Exploring the adoption of Lean principles in medical laboratory industry

Empirical evidences from Namibia

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Abstract

Purpose – As the demand for efficiency and quality in the health-care industry has increased over the past few years, adoption of Lean principles and tools in the medical laboratory industry has become increasingly crucial. The purpose of this study is to explore the level of adoption, barriers and enablers of Lean principles and tools in the Namibian medical laboratory industry.

Design/methodology/approach – A descriptive cross-sectional study was carried out to examine the level of usage, barriers and enablers, impact of Lean tools and to suggest appropriate strategies for adopting Lean in the Namibian medical laboratory services.

Findings – Research findings reveal that Lean tools are moderately implemented in most laboratories. Standard operating procedures, root cause analysis, overall equipment effectiveness and visual management are the important Lean tools used in the industry. Results of the survey also show that Lean tools had a positive impact on operational performance, employee motivation, turnaround time and cost reduction. Furthermore, top management involvement, adequate training and proper planning emerged as important enablers, while lack of support from the management, financial constraint and staff resistant to change are major barriers to the adoption of Lean principles in the Namibian medical laboratory industry.

Research limitations/implications – The paper has inherent limitations of survey research, which the authors will overcome by using case studies with medical laboratories.

Practical implications – The findings of the authors' work will help in widening the application of Lean principles in more medical laboratories in Namibia and in other parts of the world.

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Originality/value – The paper is based on numerous health-care studies on Lean. This is one of the few papers investigating the adoption of Lean principles, specifically in medical laboratories, from an emerging economy such as Namibia.

Keywords Turnaround time, Namibia, Lean principle, Lean tools, Medical laboratory industry

Paper type Research paper

Introduction

Health-care organizations are under excessive pressure to improve operational performance in medical laboratories. The Namibia National Public Health Laboratory (2012) stated that the demand for laboratory services has continued to rise every year, as countries increasingly require evidence-based decision-making for the health-care interventions. Laboratory services are mostly tasked to address clinical diagnosis and interventions. The Namibia Ministry of Health and Social Services recognised that an efficient laboratory system is critical for the correct diagnosis of clinical conditions in the shortest possible time (NPHL, 2012). The ministry also reported that owing to logistical challenges, a total of 58 clinical laboratories countrywide experienced long laboratory turnaround times.

Turnaround time (TAT) is the most significant measure of performance for laboratory services. It is defined as the length of time from when a test is ordered to the time the result is reported to the clinician (Alem, 2013; Dey *et al.*, 2013). Many clinicians use TAT to evaluate the operational performance (Poksinska, 2010; Hawkins, 2007). The Namibia Institute of Pathology (NIP) report stated that TAT is the most noticeable key performance indicators of laboratory services (NIP, 2014).

A study by Moyo *et al.* (2015) stated that about 91 per cent of laboratory results have been used by clinicians in making diagnosis or planning patient management such as ruling out diseases, monitoring therapy and hospital discharge and admission. TAT is considered as the most significant measure of laboratory performance and as a laboratory key performance indicator by clinicians and many laboratories (Poksinska, 2010; Hawkins, 2007).

The demand for efficiency and quality in the industry has increased over the past few years and financial conditions for health-care systems are not improving. In these years, health-care systems are challenged to be affordable, accessible, safe, efficient and cost effective. This has raised the need for strategies on how the industry can be improved. Consequently, the Lean concept has spread in the health care industry (Drotz, 2014). Poksinska (2010) stated that many organizations adopt the Toyota Production System, mostly called the Lean principles in the health care management system.

The aim of this research is to examine the level of usage of Lean principles in the Namibian medical laboratory industry. The study mainly focuses on the Lean principle in the medical laboratory setting, the tools used when Lean is applied, the reasons for applying Lean, achievements in using Lean and barriers and enablers of Lean application. Currently, there are no studies on the application of Lean principles in the context of the Namibian medical laboratory industry. Lean principles have been applied in health care in recent years, but a few articles report specifically on Lean application in medical laboratories (Persoon *et al.*, 2006). A study by Lawal *et al.* (2014) stated that research on the application and implementation of Lean principles in health care has been limited.

The study aims at benefiting the private laboratories, public laboratories, clinicians, patients and the entire community. The study can help policymakers to improve operational performance, leading to efficient result provision and decision-making by clinicians. This can prevent the spread of infections in the community. When patient receives their laboratory test results on time and receive treatment on time, it will increase customer

satisfaction. Improved TAT means increased efficiency and customer satisfaction, which can lead to improved client retention by the laboratories. The implementation of Lean techniques in medical laboratories can also improve operational quality.

The rest of the paper is structured thus: the next section presents a literature review on Lean health care. This is followed by research methodology. Results and discussions are then presented, followed by managerial implications, conclusions and further research prospects.

Literature review

This section reviews the existing literature on Lean principles and their adoption in health care, with a particular focus on medical laboratories. Relevant literature is reviewed to understand the state of the art and develop guidance for this research. The review focused on the adoption and impact of Lean principles in health care, understanding the barriers and enablers of Lean principles and identification of the improved Lean implementation strategies from the context of medical laboratory industry.

Lean health care

Lean health care has developed into a major stream of research since the beginning of the twenty-first century (Dickson *et al.*, 2008; Fillingham, 2007; Ki *et al.*, 2007; Kim *et al.*, 2006; Spear, 2006; Jimmerson *et al.*, 2005; Young *et al.*, 2004; Thompson *et al.*, 2003; Laursen *et al.*, 2003). A growing body of literature has been disseminated from a significant number of countries. Health organizations, such as the Institute for Healthcare Improvement in the USA, the National Health Service (NHS) Confederation and the Institution for Innovation and Improvement in the UK, advocated the use of Lean, following its success in other industry sectors (Westwood *et al.*, 2007; Womack and Miller, 2005). The NHS Institution for Innovation and Improvement has since adapted the phenomena to health-care wastes (Westwood *et al.*, 2007). This means that health-care professionals can increase the efficiency of patient care and reduce costs by applying the same capabilities that were applied in Lean manufacturing. Spear (2005) claimed that learning on the job how to improve the work can create tremendous savings. However, reviews in the literature have indicated that the adoption of Lean in health care has faced its own successes and challenges.

