DETERMINING THE USE OF SIMULATION IN TEACHING AND LEARNING AMONG STAFF IN KENYA MEDICAL TRAINING CAMPUSES OFFERING MEDICAL LABORATORY SCIENCES

BY

MUIA PROMINAH KAVINYA

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MOI UNIVERSITY

DECLARATION

DECLARATION BY THE CANDIDATE

This thesis is my original work and has not been presented for a degree in any other university or Institution for any other academic award. No part of this document should be reproduced without prior written permission of the author and or Moi University.

Prominah K. Muia

Ph.D./ME/5742/21

Signature -- Date ------------------------

DECLARATION BY SUPERVISORS

This thesis has been submitted for examination with our approval as University Supervisors.

Dr. Joyce Lugulu

Department of Family Medicine, Community Health and Medical Education, School of Medicine, College of Health Sciences, Moi University

Signature --------------------------------------- Date ----------------------------

Dr. Priscah Mosol

Department of Nursing Education, Leadership Management & Research, School of Nursing, College of Health Sciences, Moi University

Signature -- Date --------------------------

DEDICATION

Dedication of this thesis goes to my daughter Joan Mwende for her understanding of my commitment to do my PhD rather than assisting with her school assignments. May this work be an inspiration as you journey up academically

ABSTRACT

Background: Medical education utilizes simulation, which is a strategy that enhances learning, teaching, and assessment as students get ready to practice clinically. Acquisition of knowledge, skills, and attitudes by medical laboratory students before real-life practice on patients is important. MLS training deals with clinical care of patients, which has been reported to be inadequate by students even after graduation. More than 70% of the information a doctor requires to treat a patient comes from laboratory investigations. Well-trained students produce laboratory test results that are accurate, reliable, and timely for screening, diagnosis, and prognosis of diseases hence reducing medical errors to zero levels, ensuring safe patient care. The dynamic healthcare environment and the rapidly changing medical science field has made simulation teaching critical in training. Experiential Learning theory informed this study as it integrates conceptual and experimental learning and enables students to bridge the gap between theory and practice hence enabling them get ready to practice in real life.

Objectives: The objectives were to: appraise the institutions' ability to apply simulation laboratory sessions for their teaching and learning, determine the opportunities for innovative Simulation-Based Medical Teaching and Learning, establish the aspects that influence the ability of a teaching program to use simulation as a strategy of learning and teaching, and examine the troubles that teachers face when applying teaching and learning strategies that implement innovative simulation.

Methods: Mixed-methods research design was used. Fifty-eight (58) respondents (principals and lecturers) recruited through census method. The study was done from 1st July 2022 to 30th Dec 2022. Data was collected using document analysis, interview schedules, checklists, questionnaires, and site visits. Data was integrated sequentially and a chi-square test was done to test the hypothesis while skewness and kurtosis were used to test for normality. Descriptive statistical analysis was done and expressed as the mean ± standard error of the mean, while qualitative data were thematically analyzed.

Results: Majority of the lecturers, 39 (83.0%) indicated that they understood and defined simulated medical laboratory experiences both actual and anticipated. This was confirmed by a Chi-Square test result of 0.000 ($p<0.05$). Opportunity for allowing assessment of psychomotor and interpersonal skills was reported (80.9%) to be key. Educational validity of simulation experiences was reported 47(100%) to be very key in shaping the department's decision to implement simulation-based teaching and learning. However, there was positive skewness (0.347) and kurtosis (0.681) on the critics of simulations use. 46(97.9%) of the respondents said that simulations are resource-intensive (administrative support, scheduling and space, specimens, and financing). 63.6% of the respondents reported that the facilities in the simulation laboratories were inadequate.

Conclusion: It was concluded that Simulation for teaching and learning was used by the staff in this department and was well outlined in the teaching curriculum and course outlines. Student assessment of psychomotor and interpersonal skills was a significant educational opportunity for applying simulations. The educational validity of simulation experiences was considered a key factor as the department embraced simulation. However, full implementation was a challenge due to inadequate infrastructure and inadequate training of simulator instructor staff.

Recommendations: KMTC management should recruit, train, use, and facilitate simulation instructors. Also, the government of Kenya to provide adequate quality infrastructure for simulation training across all Medical Laboratory Science departments of Kenya Medical Training campuses.

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ABBREVIATIONS AND ACRONYMS

CBE Competency-Based Education

CBT Competency-Based Teaching

COVID-19 Coronavirus Disease-2019

CRM Crew Resource Management

CSMLS Canadian Society for Medical Laboratory Science

DREEM Dundee Ready Education Environment Measure

HIV/AIDS Human Immunodeficiency Virus/ Acquired Immunodeficiency Syndrome

ICAP International Centre for Aids Care and Treatment Program

ImPACT Improving Preoperative Anesthesia Care Training

KMTC Kenya Medical Training College

ME Medical Education

METI Medical Education Technologies, Inc

MLS Medical Laboratory Sciences

MLTs Medical Laboratory Technologists

MOH Ministry of Health

MTCs Medical Training Colleges

MU/MTRH-IREC Moi University/Moi Teaching and Referral Hospital - Institutional Research and Ethics Committee

NACOSTI National Commission for Science, Technology, and Innovation

OSCE Objective Structured Clinical Examinations

PhD Doctor of Philosophy

PRIME-K Partnership for Innovative Medical Education in Kenya

SAFER Stavanger Acute medicine Foundation for Education and Research

SBAs	Skilled Birth Attendants
SBE	Simulation-Based Education
SBME	Simulation-Based Medical Education
SBT	Simulation-Based Training
SPSS	Statistical Package for Social Science
U.S.	United States
SBTL	Simulation-Based Teaching and Learning
KMLTTB	Kenya Medical Laboratory Technicians and Technologists Board
PCR	Polymerase Chain Reaction
HPLC	High Performance Liquid Chromatography
Crispr-Cas9	Clustered regularly inter-spaced short palindromic repeats- associated protein 9

OPERATIONAL DEFINITION OF TERMS AS USED IN THIS STUDY

Assessment: entails collecting information from different and varied sources to assist with high comprehension of the progress of students in learning. Assessment compels learning thus, can be used as a tool for evaluating the process of learning, method of teaching, and the entire program.

