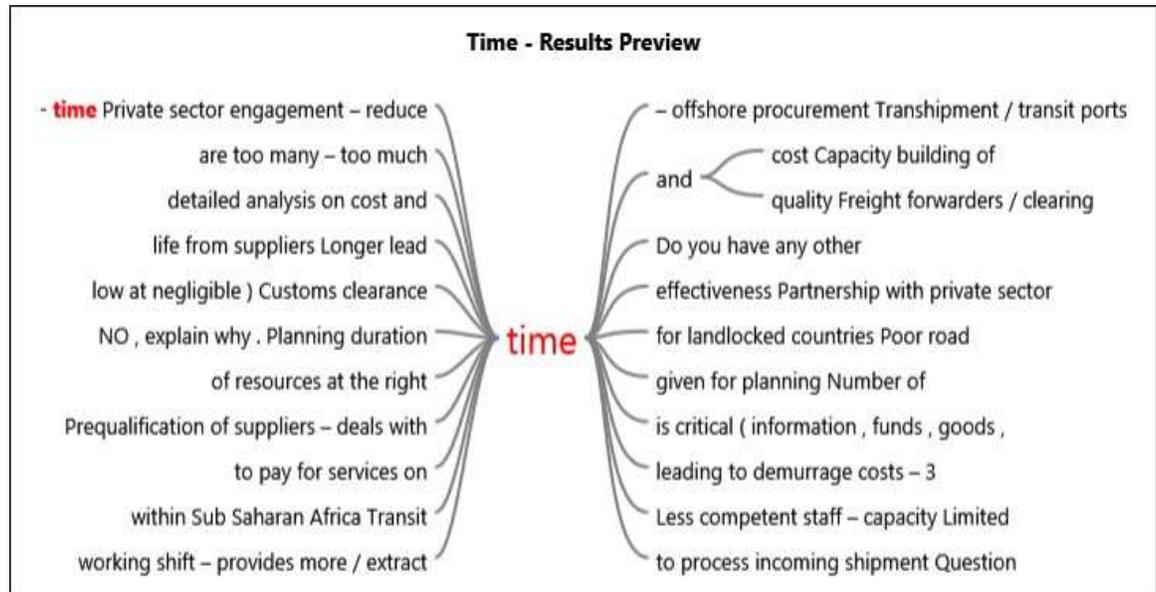


Figure 4. 20 Time Word Query - Mitigation strategies



4.4.2. Risk Mitigation Strategies on cost

RQ2b. *What risk mitigation strategies minimise the impact/severity of risk factors on supply chain cost?*

Interviews were conducted to answer RQ2b on the mitigation strategies suitable for minimising the occurrence and impact of supply chain cost risk factors. The data is processed through Nvivo tool to show the 10 most recommended strategies as presented in Figures 4.21 and 4.22 below. The following are the top 10 cost related strategies with their weighted percentage rating.

- *Direct delivery (6.74%)*
- *Insurance cover (5.06%)*
- *Supply planning (4.49%)*
- *Advance Permits (3.37%)*

- *Correct Customs Documentation (3.37%)*
- *Private Sector Partnerships (3.37%)*
- *Liquidated damages (2.81%)*
- *Adequate funding (2.25%)*
- *Staff knowledge (2.25%)*
- *Pipeline monitoring (2.25%)*

Figure 4. 21 Most recommended Cost mitigation strategies

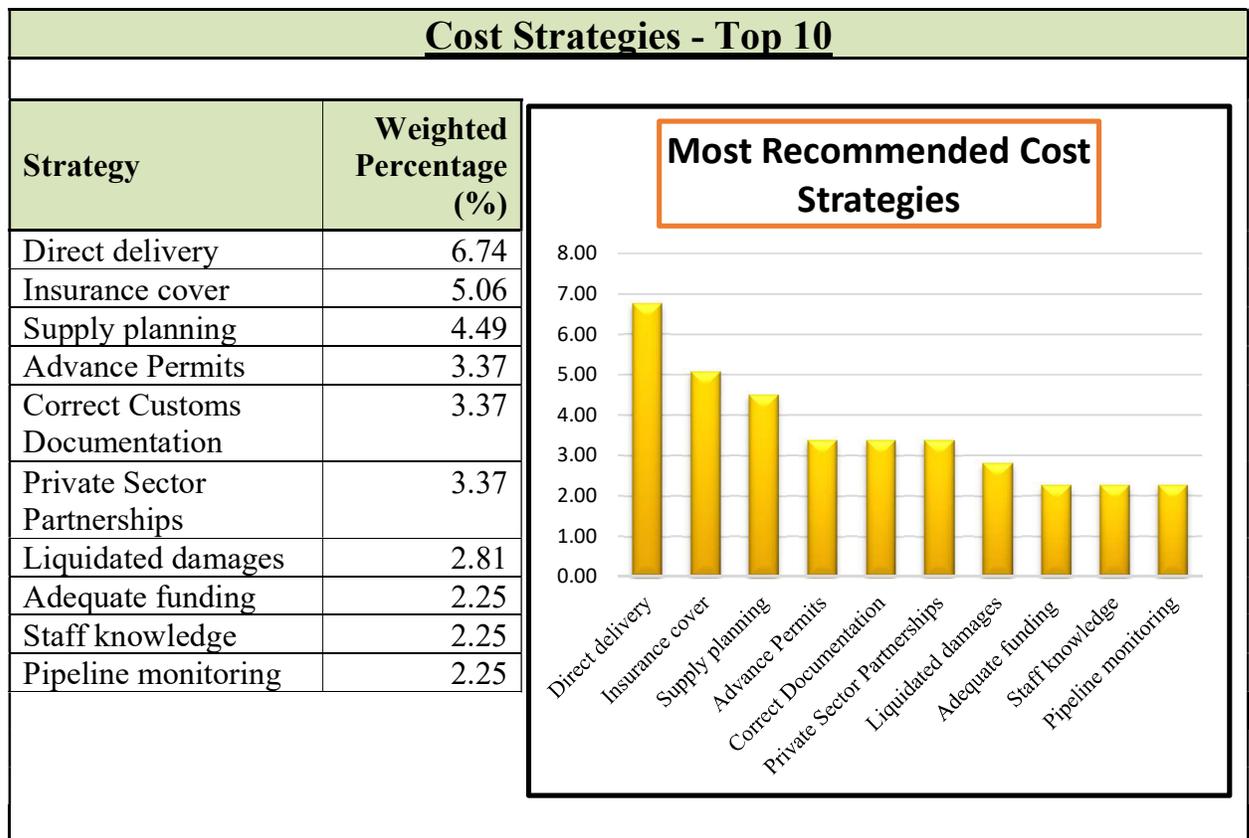
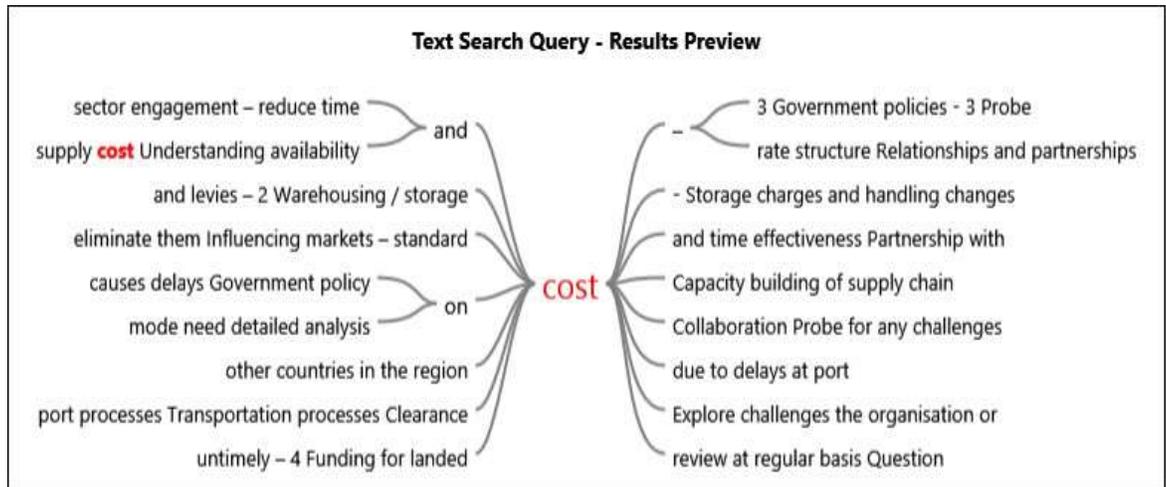


Figure 4. 22 Cost Word Query - Mitigation strategies



4.4.3. Risk Mitigation Strategies on material quality

RQ2c. *What risk mitigation strategies minimise the impact/severity of risk factors on supply chain performance material quality?*

Interviews were conducted to answer RQ2c on the mitigation strategies suitable for minimising the occurrence and impact of material quality risk factors. The data is processed through Nvivo tool to show the 10 most recommended strategies as presented in Figures 4.23 and 4.24 below. The following are the top 10 material quality related strategies with their weighted percentage rating.

- *Pre-delivery inspection (3.41%)*
- *Minimum quality standards (2.27%)*
- *Temperature control equipment (2.27%)*
- *Product Regulatory frameworks (2.27%)*
- *Product selection and specification (2.27%)*

- *Proper material handling systems (2.27%)*
- *Market surveys & assessments (2.27%)*
- *Adequate funding for quality products (2.27%)*
- *Staff training in pharmaceutical systems (2.27%)*
- *Correct transportation mode (1.14%)*

Figure 4. 23 Most recommended Quality mitigation strategies



Figure 4. 24 Quality Word Query - Mitigation strategies



4.4.4. Risk Mitigation Strategies on additional key performance Indicators

Interview participants were also asked to provide additional key performance indicators other than time, cost and material quality. The following 3 additional KPIs featured the most during the interviews.

- *Material availability*
- *Environmental impact*
- *Organisation reputation*

Interviewees also gave the mitigation strategies suitable for minimising the occurrence and impact of material quality risk factors. The data is processed through Nvivo tool for the 10 most recommended strategies and the relevant performance indicator as presented in Table 4.22 below. The following are the top 10 strategies recommended for material availability, environmental impact and organisational reputation. Risk profiling and risk strategy designing are also mentioned and highlighted as recommended strategies in risk management strategy.

Table 4. 22: Additional recommended mitigation strategies

Additional Mitigation Strategies - Top 10	
Strategy	Relevant KPI
Waste Management	Environmental Impact
Disposal Policy	Environmental Impact
Risk Profiling	All KPIs
Transportation Mode	Environmental Impact
Government Involvement	All KPIs
Certified Partners	Organisation reputation
Risk strategy	All KPIs
Humanitarian Regulations	Organisation reputation
Cold Chain Analysis	All KPIs
Performance Matrix	All KPIs

The overall risk mitigation strategies gathered from interviews are presented in Figure 4.25 generated from Nvivo through word frequency. The top 10 themes and strategies from the list are (in order of importance):

- *Planning*
- *Partnerships*
- *Government (regulations)*
- *Documentation*
- *Monitoring*
- *Systems*

Table 4. 23: Challenges in implementing Risk Mitigation Strategies			
Challenge Description	Key Performance Indicators		
	Delivery Time	Cost	Material Quality
• Lack of strategic management approach	✓	✓	✓
• Collaboration across supply chain partners is lacking	✓	✓	✓
• Long lead time on processing import permits	✓	✓	✓
• Staff skills and expertise in pharmaceutical logistics	✓	✓	✓
• Lack of competent third party inspection companies	✓	✓	✓
• Long shelf life for humanitarian goods which are consumed immediately	✓	✓	
• High workload for staff	✓	✓	
• Short term funding	✓	✓	
• Tax collection approach slow down processes	✓	✓	
• Timely and accurate documentation	✓	✓	✓
• Qualified technicians to assess storage equipment		✓	✓
• Temperature controlled trucks during movement		✓	✓
• Lack of funding for logistics systems		✓	✓
• Lack of infrastructure such as laboratories		✓	✓

4.6. Risk Mitigation Opportunities

RQ2g. What risk management opportunities exists in Sub-Saharan Africa region?

The enquiry addresses RQ2g through interview method to identify potential opportunities that countries can tap into in order to better manage risk factors and improve on supply chain

performance. The opportunities are presented in Table 4.24 and allocated according to the supply chain performance indicators that they can potentially improve.

Table 4. 24: Opportunities in managing Supply Chain Risks

Opportunities in managing Supply Chain Risks in Sub-Saharan Africa			
Opportunity Description	Key Performance Indicators		
	Delivery Time	Cost	Material Quality
• One / Common customs processing system in EAC countries	✓		
• Move from tax based custom clearance system to facilitation process	✓		
• Separation of humanitarian and commercial shipment	✓		
• One stop centre or single desk approach at customs documentation	✓		
• Procurement of commodities/pharmaceuticals with longest shelf life	✓		
• Introduction of regional rail system		✓	
• Introducing 24/7 operations at ports of entry		✓	
• Increase economic regional collaboration (EAC) – going beyond political boundaries,		✓	
• Use of drones to reach difficult areas		✓	
• Industrialisation and investment in local or regional production of medical products and equipment			✓
• Establishment of laboratories in African countries			✓
• Local presence of global manufacturers			✓

4.7. Chapter Summary

This chapter gave an account of the research findings based on outputs from the quantitative analysis through descriptive statistics, regression, FMEA and Pareto and the content and Nvivo analysis of qualitative data. The findings covered aspects on critical risks in terms of likelihood of occurrence, detection and severity. It also presented the detection capability and strategies and the risk mitigation strategies, challenges and opportunities. The next chapter 5 is going to provide an analytical review and discussion on these findings before making research conclusions.

Chapter 5: Research Analysis and Discussion

5.0. Introduction

This study aims to address the research gap in risk prioritisation and mitigation for humanitarian pharmaceutical supply chains in Sub-Saharan Africa, using FMEA methodology. FMEA is a proactive tool developed to identify, evaluate and prevent product and/or process failures (Bluvband, 2009). Sinha *et al.* (2004) sees FMEA methodology as a developed prescriptive method to decrease risk occurrence and impact. According to Sinha *et al.* (2004) and Zsidisin *et al.* (2004), risk prioritisation helps organisations identify the most significant risks and develop strategies to immediately mitigate against high impact risks, allowing a firm to manage its limited risk treatment resources. Hence, the selection of FMEA methodology to support this enquiry.

With FMEA, all potential failures are evaluated in terms of likelihood, severity, and detectability. A higher FMEA score (known as RPN) implies higher risk. The findings on risk prioritisation and mitigation for a humanitarian pharmaceutical supply chain in Sub-Saharan Africa have been presented in previous chapter. These findings will be analysed and discussed in detail in this chapter in line with the two research questions:

***RQ1:** What are the critical risk factors to be prioritised and managed in humanitarian pharmaceutical supply chain system in Sub-Saharan Africa?*

***RQ2:** How can an organisation effectively manage risk factors for a humanitarian pharmaceutical supply chain system in Sub-Saharan Africa?*

The analysis and discussion will embed the study findings into the existing literature and work experience in order to identify and reflect on the contribution of the study to knowledge, and will also compare and contrast qualitative with quantitative findings where appropriate. In a critical way, the research questions will be addressed and the managerial implications thereof analysed.

5.1. Prioritisation of critical pharmaceutical supply chain risk factors

Understanding how to prioritise and mitigate risks that impacts on project performance is noted as the starting point for effective risk management, a recipe for project success (Manuj & Mentzer, 2008, Tang & Tomlin, 2008, Wieland & Wallenburg, 2012, Faizal & Palaniappan, 2014). To understand the risks to be prioritized, one has to understand their criticality levels, found by multiplying risk impact by its likelihood. The capability to detect the risk is also added to the formula to determine the priority ranking.

5.1.1. Risk Likelihood of Occurrence (Upstream, Midstream and Downstream)

The supply chain for humanitarian operation is usually divided' into three phases; the *upstream* (from point of origin to port of entry), the *midstream* (from port of entry storages at national level) and the *downstream* (from national storage to point of distribution). Such classification of risks is appropriate for the supply chain under investigation as it analyses the risks associated with management of the upstream supply chain, operational / midstream risks, and the risks associated with management of the downstream supply chain (Spekman et al 2004; Christopher and Lee 2008; Juttner et al 2003).