Kim *et al.* (2006) postulated cultural and practical barriers that should be overcome for effective adoption of Lean techniques. These include suspicion against usefulness of tools imported from a manufacturing context, misunderstanding of what Lean can achieve, the difficulty in changing from silo work organization to team work, resistance to change and lack of training. These studies opened up more interest in Lean health care that led to a significant number of literature reviews. Furthermore, Poksinska (2010) discussed how Lean principles have been applied in health care, presenting barriers, challenges and out-comes. Mazzocato *et al.* (2010) studied realistic mechanisms that can be applied in the adoption of Lean. Thus, it is important to understand barriers and challenges to successful implementation of Lean in the health-care sector, with particular focus on medical laboratories.

A closer look at enablers or success factors of Lean adoption is critical. Radnor *et al.* (2006) highlighted critical features of Lean adoption in the public sector, emphasizing on how Lean works, its outcomes, barriers to change and success factors for its sustainability. Boaden *et al.* (2008) outlined some difficulties in identifying guidelines for the Lean adoption. Recently, Mutingi *et al.* (2015) presented a SWOT (strengths, weaknesses, opportunities and threats) analysis associated with the adoption of Lean health care in the Southern African region, citing critical factors such as management support at all levels, education and

training, resistance to cultural change, lack of awareness of what Lean can do, among others. From these discussions, it can be seen that further training on Lean health care, performance measurement and continuous improvement are imperative, specifically in developing economies.

Turnaround time

TAT is defined as the length of time from when the test is ordered to the time when the result is reported (Alem, 2013). Hawkins (2007) described TAT as a series of nine steps, which are ordering, collections, identifications, transportation, preparation, analysis, reporting, interpreting and action taken to provide results to the clinicians and patients. It is also viewed as the time from when the test is ordered to the time when the result is received by the clinicians (Dey *et al.*, 2013).

Dissatisfaction with the TAT of medical laboratory test results still remains a problem in most countries. Despite increased technical, transport, information technology and technological innovations such as instrument automation in medical laboratories, over 80 per cent of laboratories receive complaints about long TAT. TAT continues to be the major cause of customer dissatisfaction with medical laboratory services (Hawkins, 2007).

Short TAT is essential to all laboratories. The 2014 NIP report stated that short TAT enables the laboratory to decrease cost, increase efficiency and promote customer satisfaction (NIP, 2014). A study by Moyo *et al.* (2015) showed that about 91 per cent of laboratory results have been used by clinicians in making diagnosis or planning patient management such as ruling out diseases, monitoring therapy and hospital discharge and admission. Long TAT is associated with several factors such as specimen referral system, serious stock shortages, shared specimen, increased workload, shortage of skilled professionals, instrument breakdown, test complexity, no written standard operating procedures (SOPs) and inadequacy space (White *et al.*, 2015; NIP, 2014; Alem, 2013; Rutledge *et al.*, 2010; Stankovic, 2008). Thus, TAT is considered as the most significant measure of laboratory performance and as a laboratory key performance indicator by clinicians and many laboratories (NIP, 2014; Poksinska, 2010; Hawkins, 2007).

Lean principles

Henry Ford was the first to integrate a full production process in 1913. In 1930, the Toyota Production System was introduced by some simple innovations and revising Ford's original process. As early as in 1990, Lean was applied to the health-care setting and continues to grow across the industry (Stankovic, 2008).

Lean is defined as a systematic approach to shorten the time between customers request and the service delivery by identifying and eliminating wastes (Coons, 2007). Amirahmadi, *et al.* (2007) defined Lean principles as an approach to a process improvement that focuses on the reduction and elimination of waste, variation and imbalances in the process to pursue perfection through continuous improvement. There are seven common wastes, i.e. transportation, inventory, motion, waiting, over-production, over-processing and defect (Womack and Jones, 2003). Lean principles are defined as a quality philosophy that minimizes the consumption of resources that do not add value to the finished product by (Stankovic, 2008).

Recently, the demand on efficiency and quality has increased, which has raised the need for new strategies on how to improve it. The concept of Lean tools, Lean principles or Lean production has become increasingly spread in health care and other industries (Drotz, 2014).

According to Rosmulder (2011), there are five basic principles of Lean, outlined as follows:

(1) specify/define value (service or product) from the perspective of the end user;

(2) identify the entire value stream and eliminate waste;

(3) make the value-creating steps occur in tight sequence so the product will flow smoothly towards the customer;

(4) as flow is introduced, design and provide what the customer wants only when they want it, or letting customers pull value from the next upstream activity, focusing on shortening the lead-time; and

(5) pursue perfection, as value is specified, value stream identified, wasted steps removed, flow and pull introduced, begin the process again and continue until a state of perfection is reached.

A careful application of Lean in medical laboratories can deliver benefits in terms of productivity, faster testing, quality patients' results, at the lowest cost by eliminating waste while maintaining client satisfaction (Sandle, 2014; Stankovic, 2008; Amirahmadi *et al.*, 2007). Lean creates solutions for processes, making the organization to receive more output of work and progress with less amount of effort, helps to recognise inefficiencies, reduce cycle time, reduce non-value added activities and increases customer order accuracy (Mallick *et al.*, 2012).

Enablers and barriers of Lean principles. Drotz (2014) and Mallick *et al.* (2012) pointed out the possible barriers and enablers of Lean principles adoption, as listed in Table I.

Lean principles in health care. Coons (2007) defined Lean principle in health care as the systemic approach to shorten the time between customer's request and service delivery by the laboratory, by identifying and eliminating wastes. Rosmulder (2011) explained the five principles of Lean as shown in Figure 1.