Challenges: Affecting Application: undesirable effects of something. The challenges that teachers face while applying teaching and learning that implement innovative simulation.

Clinical Examination: the first examination of all medical examination and treatment processes. The doctor will directly examine the patient through the basic clinical skills of seeing, touching, typing, listening, to detect abnormal signs of the organs in the body. It is developed to help with the application of clinical knowledge.

Competence: is the ability to apply knowledge, skills and attitude to do a duty. Competence enables medical staff perform their duties safely and effectively. This study defines competence as the ability to autonomously do a task.

Competency-Based Education: it entails learning while engaging in practical with the aim of making students develop explicit competencies that enables to perform at the desired quality. Achieving Competency-Based Education (CBE) needs (Competency-Based Teaching (CBT)).

Computer-Based Medical Simulation: it uses computer to develop models that enhance skills and knowledge of medical students. The study herein will call the simulation virtual reality.

Conducted Simulation Laboratory Sessions: preparing students for practical sessions using a series of laboratory themed simulations developed by learning science.

Effective Teaching: it is the capacity to ensure students gain necessary knowledge and skills after teaching. The study refers to it as making learners realize the desired competencies that enable them ensure quality and safety healthcare.

High Fidelity: complex simulation that involves the entire patients or varied anatomical parts.

Implemented: put (a decision, plan, agreement, etc.) into effect; whether institutions implemented simulation-based teaching and learning for their teaching and learning.

Independent Practice: is person, a skill learning that is autonomously directed in the lab.

Innovative Simulation-Based Medical Teaching and Learning: is an action that imitates real world, a surrounding that is restricted, experiences that are directed, tasks that are fully interactive, a substitute of what happens in the real world with experiences that are directed and always immersive in nature.

Learning Environment: are various issues that affect the experience of learning. The study refers to it as a resource for learning skills.

Learning Resources: they are items that promote learning and teaching, be they physical, financial, human, or simulation environment.

Low-Tech/low Fidelity Simulators: models that help maneuver simple processes.

Medical Simulation: is a strategy that models learning and teaching without risking the life of patients. The study concentrates on innovative means of utilizing simulation.

Opportunities: a set of circumstances that makes it possible to do something.

Simulated/Standardized Patients: these are actors that mimic patients. The study refers to them as actors that imitate varied instances.

Simulation-Based Learning: a type of learning where the learners do not interact with the real patients.

Simulation-Based Medical Education (SBME): this is learning and teaching method that entails the use of simulation. This study refers to it as a virtual reality strategy where learners use models to learn the behavior and actions of patients as they would in real life with the aim of improving skills.

Simulation-Based Teaching: impacting specific skills to learners through the use of a simulated environment

Skills Laboratory Methodology: is a method of providing clinical skills in the laboratory. Sites for skills acquisition for health professionals.

Skills Trained in the Laboratory: entails taking of history, examining of simulated patients physically, investigating the patient clinically, documenting and interpreting data, managing patients, resuscitating patient, prescribing drugs, suturing, utilizing diagnostic reasoning, perfecting procedures, communicating effectively, providing leadership, and establishing professionalism and teamwork.

Teaching Staff: professional personnel directly involved in teaching students, including classroom teachers; special education teachers; and other teachers who work with students as a whole class in a classroom, in small groups in a resource room, or in one-to-one teaching inside or outside a regular classroom.

The decision to implement simulation-based teaching and learning: simulations make learners be ready for events that may take place in real practice. It also enhances students' ability to continue with their education, get re-credentialed, and pursue undergraduate education. Learning based on simulations trains students on various clinical environment they will encounter in real practice and helps evaluate clinical shortages.

Debriefing Session: an activity that follows a simulation experience led by a facilitator wherein feedback is provided on the simulation participants' performance while positive aspects of the completed simulation are discussed and reflective thinking encouraged

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Overview

This chapter discusses the background of the study, statement of the problem, justification, and significance of the study, the purpose of the study, objectives, research questions, theoretical framework, and conceptual framework, scope of the study, limitations and delimitation of the study. The purpose of this chapter is to introduce the reader to the conducted study by giving preliminaries. This chapter gives a brief history, brings out the problem statement and explains why the study was done.

1.2 Background to the study

To simulate is to create an artificial environment that represents the real-world environment for various reasons. It is a reproduction of some aspect of reality to better understand, manipulate or predict real behavior (Knee-bone et al., 2005). Scientists have been doing simulations to recreate an operation of an existing or proposed system so as to provide evidence for decision making or otherwise. In the simulation process as explained by Gran, (2012). the first step is to define the system one intents to simulate, secondly, the intended model for use is formulated, thirdly, this model is tested by comparing its behavior with the behavior of the actual system, then finally, once the behavior is identified, data is collected in order to test the model.

Medical laboratory education was defined by Collins & Varmus, (2015 as a combination of theoretical and practical learning experiences that enable medical laboratory students to acquire the knowledge, skills, and attitudes for providing proper sample collection, analysis and results dispatch. Clinical practice provides opportunity for students to apply the theoretical knowledge into actual health care provision.

Acquisition of knowledge and skills by medical laboratory students before real-life practice is a medical laboratory education challenge because this knowledge, skills and attitudes are mostly acquired through real life practice due to lack of simulations. In areas where simulation learning is limited or not available at all, learning takes place in the real environment (Papp, Markkanen & von Bonsdorff, 2003), posing threat to the patient's safety and variance on the laboratory processes.

