

**A lean management framework for orthopaedic
operating theatres of a level three public
hospital, North West Province**

K Sekoto

 **orcid.org 0000-0002-6729-3747**

Mini-dissertation accepted in partial fulfilment of the
requirements for the degree *Master of Business
Administration* at the North-West University

Supervisor: Prof P Bester

Co-Supervisor: Dr C Niesing

Assistant-Supervisor: Mrs D Kruger

Graduation: October 2019

Student number: 28103068

DECLARATION

I Khosi Emmanuel Sekoto declare that this research dissertation titled: **A lean management framework for orthopaedic theatres of a level three public hospital, North West Province** and the work presented in this research dissertation are both my own, and generated by me as a result of my own original research. It is submitted in partial fulfilment of the requirements of the degree of Master of Business Administration at the Business School, North-West University. To the best of my knowledge and belief, no material previously published or written by another person except where due references in made is contained in this mini-dissertation.

Khosi Emmanuel Sekoto

9 April 2019

PREFACE AND ACKNOWLEDGEMENTS

I wish to express my sincere gratitude and appreciation to God Almighty for granting me the opportunity to carry out this study. I sincerely appreciate and recognise the huge contribution by my supervisors, Prof P Bester, Dr CM Niesing, and Mrs DM Kruger, thank you for your valuable knowledge and guidance in completing this study.

Many appreciations to the Department of Health North West Province for allowing me to conduct interviews and collect data at the partner hospital. Without your approval the research would not be feasible. Vote of thanks to the senior management, orthopaedic staff in wards and theatres at the Klerksdorp/Tshepong Hospital Complex for given up their time for interviews and special meetings as well as supplying data and supportive observation on the scheduling of orthopaedic theatres.

A special thanks to my lovely daughter Relebohile for your patience, love and support during my dedicated time to my studies. I apologise for not having our quality time as we used to before I enrolled at the North-West University for this qualification, I promise to spend more time like before in future.

ABSTRACT

Background: Operating theatres are dedicated venues within hospitals designed for safe surgical interventions and account for a large portion of their revenue and expenditure. Within the public health system in South Africa, there is a high demand from patients seeking medical treatment through surgical procedures, especially orthopaedic procedures. Hence optimal scheduling of operating theatres geared towards efficiency and production is essential in the management of hospitals.

Problem statement: Surgery of elective patients is a challenge in public hospitals amid staff shortages, long waiting times, cancellation by patients on short notice, limited post-operative recovery beds, and orthopaedic wards. The challenge is even more pronounced when there is no software program use to schedule orthopaedic surgeries. The researcher was requested by the Chief Executive Officer of a level three public hospital in the North West Province, South Africa, to explore and describe how orthopaedic theatres function in this hospital in order to propose how orthopaedic surgery scheduling with lean management principles could improve orthopaedic theatres' efficiency and production. The hospital is a level three public hospital servicing the Dr Kenneth Kaunda District and other districts within the North West Province. Due to its good performance with orthopaedic theatre surgeries it attracts patients from other provinces and some African countries.

Aim and objectives: The aim was to gain a better understanding of the current scheduling system for orthopaedic theatres at a level three public hospital in the Dr Kenneth Kaunda District, North West. The first objective was to explore and describe how orthopaedic theatres and the current scheduling system function. Secondly, a lean management framework for orthopaedic theatre scheduling was proposed.

Methods: The research followed a qualitative single-case embedded design, with the two units of the orthopaedic operating theatres, theatres 1, and 3. The setting was the orthopaedic, administration, finance, pharmacy, and X-ray departments of a level three public hospital in the Dr Kenneth Kaunda District, North West. The literature reviews studied lean management in the healthcare environment, globally and in South Africa and Lean Six Sigma and 5S were found to be the most suitable lean management frameworks. The data was collected from multiple sources of evidence listed as 36 archival documents, eighteen (18*n*) semi-structured interviews and 250 pages of reflective notes. The research concluded with a proposed lean management framework developed from the typical activity flow for a patient from diagnosis, through surgery to discharge and was based on multiple objective programming, reactive and simulation models.

Five steps in the workflow were highlighted and applied to lean management principles. This framework addresses orthopaedic scheduling aiming to reduce waiting lists, cancellation of elective patients, and to improve efficiency and production.

Recommendations: It is recommended that the hospital invest in a central computerised network, linking departments, and application of scheduling software for operating theatres. Text messages could be sent to patients' phones from a centralised scheduling system. It is also recommended to have dedicated orthopaedic theatre staff, especially an anaesthetist, nursing staff, and a porter available on orthopaedic surgery days. Adopting such a lean management framework will help improve scheduling in the orthopaedic operating surgeries, theatre efficiency, as well as production.

Key words: Lean management, orthopaedic operating theatres, public hospitals, theatre scheduling, public health system.

(Abstract word count: 532)

TABLE OF CONTENTS

DECLARATION	I
PREFACE AND ACKNOWLEDGEMENTS.....	II
ABSTRACT	III
ABBREVIATIONS.....	XI
LIST OF DEFINITIONS.....	XII
CHAPTER 1: INTRODUCTION TO RESEARCH AND OVERVIEW OF THE METHODOLOGY.....	1
1.1 Introduction	1
1.2 Background	1
1.2.1 Increased demand for hospitalisation and orthopaedic surgery	1
1.2.2 Operating theatres expensive cost drivers in hospital	2
1.2.3 South African healthcare system	2
1.2.4 Current trends in South African public healthcare	3
1.2.5 Lean management in healthcare globally.....	4
1.2.6 Lean management in South African healthcare systems	7
1.3 Problem statement and research questions.....	7
1.4 Aims and objectives	8
1.5 Central theoretical argument.....	8
1.6 Context of the research.....	9
1.7 Research design.....	9
1.8 Type of case study in this research	12
1.8.1 Present the case.....	12

1.8.2	Research process.....	12
1.9	Research setting.....	17
1.9.1	Population	18
1.9.2	Sample	18
1.10	Data collection	19
1.10.1	Recruitment.....	19
1.10.2	Process of obtaining informed consent	19
1.10.3	Process of data collection.....	20
1.11	Data analysis.....	21
1.12	Rigour.....	22
1.12.1	Reliability	22
1.12.2	Validity.....	23
1.12.3	Trustworthiness	24
1.13	Ethics	25
1.13.1	Inclusion/exclusion	25
1.13.2	Disclosure.....	26
1.13.3	Direct and indirect benefits	26
1.13.4	Potential risks	26
1.13.5	Feedback.....	26
1.13.6	Data management	27
1.14	Outline of the mini-dissertation	27
1.15	Summary	27
1.16	Bibliography.....	29

CHAPTER 2: LITERATURE REVIEW ON LEAN MANAGEMENT APPLIED TO HEALTH SYSTEMS.....	36
2.1 Introduction	36
2.2 Conceptual framework.....	36
2.3 Lean management in healthcare defined.....	36
2.4 The history of Lean management.....	37
2.4.1 Lean management in production	38
2.4.2 Lean management in health	39
2.5 Lean principles	40
2.5.1 Lean Six Sigma methodology	40
2.5.2 5S methodology.....	40
2.6 Models of Lean management.....	41
2.6.1 Multiple objective programming	41
2.6.2 Modular model.....	43
2.6.3 The long waiting list of the stochastic programming.....	43
2.6.4 Goal programming.....	45
2.6.5 Mixed integer-programming.....	46
2.6.6 Simulation model.....	46
2.6.7 Reactive scheduling.....	47
2.7 Summary	48
2.8 Bibliography.....	49
CHAPTER 3: ARTICLE FOR PUBLICATION IN THE JOURNAL FOR PERIOPERATIVE CARE AND OPERATING ROOM MANAGEMENT.....	54

3.1	Introduction	54
3.2	Authorship	54
3.3	Authors guidelines	54
	MANUSCRIPT	59
1.	INTRODUCTION	59
1.1.	Orthopaedic surgeries a high cost driver in South African hospitals	60
1.2.	Lean management in healthcare	62
2.	RESEARCH AIM AND OBJECTIVES	64
3.	METHODS	65
3.1.	Data sources	65
3.2.	Inclusion criteria	66
4.	RESULTS	66
4.1.	Demographic data on orthopaedic wards occupancy	67
4.2.	Activity flow of scheduling orthopaedic surgeries	69
4.3.	Themes and sub-themes	71
4.4.	Current scheduling of the orthopaedic surgeries	74
4.5.	Recommended scheduling framework based on lean management	77
5.	DISCUSSION	80
6.	CONCLUSIONS AND RECOMMENDATIONS	81
7.	REFERENCES	83

CHAPTER 4: CONCLUSIONS, EVALUATION, LIMITATIONS AND RECOMMENDATIONS	91
4.1 Introduction	91
4.2 Evaluation	91
4.2.1 Research methodology	91
4.2.2 Aim and objectives of the research	92
4.2.3 Central theoretical statement	92
4.2.4 Rigour	92
4.3 Limitations	92
4.4 Recommendations.....	93
4.4.1 Recommendations for MBA curriculum.....	93
4.4.2 Recommendations for healthcare research	93
4.5 Summary	94
4.6 Bibliography.....	95
APPENDIX A: EMS-REC CERTIFICATE.....	96
APPENDIX B: APPROVAL LETTER FROM DEPARTMENT OF HEALTH NORTH WEST PROVINCE	97
APPENDIX C: INFORMED CONSENT FORM.....	98
APPENDIX D: DECLARATION BY PARTICIPANTS	101
APPENDIX E: LANGUAGE EDITING CERTIFICATE	102
APPENDIX F: TURNITIN DIGITAL RECEIPT	103

LIST OF TABLES

Table 1-1: Relevant situations for different research methods..... 11

Table 1-2: Data sources/type of evidence utilised in this research 17

Table 1-3: Summary of standards, strategies and criteria to ensure trustworthiness 24

MANUSCRIPT

Table 1: The activity flow of scheduling orthopaedic surgeries..... 72

Table 2 Themes and sub-themes..... 73

LIST OF FIGURES

Figure 1-1: The public health system in South Africa applied to orthopaedic care 3

Figure 1-2: Single-case embedded unit of analysis (adopted from Yin, 2014:50) 10

Figure 1-3: The research process 13

Figure 1-4: Single-case study procedure utilised in this research 16

Figure 2-1: Conceptual framework utilised in this research 37

Figure 2-2: Modular model of total hip replacement..... 44

Figure 2-3: Stages of delivery system for elective surgeries..... 45

Figure 2-4: Simulation optimisation interactive scheme 47

ABBREVIATIONS

ARV	Antiretroviral treatment
CEO	Chief Executive Officer
DoH	Department of Health
GDP	Gross domestic product
HHC	Health and Hospital Corporation
HIC	High income countries
HIV	Human immunodeficiency virus
ISO	International Organisation of Standard
KPI	Key performance indicator
LMIC	Low middle income countries
MIT	Massachusetts Institute of Technology
NHI	National Health Insurance
ORIF	Open reduction internal fixations
PHC	Primary health care
SADC	South and Sub-Saharan Development Community
UK	United Kingdom
USA	United States of America
UMIC	Upper middle income countries
VSM	Value stream mapping

LIST OF DEFINITIONS

Lean management: the operational principles and methods aiding organisations to improve on quality, and create maximum value for the patients by reducing waste and waiting times (Lawal *et al.*, 2014:103). In the context of this research the term implies the use of the Lean Six Sigma and 5S principles in addressing the reduction in the waiting list, cancellation by patients, theatre efficiency, and production.

Orthopaedic operating theatres: are operating theatres equipped with specialist equipment for surgical procedures and interventions of patients seeking orthopaedic surgery. There are two dedicated orthopaedic theatres in this level public hospital, namely theatres 1, and 3.

Level three public hospital: an academic or tertiary public hospital servicing patients on a referral system with specialist and intensive clinical care. This research focused on a level three public hospital in the North West Province.

CHAPTER 1: INTRODUCTION TO RESEARCH AND OVERVIEW OF THE METHODOLOGY

1.1 Introduction

Across the world, operating theatres are among the most expensive hospital resources due to a high demand of outpatients seeking treatment through surgical procedure, and a prolonged waiting list. This research proposed a Lean management framework to reduce the long waiting list of elective patients of orthopaedic surgeries for a level three public hospital in the North West Province. There have been a number of studies done across the world in high income countries (HIC) exploring various aspects of theatre scheduling. However, very few studies are done in both private and public healthcare systems in low to middle income countries (LMIC) and upper middle income countries (UMIC), including South Africa. There is limited implementation of theatre scheduling programmes in public healthcare systems in South Africa. The goal of this chapter is to provide the reader with a brief background and the rationale for the research. The problem statement, research objectives, questions and design, and methodology are presented followed by ethical considerations and strategies that enhance the rigour. The last part of this chapter provides the outline of the mini-dissertation.

1.2 Background

Theatres are equipped with specialist equipment for anaesthetic procedures and surgical interventions (Durán *et al.*, 2017:6). Operating theatres are an integral part of comprehensive healthcare and health systems.

1.2.1 Increased demand for hospitalisation and orthopaedic surgery

The rising demand for hospitalisation for an ageing society results in prolonged waiting lists of theatre scheduling and access to healthcare treatment (Denton, 2013:184). Globally, hospitals are challenged by the needs of older patients, neonate diseases and budget constraints (Jebali & Diabat, 2015:7252). Hospitals worldwide experience high numbers of outpatients seeking medical treatment through surgery, especially in orthopaedic theatres. These surgical procedures are grouped according to surgeons' specialities within the hospital (Morris *et al.*, 2015:128); for example, general, orthopaedic, gynaecology and obstetrics, and neurosurgery. Increased performance of orthopaedic surgeries such as joint replacements are presented in private and public hospitals (Jakovljevic & Getzen, 2016:1). According to Boas *et al.* (2015:283), hip and knee joint replacements are examples of such successful orthopaedic surgical procedures.

1.2.2 Operating theatres expensive cost drivers in hospital

Globally, health systems' costs have increased substantially in the last two decades due to progressive ageing populations, new diseases, new technologies and customers' expectation of high quality healthcare (Crema & Verbano, 2016:580). Operating theatres are major cost drivers in private and public hospitals considering that operating theatres account for approximately 40% of revenue and expenditure of the hospital despite limited resources (Penn, 2014:1). Theatres as main cost drivers are confirmed by Guerriero and Guido (cited by Freeman *et al.*, 2018:160) who stated that 60–70% of hospitalised patients required some kind of surgical intervention. In order to efficiently reduce waiting lists for elective patients and the costs of running the operating theatres, hospitals' management have invested in various research and development projects to explore efficient and productive operating theatres (Addis *et al.*, 2014:17).

1.2.3 South African healthcare system

Orthopaedic operating theatres in public hospitals are best understood within the complexities of the dualistic South African health system which is driven from a primary health care (PHC) philosophy and is geared to address a typical disease burden. South Africa and Nigeria have the highest human immunodeficiency virus (HIV) prevalence and incidence globally (Granich *et al.*, 2015:3). The South African Department of Health (DoH) initiated the integrated approach and management of chronic diseases at PHC clinics (Hussain & Malik, 2016:459). HIV has transformed into a chronic disease and South Africa has the biggest distribution of antiretroviral treatment (ARV) in the world with 7 million people infected by HIV; half of them are on ARV medication (Nordling, 2016:215). With the improved patient flow in the designated service areas of healthcare, PHC aims to integrate patients with chronic and communicable diseases to enhance improved patient outcomes with less waste (Mahomed *et al.*, 2014:1725).

The South African National Health Insurance (NHI) system stipulates that a hospital should service patients based on different categories within the health system (Le Roux *et al.*, 2015:116). There are three levels in the public health system, namely: level one, the primary health clinics; level two, district hospitals; and level three; academic or tertiary hospitals servicing provinces (Mohapi & Basu, 2012:79). Patients are referred upwards within the structure as shown in Figure 1.1 from PHC to specialist and intensive clinical care. However, patients still skip levels and move directly to level three, putting pressure on level three hospitals. The level three hospitals, therefore, end up providing a service that should belong to lower levels hospitals categories and this results in an overburdened, compromised quality of healthcare, and over expenditure (Mohapi & Basu, 2012:79).

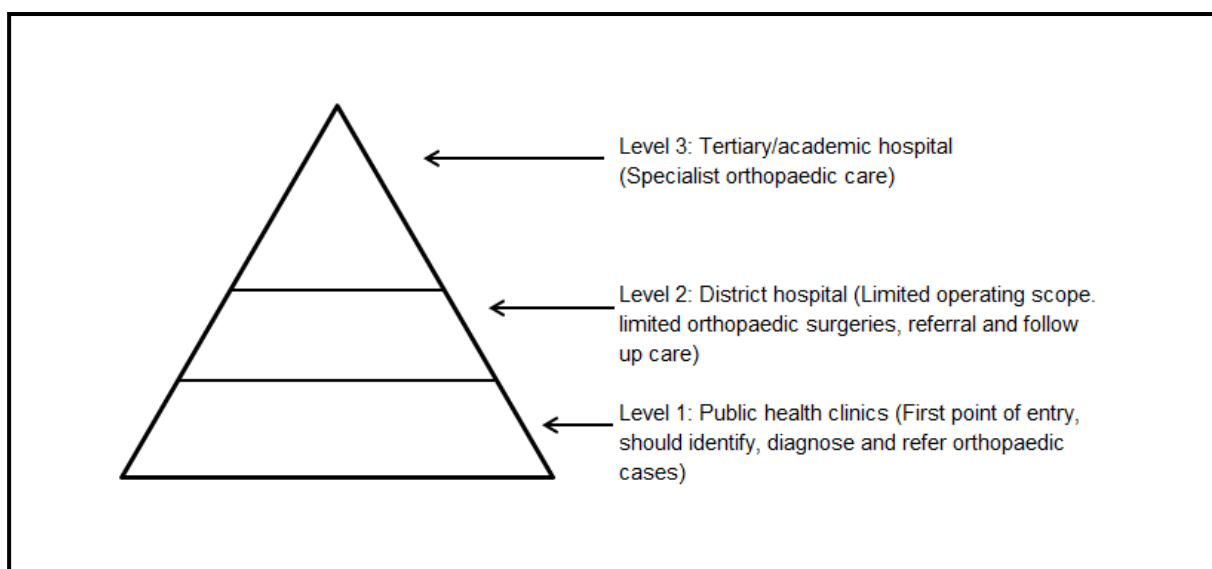


Figure 1-1: The public health system in South Africa applied to orthopaedic care

From 2009 to 2010 South Africa, regarded as the economic powerhouse of African Continent with its gross domestic product (GDP) of US\$364 billion, had an estimated spending of just over R200 billion or 8.6% of its GDP for both public and private healthcare (Naledi *et al.*, 2011:18). Such spending in terms of public health by the South African government is similar to countries such as Italy, England, and Spain; however, this investment has unfortunately not translated to improved health outcomes. The World Bank regards South Africa as one of the four African countries ranked as upper middle income countries (UMIC) like Botswana, Gabon and Mauritius (Naledi *et al.*, 2011:18). High demand for orthopaedic surgery in public hospitals also results from the high cost that private hospitals charge for orthopaedic operating procedures that compel private patients to seek surgeries at public hospitals due to low medical aid funds (Mokatsane, 2018). Scheduling of orthopaedic surgeries is also multidimensional when considering factors that impact scheduling and waiting times such as the cancellation of scheduled orthopaedic surgeries by elective patients on short notice, the unavailability of post-operative recovery beds (Dimitriadis *et al.*, 2013:1126), and the change in patients' health status that are contraindicated for surgery.

1.2.4 Current trends in South African public healthcare

There is a shortage of surgeons in obstetrics, anaesthesia, and orthopaedics in both the public and private health systems (Hoyler *et al.*, 2014:269) and South Africa has also experienced the pressure of a number of medical personnel being recruited by international countries. This loss results from several factors such as the country's high standard of medical personnel training, migration of personnel to international countries, heavy workloads, working conditions, and for economic reasons (Biermann, 2017:36-62). The public health system of South Africa contains only 30% of doctors while the remaining 70% are in private healthcare facilities. Approximately

only a mere 16% of South Africans are members of medical schemes or are covered by medical insurance while 84% (47.9 million people) rely on public health facilities (Biermann, 2017:38). Overburdened hospitals are characterised by deteriorated infrastructure, dysfunctional due to limited budgets, mismanagement, and neglect (Mayosi & Benatar, 2014:1346).

The South African public health system faces a steady increase in chronic diseases, its disease burden being four times higher than developed countries and sometimes double that of developing countries such as Brazil, Columbia, Ghana, Indonesia and Tunisia (Naledi *et al.*, 2011:18). Since the dawn of democracy, South Africa has experienced large numbers of refugees from African countries seeking political asylum and economic opportunities which has added even more strain on the public health system (Crush & Chikanda, 2015:313). South Africa has also become one of the leading medical tourism destinations as related to the North, South and Sub-Saharan Development Community (SADC) (Chikanda & Crush, 2017:6). Referrals of patients from the SADC to South Africa to receive specialist treatment like orthopaedic surgeries add more pressure to an already overburdened health system. For example, while Swaziland operates a government funded medical scheme for its civil servants and Phalala Medical Fund, citizens are referred to public and private hospitals in South Africa (Chikanda & Crush, 2017:6).

1.2.5 Lean management in healthcare globally

Operational efficiency and scheduling through Lean management may present a functional approach to orthopaedic operating theatres in public hospitals. Lean management is comprised of the operational principles and methods aiding organisations to improve on quality, and create maximum value for the patients by reducing waste and waiting times (Lawal *et al.*, 2014:103). According to De Koeijer *et al.* (2014:2911), improving the organisational performance is an urgent matter in the public healthcare environment, and many public healthcare sectors are embracing the methodologies derived from the car manufacturing industry in terms of Lean management. Lean management was copied from Toyota Car Manufacturer, an approach based on how efficiently the resources are used in terms of adding value to the product or service to the customers (Kinsman *et al.*, 2014:29). Eliminating waste speeds up response by the business to customer requirements (in the case of healthcare, for example, the patients' waiting time) and identifies system delays (for example, the time a patient spends from entry into a health facility until discharge). Furthermore, Singh *et al.* (2014:1) concluded that any organisation, including healthcare institutions, requires continuous improvement and innovation to remain cost effective, efficient, provide quality service with limited resources, and cope with equipment breakdown and budget constraints.

Since the early 2000s Lean management has emerged as a revolution in the healthcare environment for a better value-based, quality healthcare (D'Andreamatteo *et al.*, 2015:1197). While the State of Saskatchewan's Health Ministry in Canada rolled out transformation based on Lean management in its hospitals and claimed it to be the largest global Lean project, project reports agreed that patients' needs were not addressed in these Lean management processes (Kinsman *et al.*, 2014:29). According to Kinsman *et al.* (2014:29); Marchildon (2013:2), the Mason Health System in the United States of America (USA) uses Lean principles to improve patient flow, supply, procurement, and supplier payment in the hospitals. Generally, however, research has shown that implementing Lean management principles in health systems can help to create continuous learning cycles geared towards achieving positive health outcomes (Kinsman *et al.*, 2014:29).

In recent years, quality as a major challenge in health systems has led to the adoption of a series of standards such as the International Organisation of Standard (ISO) (9001:2000) (Yurtkuran *et al.*, 2017:11). This is a quality management system used by Iran, Turkey, and the Netherlands to name but a few (Forough & Valmohammadi, 2015:598). Despite meeting accredited levels approved by the ISO and adopting a series of standards, hospitals in Europe could not reduce their expenditure costs (Yurtkuran *et al.*, 2017:11). With ever-rising health expenditure, many health systems globally have started to explore various quality improvement methodologies to reduce cost without compromising on quality. One such selected methodology was Lean management and is still applied by management in many countries around the world in both public and private hospitals (Hussain & Malik, 2016:1).

Lean management and Six Sigma methodologies are popular in terms of operations management (Lighter, 2014:9). On one hand, Lean management methodology concentrates on improving and adding value to products or services in order to remove waste and lessen waiting times (Mason *et al.*, 2015:92), while Six Sigma, on the other hand, is a quality improvement methodology aimed at reducing variations in quality products (Ahmed *et al.*, 2013:190). It originated from the Japanese concept of "Kaizen" which is continuous quality improvement and was adopted by Toyota in the early 1990s (Stanton *et al.*, 2014:2926). Combining Lean and Six Sigma, re-engineered into Lean Six Sigma; a continuous product/service quality improvement, to create the maximum value for patients, reduce waste and waiting times at health facilities (Stanton *et al.*, 2014:2926). Later in the early 2000s, the Department of Health of the Australian State of Victoria adopted the use of Lean Six Sigma and other processes to improve the efficiency and effectiveness of its public hospitals with limited resources and budget constraints (Stanton *et al.*, 2014:2927). One of the biggest public hospitals in Australia uses Six Sigma methodology in its emergency department to resolve access blockages that result from high

service demands with patients waiting long before getting emergency medical treatment and being transferred to hospital (Holden, 2011:265; Stanton *et al.*, 2014:2926).

The Health and Hospital Corporation (HHC) in New York, the largest public health system in the USA, began using Lean management methodology in various operating theatres to measure performance, utilisations, on-time starts, turnover times and same day cancellations (Castaldi *et al.*, 2016:25). The Lean Six Sigma applications used in the public and private hospitals led to the improved efficiency and increased resources. One of the public hospital in Australia's Victoria State had a positive outcome with the increased flow of patients in the emergency department (Castaldi *et al.*, 2016:25). Contrary to adoption of Lean Six Sigma methodology in Australia, with the existing insignificant budgets, resources, and less commitment by staff, the project will not see the positive results that hospital management wanted to achieve (Stanton *et al.*, 2014:2935). In the United Kingdom (UK), hospitals face an increased patient influx, budget constraints, resource and equipment failures (Penn, 2014:1). Lean management has enabled reduced waiting times for surgery, eliminated waste in terms of scheduling and operating time until the patients is discharged from the hospital (Stanton *et al.*, 2014:2926). In 2005, the Department of Health, UK, adopted the National Health Service eight-hour rule as key performance indicator (KPI). This KPI implies 80% of patients entering the emergency department are admitted, will receive medical treatment, and be transferred to the wards within eight hours and without delays (Stanton *et al.*, 2014:2926). According to Rasmussen and Johnsen (2017:6), in the last 15 years Norwegian hospitals were subjected to frequent changes in healthcare management by applying Lean management which resulted in improved scheduling and more efficient management of orthopaedics theatres.

Despite Lean management being applied to health systems in high income countries (HIC), there is little implementation in low-income countries (LIC) to upper middle income countries (UMIC) due to challenges with infrastructure, limited resources and government funding said Souza and Mazzacato (cited by Costa *et al.*, 2017:100). According to Barraza and Pujol (cited by Tortorella *et al.*, 2017:1544), the new management practice in Brazil uses value stream mapping (VSM) to deal with obsolescence of administrative models as adopted in public organisations in striving to achieve better quality standards in the public service delivered in general to citizens. VSM is also used in Brazilian public healthcare to reduce wastes, manage inventory levels and production lead times, and improved the validity of Lean management, especially in the sterilisation department of public hospitals (Tortorella *et al.*, 2017:1544).

Help Private Hospital in India used Lean management to improve value and reduce the waiting times of outpatients while VSM and root cause analysis enabled waste reduction, reduced patient waiting times, improved productivity and quality in the health system (Miller & Chalapati,

2015:58). The 5S management method is one of the Lean management methodologies *and stands for the Japanese abbreviation for Seiri, Seiton, Seisou, Seiketsu, and Shitsuke*, which mean sort, set in order, shine, standardise, and sustain, respectively (Kanamori *et al.*, 2016:2). Sri Lanka, Tanzania, and Senegal have adopted the 5S management method as their national health strategy to improve public healthcare quality and it has been indicated that this management method, when applied to public healthcare facilities, leads to the improvement of common problems such as lack of orderliness with documents and supplies, deficient labelling, directional indicators of service units, and precarious, overall cleanliness (Kanamori *et al.*, 2016:2). Other observed changes from the 5S management method include improved working processes and clinical indicators, increased patient satisfaction, elimination of safety violations, and increased physical space (Ikuma & Nahmens, 2014:245).