The NHS Institute for Improvement and Innovation (NHSI) adapted the phenomena of the seven basic Lean wastes to corresponding seven health-care wastes (Westwood *et al.*, 2007). Table II presents a description of health care service wastes.

In an effort to eliminate or reduce these health-care service wasters, several tools can be used in the application of Lean in health-care settings. These tools include 5S methodology, value stream mapping, visual management, Kanban, Kaizen, policy deployment standardization and many others. A list of some of these tools and with their descriptions is presented as follows:

Enablers	Barriers
Top management involvement	Staffs resistant to change
Employee empowerment	Leadership failures
Flow orientation	Weak links between improvement programme and the strategy
Ability to learn and accept changes	Improper planning
Proper planning	Lack of training
Quality workshops organised regularly	Lack of democratic talk
Open talk about all wastes	Inadequate attention to internal and external customers
Internal and external customer satisfaction is tracked and reviewed	

Table I. Lean principles enablers and barriers

The 5S technique. The 5S techniques is defined by (Rutledge *et al.*, 2010; Coons, 2007) as a methodical way to organise your workplace and working practices as well as the overall philosophy and way of working (sort, straighten, shine, standardize and sustain):

- *Sort*: The removal of unnecessarily materials and paper from all items in a given area.
- *Set in order*: Identify the best location for all items, set inventory limit and taping the workplace with label for all objects in place.
- *Shine*: General cleaning, clean everything in and out especially where unnecessary material was stored and continued to inspect items by cleaning them and to prevent dirt and contamination from occurring.
- *Standardize*: Create the rules for maintaining and controlling the first 3S, use visual controls and standard procedures.
- *Sustain*: Ensure adherence to the 5S standards through communication, training and self-discipline.

Value stream mapping. Amirahmadi *et al.* (2007) described value stream mapping as the component of lean process which can identify, document and review he entire processes. The process begins by tracking the movement of samples in the entire process, tracking the

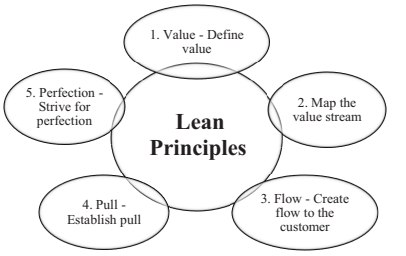


Figure 1.
The five lean principles

Original waste	Corresponding health-care waste
Transportation	Staff walking to the other end of a ward to pick up notes; central equipment stores for commonly used items instead; and items located where they are used
Inventory	Excess stock in storerooms that is not being used, patients waiting to be discharged; and waiting lists
Motion	Unnecessary staff movement looking for paperwork, e.g. drug sheets not put back in the correct place, storing syringes and needles at opposite ends of the room; and not having basic equipment in every examination room
Waiting (delay)	Waiting for patient theatre staff results, prescriptions and medicines; and waiting for doctors to discharge patients
Over-production	Requesting unnecessary tests from pathology; and keeping investigation slots "just in case"
Over-processing	Duplication of information asking for patient data several times; and repeated clerking of patients
Defects/errors	Re-admission owing to failed discharge and adverse drug reactions; and repeating tests because of initial incorrect information

Table II.
Defining health-care wastes

movement of staffs at each work station, observing where the value of the customer is being created, highlighting the waste, break down the time spent in each of the process steps and documenting the current state and future state of the process with a map in the way that highlights opportunities for improvement.

Kaizen (continuous improvement). This is the philosophy that focuses upon continuous improvement of processes. It includes the standardization of and measurements of operation (Sandle, 2014).

Overall equipment effectiveness. This is a framework for measuring productivity loss for a given process such as slow performance and down times (Vorne, 2011).

Plan-Do-Check-Act. According to Vorne (2011), the plan-do-check-act (PDCA) cycle is an interactive methodology for implementing improvements whereby:

- *Plan*: a plan is established and results are expected;
- *Do*: implement plans or do experiments;
- *Check*: verify if expected results are achieved or evaluate results; and
- *Act*: review and assess results and do it again or refine your experiment and try again.

Root cause analysis. This is a problem-resolving methodology that focuses on resolving the underlying problem instead of applying quick fixes to the symptoms of the problem (Vorne, 2011).

Standardization Vorne (2011) explained standardization as documented procedures that capture best practices and such documentations should be easy to change.

Visual factory/visualization. This includes visual indicators, display and control used throughout the organization to improve communication of process easily accessible and clear to all employees (Vorne, 2011).

Effective implementation strategy for Lean implementation in health care. Implementation strategy refers to the translation of effective strategies into action so as to achieve strategic goals and objectives. Past studies Teich and Faddoul (2013) and Kovacheva (2010) outlined the lean principles implementation strategy as follows:

- Identify the "vital few" areas that will benefit most from implementing lean;
- involves and empower employees by providing lean training; get management support early;
- be committed to allocate the supporting resources necessary for the required changes, and in turn, the site managers will be solely in charge of the process and periodically communicating progress;
- bring in an outside expert to assist in lean implementation;
- begin with value stream analysis; and
- manager should be in charge to ensure effective communication the results of the changes to the stakeholders in the organization, especially those who are not participating in the lean process and implement the change through continuous improvement.

The implementation of Lean principles and tools in the Namibian medical laboratory industry is still in a learning and growth stage. The tools are being used but at a limited pace and most of the staffs are not aware that the tools they are using are called Lean tools or techniques. Most likely, this is because medical laboratory industry uses different

instruments and tools that are in line with Lean principles, though having different names. For instance, the policy deployment/standardization tool is called SOPs.

Tools such as PDCA cycle, inventory control cards, visual management, standard operating procedure, fishbone diagram, 5 Whys and Pareto analysis are commonly used in the industry. Literature suggests no Lean health care research been done in the Namibian medical laboratory industry.