Risk is about the uncertainty concerning the occurrence of a loss (Regda, 2007) or even a chance of injury, damage or loss (Vatsa, 2004). This points to the importance of supply managers knowing the probability of risk occurrence, as the first step towards risk prioritisation. According to Sinha *et al.* (2004) and Zsidisin *et al.* (2004), risk prioritisation helps organisations identify the most significant risks and develop strategies to immediately mitigate against high impact risks, allowing a firm to manage its limited risk treatment resources.

Previous research (Ouabouch *et al.*, 2013; Jüttner, *et al.*, 2003; Christopher, *et al.* 2008; Spekman *et al.* 2004) shows that complex supply chains classify and analyse risks into three families, that is, the risks associated with management of the upstream supply chain (relations with suppliers), mid-stream/operational risks (internal to the company), and the risks associated with management of the downstream supply chain (customer relationships). This is probably the closest way to classify supply chain risks for complex humanitarian pharmaceutical supply chains in developing world as it reflects well the configuration of these supply chains.

The knowledge of risk likelihood or occurrence in a particular supply chain is important for managers to build detection mechanisms to reduce such occurrence. The pharmaceutical supply chain system under study has several risk factors, starting from port of origin to point of distribution/consumption, through an array of risks at supply hubs and along supply routes.

The weighted scores from 202 participants in the questionnaire survey confirmed that all the thirty predefined risk factors (ten risks in each phase) are likely to occur in a single shipment. Risk ranking in terms of probability of occurrence provides a guide for risk managers to know where detection capacity is or is not needed in reducing this occurrence. Addressing risk factors by phase is important as it help to designate risk focal points in each affected phase for effective management.

In the upstream phase, the top three risk factors with probability of occurrence are; *supplier communication problems, trans-shipment delays at transit hubs and supplier delivery problems* (Table 4.1 and Figure 4.1). On the other side of the spectrum, *pipeline visibility and tracking; supplier's quality standards and transit security* were seen as the three most unlikely to occur risk factors. In the case of UNICEF, it is true that communication with suppliers and delayed delivery time are critical factors particularly for health products. More often than not, supplier's limited capacity to meet high demand for high quality health products such as vaccines and therapeutic food is a cause of concern. Buyers are sometimes left to trade-off fast delivery with limited product shelf life.

Trans-shipment delays feature as one with second most occurrence in this study. This is true for UNICEF's air shipments and not for sea shipments where vessel direct route to destination are used. The high rate of occurrence on rans-shipment also tells us that most humanitarian operations in Sub-Saharan Africa use transit hubs such as Jebel Ali seaport in Dubai and the Dubai airport. The above findings have also confirmed the researcher's

practical knowledge that product quality and pipeline visibility and tracking are less likely to occur given the available quality assurance and pipeline monitoring tools.

In the midstream phase, the top three risk factors with probability of occurrence are the lengthy process to obtain *importation permits, the congestion at entry ports and the high port charges levied against humanitarian goods* (Table 4.2 and Figure 4.2). On the other hand, the risk factors with the lowest probability of occurrence includes the *capacity of clearing agents, clearing agent's communication problems and security at ports of entry*. The researcher cannot agree more with these findings. The most risks that UNICEF supply team deals with each day is finding solutions to customs clearance challenges. These stems from unloading delays due to congestion which has since started reducing due to the introduction of 24-hour shift and for 7 days a week. The risk on high taxation on humanitarian shipments still remains a critical element at most entry ports in Sub Saharan Africa. Most humanitarian organisations such as the United Nations use globally reputable customs clearing agents with adequate capacity and modern quality standards. This is confirmed by the very low score on this risk factor.

The last mile is usually the phase where supply chain risks hit the most. As presented in Table 4.3 and Figure 4.3, the top three critical risks available in the downstream are *limited refrigerated vehicles; stock out and incorrect forecasting*. In the reverse, *stock oversupply, poor storage and handling and stock expiration* were given as the most unlikely to happen risk factors.

Stock out, also caused by incorrect demand forecasting is a common cry by most supply managers. Thus, correct forecasting coupled with effective inventory management systems help to reduce stock out. Refrigerated vehicles are in limited supply due to the heavy investment needed to procure and maintain them. This is a true reflection in most programs in the case study location, hence the recent introduction of cold chain equipment optimisation platforms that supports health systems strengthening. The ever-high demand for health products would mean low probability rate of occurrence for stock expiration as confirmed by the findings.

Collectively across the supply chain, the top 10 risk factors with likelihood of affecting the supply chain as recorded in Figures 4.4 are (in order of occurrence rate):

- *Permits to import are taking long (too many bodies, documentation and registration)*
- *Limited cold chain trucks/refrigerated vehicles*
- *Stock out*
- *Port congestion leading to shipment delays (lack of capacity)*
- *Incorrect forecasting*
- *Unexpected demand fluctuations*
- *Port charges/cost are too high on humanitarian shipments (handling and storage)*
- *Communication problems between supply team and last mile recipient*
- *Transporter's failure to meet agreed delivery time*
- *Manual order processing at port of entry leading to clearing delays*

Permits application process (score of 7.89), limited refrigerated vehicles (score of 7.75) and stock outs (score of 7.56) leads the pack of risk factors in terms of their probability of

occurrence. The findings are true for pharmaceutical supply chains with products like vaccines whose potency depends heavily on effective cold chain equipment during transit and storage. Lack of local production of quality health products in most countries in the region of study means that operations survive on imported products, the main reason why permits application leads the pack as one with the highest chance of occurring. Stock availability also remains the most risk factor and is due to limited supplier capacity or transit delays at port of entry as already identified above.

The study also gathered data through semi-structured interviews (15 participants) to determine the risk factors with high probability of occurrence. The top 10 risk factors as analysed by NVivo are (Figure 4.5):

- *Government Regulations*
- *Product Expiration*
- *Lack of Technical Capacity*
- *Staff/Personnel*
- *Government Policies*
- *Transportation system*
- *Customs Procedures*
- *Product Quality*
- *Security*
- *Communication Problems*

The mixed methods employed in this research also enabled a close comparison between risk occurrence rate as gathered quantitatively through questionnaires and qualitatively through

interviews. Generally, the two methods concur that risk factors related to **government regulations and policies** are a great concern for the occurrence of risk in the pharmaceutical supply chain in region of study. Government related risks may include permits processing, port congestion and manual customs process as provided into the questionnaire survey. Summing up on government related risks is a quote from one of the interviewees who lamented that:

“There is need to change the mind-set of people that believes supply chain management is difficult, and those used to bureaucratic systems in supply chain management. Only then will we see efficiency in supply chain system with reduced risk occurrences”. [Interview Candidate 13]

Inadequate supply chain infrastructure and systems in areas such as ports, transportation and communication were also identified as critical for the case study. This was identified as one area where risk occurrence is high leading to delivery delays, mishandling of supplies, poor storage and transportation standards which affects product quality and delivery cost. These effects can be mitigated by reducing or eliminating the rate of occurrence through increasing advance detection capability.

It is also paramount to note that *staff technical capacity* is flagged as a critical factor from interviews. Limited staff capacity has a multiplier effect, thus can result in incorrect forecasting and communication problems which resonate with questionnaire findings.

Transportation risks across the entire supply chain were highlighted by both methods and is truly a major concern for pharmaceutical supply chain that sometimes require specialised trucks or vehicles with cold chain facilities. Thus, the findings from both questionnaire

survey and interviews complimented each other by using interviews to not only confirm the findings, but to also add new risk dimensions such as the capacity of supply chain personnel.

5.1.2. Risk Detection (Upstream, Midstream and Downstream)

The ability to detect risk factors in advance of their occurrence is a key element in risk prioritisation. Advance detection works as an amber signal of a traffic robot to warn risk managers about the expected occurrence of a risk. According to Lee (2014), there are four key dimensions of supply chain risk, which are; elements of loss, significance of loss, uncertainty associated with the loss and probability of loss. In support of this conceptual view, Manuj & Mentzer (2008a) found probability (likelihood) of the occurrence; criticality of risk and significance of impact/severity as the three components in risk conceptualisation. Thus, the detection element in risk management help supply managers to foresee potential risks and as much as possible mitigate to minimise or eliminate their occurrence and or reduce impact on supply chain performance.

This study looked at risks factors where organisations claim to have weak detection capability so that they can prioritise on investing in risk detection tools. The lower the risk detection capability, the higher the probability of occurrence and impact of a risk factor. The 10 risk factors with weak detection capability tools across the supply chain in order of priority as shown in Figure 4.11 are;

- *Trans-shipment delays at transit hubs*
- *Pipeline visibility and tracking problems*
- *Clearing agent's delivery problems*

- *Exposure to natural disasters and accidents during transit*
- *Incorrect forecasting*
- *Security problems during transit transportation*
- *Security problems at port storage leading to theft*
- *Permits to import*
- *Transporter's failure to deliver on agreed time*
- *Manual order processing at port of entry leading to clearing delays*

Trans-shipment delay is recorded as one risk area with weak advance detection capability. This is so because the onward shipment of consignments depends heavily on availability of connecting vessels and flights. The best-case scenario assumes that all arriving and connecting means are on time and that trans-shipment process happens smoothly. This is not usually the case and this is worsened by the fact that supply chain may not be aware of the shipment status even with the electronic tagging system.

The findings also point to pipeline visibility and tracking and clearing agent capacity as risks where detection is weak. While this may be true for other humanitarian organisation, this is unlikely to be true for UNICEF and other United Nations organisations where advance SAP pipeline tools such as Atlas and VISION are used. To support this argument, interview participants identified several risk detection tools (Table 4.8 and Figure 4.12) that organisations are currently using to monitor and detect the occurrence of potential risks. Notably, SAP management systems, Microsoft excel spreadsheet tracking tools and context analysis tools are mostly used to detect potential risks.

Clearing agents' ability to deliver on time has weak detection rate. Detection for this risk could be difficult since a lot of their performance depends on port efficiencies and government regulations. The study shows that permits processing is the risk factor with highest probability of occurrence and yet there is high level of detection on this risk. This tells us that supply chain managers can detect the potential delays caused by permit processing yet they still fail to reduce or eliminate its occurrence. This could be because of the many regulatory bodies involved which makes the timing very unpredictable.

5.1.3. Risk Impact/Severity on supply chain performance

According to Lavastre et al (2012), risks influence negatively the achievement of organizations' goals. Understanding risk goes beyond knowing about its likelihood and detection. It is also about the level of damage or loss caused by the risk in the event of its occurrence. Risk is about the uncertainty concerning the chance of injury, damage or loss (Vatsa, 2004). Thus, damage or loss happens to the key performance indicators of supply chain such as delivery time, cost, material quality and availability, organisational reputation and even the environmental impact. Supply chain risk adversely affects the desired performance measures such as cost, responsiveness and service levels (Tummala and Schoenherr, 2011 cited in Sofyalioglu C et al 2012). In support of the adverse effects of supply chain disruptions, Ponomarov and Holcomb (2009), argued that disruptions of any form, be it loss of a critical supplier, fire at a plant or act of terrorism does leads to loss of revenue and comes at a cost.

This study used the FMEA methodology to identify the impact of supply chain risk factors on delivery time, cost and material quality. The enquiry was carried out through both

questionnaire survey and interviews. Risk severity or impact is the major element of the FMEA technique. With FMEA, it all starts with the impact/severity of the risk factors. The level of severity is determined by the RPN value. The RPN was calculated for the entire supply chain with focus on delivery time, cost and quality indicators. Results reveal the most problematic areas, and the highest RPNs should get highest priority for corrective measures.

Goals of corrective measures include, in order of desirability:

- *Eliminate failure modes (some are more preventable than others)*
- *Minimize the severity of failure modes*
- *Reduce the occurrence of failure modes*
- *Improve detection of failure modes*

When corrective measures are implemented, RPN is calculated again and the results documented in the FMEA. Any possible limitation of FMEA can be addressed by using various methods such as fuzzy logic, cost basis and grey theory (Liu et al. 2012).

This study identified the priority risk factors that impact on the supply chain performance indicators of delivery time, cost and material quality. Table 4.12 and Figure 4.16 shows the risks plotted on Pareto distribution according to their RPN. Pareto distribution help to statistically calculate the list of risk factors with 80% of the impact on supply chain led-time, cost and quality. Delivery time and cost related risks have the highest RPN average of 367 each and material quality at 361. The overall findings are true in the case of Tanzania. The quality of the product is not a major concern because most humanitarian operations imports high quality health supplies from manufacturers who complies with World Health Organisation (WHO) quality assurance guidelines. The WHO prequalification process and registration is mandatory for suppliers of the United Nations.

The identified critical risk factors were classified by the performance indicators that they affect. Results from this study the following as the most critical risks that constitute 80% of the impact as per Pareto rule. ***The strategic performance objective approach is used to define and prioritise risks, which is delivery time risks, cost risks and quality risks. This is approach is the most appropriate as it allows organisations or supply operations to select the relevant risk factors based on its supply chain strategic objective(s).***

- ***Delivery time risks***

- ✓ Permits to import are taking long (too many bodies, documentation and registration) - *Midstream*
- ✓ Communication problems between freight forwarders and supply team in receiving country - *Upstream*
- ✓ Supplier's failure to meet agreed delivery time - *Upstream*
- ✓ Freight forwarder's failure to collect and ship consignment at agreed time - *Upstream*
- ✓ Transporter's failure to deliver on agreed time - *Downstream*
- ✓ Port congestion leading to shipment delays (lack of capacity) -*Downstream*

In humanitarian operations, profit is replaced by the objective of timely and appropriate provision of aid to beneficiaries (Tomasini & Van Wassenhove, 2009). Thus, delivery delays can cost lives. Delivery delays as a result of delays in the permits issuance remain the top issue in the pharmaceutical supply chain in Tanzania. Most operations in Sub-Saharan Africa trade-off delivery time with quality. They chose to maintain high quality standards by

importing products from reputable suppliers overseas. This results in lengthy delivery timescales.

Communication problems between freight forwarders also happens because there is usually an indirect line between forwarders and receiving office. The procurement unit at headquarters contracts these forwarders and keeps a direct communication link with them. Possibly the reason for this high impact of communication problems with forwarders on delivery time.

The results also revealed that clearing agent's failure to perform customs clearance processes on time, exposure to natural disasters and accidents during transit and pipeline visibility and tracking problems from port of origin to port of entry are the least risk factors to impact on supply chain delivery time. One possible reason for this outcome is that unlike sea transportation, air transportation used by most health products like vaccines is less likely to be affected by natural disasters and accidents. Vaccines use a special express route at the port of entry to ensure potency is maintained. This explains why delays in customs clearance by clearing agent is one of the risk factors that least impact on supply delivery time.

- ***Cost risks***

- ✓ Port charges/cost are too high on humanitarian shipments (handling and storage) -

Midstream

- ✓ Storage spaces at national hubs is inadequate - *Midstream*

- ✓ Permits to import are taking long (too many bodies, documentation and registration)

- *Midstream*

- ✓ Communication problems between supply team and last mile recipient -

Downstream

According to Yang and Geunes (2007), certain customers place a high premium on shorter order lead times, while others may be willing to trade a longer lead time for a lower price.

While delivery time is important for humanitarian operations, cost element is equally important particularly of late when donor funding is on the decline. Midstream risk factors dominate the impact on cost. This is no surprise because most countries in Sub Saharan Africa lacks modern infrastructure which helps reduce operational cost. Logistics costs are very high stemming from high taxation system and poor infrastructure.

The results also revealed that incorrect forecasting, security problems during transit transportation including piracy and terrorism and pipeline visibility and tracking problems from port of origin to port of entry are the least risk factors to impact on supply chain cost.

- ***Material quality risks***

- ✓ Stock expiration - *Downstream*
- ✓ Lack of temperature controlled storage facilities at port/national hubs - *Midstream*
- ✓ Incorrect forecasting - *Downstream*
- ✓ Quality problems due to poor handling and storage of shipments - *Midstream*
- ✓ Limited cold chain trucks/refrigerated vehicles - *Downstream*
- ✓ Supplier's failure to meet agreed product quality standards – *Upstream*

Stock expiration leads the pack of quality risk factors. Incorrect forecasting may result in too much stock that exceeds demand and will lead to stock expiration. At times, poor storage conditions damage product quality and make it hazardous.

Results shows that quality standards by offshore suppliers is less of a worry than storage and handling once received in-country. There is need to invest in risk detection tools that can help reduce the occurrence of risks related to storage, handling and transportation.