In medical institutions, teaching programs in medical education have been implemented, and given the potential they possess, but the units/topics/modules contained therein have not been given the attention as expected (Duttweier & Dayton, 2019). There has been a lag in classroom learning that has led to the underachievement of goals regardless of inspirational examples of teaching that are innovative. This gap between the idealism of change and the realism that is witnessed in classroom is attributed to inaccessibility of resources, low levels of training and the inadequacy in the overall objectivity of the systems (Kafu, 1994). The "Gap problem" defined by Nowacyzk et al, (2007), means situation where the information, the understanding and the skills that students have are not what is needed for performing a given laboratory activity.

There is great variability on how medical schools go about planning and carrying out the educational experiences required of and by the medical students. This has been brought up by the fact that most medical school faculty members have little, if any, formal training in educational methods (Musick, 2005). The current systems although organized, are still inclined to the traditional or rather conventional measures of achievement. Majority of the students are subjected to lecture- based methodological practices that are deficient of technological advancements (Kafu, 1994). Hence, the question remains; which mitigation measures should be used to redress this persisting conservative approach to preparing medical laboratory health professionals in a better way?

Like the other programs such as nursing and dentistry, staff in the department of medical laboratory science started using simulation slowly by slowly in their teaching by doing demonstrations to the students to reinforce what they have already taught. This was further supplemented by then taking the students to the clinical laboratories in the hospitals but the clinical sites were faced with unique challenges hence the decision of this department's interest in simulation-based learning experiences for their students, which previously was not the case (Van-Kerkhove, et al., 2010). Laboratory practices in the hospitals help learners convert the skills they acquire into practice when they repeatedly experience them. Hospital laboratories must have specialized equipment, and a working area for laboratory education, hence causing a significant financial burden to the hospitals in the developing countries (Keleş, et al., 2022), bringing about the need to decrease reliance on clinical training sites (Van-Kerkhove, et al., 2010), which have not been reliable of late hence the need to shift to simulation.

The changing healthcare environment, with the movement of medical care from the traditional hospital setting to ambulatory medicine (medical services performed on an outpatient basis, without admission to a hospital or other facility, for example, offices of physicians and other health care professionals, hospital outpatient departments, ambulatory surgical centers, specialty clinics or centers, e.g., dialysis or infusion, urgent care clinics) (Safadi & Abushaikha, 2022), has necessitated the ability to provide care in a much shorter period and requires changes in documentation with all information, including both health knowledge and medical records, becoming digital.

Medical education has undergone significant changes all over the world because of concerns for the patient safety (Abdulmohsen, & Elq, 2007). Preventable medical errors result in more than 400,000 deaths among American citizens each year and are the third cause of death in the United States, followed by cardiovascular diseases and cancer (Brennan et al., 2004). Non-fatal iatrogenesis (unintended adverse patient outcome because of a health care intervention) resulted in disability in 3.5 million American patients per year and therefore, the major cause of such alarming statistics may be related to the medical education culture majorly characterized by the mere acquisition of knowledge and therefore, the need to also adopt simulation-based teaching and learning.

Many advances have been made in technology and teaching strategies (Safadi & Abushaikha, 2022); however, it is still not unusual for medical students to be taught in a traditional classroom the same way they were, decades ago because questions are being raised as to how should the medical curriculum be redesigned and implemented to serve the scientific foundations of medicine in the 21st century (Gwee, Samarasekera, & Chay-Hoon. 2010). Embracing teaching and learning based on simulation requires a significant shift in previous teaching practices. The shift must be well planned for in terms of resources for education and its relevance should have research-based evidence which may not be accessible to the teaching staff today. These staff are the implementers of the curriculum and hence, they require constant updates.

Medical education is rapidly changing, influenced by many factors including the changing health care environment, role of the physician, altered societal expectations, rapidly changing medical science, and the diversity of pedagogical techniques (Owolabi, 2021). Changes in societal expectations put patient safety at the forefront, and raise the ethical issues of learning interactions and procedures on live patients, with the long-standing teaching method of “see one, do one, teach one” no longer acceptable (Bonk, 2009). The goals of using technology in medical education include facilitating basic knowledge acquisition, improving decision making, enhancement of perceptual variation, improving skill coordination, practicing rare or critical events, learning team training, and improving psychomotor skills.

Different technologies can address these goals (Lane, Slavin, & Ziv, 2001). Some of the technologies and techniques available to address the changing educational environment according to Nosta, (2013) include podcasts and videos with flipped classrooms, mobile devices with apps, video games, simulations (part-time trainers, integrated simulators, virtual reality), and wearable devices (google glass) are medical education that is based on simulation concentrates more on the learner as its foundation relies on learning realism-based theories.

Simulation is suited to a realist approach as it is highly experiential, requires mental and physical activity and allows reflection (Gordon, Oriol, & Cooper, 2004). Key concepts such as ‘self-efficacy’ and ‘self-regulation (the ability to understand and manage your behavior and your reactions to feelings and things happening around you) are essential to learning. The educators and learners should highlight and manage how the ‘real’ practice environment will vary from the simulated learning environment. Change of practice or learning can occur where there are serious contradictions within the activity system. As such, learners create their reality, truth and integrate experiential and conceptual learning (Keleş, et al., 2022). To support this type of learning, Kriz, (2010) proposes activities such as discussion, self-reflection, questioning and feedback so that learners can engage actively in the learning process.

Healthcare simulations have been used worldwide to reduce adverse outcomes in patient care settings (Escudero, Silva, & Corvetto, 2019).   as reported by Ariko, (2017) and in recent decades, globally, nursing instructors have tended to use skills laboratories in training for pre-service nursing students rather than traditional methods due to benefits such as increased self-confidence and competency levels.