Mallick *et al.* (2012) stressed that Lean is the key ingredient of quality management principles, practices, tools and techniques, which can provide the philosophy and the most powerful tools to solve problems and create rapid transformational improvement. Lean approach seeks improvements within the framework of the organization's existing process, giving the organization an alternative methodology for achieving improvement without high investments (Poksinska, 2010).

Amirahmadi *et al.* (2007) stated that born in the automotive industry, Lean principle has been successfully implemented in medical laboratory. Applying Lean principles to the medical laboratory could deliver benefits in terms of improved productivity, improved quality, faster testing throughput and cost control (White *et al.*, 2015; Sandle, 2014; Series, 2005). It also reduces the seven common wastes as mentioned by Mutingi *et al.* (2015) and Womack and Jones (2003).

Naturally, it is appealing to apply Lean principles in health care. The basic concept of Lean principles is to minimise activities that consume resources but do not add value for the customers.

Research methodology

This section describes the research approach followed in this study and methodologies for data collection and analysis. Research methods that were used to gather information that is required to answer the research questions are explained in this section. The research design, research setting, population, sampling methods and size that were used during data collection are also discussed. The section also presents the ethical considerations and the possible limitations of the study.

Approach

A comprehensive search of the peer reviewed literature concerning the adoption and implementation of Lean principles in health care was used to generate the synthesis of the literature around the chosen research questions and objectives. The search was done in several databases such as PubMed, Science Direct, Emerald, Science Hub, Google Scholar and IEEE Xplore. Various journals such as medical journals, engineering journals, quality management journals and operational management journals were reviewed.

Research design

A descriptive, cross-sectional, mixed study approach was applied in the study. This research design was chosen because the primary goal was to not only assess the sample at one specific point in time for a defined population without making an inference but also identify areas for further research and to provide informal information on specific conditions. The descriptive cross-sectional study design is easy, inexpensive and quick to conduct. Moreover, data are collected at once in a given period of time, no follow up is needed, multiple outcomes and exposures can be studied which means a lot of information can be collected, providing good opportunity to gain a broader base of knowledge about the topic (Levin, 2006).

Both qualitative and quantitative research methods were applied in this study. Terrell (2011) described mixed methods as a combination of qualitative and quantitative approaches within different phases of the research process.

Qualitative methods are used to gain an understanding of underlying reasons, opinions and motivations. It provides insights into the problem or helps to develop ideas or hypotheses for potential quantitative research. On the other hand, quantitative methods are used to quantify the problem by way of generating numerical data or data that can be transformed into useable statistics (Wyse, 2011).

Setting and population

The study was conducted in 72 medical laboratory services in the country. Thus, the participating laboratories included NIP, path care Namibia, excellent medical laboratory, clinical pathology laboratory, century laboratory, alpha medical laboratory, Oshana medical laboratory, clinical laboratory services, maxi medical laboratory, high care medical laboratory and proquest laboratory. The study involved a total of 72 medical laboratory employees from private and public laboratories in a specified period beginning from 14 to31 August 2016.

Sampling techniques

Both probability and non-probability (purposive sampling) techniques were used to select research participants for this study. Probability sampling was used to select non-management respondents, while non-probability sampling was used to select respondents with managerial positions. Purposive sampling procedure was used because the researcher already knew something about the study population, that they are able to provide valuable data. Questionnaires were given to non-technical employees too to generalize the results to the entire organizations.

Data collection

For quality assurance purposes, permission to carry out the study was granted by the postgraduate studies committee, Namibia University of Science and Technology. Furthermore, permission to carry out the study was obtained from the participating laboratory personnel.

Primary and secondary data were collected using a designed questionnaire. The questionnaire comprised rating scale questions, which were aimed at obtaining respondent knowledge about TAT, Lean principles, Lean tools and enablers and barriers of Lean principles implementation in Namibian medical laboratory industry.

The Likert scale designed questionnaire contained closed questions with extra space provided to give their opinions, suggestions and recommendation. The questionnaires were emailed to participants outside the Northwest part of Namibia, as this saved the traveling expenses. Questionnaires were personally delivered to participants who were stationed in the North. Data were recorded anonymously and stored in a secured database.

Data analysis

Questionnaire questions were analysed using an ordinal Likert scale, which was the most convenient way of analysing the data. The online Survey Monkey software categorized and tabulated the data with similar scale scores into frequencies, weighted average, percentages and total. Computer software, excel presented the final results with tables and graphs, as they make the discussion of the finding easier.

Validity and reliability

To ensure validity and reliability (Drotz, 2014), several methods of data collection were used such as hand delivered and online questionnaire. In all questionnaires, there was a part where participants were given the opportunity to comment by giving suggestions, recommendations or to criticize the study. Participants were also granted the opportunity to provide their emails, so they will get the report at the end of the study and this will allow them to comment on the perceptions from the study.

External validity determines if the findings are valid in another context or if the results are generalizable (Drotz, 2014). Similar questionnaires were used both online and hand administration. Two participants from medical laboratories tested the questions before the data collection period commenced. This helped in modifying the questionnaire and made it understandable to the practitioners. Data collection started after finalizing the questionnaire based on the suggestions received.

Reliability means the results of the study should be the same if the same study was done again (Drotz, 2014). To achieve this, the research process was documented, meaning all the data were well-documented and they can be retrieved anytime when needed.

Ethical consideration. As the data of this study were not obtained from specific laboratories, but from individual laboratory employees, permission to participate in the study was obtained from individual participating laboratory employees. Participants were informed that it is voluntary to participate in this study and that the research is impartial. As humans were involved in this study, the data were recorded anonymously and the filled documents were archived properly to ensure confidentiality and to make sure no third person have access to the data. Data fabrications and falsifications were highly avoided.

Limitations. The possible limitation of this study is the fact that there was less contextual knowledge about the tools among the studied population. Another possible limitation was the lack of specific prior studies on the topic. Most of the studies done are about general Lean health care and not specifically about medical laboratories.

The next section focuses on analysis of results and, discussions and managerial implications in accordance with the research questions and objectives.