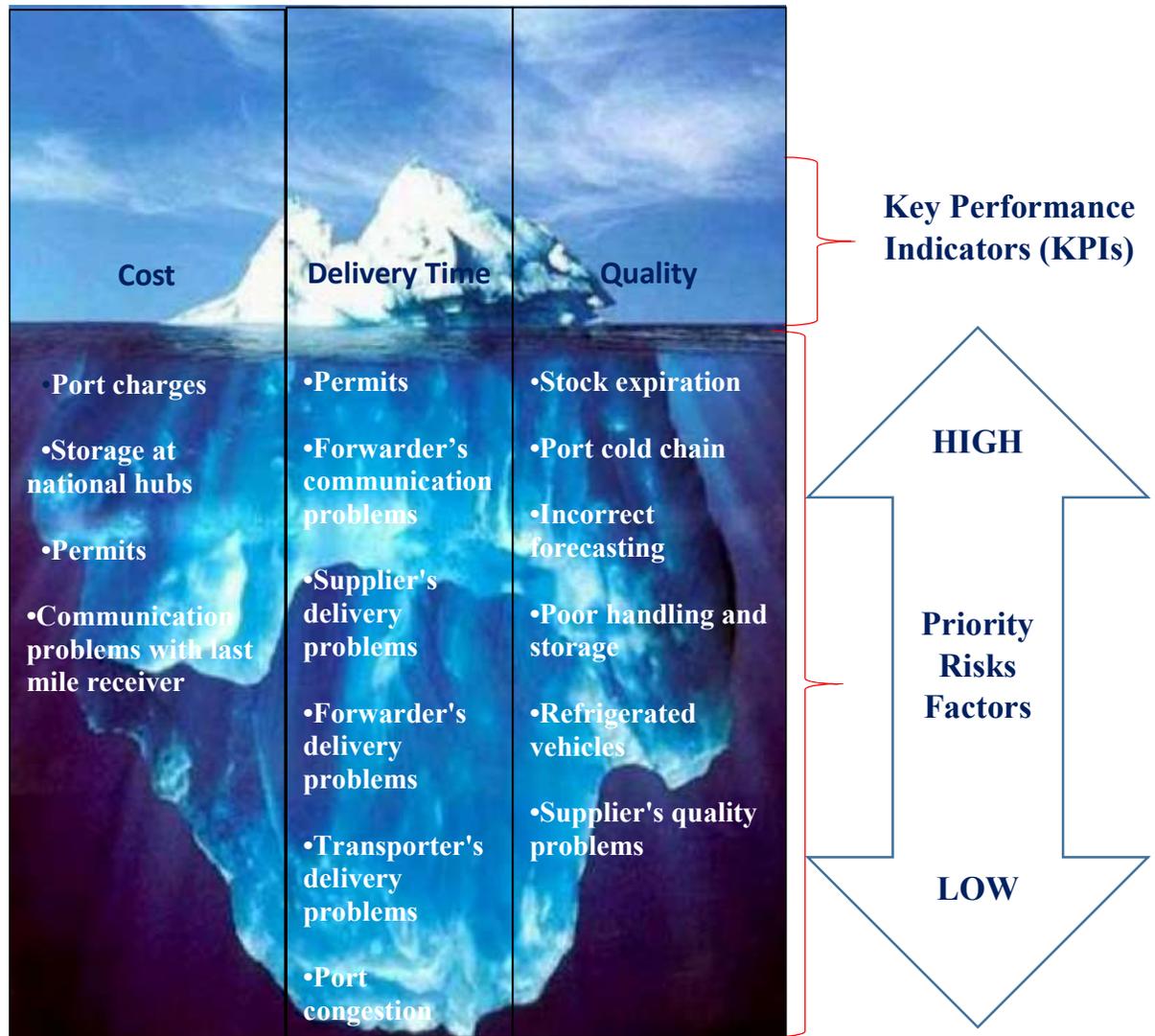
The results also show that freight forwarder's failure to keep consignment at agreed quality standards and stock oversupply are the risk factors that impact the least on material quality. All forwarders used have specialised transportation, storage and handling equipment. This helps to keep or maintain high quality standards. Cases of oversupply are also rare due to limited donor or government funding for health products.

The results from interviews help to summarise the critical factors impacting on supply delivery time, cost and quality. As presented in in Figures 4.17 and 4.18, the main issues emanate from unfavourable local government regulations and policies, inadequate infrastructure at entry ports, transportation systems and storage systems, and the lack of expert personnel in the area of pharmaceutical supply chain management.

The impact of supply chain risk factors on performance can be summarised in the form of a Supply Chain Risk Management Iceberg Model (SCRMIM). In its literal meaning, the tip of the iceberg is what can be seen as a representation of the large piece of ice underneath. The poorly performing indicators is the visible part of the iceberg and the supply chain risk factors

represents the invisible part of the iceberg. The researcher is using the iceberg metaphor to explain how the performance indicators (icebergs) are affected by the different risk factors (ice beneath). Using this model, supply managers are required to explore the root causes of poor performance which is usually found in the numerous supply chain risk factors. Figure 5.1 below provides a summary of risk factors that should be prioritised for supply chains in Sub Saharan Africa. Such prioritization helps an organisation to focus the decision making and risk management effort on the most important risks (Hallikas et al., 2002)

Figure 5. 1 SCRM Iceberg Model (Linking supply chain risks to its performance)



Source: Author

SCRM Iceberg Model illustrates how supply chain risk factors can be linked to supply chain performance metrics according to the research findings for UNICEF Tanzania case study. While some risk factors affect more than one performance metrics, this model has placed these risk factors into the metrics which they affect the most. The model identifies the risk factors in terms of their position in the hierarchy of prioritisation. That is, high priority in

treatment or mitigation of risks should be given to those risks closer to the top of the iceberg, while risks beneath the iceberg should be given low priority.

For example, high port charges for imported pharmaceuticals is the most critical risk factor affecting the performance metrics of cost, while communication problems at last mile is ranked the lowest for this metrics. The delivery time metrics is most affected by delays in the issuance of importation permits and freight forwarders' communication problems. Delays due to port congestion and due to last mile transporters are the least risks affecting on-time delivery. As for quality measures, stock expiration tops the list of critical risk factors while supplier's quality problem is the least risk factor. The study shows that on-time delivery and quality metrics constitute the most critical risk factors (each 6 out of 16) and quality metrics has the least number.

Regardless of the position of the risk factor along the iceberg, their impact on the performance of the supply chain still matters. Thus, supply chain managers should endeavour to mitigate each of the risks listed in the iceberg.

5.2. Managing critical pharmaceutical supply chain risk factors

5.2.1. Risk mitigation strategies

Prevention is better than cure, goes the old adage. This is true in the case of humanitarian pharmaceutical supply chain risk management the cost of poor risk management are huge. The impact of certain risks is fatal (for example, vaccines losing potency), thus, managers are

advised to focus more on preventive measures rather than treatment measures. The study on supply chain risks and mitigating strategies has increasingly become popular (Wei and Choi, 2010). The primary objective of any risk mitigation strategy is to improve customer satisfaction or service delivery by reducing the likelihood of occurrence and/or negative impact of risk disruption (Tang & Tomlin, 2008). The supply chain configuration and risks determines the appropriate mitigation strategy (Zsidisin et al., 2004; Christopher & Peck, 2004 & Christopher et al., 2011). This study will consider the performance objective approach in identifying the risk mitigation strategies; that is, delivery time strategies, quality strategies and cost strategies. The risk mitigation strategies for material availability, environmental impact and organisational reputation were also identified during the study.

Managing risks is about detecting or identifying potential pitfalls or hurdles and design ways to eliminate them or reduce their probability and or their impact these risks may cause to the business performance. Risk management strategy is about proactive prevention and risk mitigation. It involves plans or ways on how to deal with potential unexpected losses caused by an unexpected event (Manuj & Mentzer, 2008a). The classification of risk strategies by performance objectives will help organisations to prioritise risks for treatment objectively. It is also important to note that in spite of every mitigation effort an organisation takes, risk cannot be completely eliminated (Fisher, 1997 cited in Micheli, et al, 2008). Since the cost of risk severity is huge, humanitarian managers should effectively manage their supply chains for an uninterrupted flow of goods, services and information as a technique for preventing or mitigating on potential risks. This point was echoed by one interviewee who noted that:

“The flow of resources such as goods, services, funds, information at the right time is critical, and with better communication can help in risk mitigation” [Interview Candidate 10]

A lot of literature exists on risk mitigation strategies or approaches. Jüttner et al. (2003) proposes four risk mitigation strategies of avoidance, control, cooperation and flexibility. The Husdal.com (2009) suggested avoid, reduce, retain and transfer as the four popular mitigation strategies. Moreover, increasing some factors such as inventory level, capacity, responsiveness, number of suppliers and the number of customer accounts can be mitigation strategies to reduce the impact of supply chain risk (Chopra and Sodhi, 2004). Faisal *et al.* (2006) found that information sharing, agility in the supply chain, trust among supply chain counterparts, collaborative partnerships, risk sharing and transfer, increased knowledge of supply chain risk and continuous risk analysis and assessment are the enablers of risk mitigation in the supply chain. The basic strategies suitable to confront risk (Lavastre *et al.*, 2012) are elimination risk by internal actions; security; transferring risk to another partner ; sharing risk to another partner and ignoring the risk.

When asked on strategies they use to mitigate supply chain risks, managers identified elements such as ***planning, partnerships, government regulations, documentation, monitoring, systems, inspection, communication, training and insurance cover*** as the various practical steps / methods of mitigating risks. In line with the performance objective approach, the strategies were also analysed and grouped according to preventive measures against supply delivery time, supply cost and material quality as presented in Table 5.1.

Table 5. 1: Risk Preventive & Mitigation Strategies

Time strategies	Cost strategies	Quality strategies
<ul style="list-style-type: none"> • Supply Planning tool • Staff Capacity enhancement • Communication efficiency • Advance and Correct Documentation • Pipeline Monitoring tool • Customs Systems efficiency • Freight Forwarders efficiency • Private Sector partnerships • Prequalification of Suppliers • Tracking & Tracing tool 	<ul style="list-style-type: none"> • Direct delivery • Insurance cover • Supply planning • Advance Permits • Correct Customs Documentation • Private Sector Partnerships • Liquidated damages • Adequate funding • Staff knowledge • Pipeline monitoring 	<ul style="list-style-type: none"> • Pre-delivery inspection • Minimum quality standards • Temperature control equipment • Product Regulatory frameworks • Product selection and specification • Proper material handling systems • Market surveys & assessments • Adequate funding • Technical training • Correct transportation mode

The list of preventive and mitigation strategies or techniques in Table 5.1 is non-exhaustive of all the measures, techniques and tools that managers can use in managing humanitarian risks. This long list also support the idea that there is no one method fits all in humanitarian pharmaceutical supply chain management and that the supply chain system of this industry is still developing. In addition to use of the preventive tools, players in the pharmaceutical supply chain are expected to improve in collaboration, coordination and in the application of risk management tools among the partners, to ensure continuity coupled with long term profitability of the supply chain (Sofyalioglu and Kartal, 2012). The statement by interview candidate 8 below summed up a few of the key areas that if address well can enhance efforts in supply chain risk management.

“Invest more in technology and infrastructure, open borders within economic blocks and privatisation of government run logistics institutions. With these, supply chain risks can be better managed” [Interview Candidate 8]

5.2.2. Factors that impede implementation of risk mitigation strategies

The implementation of proposed risk mitigation does not usually happen without difficulties.

There are always factors that impedes the implementation of these strategies. One of the interview candidate summed up that on challenges faced with fragile states saying:

“Managing emerging risks and threats in modern supply chain such as security, terrorism and piracy will remain a major challenge for the Sub Saharan Region” [Interview Candidate 4]

Table 5.2 provides a summary list of some of the key challenges commonly faced by most organisations. It is not surprising that lack of strategic management approach to supply chain risk management and lack of coordination tops them all and cuts across all the three key performance indicators. This is a correct finding as most of the organisations interviewed did not have a well pre-defined risk supply chain strategy for their operations.

Capacity issues across organisations including in the logistics agents and forwarders was also flagged as another critical challenge in efforts to mitigate risks. Staff have inadequate technical skills and expertise in the management of pharmaceutical supply chains. It is the reality and organisations are working on designing training programs to support human capacity development.

Limited funding and low investment in both humanitarian programs and government projects is a key challenge in the implementation of risk mitigation strategies. Organisations lack funding to support logistics systems, equipment and infrastructure. The government also unable to improve infrastructure at ports, road networks and warehousing and storage due to limited investment.

Table 5. 2: Challenges in implementing Risk Mitigation Strategies			
Challenge Description	Key Performance Indicators		
	Delivery Time	Cost	Material Quality
• Lack of strategic management approach	✓	✓	✓
• Collaboration across supply chain partners is lacking	✓	✓	✓
• Long lead time on processing import permits	✓	✓	✓
• Staff skills and expertise in pharmaceutical logistics	✓	✓	✓
• Lack of competent third party inspection companies	✓	✓	✓
• Long shelf life for humanitarian goods which are consumed immediately	✓	✓	
• High workload for staff	✓	✓	
• Short term funding	✓	✓	
• Tax collection approach slow down processes	✓	✓	
• Timely and accurate documentation	✓	✓	✓
• Qualified technicians to assess storage equipment		✓	✓
• Temperature controlled trucks during movement		✓	✓
• Lack of funding for logistics systems		✓	✓
• Lack of infrastructure such as laboratories		✓	✓

5.2.3. Risk management opportunities in Sub-Saharan Africa

While the many challenges listed in Table 5.2 paint a gloomy picture on the future of the region in how they manage risks, there is also an almost equal number of opportunities that the region can exploit. These opportunities are listed in Table 5.3 with a recommendation for a common regional customs system (one stop shop) leading the pack. Regional collaboration, regional infrastructure development, introduction of modern tax system and set of pharmaceutical manufacturing companies within Sub-Saharan Africa are some of the opportunities available in the region.

Table 5. 3: Opportunities in managing SC Risks in Sub-Saharan Africa			
Opportunity Description	Key Performance Indicators		
	Delivery Time	Cost	Material Quality
• One / Common customs processing system in EAC countries	✓		
• Move from tax based custom clearance system to facilitation process	✓		
• Separation of humanitarian and commercial shipment	✓		
• One stop centre or single desk approach at customs documentation	✓		
• Procurement of commodities/pharmaceuticals with longest shelf life	✓		
• Introduction of regional rail system		✓	
• Introducing 24/7 operations at ports of entry		✓	
• Increase economic regional collaboration (EAC) – going beyond political boundaries		✓	
• Use of drones to reach difficult areas		✓	
• Industrialisation and investment in local or regional production of medical products and equipment			✓
• Establishment of laboratories in African countries			✓
• Local presence of global manufacturers			✓

5.3. Impact of Risk Detection on Risk Occurrence (Hypothesis Testing)

This enquiry also wanted to establish if there is any relationship between the level of risk detection and the rate of occurrence against the fourteen (14) risks factors found to be critical in the supply chain based on FMEA methodology and the 80-20 Pareto rule. This is important because it can inform organisations whether or not to invest in expensive risk detection tools knowing their level of contribution to risk occurrence and impact.

To address this, fourteen (14) hypothesis were derived from the prioritised risk factors with the highest impact (RPN) and those that contributed to 80% of occurrence and impact, and tested using SPSS's regression analysis. A positive correlation exists when the significance level of $p \leq 0.05$ is achieved. Any value of more than 0.05 (5%) informs there is no correlation between advance detection capability and likelihood of risk occurrence.

The overall results of the hypothesis testing through regression statistical analysis shows that only four (4) risk factors have a significant relationship between its detection capacity and its occurrence. A positive correlation was established and significance at the $p \leq 0.05$ level was achieved on below 4 risk factors. The results tell us that investment in building detection capability in the following four risk factors is likely to yield significant results in reducing the rate of occurrence of the same risks.

- *H3: Advance detection of causes of permits processing delays reduces rate of its occurrence (Sig = 0.015)*
- *H5: Advance detection of supplier delivery problems reduces its rate of occurrence (Sig =0.027)*

- *H11: The capability to detect potential shortage of refrigerated vehicles reduces the rate of its occurrence (Sig = 0.051)*
- *H12: The capability to detect causes of product quality failures by suppliers reduces the rate of its occurrence (Sig =0.012)*

The other 10 hypothesis shows no significant. That is to say, no relationship exists between detection and occurrence. Thus, any effort to build on or increase on the capacity to detect these risks has no significant will not result in a direct reduction in occurrence of similar risks. As such, organisations should not waste resources in investing in any of the following risk factors.