The basic nursing procedures taught to these students are of great importance during initiation into clinical placement. In the training of medical laboratory students, there is a need for medical students to expose live patients to some procedures so that they get the necessary and adequate skills (Bello, 2008). On the other hand, students are obligated to offer optimal treatment and also to ensure their patients' safety and general well-being. As much as medicine is considered a science, it is also a creative activity and so repeating the activity again and again together with improved experience are required to enhance skills, attitudes, and the required confidence (Jha, Duncan, & Bates, 2001). It is true that clinical learning is very significant to healthcare learners because of their future assignments and therefore, the current practice is that these medical laboratory students, after basic introduction to the course, they are taken to the clinical area to learn more by practicing on real patients.

In the medical field, simulation finds its origin in ancient past, in the 18th century, when models of human patients were built in clay and stone to demonstrate the clinical features of diseases and their effects on humans in the USA (Meller, 1997). In India, standardized patient simulations facilitated interactive teaching through the innovative combination of technology and patient actors (Aggarwal, et al. 2016). In China, healthcare simulation was still facing great challenges due to heavy under-developed teaching approaches (Li, et al. 2019). In Israel, the Israel Center for Medical

Simulation was established at the Chaim Sheba Medical Center in 2001 (Ziv, et al., 2006). In a study by Abdelaziz, et al., (2018), simulation in medical education in Egypt dates back to 1827, whose most important goal was to qualify physicians who can provide high-quality health care services for their local community and other communities in the Middle East region.

In Nigeria, medical schools began teaching and learning medical sciences through simulation in 2015. A visiting professor in the commission of higher education, Eugene Okpere, explained that the best way to train medical students is through implementing simulation. This way is safer to both the patients and the students and also the students will be more competent in their future work as health care professionals.

Okpere added that the use of the electronic human body would enable students to identify forms of disease components or clinical signs. Students who go through thorough training in simulation technology will have 35 percent competency before their physical contact with live patients. Again, patients are now getting very smart and wise. They know their rights and not many patients will be happy to be used as materials for experiments (https://www.vanguardngr.com/2013/12/medical-schools-nigeria-begin-learning-simulation-2015-don/).

Ophthalmic surgical education including for cataracts was simulated by use of animals, cadaver, artificial and virtual reality models in Zimbabwe. Studies have shown a reduction in complication rates with access to, and mandatory training using a virtual reality simulator for cataract surgery training (Dean, et al., 2021). Simulation-based training model where the learner is immersed in realistic situations was used in Ethiopia to strengthen the training for SBAs and build the capacity of healthcare providers so that they can recognize and manage emergency obstetric problems during pregnancy, childbirth, and the postpartum period (Yaya, et al., 2014).

In Uganda, the implementation of simulation-based education in managing maternal, newborn, and child health emergencies was started in 2016. A dedicated simulation Centre was established with a range of low, medium, and high-fidelity mannequins. (Simulation For Life. (2023b, August 17). *Simulation for Life - Global Health Initiative*. Simulation for Life. Retrieved from http://mustsimulationcenter.ac.ug/).

Simulation-based education has not yet been fully implemented in Tanzania although nursing schools located in a highly rural area in north-central Tanzania have a new skills training and simulation Centre and the teachers know the simulation method. The training of nursing students involves a bit of theory and lots of practice. Any gap arising from the two can be compensated for through the use of innovative simulation teaching and learning. This strategy helps prepare nurse students for their practice and professional life (Tjoflåt, Våga & Søreide, 2017). There was no documented study done for medical laboratory students so far.

In Somalia an implementation of 'Distance Basic Training of Healthcare Professionals', a blended training course was provided by the University of Geneva to complement on-the-job training of junior health personnel in Dadaab. Technology, through blended learning, was used to enable capacity building among the health workforce in refugee camps (Behind, 2017).

In Kenya, simulations on Laparoscopic training were started in Tenwek Hospital to train general surgery resident doctors on laparoscopic skills and learn how to train health care providers in their own country through the use of simulation technology and to receive guidance on establishing the first medical simulation lab in sub-Saharan Africa (Long, et al., 2014). In the following year, the Center for Healthcare Simulation and Patient Safety was established in Kijabe mission hospital. Ariko, (2017) reported that the skills laboratory in Bomet KMTC had an inadequate number of simulated patients which were only used by the nursing and clinical medicine students mostly during their first year of study. There is a scanty evidence of research studies that have been done among medical laboratory students and hence the research gap.

According to Kihuba, et al., (2014), the provision of safe healthcare cannot be guaranteed in a majority of healthcare facilities both in the public and private facilities. In a MoH survey done in collaboration with World Bank, of the 13 healthcare facilities surveyed, the overall patient safety compliance was relatively poor at 97% and less than 1% of the public healthcare facilities and only 2% of private facilities met some minimal standards on patient safety further widening the gap as far as quality healthcare to all is concerned. To the medical training institutions, this call for use of more innovative teaching strategies which ensure proper preparation of the health care workforce.

Due to challenging issues in many hospital settings, safe healthcare cannot be guaranteed in majority of healthcare facilities where majority of Kenyan citizens seek medical attention. The inadequacies in healthcare facilities are diverse and according to Lindfield, & Bwonya, (2015), they may be as a result of organizational & cultural challenges, communication issues, leadership challenges, or the failure to adequately engage the patient in the care process.

Most studies on simulation learning have been done in other departments with very little if any being done and documented in literature concerning medical laboratory science (Grant, 2007). The public has become more aware of their health needs hence increasing the demand for laboratory services, which also includes the use of technology and techniques that were not available previously. Medical laboratory science is a key contributor of data relevant to evidence-based practice, preventive medicine, and disease management. According to Rohr, et al., (2016), more than 70% of the information a doctor needs to treat the patient comes from diagnostic laboratories.