1.2.6 Lean management in South African healthcare systems

Lean management has also been applied in both private and public hospitals in South Africa. Arwyp hospital, a private hospital in Gauteng, has applied Lean management to solve the shortage of nurses, doctors, and specialists, and has focused on patient quality and safety, balancing the cost and the service benefit, infection control, and reduced infection rates from central lines associated bloodstream infections in all hospital departments. Reduced patient waiting time in the emergency department has removed waste (Theunissen, 2012:2). As South Africa applies a PHC philosophy, various challenges in rural healthcare facilities staff shortages, limited resources, and legacy infrastructure are real challenges. Catherine Booth, a rural district hospital in KwaZulu-Natal, applied Lean thinking to determine its impact on operational efficiency and staff morale within the outpatient department and provided interesting insights. The patient treatment cycle and waiting times were measured for all service nodes and with the use of Lean management it was concluded that staff morale and efficiency improved significantly (Naidoo, 2013:2). (Dube, 2017), the CEO of Leratong Hospital in Johannesburg said the application of Lean management methodology assisted in eliminating patients' waiting times and congestion in clinics, pharmacy, and other departments. The CEO of Charlotte Maxeke Hospital in Johannesburg confirmed that the hospital used Lean management in operating theatres and reported 36% utilisation improvement in this sphere (Bogoshi, 2017).

1.3 Problem statement and research questions

Pre-operative patient care is challenged by the lack of dedicated anaesthetic wards, the prevalence of broken equipment, shortage of staff availability, cancellations by elective patients, and limited post-operative recovery beds. When there is no software or system for orthopaedic theatre scheduling, and when planning is done manually with a long waiting list of elective

patients, these challenges become even greater and are representative of various public hospitals in South Africa and in this research, a level three public hospital in the Dr Kenneth Kaunda District, North West Province, South Africa. This serves as a catalyst to understand what these orthopaedic theatres entail and how they function.

Expounded from the background and problem statement, the research questions raised were: “How did the scheduling system of the orthopaedic theatres of a level three public hospital in the Dr Kenneth Kaunda District function at the time of the research?” and “What was the most appropriate Lean management framework to improve the orthopaedic theatre scheduling, efficiency, and production of the orthopaedic theatres of the level three public hospital in the Dr Kenneth Kaunda District?”

1.4 Aims and objectives

The aim of the research was to gain a better understanding of the current scheduling system of the orthopaedic theatre at the level three public hospital in the Dr Kenneth Kaunda District in order to improve this system by means of an appropriate Lean management framework. The aim was achieved by means of the following objectives.

- **Objective 1:** To explore and describe the current scheduling system of the orthopaedic theatre system of a level three public hospital in the Dr Kenneth Kaunda District by means of research.
- **Objective 2:** To propose a Lean management framework to improve the orthopaedic theatre scheduling, efficiency, and production of a level three public hospital in the Dr Kenneth Kaunda District.

1.5 Central theoretical argument

Orthopaedic theatres are expensive, overburdened, and continuously in demand in public hospitals both globally as well as in South Africa. The orthopaedic theatres of a level three public hospital in the Dr Kenneth Kaunda District, North West Province, experience a high demand, long waiting times, lack a scheduling system, and are in need of a system to enhance efficiency and production. A case study was used to assist the researcher to gain a deeper understanding of how the scheduling system of the orthopaedic operating theatres of this hospital functions. This insight was combined with literature about Lean management and led the researcher to propose an appropriate Lean management framework to the hospital to improve orthopaedic theatre scheduling, and eventually facilitate efficiency and production.

1.6 Context of the research

The hospital is a level three public hospital in the North West Province of South Africa that services the Dr Kenneth Kaunda District and neighbouring districts with specialist care and attracts patients from neighbouring provinces and other African countries with its good performance, shorter waiting list of elective patients (compared to other hospitals), and good reputation. Section 1.9 of the research demonstrates how this hospital attracts orthopaedic patients from far due to its good reputation and shorter waiting list as compared to other level three public hospitals in South Africa.

1.7 Research design

According to Yin (2014:9), a case study enquiry is preferred when the enquiry seeks the answers to “how” or “why” questions. The research question asked how the scheduling of the orthopaedic operating theatres has been done and how successful it has been in theatre optimisation. The “why” question for this research corresponds to the long waiting list of the elective patients of orthopaedic surgeries procedures since the researcher had little control over the events of the orthopaedic scheduling in its real life context (Yin, 2014:16).

The research is defined as a strategic or empirical enquiry in which the case to be investigated takes centre stage. The researcher was able to explore in detail a programme, activities and processes (Yin, 2014:16) in the orthopaedic department when scheduling theatre block time from the time the patient is first scheduled until he/she is discharged from hospital. A qualitative research strategy was implemented. As there were two units that had similarities (Yin, 2014:62) because of the hospital having two dedicated orthopaedic operating theatres, a single-case embedded design was implemented (Yin, 2014:62). In this research, the operating theatres did not deal with the same type of orthopaedic procedures all the time. Theatre 1 was used mostly for what is termed “clean surgeries”, total hip replacements, total knee replacements, arthroplasties and laminectomies or fusion. Theatre 3 dealt with surgeries where patients had an existing infection, and emergencies cases from the morning until midnight.

This research focused on the orthopaedic department, on how the scheduling for the operating theatre block time was done, and how effective it was. In addition, the choice of certain procedures that were followed in scheduling was investigated as well as the operating theatre block time for elective patients, regulations, and policies. Moreover, the research was aimed at uncovering if there were factors that contributed to the long waiting list of the elective patients and the maximum utilisation of operating theatres.

The research included exploring the interaction of the sections of the orthopaedic scheduling, theatres and wards; and how they function to provide medical treatment to patients. The single-case embedded strategy was proposed as it involved two units of analysis and attention was given to embedded sub-units (Yin, 2014:51). Figure 1.2 presents the proposed single-case embedded design of the two dedicated orthopaedic operating theatres in a level three public hospital, titled theatres 1 and 3.

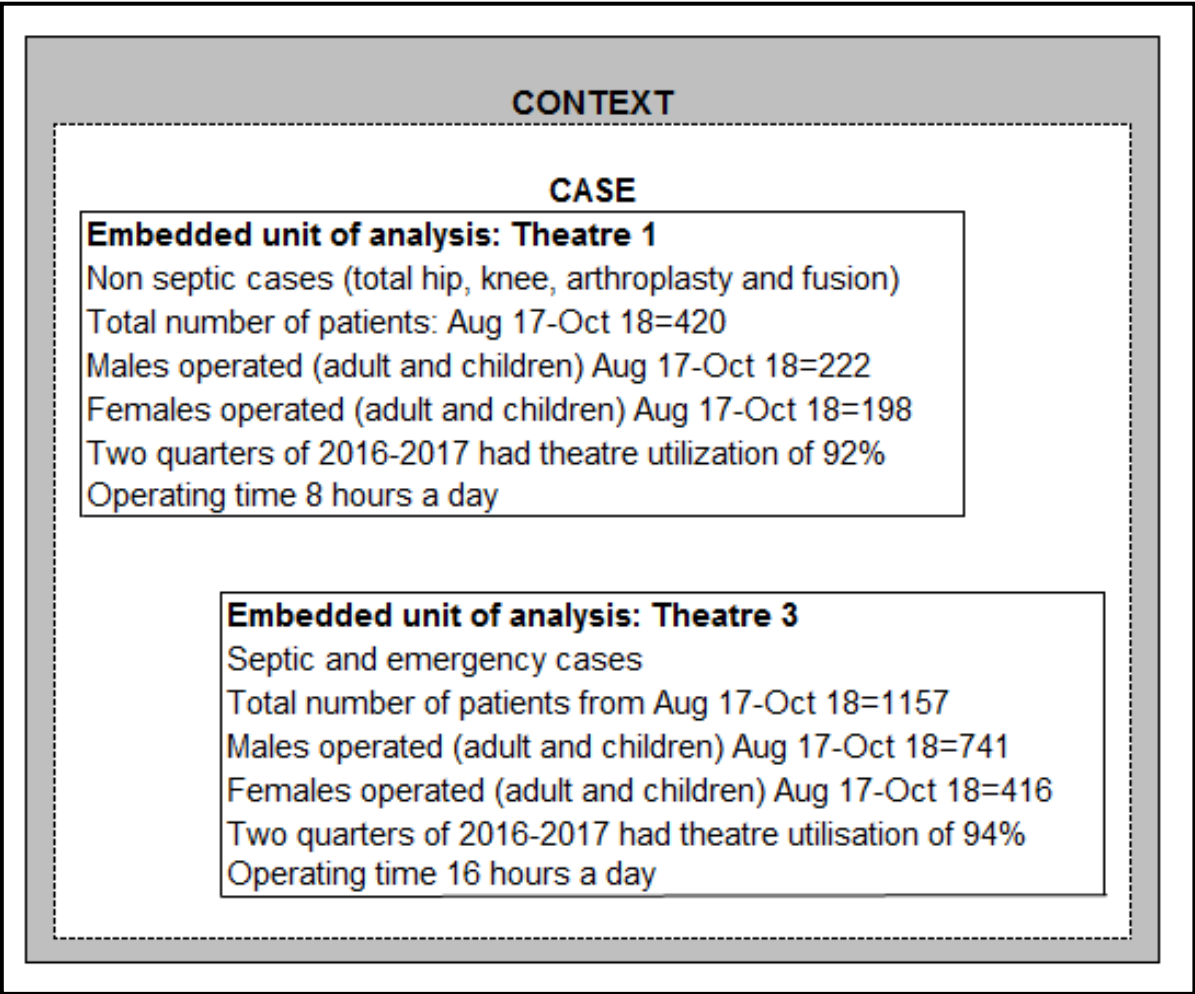


Figure 1-2: Single-case embedded unit of analysis (adopted from Yin, 2014:50)

There are different conditions that necessitate different methods in case studies. Table 1.1 presents four conditions and how each relate to the five major research methods, namely: experiment, archival documents, history, reflective notes and case study (Yin, 2014:9). The importance of how the four conditions are distinguished from the five methods (column 1) is as tabulated below and described thereafter. Each research design has advantages and disadvantages relying mostly on the researcher’s conduct in collecting, evaluating, analysing data and subjective to the following three conditions:

- The type of research question posed.

- The extent of control the researcher has over the behaviour/events.
- The degree of focus on contemporary events as opposed to historical events.

Table 1-1: Relevant situations for different research methods

1 General strategy	2 From research question	3 Requires control of behavioural events?	4 Focuses on contemporary events?	5 Applied to this research
Experiment	How, why?	No	No	Not applied to this research
Archival documents	Who, what, where, how many, how much?	No	Yes	Years retrospective (2016-2017), history, types of surgery procedures, how and why
History	How, why?	No	Yes	Included in archival documents and reflective notes
Reflective notes	How, why?	Yes	Yes	Wrote down field notes
Case study	How, why?	No	Yes	All of the above conditions applied

(Adopted from Yin, 2014:9)

The type of research question posed: (see Table 1.1, column 2). The first condition covers the research questions, “who”, “what”, “where”, “how”, “why”, “how many” and “how much” questions. An experiment is favoured by the “how” and “why” and why questions: how was the scheduling in the orthopaedic done and why was it done that way. Looking at the second condition the researcher has no control of the behavioural events, no focus on contemporary events. The experiments strategy is not applicable to this research.

Archival documents are reflected on the following research questions: “who”, “what”, “where”, “how many”, and “how much” line of enquiry, for example who were the elective patients operated, what type of operation procedure they received, how many patients were operated over a specific period. Lastly, how much it cost to do such an operating procedure. On the second condition the research had no control over behavioural events, yes on the focus contemporary events. The last condition involves the research looking at the last years of retrospective between 2017-2018 on the history and types of surgery procedures, how and why as applied to this research.

History strategy covers the questions of “how” and “why” the scheduling was done in the past. The research has no control over behavioural events. And focused on contemporary events as it zooms in to the specific period. The researcher reflected on the archival documents and reflective notes as applied to this research from the beginning until the end (December 2017-December 2018).

Case study strategy is represented by the “how” and “why” questions, for example how was the scheduling in the orthopaedic theatre done and why was it done that way. The research had no control over the behavioural events, focusing on the contemporary events only and included archival documents, reflective notes, and semi-structured interviews into the research.

1.8 Type of case study in this research

To avoid duplication between the two theatres, collected data and evidence are separated from each other. For the purpose of this research the single-case embedded design procedure of a level three public hospital was studied as shown in Figure 1.3.

1.8.1 Present the case

The participating level three public hospital in the Dr Kenneth Kaunda District in North West Province of South Africa is made up of two hospitals that used to operate independently, one serving the African community and the other the White community. In the 1990s the two hospitals merged to become a fully departmental hospital complex. The hospital complex renders level 1 and 2 services to the Dr Kenneth Kaunda District, Bophirima District, and partial level 3 services to the whole of North West Province. One of the specialist services that the hospital provides are orthopaedic surgeries which have a high volume of elective patients on the hospital waiting list. The hospital attracts orthopaedic patients from neighbouring provinces and certain African countries due to its good reputation and shorter waiting list compared to other public hospitals.

1.8.2 Research process

The steps followed in the research are graphically depicted in Figure 1.3 and briefly discussed hereafter. These steps are summarised in Figure 1.3.

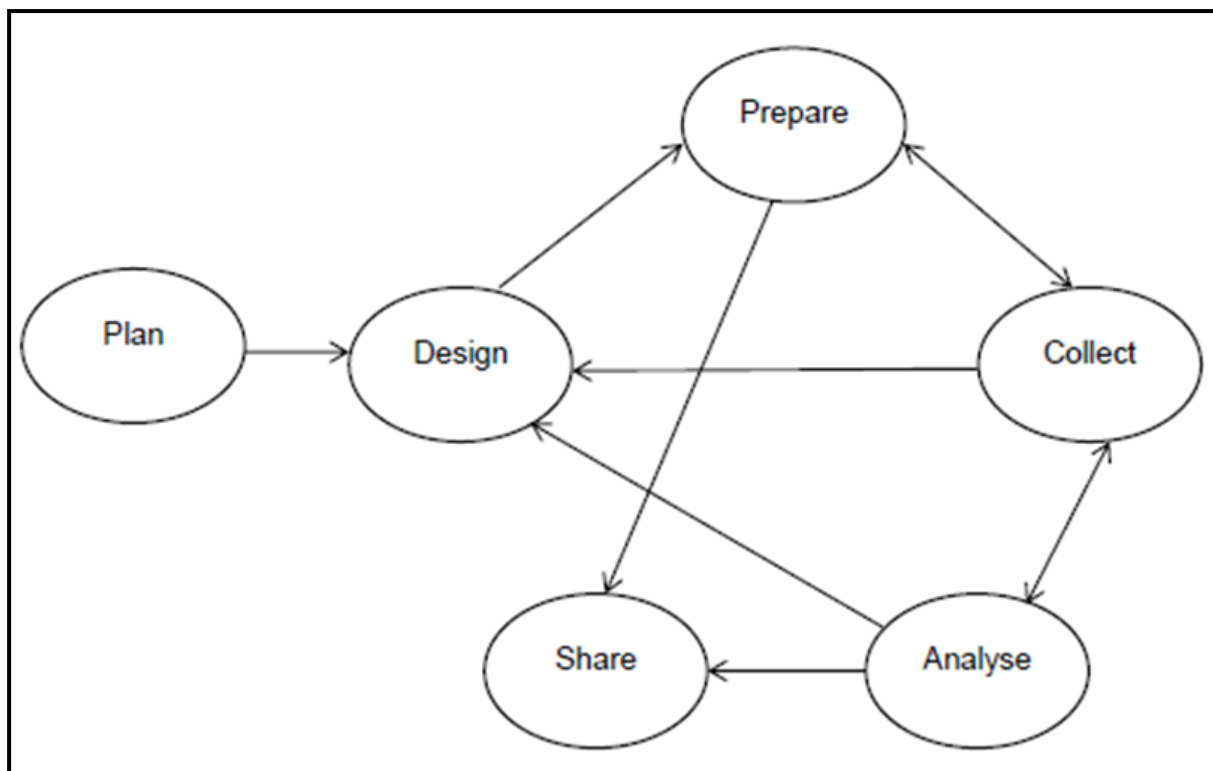


Figure 1-3: The research process

(Adopted from Yin, (2014:1))

STEP 1: PLAN

Planning was the first step the researcher took to distinguish which research method to follow, by reviewing the advantages and disadvantages of each method (Yin, 2014:3). The researcher identified a single-case embedded design as the most suitable research design to be used. The strengths of the research methods were explored and aimed to collect, present, and analyse data fairly. While other research methods have limited archival information, histories, and survey data, this method seemed more appropriate. The researcher was able to understand the unfolding data from the research enquiry.

STEP 2: DESIGN

A research design is the logic sequence in linking the collected data by answering the initial question as to the reason to do research (Yin, 2014:26). The researcher defined the unit of analysis and the two cases to be studied, namely those of theatres 1 and 3. A single-case embedded design was identified as the best approach.

STEP 3: PREPARE

In this step the researcher identified the critical skills required to do research and then developed a research protocol. Through regular supervision the researcher was trained to do the research.

STEP 4: COLLECT

A researcher can have many sources of evidence with the following six types: documentation, archival records, interviews, direct observation, participant observation, and physical artefacts (Yin, 2014:103). The following three types of evidence were included in the research for the period between December 2017 up to October 2018:

Type 1: Archival documents included booking policies and related documentation of the day-to-day bookings of elective patients for orthopaedic theatre surgeries. Through the archival documents, the researcher was able to retrieve the files in Microsoft Excel format and records of past scheduled orthopaedic surgeries cases, number, patients' gender, organisational records, theatre efficiency, and types of surgeries performed over a given period between August 2017 up to October 2018.

Type 2: Eighteen (18n) semi-structured interviews were conducted with health professionals, healthcare workers, senior management, and administrative staff over a period August 2017 up to October 2018. The interviews allowed conversation with the participants and took place at the workplace of the participants; professionalism, and ethical contact was always maintained by the researcher. With the permission from participants, the interviews were recorded for transcription. The interviews were kept to a minimal time, during breaks, as not to distract the participants from the daily operations of the department. The identity of the participants was kept anonymous in the interview sessions and confidential thereafter.

Type 3: 250 pages of written reflective notes were done from the beginning of the research to the end. Yin (2014:102) noted that incorporating different sources of evidence calls for mastering different data collecting procedures which prolonged the inquiry of the research fieldwork time. The three sources of evidence used, increased the quality of the research and enhanced the enquiry outcome substantially because of provided rigour throughout triangulation. (Yin, 2014:102). During the research, the researcher reflected on the relevant social and environmental conditions that occurred in the orthopaedic department. The culture of the organisations and activities observed formed part of the evidence. Table 1.2 shows the data source/types of evidence and the research method used in this research.

STEP 5: ANALYSE

There are five specific techniques in determining which data to analyse and why in any research that could be used, in this research the researcher chose the pattern matching and time series analysis (Yin, 2014:132). In this research, the researcher developed a general analytic strategy. The data was displayed in different ways over and above the interpretations, and the researcher tried to stay true as possible to the findings gleaned from the data collection. The researcher

relied on theoretical propositions and Lean management principle that developed the research description. Figure 1.4 presents the flow diagram that was drawn and then adapted according to Lean management principles. The figure indicates that the initial step in designing the research was identifying the theory on Lean management in orthopaedic theatre scheduling. The second step was single-case embedded study consisting of two orthopaedic theatres of which data was prepared, collected, combined and then analysed. The final step was the adaptation of the activity workflow referred back to the original theoretical proposition and applied Lean management principle to propose an adapted workflow for orthopaedic scheduling.

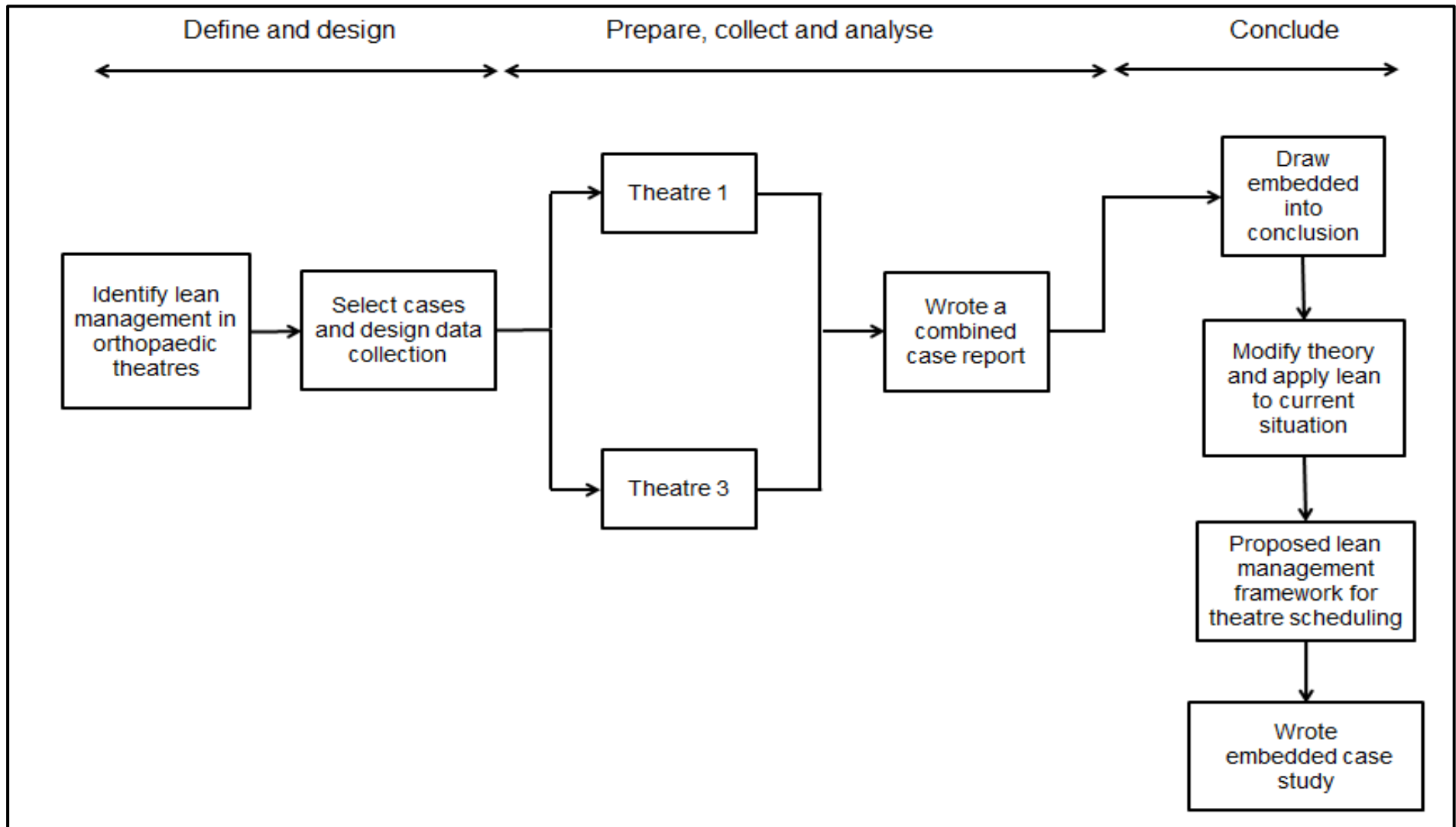


Figure 1-4: Single-case study procedure utilised in this research
 (Adopted from Yin, 2014:60)

STEP 6: SHARE

The research findings are shared in this written report. The collected evidence was presented in such a way that the researcher was able to reach a conclusion about the research findings and reviewed the findings several times for the sake of quality. The researcher prepared the article to be published about the research consent.

Table 1-2: Data sources/type of evidence utilised in this research

	Archival documents	Semi-structured-interviews	Reflective notes
Population	Archived documents of operating theatre scheduling, booking policies, theatre utilisation	n=2 senior managements, n=3 management, n=2 doctors, n=6 orthopaedic staff, n=2 pharmacy and n=1 for administration, finance, and X-ray	Embedded case
Sample size	All inclusive	n=18 participants	Embedded case
Inclusion	Relevant documents to the research	All inclusive	All inclusive
Data collection		Semi-structured interviews	Reflective notes
Trustworthiness	Triangulation Multiple source of documents	Strategies to enhance trustworthiness Guba and Lincoln (Krefting, 1991:217)	Strategies for reflective notes (Yin, 2014:113)

1.9 Research setting

In order to contextualise this research, a level three public hospital in Dr Kenneth Kaunda District with specific reference to orthopaedic theatres served as the research setting. The hospital has eight operating theatres of which two are dedicated to orthopaedics, three generals are surgical wards, and two are orthopaedics wards, one for females and one for males; both wards have 34 beds each. Theatre 3 is one of the orthopaedic theatre is functioning on a 16-hour basis (continues with scheduled and emergency cases until midnight). During the two-quarters of 2016 and 2017 theatre 1 and 3, utilisation was at 92% and 94% respectively. The hospital does not have a computer scheduling program for the elective patients of the orthopaedic theatres. There are no dedicated anaesthetic wards for the patients prior to and after the operation. The staff shortage in the orthopaedics theatres, heavy equipment used in the theatres, unavailability of equipment and breakdowns affect the flow of scheduling operating times (Mokatsane, 2018). This level three hospital (also referred to as a tertiary or an academic hospital) attracts a large number of patients from districts within the province, neighbouring provinces, and African countries seeking orthopaedic surgeries. Some private patients with low medical funds and patients paying for their surgery cost bring much-needed revenue to the

hospital to cover the high operating theatre expenditures (Mokatsane, 2018). The majority of orthopaedic surgeries concern fractured legs, amputations, fingers, toes, arms, femurs, shoulders, vascular procedures etc. The elective patients follow with the number of orthopaedic surgeries performed of knee and hip replacements.

1.9.1 Population

For the purpose of this research the orthopaedic theatre department, which entails two theatres with the associated departments and staff, served as the population. The orthopaedic health workforce, administration, pharmacy, finance, X-ray and management are the main departments included in the embedded case. The main reason for the selection of the above-mentioned population was that these departments are mostly involved in or interact with the scheduling orthopaedic theatres surgeries. In order to create awareness about this research, the researcher informed potential participants about the research and they were invited to participant in semi-structured interviews.

1.9.2 Sample

To select the participants for interviews, the purposeful sampling was used since the population was responding to the researcher questions. According Patton (cited by Palinkas *et al.*, 2015:534), purposeful sampling strategy is widely used in the qualitative research for the identification and selection of in-depth understanding in research for the most effective use with limited resources. Qualitative research is more flexible than quantitative research with this sampling technique (Dolley, 2014:68). The orthopaedic staff and management involved with the scheduling of orthopaedic theatres are ideal participants for commenting on the research. A comprehensive sampling of all available participants within the research record was accessed. The researcher purposively selected the following members for sampling: two senior managers of the hospital (the CEO of the hospital and the clinical manager), orthopaedic management, and staff in the orthopaedic, administration, pharmacy, and X-ray departments.

The following reasons justify why the sample size of a qualitative research was kept to a minimal:

- The data was properly analysed, at some point saturation was reached as no new evidence was uncovered.
- The sample size was adequate enough as it was diverse and incorporated from all the disciplines involved with the scheduled orthopaedic theatre surgeries.

- The researcher used multiple sources of data collection, archival document, semi-structured interviews, and reflective notes.

The qualitative research's strength is its ability to produce rich source of information from data collected. The sample size that answered the research questions was appropriate for this qualitative research and relied on data saturation (Yin, 2014:110).

1.10 Data collection

The data was collected by archival documents, semi-structured interviews and reflective notes with management, orthopaedic, administration, finance, pharmacy, and X-ray departments. The researcher found the three above-mentioned data collection methods collectively to be more appropriate when looking for more evidence in this research.

1.10.1 Recruitment

The participant engagement and recruitment process followed are declared step-by-step hereafter:

STEP 1: Obtained ethical approval from the Economic and Management Sciences Research Ethics Committee (EMS-REC) at the North-West University (see Appendix A).