- *H1: The capability to detect unexpected port charges on humanitarian shipments reduces its rate of occurrence (Sig = 0.771)*
- *H2: Advance detection of stock expiration reduces the risk of actual stock expiry (Sig = 0.801)*
- *H4: The capability to detect communication problems with freight forwarders reduces the rate of its occurrence (Sig = 0.768)*
- *H6: The capability to detect delivery problems by freight forwarder reduces on the rate of its occurrence (Sig = 0.449)*
- *H7: Advance detection of last mile transporters' problems improves on the timely delivery of shipments (Sig = 0.196)*
- *H8: Advance detection of shortage of temperature controlled storage facilities at port reduces the rate of its occurrence (Sig = 0.992)*
- *H9: The capability to detect causes of incorrect product forecasting reduces the rate of its occurrence (Sig = 0.284)*

- *H10: The capability to detect causes of poor handling and storage reduces the rate of its occurrence (Sig = 0.131)*
- *H13: The capability to detect causes of communication problems with end user reduces the rate of its occurrence (Sig = 0.462)*
- *H14: The capability to detect quality failures by freight forwarders can reduces rate of its occurrence (Sig = 0.200)*

5.4. Research implications to theory

This study aims to contribute to professional practice; however, the results have implications to theory in SCRM in terms of risk profiling, prioritisation and mitigation and the impact it has on supply chain performance for a humanitarian pharmaceutical supply chain in Sub-Saharan Africa. Generally, few researchers agree that there is only limited work on the effect of SCRM on supply chain performance (Thun and Hoenig, 2011; Mishra et al., 2016) or risk performance (Kern et al., 2012; Hallikas and Lintukangas, 2016). The literature has shown studies have been undertaken about supply chain risk management in general, to understand the link between risk types and the corresponding management and mitigation strategies (Manuj & Mentzer, 2008) and also to understand the link between strategies and performance (Wieland & Wallenburg, 2012). However, the research by Wieland and Wallenburg, (2012) addressed this link using private sector manufacturing companies. Thus, the researcher cannot agree more with Nooraie and Parast, (2016) who suggested further research in investigating the link between SCRM strategies and supply chain performance capabilities.

Most researchers agree that the interest in studying SCRM is on the rise (Khan and Burnes, 2007; Sodhi et al., 2012; Colicchia & Strozzi, 2012) and that the field of SCRM is still

developing (Khan and Burnes, 2007; Ghadge et al., 2012; Sodhi et al., 2012). So far, most of these studies focused on setting out concepts and frameworks. While these frameworks and concept are very important in providing foundational base, their application to various industries and settings still remain untapped. While a few studies have been much on risk identification and treatment, very few has been able to link these risks to supply chain performance measures, especially for humanitarian pharmaceutical programs in general and Tanzania in particular. The implementation challenges that programs face has been largely attributed to poor performance of the supply chain system and understanding their impact is the starting point for excellence (Faizal & Palaniappan, 2014). Understanding of risk(s) in a particular environment helps to establish the level of vulnerability or exposure to such risks (Vatsa, 2004).

This study managed to contribute to theory by using FMEA methodology to carry out a case study through mixed methods. The outcome of this study provided a list of prioritised risks, the list of appropriate mitigation strategies and the strategic performance objective approach to risk management that can be applied to humanitarian pharmaceutical supply chains in Sub-Saharan Africa.

The study also gathered new knowledge on the following areas as found in humanitarian operations in Sub-Saharan Africa.

- Importance and impact of risks on supply chain performance
- Classification of supply chain risk factors by performance measures / indicators
- The relationship between risk detection capability and risk likelihood of occurrence
- Factors that impede the implementation of mitigation efforts

- Factors that enhance the implementation of SCRM (regional opportunities)

5.5. Chapter Summary

This chapter provides a critical review and analysis on the findings of this research. It explains on the answers to the research questions as derived from the research findings. The prioritised risks according to occurrence, detection and impact were discussed and presented. This chapter went on to determine the risk mitigation strategies applicable to the study, including the key challenges and opportunities. The research conclusions, including research contribution, limitation and future research are all covered in the coming chapter, chapter 6.

Chapter 6: Conclusion

6.0. Introduction

This chapter provides an overview of the study, highlighting the rationale of the study, its key findings and conclusions and its contribution to the body of knowledge. The research limitations, implications and recommendations are also discussed in this chapter. This research was born out of the quest to provide answers to the daily critical challenges organisations face implementing humanitarian health programs in Sub-Saharan Africa. Existing research believed that SCRM approach ensures profitability (Faisal et al., 2007), save costs (Manuj and Mentzer, 2008b) and potentially generate value (Trkman et al., 2016) for organisations. This research found the strategic performance objective approach to SCRM as most essential way to mitigate risks and improve on performance. This approach will ensure prioritisation in the implementation of mitigation strategies based on strategic performance objectives. Hallikas et al (2002) also argued that prioritization of risks helps a company to focus the decision making and risk management effort on the most important risks.

The aim of this research is to contribute to professional practice in effective management of humanitarian pharmaceutical supply chains, firstly by presenting a list of priority risks that impact on humanitarian pharmaceutical supply chain performance metrics of time, cost and quality. Secondly, to suggest risk mitigation measures or strategies that managers can use against the prioritized risks. Understanding of risk(s) in a particular environment helps to establish the level of vulnerability or exposure to such risks (Vatsa, 2004). The knowledge and understanding of risk factors that causes supply process failures, in a proactive way, can

help supply managers to use the limited resources efficiently through risk prioritization and treatment. Supply chain function is criticised for poor performance of humanitarian programs. Thus, the researcher suggests that the answer to this criticism lies in a systematic and strategic supply chain risk management through prioritisation, treatment and mitigation. And for Faizal & Palaniappan (2014), understanding the types of risks and their probability of occurrence as well as the associated impacts is a starting point for companies to develop effective risk management strategies.

6.1. Summary of Findings

The criticism “*Supply chain management is our Achilles heel; we receive the most criticism for this*”, triggered the researcher’s desire to dig deeper on why supply chain systems fail.

Humanitarian operations are susceptible to attacks from many risk factors. Hence, the possible reason behind the underperformance in this supply chain system may be the presence of many risk factors found along the supply process that the organisation has been unable to properly assess, prioritize and mitigate. The research findings has proven this assumption that poor risk management is the primary cause of poor supply chain performance. The research also found a causal relationship existing between detection capability and likelihood of occurrence on a few of the risks, and a zero relationship on most risks tested. Overall, the research confirmed the proposition that effective supply chain risk management approach (prioritisation and mitigation/treatment) contributes to an improvement in supply chain performance of health projects in Sub Saharan Africa and developing nations the world over.

An understanding of critical risks at each phase is critical for prioritization and designing the right mitigation strategies and for resource allocation. Recent and relevant literature is used to predetermine potential risk factors that can be found in a typical pharmaceutical supply chain in developing world. A number of SCRM studies mainly identified risks factors without much focus on prioritisation using FMEA methodology, particularly for humanitarian pharmaceutical supply chains in Sub-Saharan Africa.

The two main objectives of the research were:

- 3) *To investigate the impact of risk factors on pharmaceutical supply chain performance, especially using FMEA as a tool for risk assessment and prioritization*
- 4) *To identify possible risk mitigation strategies that can be used to manage risks and improve on supply chain performance.*

Two broad questions and one leading hypothesis are used to address these two research objectives related risk prioritisation and risk treatment or mitigation for humanitarian pharmaceutical supply chain system.

RQ1: What are the critical risk factors to be prioritised and managed in pharmaceutical supply chain system in Sub-Saharan Africa?

RQ2: How can an organisation effectively manage risk factors for a pharmaceutical supply chain system in Sub-Saharan Africa?

H1: If risk detection capability is increased and applied through use of FMEA model, then the risk likelihood in pharmaceutical supply chain will be reduced

So, what has been the summary findings of this study and has the answers to the research questions been found and the hypothesis proven?

6.1.1. Research Objective 1 - Risk Prioritisation

The research used the combination of FMEA methodology and the 80-20 Pareto rule to identify the most critical risk factors to be prioritised for treatment. The identified critical risk factors were classified by the performance indicators that they affect. *The strategic performance objective approach was used to define and prioritise risks, which is delivery time risks, cost risks and quality risks. This is approach is the most appropriate as it allows organisations or supply operations to select the relevant risk factors based on its supply chain strategic objective(s).*

- ***Delivery time risks***

- ✓ Permits to import are taking long (too many bodies, documentation and registration) - *Midstream*
- ✓ Communication problems between freight forwarders and supply team in receiving country - *Upstream*
- ✓ Supplier's failure to meet agreed delivery time - *Upstream*
- ✓ Freight forwarder's failure to collect and ship consignment at agreed time - *Upstream*
- ✓ Transporter's failure to deliver on agreed time - *Downstream*
- ✓ Port congestion leading to shipment delays (lack of capacity) - *Downstream*

- **Cost risks**
 - ✓ Port charges/cost are too high on humanitarian shipments (handling and storage) - *Midstream*
 - ✓ Storage spaces at national hubs is inadequate - *Midstream*
 - ✓ Permits to import are taking long (too many bodies, documentation and registration) - *Midstream*
 - ✓ Communication problems between supply team and last mile recipient - *Downstream*

- **Material quality risks**
 - ✓ Stock expiration - *Downstream*
 - ✓ Lack of temperature controlled storage facilities at port/national hubs - *Midstream*
 - ✓ Incorrect forecasting - *Downstream*
 - ✓ Quality problems due to poor handling and storage of shipments - *Midstream*
 - ✓ Limited cold chain trucks/refrigerated vehicles - *Downstream*
 - ✓ Supplier's failure to meet agreed product quality standards – *Upstream*

The poorly performing indicators is the visible part of the iceberg and the supply chain risk factors represents the invisible part of the iceberg. The researcher used the iceberg metaphor to explain how the performance indicators (icebergs) are affected by the different risk factors (ice beneath). Using this model (Figure 5.2), supply managers are required to explore the root causes of poor performance which is usually found in the numerous supply chain risk factors.

The 14 hypotheses tested resulted in 4 hypotheses being retained and 9 of them were nullified as per Table 6.1

Table 6. 1: Summary of Hypotheses Testing		
Hypotheses	Finding	Conclusion
<i>H1</i> : The capability to detect unexpected port charges on humanitarian shipments reduces its rate of occurrence	Rejected Null hypothesis	Entry ports system still levy high charges on humanitarian shipments
<i>H2</i> : Advance detection of stock expiration reduces the risk of actual stock expiry	Rejected Null hypothesis	Stock is still expiring even in situations where managers receive advance notification about their expiry
<i>H3</i> : Advance detection of causes of permits processing delays reduces rate of its occurrence	Null hypothesis retained	Managers should obtain import permits prior to dispatch of shipments from origin.
<i>H4</i> : The capability to detect communication problems with freight forwarders reduces the rate of its occurrence	Rejected Null hypothesis	It is difficult to foresee communication problems and prevent it
<i>H5</i> : Advance detection of supplier delivery problems reduces its rate of occurrence	Null hypothesis retained	Managers can reduce or eliminate late deliveries by continuous follow up and expediting deliveries with suppliers
<i>H6</i> : The capability to detect delivery problems by freight forwarder reduces on the rate of its occurrence	Rejected Null hypothesis	There is no relationship in this hypothesis since most shipments are loaded in direct vessels (not passing through transit hubs)
<i>H7</i> : Advance detection of last mile transporters' problems improves on the timely delivery of shipments	Rejected Null hypothesis	There is no relationship

Table 6.1. (continued)		
<i>H8</i> : Advance detection of shortage of temperature controlled storage facilities at port reduces the rate of its occurrence	Rejected Null hypothesis	There is no relationship
<i>H9</i> : The capability to detect causes of incorrect product forecasting reduces the rate of its occurrence	Rejected Null hypothesis	There is no relationship
<i>H10</i> : The capability to detect causes of poor handling and storage reduces the rate of its occurrence	Rejected Null hypothesis	There is no relationship
<i>H11</i> : The capability to detect potential shortage of refrigerated vehicles reduces the rate of its occurrence	Null hypothesis retained	Advance knowledge of the required refrigerated vehicles help to reduce loss of vaccines to poor cold chain capability
<i>H12</i> : The capability to detect causes of product quality failures by suppliers reduces the rate of its occurrence	Null hypothesis retained	Prequalification of suppliers for medical products can help reduce likelihood of receiving sub-standard products
<i>H13</i> : The capability to detect causes of communication problems with end user reduces the rate of its occurrence	Rejected Null hypothesis	No relationship exists
<i>H14</i> : The capability to detect quality failures by freight forwarders can reduces rate of its occurrence	Rejected Null hypothesis	No relationship exists

6.1.2. Research Objective 2 – Risk Treatment

Effective risk management includes prevention from occurrence, mitigation of impact and treatment. This study has identified strategies that can be used to address delivery time risks, cost risks and quality risks (Table 6.2). The factors that impedes and promotes implementation of mitigation strategies are presented in Table 6.3 and Table 6.4 respectively.

Table 6. 2 Risk Preventive & Mitigation Strategies

Time strategies	Cost strategies	Quality strategies
<ul style="list-style-type: none"> • Supply Planning tool • Staff Capacity enhancement • Communication efficiency • Advance and Correct Documentation • Pipeline Monitoring tool • Customs Systems efficiency • Freight Forwarders efficiency • Private Sector partnerships • Prequalification of Suppliers • Tracking & Tracing tool 	<ul style="list-style-type: none"> • Direct delivery • Insurance cover • Supply planning • Advance Permits • Correct Customs Documentation • Private Sector Partnerships • Liquidated damages • Adequate funding • Staff knowledge • Pipeline monitoring 	<ul style="list-style-type: none"> • Pre-delivery inspection • Minimum quality standards • Temperature control equipment • Product Regulatory frameworks • Product selection and specification • Proper material handling systems • Market surveys & assessments • Adequate funding • Technical training • Correct transportation mode

Table 6.3 Challenges in implementing Risk Mitigation Strategies			
Challenge Description	Key Performance Indicators		
	Delivery Time	Cost	Material Quality
• Lack of strategic management approach	✓	✓	✓
• Collaboration across supply chain partners is lacking	✓	✓	✓
• Long lead time on processing import permits	✓	✓	✓
• Staff skills and expertise in pharmaceutical logistics	✓	✓	✓
• Lack of competent third party inspection companies	✓	✓	✓
• Long shelf life for humanitarian goods which are consumed immediately	✓	✓	
• High workload for staff	✓	✓	
• Short term funding	✓	✓	
• Tax collection approach slow down processes	✓	✓	
• Timely and accurate documentation	✓	✓	✓
• Qualified technicians to asses storage equipment		✓	✓
• Temperature controlled trucks during movement		✓	✓
• Lack of funding for logistics systems		✓	✓
• Lack of infrastructure such as laboratories		✓	✓

Table 6. 4 Opportunities in managing SC Risks in Sub-Saharan Africa			
Opportunity Description	Key Performance Indicators		
	Delivery Time	Cost	Material Quality
• One / Common customs processing system in EAC countries	✓		
• Move from tax based custom clearance system to facilitation process	✓		
• Separation of humanitarian and commercial shipment	✓		
• One stop centre or single desk approach at customs documentation	✓		
• Procurement of commodities/pharmaceuticals with longest shelf life	✓		
• Introduction of regional rail system		✓	
• Introducing 24/7 operations at ports of entry		✓	
• Increase economic regional collaboration (EAC) – going beyond political boundaries,		✓	
• Use of drones to reach difficult areas		✓	
• Industrialisation and investment in local or regional production of medical products and equipment			✓
• Establishment of laboratories in African countries			✓
• Local presence of global manufacturers			✓

6.2. Research Contribution to professional practice

The purpose of this study would not have been realised if no contribution to professional practice was established. Within the context under study, the contribution of this thesis is manifold. Firstly, it provided the general overview and assessment of humanitarian pharmaceutical supply chain in the context of risk management. This highlights the uniqueness of humanitarian supply chains by comparing and contrasting with commercial/private sector supply chains. The performance objective of humanitarian supply chains is to save lives and help beneficiaries, yet commercial supply chains target profit maximisation. Thus, the two systems should be structured differently and rates the performance metrics differently. While humanitarian supply chains will prioritise on-time delivery in order to save lives, commercial chains are likely to prioritise the right cost.