Results and discussions

To answer the research questions and fulfil the objectives of this study, collected data were analysed accordingly. First, preliminary results are presented, followed by major findings and discussions.

Preliminary analysis

Data were collected via mailed and hand delivered questionnaires from medical laboratory staffs.

Response rate. A total of 72 medical laboratories, private and public employees have been assessed in this study. Questionnaires were distributed to 99 invited respondents. A total of 72 responses were received, 5 were returned because of wrong mailing address and 22 participants did not respond in spite of several reminders and even extending the deadline. The response rate of approximately 72 per cent was recorded.

Among the 72 questionnaires, 53 were fully completed while 19 were partially completed. The partially completed questionnaire was also analysed on the parts, which were completed.

Respondents. The majority of respondents of 40 (56 per cent) were from the public medical laboratories, while 32 (44 per cent) were from the private medical laboratories. This is understandable, as there are more public than private laboratories in Namibia.

Table III indicates the distribution of respondents' position. Majority of responses were from medical technologists (58 per cent), followed by 11 per cent medical laboratory scientists, 10 per cent medical technicians, 8 per cent laboratory assistants, 6 per cent phlebotomists, remaining include managing director, quality assurance manager, quality assurance officer and drivers. This indicates that participants' job titles are relevant to the study, as the aim was to survey those working in medical laboratory industry only.

Descriptive analysis

Respondent knowledge about turnaround time. This section examines the degree to which TAT is practiced in the Namibian medical laboratories. The analysis shows that TAT is set-up for every test analysed in around 85 per cent of the laboratories under study and the same percentage of laboratories monitor this time to ensure that the process remain in control. Out of the 72 respondents a total of 65 respondents agreed that the TAT is used as a key performance indicator in the laboratory. The abovementioned results show that the Namibian medical laboratory industry is well-educated about the TAT.

Respondent knowledge about lean tools adoption in the laboratory. The aim of this section was to assess the extent of knowledge about lean principles in the Namibian medical laboratory industry. The investigation shows that the knowledge about lean principles is not as high as the knowledge about TAT in the Namibian medical laboratories with around 72 per cent laboratories implementing lean principles. 41 respondents agreed that they follow the JIT system and material, equipment and other resources are provided just in time when needed whereas, 55 respondents out of total 72 respondents agreed that their laboratory uses stock card to monitor the level and quantity of inventory. The analysis also shows that internal motivators (safe working conditions, reasonable salary and job rotation) are used more than external motivators (rewards and performance review) to motivate employees towards lean principles in the Namibian medical laboratories.

Tools for adopting lean principles in the laboratory. This section brings out the most common quality tools used while adopting Lean principles in the medical laboratories. The most common tools as shown in Figure 2 are:

- policy deployment standardization;
- root causes analysis;
- overall equipment effectiveness (downtime and performance);
- visual management (warning signs, regulatory signs and guide signs);
- Kaizen (continuous improvement);

Position	No.	(%)
Medical technologists	42	58
Medical laboratory scientists	8	11
Medical technicians	7	10
Laboratory assistant	6	8
Phlebotomist	4	6
Driver	2	3
Quality assurance officer	1	1
Quality assurance manager	1	1
Managing director	1	1
Total	72	100

Table III. Position of the respondents

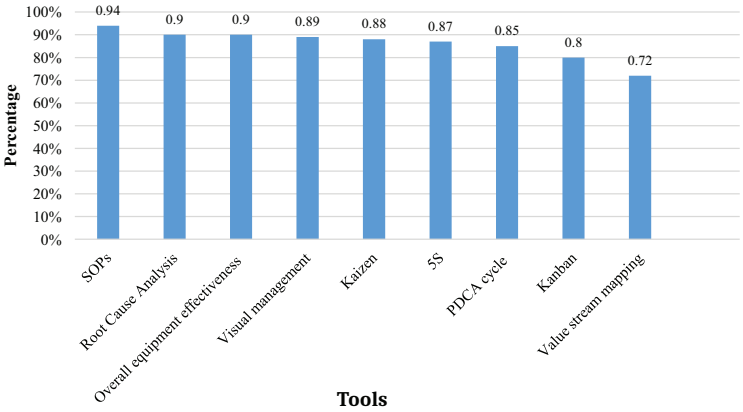


Figure 2.
Tools for adopting lean principles in laboratory

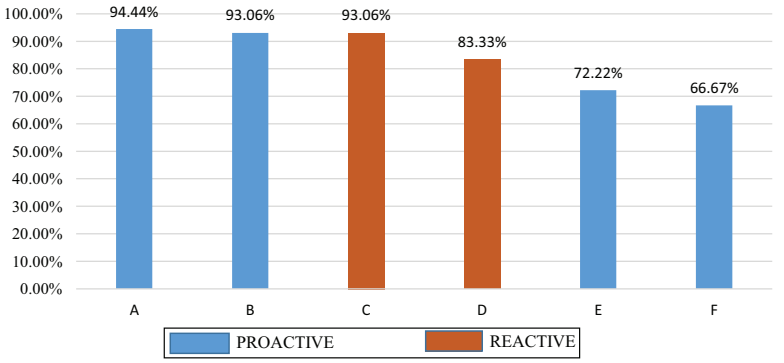
- 5S (sort, straighten, shine, standardize, sustain) methodology;
- plan-do-check-act (PDCA) cycle;
- Kanban (inventory regulator); and
- value stream mapping.

The major reason behind the use of these tools and techniques in most cases is the simplicity, as they do not contain rigorous statistical analysis. The figure shows that policy deployment using SOPs is the most important tool for Lean implementation. There is not much variation in terms of the agreed importance of the tools used while adopting Lean principles which shows that the above mentioned tools are all of vital importance for implementing Lean practices in medical laboratory services.

Reasons why laboratory decides to practice Lean principles. The survey unearthed that the reasons behind the implementation of Lean principles in laboratories are inspired by two categories of reasons: proactive (i.e. self-desire by the company) and reactive (responds to customer requirements and threats whereby failure comply may result in adverse effects). These reasons are presented in Figure 3 ranked on the basis importance as perceived by the laboratories.