STEP 2: Permission from North West Provincial Department of Health (see Appendix B).

STEP 3: Permission from CEO of the hospital as the gatekeeper.

STEP 4: Gatekeeper appointed mediators.

STEP 5: Individual participants identified.

1.10.2 Process of obtaining informed consent

The researcher issued the informed consent form to the target population prior to commencement of the research (see attached Appendix C) and ensured the following:

- The consent was issued to the target population alerting them of the nature of the research, what the research was all about and formally soliciting them to participate in the research.
- Participants were protected from any harm and the researcher avoided deception in the research.

- The researcher ensured the privacy and confidentiality of the participants and conducted the research ethically at all times.
- In this research there were no vulnerable groups.
- Selected orthopaedic staff represented different occupation levels within the department so that no other people are unfairly included or excluded in the research population.

1.10.3 Process of data collection

According to Creswell (cited by Crowe *et al.*, 2011:106), in increasing internal validity, multiple sources of data (data triangulation) was used and is advocated as the best approach. The archived documents were retrieved from the administration, finance, pharmacy, orthopaedic and X-ray departments, analysed, and processed. These documents included the booking policies and related documents for the day-to-day bookings of elective patients of orthopaedic surgeries. These Microsoft Excel documents were downloaded from the hospital computers data storage file of the scheduled orthopaedic theatre surgeries of the period August 2017 to October 2018. The documents had information of records of the past orthopaedic surgery cases, number of patients, gender, and type of surgeries performed.

The semi-structured interviews were conducted, with the management, and staff from the administration, finance, orthopaedic, pharmacy, and X-ray departments. The interviews were useful as they encouraged openness while eliciting multiple perspectives on a phenomenon, effective but sensitive in some areas. The researcher interviewed all the participants at the hospital premises in a quiet area during breaks and before the start of the shifts. The smaller groups allowed all the participants a chance to talk and share their thoughts and, at the same time, was large enough to enable a diverse data collection (Lasch *et al.*, 2010:1092). It is the standard practice to audio record the interviews and used as another way of gathering data as it becomes a more neutral and less intrusive to the interview proceeding due to the researcher taking notes (Ritchie *et al.*, 2013:167). The researcher indicated the desire to record the interviews for transcription and it was left up to the participants to agree or not. The participants identified were protected by the researcher who used only numbers as references in the research. Two participants were unsettled to be recorded, even when the researcher provided a logical explanation about the value and confidentiality. The researcher honoured their wishes and interviewed them without recordings. Later, the researcher noted down what was said by the participants. The transcript data from the interviews was coded and used at the later stage with the data derived from the literature (Crowe *et al.*, 2011:7).

Reflective notes of 250 pages were done taken from the beginning of the research until the end. During the research, the researcher reflected on the relevant social and environmental conditions that happened in the orthopaedic department. The culture of the organisations and activities observed formed part of the evidence. Table 1.2 shows the data source/types of evidence and the research method used in this research.

1.11 Data analysis

Archival documents were studied in order to make sense of how the orthopaedic theatre scheduling was done in the hospital and later analysed. The initial data was transferred from the reflective notes and memos and analysed for the findings' outcome. The original recording of the audio was transcribed and this allowed the researcher to access the original recordings as raw as they were. After transferring the audio files into the computer and beginning to transcribe, the resulting file was stored on the computer (Friese, 2014:50). In working with data, the researcher broke it down into manageable sizes, synthesised it, determined what was important, and searched for promising patterns and lessons. The research questions and research aim were used as the guiding tool in collecting pieces of data and logical arranging them. The researcher reconstructed the collected data into manageable format that was used for findings purposes.

Creswell (2014:197-200) suggests blending the general steps of data analysis with the specific research strategy looks into; this step involves the multiple levels of analysis in which the research follows this technique in the research:

STEP 1: Organised and prepared data for data analysis; this was done in different ways, the audio recordings of the interviews with the target population was transcribed into data for analysis. The reflective notes were typed in Word format and stored on the researcher's laptop. Useful data for the research was scanned and sorted for data analysis.

STEP 2: All the data was read thoroughly in order to get a better understanding of the overall information collected. The notes were jotted down along the data margins as the researcher was reading the data.

STEP 3: The audio recordings of the interviews conducted were transcribed; even though it was a time-consuming exercise, it gave researcher the sense of the first review of the material collected. Coding was done in order to organise the collected data into manageable chunks, starting at the earliest stages of data collection and continuing throughout the research process.

STEP 4: The coding process was used to generate settings of the orthopaedic theatres and the orthopaedic staff of the hospital. The detailed description of the theatres and the staff was done in the research.

STEP 5: The findings were written down and represented the two dedicated orthopaedic theatres. This included the detailed discussion of several themes of the orthopaedic theatres with interconnecting themes.

STEP 6: Made sense of the data by interpreting the data analysis; the researcher learned a lot from this research. Through interpretation of data the theories and literature could be referred to in order to allow the researcher to interpret this data. The qualitative research design was so flexible that through the research journey new questions emerged (for example, interaction of pharmacy, and radiology department with orthopaedic theatres).

1.12 Rigour

The researcher used multiple sources of data for the interpretation, and philosophical concepts to come up with the conclusive research findings. Such multiple sources were: archival document, semi-structured interviews, and reflective notes to gain a better understanding of the phenomenon (Claydon, 2015:43). In order to enhance the quality or the rigour of the qualitative findings, the researcher adhered to reliability, validity, and trustworthiness (Anney, 2014:272). According to Polit and Beck (cited by Cope, 2014:89) the credibility of the research is of the utmost importance as it reflects the truth of the data or the participants' views about the topic and interpretation. In supporting the credibility when reporting the qualitative research, the researcher showed engagement, methods of reflective notes, archival documents, and semi-structured interviews.

1.12.1 Reliability

The researcher ensured a constant reliability relating to multiple sources of evidence and data retrieved for analysis without being biased. The researcher also ensured that he followed the same procedure for all cases without replicating the results of one case to the next. Yin (2017:36) defines the objective of reliability in a case study as minimising the errors and biases. The researcher used the following approaches in enhancing the reliability processes and results as mentioned below:

- Ensured constantly that data was accurate and comprehensive.
- Checked the transcripts for correctness, ensuring there was no deviation of codes while analysing data.

The researcher ensured the data extracted from the original sources were verified for accuracy in terms of context and made constant comparisons.

1.12.2 Validity

In ensuring the accuracy of findings in a qualitative research, the researcher used the following tools in processing data: credibility, authenticity, and trustworthiness which were used in checking the validity of qualitative research (Leung, 2015:325). Creswell (2014:197-200) recommends the use of multiple strategies to ensure validity. Creswell suggests the eight strategies; and the researcher used the following four strategies:

- Triangulated different sources of information by examining the evidence from sources and using it to build a single-case embedded research theme. The methods used were interviews and reflective notes through the research process.
- After the report findings have been compiled, the researcher took back the report to the participants for confirmation of accuracy of the data captured. This was done by arranging the follow up interviews.
- In order to ensure the quality of the research a detailed description of the single-case embedded research was provided.
- The researcher avoided being biased and used the self-reflection as the core characteristic of the qualitative researcher.

The researcher avoided any negativity or discrepancy in doing the research as it would defeat the original objective of doing research.

- Spent more time in the field in order to have an in-depth understanding of the phenomenon being studied and have informed fair findings that are credible, trustworthy, and dependable.
- Made sure that debriefing was done with the research supervisor and co-supervisor in order to enhance the accuracy of the research and to ensure engagement with the supervisors about the phenomenon.
- The researcher made some observations in different departments in conjunction with the scheduling of the orthopaedic theatre surgeries about the activities happening in the departments.

1.12.3 Trustworthiness

The trustworthiness of the qualitative research ensured the credibility and validity which the researcher subscribed to through the research process. In ensuring the trustworthiness of a qualitative research, the following five epistemological standards were established by the researcher:

With the multiple realities and sources within the researcher's reach, the researcher was always neutral to the findings and reflected the true value of the findings; reflected on the notes taken and documentation and this assisted with the matters that the researcher might have taken for granted that could have added value to the research. Semi-structured interviews audio recordings were revisited for verification and emerging themes, and the researcher remained true to the participants' inputs. The researcher provided sufficient information of the research findings enabling the reader the opportunity to assess the findings and capability used in another context that fits transferable. The researcher ensured that the strategy of dependability was used by keeping an audit trail, traceable validity that can be attributed to sources, triangulation, and theories. The researcher maintained neutrality while conducting the research and in terms of which findings of the research are shaped around the participant's responses and not the researcher's bias or motive of interest.

Polit and Beck (cited by Cope, 2014:89) define authenticity as the researcher's ability to express the feelings and emotions of the participants experiences in a faithful and unbiased manner. The researcher reported the research in descriptive approach that allowed the reader to be able to grasp the essence through the participant's quotes. To ensure the trustworthiness of the research, the researcher used the Guba and Lincoln (cited by Krefting, 1991:217) summary of standards, strategies, and criteria as shown in Table 1.3 below.

Table 1-3: Summary of standards, strategies and criteria to ensure trustworthiness

Epistemological standards	Strategy	Criteria
Truth value	Credibility	Prolonged engagement: Reflection of the researcher Triangulation: Methods Data sources Theory Investigator Member checking Interview technique
Applicability	Transferability	Selection of sources: Comparison of samples to demographic data Saturation data

Epistemological standards	Strategy	Criteria
Consistency	Dependability	Dependability audit: Traceable variability ascribed to identification sources Thick/dense description of the methodology Triangulation: Methods Data sources
Epistemological standards	Strategies	Criteria: Theory Investigator Code-recode/co-code
Neutrality	Confirmability	Confirmability audit: Triangulation
Authenticity	Faithful	Convey feeling/tone of participant

(Botma et al., 2010:233; Krefling, 1991:217)

1.13 Ethics

The research was subjected to the ethical clearance by the Economics and Management Sciences Ethics Committee (EMS-REC) (NWU-00545-18-A4) at the North-West University. Permission was obtained from the North West Provincial Department of Health to conduct a research in a respective level three public hospital. The consent was given in writing and presented to senior management, orthopaedic, administration, finance, pharmacy, and X-ray departments involved/interacting in scheduling of orthopaedic theatres surgeries at the hospital. Management, orthopaedic, administration, finance, pharmacy, and X-ray staff were made aware that the participation was entirely voluntary. Audio recordings were used for the semi-structured interviews as another form of data collection; after the researcher indicated the desire to record the interviews transcript, it was left to the participants to agree or not. The participants' identified were protected by the researcher who assigned each of them numbers instead of their names for referencing in this research. Other ethical considerations important to this research were:

1.13.1 Inclusion/exclusion

The participants in this research were limited to the management, orthopaedic, administration, finance, pharmacy, and X-ray departments' staff involved/interacting with scheduling of orthopaedic theatre surgeries. Patients and the vulnerable group were excluded; thus, eliminating the ethical issues that may have been encountered if these groups were included.

1.13.2 Disclosure

All the participants were made aware of this research, its purpose, and the benefits involved in the research.

1.13.3 Direct and indirect benefits

This research had no indirect benefits, only direct ones. The level three public hospital and the North West Provincial Department of Health are the main, direct beneficiaries of this research. The researcher paid special attention not to be biased in terms of the outcome of the research. In order to archive unbiased findings, regular input was given by the research leaders who are completely independent of the partner hospital. This research will benefit the level three public hospital and the North West Provincial Department of Health in the following ways:

- It will lend the context of the proposed lean management framework that could be used in improving orthopaedic theatre scheduling, efficiency, and production.
- It will inform the hospital management and the North West Provincial Department of Health of the challenges the orthopaedic department are faced with and the current orthopaedic theatre scheduling of the orthopaedic surgeries.

The biggest benefit may be that other public and private hospitals within the borders of South Africa and beyond to be introduced to lean management methodologies applied in improving scheduling of orthopaedic theatre surgeries, efficiency, and production. The research might also benefit the management, orthopaedic, and other department interacting with scheduling as this will give them an opportunity to reflect and evaluate how they can improve efficiency and production in orthopaedic theatres. Management can also look into how they can improve efficiency and production in other operating theatres and disciplines within the hospital environment.

1.13.4 Potential risks

This research focused on the scheduling of the orthopaedic operating theatre, not necessarily interaction with the elective patients. No vulnerable group were involved in the research as participants and no specific risks were identified during the research.

1.13.5 Feedback

On completion of the research, the North West Provincial Department of Health, hospital management, and all the participants will be provided with a copy of the final document in

electronic format by means of an e-mail. The researcher will obtain the MBA degree and the findings of the article will be published in an academic journal.

1.13.6 Data management

Data will be stored in electronic format for five years. All forms of documents not used will be discarded upon completion of the research. Physical documents will be returned to the hospital and the digital documents permanently removed and destroyed from the laptop of the researcher.

1.14 Outline of the mini-dissertation

This mini-dissertation was conducted in article format and consists of four chapters, namely:

Chapter 1 Introduction to the research and overview of the methodology.

Chapter 2 Literature review on lean management applied to health systems.

Chapter 3 Article for publication in the Journal for Perioperative Care and Operating Room Management.

Chapter 4 Conclusions, evaluation, limitations, and recommendations for the Lean management framework for orthopaedic operating theatres of a level three public hospital, North West Province.

1.15 Summary

Chapter 1 presented the theoretical background underpinning the research and the outline of the mini-dissertation. An overview of the topic and context of the research was given, indicating the need for the application of Lean management techniques at the level three public hospital in the Dr Kenneth Kaunda District. Different Lean management techniques applied in the healthcare sector were presented as functional programmes that could help hospital management with improving the scheduling of the orthopaedic theatre surgeries, efficiency, and production. The basis of the research design and methodology used in this research is provided in this chapter. The technique selected for this research was a single-case embedded research design and was discussed in detail. The technique involved making use of the qualitative analysis in a structured manner. The limitations of this research are clearly described in detail during data collection. The research methodology and research instruments are also presented, including the advantages, and disadvantages of each instrument. The ethical aspects during

data collection were given special attention. Chapter 2 will discuss literature related to the research problem, objectives, and goals.

1.16 Bibliography

Addis, B., Carello, G., Grosso, A. & Tanfani, E. 2014. A rolling horizon framework for the operating rooms planning under uncertain surgery duration. https://hal.archives-ouvertes.fr/hal-00936085/file/Addis_al.pdf Date of access: 15 Jan 2018.

Ahmed, S., Manaf, N.H. & Islam, R. 2013. Effects of Lean Six Sigma application in healthcare services: a literature review. *Reviews on environmental health*, 28(4):189-194.

Anney, V.N. 2014. Ensuring the quality of the findings of qualitative research: looking at trustworthiness criteria. *Journal of emerging trends in educational research and policy studies*, 2(5):272-281.

Biermann, J. 2017. South Africa's healthcare under threat. (In Stevens, P., ed. *Fighting the diseases of poverty*. New Brunswick, N.J: Transaction p. 36-64).

Boas, R., Ensor, K., Qian, E., Hutzler, L., Slover, J. & Bosco, J. 2015. The relationship of hospital charges and volume to surgical site infection after total hip replacement. *American Journal of Medical Quality*. , 30(3):283-288.

Bogoshi, G. 2017. Hospitals in South Africa share their lean management success stories. <https://www.leanblog.org/2019/03/podcast-336-gladys-bogoshi-a-lean-healthcare-ceo-from-south-africa/> Date of access: 03 Oct 2017.

Botma, Y., Greeff, M., Mulaudzi, F.M. & S.C.D., W. 2010. *Research in Health Sciences*. Cape Town: Pearson Education South Africa.

Castaldi, M., Sugano, D., Kreps, K., Cassidy, A. & Kaban, J. 2016. Lean philosophy and the public hospital. *Perioperative care and operating room management*, 3(1):25-28.

Chikanda, A. & Crush, J. 2017. South-South cross-border patient travel to South Africa. *Global public health.*, 194(1):1-14.

Claydon, L.S. 2015. Rigour in quantitative research. *Nursing standard*, Jul 22, 29(47):43.

Cope, D.G. 2014. Methods and meanings: credibility and trustworthiness of qualitative research. *Oncology nursing forum*, 41(1):89-91.

Costa, L.B.M., Rentes, A.F., Bertani, T.M. & Mardegan, R. 2017. Lean healthcare in developing countries: evidence from Brazilian hospitals. *The international journal of health planning and management*, 32(1):99-120.

Crema, M. & Verbano, C. 2016. Safety improvements from health lean management implementation: evidences from three cases. *International Journal of Quality & Reliability Management*. , 33(8):1150-1178

Creswell, W., John. 2014. Reserach design: qualitative, quantitative, and mixed methods approach. 4th ed. London: Sage.

Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A. & Sheikh, A. 2011. The case study approach. *BMC medical research methodology*, 11(1):100-108.

Crush, J. & Chikanda, A. 2015. South–South medical tourism and the quest for health in Southern Africa. *Social Science & Medicine*. , 124:313-320.

D'Andreamatteo, A., Ianni, L., Lega, F. & Sargiacomo, M. 2015. Lean in healthcare: A Comprehensive Review. *Health policy*. , 119(9):1197-1209.

De Koeijer, R., Paauwe, J. & Huijsman, R. 2014. Toward a conceptual framework for exploring multilevel relationships between Lean Management and Six Sigma, enabling HRM, strategic climate and outcomes in healthcare. *The international journal of human resource management*. , 25(21):2911-2925.

Denton, B.T. 2013. Handbook of healthcare operations management: methods and applications. New York: Springer.

Dolley, L.T. 2014. Plan it and they will come: a case study of the impact of HPT interventions on church growth. Minneapolis: Capella University. (Dissertation-PhD).

Dube, G. 2017. Hospitals in South Africa share their lean management success stories. <https://www.leanblog.org/2019/04/podcast-338-grey-dube-another-lean-healthcare-ceo-from-south-africa/> Date of access: 3 Oct 2017.

Durán, G., Rey, P.A. & Wolff, P. 2017. Solving the operating room scheduling problem with prioritized lists of patients. *Annals of operations research*, 258(2):395-414.

Forough, A. & Valmohammadi, C. 2015. A comparative study between the performance of ISO 9001certified and non-certified hospitals and health care centers: the case of Tehran province. *European online journal of natural and social sciences*, 4(3):596-610.

Freeman, N., Zhao, M. & Melouk, S. 2018. An iterative approach for case mix planning under uncertainty. *Omega*, 76:160-173.

Friese, S. 2014. Qualitative data analysis with ATLAS. ti. 2nd. ed. London: Sage.

Granich, R., Gupta, S., Hersh, B., Williams, B., Montaner, J., Young, B. & Zuniga, J.M. 2015. Trends in AIDS deaths, new infections and ART coverage in the top 30 countries with the highest AIDS mortality burden; 1990–2013. *Public library of science one*, 10(7):e0131353.

Holden, R.J. 2011. Lean thinking in emergency departments: a critical review. *Annals of emergency medicine*, 57(3):265-278.

Hoyler, M., Finlayson, S.R., McClain, C.D., Meara, J.G. & Hagander, L. 2014. Shortage of doctors, shortage of data: a review of the global surgery, obstetrics, and anesthesia workforce literature. *World Journal of Surgery*. , 38(2):269-280.

Hussain, M. & Malik, M. 2016. Prioritizing lean management practices in public and private hospitals. *Journal of health organization and management*, 30(3):457-474.

Ikuma, L.H. & Nahmens, I. 2014. Making safety an integral part of 5S in healthcare. *Work*, 47(2):243-251.

Jakovljevic, M. & Getzen, T.E. 2016. Growth of global health spending share in low and middle income countries. *Frontiers in pharmacology*, 7(21):1-4.

Jebali, A. & Diabat, A. 2015. A stochastic model for operating room planning under capacity constraints. *International journal of production research*, 53(24):7252-7270.

Kanamori, S., Sow, S., Castro, M.C., Matsuno, R., Tsuru, A. & Jimba, M. 2016. Implementation of 5S management method for lean healthcare at a health center in Senegal: a qualitative study of staff perception. *Global Health Action.* , 8(1):1-10.

Kinsman, L., Rotter, T., Stevenson, K., Bath, B., Goodridge, D., Harrison, L., Dobson, R., Sari, N., Jeffery, C. & Bourassa, C. 2014. 'The largest lean transformation in the world': the implementation and evaluation of lean in Saskatchewan healthcare. *Healthcare Quarterly.* , 17(2):29-32.

Krefting, L. 1991. Rigor in qualitative research: The assessment of trustworthiness. *American journal of occupational therapy*, 45(3):214-222.

Lasch, K.E., Marquis, P., Vigneux, M., Abetz, L., Arnould, B., Bayliss, M., Crawford, B. & Rosa, K. 2010. PRO development: rigorous qualitative research as the crucial foundation. *Quality of life research*, 19(8):1087-1096.

Lawal, A.K., Rotter, T., Kinsman, L., Sari, N., Harrison, L., Jeffery, C., Kutz, M., Khan, M.F. & Flynn, R. 2014. Lean management in health care: definition, concepts, methodology and effects reported (systematic review protocol). *Systematic reviews.* , 3(1):103-108.

Le Roux, K., Le Roux, I.M., Mbewu, N. & Davis, E. 2015. The role of community health workers in the re-engineering of primary health care in rural Eastern Cape. *South African family practice*, 57(2):116-120.

Leung, L. 2015. Validity, reliability, and generalizability in qualitative research. *Journal of family medicine and primary care*, 4(3):324-327.

Lighter, D.E. 2014. The application of Lean Six Sigma to provide high-quality, reliable pediatric care. *International Journal of Pediatrics and Adolescent Medicine.*, 1(1):8-10.

- Mahomed, O.H., Asmall, S. & Freeman, M. 2014. An integrated chronic disease management model: a diagonal approach to health system strengthening in South Africa. *Journal of health care for the poor and underserved*, 25(4):1723-1729.
- Marchildon, G. 2013. Implementing Lean health reforms in Saskatchewan. *Health Reform Observer—observatoire des Réformes de Santé*, 1(1):1-9.
- Mason, S., Nicolay, C. & Darzi, A. 2015. The use of Lean and Six Sigma methodologies in surgery: a systematic review. *The Surgeon*, 13(2):91-100.
- Mayosi, B.M. & Benatar, S.R. 2014. Health and health care in South Africa—20 years after Mandela. *New England Journal of Medicine*, 371(14):1344-1353.
- Miller, R. & Chalapati, N. 2015. Utilizing lean tools to improve value and reduce outpatient wait times in an Indian hospital. *Leadership in health services*, 28(1):57-69.
- Mohapi, M.C. & Basu, D. 2012. PHC re-engineering may relieve overburdened tertiary hospitals in South Africa. *South African medical journal*, 102(2):79-80.
- Mokatsane, P. Lean management framework for orthopaedic operating theatres of a level three public hospital, North West Province [personal interview]. 23 Jan Matlosana.
- Morris, J.H., James, R.E., Davey, R. & Waddington, G. 2015. What is orthopaedic triage? A systematic review. *Journal of Evaluation in Clinical Practice*, 21(1):128-136.
- Naidoo, L. 2013. The impact of Lean thinking on operational efficiency in a rural district hospital outpatient department in KwaZulu-Natal. Durban: UKZN. (Dissertation-Master of Public Health).
- Naledi, T., Barron, P. & Schneider, H. 2011. Primary health care in SA since 1994 and implications of the new vision for PHC re-engineering:. *South African health review*, 11(1):17-28.
- Nordling, L. 2016. A new era for HIV. *Nature*, 535(7611):214-218.

Palinkas, L.A., Horwitz, S.M., Green, C.A., Wisdom, J.P., Duan, N. & Hoagwood, K. 2015. Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and policy in mental health and mental health services research*, 42(5):533-544.

Penn, M.L. 2014. Developing a multi-methodological approach to hospital operating theatre scheduling. Southampton: University of Southampton. (Thesis-PhD).

Rasmussen, T. & Johnsen, F. 2017. Flexibility in operation theatres. Molde: Molde University College. (Thesis-Masters).

Ritchie, J., Lewis, J., Nicholls, C.M. & Ormston, R. 2013. Qualitative research practice: a guide for social science students and researchers. 1st ed. New Delhi Sage.

Singh, S., Remya, T., Shijo, T., Nair, D. & Nair, P. 2014. Lean six sigma application in reducing nonproductive time in operation theaters. *The journal of national accreditation board for hospitals & healthcare providers*, 1(1):1-6.

Stanton, P., Gough, R., Ballardie, R., Bartram, T., Bamber, G.J. & Sohal, A. 2014. Implementing lean management/Six Sigma in hospitals: beyond empowerment or work intensification? *The international journal of human resource management*, 25(21):2926-2940.

Theunissen, D.P. 2012. Improving service quality and operations at a South African private healthcare clinic through the implementation of lean principles. Port Elizabeth: NMMU. (Dissertation-MBA).

Tortorella, G.L., Fogliatto, F.S., Anzanello, M., Marodin, G.A., Garcia, M. & Reis Esteves, R. 2017. Making the value flow: application of value stream mapping in a Brazilian public healthcare organisation. *Total quality management & business excellence*, 28(13-14):1544-1558.

Yin, R.K. 2014. Case Study Research: Design and Methods. 5th ed. London: Sage Publications.

Yin, R.K. 2017. Case study research and applications: Design and methods. 2nd ed. Vol. 5. London: Sage publications.

Yurtkuran, A., Özdemir, D., Yurtkuran, D.M. & Emel, E. 2017. Lean transformation to reduce costs in healthcare: a public hospital case in Turkey. *Journal of hospital administration*, 6(4):10-22.

CHAPTER 2: LITERATURE REVIEW ON LEAN MANAGEMENT APPLIED TO HEALTH SYSTEMS

2.1 Introduction

Chapter 1 introduced the research problem and methodology and Chapter 2 presents a literature review on the application of the possible Lean management techniques that could be applied for scheduling the orthopaedic theatres block time considering the past research studies done on the subject.

- Section 2.2 shows the conceptual framework of how the chapter is structured.
- Section 2.3 defines the Lean management methodology.
- Section 2.4 describes the origin of Lean management.
- Section 2.5 explains the principles of Lean management in detail.
- Section 2.6 presents the models of Lean management as applied in the orthopaedic operating theatres.
- Section 2.7 provides the conclusion reached from the literature review.

2.2 Conceptual framework

Figure 2.1 shows the conceptual framework of the research in terms of the definition of Lean management, the origin of Lean management methodology, principles of Lean management, and models of Lean management as applied to orthopaedic operating theatre, and the conclusion.

2.3 Lean management in healthcare defined

According to Krafcik (cited by Poksinska *et al.*, 2017:96), Lean production has its roots in Toyota Production System (TPS), which was considered lean as it requires few resources to produce variety of product with fewer defects in the production process. The public healthcare environment is experiencing growing pressure to improve its efficiency and quality of healthcare; the sector is; therefore, adopting the concepts and methodologies associated with private business and manufacturing. The recent reviews have shown that in public organisations 51% of publications focused on Lean, a further 13% on Business Process Reengineering, and 35% started their use in health services (Radnor *et al.*, 2012:364). The

Lean methodologies and philosophies applied in the healthcare in pursuit of improving the performance are derived from the manufacturing industry (De Koeijer *et al.*, 2014:2911). This kind of management has been discussed extensively in medical literature and can be defined as elimination of waste from healthcare delivery; furthermore, waste can be defined as a product, service or activity that does not add value for the patient (De Koeijer *et al.*, 2014:970).