Hallworth, et al., (2015) reported that clinical laboratories supply healthcare professionals with the objective data necessary to provide high-quality, safe, effective, and appropriate care for disease prevention, diagnosis, treatment, and management. Simulation-Based Learning (SBL) interventions have been under-utilized due to the shortage of well-trained staff and shortage of equipment in resource-limited areas which includes Kenya.

New information, new laboratory tests, and new protocols are constantly being added to the laboratory profession and hence adding new content to the curriculum is inevitable (Riding & Polancic, 2016).

Issues surrounding staff training, competence, and extremely expensive clinical simulation laboratory infrastructure have caused the training of medical laboratory students to be the same as they were since inception. Some restructure in resources both human and otherwise need to be done in order to embrace innovation as seen with teaching and learning based on simulation as well as online blended learning (Hartfield, 2013).

Traditional teaching strategies used in the department of medical laboratory sciences include traditional lectures, face-to-face learning, laboratory lessons using manual procedures, and assignments/homework, and these strategies according to Ersdal et al.,

(2013) do not encourage student interaction and independent thinking by the students but the innovative teaching strategies characterized by so many challenges such as the use of expensive equipment and a decreased equipment budget, reduced staffing, experiments involving animal dissection, experiments taking days to months to give results, patients awareness on their personal safety and congestion during students' clinical experience do encourage student interaction and independent thinking.

Garrison, & Kanuka, (2004) reported that innovative teaching strategies advocated for utilize normal and advanced technology such as the use of artificial intelligence and hands-on activities that are engaging to the student and encourages them to take an active role in their learning.

To address the above issues Appiagyei, et al., (2014) recommended the use of teaching and learning based on innovative simulation for most health care professions.

Kenya Medical Laboratory Technicians and Technologists Board (KMLTTB) is the regulatory body mandated with the responsibility to regulate the training of the medical laboratory sciences profession in Kenya. This agency was established by the Act of Parliament No. 10 of 1999. This board plays a critical role in the National Health infrastructure by ensuring that medical diagnostic services holistically meet expected standards, from personnel, equipment, reagents to safety requirements. It works with local, regional, international, regulatory and scientific partners to ensure that Kenya's Medical Laboratory Science Sector is reliable and fully compliant to current and emerging capacities (https://kmlttb.org/index.php/contact-us/).

The workload of medical laboratory officers include; sample collection, reception, preparation, analysis, manage and supervise the removal and destruction of medical laboratory wastes, validation, interpretation and the dispatch of results to the relevant departments and offices, results analysis, carrying out internal/external quality controls in the laboratory to ensure quality and accuracy of results, attending departmental meetings, participating in the ward rounds, keeping an inventory of laboratory reagent and materials needed, used and requested, developing, improving and updating laboratory standard operating procedures. (http://kenyalaw.org:8181/exist/kenyalex/sublegview.xql?subleg=No.%2010%20of%201999).

In conclusion, this study is not made to say that innovative simulation-based teaching and learning will totally substitute the presence of people and practical learning in the laboratory, but to determine the application of innovative Simulation-Based Medical Teaching and Learning in selected KMTC Campuses offering Medical Laboratory Sciences in Kenya.

In their study, Sorensen, et al, (2017) reported that innovative simulation-based teaching and learning experiences are useful options when the practical method is too intricate for learners in their first year, costly, or unattainable because of limitations in the laboratory, or the practical takes a lot of time for it to be finished in the laboratory. They went further to report that this innovation has the capability of preparing the student for laboratory processes in the real world as well as encouraging augmented and sustainable experience of learning.

This study was done in the department of medical laboratory sciences because the researcher is a medical laboratory scientist by profession and wishes to see the learners gain the right competencies during their training and their subsequent transferability of the same to their professional life. This is also in line with the institutions' mission which intends to develop fit-for purpose middle-level health professionals through transformative training, research and consultancy.

1.3 Statement of the problem

As noted from the background, the paradigm shift from traditional instructional methods to innovative instructional methods has been emphasized in order to respond to challenges and trends in Medical Laboratory Science professions training and education. Not seeing and practicing on a number of important diagnoses during training periods could pose a significant knowledge gap.

This gap can lead to the professional incorporating errors in their investigations. These Medical laboratory errors emanate from mechanical, chemical, biological, and environmental hazards that the laboratory practices involve and can affect the delivery of the services in the laboratory as well as the patient management either directly or indirectly.

These errors can also be caused by inadequate knowledge and skills among the medical laboratory personnel, while others are caused by ineffective equipment used in the laboratories. To address the presence of medical laboratory errors, the training as well as clinical and laboratory practice of these professionals needs to be adequate enough. These medical errors and inadequate confidence could be attributed to the traditional hospital-based clinical instruction which has been observed not to always provide the same type of patients discussed in the classroom. From the documented reports in literature, outcomes of learning and levels of competence can be enhanced in medical laboratory science student through simulations learning. This can be actualized if only simulation-based medical teaching and learning has been integrated in the teaching curriculum. Enough exposure of the students is very important although improved health care systems and information technology have reduced the length of hospital stay for patients thus preventing students to have sufficient time to understudy a particular disease condition and care with real life patients.

As a result of these, educators have to switch to effective teaching strategies and innovative approaches which are critical in producing a competent all-round medical laboratory health care professional in an ever-changing medical laboratory field. Instructors handling these Health Professionals should be conversant with simulated laboratory learning for its use to be effective. For their efforts to be supported, curriculum review, which will incorporate in detail, the content for simulation in every unit is advocated for.

Simulation teaching and learning in the medical laboratory science department has scarce documented information in literature hence the researcher's motivation in carrying out the present study. The construction of the evidence base in the use of simulation in teaching and learning is important for making decisions and developing policies regarding future prospects for medical laboratory education. This innovative teaching strategy have been reported to be a rewarding teaching and learning experience when supported with sufficient and appropriate resources.