Further analysis shows that more than 60 per cent of the reasons are proactive, while around 33 per cent of the reasons behind implementing Lean principles are reactive. The most agreed reason (94.44 per cent) for applying Lean principles in medical laboratories is for quality improvement followed by reasons such as to maintain competitive advantage (93.06 per cent) and to reduce TAT on client demand (93.06 per cent), which is a reactive reason. The other reactive reason why laboratories decide to practice Lean principles is owing to the pressure to improve operational performance. Around 72 per cent of the respondents reported increasing staff motivation as one of the major reason, while only 66.67 per cent laboratories stated cost reduction as the reason to implement Lean practices.

Perceived outcomes (impact) of applying Lean principles. Analysis of Lean implementation in the 72 medical laboratories resulted in eight expected outcomes. The authors categorized the perceived outcomes or impact of Lean implementation in medical laboratory services in terms of their nature, operational and perceived managerial and organizational outcomes, as shown in Figure 4. The perceived outcomes that account for around 80 per cent of the expected outcomes mentioned in the survey are:



Notes: A = for quality improvement; B = to maintain competitive advantage in service (market shares); C = client demanding shorter lead time (turnaround time); D = pressure to improve operational performance; E = to increase staff motivation; F = for cost reduction

Figure 3. Reasons for adopting lean principles in laboratory

- quality improvement;
- improved operational performance;
- shorter TAT;
- improved customer retention/satisfaction; and
- gaining competitive advantage in service (market share).

Other outcomes are high employee motivation, cost reduction and waste reduction. The outcomes are in line with the reasons of practicing Lean principles in the medical laboratories. In more than 85 per cent of the laboratories, quality improvement was observed as an outcome of applying Lean principles, which was also the most agreed reason for the same. Improvement in customer satisfaction/retention and reduced waste were also identified as the outcomes of implementing Lean principles, which were not mentioned in the reasons. This can be attributed to the other outcomes such as quality improvement, operational performance improvement and shorter TAT which results in waste reduction and thus improving customer satisfaction in services.

Enablers of lean principles. This section brings out the enablers of lean principles in the medical laboratories as identified in the survey. The authors find out the enablers, which have strong influence on the application of Lean implementation by calculating the average response on a five-point Likert scale ranging from no influence to very strong influence on the extreme ends.

The analysis shows that adequate training is the strongest enabler of Lean principles in medical laboratory closely followed by proper planning and involvement from top management, as shown in Figure 5. The other enablers in the top five are internal and external customer satisfaction and ability to learn and accept change. The average response for all the top five enablers was reported to be more than four (strong influence). The only enabler with a score less than four was democratic talk about all wastes, which was reported to have an average response of 3.74 (some influence). The result suggests that top management involvement is the most vital factor for implementation of Lean principles as

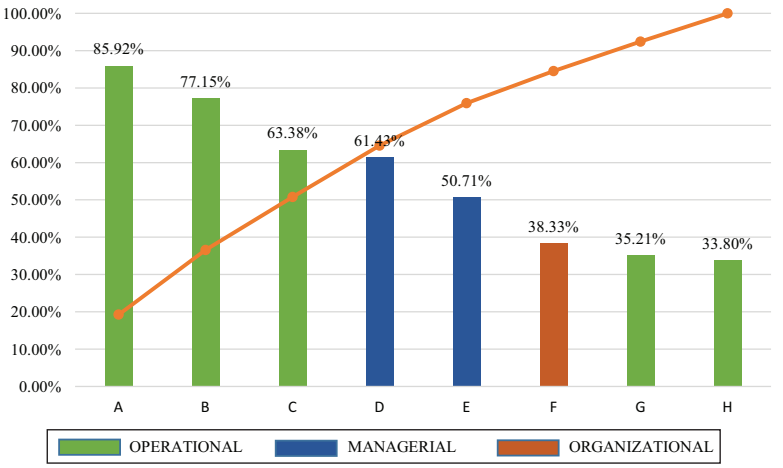


Figure 4. Perceived outcomes of adopting lean principles in laboratory

Notes: A = quality improvement; B = operational performance; C = customer retention/satisfaction; E = market share; F = employee motivation; G = cost reduction; H = reduced waste

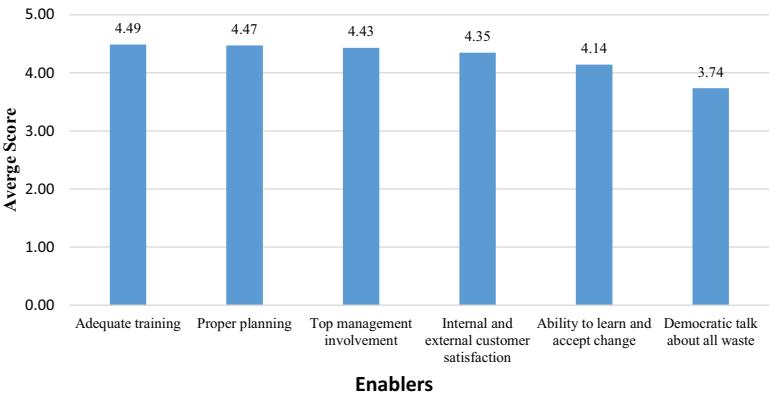


Figure 5. Enablers of adopting lean principles in laboratory

top management is involved in planning and training decisions, which further leads to learning capabilities.

Barriers of Lean principles application. The analysis of survey in 72 medical laboratories has resulted in identification of five barriers in application of Lean principles. The five barriers as shown in Figure 6 are:

(1) lack of support from the management;

(2) financial constraints;

(3) staff resistant to change;

(4) lack of conceptual knowledge on lean principles; and

(5) the absence of Lean culture in the laboratory.