Secondly and more specifically, the research analysed the risk factors that are found in the humanitarian pharmaceutical supply chains, with the ultimate goal of providing a catalogue of prioritised critical risks according to the respective strategic performance metrics of time, cost and quality. This is an important finding of this research and has contributed to professional practice by confirming that supply chain risks are better managed if they are prioritised according to organisational strategic performance objectives of delivery time, cost and quality. Establishing this linkage between risk factors and key performance indicators is a major contribution to practice and supply chain managers for humanitarian health programs in Sub-Saharan Africa can use these linkages in their decision-making process. In addition, the research provided a catalogue of risks in their order of priority/criticality and can help managers to have easy access to some of the critical factors as they make day to day managerial decisions for humanitarian pharmaceutical supply chain operations.

Thirdly, the visual presentation of supply chain risks through the SCRM iceberg model is another contribution to professional practice as this help supply managers to deal with causes of poor performance (risk factors) than effects (performance metrics). The application of the SCRM iceberg model is expected to make supply chain managers aware that the solutions to supply chain performance lies in the ability to address root causes by building detection and mitigation capabilities for each and every critical risk factor. The iceberg model provides a summary of the risk factors to be prioritised as per the respective performance metrics. **Cost risk factors** are high port charges, high storage charges at national hubs, high import permits charges and high cost of communication at last mile. **On time delivery risk factors** to be prioritised are delays in issuance of import permits, forwarders' communication delays, suppliers' delivery delays, forwarders' delivery delays, last mile transporters' delivery delays and delays due to port congestion. Quality risk factors to be prioritised for mitigation includes stock expiration, inadequate cold chain equipment, incorrect forecasting, poor handling and storage and supplier's quality problems.

The fourth contribution of this research is the identification of risk mitigation strategies that provide ways to improve on supply chain performance in Sub Saharan Africa. The strategies were also grouped according to the performance metrics/objectives that they improve. The top most strategies suggested for **on-time delivery metrics** are supply planning, pipeline monitoring, communication efficiency, staff capacity enhancement, advance and correct documentation, prequalification of suppliers and supply chain partnerships. **Cost strategies** that are being suggested includes direct delivery, insurance cover, liquidated damages in

supply contracts and advance processing of importation documents to avoid cost of port storages. Quality strategies identified includes predelivery inspections, use of temperature control equipment, use of prequalified and approved suppliers, importation by permit approach and proper material handling systems.

This is a critical contextual contribution within Tanzania and Sub-Saharan Africa and can be considered as new knowledge that supply chain managers can use to manage their supply chains. As already mentioned in literature chapter, humanitarian pharmaceutical supply chains are loaded with risks, most of them are unavoidable, and hence the portfolio of mitigation strategies and opportunities will come handy for effective and efficient decision making.

The fifth contribution of this research to professional practice is by elaborating and revealing the relationship between risk detection capability and the likelihood of occurrence, which has not been addressed extensively and contextually in literature. The results showed (through hypotheses testing) that few risk factors (only 4 out of 14) can have their likelihood of occurrence reduced by higher level of detection capability. The four risks are delays in issuance of import permits, supplier's delivery problems, supplier's quality problems and shortage of refrigerated vehicles. Supply managers should build risk detection capability for these four risks which can have a direct effect on reduction of risk occurrence. This is important new knowledge for humanitarian supply chain managers which can be used to effectively allocate resources towards risk detection tools and software.

The sixth contribution of this study is the identification of current opportunities that supply chain managers should explore in managing supply chain risks in Sub Saharan Africa. The opportunities available to improve on-time delivery includes use of one/common customs processing systems within regional economic blocks, moving from tax based customs system to facilitation process and setting up of one stop centre or single window approach. These opportunities will help reduce delays in importation of pharmaceuticals. Cost reduction opportunities identified are introduction of regional rail system, introduction of 24/7 port operations to eliminate cost of prolonged port storage and removal of government taxes on humanitarian goods/donations. Managing material quality is still very critical but few opportunities are seen in setting up local production factories and laboratories and in the increase in local presence of global manufacturers.

Overall, based on the in-depth case study of UNICEF Tanzania and with reference to Sub-Saharan Africa, this research revealed that humanitarian organisations design their supply chain configurations differently based on their strategic performance objectives. Such has an effect on how they manage supply chain risk factors. Purely emergency supply chains tend to focus on delivery time metrics while development supply chains are cost and quality focused. Regardless of the nature of supply chain, the researcher sees the use of strategic performance objective approach in managing risks as the key contribution to professional practice for supply chain managers working for humanitarian health programs in Sub-Saharan Africa.

6.3. Research Implications to practice

This research was born from a real-life supply chain challenges that a humanitarian project faced. The findings of this study were also shared with supply chain experts to provide what they also see as managerial implications. Thus, the findings and outcome of this study has the following managerial implications:

- The established risk profiles by performance metrics of delivery time, cost and quality will enable managers to anticipate and proactively manage the potential risks found in their operations. While the listed risks are not exhaustive, it is adequate to provide a starting point and guidance to managers of humanitarian pharmaceutical operations, and even to other non-health operations which are usually less complicated.
- The case study organisation and other humanitarian players to implement the recommendations of this study in order to provide practical advancement to practice. SCRM is a continuous pro-active process and thus, managers are reminded to manage their supply chains proactively and continuously
- This study also identified risks by phases in the supply chain pipeline, that is upstream, midstream and downstream. This is important to provide managers with easy identification of the sources where risks with most impact are found.
- The outcome of the hypotheses testing revealed that not all investment on detection capability result in reduction in risk occurrence. With this new knowledge, managers can now re-assessment the potential benefit of every investment on risk detection
- The suggested SCRM iceberg model should help managers to know that the poor performance seen in metrics/indicators is an effect (visible iceberg) of the poor management of supply chain risks (invisible iceberg). This help manager to focus

their limited resources (financial and human) on addressing the root causes in a prioritised manner

- The study also identified the risk mitigation strategies applicable to cost, time, and quality related risks. These are ready to use tools that managers can apply rationally based on the nature of their supply chains and performance objectives.
- The study identified a list of challenges managers needs to be aware of and take care of if they are to succeed in managing risks for humanitarian operations in Sub-Saharan Africa and similar context globally.
- The study identified a list of opportunities that supply managers and other key players can tap into in their effort to effectively manage supply chain risks for humanitarian operations in Sub-Saharan Africa and similar context globally.

6.4. Limitations of the Research

The limitations of this research are few and are highlighted below:

- This research only focused on humanitarian pharmaceutical supply chain risks in Sub-Saharan Africa while the methodological approach used can also apply to commercial pharmaceutical supply chains globally. This will provide a different angle and depth in risk prioritisation and mitigation strategies.
- The study also selected a limited number of pre-defined risks (10 for upstream, 10 for midstream and 10 for downstream). The interview too has limited questions as a way for keeping the interview session short and interesting. The use of limited pre-defined risks and interview questions may have closed the door for other risks that maybe important and yet not yet in literature

- The sample size of N= 202 for questionnaire survey was drawn largely from one association of professional pharmaceutical logisticians. This may have limited the scope to health sector, yet the participation of other non-health experts could have added more knowledge to this unique subject. There may be an element of biasedness by the researcher in the selection of sources of respondents, which is a limitation although this was seen as the best option for this study.
- The use of snowballing and self-selecting approach for the N=15 sample for interviews can be one of the limitations to this study, given the complexity and variability of humanitarian operations across Sub-Saharan Africa. While the sample size was cautiously selected, there is a possibility that not all types or contexts of humanitarian operations were represented in this sample.
- This study used interviews only for identifying mitigation strategies. The use of two or more techniques such as focus groups and system observations would have brought up a rich discussion and more knowledge contribution.
- Lastly, there is also bias in what managers perceived as critical risks and mitigation strategies, challenges and opportunities. This can also be considered a limitation to this study.

6.5. Recommendations for future Research

Supply chain management is considered a profession in transition and one that is still developing (Khan and Burnes, 2007; Ghadge et al., 2012; Sodhi et al., 2012). There are research opportunities that can build on the findings of this study and the following are recommended.

- The empirical in SCRM that involves firstly, the implementation of the recommendations risks mitigation strategies and secondly, the re-assessment of the outcome. This will be important to provide the level of impact of these prioritised risks and their corresponding mitigation strategies
- A comparative study of two or three economic regional blocks in terms of risk prioritisation and mitigation strategies for humanitarian operations. For example, Middle East versus Asia region versus Africa versus Europe.
- The findings of this study can also be verified in other case study organisation and country or regional block.
- The hypothetical testing of the relationship between risk occurrence and their impact on supply chain performance indicators. This will build on this study that looked at detection versus occurrence of prioritised risks
- The empirical study in risk treatment and mitigation strategies for humanitarian supply chains using multiple qualitative techniques such as focus group discussions and observations. This will provide a deep insight and prevent potential bias
- Role mapping of all humanitarian supply chain actors and their role in managing risks. This will make actors aware of their critical responsibilities and also to identify gaps therein

- An in-depth study on risk factors that affect other supply chain performance indicators other than economic factors (delivery time, cost and quality). Such studies can focus on social and environmental factors of sustainable supply chain.

6.6. Chapter Summary

The effective management of supply chain risks in a humanitarian context is very challenging. This chapter concluded this study by providing a summary of research findings and detailed review of the contribution made by the researcher to the body of knowledge. This specifically looked at the research findings against the research objectives and questions and how each of these contributed to professional practice and to the body of knowledge. The theoretical and managerial implications of this study were also identified and discussed. Further, the researcher discussed the potential limitations and the recommended future research that can build on the finding of this study. In spite of the stated study limitations, the research strategy used can still be seen as the best option currently to carry out this study. If carefully and rationally applied, the findings and recommendations in this study can help risk managers to proactively use the strategic performance objective approach to prioritise and mitigation humanitarian pharmaceutical supply chain risks, particularly in Sub-Saharan Africa.

List of References

1. Adhitya, A., Srinivasan, R., Karimi, I.A. (2008), Supply Chain Risk Management through HAZOP and Dynamic Simulation, in Braunschweig, B. and Joulia, X. (Ed.), *18th European Symposium on Computer Aided Process Engineering - ESCAPE 18*, pp. 37-42.
2. Alizadeh S.S. and Moshashaei. P. (2015) The Bowtie method in safety management system: A literature review. *Scientific Journal of Review* 4(9) 133-138
3. Anleitner M. (2010), “The Power of Deduction. Failure Mode and Effects Analysis for Designs”. *American Society for Quality*. Milwaukee vol.53, p.203.
4. Aqlan, F. and Lam, S.S. (2015), “Supply chain risk modelling and mitigation”, *International Journal of Production Research*, Vol. 53 No. 18, pp. 5640-5656.
5. Blackhurst, J.V., Scheibe, K.P. and Johnson, D.J. (2008), “Supplier Aronsson. H, Abrahamsson, M and Spens K (2011), Developing lean and agile health care supply chains, *Supply Chain Management: An International Journal*, no. 16/3, pp. 176- 183.
6. Bak, O. (2018). Supply chain risk management research agenda—from a literature review to a call for future research directions. *Business Process Management Journal*, <https://doi.org/10.1108/BPMJ-02-2017-0021>
7. Bandaly, D., Satir, A., Kahyaoglu, Y., Shanker, L. (2012), Supply chain risk management - I: Conceptualization, framework and planning process, *Risk Management*, Vol. 14, No. 4, pp. 249-271.
8. Beamon, B.M. and Balcik, B. (2008). Performance measurement in humanitarian relief chains, *International Journal of Public Sector Management*, 21(1), pp. 4-25
9. Blaikie, N. (2007) *Approaches to Social Inquiry*, 2nd edition, Cambridge: Polity.
10. Blome, C., Schoenherr, T. (2011) Supply chain risk management in financial crises: A multiple case-study approach, *International Journal of Production Economics*, 134, pp. 43–57
11. Bluvband Z., Grabov P., Failure Analysis of FMEA. *IEEE* 09.2009.
12. Bogataj, D. & Bogataj, M. (2007). Measuring the supply chain risk and vulnerability in frequency space. *International Journal of Production Economics*, 108 (1), 291 {301.
13. Bryman, A. and Bell, E. (2011). *Business research methods*. Cambridge: Oxford University Press.
14. Burt, T. (2006), *Seeing the future: innovative supply chain management strategies*.

15. Carter, C.R., Rogers, D.S., 2008. A framework of sustainable supply chain management: moving toward new theory. *International Journal of Physical Distribution and Logistics Management* 38(5), 360-387.
16. Chaudhuri, A, Boer, H and Taran, Y, (2018) "Supply chain integration, risk management and manufacturing flexibility", *International Journal of Operations & Production Management*, Vol. 38, Issue: 3, pp.690-712.
17. Chen. D.Q, Preston. D.S and Xia W (2013) Enhancing hospital supply chain performance: A relational view and empirical test, *Journal of Operations Management* 31 (2013) 391–408
18. Chopra, S., Sodhi, M. (2004). “Managing Risk To Avoid Supply Chain Breakdown”, *MIT-Sloan Management Review*, Vol. 46 No. 1, Pp. 53-61.
19. Christopher M and Lee, H (2008), “Mitigating Supply Chain Risk Through Improved Confidence.” *International Journal of Physical Distribution & Logistics Management*, vol. 34, no. 5, pp. 388–396.
20. Christopher M., Mena C., Khan O. & Yurt O. (2011). Approaches To Managing Global Sourcing Risk, *Supply Chain Management: An International Journal*, Vol. 16, No. 2, pp. 67–81
21. Christopher, M. (2005). Managing risk in the supply chain. In *Logistics and Supply Chain Management* (3rd ed., pp. 231-258). Harlow: Prentice Hall.
22. CIPS (2018) Supply Chain Risk and Resilience: A CIPS introduction to good practice. Available at: <https://www.cips.org/en/knowledge/procurement-topics-and-skills/risk-mitigation/cips-risk-and-resilience-assessment-tool/> (Accessed 21 October 2018)
23. Coburn, A., Spence, R.J.S, and Pomonis, A. 1994. “Disaster Mitigation.” 2nd Edition. *Disaster Management Training Programme*. UNDP.
24. Colicchia, C. & Strozzi, F. (2012). Supply chain risk management: a new methodology for a systematic literature review. *Supply Chain Management: An International Journal*, 17 (4), 403-418.
25. Collins, C. (2008), “Supply Chain Life or Death - Five Trends That Will Determine the Future of Your Career”, *APICS Magazine*, pp. 36-38.
26. Collis, J. & Hussey, R. (2003). *Business Research: a practical guide for undergraduate and postgraduate students*. Basingstoke: Palgrave Macmillan.