1.4 Purpose of the Study

The study is aimed at determining the use of simulations for teaching and learning by the staff in the department of medical laboratory sciences at Kenya Medical Training College

1.5 Objectives

An objective is something that one plan to do or achieve, based on real facts and not influenced by personal beliefs or feelings (*Objective*. (2024). Retrieved from https://dictionary.cambridge.org/dictionary/english/objective). The broad objective of this study was to determine the use of Simulation teaching and learning among staff in selected KMTC Campuses offering Medical Laboratory Sciences in Kenya

1.5.1 Specific Objectives

The specific objectives of this study were to:

1) Appraise the institutions' ability to use simulation laboratory sessions for their teaching and learning.

2) Analyze the educational opportunities brought about by simulation as an innovative strategy used for teaching and learning among teaching staff.

3) Establish the factors considered by implementers in using simulations for their teaching and learning and what influences its implementation among teaching staff.

4) Examine the challenges teaching staff face when they apply teaching and learning strategy based on innovative simulation.

1.5.2 Research Questions

1. Do institutions offering medical laboratory science course use simulations for supplementing their class room teaching?
2. Are there educational opportunities for those directly involved in simulated-based learning in MLS?
3. What do implementers consider when making their decision to apply simulations in their institutions?
4. What challenges do they encounter while implementing innovative simulation-based Teaching and Learning?

1.6 Hypothesis

1.6.1 Null hypothesis

That teaching staff in the department of medical laboratory sciences do not use simulated medical laboratory experiences both actual and anticipated for their teaching and learning.

1.6.2 Alternative hypothesis

That teaching staff in the department of medical laboratory sciences use simulated medical laboratory experiences both actual and anticipated for their teaching and learning.

1.7 Significance of the Study

The significance of a study is its importance in a specific research area and its relevance to the target group. The significance tells the reader how the findings affect the topic/broad field. The study findings obtained from this research will help the lecturers in the department of medical laboratory sciences to understand what's new and what they can improve or stop using in simulations. They will also be able to do proper budgeting in order to cater for any new development they want to bring onboard to better their simulation experiences.

The staff in the department will be able to conduct research to see what works and what does not on this innovative simulation-based teaching and learning, its relevance in medical laboratory education based on simulation. The results obtained will help the training institutions to better the implementation, understanding of the opportunities across board and the emerging and re-merging issues concerning simulations as well as the challenges that can be encountered during the implementation of simulation-based teaching and learning in this department.

In collaboration with other training institutions and stemming from the KMTC mission "to develop fit-for purpose middle-level health professionals through transformative training, research and consultancy", Simulation-Based teaching and learning in MTC's offering MLS can be a center of excellence that can grow to provide short term clinical courses such as phlebotomy through simulation for healthcare workers who would want to build their capacity in patient sample collection, to provide safe and high-quality of care to patients.

1.8 Justification for the study

The health of every person is everything for a nation. Ailing citizens cannot be productive enough to move the development of the nation forward. This is well stipulated under the Bill of Rights, chapter four of the constitution; Article 43 (1) a; that every person has the right to the highest attainable standard of health, which includes the right to health care services, including maternal, child health and reproductive health care (Centre for Human Rights, University of Pretoria, 2021). It should be noted that this bill of rights takes care of all ages of the patient, both young and the old.

Vision 2030 outlines quality healthcare as one among its social pillars. In addition, providing quality education to healthcare workers ensures they give excellent care (Social Pillar Kenya Vision 2030. (n.d.). Retrieved from https://vision2030.go.ke/social-pillar/). The interaction of healthcare professionals with patients makes them know the problems they go through with the aim of providing primary, secondary, and tertiary care. Medical laboratory training institutions implement top notch bench marks to ensure the graduates they produce offer quality and safe healthcare that satisfy the needs and expectations of customers. Achieving this need requires re-looking at the strategies of training particularly innovative simulation-based teaching and learning (Willmington, et al, 2022).

Some procedures implemented in the laboratory including collecting of blood, urinalysis, and smearing of peripheral blood, are hard to perform without earlier experience, therefore, such applications require models, which can be realized by innovative simulation-based teaching and learning. These challenges make medical laboratory technologists experience inequities of opportunities (Keleş et al, 2022). Variation in commitment to the approaches and teaching strategies as observed with the simulation-based medical teaching and learning shows that the training of medical laboratory specialists does not have proper standards and lacks harmony. (Willmington, et al, 2022).

This was seen from the study findings where some respondents 2(4.3%) reported that they were not sure or they did not have simulated laboratories in their institution as part of their curriculum which they used for teaching and learning. Also 5(10.6%) reported that they were not aware how these simulated laboratory experiences were constructed. This may be because they were not directly involved with simulations to the students or just ignorance.

Changes in technology, need for student's and patient's safety, decreasing reliance on clinical practical sites where performance of experiments done occasionally, changes in work routines at the hospitals (Keleş et al, 2022), and practical dilemmas such as students paying for clinical placement sites, dilemma brought about by COVID-19 necessitating social distancing, possibly lower the opportunities for learning (Willmington, et al, 2022). leaving room for simulations implementation for enhanced learning experience that concentrates on meeting the needs of the learner (Aebersold, 2018), and based on principles of learning that implement realism and evidence-based curriculum (Sherwin, 2011).

Simulations eliminate geographical boundaries while providing a safe learning environment. Although they cannot completely replace clinical experiences, simulations offer opportunities for experiential learning that supplement clinical experiences. Establishment of skills laboratories which are fully equipped with the state-of-the-art equipment (equipment which have been made using the most modern techniques and technology such as new tests and advances in equipment and testing techniques, which have made testing more efficient and automated) is paramount to ensure excellent training of healthcare professionals (Grant, 2007).