The analysis shows that lack of support from management is the most influential barrier in the application of Lean principles in medical laboratories. This further strengthens the fact that involvement of top management is the most vital factor in Lean implementation. The other barriers with strong influence are financial constraint and resistance from the staff. Lack of know-how and conceptual knowledge along with the absence of Lean culture in the laboratory were also found to have some influence in resisting the application of Lean principles in medical laboratory services.

Discussion

The level of usage of Lean tools in medical laboratory industry

Results of this study revealed that Lean tools are moderately implemented in most of the Namibian medical laboratories. The most implemented tools are SOPs, root cause analysis, overall equipment effectiveness and visual management. Surprisingly, the study showed that value stream mapping and 5S methodology are moderately practised and that they are not considered as very important tools in Lean health care implementation. This contradicts with findings in most studies (Poksinska, 2010; Joosten *et al.*, 2009) which stressed that value stream mapping is the most popular tool in Lean health care implementation. SOPs emerged as one of the most used Lean tool in the Namibian medical laboratory industry. This is because each laboratory is required to have SOPs, which are sets of documents that define practices, which need to be followed in word and spirit by all employees, strictly and without deviations (ISO 15189, 2012).

Further analysis of the results showed management ability to teach and pass on the knowledge to others was barely used in the medical laboratory industry. This is an indication that the managers are doing less when it comes to sharing knowledge with the people on the ground. This finding is contrary to past studies which emphasize on supportive management and work environment conducive knowledge transfer for enhancing successful implementation of Lean (Smith, 2001). However, the medical laboratory services have adopted advanced improvement tools such as Kanban and Kaizen to improve quality of service provided, as was also indicated by Gomez *et al.* (2013).

The impact of Lean tools in medical laboratory industry

Findings from the survey showed that the perceived impact of Lean tools on the medical laboratory industry was positive. Lean tools were perceived as instrumental for the observed improved operational performance, shortened TAT, improved employee

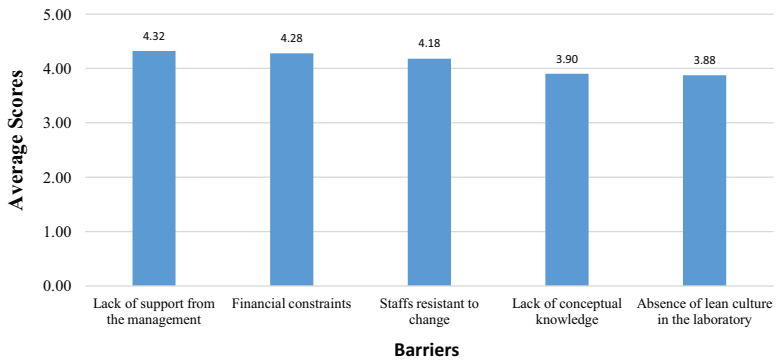


Figure 6. Barriers of adopting lean principles in medical laboratories

motivation and reduced cost. These findings are similar to the outcome of the study by Poksinska (2010) who argued that better outcomes for patients implies more on shortened treatment time and reduced waiting time. The same study also stated that the outcomes of Lean initiatives relates to performance and employees development.

Regarding the overall outcome of Lean principles implementation, the study revealed that most laboratories partially achieved the overall expected outcomes of Lean principles. Poksinska (2010) stressed that health organizations only implement the first three Lean principles. Furthermore, the fact that the Lean principle steps "establish pull" and "seek perfection" are not well-represented in the Lean health care articles may indicate that the implementation of Lean principles in health care has not achieved the level of maturity.

Enablers of Lean principles in medical laboratory industry

Top management involvement, adequate training and proper planning emerged as the most important enablers of Lean principles application in the Namibian medical laboratory industry, while democratic talk emerged as the least influential enabler. These findings are in congruence with studies such as by Mallick *et al.* (2012), Poksinska (2010) and Joosten *et al.* (2009).

Barriers of Lean principles in medical laboratory industry

Another finding of the study was that lack of support from the management, financial constraint and staff resistant to change are the most influential barriers in the Namibian medical laboratory industry, while the absence of Lean culture, lack of Lean conceptual knowledge and the ability to learn and accept change were found to have little influence. These findings are similar to what was observed in past studies by Drotz (2014) and Mallick *et al.* (2012).

Appropriate implementation strategy for Lean principles in medical laboratory industry

Various studies provide different strategies on how to implement Lean principles in different industries. This study suggests that the following approaches should be considered when Lean principles are applied in the medical laboratory industry:

- identify the KPIs which are not meeting the target and the existing wastes;
- once the wastes are identified, the improvement project on affected KPIs should be initiated and communicated to appropriate personnel;
- all personnel involved should be inducted, trained and assigned responsibilities;
- appropriate Lean tools should be identified and applied to eliminate wastes;
- if there is little or no improvement, restart the process over and over until the wastes are removed;
- if wastes are eliminated, keep monitoring the process often to see if the wastes are re-appearing; and
- sustain the process and strive for perfection by continually removing the wastes as they appear.

The suggested strategies are slightly in agreement with Poksinska (2010) who stated that there is no single correct way of implementing Lean in health care and that the usual implementation steps include conducting Lean training, initiating pilot projects and implementing improvement using interdisciplinary teams. In addition, the suggested strategies are slightly similar to Venugopal (2013) who reported the following strategy:

- define and assess the current strategic system in the company;
- form the Lean implementation team; define the area which need improvement (identify the KPIs);
- sketch the existing process status and map (using value stream mapping and visual management;
- measure the current state of the process and identify the wastes (7 types of wastes);
- implement Lean tools based on the identified wastes;
- evaluate the effectiveness and efficiency of the proposed approach; and
- continuous improvement techniques and culture must be developed in the process improvement (Kaizen, 5S).

Conclusions and recommendations

This study examined the usage and impact of Lean principles, identified tools, as well as the enablers and barriers of Lean principles applications in the Namibian medical laboratory industry; it also proposed Lean principles implementation strategy for Namibian medical laboratory industry.