27. Cooligan, H. (1999). *Research Methods and Statistics in Psychology* (Second ed.). London: Hodder & Stoughton.
28. Craighead, C.W., Blackhurst, J., Rungtusanatham, M.J., Handfield, R.B. (2007). The severity of supply chain disruptions: design characteristics and mitigation capabilities. *Decision Sciences* 38 (1), pp. 131–156.
29. Creswell J. and Plano Clark, V. (2007). *Designing and conducting mixed methods research*. London: Sage
30. Curkovic, S., Scannell, T., & Wagner, B. (2013). Using FMEA for Supply Chain Risk Management. *Modern Management Science & Engineering*, 1, 251-265.
31. Deloach, J.W. (2000), *Enterprise-Wide Risk Management: Strategies for Linking Risk and Opportunity*, Financial Times – Prentice-Hall, Upper Saddle River, NJ.
32. Drever, E. (1995). *Using Semi-Structured Interviews in Small-Scale Research*. A Teacher's Guide. pp. 34-55.
33. Dubois, A. and Gadde, L.E. (2002), “Systematic combining: an abductive approach to case research”, *Journal of Business Research*, Vol. 55, pp. 553-60.
34. Durach, C.F and Wiengarten, F. (2017) "Exploring the impact of geographical traits on the occurrence of supply chain failures", *Supply Chain Management: An International Journal*, Vol. 22 Issue: 2, pp.160-171.
35. Elahi, E. (2013),"Risk management: the next source of competitive advantage", *Foresight*, Vol. 15 Iss 2 pp. 117 - 131
36. Ellegaard, C. (2008). Supply risk management in a small company perspective. *Supply Chain Management: An International Journal* 13(6), pp. 425–434.
37. Ertem, M. A., Buyurgan, N., & Rossetti, M. D. (2010), "Multiple-buyer procurement auctions framework for humanitarian supply chain management", *International Journal of Physical Distribution & Logistics Management*, vol.40, no. 3, pp. 202-227.
38. Faisal, M. N., Banwet, D. K., & Shankar, R. (2006). Supply Chain Risk Mitigation: Modeling The Enablers. *Business Process Management Journal*, 12(4), 535 - 552.
39. Faizal, K, & Palaniappan. PL. K. (2014) Risk Assessment and Management in Supply Chain. *Global Journal of Researches in Engineering: G Industrial Engineering*, Volume 14 Issue 2 Version 1.0
40. Faisal, M. N. (2009). Prioritization of Risks in Supply Chain. *Managing Supply Chain Risk and Vulnerability: Tools and Methods for Supply Chain Decision Makers* (Ed. Wu, T. & Blackhurst, J.). Springer-Verlag London Limited, NY

41. Faisal, M.N., Banwet, D.K. & Shankar, R., (2007), "Management of Risk in Supply Chains: SCOR Approach and Analytic Network Process", *Supply Chain Forum: An International Journal*, Vol. 8 No. 2, pp. 66-79.
42. Fan, Y. & Stevenson, M. (2018) "A review of supply chain risk management: definition, theory, and research agenda", *International Journal of Physical Distribution & Logistics Management*, Vol. 48, Issue: 3, pp.205-230.
43. Fleetwood, S. (2005). Ontology in organization and management studies: A critical realist perspective. *Organization*, 12 (2), 197-222.
44. Foerstl, K., Reuter, C., Hartmann, E., Blome, C. (2010). Managing supplier sustainability risks in a dynamically changing environment: sustainable supplier management in the chemical industry. *Journal of Purchasing and Supply Management* 16, pp. 118–130.
45. Foroughi A., Albin M. & Kocakulah M. (2006). Perspectives on Global Supply Chain Supply-Side Risk Management, *Portland International Center For Management Of Engineering And Technology*, pp. 2732-2740
46. Fritz Institute (2015) available at: <http://www.fritzinstitute.org> .
47. Gaudensi, B. and Borghesi, A. (2006), "Managing risks in the supply chain using the AHP method", *The International Journal of Logistics Management*, Vol. 17 No. 1, pp. 114-136.
48. Ghadge, A., Dani, S., & Kalawsky, R. (2012). Supply chain risk management: present and future scope. *International Journal of Logistics Management*, 23 (3), 313-339.
49. Gibbs, G. (2007) *Analyzing qualitative data*, California: SAGE
50. Gilchrist, W. (1993). Modelling failure modes and effects analysis. *International Journal of Quality & Reliability Management*, 10 (5), 16-23.
51. Gillham, B. (2000). Case Study Research Methods. Bloomsbury Academic.
52. Giunipero L. C. and Aly Eltantawy R (2004) 'Securing the upstream supply chain: a risk management approach', *International Journal of Physical Distribution & Logistics Management*, Vol. 34 No. 9, 2004
53. Haavisto, I and Goentzel, J. (2015) "Measuring humanitarian supply chain performance in a multigoal context", *Journal of Humanitarian Logistics and Supply Chain Management*, Vol. 5 Issue: 3, pp.300-324,
54. Handfield, R., Blackhurst, J., Craighead, C., & Elkins, D. (2011). Introduction: a managerial framework for reducing the impact of disruptions to the supply chain.

Retrieved from: <http://scm.ncsu.edu/scmarticles/article/introduction-a-managerial-framework-for-reducing-the-impactof-disruptions>

55. Hallikas, J., Virolainen, V.M. and Tuominen, M. (2002), "Risk analysis and assessment in network environments: a dyadic case study", *International Journal of Production Economics*, Vol. 78 (1), pp. 45-55.
56. Henry L. Petersen, Fred Lemke, (2015) "Mitigating reputational risks in supply chains", *Supply Chain Management: An International Journal*, Vol. 20 Issue: 5, pp.495-510,
57. Hensley, R.L., and Utley, J.S. (2011) 'Using Reliability Tools In Service Operations', *International Journal of Quality and Reliability Management*, Vol. 28, Iss.5, pp. 587-598.
58. Horvath, L (2001) 'Collaboration: the key to a value creation in supply chain', *Supply Chain Management: An International Journal*, 6(5), pp.205-207
59. Hsieh, H.F., & Shannon, S. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, 15, pp. 1277-1288.
60. Hult, G.T.M., Ketchen, D.J., Cavusgil, T., Calantone, R.J., 2006. Knowledge as a strategic resource in supply chains. *Journal of Operations Management* 24, 458–475.
61. Hussey, J., & Hussey, R. (1997). *Business Research - A practical guide for undergraduate and postgraduate students*. London: Macmillan Press Ltd
62. ISO 31000 (2009) <https://www.iso.org/obp/ui/#iso:std:iso:31000:ed-1:v1> (Accessed 25 Feb 2018)
63. Jackson, M. (1987). Present positions and future prospects in management science. *Omega*, 15 (6), 455-466.
64. Jahre. M, Dumoulin.L, Greenhalgh. L. B, Hudspeth. C, Limlim. P & Spindler, A (2012) "Improving health in developing countries: reducing complexity of drug supply chains", *Journal of Humanitarian Logistics and Supply Chain Management*, Vol. 2 (1), pp.54-84,
65. Jahre. M (2017) "Humanitarian supply chain strategies – a review of how actors mitigate supply chain risks", *Journal of Humanitarian Logistics and Supply Chain Management*, Vol. 7 Issue: 2, pp.82-101
66. Jereb.B, Cvahte.T & Rosi.B. Mastering Supply Chain Risks, *Serbian Journal of Management* 7 (2) (2012) 271 - 285
67. Johnson, B. & Christensen, L. (2008). *Educational Research: Quantitative, Qualitative, and Mixed Approaches*. SAGE Publications.

68. Johnson, M. and Templar, S. (2011), "The relationships between supply chain and firm performance: the development and testing of a unified proxy", *International Journal of Physical Distribution & Logistics Management*, Vol. 41 No. 2, pp. 88-103.
69. Jüttner, U (2005), "Supply Chain Risk Management: Understanding the Business Requirements from a Practitioner Perspective," *The International Journal of Logistics Management*, vol. 16, no. 1, pp. 120–141.
70. Jüttner,U.,Peck, H, and Christopher, M (2003), "Supply Chain Risk Management: Outlining An Agenda For Future Research," *International Journal of Logistics*, vol. 6, no. 4, pp. 197–210
71. Kaufmann, J. R., Miller R and Cheyne J (2011). 'Vaccine Supply Chains Need to better funded and strengthened or lives will be at risk', *Health Affairs* ', 30, no.6 (2011): 1113-1121. Available from: <http://content.healthaffairs.org/content/30/6/1113.full.html>. (Retrieved on 25 Feb 2014)
72. Khan, O. & Burnes, B. (2007). Risk and supply chain management: creating a research agenda. *International Journal of Logistics Management*, 18 (2), 197-216.
73. Kouvelis, P and Li J (2008) 'Flexible Backup Supply and the Management of Delivery time Uncertainty', *Production and Operations Management*, 17(2), pp.184-199
74. Kovacs, G. (2009). 'Identifying challenges in humanitarian logistics', *International Journal of Physical Distribution & Logistics Management*, 39(6), pp.506-528
75. Kovács, G.and Spens, K.M. (2005) "Abductive reasoning in logistics research", *International Journal of Physical Distribution & Logistics Management*, Vol. 35 (2), pp. 132-144
76. Kurniawan, R., Zailani, S.H., Iranmanesh, M and Rajagopal, P (2017) "The effects of vulnerability mitigation strategies on supply chain effectiveness: risk culture as moderator", *Supply Chain Management: An International Journal*, Vol. 22 Issue: 1, pp.15,
77. Kvale, S. (1996). *Interviews: An Introduction to Qualitative Research Interviewing*, Sage.
78. Larson.C, Burn.R, Minnick-Sakal.A, Douglas. M.O and Kuritsky J (2014) Strategies to reduce risks in ARV supply chains in the developing world, *Global Health: Science and Practice 2014 | Volume 2 | Number 4*

79. Lavastre, O., Gunasekaran, A., and Spalanzani, A. (2012) "Supply Chain Risk Management in French Companies," *Decision Support Systems*, vol. 52, no. 4, pp. 828–838, Mar. 2012
80. Lee, C.-W. (2014). Establishing a decision-making model of global supply chain risk management from the perspective of risk and vulnerability. *International Journal of Supply Chain and Operations Resilience*, 1 (1), 28-53.
81. Lupton, D. (1999). Risk. Routledge
82. Maheshwari, S and Jain, P.K (2014) Supply Chain Management – Review of Risk Management from Supplier’s Perspective; *Daam International Scientific Book 2014*, pp.557-566
83. Manuj I and Mentzer J T (2008), ‘Global Supply Chain Risk Management’, *Journal of Business Logistics*; Vol.29, No.1, 2008
84. Marshall, C., & Rossman, G. B. (2011). *Designing Qualitative Research* (5th ed.). Thousand Oaks, CA Sage Publications.
85. Matthias D.M., Robertson J, Garrison M.M., Newland S, Nelson C (2007) ‘Freezing temperatures in the vaccine cold chain: A systematic literature review’, *Science Direct, Vaccine* 25 (2007) 3980–3986
86. McKone-Sweet, K.E., Hamilton, P, and Willis, S.B (2005), “The Ailing Healthcare Supply Chain: Prescription for Change,” *The Journal of Supply Chain Management: A Global Review of Purchasing and Supply*, pp.4-17.
87. McLachlin, R., Larson, P. D., & Khan, S. (2009), "Not-for-profit supply chains in interrupted environments: the case of a faith-based humanitarian relief organisation", *Management Research News*, vol. 32, no. 11, pp. 1050-1064.
88. Micheli, G.J.L, Enrico Cagno, E. and Zorzini, M. (2008) Supply risk management vs supplier selection to manage the supply risk in the EPC supply chain; *Management Research News*; Vol. 31 No. 11, 2008, pp. 846-866, Emerald Group Publishing Limited
89. Mitchell, V. W. (1995), Organisational risk perception and reduction: A literature review. *British Journal of Management*, 6(2), pp. 115-133.
90. Nepal, B. & Yadav, O. P. (2015). Bayesian belief network-based framework for sourcing risk analysis during supplier selection. *International Journal of Production Research*, 53 (20), 6114-6135.
91. Noel, W, Serumaga, B, McCord, J, and Inglis, A (2013). Risk Management for Public Health Supply Chains: Toolkit for Identifying, Analyzing, and Responding to Supply

Chain Risk in Developing Countries. Arlington, Va.: USAID | DELIVER PROJECT, Task Order 4.

92. Norrman, A. and Lindroth, R. (2004), "Categorization of supply chain risk and risk management", in Brindley, C. (Ed.), *Supply Chain Risk*, Ashgate, London, pp. 14-28.
93. Northumbria University portal, *Research Ethics and Governance Handbook*, 6th Ed, 2014-2014. Available at <https://elp.northumbria.ac.uk> (Retrieved on 11 January 2015)
94. Noy, C. (2008). Sampling knowledge: The hermeneutics of snowball sampling in qualitative research, *International Journal of social research methodology*, 11, pp.327-344.
95. Oloruntoba, R (2007) *Bringing Order Out Of Disorder: Exploring Complexity in Relief Supply Chains*. In Laptaned, U., Eds. *Proceedings 2nd International Conference on Operations and Supply Chain Management: Regional and Global Logistics and Supply Chain Management*, Bangkok, Thailand.
96. Oloruntoba, R and Kovács, G (2015) "A commentary on agility in humanitarian aid supply chains", *Supply Chain Management: An International Journal*, Vol. 20 Issue: 6, pp.708-716,
97. Ouabouch L and Amri M (2013) *Analysing Supply Chain Risk Factors: A Probability-Impact Matrix Applied to Pharmaceutical Industry*, *Journal of Logistics Management*, 2(2): 35-40
98. Overstreet R. E., Hall D, Hanna J. B. and R. Rainer Jr K (2011) 'Research in humanitarian logistics', *Journal of Humanitarian Logistics and Supply Chain Management*, Vol. 1 No. 2, 2011, pp. 114-131
99. Patton, M. Q. (2005). *Qualitative research*. John Wiley & Sons, Ltd. pp. 64-86.
100. Paulson, U., (2005). Developing a supply chain flow risk model. *NOFOMA 2005 Conference*, Copenhagen, 9-10 June 2005.
101. Peck, H., (2006). Reconciling supply chain vulnerability, risk and supply chain management. *International Journal of Logistics: Research and Application*, Vol. 9, No. (2), June 2006, 127-142.
102. Phillips, Estelle; Pugh, Derek S. (2010). *How To Get A PhD: A handbook for students and their supervisors* (5th Edition). Berkshire, GBR: Open University Press.
103. Ponomarov, S.Y & Holcomb, M.C. (2009), "Understanding the concept of supply chain resilience", *The International Journal of Logistics Management*, Vol. 20, Iss.1, pp. 124– 143

104. Price, W. (2004), "Reducing the risk of terror events at seaports", *Review of Policy Research*, Vol. 21 No. 3, pp. 329-349.
105. Punniyamoorthy, M., Thamaraiselvan, N., & Manikandan, L. (2013), Assessment of supply chain risk: scale development and validation. *Benchmarking: An International Journal*, Vol. 20 No. 1, 2013, pp. 79-105, Emerald Group Publishing Limited 1463-5771, DOI 10.1108/14635771311299506
106. Rao, S and Goldsby T. J (2009), "Supply chain risks: a review and typology," *The International Journal of Logistics Management*, vol. 20, no. 1, pp. 97–123, 2009.
107. Regda, G.E. (2007), *Principles of Risk Management and Insurance*, 10th ed., Prentice Hall, Upper Saddle River, NJ.
108. Reuter, C., Foerstl, K., Hartmann, E., Blome, C. (2010). Sustainable global supplier management: the role of dynamic capabilities in achieving competitive advantage. *Journal of Supply Chain Management* 46 (2), 45–63.
109. Riley, J.M, Klein. R, Miller.J and Sridharan.V, (2016) "How internal integration, information sharing, and training affect supply chain risk management capabilities", *International Journal of Physical Distribution & Logistics Management*, Vol. 46 Issue: 10, pp.953-980
110. Ritchie, B and Brindley, C (2007) "Supply chain risk management and performance: A guiding framework for future development", *International Journal of Operations & Production Management*, Vol. 27 Issue: 3, pp.303-322
111. Ritchie, J. and Lewis, J. (2010). *Qualitative research practice*. London: Sage Publications.
112. Ritchie, J., Lewis, J., Nicholls, C.M., Ormston, R. (2014) *Qualitative Research Practice; A Guide for Social Science Students and Researchers*. London: Sage.
113. Robson, C. 2002. *Real world research: A resource for social scientists and practitioner researchers*, Blackwell Oxford.
114. Rubin, Herbert & Rubin, Irene. (1995). *Qualitative Interviewing: The Art Of Hearing Data*. Thousand Oaks, CA: Sage.
115. Ryan, Jennifer K., "Systems Engineering: Opportunities for Health Care," *Building a Better Delivery System: A New Engineering/ Health Care Partnership*, National Academy Press (2005), pp.141-142.