Laboratories should be fully utilized by most of the departments if not all of them (Mosadeghrad 2013). Teaching the skills will help students ensure patient safety as they acquire non-technical skills including decision-making, communication, situation and personal limitation awareness, teamwork, and leadership (Prineas, et al., 2020).

This study will be beneficial to the KMTCs which on average produces more than 80% of all the healthcare workforce working in all hospitals in Kenya achieve their mission and vision. It will also help in yielding information on when resources are accessible and sufficient. Further, it will assist with knowledge of insufficient resources that are required for effective interventions, recommendations, and judgments (Norman, 2018) on innovative simulation-based medical teaching and learning.

1.9 Scope and Limitations of the Study

1.9.1 Scope

This study was on the use of simulation medical teaching and learning in Kenya Medical Training campuses offering Medical Laboratory Sciences. The study was carried out among the eleven (11) KMTC's distributed across the country. Respondents were confined to campus principals, Lecturers and clinical instructors in the various campuses offering a diploma in medical laboratory program.

1.9.2 Limitations

KMTC has more than 74 campuses distributed in the 46 counties of Kenya. Samburu County is the only county without a KMTC. However, this study focused on 12 campuses. KMTC has more than eighteen programs both certificate and diploma as well as various short courses. However, this study focused on diploma in medical laboratory sciences. Only 12 out of the more than 74 KMTC's offer diploma in MLS. These 12 campuses are widely distributed in twelve counties of the country. Total population of staff in the 12 campuses was 64 where 10% of it was involved in pilot study. This was a small population hence the researcher used mixed method design and various data collection tools. Furthermore, medical laboratory science program is also offered in other Public and Private tertiary colleges in Kenya but for this study, only KMTC campuses offering medical laboratory science program were involved. Therefore, the findings of this study may not be generalized to other programs in KMTC campuses and other medical laboratory science programs of other public and private tertiary colleges in Kenya. To enable the generalizability of the findings, further research needs to be carried out to determine the use of teaching and learning strategy based on simulation in medical laboratory education in Kenya, Current perspectives and practices.

Simulation laboratories are very expensive in terms of infrastructure and sensitivity of the equipment, hence the access to the simulation laboratories by the researcher was authorized by the Chief Executive Officer, KMTC Headquarters. Due to the fact that the respondents have independent thinking, there was a likelihood that the respondents did not provide social responses because the researcher had carried pilot study prior to the actual study and adjusted the questions which were not clear or confusing to the respondents and also used various data collection tools to confirm the truthfulness of responses from the respondents. Also, all observations, document analysis, and interviews of the study were conducted and analyzed by one researcher. This may have limited the understanding of the results to the researcher's own bias but the researcher considered all the data collected and analyzed it with a clear and unbiased mind.

1.10 Assumptions of the Study

Assumptions are statements that are taken for granted or are considered true, even though they have not been scientifically tested. They are principles that are accepted as being true based on logic or reasons, but without proof or verification. The assumption for this study included the following:

i. The study assumed that staff would be available, willing to participate in the study and again they gave relevant and truthful information.
ii. The simulation equipment would be available, adequate and of the required quality, which would accommodate all the students at a particular sitting.
iii. The managers of the various institutions would provide a conducive environment for the researcher to collect data and that they would participate freely in the process of data collection.

iv. That the research assistants would be keen enough to avoid errors while collecting data and that care was taken during data analysis to ensure accuracy.

This was exactly the picture on the ground during the said period of time.

1.11 Theoretical Framework and Philosophical Paradigm for the Study

1.11.1 Theoretical Framework

The theoretical framework is the structure that can hold or support a theory of a research study. It demonstrates an understanding of theories and concepts that are relevant to the topic of the research paper and that which relates to the broader field of knowledge in the class one is undertaking. The selection of a theory should depend on its appropriateness, ease of application, and explanatory power (Orodho, 2003). Theoretical framework connects the researcher to existing knowledge, permits the reader to evaluate the theoretical assumptions critically, forces the researcher to address questions of why and how by moving from simply describing a phenomenon observed to generalizing about various aspects of that phenomenon (Sutton, Robert & Barry, 1995).

The study done by Owen, (2017), reported an educational theory as a set of suppositions and ideas which assist with comprehending a phenomenon. The study further reported that a theory should have characteristics such as being comprehensive, coherent and having internal consistence. The same theory should also help inform and guide practice in medical education as reported by Rees and Monrouxe, (2010), and in enabling understanding, planning, delivering and evaluation (Prideaux and Spencer, 2000).

Pursuing the Medical Laboratory Scientist course is multifaceted and cannot be elucidated by a sole theory. As such, several theories which have been explained by several theorists have been used to explain learning in medicine. Examples of these theories and the persons who developed them include deliberate practice by situated learning by Jean Lave and Etienne Wengerin (1990), Karl Anders Ericsson (Ericsson, 1998) and Social Cognitive Model, which started as Social Learning Theory by Albert Bandura (1960), and Kolb's experiential learning model by David Kolb, (1984) (Lave and Wegner, 1991).

Owen (2017) reported that Kolb's experiential learning model aimed at identifying the main trigger for learning as being concrete experience and the learner should transact with the environment, then reflect upon and form conceptualization that are abstract, to assist in significant and active testing.

Concrete experience is provided by simulation and this is sensed via experiences that rely on scenarios and majority of experiences of simulation allow learners to reflect and formulate abstract conceptualization that can be symbolic. The conceptualization allows learners to experiment and rehearse new concepts that have been developed. The environment of simulation enables a safe place to experiment with the patient. The work of the teacher is to guide the learner while facilitating learning so the latter connects the abstractions developed. The use of multiple analogies as examples instead of single case studies is significant to learning deeply and shift to new instances (https://discovery.dundee.ac.uk/en/student Theses/1b6c5cd6-574c-4683-a372-0761be7d276a?).