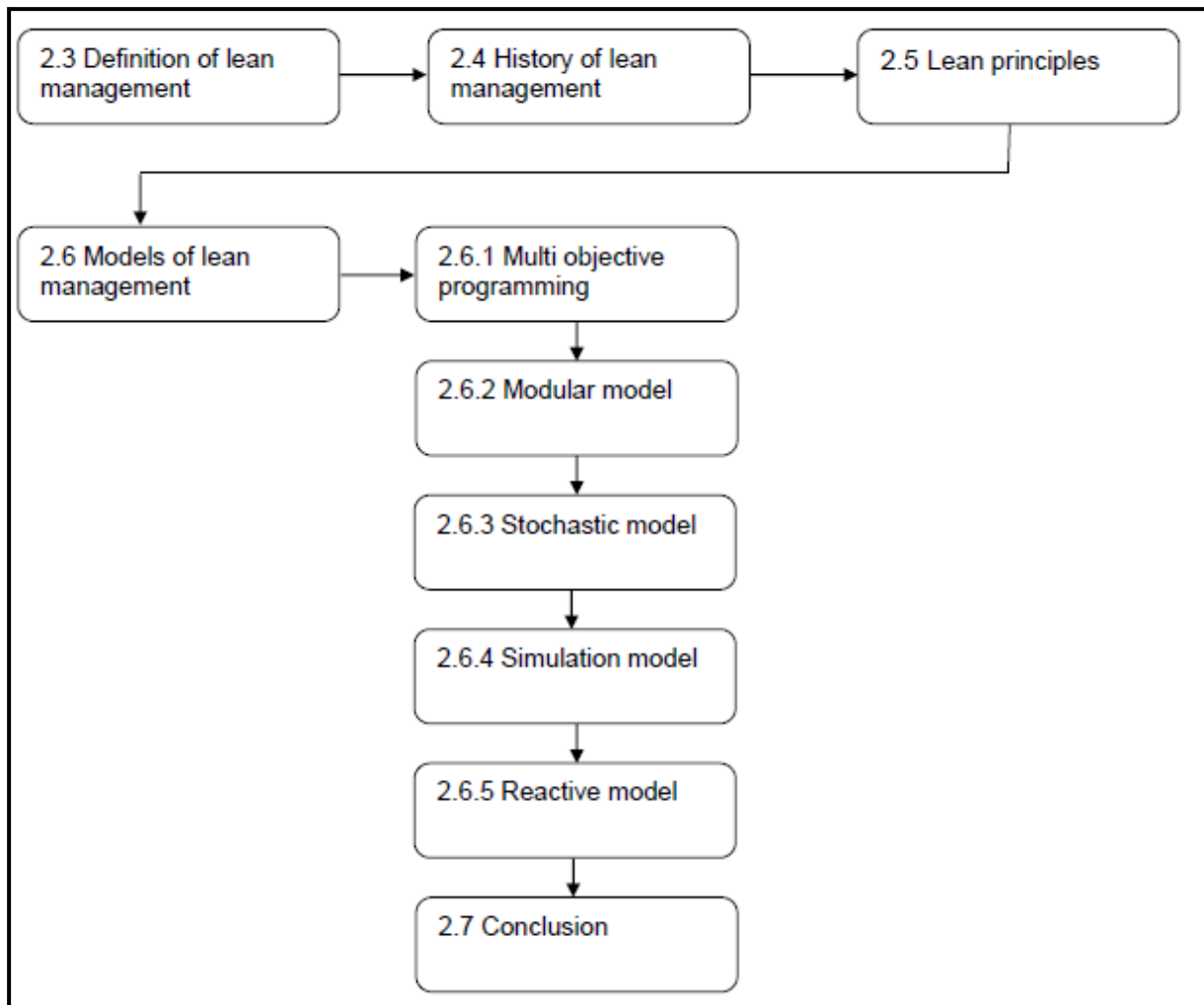


Figure 2-1: Conceptual framework utilised in this research

2.4 The history of Lean management

The term “Lean production” (or “Lean manufacturing”) was first coined by Krafcik in 1988, a student at the Massachusetts Institute of Technology (MIT). It was popularised by the bestselling book by Womack and Jones published in 1990 selling over 40 000 copies (Curatolo *et al.*, 2014:433). In 1996 Womack and Jones (cited by Curatolo *et al.*, 2014:433) further redefined Lean concept into five main principles in a book called “Lean thinking”. With the assistance of these principles, Lean has evolved into a customer focused management

approach (“Lean management”) and was adopted by different service sectors such as education, banks, financial institutes, hotels and, finally, healthcare (Teich & Faddoul, 2013:2).

2.4.1 Lean management in production

The evolution of production systems is linked to the story of Toyota Motor Company (TMC) back in 1929; it has its roots in about 1918 when the former textile business owner Sakichi Toyoda was experiencing interruptions in production when the thread of the weaving machine snapped during production. Sakichi Toyoda sold his textile business and joined the automotive industry, he (and Kiichiro Toyoda) reinvented the company but could not produce enough high volumes of vehicles. By this time Ford and General Motors dominated the Japanese automotive industry, and the entire Japanese auto industry was producing an annual output equivalent to three days of United States car production. This caused concern in Toyota Motor Company; after joining the company, Eiji Toyoda was sent, along with Taiichi Ohno, to the United States of America to study their car production methods (Teich & Faddoul, 2013:2). In 1913 Henry Ford was the first to integrate the manufacturing process into the car assembly that incorporated the flow of the product on a conveyor belts best suited for mass production of cars. However, some essential elements of Lean were still missing in the production as the process was incapable of providing a variety of products tailored to customer needs. The Model T of Ford was produced only in black colour. Additionally, car specifications were limited, and all the Model T’s were identical in every aspect (Damrath, 2012:5). Ford’s achievements in mass production had consequences that ended up being the basis for rethinking the way the process of mass production should be structured and implemented.

Taiichi Ohno identified two major flaws of the Western car production after the visit to the United States of America (Teich & Faddoul, 2013:2):

- Producing car components in large batches resulted in large inventories, which led to negative capital cost and defects in production.
- The method of production preferred large production over customer preferences or variance in the product.

Over the years, the Toyota Production System evolved and provided a tool that is innovative, functioning well in the car mass production, and diverse, catering more effectively to the cultural values in comparison to traditional Western mass production.

The Lean philosophies were developed in the mid-1950s, and produced Lean thinking, Lean manufacturing and Toyota Production System (TPS), widely adopted by many companies, even outside automotive industries (Leite & Vieira, 2015:529). According to Curatolo (cited by Rotter

et al., 2017:2), the original aim of Lean management was to ensure a defect-free manufacturing process, to eliminate or minimise waste (or *muda* in Japanese), and meet the customer's expectations in terms of variability in the product or service offered. Lean is regarded as a philosophy of leadership, teamwork in problem-solving and aims to continuously improve the organisation in terms of producing the final product or service by meeting the needs of the customer and empowering the employees (Damrath, 2012:9).

2.4.2 Lean management in health

Healthcare organisations around the world are facing continuous conflict. The focus of healthcare centres is high quality patient care, preventing infections, and ensuring patient safety. On the other hand, they are limited in terms of budget cuts with limited resources (Dammand *et al.*, 2014:20). They are forced to operate the healthcare centres efficiently and profitably with limited funding and resources available. Healthcare organisations have recently faced two challenges, namely budget constraints, and patient satisfaction (Rahbek Gjerdrum Pedersen & Huniche, 2011:550). The application of Lean management philosophy in the healthcare environment offers a potential solutions to these challenges by providing patient satisfaction with limited, available resources (Dammand *et al.*, 2014:20). The Lean strategy approach allows healthcare centres to improve patient quality healthcare by eliminating waste and waits. This is done by involving staff in the process of continuous improvement of the healthcare according to Graban (cited by Curatolo *et al.*, 2014:434) by addressing the waste and waits that do not add value to the service the patient is expecting. Lean management is well accepted and implemented for two reasons:

- Lean principles are perceived to be compelling and understood very easily by the healthcare staff Andell (cited by Curatolo *et al.*, 2014:434).
- The Lean approach is useful in targeting the waste and waits in the healthcare environment, two of the greatest problems in the public healthcare Murphy (cited by Curatolo *et al.*, 2014:434).

The Lean concepts are starting to form a part of vocabulary in both public and private healthcare environments struggling with the demand of patient/client satisfaction and limited resources (Rahbek Gjerdrum Pedersen & Huniche, 2011:550). The growing ageing population and new diseases are putting even more pressure on healthcare providers. Lean principles have been applied in some healthcare centres of developed countries such as Canada, the United States of America, and the United Kingdom. However, there seems to be a lack of evidence of the effectiveness of lean management being applied in the healthcare in terms of the perceptions of patients, healthcare staff, and manager (Hamilton *et al.*, 2014:5). The

successful implementation and positive results of the Lean management requires the commitment of everyone involved in the healthcare environment.

2.5 Lean principles

As stated earlier, the Lean production has its roots in the Toyota Production System which focused on producing a greater variety of products with fewer defects and limited resources Krafcik (cited by Poksinska *et al.*, 2017:2). There are number of Lean principles used in manufacturing and production, and the ones used the most in the healthcare environment can be identified as the 5S, Lean, and Six Sigma.

2.5.1 Lean Six Sigma methodology

Poksinska *et al.* (2017:2) describe Womack and Jones as the first authors to suggest that Lean production could be applied to healthcare. While Six Sigma is methodology was implemented by Motorola in 1987 to improve the quality while reducing the level of errors. The company decided on this approach while facing tough competition in the telecommunications business (Ahmed *et al.*, 2013:190). Lean and Six Sigma (LSS) are combined in the healthcare system as they address two related issues separately. Lean concentrates on cost reduction and efficiency and complements Six Sigma's pursuit goal of effectiveness and precision (Lighter, 2014:2). According to Mason *et al.* (2015:2), Lean and Six Sigma are the two most prominent and successful quality improvement methodologies that have dominated the healthcare environment since 1998. In order to fulfil the expectations of patients, healthcare organisations have followed the Lean Six Sigma methodology since it is one of the favourite and has been proven to work (Lighter, 2014:9). The Lean Six Sigma approach improves quality high care of patients and increases patient satisfaction by reducing cost and increasing productivity. Healthcare embraced the Lean Six Sigma concept after it was developed successfully by companies like Motorola, later followed Toyota, ABB, Texas Instruments, Caterpillar, Sony, Toshiba, City Bank, Bank of America, General Electric and so on (Agarwal *et al.*, 2016:95).

2.5.2 5S methodology

One of the Lean management methodologies widely used in healthcare is 5S. The 5S stands for the five Japanese words *Seiri*, *Seiton*, *Seisou*, *Seiketsu* and *Shitsuke*, which all relate to order and organisation (Young, 2014:241). These five words are translated to English as sort, set in order, shine, standardise, and sustain. They represent a practice aimed at improving the organisation of the workplace in order to achieve high productivity in the organisation (Ikuma & Nahmens, 2014:244). The methodology evolved in the manufacturing sector in Japan in 1980 and later spread to the West. It has been applied in the healthcare sector in a systematic

method of organising and standardising Lean in the healthcare sector (Kanamori *et al.*, 2016:1). The methodology is characterised as continuous, never ending in creating and maintaining the organised, clean, and safe workplace; 5S is part of the Japanese term “Kaizen” meaning good change or continuous improvement (Patwa *et al.*, 2015:408).

2.6 Models of Lean management

The most common Lean management techniques applied in healthcare as pertaining to theatre planning and scheduling vary and include combinations of the following models: multiple objective programming, simulation, and heuristics, robust, reactive, and stochastic. These models will be discussed in this section giving the reader a brief description of each and including examples illustrating how they could be used in areas of theatre scheduling and optimising. The other models, less used, and the studies done on them are discussed. It could happen that other techniques become apparent during the research, in which case, they could be employed.

2.6.1 Multiple objective programming

The operating theatre management is faced with the difficult task of arranging efficient scheduling of orthopaedic surgeries in terms of great number of quality surgeries as possible with limited available resources. This includes scheduling that meets the needs or expectation of the patients, is delivered timeously, provides quality treatment with the orthopaedic staff working reasonable times, and the management being satisfied with the theatre efficiency and production of orthopaedic department (Xiang, 2017:607). Improving the performance of any hospital department is a complicated matter that is of a political nature, especially when it involves many stakeholders, patients, orthopaedic departments, hospital management, and the Department of Health (Stuart, 2010:42) since these parties sometimes do not agree with each other when trying to achieve their one common goal which is quality surgery in time; the time surgery may lead to excessive overtime by the orthopaedic staff and inefficient utilisation of operating theatres. The high overtime may cause unhappiness and stress in orthopaedics staff and inefficient usage of the theatre result in the high costs of maintaining the theatre (Xiang, 2017:607). The hospital administration has to manage the waiting list and schedule of the theatres while applying rational decisions on a case by case basis (Stuart, 2010:43). The South African Department of Health have the health policy governing the elective patients scheduled for surgeries, this policy stipulates that children and the elderly patient should take precedents over the elective patients. Other patients that take precedence are the patients with chronic health condition. However, the emergency patients can disrupt the scheduled elective patient

block time but once the surgery procedure has started the emergency patients will have to wait and only be operated on when the elective patient's surgery is completed.

Well known problems, especially in the public hospital sector that lead to the long waiting list of elective patients, cancellation, overloaded resources, cannot be approached in a traditional way of hiring more medical staff, purchasing of equipment, and more bed availability. The shortage of staff and high costs of running the operating theatres will always be present if human resources and theatres are not managed properly (Meskens *et al.*, 2013:650).

The goal of the operating theatre scheduling is, as identified by (Stuart, 2010:42):

- Effective use of operating theatre suites.
- Satisfied surgeons, anaesthetists, orthopaedic nurses.
- Satisfied patients.
- Effective usage of anaesthetic wards.
- User friendly scheduling system.
- Effective booking of recovery beds.
- Fewer cancellations.

Guido and Conforti (2016:271) states that operating theatre scheduling is classified as open scheduling, block scheduling, and hybrid scheduling. The difference between the open scheduling and block scheduling is that with open scheduling, the surgery time is allocated to the surgeon who requests it first. In contrast to this, block scheduling involves the allocation of to a single surgical group of similar surgical speciality or more than one surgeon of the same surgical speciality. Many hospitals that are working under budget constraint state that they have staff compliments of two surgeons with no specific surgery specialities; the same applies with the relevant level three public hospital in North West Province.

Three hierarchical decisions are distinguished as follows:

- **Strategic level** concerns the planning and distribution of surgery specialists and an efficient mix of surgeons, of which the planning horizon is one/two years planning; is informed by historical data of demand forecast.
- **Tactical level** refers to the master surgical scheduling that defines the number of scheduled theatre rooms available for surgery, the open theatre time, and the surgeon allocated which

case and what time. Usually the masters' surgical scheduling is done in advance with horizon of weeks or years informed by the historical data and forecast demand. Some of the months or seasons of the year have more hip replacements than other months or periods of time so this data will inform the scheduling administrator as to what to expect.

- **Operational level** details the elective surgery, what type surgery case assignment, the date, time, and the sequence of the start and ending of the surgery.

2.6.2 Modular model

Each hospital has a scheduling module that it uses. For illustration purposes, Figure 2.2 is of a generic and modular model related to surgery cases, specifically with regard to total hip replacement. The arrows around it reflect all the factors that can affect the smooth running of the operation (circle in the centre of hip replacement), ranging from patient referral by the surgeons to the patient discharge from the recovery ward. It further stipulates the hip surgery, which in this case happened once; the operations cannot overlap until the latter is finished. The surgeon cannot simultaneously operate on two patients and only one patient is allowed in the operating room or recovery bed.

One of the elements that may create a bottleneck is the flow of elective patients from the pre-operative rooms until they are discharged from the hospital. If the flow is not synchronised properly it could cause problems, such as patients not having a bed available to them in the recovery ward, which poses a health risk. Figure 2.3 shows the basic flow of parts before and after the operation theatre.

2.6.3 The long waiting list of the stochastic programming

Elective patients of orthopaedic surgeries are putting pressure on theatre scheduling to push through as many patients as possible theatres and out of recovery beds. The biggest problem is the surgery duration, which is uncertain; sometimes this can cause a disruption to the schedule due to the unpredictable overrun of surgeries. This overrun can result in cancellation of the theatre time for the next elective patient (Min & Yih, 2010:642). The accuracy of the estimation of procedure time is very important when developing an effective and efficient scheduling for orthopaedic theatres, especially considering the uncertainty of disruption of emergency patients, or even the unavailability of recovery beds. It is important to make the task of the scheduler easier so that as many operating procedures as possible are scheduled with much accuracy estimation with the best scheduling programs available.

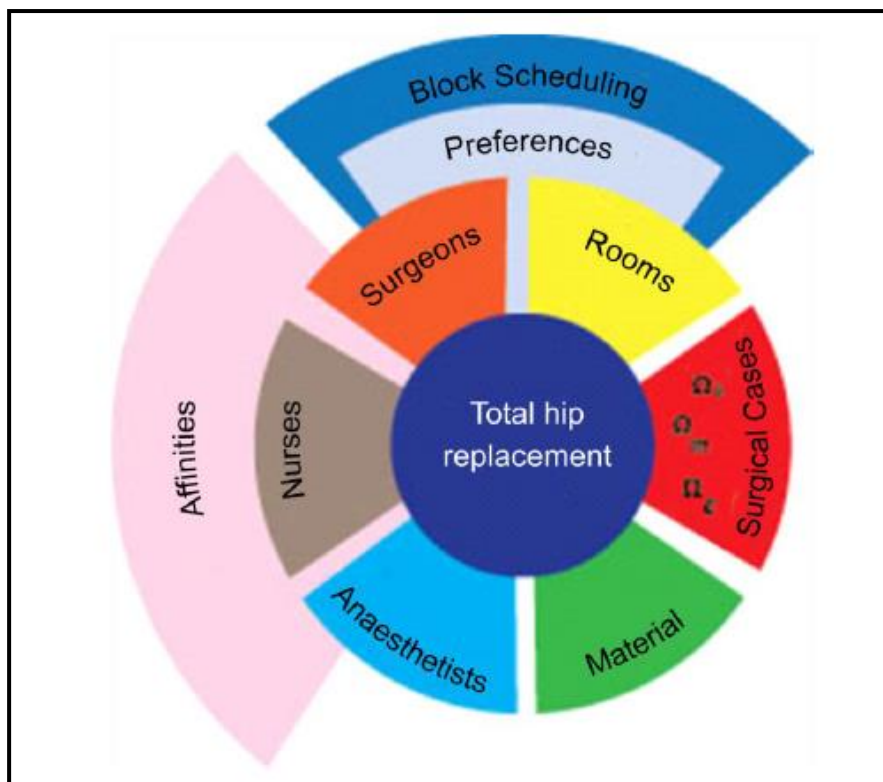


Figure 2-2: Modular model of total hip replacement (Meskens *et al.*, 2013:652)

The scheduler is not relying on mental and manual scheduling but rather relies on the computerised decision support system that will choose different types of orthopaedic procedures to be performed from the waiting list and assign them to the operating theatres (Saadouli *et al.*, 2015:72). Operating theatres are highly stochastic due to the fact that there is no pattern or characteristic in the occurrences of surgery cases with the emergency cases contributing to the uncertainty in theatre scheduling. In order to improve operating theatre utilisation, efficiency and production, the stochastic elements should be taken into account and be removed; and, hence, the increase in the stochastic approaches in operating theatres scheduling are on the increase in academic research (Jebali & Diabat, 2015:7252). There are different stochastic models that can be applied in decision making when scheduling operating theatre surgery procedure of the elective patients. Bruni *et al.* (2015:99) applied the two-stage stochastic programming model to handle the uncertainty in the scheduling disruption by emergency patients' duration of surgery for a single stage or multi operating theatres. The decision taken weekly relates to the assignment of theatres for surgeons and the day of the operating procedures; this is done at the beginning of the week and when there is uncertainty in the system.

There are three key strategies to consider when dealing with such situations

- Overtime recourse strategy.

- Swapping recourse strategy.
- Changing the planning strategy.

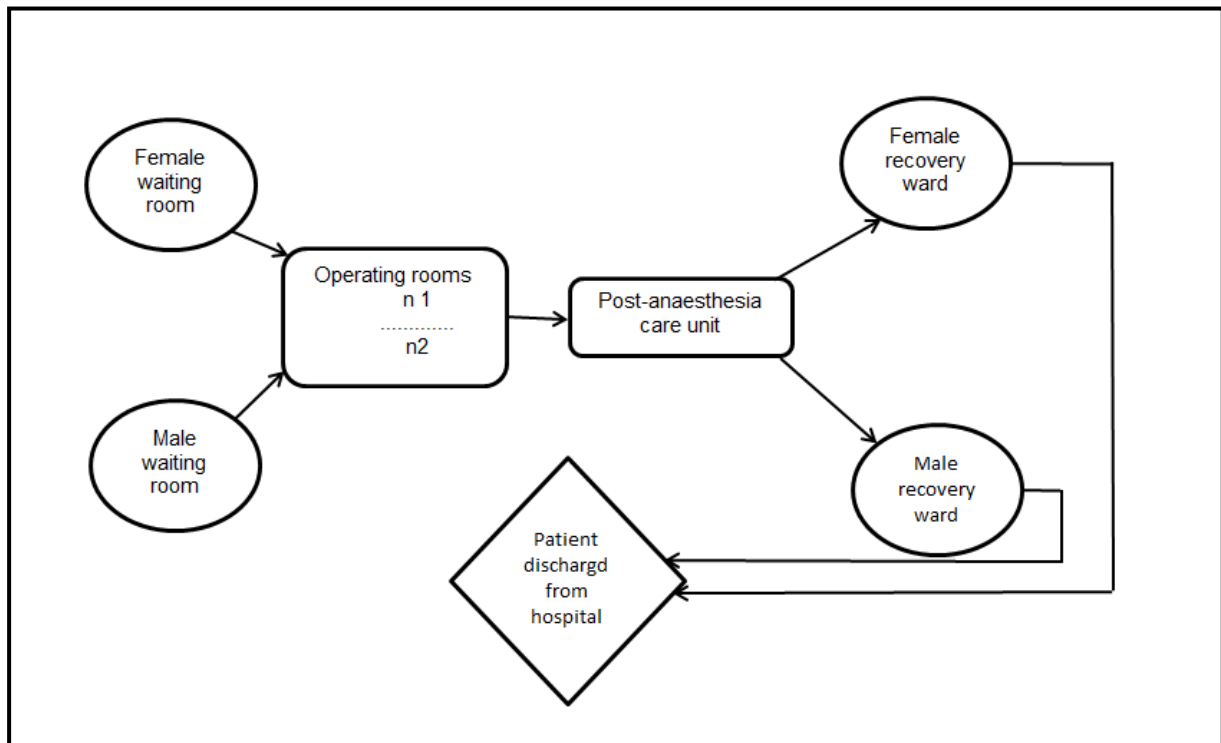


Figure 2-3: Stages of delivery system for elective surgeries
(Bam *et al.*, 2017:943)

2.6.4 Goal programming

Li *et al.* (2017:35) suggest the use of the goal programming model when dealing with minimising deviations from targets of the surgical specialties and the four important goals:

- The anticipated number of elective patients showing up at the day of the surgery.
- The maximum expected number of patients in the recovery wards.
- Utilisation of the operating theatre time.
- The expected range, which is the difference between the minimum and the maximum patients in the recovery wards.

From the goal programming model, Li *et al.* (2017:35) developed two goal programming models to support the main model, namely the lexicographic model and weighted goal programming model. The lexicographic goal programming model scheduler is designed for operating theatres when making decisions about the above-mentioned priority levels. The lexicography and weighted goal programming models are useful in cases where fewer recovery beds are

occupied in the beginning and end of the week. With constraints of bed availability, it is important that the recovery wards be utilised efficiently by the use of weighted goal programming. In the case of the already in service hospital, the model can help to balance the booking of the recovery beds and in the case of a new hospital about to be built, it can determine optimal number of beds required.

2.6.5 Mixed integer-programming

Saadouli *et al.* (2015:73) proposes the mixed integer programming model based on heuristics and meta-heuristics when improving master surgical schedules, considering the block time of the operating theatres and the surgical specialist. These models look at the stochastic patients in the block operating theatres and the length of stay in the operating theatres before moving into the recovery bed. There are factors that could affect the long stay of the patients in or out of the theatre, not to mention the overrun of the operating procedures, surgical complexity, anaesthesia and the setup of the following surgery procedure (Lehtonen *et al.*, 2013:82).

2.6.6 Simulation model

Simulation is defined as the act of the imitation of real life situations and is used to find solutions to complicated problems where, in healthcare studies, human lives cannot be risked to test the scheduling and throughput of orthopaedic patients (Stuart, 2010:43). The model is widely used to test system behaviour when subjected to variety of situations and operating policies (Penn, 2014:16). The system is based on the mathematical models that are built to act like a system and mimic certain situations in the theatre scheduling environment by changing some variables. The effects can be observed and predictions be made about the behaviour of the system without changing the real settings (Baesler *et al.*, 2015:216). Persson *et al.* (2017:2) sees the simulation model as a system analyst tool that is used to identify processes to improve the performance, theatre utilisation, and production in order to reach the goals of the orthopaedic department. There are many types of models used in theatre simulations to mention, discrete-event and mix integer programming. The discrete-event model considers the randomness associated with the entire flow of the patient from admission, surgery setup, surgery procedure and recovery ward (Baesler *et al.*, 2015:216). Some authors use the combination of these models to produce the comparative simulation model. Combination of discrete-event and mix integer programming models is useful in optimising the master surgical scheduling with the mix integer finding the optimal solution and discrete-event model to test the robustness of the scheduling (Banditori *et al.*, 2013:155).

Another approach is using the Monte Carlo simulation and the mix integer programming to optimise the master surgical scheduling (Baesler *et al.*, 2015:2). When faced with stochastic

operating and theatre scheduling, some authors use the simulation model to determine the number of post-anaesthesia care beds required and the effects of the theatre utilisation of treating patients. In the past the simulations model was widely challenged by academics for its effectiveness in the healthcare environment since it was thought that it might not be flexible enough to handle the non-standard situations as it was first introduced in the manufacturing industry where the situation is standard throughout the manufacturing process (Brailsford & Klein, 2015:8). Later development has resulted in simulation being advanced to such an extent that some simulation models like Extendsim provide opportunity for both standard simulation blocks and the ones that can be built from scratch (Stuart, 2010:45).

There is more in the market of simulation models that can be built to fit the system of operating theatre planning and free simulation software programs are available in the internet. Figure 2.4 shows the simulation optimisation scheme. At the beginning of the scheme, the patients with different operating procedure are fed to the input of the simulation model. The simulation model measures the performance of the system after scheduled patients are in the system. The results of the performance will inform which scheduling model to use to achieve the best results; this interactive cycle is repeated until the determination condition is met.

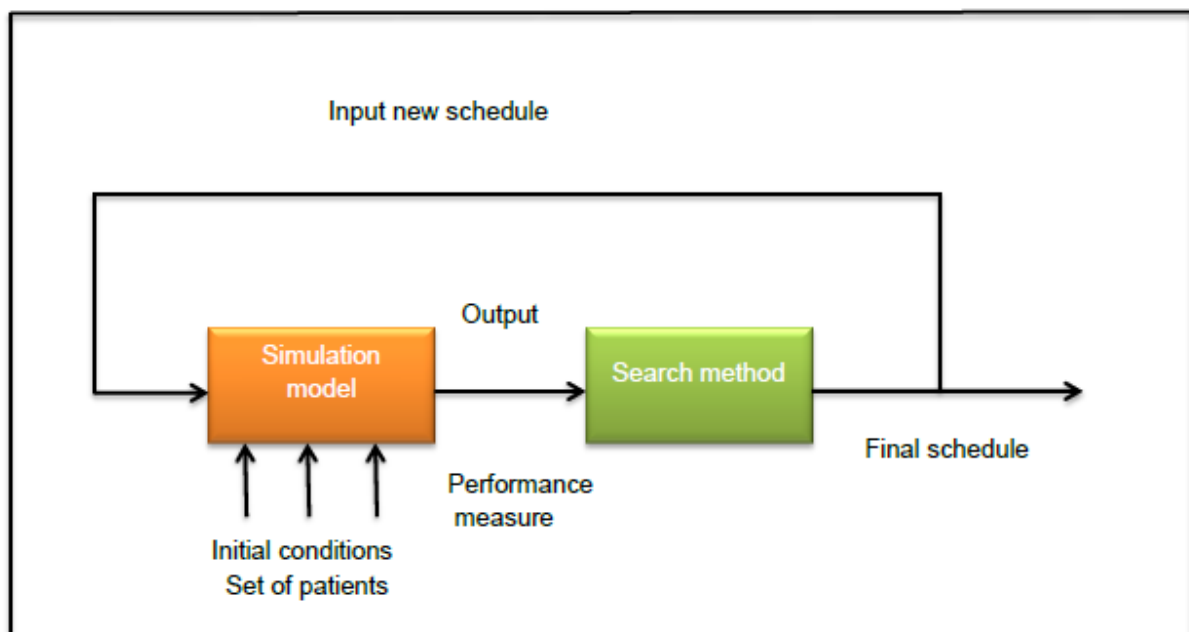


Figure 2-4: Simulation optimisation interactive scheme

(Baesler *et al.*, 2015:217)

2.6.7 Reactive scheduling

Reactive scheduling model is classified as a single machine problem in which the system looks at the disruptions and re-scheduling of the elective patient's time of surgery. The system processes the emergency, elective, and outpatients operated on that are discharged to recover

at home. The system focuses on how to solve the disruptions of the elective patients' time in theatre by emergency patients that arrive randomly without scheduling; however, once the operation of the elective patient has started it cannot be disrupted by an emergency patient's arrival at the operating theatre. The system is used to repair the baseline scheduling to minimise and keep the disruptions at low levels, and include the changes to the original scheduling (Stuart & Kozan, 2012:400).