116. Sadler, G. R., Lee, H.-C., Lim, R. S.-H., & Fullerton, J. (2010). Research article: Recruitment of hard-to-reach population subgroups via adaptations of the snowball sampling strategy. *Nursing & Health Sciences*, 12 (3), 369-374.
117. Sarantakos. S (2005) Social Research. First Published by Palgrave Macmillan Third Edition
118. Saunders, M., Lewis, P. & Thornhill, A. (2007) Research methods for business students, 5th ed., Harlow, Pearson Education.
119. Saunders, M., Lewis, P. & Thornhill, A. (2009). Understanding research philosophies and approaches. *Research Methods for Business Students*, 4, 106-135
120. Schneller, E. S. and Smeltzer, L.R (2006), *Strategic Management of the Healthcare Supply Chain*, Jossey-Bass.
121. Shuttleworth, M. (2008). Deductive Reasoning [Electronic Version]. *Experiment Resources*, <http://www.experiment-resources.com/deductive-reasoning.html> (Retrieved 17 February 2018).
122. Singh, Y. (2006). Fundamentals of Research Methodology and Statistics. New Delhi: New Age International Ltd.
123. Sinha, P., Whitman, L. And Malzahn, D. (2004). "Methodology To Mitigate Supplier Risk In An Aerospace Supply Chain", *Supply Chain Management: An International Journal*, Vol. 9 No. 2, Pp. 154-68.
124. Slovic, P and Weber E.U. (2002). "Perception of Risk Posed by Extreme Events." *Paper prepared for discussion at the conference "Risk Management strategies in an Uncertain World," Palisades, New York, April 12-13.*
125. Sodhi M. and Tang, C.S. (2009) Time-based disruption management: a framework for managing supply chain disruption. In: Blackhurst J, Wu T (eds). *Managing Supply Chain Risk and Vulnerability: Tools and Methods for Supply Chain Decision Makers*. Springer, New York.
126. Sodhi, M. S., Son, B.-G., & Tang, C. S. (2012). Researchers' perspectives on supply chain risk management. *Production and Operations Management*, 21 (1), 1-13.
127. Sofyalioglu C and Kartal B (2012), The selection of global supply chain risk management strategies by using fuzzy analytical hierarchy process - a case from Turkey, *Procedia - Social and Behavioral Sciences* 58, 1448 – 1457

128. Spekman, R.E and E. W. Davis (2004), “Risky business: expanding the discussion on risk and the extended enterprise,” *International Journal of Physical Distribution & Logistics Management*, vol. 34, no. 5, pp. 414–433.
129. Supply chain council (SCC) (2010), “Supply Chain Operations Reference Model. Version 10.0”, Available at: <http://www.apics.org/apics-for-business/frameworks/scor> (Accessed on 20 October 2018)
130. Supply Chain Risk Leadership Council (2011) ‘Supply Chain Risk Management: A Compilation of Best Practices’. Available from: http://www.scrhc.com/articles/Supply_Chain_Risk_Management_A_Compilation_of_Best_Practices_final%5B1%5D.pdf (Retrieved on 16 March 2014)
131. Supply Chain Risk Leadership Council (2014), Supply Chain Risk Leadership Council <http://www.scrhc.com/about.php> (Retrieved on 29/03/13)
132. Supply Management (2014) *The International magazine for supply chain professionals*, February 2014, Volume 19, Issue 2
133. Sutrisno. A., Kwon. H.M., Gunawan. I, Eldridge. S, and Lee. T.R., (2016) “Integrating SWOT Analysis into the FMEA Methodology to Improve Corrective Action Decision Making,” *International Journal of Quality and Productivity Improvement*, vol. 17, no. 1, pp. 104–126
134. Tang, C.S. (2006), “Perspectives in supply chain risk management”, *International Journal of Production Economics*, Vol. 103, pp. 451-88.
135. Teddlie, C.B., & Tashakkori, A. (2009). *Foundations of mixed methods research: Integrating quantitative and qualitative approaches in the social and behavioural sciences*. Thousand Oaks, CA: Sage
136. The Sphere Project (2011) *Humanitarian Charter and Minimum Standards in Humanitarian Response*, Third Edition, Practical Action Publishing, United Kingdom. Available from: <http://www.spherestandards.org/handbook/editions/> (Retrieved on 15/09/2018)
137. Tomasini, R.M and Van Wassenhove (2009) ‘From preparedness to partnerships: case research on humanitarian logistics’, *International Transactions In Operational Research*, 16, pp.549-559

138. Tomlin, B. (2006). "On The Value Of Mitigation And Contingency Strategies For Managing Supply Chain Disruption Risks", *Management Science*, Vol. 52 No. 5, Pp. 639-57.
139. Tracey, M., Lim, J and Vonderembse M.A. (2005). 'The impact of supply chain management capabilities on business performance', *Supply Chain Management: An International Journal*, 10 (3), pp.179-191
140. Trkman, P., De Oliveira, M.P.V. & McCormack, K., (2016), "Value-oriented supply chain risk management: you get what you expect", *Industrial Management & Data Systems*, Vol. 116 No. 5, pp. 1061-1083.
141. Tummala, R. and Schoenherr, T. (2011), "Assessing and managing risks using the supply chain risk management process (SCRMP)", *Supply Chain Management: An International Journal*, Vol. 16, No. 6, pp. 474-483.
142. Tuncel, G. & Alpan, G. (2010). Risk assessment and management for supply chain networks: A case study. *Computers in Industry*, 61 (3), 250-259.
143. Udawatta, N., Zuo, J., Chiveralls, K., & Zillante, G. (2015). Attitudinal and behavioural approaches to improving waste management on construction projects in Australia: benefits and limitations. *International Journal of Construction Management*, 15 (2), 137-147.
144. UNGM (2006) UN Procurement Practical Handbook. Available Online: <https://www.ungm.org/Areas/Public/pph/channels/PPH.pdf> (Accessed on 25 Feb 2018)
145. UNICEF (2013) Innovation. Available at: <http://www.unicefinnovation.org/case-studies/solar-direct-drivenbsptechology-using-sun-keep-vaccines-cool-worldwide#sthash.gH5gES0T.dpuf> (Retrieved on 15 November 2013)
146. UNICEF (2014) Immunization. Available at: <https://intranet.unicef.org/Denmark/DanHomepage.nsf/0/8D550CCC51EE8E67C12572D800383EE5?open&expandlevel=MainLevel1&expandlevel2=SecondLevel1> (Retrieved on 22 January 2014)
147. UNICEF Risk Management (2015) Available at: <http://www.unicefinemergencies.com/downloads/eresource/docs/Remote%20Programming/In%20struction%201%20-%202015%20Risk%20Assessment%20and%20Reporting.pdf> (Retrieved on 18 October 2018)

148. UNICEF (2018) The UNICEF Supply Chain. Available at:
https://www.unicef.org/supply/index_54257.html (Retrieved on 20 October 2018)
149. UNICEF (2018) UNICEF In Tanzania. Available at:
<https://www.unicef.org/tanzania/about.html> (Retrieved on 20 October 2018)
150. United Nations International Strategy for Disaster Reduction (2005), UNISDR, New York, NY.
151. Vatsa, K.S, (2004),"Risk, vulnerability, and asset-based approach to disaster risk management", *International Journal of Sociology and Social Policy*, Vol. 24 Iss 10/11 pp. 1 – 48
152. Vereecke, A., Pandelaere, E, Danny Boeykens, D (2010): Supply Chain Risk Management a unique function, or simply one of the Supply Chain Manager's tasks? Available online: <http://www.mobiusuk.co.uk/media/blg/1090/1377159784/supply-chain-risk-management-a-unique-function-or-simply-one-of-the-supply-chain-managers-tasks.pdf> (Accessed on 28 February 2018)
153. Vilko J and Ritala P (2014) Service Supply Chain Risk Management, *Operations and Supply Chain Management Vol. 7, No. 3*, pp. 114 – 120
154. Vlachos Ilias. P (2013) Key performance indicators of the impact of radio frequency identification technologies on supply chain management. *International Journal of RF Technologies*, Vol. 4, no. 2, pp. 127-146.
155. Vlachos, Ilias (2014) Reverse Food Logistics during the Product Life Cycle. *International Journal of Integrated Supply Management*, 9 (1/2). pp. 48-83.
156. Voss, C., Tsikriktsis, N. & Mark, F. (2002). "Case Research In Operations Management". *International Journal of Operations & Production Management*, Vol. 22, No. 2, Pp. 195-219.
157. Wagner, S.M. and Bode, C. (2008), "An empirical examination of supply chain performance along several dimensions of risk", *Journal of Business Logistics*, Vol. 29, No. 1, pp. 307-25.
158. Michael Wang, (2018) "Impacts of supply chain uncertainty and risk on the logistics performance", *Asia Pacific Journal of Marketing and Logistics*, Vol. 30 Issue: 3, pp.689-704
159. Wassenhove, L. V. (2006), "Humanitarian aid logistics: supply chain management in high gear", *Journal of the Operational Research Society*, vol. 57, pp. 475-489.

160. Waters, D. (2007). *Supply Chain Risk Management: Vulnerability and Resilience in Logistics*. London: Kogan Page.
161. Waters, D (2009), 'Supply Chain Risk Management: Vulnerability and Resilience in Logistics', 1st Edition. Available at: <http://cips.org/en/book-shop/Books1/supplychainriskmanagement/> (Retrieved on 20 March 2014)
162. Wei, Y. and Choi, T. (2010). Mean–variance analysis of supply chains under wholesale pricing and profit sharing schemes. *European Journal of Operational Research*, 204(2), pp.255-262.
163. Welborn, C. (2007). Using FMEA to Assess Outsourcing Risk. *Quality Progress*, 40(8), 17-21.
164. White, D. (1995). Application of systems thinking to risk management: a review of the literature. *Management Decision*, 33 (10), 35-45.
165. WHO (2014). Immunization. Available at: <http://www.who.int/immunization/research/implementation/en/>. (Retrieved on 8 March 2014).
166. Wheeldon, J. & Ahlberg, M.K. (2012). *Visualizing Social Science Research: Maps, Methods, & Meaning*. USA: Sage
167. Wieland, A. and Wallenburg, C.M. (2012). Dealing with supply chain risks: Linking risk management practices and strategies to performance, *International Journal of Physical Distribution & Logistics Management* Vol. 42 No. 10, 2012, pp. 887-905,
168. Yang, B and Geunes, J (2007) 'Inventory and lead time planning with delivery time sensitive demand', *IIE Transactions*, 39. pp.439-452.
169. Yin, R. K. (2009). *Case Study Research: Design and Methods (Fourth Ed.)*. volume 5. SAGE Publications.
170. Yin, R.K. (2013). *Case Study Research: Design and Methods*, London, Sage Publications.
171. Zhu, Q, Krikke, H, and Caniëls. M.C.J, (2017) "Integrated supply chain risk management: a systematic review", *The International Journal of Logistics Management*, Vol. 28 Issue: 4, pp.1123-1141
172. Zsidisin, G.A., Ellram, L.M., Carter, J.R. & Cavinato, J.L., (2004), "An analysis of supply risk assessment techniques", *International Journal of Physical Distribution & Logistics Management*, Vol. 34 No. 5, pp. 397-413.

List of Appendices

Appendix A: Questionnaire on Supply Chain Risk Assessment

Start of Block: INTRODUCTION AND EXPLANATORY STATEMENT

Thank you for taking part of your precious time to participate in this survey. This survey is for all supply chain professionals and program officers/experts who are willing to contribute to the growth of resilient supply chains in Africa.

This is a Post Graduate Research Project whose objective is to investigate ways in which supply chain risk factors are assessed / identified, prioritised and mitigated in an effort to reduce or eliminate their impact on the performance of a public health supply chain system in Sub Saharan Africa. The end product of this research is to propose a model for managing risks in the public health supply chain system for Sub-Saharan Africa, with particular focus on Tanzania. This should take approximately 30 minutes to complete and can be done at your convenience, before 15 May 2017. Individual information and responses will be kept strictly confidential. No findings which could identify any specific organisation or individual will be published. Only the combined results of all the participants will be published to advance the learning in understanding supply chain risks factors affecting project performance. All participants who will fully complete the survey by 15 May 2017 will be sent copy of the executive summary of the final research report by email if they so wish. Please SAVE your answers once you have completed all questions. If you have any queries regarding this survey questionnaire, please contact: Fredrick Sheshe (Student) Tel: +255 22 219 6688 Mobile: +255 787 600 081 Email: fsheshe@unicef.org **If further advice is required from Northumbria University, please contact the Faculty Research Ethics Committee through bl.ethics.administrator@northumbria.ac.uk**

End of Block: INTRODUCTION AND EXPLANATORY STATEMENT

Start of Block: RISK IDENTIFICATION AND LIKELIHOOD

Q1 Please, score each risk in terms of its presence in your UPSTREAM Supply Chain / Inbound Route (from supplier/port of origin to the port of entry) and its likelihood of occurrence in a single shipment

Communication problems between suppliers and supply team in receiving country (1)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Communication problems between freight forwarders and supply team in receiving country (2)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Security problems during transit transportation including piracy and terrorism (3)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Exposure to natural disasters and accidents during transit (4)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Supplier's failure to meet agreed delivery time (5)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Supplier's failure to meet agreed product quality standards (6)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Freight forwarder's failure to collect and ship consignment at agreed time (7)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Freight forwarder's failure to keep consignment at agreed quality standards (8)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Transshipment delays at transit hubs due to congestion (9)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Pipeline visibility and tracking problems from port of origin to port of entry (10)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)

Q2 please, score each risk in terms of its presence in your NEAR-STREAM Supply Chain (from port of entry to national warehouse) and its likelihood of occurrence in a single shipment

Communication problems between clearing agents and supply team in receiving country (1)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Port congestion leading to shipment delays (lack of capacity) (2)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Port charges/cost are too high on humanitarian shipments (handling and storage) (3)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Permits to import are taking long (too many bodies, documentation and registration) (4)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Security problems at port storage leading to theft (5)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Quality problems due to poor handling and storage of shipments (6)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Storage spaces at national hubs is inadequate (7)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Lack of temperature controlled storage facilities at port/national hubs (8)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Manual order processing at port of entry leading to clearing delays (9)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Clearing agent's failure to perform customs clearance processes on time (10)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)

Q3 please, score each risk in terms of its presence in your DOWNSTREAM supply chain (from national warehouse to distribution point) and its likelihood of occurrence in a single shipment

Communication problems between supply team and last mile recipient (1)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Stock out (2)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Stock expiration (3)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Stock oversupply (4)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Unexpected demand fluctuations (5)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Incorrect forecasting (6)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Quality problems due to poor handling and storage of shipments (7)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Storage spaces at regional/destination hubs is inadequate (8)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Limited cold chain trucks/refrigerated vehicles (9)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)
Transporter's failure to deliver on agreed time (10)	▼ Very Likely to Occur (1) ... Very Unlikely to occur (5)

End of Block: RISK IDENTIFICATION AND LIKELIHOOD

Start of Block: RISK SEVERITY/IMPACT

Q4 Please score on how each risk factor listed below would impact on supply chain DELIVERY TIME / DELIVERY TIME

Failure to meet agreed delivery time by suppliers and forwarding agents (1)	▼ Very High (Time increase by Over 20%) (1)... Very Low (Time increase is negligible) (5)
Exposure to natural disasters and accidents during transit (2)	▼ Very High (Time increase by Over 20%) (1)... Very Low (Time increase is negligible) (5)
Transshipment delays at transit hubs due to congestion (3)	▼ Very High (Time increase by Over 20%) (1)... Very Low (Time increase is negligible) (5)
Port congestion leading to shipment delays (lack of capacity) (4)	▼ Very High (Time increase by Over 20%) (1)... Very Low (Time increase is negligible) (5)
Permits to import are taking long (too many bodies, documentation and registration) (5)	▼ Very High (Time increase by Over 20%) (1)... Very Low (Time increase is negligible) (5)

Q5 Please score on how each risk factor listed below would impact on supply chain COST of order delivery

Port charges/cost are too high on humanitarian shipments (handling and storage) (1)	▼ Very High (Cost increase by Over 20%) (1)... Very Low (Cost increase is negligible) (5)
Permits to import are expensive for humanitarian shipments (taxation) (2)	▼ Very High (Cost increase by Over 20%) (1)... Very Low (Cost increase is negligible) (5)
Freight/transportation from shipper to receiver (3)	▼ Very High (Cost increase by Over 20%) (1)... Very Low (Cost increase is negligible) (5)
Disasters including terrorism (high insurance cost) (4)	▼ Very High (Cost increase by Over 20%) (1)... Very Low (Cost increase is negligible) (5)
Shortage of resources to cover supply/logistics costs (5)	▼ Very High (Cost increase by Over 20%) (1)... Very Low (Cost increase is negligible) (5)

Q6 Please score on how each risk factor listed below would impact on QUALITY of products

Supplier's failure to meet agreed product quality standards (1)	▼ Very High (Product is unusable) (1) ... Very Low (Effect is negligible) (5)
Quality problems due to poor handling and storage of shipments (2)	▼ Very High (Product is unusable) (1) ... Very Low (Effect is negligible) (5)
Lack of temperature controlled storage facilities at port/national hubs (3)	▼ Very High (Product is unusable) (1) ... Very Low (Effect is negligible) (5)
Stock expiration (4)	▼ Very High (Product is unusable) (1) ... Very Low (Effect is negligible) (5)
Limited cold chain trucks/refrigerated vehicles (5)	▼ Very High (Product is unusable) (1) ... Very Low (Effect is negligible) (5)

End of Block: RISK SEVERITY/IMPACT

Start of Block: RISK DETECTION

Q7 Please score on the capacity and possibility of the existing organisational systems/tools to detect each risk before happening in your UPSTREAM supply chain (from supplier to port of entry)