This study showed that Lean is implemented and mostly used in Namibian medical laboratory industry as a quality-improvement approach rather than as a TAT improvement approach. Standard operating procedure (SOP) is the most adopted tool in Namibian laboratories, opposing many studies, which shows that value stream mapping is the most frequently used tool in health care. Management support plays a huge role in the success of Lean principles implementation. Lean is a useful tool in identifying and eliminating the wastes, and this can only be achieved by applying the right tools at the right time.

Lean plays a role in increasing efficiency, reducing wastes while improving quality of patient care and processes, balance costs, increase employees job satisfactions. This research recommends the following:

- The Ministry of Health and Social Services in Namibia should come up with policies and guidelines, which laboratories have to follow while operating for them to provide fast and quality laboratory services.
- The medical laboratory industry should be on the lookout for the modern quality improvement tools, they should research how and when these tools can be applied in the laboratory services, and they should communicate the tools to all laboratory personnel to encourage Lean culture in the industry
- Medical laboratory personnel should be able to accept change, as this is the only way they will be able to implement Lean successfully. They should be well inducted and trained on Lean tools for best practice.
- It is essential that the knowledge about how Lean principles can be applied in the medical laboratory industry is shared so that the laboratories can effectively apply Lean principles for good customer satisfaction.

Future research

Similar research is required to evaluate why Lean tools are not fully used and incorporated into day-to-day activities to influence the success and the sustainability of

Lean principles in the Namibian medical laboratory industry. Further studies on the importance of value stream mapping in medical laboratory industry are suggested as the best tool that can identify loop holes with the process flow by identifying value adding and non-value adding activities, allowing corrective actions to be taken. Finally, a study on the impact of developed implementation strategy could be carried out to determine how effectively these procedures prepare the laboratory for the full implementation of Lean tools.

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Appendix. The Questionnaire

Part 1: General information

Are you willing to participate in this survey? Yes/No	
Company type (Public/Private)	
Position held	
Years of industrial experience	

Part 2: Knowledge about turnaround time. Using a scale of 1-5, rate to what extent the following is applicable (1 = Strongly disagree to 5 = Strongly agree)

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Is turnaround time setup for every test analyzed in your laboratory?					
Is your laboratory monitoring TAT?					
Is your laboratory using TAT as one of your Key Performance indicator?					
Does the client complain about long TAT?					
Does fast TAT retain clients?					
Does fast TAT increase market shares?					
Can patient results be used for patient management?					
Others:					

Part 3: Knowledge about lean tools adoption in the laboratory. Using the scale of 1-5, rate the following practices in your laboratory (1 = Not at all to 5 = To a Large extent)

	Not at all	Very little	Somewhat	Moderately	To a Large Extent
Lean principles have been implemented in our laboratory					
Material, equipment and other resources are provided just in time when needed					
We are using stock cards to monitor inventory quantity and level					
We prevent or reject defective material and equipment					
We have established standard operating procedures (SOPs) for each operation					
Visual aids are adopted to make warning signs, regulatory signs and guide signs apparent in our laboratory					
We follow the 5S methodology (sort, straighten, shine, standardize and sustain) in our workplace					
New technology procured support laboratory values					
Management has teaching ability and are able to pass their knowledge on to others					
Employees are trained before assigned to work					
Internal motivation methods such as safe working conditions, reasonable salary, job rotations are used to motivate employees					
External motivation methods such as rewards, performance review are used to motivate employees					
Continuous improvement (kaizen) is conducted in our laboratory					
Problems are addressed according to the root causes analysis					
The flow of production is visually mapped using value stream mapping					
Others:					

Part 4: Which tools are important when adopting lean principles in your laboratory? Using a scale of 1-5, rank the importance of the tools (1 = Not important to 5 = Very important).

	Not important	Less important	Neutral	Important	Very important
Value stream mapping					
Kaizen (continuous improvement)					
5S (sort, straighten, shine, standardize and sustain – clean, safe workplace organization)					
Visual management (warning signs, regulatory signs and guide signs)					
Policy deployment- Standardization (SOPs)					
Plan Do Check Act (PDCA) cycle					
Root causes analysis					
Kanban (inventory regulator)					
Overall equipment effectiveness (down time and performance)					
Key performance indicator (KPI)					
Other:					

(*continued*)

Part 5: Reasons why the laboratory decides to practice lean principles (Using the scale of 1-5, please rate the following reasons (1 = Strongly disagree to 5 = Strongly agree).

	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Pressure to improve operational performance					
To maintain competitive advantage in service (market shares)					
Client demanding shorter lead time (turnaround time)					
To increase staff motivation					
For quality improvement					
For cost reduction					
Other:					

Part 6: Perceived outcomes of using lean principles (1 = Not achieved to 5 = Fully achieved).

	Not achieved	**Very limited achievement**	**Partially achieved**	**Largely achieved**	**Fully achieved**
Turnaround time					
Cost reduction					
Employee motivation					
Customer retention/satisfaction					
Reduced waste - waiting, transportation, motion					
Market shares					
Quality improvement					
Operational performance					
Was the overall perceived impact of using lean principles achieved?					
Others:					

Part 7: Enablers and barriers of the lean principles application in the laboratory. Rate how the following factors influence lean principles application (1 = No influence to 5 = Very strong influence)

	No influence	**Little influence**	**Some influence**	**Strong influence**	**Very strong influence**
Top management involvement					
Proper planning					
Adequate training					
Internal and external customer satisfaction					
Democratic talk about all waste					
Ability to learn and accept change					
Lack of conceptual knowledge on lean principles					
Financial constraints					
Staffs resistant to change					
Absence of lean culture in the laboratory					
Lack of support from the management					
Others:					

Part 8: Participant suggestions
Do you have any comments, suggestions, recommendations and proposal? Yes, or No
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If yes, please specify
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Part 9: Contact Information
Would you like the copy of the findings? If yes, please provide your email
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THANK YOU

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