There are various disruptions to management policies that are used in disruption environment such as the post disruption management, and predictive disruption management. Predictive management is used for the disruption that may be anticipated in a situation such as emergency patients that may require treatment at some time in the future because of accidents or deteriorating health condition, while post disruption management deals with the unpredictable disruptions, and the scheduling of the elective patient can only be updated after the predictive period ends (Stuart, 2010:53). According to Gerami and Saidi-Mehrabad (2017:565), dynamic scheduling is divided into three categories, namely: reactive, proactive, and predictive-reactive while Chaari *et al.* (2014:2) identified four types of scheduling problem under uncertainty: proactive, reactive, proactive-reactive, and predictive-reactive. Poor planning of the predictable emergency surgeries can create a stumbling block during the standard operating hours of the theatres (Meredith *et al.*, 2011:89).

2.7 Summary

Chapter 2 described the literature on the application of the Lean management techniques that can be applied to scheduling the orthopaedic theatres' block time, considering the past research studies done on the subject. The research looked at the past studies done about the subject or similar subjects; identified the gaps and how those gaps can be closed in order to achieve the most efficient and productive orthopaedic department possible. In order to understand any system in the organisation that is to be studied, it was important to look at a wider angle of all the possible factors that might contribute directly or indirectly to the cause of the problem. The different lean management models used in the healthcare were discussed.

2.8 Bibliography

Agarwal, S., Gallo, J.J., Parashar, A., Agarwal, K.K., Ellis, S.G., Khot, U.N., Spooner, R., Tuzcu, E.M. & Kapadia, S.R. 2016. Impact of lean six sigma process improvement methodology on cardiac catheterization laboratory efficiency. *Cardiovascular revascularization medicine*, 17(2):95-101.

Ahmed, S., Manaf, N.H. & Islam, R. 2013. Effects of Lean Six Sigma application in healthcare services: a literature review. *Reviews on environmental health*, 28(4):189-194.

Baesler, F., Gatica, J. & Correa, R. 2015. Simulation optimisation for operating room scheduling. *International journal simulation model*, 14(2):215-226.

Bam, M., Denton, B.T., Van Oyen, M.P. & Cowen, M.E. 2017. Surgery scheduling with recovery resources. *IIE Transactions*, 49(10):942-955.

Banditori, C., Cappanera, P. & Visintin, F. 2013. A combined optimization–simulation approach to the master surgical scheduling problem. *Journal of management mathematics*, 24(2):155-187.

Brailsford, S. & Klein, J.H. 2015. The value of modelling and simulation in healthcare. Paper presented at the Festival of evidence, Southampton. <https://pdfs.semanticscholar.org/161e/c75feef451fbc1e49d8bb454881cfcf7cb81.pdf> Date of access: 10 Nov 2017.

Bruni, M., Beraldi, P. & Conforti, D. 2015. A stochastic programming approach for operating theatre scheduling under uncertainty. *Journal of management mathematics*, 26(1):99-119.

Chaari, T., Chaabane, S., Aissani, N. & Trentesaux, D. 2014. Scheduling under uncertainty: Survey and research directions. Paper presented at the International Conference on Advanced Logistics and Transport, Hammamet, Tunisia 28 July. <https://ieeexplore.ieee.org/document/6866316> Date of access: 10 Feb 2018.

Curatolo, N., Lamouri, S., Huet, J.-C. & Rieutord, A. 2014. A critical analysis of Lean approach structuring in hospitals. *Business process management journal*, 20(3):433-454.

Dammand, J., Hørlyck, M., Jacobsen, T., Lueg, R. & Röck, R. 2014. Lean management in hospitals: evidence from Denmark. *Administration and Public Management Review*, 23:19-35.

Damrath, F. 2012. Increasing competitiveness of service companies: developing conceptual models for implementing Lean Management in service companies. Madrid: Politecnica.

De Koeijer, R., Paauwe, J. & Huijsman, R. 2014. Toward a conceptual framework for exploring multilevel relationships between Lean Management and Six Sigma, enabling HRM, strategic climate and outcomes in healthcare. *The international journal of human resource management*, 25(21):2911-2925.

Gerami, F. & Saidi-Mehrabad, M. 2017. Stochastic reactive scheduling model for operating rooms considering the moral and human virtues. *Applied ecology and environmental research*, 15(3):563-592.

Guido, R. & Conforti, D. 2016. A hybrid genetic approach for solving an integrated multi-objective operating room planning and scheduling problem. *Computers & operations research*, 87:272-282.

Hamilton, J., Verrall, T., Maben, J., Griffiths, P., Avis, K., Baker, G.R. & Teare, G. 2014. One size does not fit all: a qualitative content analysis of the importance of existing quality improvement capacity in the implementation of releasing time to care: the productive ward™ in Saskatchewan, Canada. *BMC Health Services Research*, 14(1):1-14.

Ikuma, L.H. & Nahmens, I. 2014. Making safety an integral part of 5S in healthcare. *Work*, 47(2):243-251.

Jebali, A. & Diabat, A. 2015. A stochastic model for operating room planning under capacity constraints. *International journal of production research*, 53(24):7252-7270.

Kanamori, S., Shibamura, A. & Jimba, M. 2016. Applicability of the 5S management method for quality improvement in health-care facilities: a review. *Tropical medicine and health*, 44(1):1-8.

Lehtonen, J.-M., Torkki, P., Peltokorpi, A. & Moilanen, T. 2013. Increasing operating room productivity by duration categories and a newsvendor model. *International journal of health care quality assurance*, 26(2):80-92.

Leite, H.R. & Vieira, G.E. 2015. Lean philosophy and its applications in the service industry: a review of the current knowledge. *Production*, 25(3):529-541.

Li, X., Rafaliya, N., Baki, M.F. & Chaouch, B.A. 2017. Scheduling elective surgeries: the tradeoff among bed capacity, waiting patients and operating room utilization using goal programming. *Health care management science*, 20(1):33-54.

Lighter, D.E. 2014. The application of Lean Six Sigma to provide high-quality, reliable pediatric care. *International Journal of Pediatrics and Adolescent Medicine.*, 1(1):8-10.

Mason, S., Nicolay, C. & Darzi, A. 2015. The use of Lean and Six Sigma methodologies in surgery: a systematic review. *The Surgeon.* , 13(2):91-100.

Meredith, J.O., Grove, A.L., Walley, P., Young, F. & Macintyre, M.B. 2011. Are we operating effectively? A lean analysis of operating theatre changeovers. *Operations management research*, 4(3-4):89-98.

Meskens, N., Duvivier, D. & Hanset, A. 2013. Multi-objective operating room scheduling considering desiderata of the surgical team. *Decision support systems*, 55(2):650-659.

Min, D. & Yih, Y. 2010. Scheduling elective surgery under uncertainty and downstream capacity constraints. *European journal of operational research*, 206(3):642-652.

Patwa, J.R., Patel, N.G., Viradiya, R. & Patel, M.K. 2015. Assessment of implementation of "5 S" in PHC of Ahmedabad. *International journal of applied research and studies*, 1(9):408-410.

Penn, M.L. 2014. Developing a multi-methodological approach to hospital operating theatre scheduling. Southampton: University of Southampton. (Thesis-PhD).

Persson, M., Hvitfeldt-Forsberg, H., Unbeck, M., Sköldenberg, O.G., Stark, A., Kelly-Pettersson, P. & Mazzocato, P. 2017. Operational strategies to manage non-elective orthopaedic surgical flows: a simulation modelling study. *Biomedical journal open*, 7(4):1-8.

Poksinska, B.B., Fialkowska-Filipek, M. & Engström, J. 2017. Does Lean healthcare improve patient satisfaction? A mixed-method investigation into primary care. *British Medical Journal Qual SAF.* , 26(2):95-103.

Radnor, Z.J., Holweg, M. & Waring, J. 2012. Lean in healthcare: the unfilled promise? *Social Science & Medicine.* , 74(3):364-371.

Rahbek Gjerdrum Pedersen, E. & Huniche, M. 2011. Negotiating lean: the fluidity and solidity of new management technologies in the Danish public sector. *International Journal of Productivity and Performance Management.*, 60(6):550-566.

Rotter, T., Plishka, C.T., Adegboyega, L., Fiander, M., Harrison, E.L., Flynn, R., Chan, J.G. & Kinsman, L. 2017. Lean management in health care: effects on patient outcomes, professional practice, and healthcare systems. *The Cochrane database of systematic reviews 2017*. https://www.cochrane.org/CD012831/EPOC_lean-management-health-care-effects-patient-outcomes-professional-practice-and-healthcare-systems Date of access: 20 Feb 2018.

Saadouli, H., Jerbi, B., Dammak, A., Masmoudi, L. & Bouaziz, A. 2015. A stochastic optimization and simulation approach for scheduling operating rooms and recovery beds in an orthopedic surgery department. *Computers & industrial engineering*, 80:72-79.

Stuart, K. & Kozan, E. 2012. Reactive scheduling model for the operating theatre. *Flexible services and manufacturing journal.* , 24(4):400-421.

Stuart, K.L. 2010. Using operations research methodologies to improve operating theatre scheduling. Brisbane: Queensland University of Technology. (Thesis-PhD).

Teich, S.T. & Faddoul, F.F. 2013. Lean management—the journey from Toyota to healthcare. *Rambam maimonides medical journal*, 4(2):1-9.

Xiang, W. 2017. A multi-objective Ant Colony Optimization for operating room scheduling optimization. *Natural computing.* , 16(4):607-617.

Young, F.Y. 2014. The use of 5S in healthcare services: A literature review. *International Journal of Business and Social Science.* , 5(10):240-248.

CHAPTER 3: ARTICLE FOR PUBLICATION IN THE JOURNAL FOR PERIOPERATIVE CARE AND OPERATING ROOM MANAGEMENT

3.1 Introduction

Chapter 2 presented the literature review regarding Lean management philosophies that could be applied within the South Africa healthcare system. The literature review looked at the possible Lean management philosophies that could be proposed in terms of scheduling orthopaedic theatre surgeries at a level three public hospital. In this chapter the results of the research are presented in the manuscript format. The manuscript: *A lean management framework to schedule orthopaedic operating procedures for a level three public hospital, North West Province*, was prepared for the *Journal of perioperative care and operating room management* published by Elsevier. The manuscript maintained the APA (American Psychological Association) reference style.

3.2 Authorship

Authorship to this manuscript adhered to the *perioperative care and operating room management journal's* three criteria.

Perioperative care and operating room management journal	K Sekoto	P Bester	CM Niesing	DM Kruger
Conception and design of the study, or acquisition of data, or analysis and interpretation of data	X	X	X	X
Drafting the article or revising it critically for important intellectual content	X	X	X	X
Final approval of the version to be submitted	X	X	X	X
Signatures				

3.3 Authors guidelines

The objective of this journal is to serve as a multidisciplinary, peer reviewed source of information related to the administrative, economic, operational, safety, and quality aspects of the ambulatory and in-patient operating room and interventional procedural processes. The journal will provide high quality information and research findings on operational and system-based approaches to ensure safe, coordinated, and high value pre-procedural care to all patients. With the current focus on value in health care it is essential that there is a publication for researchers to publish on quality improvement process initiatives, process flow modelling,

information management, efficient design, cost improvement, use of novel technologies, and management.

This journal's audience includes all groups who participate in the planning, execution, and monitoring of the perioperative process such as medical specialists (surgeons, anaesthesiologists, hospitalists), nurses, administrators, pharmacists, systems and process engineers, and others health care providers involved in the development and implementation of perioperative or pre-procedural care processes.

For authors guideline package on the requirements of the article to be submitted please refer to the link <https://www.elsevier.com/journals/perioperative-care-and-operating-room-management/2405-6030?generatepdf=true>

Manuscript title: Go Lean! A Lean management framework to schedule orthopaedic operating procedures for a public hospital, South Africa.

Khosi Emmanuel Sekoto, MBA candidate, senior technician at Eskom Holdings SOC, Distribution, Control Plant Maintenance, Klerksdorp, South Africa, Sekotoke@eskom.co.za, 082 335 1098.

Petra Bester, PhD (Nursing), Director Africa Unit for Transdisciplinary Health Research (AUTHeR), Faculty of Health Sciences, North-West University, Potchefstroom, South Africa, petra.bester@nwu.ac.za, 082 298 3567.

Christi Niesing, PhD (Business Administration), Senior Lecturer AUTHeR, Faculty of Health Sciences, North-West University, Potchefstroom, South Africa, christi.niesing@nwu.ac.za, 084 435 0025.

Doret Kruger, MBA (Masters in Business Administration) Project Manager, North-West University, Potchefstroom, South Africa, doret.kruger@nwu.ac.za, 082 927 0503.

Correspondence author:

Petra Bester, Office 257B, Building G16, 11 Hoffman Street, North-West University, South Africa, Private Bag X6001, Potchefstroom, petra.bester@nwu.ac.za, +27 82 2983567/+27 18 299 2094 (phone).

Word count (including abstract and references): 13 847

ABSTRACT

Aim: To propose an appropriate scheduling system contextual to the organisational challenges and based on Lean management principles to the orthopaedic theatre at a level three public hospital in the Dr Kenneth Kaunda District, North West, South Africa.

Background: The level three public hospital with two orthopaedic theatres provides services to over 22 000 patients throughout the North West Province. In the absence of a comprehensive theatre scheduling system, patients experience long waiting times. However, the principles of Lean management can be incorporated into the complexity of the interdepartmental activities in the absence of an appropriate scheduling system. This level three public hospital in the Dr Kenneth Kaunda District in the North West Province has many challenges, with the budget constraints, limited resources, over burden infrastructure being deteriorating and run down.

Methods: The research followed a qualitative, single-case embedded research design. The research type was a two embedded units of the orthopaedic operating theatres, theatre 1, and 3. The setting was the hospital management, orthopaedic, administration, finance, pharmacy and X-ray departments of a level three public hospital in the Dr Kenneth Kaunda District, North West. The selected participants of the interviews were ideal since them responding to the research questions. Archival documents were studied in order to understand how the orthopaedic theatre scheduling was done in the hospital. The literature review was studied about Lean management in healthcare environment, Lean Six Sigma and 5S were the most suitable Lean management framework. The data was collected from multiple sources of evidence, (36 archived documents, eighteen (18*n*) semi-structured interviews and 250 pages' reflective notes and later analysed for the results outcome. The research was approved by the Economic and Management Sciences Research Ethics Committee (EMS-REC) of the North-West University and permission granted by the North West Provincial Department of Health. Informed consent was obtained from orthopaedic staff, management, administration, finance, pharmacy, and X-ray departments involved in the orthopaedic theatres' surgeries scheduling prior conducting the semi-structured interviews. In enhancing the rigour, the researcher adhered to reliability, validity, and trustworthiness.

Results: The actual flow chart displayed ten stages with six gaps in the scheduling system of the orthopaedic theatre surgeries. The recommended scheduling system informed how the six stages of concern could be improved based on Lean management methodologies. A central network and mobile text messaging are identified as essential components to optimise the theatre scheduling system. The proposed framework acknowledges the contextual realities of the public hospital.

Conclusion: The multi objective programming model is a proposed scheduling model for the orthopaedic theatre surgeries under normal situation. The reactive model is proposed in cases of unexpected high number of patients seeking orthopaedic surgeries procedure. While the simulation model could be used to test the multi objective model under normal situation prior the scheduled surgeries to help the scheduler to identify which model to use. Lean management methodologies can be taught to management and staff. Despite a limited budget and resources and deteriorating infrastructure the hospital management and orthopaedic staff aims to maintain quality service.

Key terms: Lean management, framework, orthopaedic theatre, public hospital, scheduling, case study.

(Word count: 579)

Highlights

- Multi objective programming model proposed scheduling model for orthopaedic theatres. Reactive model in cases of unexpected high patients' turnover.
- A central network and text messaging system is essential for optimal orthopaedic staff scheduling.
- Despite organisational challenges such as deteriorating infrastructure and limited resources, teach Lean management methodologies to hospital management and orthopaedic theatre staff. These methodologies can be implemented in various theatre-related processes.

MANUSCRIPT

1. Introduction

Throughout the world there is a high demand for hospitalisation as a result of an ever expanding ageing population. This results in more pressure on healthcare facilities and prolonged waiting lists in terms of theatre scheduling, neonate disease, budget constraints and insufficient access to healthcare treatment (Denton, 2013, p. 183). Globally, hospitals are experiencing increasing pressure in terms of outpatients seeking surgical surgeries, especially in orthopaedic theatres (Morris, James, Davey, & Waddington, 2015, p. 128). Hospital management invests in various research developments projects with the aim of reducing the long waiting list of elective surgery patients while at the same time running the operating theatres efficiently (Addis, Carello, Grosso, & Tanfani, 2014, p. 2). Cancellation of scheduled orthopaedic surgeries across the world has been a long standing problem for many years (Dimitriadis, Iyer, & Evgeniou, 2013, p. 1126) and (Hoyler, Finlayson, McClain, Meara, & Hagander, 2014, p. 269) further added that in low and middle income countries (LMICs) public hospitals have added problems with regard to the unavailability of recovery beds, shortage of surgeons, anaesthetists, and orthopaedics. Many public healthcare facilities in South Africa are in a state crisis, possess a deteriorating legacy infrastructure and are run down, dysfunctional, underfunded, mismanaged, and neglected (Mayosi & Benatar, 2014, p. 1346).

The origin of the Lean concept goes back to just after the end of the second world war when the Japanese car manufacturers realised they could not afford massive investment to rebuild devastated facilities (Bhamu & Singh Sangwan, 2014, p. 876). The manufacturer decided to look for ways to produce the same product without compromising on quality, and there was a revolution of quality in the same era (Gupta, Sharma, & Sunder M, 2016, p. 1025). The term 'Lean' was first coined by Womack, Jones, and Roos in 1990, (as cited in Costa & Godinho Filho, 2016, p. 823) and is derived from Toyota Production System (TPS). It is based on the concept of continually trying to improve efficiency and eliminate waste in the system (Costa & Godinho Filho, 2016, p. 823). Many academics and practitioners define the term Lean as a way to focus on customer needs (Gupta et al., 2016, p. 1026). In 1996 Womack and Jones mentioned that in order to meet the customer needs, organisation first needs to identify what is the product or service that can add value to the customer. The result and findings can assist the organisation to reduce non-value-adding features and start working on improving efficiency continuously and striving for perfection (Daultani, Chaudhuri, & Kumar, 2015, p. 1083). Today Lean production is no longer exclusively linked to manufacturing; in fact, many organisations in

different sectors are using this concept in an attempt to improve their production and efficiency (Drotz & Poksinska, 2014, p. 178).

The application of a Lean management philosophy within the healthcare environment is not a new phenomenon and is able to contribute to the solutions in terms of the challenges the healthcare centres are facing by providing patient satisfaction with limited resources available (Dammand, Hørlyck, Jacobsen, Lueg, & Röck, 2014, p. 20). A Lean philosophy approach allows healthcare centres to improve patients' quality healthcare by eliminating waste and waits. Lean concepts are integrated into the operational vocabulary in both public and private healthcare environments which are struggling with the demand of patient satisfaction and limited resources (Rahbek Gjerdrum Pedersen & Huniche, 2011, p. 550). Although Lean concepts are applied in some healthcare centres in the Global North such as Canada, United States of America, and the UK, research has revealed that there remains a scope for more evidence of the effectiveness of Lean management solutions as applied to healthcare in terms of patients, healthcare workforce, and management (Hamilton et al., 2014, p. 5). Even more so in the Global South.

1.1. Orthopaedic surgeries a high cost driver in South African hospitals

Worldwide, health systems costs have progressively increased due to an ever-expanding ageing population, new diseases, technologies and high quality health expectation (Crema & Verbano, 2016, p. 1150). According to Guerriero and Guido (2011, p. 89) operating theatres are major cost drivers in private and public hospitals around the world and 60-70% of hospitalised patients require some form of surgical intervention. Operating theatres account for approximately 40% of revenue and expenditure of the hospital despite limited resources (Penn, 2014, p. 1). There are number of operating theatres in hospitals performing a variety of surgeries. The surgical procedures performed within the hospital operating theatres are grouped according to surgeons' specialities (Morris et al., 2015, p. 128).

Increased orthopaedic surgeries as the solution to ease discomfort and impaired mobility of ageing society is in high demand in both public and private hospitals (Lamagni, Elgohari, & Harrington, 2015, p. 125). Several studies (Boas et al., 2015, p. 283; Carroll, Dowsey, Choong, & Peel, 2014, p. 130) concluded that hip and knee joint replacements are the most successful orthopaedic surgical procedures; outcomes are substantial improvement in pain and quality of patient life. Unfortunately, but limited complications of prosthetic joint replacements do lead to morbidity, mortality and financial losses due to revision surgeries (Bayliss et al., 2017, p. 1424). Kurtz *et al.*, (as cited in Boas et al., 2015, p. 283) estimates an increase of 174% between 2005 and 2030 of hip replacement in the United States, this also representing an increased ageing population and healthier lifestyle. It is predicted that globally, in the next 10–20 years, joint

replacements will increase substantially not only in terms of old-aged patients, but increasingly younger patients with ages younger than 60 years as well. This younger generation is representing 15% of the entire population undergoing surgery (Bayliss et al., 2017, p. 1424).

The healthcare system in South Africa is also experiencing a high volume of patients seeking orthopaedic surgical procedures (Dell, Gray, Fraser, Held, & Dunn, 2018, p. 3850). The World Health Organization (WHO) has determined that there is shortage of surgeons in obstetrics, anaesthetists, and orthopaedics in both public and private health system of 57 LMICs (Hoyler et al., 2014, p. 269). For example, shortages in healthcare workforce, the backbone of public healthcare delivery systems, in the low to middle income countries (LMICs) like South Africa challenge the provision of essential surgical treatment (Dell & Kahn, 2018, p. 541). Several studies (Ahwireng-Obeng & van Loggerenberg, 2011, p. 40; Crush & Chikanda, 2015, p. 313; Mazzaschi, 2011, p. 305) concluded that South Africa has better healthcare facilities in comparison to other LMICs it has become one of the leading medical tourism destinations to some of these countries. According to Chikanda and Crush (2017, p. 6), the healthcare system of South Africa is getting more and more overburdened with of patients seeking specialist treatment; for example, orthopaedic surgeries of referral patients from Sub-Saharan Development Community (SADC).

Mokatsane, CEO of public hospital (personal communication, November 19, 2018) stated that due to the high costs that private hospitals charge in terms of orthopaedic operating procedures has compelled some private patients to seek surgeries at this public hospital as their medical aid funds run out. The limited healthcare infrastructure in many public hospitals in LMICs remains a challenge (Hsia, Mbembati, Macfarlane, & Kruk, 2011, p. 235). In South Africa morbidity and mortality attributed to gunshot wounds in areas with high violence and injuries are an immense burden to public healthcare theatres (Bola, Dash, Naidoo, & Aldous, 2016, p. 208; Martin, Thiart, McCollum, Roche, & Maqungo, 2017, p. 626). Several studies (Adeloye et al., 2016, p. 515; Parkinson, Kent, Aldous, Oosthuizen, & Clarke, 2014, p. 242) concluded that South Africa's road traffic accidents contribute to this burden with injured patients seeking emergency surgical procedures. Recently, improving the organisational performance of the public healthcare system has become a much debated issue all over the world by several studies (Dahlgaard, Pettersen, & Dahlgaard-Park, 2011, p. 674; De Koeijer, Paauwe, & Huijsman, 2014, p. 2911). The system been subjected to quality and financial challenges (Mohrman, Shani, & McCracken, 2012, p. 4) and according to Hood, Healy and McKee (as cited in Lindskog, Hemphälä, & Eriksson, 2017, p. 175) healthcare facilities and other government organisations have sought solutions in variety of management concepts that have originated in the private sector (e.g., Lean management methodologies). Many public healthcare systems strive to improve performance by embracing the methodologies and philosophies derived from

manufacturing such as Lean management and Six Sigma (LM&SS) (De Koeijer et al., 2014, p. 2911).

1.2. Lean management in healthcare

Womack and Jones were the first authors to introduce Mean management methodologies in a healthcare environment (Poksinska, Fialkowska-Filipek, & Engström, 2017, p. 96). Several studies (Cheng, Bamford, Papalex, & Dehe, 2015, p. 121; D'Andreamatteo, Ianni, Lega, & Sargiacomo, 2015, p. 1198) suggests that applying Lean management in the healthcare sector has resulted in an improvement in-patient quality healthcare, patient safety, and staff satisfaction. Lean management methodology is favoured and implemented by many healthcare managers worldwide and since it focuses on cost reduction and improvement to patient quality healthcare, the methodology is easily understood by healthcare staff (Matthias & Brown, 2014, p. 1435).

Lean implementation is taken seriously by the healthcare systems in some HIC, with evidence showing 57% in USA, followed by UK with (29%) and about (5%) in Australia and another (9%) internationally (as cited in Radnor, Holweg, & Waring, 2012, p. 365). In Canada, the State of Saskatchewan's Ministry of Health has invested heavily in the implementation of Lean philosophies in its healthcare system and introduced it in stages. The initial phase was the project called "The Productive Ward: Releasing Time to Care", a nurse-led quality improvement approach for hospital wards this system was adopted from the National Health Service in the UK. This process was an initiative in improving quality of care and reducing waste, it was implemented in all the medical and surgical wards across the province (Kinsman et al., 2014, p. 30). According to Marchildon (2013, p. 2), the Virginia Mason Health System in the United States has successfully implemented Lean principles to improve the patient flow, supply, and procurement in hospitals. According to Martin *et al.*, (as cited in Cheng et al., 2015, p. 122) reported that the implementation of Lean approaches at the University of Pittsburgh Medical Centre in UK has produced improvements in terms of patient flow in an emergency intake process and the discharge of cancer patients from in-patient to ambulatory services. The Bay Medical Center in Florida reported a saving of US\$2 million over eighteen-month period as a result of implementing Six Sigma across all the hospital facilities. Pre-surgical readiness was an area that showed major improvement and reported a reduction in cancellation of scheduled operating procedure and a saving of US\$1.2 million (Yaduvanshi & Sharma, 2017, p. 208).

As previously mentioned, while Lean management was first developed by Toyota, a team of engineers from Motorola Corporation led by Bill Smith developed Six Sigma with the primary approach to quality improvement within an organisation (de Freitas, Costa, & Ferraz, 2017, p.