Communication problems between suppliers and supply team in receiving country (1)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Communication problems between freight forwarders and supply team in receiving country (2)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Security problems during transit transportation including piracy and terrorism (3)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Exposure to natural disasters and accidents during transit (4)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Supplier's failure to meet agreed delivery time (5)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Supplier's failure to meet agreed product quality standards (6)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Freight forwarder's failure to collect and ship consignment at agreed time (7)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Freight forwarder's failure to keep consignment at agreed quality standards (8)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Transshipment delays at transit hubs due to congestion (9)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Pipeline visibility and tracking problems from port of origin to port of entry (10)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)

Q8 Please score on the capacity and possibility of the existing organisational systems/tools to detect each risk before happening in your NEARSTREAM supply chain (from port of entry to national warehouse)

Communication problems between clearing agents and supply team in receiving country (1)	▼ Very High (Risk will definitely be detected and controlled)r (1) ... Very Low (Risk will not be detected and controlled) (5)
Port congestion leading to shipment delays (lack of capacity) (2)	▼ Very High (Risk will definitely be detected and controlled)r (1) ... Very Low (Risk will not be detected and controlled) (5)
Port charges/cost are too high on humanitarian shipments (handling and storage) (3)	▼ Very High (Risk will definitely be detected and controlled)r (1) ... Very Low (Risk will not be detected and controlled) (5)
Permits to import are taking long (too many bodies, documentation and registration) (4)	▼ Very High (Risk will definitely be detected and controlled)r (1) ... Very Low (Risk will not be detected and controlled) (5)
Security problems at port storage leading to theft (5)	▼ Very High (Risk will definitely be detected and controlled)r (1) ... Very Low (Risk will not be detected and controlled) (5)
Quality problems due to poor handling and storage of shipments (6)	▼ Very High (Risk will definitely be detected and controlled)r (1) ... Very Low (Risk will not be detected and controlled) (5)
Storage spaces at national hubs is inadequate (7)	▼ Very High (Risk will definitely be detected and controlled)r (1) ... Very Low (Risk will not be detected and controlled) (5)
Lack of temperature controlled storage facilities at port/national hubs (8)	▼ Very High (Risk will definitely be detected and controlled)r (1) ... Very Low (Risk will not be detected and controlled) (5)
Manual order processing at port of entry leading to clearing delays (9)	▼ Very High (Risk will definitely be detected and controlled)r (1) ... Very Low (Risk will not be detected and controlled) (5)
Clearing agent's failure to perform customs clearance processes on time (10)	▼ Very High (Risk will definitely be detected and controlled)r (1) ... Very Low (Risk will not be detected and controlled) (5)

Q9 Please score on the capacity and possibility of the existing organisational systems/tools to detect each risk before happening in your DOWNSTREAM supply chain (from national warehouse to distribution point)

Communication problems between supply team and last mile recipient (1)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Stock out (2)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Stock expiration (3)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Stock oversupply (4)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Unexpected demand fluctuations (5)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Incorrect forecasting (6)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Quality problems due to poor handling and storage of shipments (7)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Storage spaces at regional/destination hubs is inadequate (8)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Limited cold chain trucks/refrigerated vehicles (9)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)
Transporter's failure to deliver on agreed time (10)	▼ Very High (Risk will definitely be detected and controlled) (1) ... Very Low (Risk will not be detected and controlled) (5)

Page Break

End of Block: RISK DETECTION

Start of Block: DEMOGRAPHIC PROFILE

Select category of your organisation

- Government (1)
 - United Nations (2)
 - Non-Governmental (NGO) (3)
 - Donor/Financier (4)
 - Logistics Agent (5)
 - Supplier (6)
 - OTHER (7)
-

Select period of your work experience in general supply chain/logistics

- Less than 1 year (1)
 - 1 - 5 years (2)
 - 6-10 years (3)
 - 11 - 15 years (4)
 - 16-20 years (5)
 - Over 20 years (6)
-

Select period of your work experience in HEALTH supply chain/logistics

- Less than 1 year (1)
 - 1 - 5 years (2)
 - 6-10 years (3)
 - 11 - 15 years (4)
 - 16-20 years (5)
 - Over 20 years (6)
-

What job title best suits your current role / responsibilities

- Supply Chain /Logistics Manager or Director (1)
 - Supply Chain /Logistics Officer/Specialist/Associate (2)
 - Supply Chain /Logistics Assistant (3)
 - Programs Director/Chief/Manager (4)
 - Program Officer/Specialist (5)
 - Programs Assistant (6)
 - OTHER (7)
-

Do you like to receive copy of the findings of this research?

Yes (1)

Maybe (2)

No (3)

Appendix B: Interview Schedule

TITLE: Supply chain risk factors and their impact on performance of public health supply chain systems in Sub Sahara Africa: A case study of the supply chain system for UNICEF Tanzania.

Course: Doctorate of Business Leadership

Institution: Northumbria University – Newcastle Business School

Student: Fredrick Sheshe

Supervisor: Dr Alireza Shokri

Candidate 0 ____: _____ **Date:** _____

Introduction to the interview (*self-opinion, confidentiality, duration of interview, recording, note taking, follow up to ongoing questionnaire survey*)

Theme A: Identifying most critical supply chain risk factors & their likelihood of happening in a single shipment

Question A1: *What do you consider as the most critical risks in managing health supply chains today in Sub Saharan Africa region? (You may state if general, country specific or organisation specific)*

- *Guide: Give at least 3 critical factors, specifying the phases where these are dominant*

(Upstream; Near/Midstream; Downstream)

- Risk 1 _____
 - Phase: _____
- Risk 2 _____
 - Phase _____
- Risk 3 _____

- Phase _____
 - Risk 4 _____
 - Phase _____
 - Risk 5 _____
 - Phase _____
- *Probe: Which are the top 2 risk factors for the entire supply chain for the organisation*
 - Risk 1 _____
 - Risk 2 _____
 - _____
- *Probe and explore: What is the 3 most products shipped and the pipeline routes used (air/road/sea/rail)?*
 - Product 1 _____
 - Route: _____
 - Product 2 _____
 - Route: _____
 - Product 3 _____
 - Route: _____
- *Probe and explore: What are other risk factors external to the country but within Sub Saharan Africa*
 - _____

Question A2: *What do you think is the likelihood of each of the risk you identified happening during a single shipment as it moves from source of supply to the point of final delivery?*

- *Guide: From scale of 5 to 1 (5 being very likely and 1 being very unlikely) – (provide the list of risk factors already given by the interviewee)*

<i>Risk Name</i>	<i>Likelihood</i>
1.	
2.	
3.	
4.	

- *Probe on likelihood of communication, freight forwarders and host government policies and systems affecting the supply chain performance*

<i>Risk Name</i>	<i>Likelihood</i>
1. <i>Government policies/systems</i> <i>Example:</i> _____	
2. <i>Organisation policies/systems:</i> _____	

- *Explore the elements/drivers that can increase the likelihood*

- _____
- _____
- _____

- *Explore the elements/blockers that can reduce the likelihood*

- _____
- _____
- _____

Theme B: Most critical risk factors & their impact on supply chain performance indicators of delivery time, cost and quality

Question B1: Do you think there are supply chain risk factors can impact on your supply **delivery time/delivery time**? If YES, please give these risk factors and their impact level. If NO, explain why.

- Probe on the 3 most critical factors and their impact level at the scale of 1 to 5 (5 is very high at over 20%) and 1 is very low at negligible)

<i>Risk Name</i>	<i>Impact</i>
1.	
2.	
3.	

- Probe and explore ways/strategies to reduce the impact of each risk factor on supply lead time

- _____
- _____
- _____

- Probe for any challenges that can hinder reducing the impact or eliminating these risk factors

- _____
- _____
- _____

- Probe and explore on the potential opportunities available to the country and organisation to improve supply delivery time

- _____
- _____

Question B2: Do you think there are supply chain risk factors that can impact on your supply **cost**? If YES, please give these risk factors. If NO, explain why.

- Probe on the 3 most critical factors and their impact level at the scale of 1 to 5 (5 is very high at over 20%) and 1 is very low at negligible)

<i>Risk Name</i>	<i>Impact level</i>
1.	
2.	
3.	

- Probe and explore what could be done/strategies to reduce the impact of these risk factors on supply cost

- _____
- _____
- _____

- Probe for any challenges that can hinder efforts to reduce the impact or eliminating the risk factors

- _____
- _____

- Probe and explore on the potential opportunities available to the country and organisation to improve supply cost

- _____
- _____

Question B3: Do you think the supply chain risk factors can impact on your supply quality? If YES, please give these risk factors. If NO, explain why.

- Probe on the 3 most critical factors and their impact level at the scale of 1 to 5 (5 is very high and 1 is very low/negligible)

<i>Risk Name</i>	<i>Impact level</i>
1.	
2.	
3.	

- Probe and explore on strategies/ways to reduce the impact of risk factors on supply quality
 - _____
 - _____
 - _____
 - Probe for any challenges that can hinder efforts to reduce the impact or eliminating the risk factors
 - _____
 - _____
 - Probe and explore on the potential opportunities available to the country and organisation to improve supply quality
 - - _____
 - _____
-

Theme C: Key Performance Indicators affecting organisational supply chain

Question C1: In your opinion, are there any other key performance indicators that you see to be at risk in your supply chain? If YES, which ones and what is the level of impact at scale of 1 to 5? If NO, explain why.

1. _____

2. _____

3. _____

- Probe on indicators such as organisational reputation, environmental impact, return on investment,

- _____

- _____

- Probe on ways to mitigate the identified risks

- _____

- _____

- _____

Theme D: Risk detection and treatment

Question D1: Does your organisation has the **mechanism or capability/capacity to detect** supply chain risk factors? If NO, explain why?

_____ -

- If YES, which ones what is the level of ability to detect each of the given risk factors on the scale of 1 to 5 (5 is very high and detection is definite.... 1 very low and detection is definitely undetectable)

<i>Mechanism/Tool name</i>	<i>Detectability level</i>
1.	
2.	
3.	

- Probe and explore the **measurement tools and ways/strategies** the organisation is using to **treat** the identified risks in order to **mitigate/ eliminate** them

- _____
- _____
- _____
- _____

- Explore challenges the organisation or respondent may face in detecting and or treating supply chain risks

- _____
- _____
- _____

- Do you have any other comments to share regarding supply chain risks in Sub Saharan Africa?

- _____

- _____
- _____

Appendix C: Participant Informed Consent Form Interviews Sample

Title of Study:	Supply chain risk factors and their impact on performance of public health supply chain systems in Sub Saharan Africa: A case study of the supply chain system for Tanzania.
Person(s) conducting the research:	Fredrick Sheshe
Programme of study:	Doctorate of Business Leadership
Address of the researcher for correspondence:	C/o UNICEF Tanzania Country Office; Plot 1403-1 Bains Avenue, Masaaki; P.O. Box 4076, Daresalaam. Tanzania
Telephone:	+255787600081
E-mail:	fsheshe@unicef.org fredrick.sheshe@northumbria.ac.uk
Description of the broad nature of the research:	This is a social science research focusing on identifying and ranking supply chain risks that can be found in public health systems in Sub Saharan Africa. The primary data will be collected through face to face or Skype interviews to compliment the survey questionnaire.
Description of the involvement expected of participants including the broad nature of questions to be answered or events to be observed or activities to be undertaken, and the expected time commitment:	The interviewees will be expected to respond to seven (7) supply chain risk related questions covering risk identification, likelihood, impact, detection, rating and treatment. These will be open ended questions and the participant will be required to freely answer the questions they feel comfortable with. The interview session will take approximately 45 minutes.
Description of how the data you provide will be securely stored and/or destroyed upon completion of the project.	The interview sessions recorded will be permanently deleted from the recorder and transcript at the end of the project

Information obtained in this study, including this consent form, will be kept strictly confidential (i.e. will not be passed to others) and anonymous (i.e. individuals and organisations will not be identified *unless this is expressly excluded in the details given above*). Data obtained through this research may be reproduced and published in a variety of forms and for a variety of audiences related to the broad nature of the research detailed above. It will not be used for purposes other than those outlined above without your permission.

Participation is entirely voluntary and participants may withdraw at any time.

By signing this consent form, you are indicating that you fully understand the above information and agree to participate in this study on the basis of the above information.

Participant's signature: XXXXXX _____ Date: 24th March 2017 (10.00hrs)

Student's signature: Fredrick Sheshe _____ Date: 24th March 2017 (10.00hrs)

Please keep one copy of this form for your own records

Appendix D: Student Research Ethical Issues Form

Student Name:	Fredrick Sheshe
Programme of Study	Doctorate of Business Leadership
Title of Research Project:	Supply chain risk factors and their impact on performance of public health supply chain systems in Sub Saharan Africa: A case study of the supply chain system for UNICEF Tanzania.
Start Date of Research Project:	November 2014
Supervisors	Dr Alireza Shokri & Prof David Wainwright

Risk Status (please mark one box):

Red

Amber

Green

Please refer to the Ethics Diagnostic Tool for advice on Risk Status (available in Blackboard – NB034BC: B and L Research).

	Comments
Brief description of the proposed research methods including (if relevant) how human participants will be selected and involved.	This is a mixed method research. Data will be collected through closed survey questionnaire and interviews. Human participants will be drawn from supply chain professionals working in supply networks that delivers public health supplies/ products in Sub Saharan Africa.
How will informed consent of research participants be acquired? (If appropriate attach draft informed consent form)	The survey questionnaire will have an introduction and explanatory statement which participants will be expected to read and consent before completing it. Interviewees will be required to complete a participant consent form ahead of the interview. The draft copy of the interview participant consent form is attached.

<p>How will research data be collected, securely stored and anonymity protected (where this is required)</p>	<p>The survey questionnaire will be completed online via Qualtrics tools. The anonymous survey questionnaire responses will be received and stored within the secured and password protected student account in Qualtrics. The analysis of data will also be done in Qualtrics.</p> <p>All interview sessions will be recorded by a voice recorder owned by the student. This recorder will be kept in a secure environment. A few of the interviews will be conducted through Skype video</p>
<p>How will data be destroyed after the end of the project? (Where data is not to be destroyed please give reasons)</p>	<p>All questionnaire responses will be permanently deleted from the Qualtrics database at the end of the project.</p> <p>The interview sessions recorded will be permanently deleted from the recorder or computer or any other storage devices at the end of the project</p>
<p>Any other ethical issues anticipated?</p>	<p>None</p>

Student Signature (indicating that the research will be conducted in conformity with the above and agreeing that any significant change in the research project will be notified and a further ‘Project Amendment’ Form submitted).

Date: 05/03/2017..... **Student Signature:**...Fredrick Sheshe.

Supervisor:

I confirm that I have read this form and I believe the proposed research will not breach University policies.

Please Note:

The appropriate completion of this form is a critical component of the University Policy on Ethical Issues in Research and Consultancy. If further advice is required, please contact the Faculty Research Ethics Committee through ethicssupport@northumbria.ac.uk in the first instance.

Appendix E: Ethical Approval

Fredrick Sheshe ▾
Guidance ▾



Supply chain risk factors and their impact on performance of public health supply chain systems in Sub Sahara Africa: A case study of the supply chain system for UNICEF Tanzania.

Research Information
Research Ethics
File Manager
Status
Reviewer Feedback

▾ Record Status Versioning

Ver.	Status	Description	Info	Set By	Record Locked
1	In progress	Form is being updated or amended by the PI	STATUS CREATED BY SYSTEM	Fredrick Sheshe ▾ on 04/04/2017	No
2	With supervisor	Form is being checked by the supervisor	STATUS SET BY SYSTEM	Fredrick Sheshe ▾ on 09/04/2017	Yes
3	Being reviewed	Reviewers have been allocated and they are reviewing the form	Sent back to reviewer via email	Jayne Forster ▾ on 10/04/2017	Yes
4	Decision: approved, research may begin	The form has been reviewed and it has been approved. The PI can start their research	Approved via email	Jayne Forster ▾ on 10/04/2017	Yes

Appendix F: Research Tasks Timeline

	Task Description	Start Date	Completion Date
1	Advanced Business Research Module	Sept 2014	Nov 2014
2	Research Proposal & Prerequisites	Nov 2014	Mar 2015
3	Literature Review	Nov 2015	March 2018
4	Methodology Development	Mar 2016	June 2016
5	Obtain Ethical Approvals & Permissions	Mar 2017	April 2017
6	Data Collection (Questionnaires, Observations, Interviews)	Apr 2017	June 2017
7	Data Interpretation	May 2017	July 2017
8	Thesis Writing	Aug 2017	March 2018
9	Submit Thesis	Mar 2018	March 2018
10	Viva & DBL Completion	Apr 2018	June 2018