262; Mason, Nicolay, & Darzi, 2015, p. 92). Since its introduction in 1995, Jack Welch the then CEO of General Electric (GE) made Six Sigma popular by successfully implemented it at GE after observing its success at Motorola (Manville, Greatbanks, Krishnasamy, & Parker, 2012, p. 7). Lean concentrates on cost reduction and efficiency and compliments Six Sigma which pursuits effectiveness and precision (Lighter, 2014, p. 9). The integration of the two methodologies to form Lean Six Sigma was introduced in the early 2000s in academic literature and Michael George in his book “ *How to Use Lean Speed and Six Sigma Quality to Improve Services and Transactions* “ (Timans, Antony, Ahaus, & van Solingen, 2012, p. 339). According to Mason et al. (2015, p. 92), Lean and Six Sigma are the two most prominent quality improvement (QI) methodologies that have successfully dominated the healthcare environment since 1998. Lean Six Sigma methodology can be used in other areas within the healthcare including finance, inventory management, information processing, pharmacy, outpatient clinics, and in-patient settings (Niemeijer, Trip, Ahaus, Does, & Wendt, 2010, p. 614). In the United State of America, Loma Linda University Children’s’ Hospital in Loma Linda, California, the research was conducted to determine if it was possible to improve the operating room efficiency using Lean Six Sigma methodology. The success was measured by the improvement in operating efficiency through coordinated multidisciplinary process redesign, without preselecting specific services or removing surgical residents, or incorporating new personnel or technologies (Tagge, Thirumoorthi, Lenart, Garberoglio, & Mitchell, 2017, p. 1041).

The 5S methodology was developed by Takshi Osada during 1980 in order to establish and sustain productivity, better quality, and a safe environment within an organisation (Randhawa & Ahuja, 2017, p. 50). According to Jackson (as cited in Kanamori et al., 2016, p. 1), 5S methodology is now applied more than ever in the healthcare sector as the measurement tool for organising and standardising the workplace for Lean healthcare. The 5S methodology is the foundation of Lean healthcare approaches aimed at achieving high productivity by maximising value-added levels by removing anything not adding value (Ikuma & Nahmens, 2014, p. 243). The 5S is the abbreviation representing the five Japanese words *Seiri, Seiton, Seisou, Seiketsu and Shitsuke*, which are all have to do with the terms orderly and organised (Young, 2014, p. 241). These five words are translated to English as sort, set in order, shine, standardise, and sustain.

Lean management in both private and public hospitals in South Africa are currently applied only on a small scale. Arwyp private hospital in East Rand Gauteng has implemented Lean management in order to reduce the infection rate with central line associated bloodstream infections across all the hospital departments (Theunissen, 2012, p. 2). Catherine Booth, a rural district hospital in KwaZulu-Natal, has applied Lean thinking to determine the efficiency and staff morale within its outpatient department. After measuring the cycle and waiting time in all service

nodes, the results showed a significant improvement relating to efficiency and staff morale (Naidoo, 2013, p. 2). G. Dube (on tweeter, October 3, 2017) CEO of Leratong Hospital in Johannesburg, said Lean management methodology was successfully applied and resulted in reducing patients' waiting times and congestion in its clinics, pharmacy, and some hospital departments. G. Bogoshi (on tweeter, October 3, 2017) CEO of Charlotte Maxeke Hospital (also in Johannesburg) said after implementing Lean management, the hospital improved efficiency across the board, and that operating room efficiency improved by 36%.

This level three public hospital in the North West Province has eight operating theatres of which two are dedicated to orthopaedics. One of the dedicated orthopaedic theatres is functioning on a 16 hrs basis (from the morning until midnight) for infection prone, septic and emergency cases. There are three general surgical wards, with two orthopaedics wards; one for females and one for males; both wards have 34 beds. The biggest problem in this hospital is that there is no software or program system for orthopaedic theatre scheduling and is coupled with a long waiting list of elective patients. Mokatsane CEO of a public hospital (personal communication, November 19, 2018) stated that the other challenges are broken or heavy equipment in theatres, staff availability, cancellation of elective patients, no dedicated anaesthetic wards, and availability of recovery beds. The research investigated the present functioning of the scheduling system of the orthopaedic theatres of a level three hospital in the Dr Kenneth Kaunda District and asked the following questions: *How did the scheduling system of the orthopaedic theatres of a level three public hospital in the Dr Kenneth Kaunda District function at the time of the research?*; and *What was the most appropriate Lean management framework to improve the orthopaedic theatre scheduling, efficiency, and production of the orthopaedic theatres of the level three public hospital in the Dr Kenneth Kaunda District?*

2. Research aim and objectives

The aim of the research was to gain a better understanding of the current scheduling system of the orthopaedic theatre at the level three public hospital in the Dr Kenneth Kaunda District in order to improve this system by means of an appropriate Lean management framework. The aim was achieved by means of the following objectives.

- **Objective 1:** To explore and describe the current scheduling system of the orthopaedic theatre system of a level three public hospital in the Dr Kenneth Kaunda District by means of a case study.
- **Objective 2:** To propose a Lean management framework to improve the orthopaedic theatre scheduling, efficiency, and production of a level three public hospital in the Dr Kenneth Kaunda District.

3. Methods

The research followed a qualitative single-case embedded design. The research type was a two embedded units of the orthopaedic operating theatres, theatre 1, and 3. The setting was in the departments of orthopaedic, administration, finance, pharmacy, and X-ray of a level three public hospital in the Dr Kenneth Kaunda District, North West. The literature review was studied about Lean management in healthcare environment and Lean Six Sigma and 5S are the most suitable Lean management framework for this research. The data was collected from multiple sources of evidence, (36 archival documents, eighteen (18n) semi-structured interviews, 250 pages' reflective notes and later combined report of the two theatres, analysed for the results outcome. The archival documents about scheduling of orthopaedic surgeries and other related documents were downloaded from the hospital's data storage in the Microsoft Excel format of a period from December 2017 to October 2018. The semi-structured interviews were audio recorded and the participant's identity was kept anonymous and confidential. The recordings were done in order to avoid distractions because of the researcher taking notes. The interviews took place at the workplace in a quiet private room and were kept to minimal time during breaks and before the start of shifts not to disturb the operations of the departments. The interviews were audio recorded and transcribed later, coded, analysed and how scheduling or the orthopaedic theatre have been done. The participants were ideal for the research to explain the activities challenges and achievements of the orthopaedic department. The reflective notes were taken by the researcher from beginning of the research until the end and later analysed with other sources of evidence to compile one report. The multiple objective programming, reactive and simulation models were recommended in orthopaedic theatre scheduling to reduce waiting list, cancellation by elective patients, improving efficiency and production. The proposed Lean management framework addresses orthopaedic scheduling to reduce waiting lists, cancellation of elective patients and to improve efficiency and production. This research was approved by the Economic and Management Sciences Research Ethics Committee (EMS-REC) of the North-West University (NWU-00545-18-A4) and permission granted by the North West Provincial Department of Health. Informed consent was obtained from orthopaedic staff, management, administration, finance, pharmacy, and X-ray departments involved in the orthopaedic theatres' surgeries scheduling prior conducting the semi-structured interviews. The three sources of evidence used, increased the quality of the research and enhanced the research outcome because it provided rigour throughout triangulation (Yin, 2014, p. 102).

3.1. Data sources

The research was set in the level three public hospital in the Dr Kenneth Kaunda District North West Province. These level three hospital complex made up of two hospitals situated apart,

both with a total bed capacity of 859. It is situated in Klerksdorp and renders specialist healthcare in the province. Data collection was activated once the ethical clearance was obtained from the Economic and Management Sciences Research Ethics Committee (EMS-REC) of the North-West University, Department of Health, North West Province, followed by the consent from the orthopaedic staff, and hospital management. The source of data for this research was the 36 archival documents (August 2017 to October 2018) financial reports, and other internal documents relating to orthopaedic theatre scheduling. The reflective notes with a total of 250 pages were taken from the beginning until the end of the research. In addition, eighteen (18*n*) semi-structured interviews were conducted in order to maximise the understanding of the scheduling system and the challenges the orthopaedic staff experience in theatres and wards. The multiple sources of data collected was analysed to come up with the research findings.

3.2. Inclusion criteria

Theory on Lean management in scheduling orthopaedic theatre surgeries was identified and studied for this research. The single-case embedded design was selected of the two dedicated orthopaedic theatres, theatre 1, and 3 of a level three public hospital. The archival documents included booking policies and related documentation of the day-to-day bookings of elective patients for orthopaedic theatre surgeries. Semi-structured interviews included management, orthopaedic staff, administration, finance, pharmacy, and X-ray department related to orthopaedic theatres scheduling. No restrictions were placed on the type of surgery, age, gender, or race in analysing the archived documents of scheduling the orthopaedic surgeries at the hospital. The researcher prepared the combined report from the two orthopaedic theatres. The current workflow of the scheduling orthopaedic surgeries was included in the research to generate the proposed new workflow chart.

4. Results

Archival documents (August 2017 to October 2018) of emergency and scheduled orthopaedic theatre surgeries were downloaded in the Microsoft Excel format, analysed for the report outcome. The sample size of the participants is eighteen (18*n*) semi-structured interviews with senior management, orthopaedic staff, finance, pharmacy, and X-ray which gave a diverse input in the scheduling of the orthopaedic theatres. The interviews were audio recorded and transcribed later, coded, analysed and how scheduling of the orthopaedic theatre surgeries have been done and what are the challenges in the orthopaedic department. The researcher had 250 pages of reflective notes from the beginning of the research to the end concerning the scheduling of the orthopaedic theatre surgeries. The reflective notes were later analysed and the report used as part of the final results of the research. Flow diagram (Figure 5) of the current

scheduling of orthopaedic theatre surgeries in the hospital was evaluated and analysed for what are the contributing factors to the cancellation by elective patients, effects on orthopaedic efficiency and production. Figure 6 recommends a framework to reduce the prolonged list of elective patients, improving efficiency and production in the orthopaedic theatres using Lean management methodologies. The departments concern is co-productive despite an absent central communication system, resulting in delayed start and ending of surgeries. The wrongfully filled consent form or unaccompanied minor do affect the schedule of the orthopaedic theatres. Both public and private hospitals are faced with the high number of outpatients seeking specialist surgical treatment especial orthopaedic surgery due to the high number of ageing population (Penn, 2014, p. 1).

4.1. Demographic data on orthopaedic wards occupancy

The high patient turnover of the selected hospital with a total of 859 beds is presented in the following discussion. The hospital accommodated a total of 272 262 serviced headcounts from outpatient departments between April 2017 to March 2018. In a typical month, the hospital caters for 2 735 admissions and a total of 20 009 in-patient days. The patient flow in a typical month in 2018 related to wards 5 and 6 (female and male orthopaedic wards, respective) is presented in Figure 1.

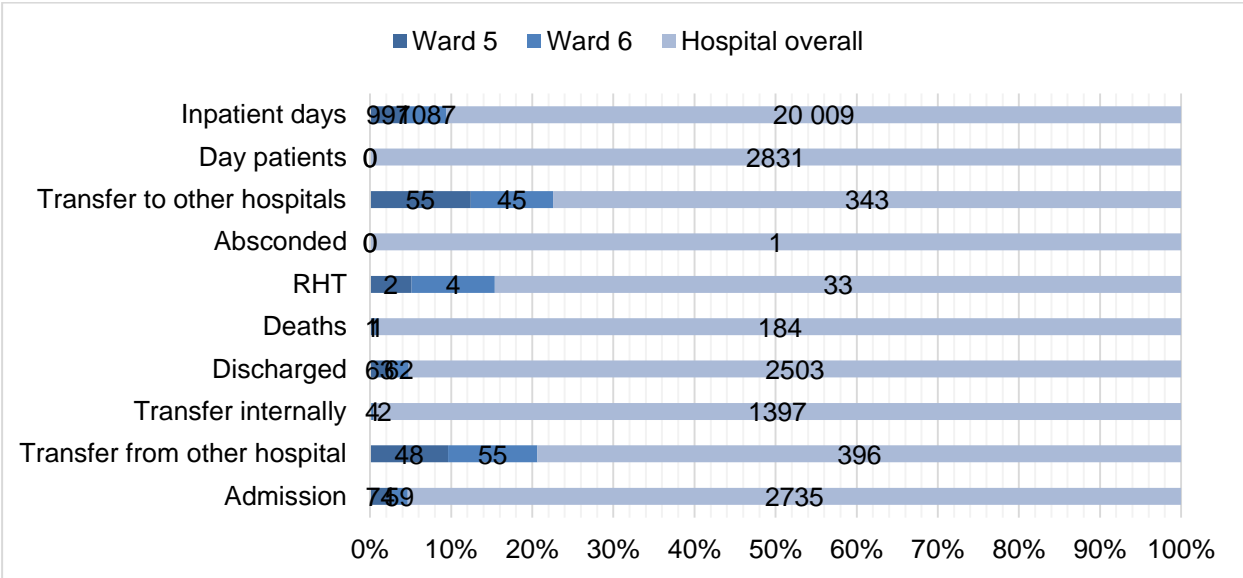


Figure 1: The patient movement of wards 5 and 6 related to the total patient movement of the hospital within a typical month in 2018

The orthopaedic wards contributed significantly to the hospital’s overall in-patient days (9.97% and 10.87% of all in-patient days are related to female and male orthopaedic wards respectively) of which 7.25% (ward 5) and 8.25% (ward 6) are the transfer of orthopaedic

patients to other hospitals, related to the 396 transfers in total. Figure 3 presents a graphic depiction of a selection of orthopaedic procedures conducted within the two orthopaedic theatres at the hospital over the course of six months (October 2017 – March 2018); while the pie diagram (Figure 4) summarise the total amount of surgical events that occurred within the two orthopaedic theatres from October 2017 to March 2018.

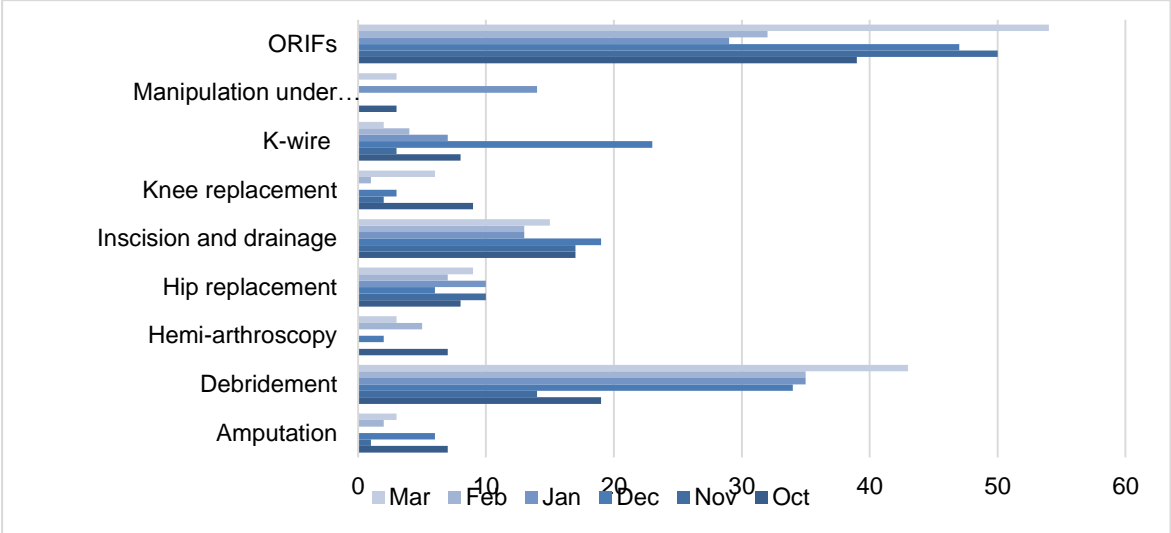


Figure 2: Selected orthopaedic procedures conducted over a course of six months by both orthopaedic theatres

Open reduction and internal fixations (ORIFs) followed by debridement were the dominant types of procedures. The theatres conduct more hip replacements than knee replacements. It was interesting to find that manipulation under anaesthetics in general as well as amputations were not as frequent as expected. The average amount of orthopaedic surgeries performed per month was 187.66. Overall November 2017 was less occupied with 161 orthopaedic surgeries for the month against the 202 surgeries performed in March 2018.

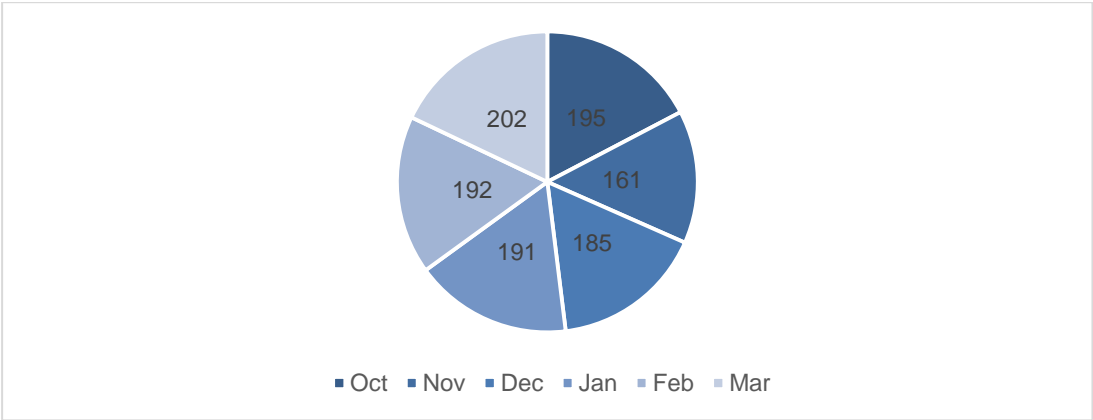


Figure 3: The total amount of orthopaedic surgeries conducted per month from 1/10/2-17 to 31/3/2018

4.2. Activity flow of scheduling orthopaedic surgeries

Table 1 shows the activity flow of scheduling orthopaedic surgeries at a level three public hospital in the Dr Kenneth Kaunda District, North West. The activity flow table illustrate all the activity step from the day the patient enters the hospital, diagnosed, and scheduled for surgery until the patient is discharged. The activity flow table also shows where the data source was captured and how the activity is related to lean management principles.

The ten distinctive actuals of the activity flow of scheduling orthopaedic surgeries are described as follows:

1. **Patient diagnosed:** the patient arrive at the hospital going through the orthopaedic clinic at the hospital or from the wards, the orthopaedic doctors diagnose the patient that there is the need for the orthopaedic surgery procedure. Other patients arrive at the hospital with the trauma cases either being involved in an incident or accident. There are no organisational barriers/gaps within the system and no Lean management principle is applicable at this moment.
2. **Booking of elective patients:** the theatre scheduler will book the elective patient for orthopaedic surgery procedure in the hospital booking system. The hospital is not using the computerised booking system to schedule the elective patients; this is the big barriers/gap for the hospital. In reducing the long waiting list of the elective patients, improving efficiency and production the hospital could use the Lean management principles using the multiple objective programming, reactive and simulation models.
3. **Inform patient of surgery:** the patient is informed of surgery by a telephone few days before the surgery; this is an organisational gap as the patient is reminded in a short time. Some patients are referrals from district hospitals, other provinces and patient commitments which will lead to cancellation of scheduled surgery. Using the computerised scheduling system, functions of reminding the patients, confirmation could be programmed in the system and the rate of cancellation by elective patients for orthopaedic surgery could go down. The 5S and Lean management principle can be of the help to the hospital in improving the organisation of the workplace in order to archive high productivity.
4. **Ready for surgery, patient admitted for pre-operative process:** the patient is monitored if is ready for surgery (health condition diabetic, hypertension patients etc.). Patient not ready for surgery will be scheduled for the next surgery until the health condition improves the same day or days later. If the patient health condition is not

improving the patient will be rescheduled at the beginning of the scheduling process. The organisational gap is referral patients travelling from their respective residing districts without being monitored if they are fit for surgery. Only to be turned away due to health risk for surgery which affects the scheduling, resources, and patients. Some referrals patients are admitted at the hospital for pre-operative procedure too early for their scheduled day of surgery which affects the expenditure of the hospital and there is no recovery system of expenditure to the referral hospitals.

5. **Consent form:** the consent form needs to be filled before the start of the surgery, minors and vulnerable people, consent forms needs to be filled by the parents or guardian. Unaccompanied minors from the referral hospitals to be operated are the biggest challenge for the hospital. The hospital could use the 5S principle in dealing with organised working procedure that before the minor is transported to a level three hospital for surgery, the consent forms are faxed or emailed to the hospital.
6. **Patient prepared for surgery:** with the staff shortages in the orthopaedic theatres the start of the surgery procedures is sometimes delayed, patient not collected on time by porters, change-over of surgeries, and low steam levels from hospital boilers. Employing more staff could reduce the heavy load and equipment which lead to increases in sick leave, low production, high staff turn around, and fatigue.
7. **Surgery procedure performed:** installation of steam level monitors could reduce the delays caused by low steam in boilers. The other delays in the system is the change-over from one operation procedure to the next with only one team per theatre, the staff not getting breaks in between and high levels of fatigue.
8. **Patient send to recovery room:** the hospital has a challenge of no dedicated orthopaedic recovery room; broken equipment and old machinery, this affects the production as they have to share with other theatres.
9. **Patient send to orthopaedic wards:** the hospital is having two orthopaedic wards for males and females with 34 beds each. The hospital servicing the province with specialist services it becomes a challenge when the wards are full. With the use of Lean management framework when scheduling the orthopaedic theatre surgeries, the scheduled patient will always have a bed available to recover after the surgery. This reflects back to the second actual of the booking of the elective patient using the multiple objective programming model. The low risk patient can be discharged the same day to recover at home.

10. The patient is discharged from hospital: the patient is discharged from hospital to recover at home; there are no barriers in the activity flow.

The ten actuals in the activity flow linked to the data obtained from were then aligned with possible best practices from the identified Lean management models, as summarised in Table 1.

4.3. Themes and sub-themes

From the thematic analysis, results emanated into themes and sub-themes (see Table 2). These themes and sub-themes originated from three data sets (archival documents, semi-structured interviews, and reflective notes). Theme one relates to the extended challenges when there is staff shortage in the orthopaedic theatres. There is a shortage of orthopaedic theatre staff, anaesthetists, orthopaedic nurses, and porters. There are no dedicated orthopaedic theatre nurses as they rotate with other operating theatres of the hospital. Due to the heavy equipment and machinery in the orthopaedic theatres nurses are reluctant to go back to orthopaedic theatre at their scheduled period. In addition, staff experience burnout as there is only one team per theatre throughout the shift without breaks. The anaesthetists alternating between two orthopaedic theatres is a challenge considering the volume of patients to attend by one anaesthetist at a time. The shortage of porters affects the start of the operating procedure when the porters transport patients between the wards and theatres.

Table 1: The activity flow of scheduling orthopaedic surgeries

Actuals	Responsible person:	Barriers/Gaps identified	Data source	Lean management (ideal situation)
1. Patient diagnosed (Clinic, trauma and wards).	Orthopaedic doctors	No barriers or gaps.	Reflective notes and semi-structured interviews.	Lean management principles were not applicable at this stage.
2. Booking of elective patients.	Orthopaedic theatre scheduler.	Booking is done on hardcopies or computer but not software scheduling.	Semi-structured interview with the orthopaedic theatre scheduler.	Use scheduling computerised software scheduling system (as discussed by Multiple objective programming and simulation models, [Reference]). Lean management principle for scheduling operating theatres.
3. Inform patient for surgery. If not found a replacement is called in.	Orthopaedic theatre scheduler.	Telephone call, sometimes patients change cellular phone numbers.	Semi-structured interview with the orthopaedic theatre scheduler.	Use scheduling computerised system to inform patient of scheduled surgery (to better the informing of patients for scheduled surgery 5s principle [Reference] should be activated).
4. Ready for surgery. Patient admitted for pre-operative process. Patient ready for surgery (will be operated); if not will be send back to the wards/home (health conditions).	Anaesthetic doctors	No observations done at lower level hospitals for patients before they get transported for surgery. Escalating hospital expenditure.	Semi-structured interviews with orthopaedic surgeons.	Lower level hospitals to be capacitated with staff to monitor patients before they travel to level three hospital for surgery. Central system, patients come on Friday/Saturday for Tuesday or Wednesday surgery. To reduce expenditure, the finance department to bill the hospital that referred the patients in recovering unnecessary costs. From which LM model, add reference
5. Consent form filled in. Without consent form surgery stops for minors and vulnerable people. Elderly/minors and health sensitive patients get operated first (e.g. diabetic patients).	Patient, minor (parent/guardian). Orthopaedic theatre staff.	Unaccompanied minor or vulnerable people by parent/guardian.	Semi-structured interviews with orthopaedic staff and orthopaedic department manager.	A minor patient to be accompanied when coming to hospital. Electronic copy of the consent form send to hospital prior transfer of a patient. Booking policy document is very functional (as discussed by 5s principle [reference]).
6. Patient prepaid for surgery. Delay surgery procedure.	Anaesthetic doctor. Porters/change-over patients.	Shortage of three anaesthetic doctors. No patients, porters fetching from wards, and change-over orthopaedic staff patients.	Semi-structured interviews with anaesthetist.	Shortage of anaesthetist. Shortage of porters servicing theatres. One team per orthopaedic theatre (shortage of orthopaedic staff) Which LM model, reference.
7. Surgery procedure performed.	Surgeons/consultant.	Delays to start surgery: Low steam from boilers. Changer-over between theatres.	Semi-structured interviews with orthopaedic surgeons.	Install steam level monitors in boilers and theatres. Employ more theatre staff (to have two teams per theatre, reduce fatigue levels, low production, and high staff turn around). Which LM model, reference.
8. Patient sends to recovery room.	Orthopaedic nurses.	No dedicated recovery room for orthopaedic. Three beds operational, one bed is not functional and old machinery.	Semi-structured interviews with anaesthetists.	Dedicated ward for orthopaedic theatres. Which LM model, reference.
9. Patient sends to orthopaedic ward. Low risks surgeries cases patients can be send home same day.	Staff in orthopaedic wards	Some patients from referrals hospitals can recover at their local hospitals for low risks surgeries. No space in orthopaedic wards, patients will be send to general wards.	Reflective notes, semi-structured interviews with orthopaedic department manager.	Reducing the hospital expenditure by having a clear directive of how long a patient can stay in recovery wards (depending on a case by case). With multiple objective programming model in scheduling [reference] the orthopaedic theatre surgeries the shortage of the recovery beds could be minimised.
10. The patient is discharged from hospital.	Orthopaedic doctors/nurses	No barriers of gaps.	Interviews with orthopaedic staff in wards.	N/A

The second theme highlights the realities of the orthopaedic theatres' infrastructure. There is no dedicated orthopaedic recovery room within the hospital and limited recovery beds considering the hospital caters for 34 beds per male and female wards. Theatres require functional and suitable operating beds as the current beds are very low and affect the productivity and ergonomics of the staff. In general staff is reluctant to work in the orthopaedic theatre due to heavy theatre metal aprons, heavy equipment and machinery. The old and frequently broken equipment in the recovery room affect the efficiency and production.

The third theme highlights the absence of scheduling technology. The hospital does not use the computerised programs to schedule the orthopaedic theatre surgeries which could be useful to the hospital to reduce the cancellation by elective patients, prolonged waiting lists. Furthermore, the hospital lacks a network infrastructure that could link all the departments interacting with the scheduling of the orthopaedic theatres and the information being central and accessed by the departments concern. The fourth theme presents the realities of lack of interdepartmental communication. There is a lack of communication between the departments concerning the scheduling of the orthopaedic surgeries. The departments seem to be working in silos. There is a gap in proper documentation of orthopaedic patients prior to surgery, including consent forms especially for vulnerable patients, affecting sometimes the start time of scheduled surgeries. The fifth theme calls for role clarification of especially nurses in the orthopaedic theatres. There is no clear job profile for the orthopaedic nurses. At times these nurses are unclear about their outputs and what is expected of them. There are no cleaning staffs in the orthopaedic theatres between the surgeries which the orthopaedic nurses have to clean the equipment, machinery, and floors. The final theme presents the challenges when scheduled surgeries are cancelled by elective orthopaedic patients. Patients are reminded for scheduled surgeries in a short time from the time they have been booked in for surgeries. Work and personal commitments are sometimes the reason patients cancel the scheduled surgeries. At times surgeries are cancelled due to health conditions by elective patients of chronic diseases.

Table 2 Themes and sub-themes

Theme	Sub-theme
1. Staff shortage in the <ul style="list-style-type: none"> • orthopaedic • theatres 	1.1 Shortage of dedicated orthopaedic nurses and professional nurses. 1.2 Only one team of orthopaedic nurses per theatre. 1.3 Shortage of anaesthetists in the orthopaedic theatres. 1.4 Shortage of porters delaying starting times of surgeries
2. Infrastructure	2.1 No dedicated orthopaedic recovery room. 2.2 Limited orthopaedic recovery wards. 2.3 Broken or not functional theatre beds for orthopaedic surgeries. 2.4 Heavy protective clothing in theatres. 2.5 Old and frequent breakdown of equipment in recovery room. 2.6 Heavy equipment and machinery in orthopaedic theatres.
3. Technology	3.1 No computerised program for scheduling orthopaedic surgeries. 3.2 No central information system in the hospital. 3.3 No proper documentation of orthopaedic patient's prior surgery, affect the

Theme	Sub-theme
	starting time sometimes surgeries are cancelled.
4. Communication	4.1 Less communication between the departments of the hospital interacting with the scheduling of the orthopaedic theatres 4.2 Wrongfully filled forms affecting the scheduled surgery starting time.
5. Clear definition of roles	5.1 Job profile of the orthopaedic theatre staff (nurses). 5.2 No dedicated cleaning staff of orthopaedic theatres between surgeries.
6. Cancellation of scheduled surgeries by elective orthopaedic patients	6.1 Patients being reminded for surgery in a short time. 6.2 Patients cancelling surgeries for personal reasons or could not be traced. 6.3 Patients not ready for surgery due to health conditions.

4.4. Current scheduling of the orthopaedic surgeries

Expounded from the three data sources, the current workflow of the scheduling for a typical orthopaedic surgery at the hospital was constructed (Figure 4). The workflow presents the activities involved with the scheduled orthopaedic surgery of an elective patient, from the day the patient arrive at the hospital doors, booked for surgery and until the patient is discharged. The workflow highlights the areas of concern where improvements are needed to reduce prolonged waiting times and increase the efficiency and production in orthopaedic theatres.

Stage 2: The theatre scheduler books in the patient for the orthopaedic surgery in the computer but not a scheduling program. The concern is that the scheduled list is not looking at the availability of staff, resources, theatre block time, and availability of recovery bed in the ward. With the multiple objective programming the orthopaedic department can schedule the surgeries using this model which is looking at available resources, increase efficiency and production (Xiang, 2017, p. 608). **Stage 3:** Informing the elective patient of the scheduled surgery at a short notice is a problem that results in high number of cancellations by patients. The orthopaedic staff informs the patient few days just before the surgeries, personal, and work commitment result in patient not available and the hospital phones the next in line patient. With the use of scheduling program, the function of reminding the patient few months ahead, weeks, and the patient confirming to honour the scheduled surgery. **Stage 4:** The patient is being admitted at the hospital for pre-operative surgery, patient is monitored if he/she is ready to receive orthopaedic surgery. If the patient is not ready for health condition, chronic disease, hypertension pressure too high for a patient to be operated. The patient is monitored if the condition improves, he/she will be operated on a next block time. When the patient's health condition is not improving, the patient will be rescheduled for a surgery. **Stage 5:** Consent forms not filled in correctly or minor not being accompanied by parent or guardian disrupt the scheduled surgeries for the day. There scheduled surgery for a minor or vulnerable person cannot continue without the consent forms signed by a parent or a guardian. The hospital can emphasise on the correct filled-in of consent forms especial a minor from referrals hospital. The

referral hospital can fax or e-mail the consent forms prior the minor being transported to level three public hospital for a surgery. **Stage 6:** Emergency patient disrupting the scheduled orthopaedic surgeries for the day. The emergency patient or patients arriving at the hospital that needs to be operated may be as results of accident or a disaster. Such unforeseen events disrupt the scheduled orthopaedic surgeries as the victim's health could deteriorate to life treating situation. The reactive scheduling can be a solution for the hospital as system is used to minimise the disruption to a low level until the scheduling is back to normal (Stuart & Kozan, 2012, p. 400). **Stage 9:** The patient is sent to the orthopaedic ward to recover before being discharged. Some patients with less risk surgery can be sent to orthopaedic ward for a day or more, instead of being sent home if the transport is available for referral patients to their respective referral hospital. The level three hospital expenditure becomes high of patients that could be discharged or referred to their respective referral hospitals.

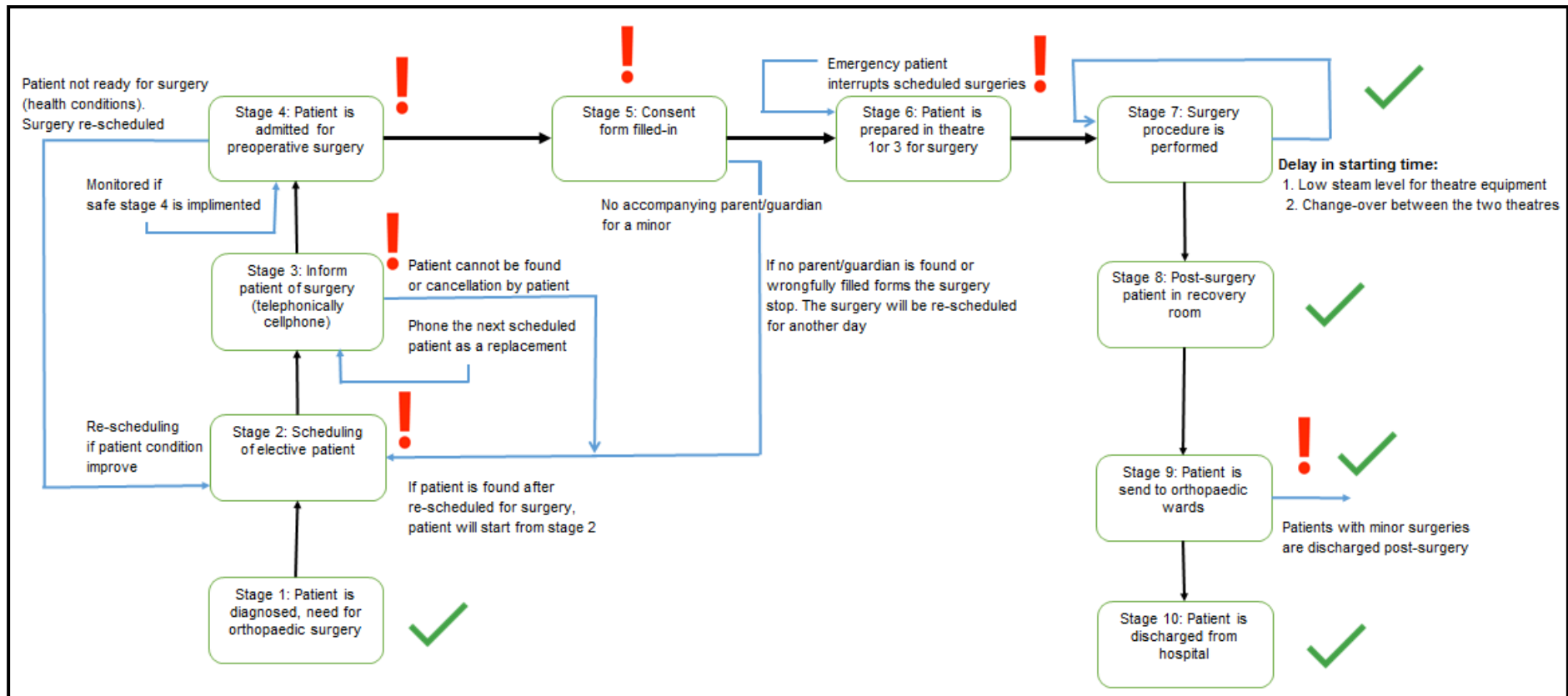


Figure 4: The current workflow of the scheduling orthopaedic surgeries

4.5. Recommended scheduling framework based on lean management

Built on the principles of Lean management, an orthopaedic theatre scheduling framework is proposed. The expected model is a generic solution that can be adopted in different cases within the hospital departments and other healthcare centres with the objective to maximise production in the short term as well as in the long term. Figure 5 depicts the recommended workflow to consider when scheduling orthopaedic surgeries aimed improving efficiency and production. The ten stages are described as follows:

STAGE 1: Patient is diagnosed; there is a need for orthopaedic surgery.

STAGE 2: The Lean management principle of multiple objective programming is used to schedule orthopaedic surgeries of elective patients. The multiple objective programming model will be used in scheduling orthopaedic elective patients and configure the type and number of surgeries to be performed on the particular day looking at the situation and resources available.

STAGE 3: The multiple objective programming model proposed to send Short Message Services (SMS), e-mail timely in advance of the scheduled day of surgery, e.g. two months, two weeks then two days before the event. This will remind the patients in time to make necessary arrangements not to miss the scheduled surgery. Should there be no acknowledgement or response from the patient months or weeks ahead, a replacement patient can be found, preferable moving forward the next in queue patient.

STAGE 4: Patient is admitted for pre-operative surgery. Referral patient monitored if ready to be operated on from another hospital. If patient is not in good health for surgery that patient should not need to be transported to the level three hospital. When a patient's health is too risky to be operated on, the surgery should be rescheduled and the patient moves back to stage 2.

STAGE 5: Consent forms are signed by a patient or guardian for minors and vulnerable people. In the case of referral hospitals, it is recommended that consent forms are forwarded to theatre by e-mail prior to transporting the patient. This could help in reducing the number of patients in orthopaedic wards waiting for consent forms.

STAGE 6: The patient is admitted, prepared for surgery, and allocated to an operating theatre according to the scheduling program. Emergency patients might disrupt the scheduling only. With a high number of trauma, the reactive model can be activated to help smooth the scheduling.

STAGE 7: Surgery procedure is performed.

STAGE 8: Post surgery patient in the recovery orthopaedic room.

STAGE 9: Patient is moved to orthopaedic wards by the porters to recover before being discharged. Patients with minor surgeries can be discharged to go home, and the referral patients with less risky surgeries can also be transported to their respective hospital until being discharged. Timely transport of stable patients back to referral hospitals is motivated.

STAGE 10: Patient is discharged from hospital to continue to recover at home.

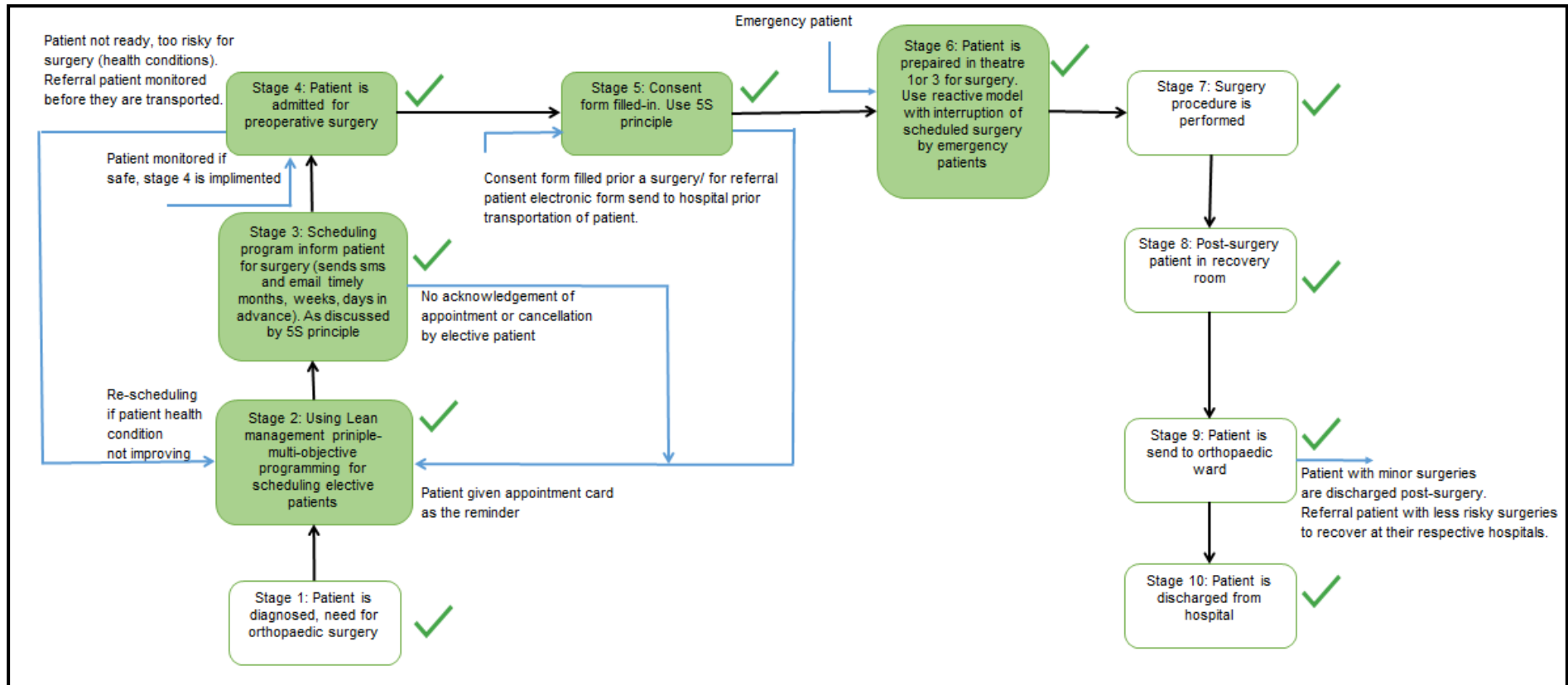


Figure 5: Recommended workflow of the scheduling orthopaedic surgeries

5. Discussion

Operating room inefficiency can be generalised as the hospital-wide factors especially in the public healthcare facilities. Hospital-wide factors such as the poor pre-operative preparations, availability of recovery beds in orthopaedic wards, staff availability, equipment and transfer of patients (Ang, Sabharwal, Johannsson, Bhattacharya, & Gupte, 2016, p. 25). The challenge for the operating theatre management is to arrange the scheduling that is able to deliver as many surgeries as possible with limited resources. This involves reducing the waiting list of elective patient, cancellations, surgeries on time, high quality surgeries, satisfied theatre staff, improved working conditions, efficiency and production (Xiang, 2017, p. 607). The multiple objective scheduling program for operating theatre is built in a sequence that it looks at factors that might affect the scheduling, availability of operating theatres, overtime, recovery beds and staff (Latorre-Núñez et al., 2016, p. 248).

Cancellation of elective scheduled surgeries leads to inefficient use of operating theatre time, increases costs and waste of resources (Kaddoum, Fadlallah, Hitti, Fadi, & El Eid, 2016, p. 1). There are number of reasons that may cause the cancellation of a scheduled surgery by an elective patient and varies from hospital to another (Lee, Kerridge, Chui, Chiu, & Gin, 2011, p. 214). With the partner hospital, the field study shows that the shorter time to inform the patient is the problem as the patient might cancel surgery for personal or work commitment and in some instances the patient cannot be reached as a result of change contact numbers. The other reasons ranges from inadequate pre-operation assessment of patients and preparation for the surgery (González-Arévalo et al., 2009, p. 487). Moreover, day of surgery cancellation creates logistic and financial burden associated with the extended hospital stay with the hospital that operates with limited resources (Mesmar, Shatnawi, Faori, & Khader, 2011, p. 652; Seim et al., 2009, p. 174). It is very important for the hospital management to identify what could be the cause of cancellations, these will help to deal with the weakness in the system and be addressed accordingly. According to Schofield *et al.* (cited by Kaddoum et al., 2016, p. 1) there is a high volume of cancellation by the elective patient on the day of the surgery, and worldwide the problem reported the rate ranging from 1.96% to 24%. However one of the studies revealed that cancellation rates ranges from 10% to 17% across the healthcare system with Norway, United States of America, New Zealand, Britain and South Africa (Seim et al., 2009, p. 173).

There are limitations to that might interfere with the implementations of the Lean Six Sigma framework in the orthopaedic theatres can be related to the organisational and infrastructure capabilities at this level three public hospital. This limitation is not related to Lean Six Sigma principle as it is easy to Learn and implement. This limitation was also the result of the findings

of the Mayo Clinic, Rochester (MCR) which is a tertiary-care academic medical centre located in the upper Midwest (Cima et al., 2011, p. 90).

6. Conclusions and recommendations

The proposed scheduling program is multiple objective programming models for scheduling the orthopaedic theatres surgeries, it is one of the useful scheduling theatre model. From the day the patient is diagnosed to be operated, the theatre scheduler uploads the patient's personal information in the system and the projected date of surgery. The reminder from the computer system is send to the elective patient through the Short Message System (SMS). If the patient has changed contact numbers, relocated outside the province, deceased, or had surgery from other hospitals it could be noticed earlier than to have a cancellation at the last minute. The scheduler few weeks before the operating day confirms with the patient if the patient is still coming for surgery, if not then a replacement could be found in time ahead of the surgery. The informed consent form to be sorted out in time especially for patients outside the Dr Kenneth Kaunda District as this causes some delays in the start of operating time. Prior the surgery the referral hospitals to e-mail/fax the necessary documentation.

The proposed multiple objective model programming and workflow of the scheduling orthopaedic surgeries is shown in (Figure 5). The reactive model should be considered in case of unexpected situations, disasters, labour strikes even during festive seasons where there is lot of trauma cases in theatres. The proposed scheduling models could be used in other theatres of the hospitals. With the scheduling system being central it could be accessed by the relevant departments (finance, pharmacy, and X-ray) this will make the hospital paper free environment, no documents missing, and confirmation is done in the system for the forthcoming surgeries.

Finance departments are advised to have online access of the computerised system of the scheduled surgeries as to be able to order from suppliers on time and plan ahead of the busy period (Easter holidays and festive session). Pharmacy to have a month order predictions of the stock, this is to reduce the chances of running out of stock or having back order form medical depot in Mahikeng, North West Province. X-ray department to see which surgeries are to be done in time and plan ahead of their appropriate staff to be at the scheduled theatre. Regarding staff, it is recommended that the hospital management should consider employing more orthopaedic staff in theatres, including porters as there are some times when there is delays to start time of operating procedures. Replacement of broken equipment, wrong beds for theatres not rising to the adequate level of operating and up being the ergonomics problem with staff complaining of back pains. Heavy equipment, should look at mechanised equipment to reduce heavy lifting. Role clarification between the nursing team and cleaning team is recommended.

Operating theatres are responsible for the hospital expenditure or revenue; this is due to the high demand of outpatients seeking surgical treatment and prolonged waiting list of elective patients. Hospitals around the world are experiencing a high demand of outpatients seeking medical treatment through surgery, especially orthopaedic theatres. Overburdened hospitals are facing a challenge of deteriorating infrastructure and budget constraints. The level three public hospital in the Dr Kenneth Kaunda District, North West is overburdened with the orthopaedic elective patients coming from the district, neighbouring districts and provinces who seeks medical treatment through surgery.

With the long waiting list of elective patients, the hospital is having difficulty not having a computerised scheduling system for orthopaedic theatre surgeries. The multiple objective programming model for normal situation could be useful for the hospital. The model will schedule the surgeries in the two theatres to reduce the long waiting list, improve efficiency, and production. The model will also schedule the patient surgery block time from the day a patient is diagnosed for orthopaedic surgery until the patient is discharged from hospital. The model is designed in a way that workflow of the scheduling orthopaedic surgeries is synchronised as to avoid errors, delays, less cancellation, and always bed available for patients in the recovery ward. In the case of emergency, disaster and unexpected situations the reactive model can be activated to smoothen the flow of patients in the orthopaedic theatres until the situation is normal. In improving the quality high care of patient and increasing the patients satisfaction and production the hospital management can implement Lean Six Sigma principle in the orthopaedic theatres (Lighter, 2014, p. 9). Improving the organisation in the hospital in order to achieve high productivity and improved working conditions 5S principle (Ikuma & Nahmens, 2014, p. 244).

Consent for publication

Not applicable.

Declaration of interest

Not applicable

Sources of funding

This research did not receive any specific grant from funding agencies in the public, commercial, or non-profit sectors.

7. References

- Addis, B., Carello, G., Grosso, A., & Tanfani, E. (2014). A rolling horizon framework for the operating rooms planning under uncertain surgery duration. 1-26. doi:https://hal.archives-ouvertes.fr/hal-00936085/file/Addis_al.pdf
- Adeloye, D., Thompson, J. Y., Akanbi, M. A., Azuh, D., Samuel, V., Omoregbe, N., & Ayo, C. K. (2016). The burden of road traffic crashes, injuries and deaths in Africa: a systematic review and meta-analysis *Bulletin of the World Health Organization.*, 94(7), 510-521. doi:10.2471/BLT.15.163121
- Ahwireng-Obeng, F., & van Loggerenberg, C. (2011). Africa's middle class women bring entrepreneurial opportunities in breast care medical tourism to South Africa. *The International Journal of Health Planning and Management.*, 26(1), 39-55. doi: <https://doi-org.nwulib.nwu.ac.za/10.1002/hpm.1034>
- Ang, W. W., Sabharwal, S., Johannsson, H., Bhattacharya, R., & Gupte, C. (2016). The cost of trauma operating theatre inefficiency. *Annals of Medicine and Surgery.*, 7, 24-29. doi:10.1016/j.amsu.2016.03.001
- Bayliss, L. E., Culliford, D., Monk, A. P., Glyn-Jones, S., Prieto-Alhambra, D., Judge, A., Beard, D. J. (2017). The effect of patient age at intervention on risk of implant revision after total replacement of the hip or knee: a population-based cohort study. *The Lancet.*, 389(10077), 1424-1430. doi:10.1016/S0140-6736(17)30059-4
- Bhamu, J., & Singh Sangwan, K. (2014). Lean manufacturing: literature review and research issues. *International Journal of Operations & Production Management.*, 34(7), 876-940. doi:10.1108/IJOPM-08-2012-0315
- Boas, R., Ensor, K., Qian, E., Hutzler, L., Slover, J., & Bosco, J. (2015). The relationship of hospital charges and volume to surgical site infection after total hip replacement. *American Journal of Medical Quality.*, 30(3), 283-288. doi:10.1177/1062860614525830

Bola, S., Dash, I., Naidoo, M., & Aldous, C. (2016). Interpersonal violence: quantifying the burden of injury in a South African trauma centre. *Emerg Med J.*, 33(3), 208-212. doi: <http://10.1136/emmermed-2014-204160>

Carroll, K., Dowsey, M., Choong, P., & Peel, T. (2014). Risk factors for superficial wound complications in hip and knee arthroplasty. *Clinical Microbiology and Infection.*, 20(2), 130-135. doi: 10.1111/1469-0691.12209

Cheng, S. Y., Bamford, D., Papalexli, M., & Dehe, B. (2015). Improving access to health services—challenges in Lean application. *International Journal of Public Sector Management.*, 28(2), 121-135. doi:<https://doi.org/10.1108/IJPSM-05-2014-0066>

Chikanda, A., & Crush, J. (2017). South-South cross-border patient travel to South Africa. *Global public health.*, 194(1), 1-14. doi:10.1080/17441692.2017.1414288

Cima, R. R., Brown, M. J., Hebl, J. R., Moore, R., Rogers, J. C., Kollengode, A., Deschamps, C. (2011). Use of lean and six sigma methodology to improve operating room efficiency in a high-volume tertiary-care academic medical center. *Journal of the American College of Surgeons.*, 213(1), 83-92. doi:10.1016/j.jamcollsurg.2011.02.009

Costa, L. B. M., & Godinho Filho, M. (2016). Lean healthcare: review, classification and analysis of literature. *Production Planning & Control.*, 27(10), 823-836. doi: 10.1080/09537287.2016.1143131

Crema, M., & Verbano, C. (2016). Safety improvements from health lean management implementation: evidences from three cases. *International Journal of Quality & Reliability Management.*, 33(8), 1150-1178 doi:10.1108/IJQRM-11-2014-0179

Crush, J., & Chikanda, A. (2015). South–South medical tourism and the quest for health in Southern Africa. *Social Science & Medicine.*, 124, 313-320. doi:10.1016/j.socscimed.2014.06.025

D'Andreamatteo, A., Ianni, L., Lega, F., & Sargiacomo, M. (2015). Lean in healthcare: A Comprehensive Review. *Health policy.*, 119(9), 1197-1209. doi:10.1016/j.healthpol.2015.02.002

Dahlgaard, J. J., Pettersen, J., & Dahlgaard-Park, S. M. (2011). Quality and lean health care: a system for assessing and improving the health of healthcare organisations. *Total Quality Management & Business Excellence.*, 22(6), 673-689. doi: 10.1080/14783363.2011.580651

Dammand, J., Hørlyck, M., Jacobsen, T., Lueg, R., & Röck, R. (2014). Lean management in hospitals: evidence from Denmark. *Administration and Public Management Review.*, 23, 19-35. doi:<https://ssrn.com/abstract=2562282>

Daultani, Y., Chaudhuri, A., & Kumar, S. (2015). A decade of lean in healthcare: current state and future directions. *Global Business Review.*, 16(6), 1082-1099. doi: 10.1177/0972150915604520

de Freitas, J. G., Costa, H. G., & Ferraz, F. T. (2017). Impacts of Lean Six Sigma over organizational sustainability: A survey study. *Journal of Cleaner Production.*, 156, 262-275. doi:10.1016/j.jclepro.2017.04.054

De Koeijer, R., Paauwe, J., & Huijsman, R. (2014). Toward a conceptual framework for exploring multilevel relationships between Lean Management and Six Sigma, enabling HRM, strategic climate and outcomes in healthcare. *The international journal of human resource management.*, 25(21), 2911-2925. doi:10.1080/09585192.2014.953974

Dell, A., Gray, S., Fraser, R., Held, M., & Dunn, R. (2018). Orthopaedic Surgeon Density in South Africa. *World Journal of Surgery.*, 3849-3855. doi:10.1007/s00268-018-4709-4

Dell, A., & Kahn, D. (2018). Surgical resources in South Africa: an international comparison and deficit calculation. *World Journal of Surgery.*, 42(2), 541-548. doi: 10.1007/s00268-017-4176-3

Denton, B. T. (2013). *Handbook of healthcare operations management: methods and applications*. New York: Springer.

Dimitriadis, P., Iyer, S., & Evgeniou, E. (2013). The challenge of cancellations on the day of surgery. *International Journal of Surgery.*, 11(10), 1126-1130. doi:10.1016/j.ijsu.2013.09.002

Drotz, E., & Poksinska, B. (2014). Lean in healthcare from employees' perspectives. *Journal of Health Organization and Management.*, 28(2), 177-195. doi:10.1108/JHOM-03-2013-0066

González-Arévalo, A., Gómez-Arnau, J., DelaCruz, F., Marzal, J., Ramírez, S., Corral, E., & García-del-Valle, S. (2009). Causes for cancellation of elective surgical procedures in a Spanish general hospital. *Anaesthesia*, *64*(5), 487-493. doi:10.1111/j.1365-2044.2008.05852.x

Guerriero, F., & Guido, R. (2011). Operational research in the management of the operating theatre: a survey. *Health Care Management Science*, *14*(1), 89-114. doi: 10.1007/s10729-010-9143-6

Gupta, S., Sharma, M., & Sunder M, V. (2016). Lean services: a systematic review. *International Journal of Productivity and Performance Management*, *65*(8), 1025-1056. doi: 10.1108/IJPPM-02-2015-0032

Hamilton, J., Verrall, T., Maben, J., Griffiths, P., Avis, K., Baker, G. R., & Teare, G. (2014). One size does not fit all: a qualitative content analysis of the importance of existing quality improvement capacity in the implementation of releasing time to care: the productive ward™ in Saskatchewan, Canada. *BMC Health Services Research*, *14*(1), 1-14. doi:10.1186/s12913-014-0642-x

Hoyler, M., Finlayson, S. R., McClain, C. D., Meara, J. G., & Hagander, L. (2014). Shortage of doctors, shortage of data: a review of the global surgery, obstetrics, and anesthesia workforce literature. *World Journal of Surgery*, *38*(2), 269-280. doi:10.1007/s00268-013-2324-y

Hsia, R. Y., Mbembati, N. A., Macfarlane, S., & Kruk, M. E. (2011). Access to emergency and surgical care in sub-Saharan Africa: the infrastructure gap. *Health Policy and Planning*, *27*(3), 234-244. doi: 10.1093/heapol/czr023

Ikuma, L. H., & Nahmens, I. (2014). Making safety an integral part of 5S in healthcare. *Work*, *47*(2), 243-251. doi:10.3233/WOR-121576

Kaddoum, R., Fadlallah, R., Hitti, E., Fadi, E.-J., & El Eid, G. (2016). Causes of cancellations on the day of surgery at a Tertiary Teaching Hospital. *BMC Health Services Research*, *16*(1), 259. doi:10.1186/s12913-016-1475-6

Kanamori, S., Sow, S., Castro, M. C., Matsuno, R., Tsuru, A., & Jimba, M. (2016). Implementation of 5S management method for lean healthcare at a health center in Senegal: a qualitative study of staff perception. *Global Health Action.*, 8(1), 1-10. doi:10.3402/gha.v8.27256

Kinsman, L., Rotter, T., Stevenson, K., Bath, B., Goodridge, D., Harrison, L., Bourassa, C. (2014). 'The largest lean transformation in the world': the implementation and evaluation of lean in Saskatchewan healthcare. *Healthcare Quarterly.*, 17(2), 29-32. doi:10.12927/hcq.2014.23880

Lamagni, T., Elgohari, S., & Harrington, P. (2015). Trends in surgical site infections following orthopaedic surgery. *Current Opinion in Infectious Diseases.*, 28(2), 125-132. doi: 10.1097/QCO.0000000000000143

Latorre-Núñez, G., Lüer-Villagra, A., Marianov, V., Obreque, C., Ramis, F., & Neriz, L. (2016). Scheduling operating rooms with consideration of all resources, post anesthesia beds and emergency surgeries. *Computers & Industrial Engineering.*, 97, 248-257. doi:10.1016/j.cie.2016.05.016

Lee, A., Kerridge, R. K., Chui, P. T., Chiu, C. H., & Gin, T. (2011). Perioperative systems as a quality model of perioperative medicine and surgical care. *Health policy.*, 102(2-3), 214-222. doi:10.1016/j.healthpol.2011.05.009

Lighter, D. E. (2014). The application of Lean Six Sigma to provide high-quality, reliable pediatric care. *International Journal of Pediatrics and Adolescent Medicine.*, 1(1), 8-10. doi:10.1016/j.ijpam.2014.09.009

Lindskog, P., Hemphälä, J., & Eriksson, A. (2017). Lean tools promoting individual innovation in healthcare. *Creativity and innovation management.*, 26(2), 175-188. doi: <https://doi.org/10.1111/caim.12201>

Manville, G., Greatbanks, R., Krishnasamy, R., & Parker, D. W. (2012). Critical success factors for Lean Six Sigma programmes: a view from middle management. *International Journal of Quality & Reliability Management.*, 29(1), 7-20. doi: 10.1108/02656711211190846

Marchildon, G. (2013). Implementing Lean health reforms in Saskatchewan. *Health Reform Observer—observatoire des Réformes de Santé.*, 1(1), 1-9. doi:10.13162/hro-ors.01.01.01

Martin, C., Thiart, G., McCollum, G., Roche, S., & Maqungo, S. (2017). The burden of gunshot injuries on orthopaedic healthcare resources in South Africa. *South African Medical Journal.*, 107(7), 626-630. doi: 10.7196/SAMJ.2017.v107i7.12257

Mason, S., Nicolay, C., & Darzi, A. (2015). The use of Lean and Six Sigma methodologies in surgery: a systematic review. *The Surgeon.*, 13(2), 91-100. doi:10.1016/j.surge.2014.08.002

Matthias, O., & Brown, S. (2014). Implementing operations strategy through Lean processes within health care: the example of NHS in the UK. *International Journal of Operations & Production Management.*, 36(11), 1435-1457. doi: <http://hdl.handle.net/10454/8913>

Mayosi, B. M., & Benatar, S. R. (2014). Health and health care in South Africa—20 years after Mandela. *New England Journal of Medicine.*, 371(14), 1344-1353. doi:10.1056/NEJMs1405012

Mazzaschi, A. (2011). Surgeon and safari: producing valuable bodies in Johannesburg. *Signs: Journal of Women in Culture and Society.*, 36(2), 303-312. doi:10.1086/655941?origin=JSTOR-pdf

Mesmar, M., Shatnawi, N., Faori, I., & Khader, Y. (2011). Reasons for cancellation of elective operations at a major teaching referral hospital in Jordan. *Eastern Mediterranean Health Journal.*, 17(8), 651-655. doi:<https://apps.who.int/iris/handle/10665/118279>

Mohrman, S. A., Shani, A. B., & McCracken, A. (2012). Organizing for sustainable health care: the emerging global challenge. *Organizing for Sustainable Health Care.*, 2, 1-39. doi: 10.1108/S2045-0605(2012)0000002005

Morris, J. H., James, R. E., Davey, R., & Waddington, G. (2015). What is orthopaedic triage? A systematic review. *Journal of Evaluation in Clinical Practice.*, 21(1), 128-136. doi:10.1111/jep.12260

Naidoo, L. (2013). *The impact of Lean thinking on operational efficiency in a rural district hospital outpatient department in KwaZulu-Natal*. (Dissertation-Master of Public Health), UKZN, Durban. Retrieved from <http://ukzn-dspace.ukzn.ac.za>

Niemeijer, G. C., Trip, A., Ahaus, K. T., Does, R. J., & Wendt, K. W. (2010). Quality in trauma care: improving the discharge procedure of patients by means of Lean Six Sigma. *Journal of Trauma and Acute Care Surgery.*, 69(3), 614-619. doi: 10.1097/TA.0b013e3181e70f90

Parkinson, F., Kent, S., Aldous, C., Oosthuizen, G., & Clarke, D. (2014). The hospital cost of road traffic accidents at a South African regional trauma centre: a micro-costing study. *Injury.*, 45(1), 342-345. doi:10.1016/j.injury.2013.04.007

Penn, M. L. (2014). *Developing a multi-methodological approach to hospital operating theatre scheduling.* (Thesis-PhD Thesis-PhD), University of Southampton, Southampton. Retrieved from <http://eprints.soton.ac.uk/>

Poksinska, B. B., Fialkowska-Filipek, M., & Engström, J. (2017). Does Lean healthcare improve patient satisfaction? A mixed-method investigation into primary care. *British Medical Journal Qual SAF.*, 26(2), 95-103. doi:10.1136/bmjqs-2015-004290

Radnor, Z. J., Holweg, M., & Waring, J. (2012). Lean in healthcare: the unfilled promise? *Social Science & Medicine.*, 74(3), 364-371. doi:<https://dspace.lboro.ac.uk/2134/15864>

Rahbek Gjerdrum Pedersen, E., & Huniche, M. (2011). Negotiating lean: the fluidity and solidity of new management technologies in the Danish public sector. *International Journal of Productivity and Performance Management.*, 60(6), 550-566. doi:10.1108/17410401111150742

Randhawa, J. S., & Ahuja, I. S. (2017). 5S implementation methodologies: literature review and directions. *International Journal of Productivity and Quality Management.*, 20(1), 48-74. doi: 10.1504/IJPQM.2017.080692

Seim, A. R., Fagerhaug, T., Ryen, S. M., Curran, P., Sæther, O. D., Myhre, H. O., & Sandberg, W. S. (2009). Causes of cancellations on the day of surgery at two major university hospitals. *Surgical Innovation.*, 16(2), 173-180. doi:10.1177/1553350609335035

Stuart, K., & Kozan, E. (2012). Reactive scheduling model for the operating theatre. *Flexible services and manufacturing journal.*, 24(4), 400-421. doi:10.1007/s10696-011-9111-6

Tagge, E. P., Thirumoorthi, A. S., Lenart, J., Garberoglio, C., & Mitchell, K. W. (2017). Improving operating room efficiency in academic children's hospital using Lean Six Sigma methodology. *Journal of Pediatric Surgery*, 52(6), 1040-1044. doi:10.1016/j.jpedsurg.2017.03.035

Theunissen, D. P. (2012). *Improving service quality and operations at a South African private healthcare clinic through the implementation of lean principles*. (Dissertation-MBA Dissertation-MBA), NMMU, Port Elizabeth. Retrieved from <http://nrfnexus.nrf.ac.za.nwulib.nwu.ac.za/handle/20.500.11892/160766>

Timans, W., Antony, J., Ahaus, K., & van Solingen, R. (2012). Implementation of Lean Six Sigma in small-and medium-sized manufacturing enterprises in the Netherlands. *Journal of the Operational Research Society*, 63(3), 339-353. doi: 10.1057/jors.2011.47

Xiang, W. (2017). A multi-objective Ant Colony Optimization for operating room scheduling optimization. *Natural computing*, 16(4), 607-617. doi:10.1007/s11047-016-9607-9

Yaduvanshi, D., & Sharma, A. (2017). Lean Six Sigma in Health Operations: challenges and opportunities—'Nirvana for operational efficiency in hospitals in a resource limited settings'. *Journal of Health Management*, 19(2), 203-213. doi: 10.1177/0972063417699665

Yin, R. K. (2014). *Case Study Research: Design and Methods* (5th ed ed.). London: Sage Publications.

Young, F. Y. (2014). The use of 5S in healthcare services: A literature review. *International Journal of Business and Social Science*, 5(10), 240-248. doi:http://ijbssnet.com/journals/Vol_5_No_10_1_September_2014/30.pdf

CHAPTER 4: CONCLUSIONS, EVALUATION, LIMITATIONS AND RECOMMENDATIONS

4.1 Introduction

Chapter 3 was the manuscript that presented the research results. Chapter 4 offers the conclusion of the research, and presents the evaluation and limitations experienced. This is followed by the recommendations for improving scheduling of the orthopaedic theatre surgeries, theatre efficiency, and production in this particular level three public hospital.

4.2 Evaluation

In this final section, the researcher conducted a self-evaluation of different aspects of the research as follows:

4.2.1 Research methodology

The qualitative research inquiry approach was suitable as it seeks to answer the “how” and “why” questions of this research (Yin, 2014:9). Due to the fact that the research is a single-embedded design with the two units of the orthopaedic operating theatres, a qualitative research strategy was implemented. The researcher was able to explore in-depth the programme, activities, process happening in the orthopaedic department and other related departments with scheduling of the orthopaedic operating surgeries. From the day the patient is diagnosed to be operated, scheduled operating block time until the patient is discharged from hospital (Yin, 2014:9).

The data collection was done through semi-structured interviews with a total of eighteen (*n*18) participants. Because the research is not designed for a larger group, the population in this research was senior management, orthopaedic staff, administration, finance, pharmacy, and X-ray department staff involved with the scheduling of orthopaedic operating surgeries (Yin, 2014:9). A purposeful sampling strategy was used in this qualitative research for identification and understating the research with limited resources (Palinkas *et al.*, 2015:3). The qualitative research is more flexible than quantitative research with this type of sampling technique (Dolley, 2014:4). The archived document report of scheduled orthopaedic surgeries and other internal documents were analysed. The direct reflective notes by the researcher were very important to gather physical evidence of the activities happening in the scheduling of the orthopaedic operating surgeries.

4.2.2 Aim and objectives of the research

The research aimed to understand how the scheduling system of the orthopaedic theatres at a level three public hospital in the Dr Kenneth Kaunda District functions. The research identified the most appropriate Lean management framework in improving the scheduling of orthopaedic theatre surgeries, theatre efficiency, and production in order to reduce the long waiting list of elective patients. The researcher's recommendations on how the orthopaedic department can improve the scheduling of orthopaedic surgeries, theatre efficiency, and production are formulated in section 4.4.

4.2.3 Central theoretical statement

These research results match the central theoretical argument, as declared in Chapter 1, namely: A better understanding into how the scheduling system of the orthopaedic theatres of this hospital functions and the most appropriate Lean management framework to be proposed in improving scheduling in theatres, efficiency, and production. Through the literature review, the researcher gained a better understanding of a number of Lean management framework that can be applied in the scheduling of theatres. The researcher was able to formulate recommendations in how the hospital gain reduces the long waiting list of elective patients, improve scheduling of orthopaedic theatres, efficiency, and production.

4.2.4 Rigour

The research used the multiple sources of data for interpretation, concepts, and philosophies to come up with the conclusive research findings and such sources of data were used to gain an understanding of the phenomenon (Claydon, 2015:43). To enhance the quality or the rigour of the research, the researcher adhered to the following reliability, validity, and trustworthiness. The researcher ensured constant reliability relating to the multiple sources of data collected and analysed without being biased throughout the period of the research. The researcher ensured that the same procedure of conducting research was observed without replicating the results of one case to another in single-case embedded research design. Credibility, authenticity, and trustworthiness were used in checking the validity of the research (Leung, 2015:325). In ensuring the trustworthiness of research, the researcher used the five epistemological standards as outlined by Lincoln and Guba (cited by Pandey & Patnaik, 2014:5746). The five epistemologies are truth value, applicability, consistency, neutrality, and authenticity.

4.3 Limitations

The researcher identified the following limitations:

- Due to the time constraints and participants work responsibility in the hospital, the researcher had to re-schedule several semi-structured interviews.
- Some participants were not comfortable for the interviews to be audio recorded, regardless of efforts by the researcher in guarantying protecting participant's identity according to the protocol of conducting a research interview. The researcher had to take some notes down about the discussion.
- The population was restricted to senior management, and staff of the following departments: administration, orthopaedic, finance, pharmacy, and X-ray.

4.4 Recommendations

Based on the findings of this research, recommendations are made to implement Lean management framework in the scheduling in orthopaedic operating surgeries at this level three public hospital. The following recommendations are formulated for a level three public hospital in North West Province and other hospitals of the same level, as well as MBA curriculum and research.

4.4.1 Recommendations for MBA curriculum

Application of Lean management in both public and private hospital is minimal in South Africa and other African countries; it is recommended that the Business School should consider paying more attention to Lean management methodologies. With the global economic condition, Lean management methodologies could be a solution to many organisations in improving quality, efficiency, and production in its business environment and MBA students about the subject matter of Lean management methodologies that could be used in current organisations of employment.

4.4.2 Recommendations for healthcare research

The following themes for future research and were identified during the research and completion of this research process and report:

- Improving scheduling in orthopaedic operating surgeries, theatre efficiency, and production using Lean Six Sigma methodology (Mason *et al.*, 2015:92). The proposed Lean Six Sigma methodologies could be used in other operating theatres of level three public hospitals and mostly to the international health community.

- Improving organised workplace in order to achieve high productivity in the level three public hospital using 5S methodology (Kanamori *et al.*, 2016:1).
- Improve patient flow in the paediatric clinic as the level three hospital has a high volume of children seeking medical treatment on a daily basis.
- With the centralised information system in the hospital, there will be a reduction in paper documentation and better communication among departments. Pharmacy department can be able to order theatre inventory just in time (JIT) of the surgeries, and supply chain will know what to buy in the market, e.g. knee replacement equipment.
- Scheduling is complex because it is a process of multiple variables requiring consideration of all role players do not understand the challenges.
- Extra costs to have patients in hospital before/after surgery, no real-time monitoring of income/expenses for departments, per patient (patient centre/customer financial system).
- Key performance indicators (KPI) for operational efficiency within the hospital departments as a way that management can identify the weakness in the systems and what could be done to improve the quality of healthcare.

4.5 Summary

Overview of the research presented the theoretical background of the research and the context of the need in applying Lean management techniques at the level three public hospital in Dr Kenneth Kaunda District. A number of Lean management methodologies were studied to see which one could be applied in improving the scheduling of the orthopaedic theatre surgeries, efficiency, and production. The research design and methodology applied in the research was provided in Chapter 1. The most appropriate research technique for the research was single-case embedded research, because of the research setting in the two dedicated orthopaedic theatres. The limitations of the research in collecting data are described in detail and the ethical aspects when collecting data were adhered to.

The research results have been formulated as a manuscript format that will be submitted for peer review. The manuscript has been prepared for the *Journal of Perioperative Care and Operating Room Management* published by Elsevier. Chapter 4 concludes the research report on the study titled *A lean management framework for orthopaedic operating theatres of level three hospital, North West Province*. The researcher committed himself to share the results report of the research with the level three public hospital concerned, and the Department of Health North West Province.

4.6 Bibliography

Claydon, L.S. 2015. Rigour in quantitative research. *Nursing standard*, 29(47):43.

Dolley, L.T. 2014. Plan it and they will come: a case study of the impact of HPT interventions on church growth. Minneapolis: Capella University. (Dissertation-PhD).

Kanamori, S., Shibamura, A. & Jimba, M. 2016. Applicability of the 5S management method for quality improvement in health-care facilities: a review. *Tropical medicine and health*, 44(1):1-8.

Leung, L. 2015. Validity, reliability, and generalizability in qualitative research. *Journal of family medicine and primary care*, 4(3):324-327.

Mason, S., Nicolay, C. & Darzi, A. 2015. The use of Lean and Six Sigma methodologies in surgery: a systematic review. *The surgeon*, 13(2):91-100.

Palinkas, L.A., Horwitz, S.M., Green, C.A., Wisdom, J.P., Duan, N. & Hoagwood, K. 2015. Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and policy in mental health and mental health services research*, 42(5):533-544.

Pandey, S.C. & Patnaik, S. 2014. Establishing reliability and validity in qualitative inquiry: A critical examination. *Jharkhand journal of development and management studies*, 12(1):5743-5753.

Yin, R.K. 2014. Case study research: Design and methods. 5th ed. London: Sage Publications.

APPENDIX A: EMS-REC CERTIFICATE



ETHICAL APPROVAL LETTER OF STUDY

Based on the approval by the Economic and Management Sciences Research Ethics Committee (EMS-REC) on 02/08/2018, the North-West University Research Ethics Regulatory Committee (NWU-RERC) hereby approves your project as indicated below. This implies that the NWU-RERC grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the project may be initiated, using the ethics number below.

Project title: A lean management framework for orthopaedic operating theatres of a level three public hospital, North West Province.																															
Project Leader/Supervisor: Prof P Bester																															
Student: KE Sekoto																															
Ethics number:	<table border="1"> <tr> <td>N</td><td>W</td><td>U</td><td>-</td><td>0</td><td>0</td><td>5</td><td>4</td><td>5</td><td>-</td><td>1</td><td>8</td><td>-</td><td>A</td><td>4</td> </tr> <tr> <td colspan="3">Institution</td> <td colspan="5">Project Number</td> <td colspan="2">Year</td> <td colspan="5">Status</td> </tr> </table> <p><small>Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation</small></p>	N	W	U	-	0	0	5	4	5	-	1	8	-	A	4	Institution			Project Number					Year		Status				
N	W	U	-	0	0	5	4	5	-	1	8	-	A	4																	
Institution			Project Number					Year		Status																					
Application Type:																															
Commencement date: 2018-08-02	Expiry date: 2019-08-02																														
Risk:	LOW																														

Special conditions of the approval (if applicable):

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, the following general terms and conditions will apply:

- The project leader (principle investigator) must report in the prescribed format to the EMS-REC:
 - annually (or as otherwise requested) on the progress of the project, and upon completion of the project
 - without any delay in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project; and
 - Annually a number of projects may be randomly selected for an external audit.
- The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the EMS-REC. Would there be deviated from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
- The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date, a new application must be made to the NWU-RERC via EMS-REC and new approval received before or on the expiry date.
- In the interest of ethical responsibility, the NWU-RERC and EMS-REC reserves the right to:
 - request access to any information or data at any time during the course or after completion of the project;
 - to ask further questions, seek additional information, require further modification or monitor the conduct of your research or the informed consent process;
 - withdraw or postpone approval if:
 - any unethical principles or practices of the project are revealed or suspected;
 - it becomes apparent that any relevant information was withheld from the EMS-REC or that information has been false or misrepresented;
 - the required annual report and reporting of adverse events was not done timely and accurately; and/or
 - new institutional rules, national legislation or international conventions deem it necessary.

The EMSREC would like to remain at your service as scientist and researcher, and wishes you well with your project. Please do not hesitate to contact the NWU-RERC or EMS-REC for any further enquiries or requests for assistance.

Yours sincerely

Prof Bennie Linde
 Chair NWU Economic and Management Sciences Research Ethics Committee

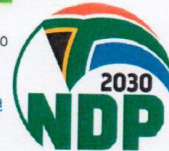
APPENDIX B: APPROVAL LETTER FROM DEPARTMENT OF HEALTH NORTH WEST PROVINCE



health

Department of Health
North West Province
REPUBLIC OF SOUTH AFRICA

Enq: Nthabiseng Mapogo
Tel: 018 391 4504
Fax: 018 388 6202
NMapogo@nwdp.gov.za
www.nwhealth.gov.za



POLICY, PLANNING, RESEARCH, MONITORING AND EVALUATION

Name of researcher : **Mr. K.E. Sekoto**
North West University

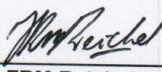
Physical Address _____
(Work/ Institution) _____

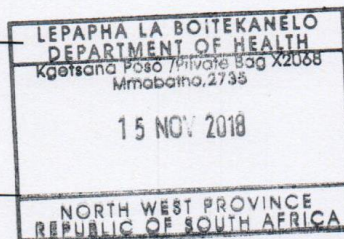
Subject : **Research Approval Letter –A lean management framework for orthopaedic operating theatres of a level three public hospital, North West Province.**

This letter serves to inform the Researcher that permission to undertake the above mentioned study has been granted by the North West Department of Health. The Researcher is expected to arrange in advance with the chosen facilities, and issue this letter as proof that permission has been granted by the Provincial office.

This letter of permission should be signed and a copy returned to the department. By signing, the Researcher agrees, binds him/herself and undertakes to furnish the Department with an electronic copy of the final research report. Alternatively, the Researcher can also provide the Department with electronic summary highlighting recommendations that will assist the department in its planning to improve some of its services where possible. Through this the Researcher will not only contribute to the academic body of knowledge but also contributes towards the bettering of health care services and thus the overall health of citizens in the North West Province.

Kindest regards.


Dr. FRM Reichel
Director: PPR&E



14/11/2018
Date

Researcher _____

Date



Healthy Living for All

APPENDIX C: INFORMED CONSENT FORM



INFORMED CONSENT DOCUMENTATION FOR SEMI-STRUCTURED INTERVIEWS

TITLE OF THE RESEARCH: A lean management framework for orthopaedic operating theatres of a level three public hospital, North West Province

ETHICS REFERENCE NUMBERS: NWU-00545-18-S4

PRINCIPAL INVESTIGATOR: Khosi Emmanuel Sekoto

POST GRADUATE STUDENT: Khosi Emmanuel Sekoto

ADDRESS: 12 Villa Di Lucca, Flamwood Dr, Flamwood, Klerksdorp, 2571

CONTACT NUMBER: 082 335 1098 W: 018 464 6811

You are being invited to take part in a research that forms part of my/our MBA please take some time to read the information presented here, which will explain the details of this research. Please ask the researcher or person explaining the research to you any questions about any part of this research that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research is about and how you might be involved. In addition, your participation is voluntary, and you are free to say no to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the research at any point, even if you do agree to take part now.

This research has been approved by the Economic and Management Sciences Research Ethics Committee (EMS-REC) of the North-West University (NWU-00545-18-S4) and will be conducted according to the ethical guidelines and principles of Ethics in Health Research: Principles, Processes and Structures (DoH, 2015) and other international ethical guidelines applicable to this research. It might be necessary for the research Ethics Committee members or other relevant people to inspect the research records.

What is this research all about?

- This research will be conducted at a level three public hospital in North West Province and will involve semi-structured interviews by the researcher.
- We plan to get a better understanding of the current scheduling system of the orthopaedic theatre.

Why have you been invited to participate?

- You have been invited to be part of this research because you are working as the senior manager of the hospital, orthopaedic, administration, finance, pharmacy, and X-ray department that interact with the scheduling of the orthopaedic theatre surgeries.
- You also fit the research because your years of experience.
- You will not be able to take part in this research if you are from a vulnerable group not working interacting with the scheduling of the orthopaedic theatre surgeries.

What will be expected of you?

- You will be expected to participate in the semi-structured interviews

Will you gain anything from taking part in this research?

- The gains for you if you taking part in this research will be having been part of the project in identifying the weaknesses and strengths of the current scheduling of orthopaedic theatres surgeries if any.

Are there risks involved in you taking part in this research and what will be done to prevent them?

- There are no risks from taking part in this research.
- There are more gains for you in joining this research than there are risks.

How will we protect your confidentiality and who will see your findings?

- Anonymity of your findings will be protected by researcher. Your privacy will be respected by researcher. Your results will be kept confidential by researcher. Only the researchers, supervisor, co-supervisor, and assistant-supervisor will be able to look at your findings. Findings will be kept safe by locking hard copies in locked cupboards in the researcher's office and for electronic data it will be password protected. (As soon as data has been transcribed it will be deleted from the recorders.) Data will be stored for five years.

What will happen with the findings or samples?

The findings of this research will only be used for this research/will be used in future research relevant to the research.

How will you know about the results of this research?

- We will give you the results of this research when done with the research.
- You will be informed of any new relevant findings by the researcher.

Will you be paid to take part in this research and are there any costs for you?

No, you will not be paid to take part in the research because it is for the good of the elective patient, level three hospital, and the Department of Health, North West Province.

Refreshments/meals will not be served during semi-structured interviews.

There will thus be no costs involved for you, if you do take part in this research.

Is there anything else that you should know or do?

You can contact me (Khosi Sekoto) at 082 335 1098 if you have any further questions or have any problems.

- You will receive a copy of this information and consent form for your own purposes.

APPENDIX D: DECLARATION BY PARTICIPANTS

Declaration by participant

By signing below, I agree to take part in the research title:
A lean management framework for orthopaedic operating theatres of a level three public hospital, North West Province.

I declare that:

- I have read a trusted person in a language with which I am fluent and comfortable explained this information/it to me.
- The research was clearly explained to me.
- I understand that taking part in this research is **voluntary** and I have not been pressurised to take part.
- I may choose to leave the research at any time and will not be handled in a negative way if I do so.

Signed at (place) on (date) 20....

.....
Signature of participant

.....
Signature of witness

Declaration by researcher

I, Khosi Emmanuel Sekoto declare that:

- I explained the information in this document to
- I did not use an interpreter
- I encouraged him/her to ask questions and took adequate time to answer them or I was available should he/she want to ask any further questions.
- I am satisfied that he/she adequately understands all aspects of the research, as described above.
- I am satisfied that he/she had time to discuss it with others if he/she wished to do so.

Signed at (place) on (date) 20....

.....
Signature of researcher

APPENDIX E: LANGUAGE EDITING CERTIFICATE



EDITING CERTIFICATE

06 April 2019

To whom it may concern

DECLARATION OF LANGUAGE EDITING

Re: A lean management framework for orthopaedic operating theatres of a level three public hospital, North West Province

This serves to confirm that I, Tanya-Lee Ruby Stewart, a SATI-registered translator undertook the language editing of the above-mentioned document on behalf of K Sekoto, NWU student number: 28103068 for the purpose of submission as a mini-dissertation.

Changes were suggested in track changes and per email. Implementation was left up to the author.

Should you have any queries please contact me on +27 84 556 7745.

Yours sincerely

TR Stewart

Member: South African Translators' Institute

SATI registration no: 1003470



APPENDIX F: TURNITIN DIGITAL RECEIPT



Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author: KHOSI SEKOTO
Assignment title: Test your thesis for similarities
Submission title: 28103068:7_April_2019_submissio...
File name: -6369-42b7-8572-6dfc50e4036d_...
File size: 6.9M
Page count: 127
Word count: 37,254
Character count: 225,490
Submission date: 09-Apr-2019 12:04PM (UTC+0200)
Submission ID: 1108867081



Copyright 2019 Turnitin. All rights reserved.