Individual experience influences and environmental factors on individual health behaviors are well described by social cognitive theory. This theory provides opportunities for social support through building on expectations, self-efficacy and using observational learning to bring about behavior change

(https://www.ruralhealthinfo.org/toolkits/health-promotion/2/theories-and-models/social-cognitive)

In simulation-based learning, the behaviorist approach in understanding learning is when feedback from both consequential clinical happenings as well as faculty or peer feedback is used to offer reward for desirable behaviors. Skills and drills in resuscitation training are typical examples of Social cognitive theory. The learners are supposed to interact with their environment as they integrate new experiences with their existing understanding. This helps them to build on the existing knowledge and application of the same in the cognitivist approach (Owen, 2017).

This theory comprises of components that relates to individual behavioral change such as expectations, self-efficacy, self-control, behavioral capability, observational learning and reinforcements (https://www.ruralhealthinfo.org/toolkits/health-promotion/2/theories-and-models/social-cognitive).

Deliberate practice is a purposeful and systematic practice that requires focused attention and is conducted with the specific goal of improving performance (https://jamesclear.com/deliberate-practice-theory). This practice describes stages of skill development that entails considerable, specific, and sustained efforts to doing something from novice towards mastery and finally to autonomy (Ericsson, K. A. (2014, August 1). *The making of an expert*. Harvard Business Review. Retrieved from https://hbr.org/2007/07/the-making-of-an-expert).

This practice can be applied in simulation learning in that the intense and focused repetitive performance of an intended cognitive or psychomotor skill in a focused domain, is coupled with rigorous skills assessment that provides learners with specific, informative feedback resulting in increasingly better skills performance, in a controlled setting (Owen, 2017).

Situated learning is an instructional approach that aims at creating meaning from the real activities of day–to-day life where learning occurs relative to the teaching environment (*Situated Learning | Center for Innovative Teaching and Learning | Northern Illinois University*. (n.d.). Northern Illinois University. Retrieved from https://www.niu.edu/citl/resources/guides/instructional-guide/situated-learning.shtml#). An example of situated learning is medical laboratories used for demonstration in which students are involved in activities which replicate actual work settings as in real clinical laboratories in the hospital. Here, learning occurs through collaboration, social interaction, and connectivity with the practice community. It is closely related to the experiential learning model as it includes learning by doing and participating in the shared experience of the community (Owen, 2017).

Constructivism learning theory: This theory was founded by Jean Piaget in 1976. The theory advances the significance of involving learning in active participation with the aim of constructing knowledge for individual learners. The students are assumed to utilize background knowledge and concept that normally aid them during the acquisition of new information. Dewey, Kolb, and Montessori’s learning theories provide the platform for the use of the constructivist learning theory comprising a myriad of concepts such as active learning, discovery, and knowledge building. Of essence is that all the concepts provide or rather enlighten the students to more flexibility within a given blueprint or system (Lombardi, 2011).

Constructivism stipulates that the role of the teacher is that of a facilitator tasked with the role of motivating students to discover new tenets and facets of knowledge by themselves. Through such a development, the students are well placed to construct their own knowledge through self-conceptualization. This can be enhanced through the facilitator who instills curiosity and debate among learners, putting into mind their autonomy. Curiosity can be developed by teachers through adding raw and challenging data, new resources and materials in order for students to critically analyze (De-Vries, & Zan, 2003).

The constructivist view to learning in the classroom is fashioned in Bruner (1961), and Dewey (1997) developmental theories. Piaget's works that gave birth to cognitive construction postulates that, a person's reaction to experiences is likely to lead or fail to lead to learning. On his part, Vygotsky's social constructivism stipulates that factors such as language, communication, and social interactions among peers, family, and teachers are significant in the construction of meaning from experiences. According to Vygotsky, meaning is co-constructed and not just constructed (Biggs 1996).

Experiential Learning theory informs and justifies this study. The theory's differentiating attribute based on Steffes' (2004) work is that the learner's core place in teaching and learning is their experiences, and that is exactly what happens during the training of a medical laboratory science learner (Foley, 2020). Experiential learning shares epistemological tenets with andragogy (the science and art that assist adults to learn) that requires learners to participate and engage in the learning process to promote successful learning (Neill, 2016). This theory is described as 'learning by doing, thinking about, and assimilation of lessons learned in everyday behaviors. This learning process is cyclical and encompasses four interrelated aspects (Steffes, 2004).

Kolb (2014), conceptualized that such learning is a process whereby knowledge is continuously acquired, tested, analyzed and reflected upon during and after an event, and so can represent a holistic learning process. This concept of reflection and analysis is the cornerstone of simulation-based education as an experiential learning context (Foley, 2020). A learner in an inter-professional simulation (a medical laboratory science student) can participate in such an immersive scenario and learn through critical thinking and adaptation rather than strictly content delivery as is often the case in a classroom setting (Boud, & Cohen, 2014; Fanning & Gaba, 2007).

Experiential learning asserts that, adults learn in ways not possible from instruction or information delivery alone, and necessitates interaction between the learner and the environment, moving between 'opposing modes of reflection and action, feeling and thinking' (Kolb & Kolb, 2005). SBME provides an experiential learning context as experiences, either real or simulated, are catalysts for experiential learning (Zigmont, Kappus, & Sudikoff, 2011), and experience is the foundation of, and the stimulus for adult learning. People learn through interactions with people and the environment and hence simulation expands on the traditional classroom and student simulation-laboratory experiences. This includes professions outside of the laboratory with which MLS students interact. MLS programs utilize experiential learning in the student laboratory with case-based specimen analysis; however, it is time to break out of the silo and teach students how to work with inter-professional teams prior to entering the professional healthcare setting.

Neill (2016), provides an additional experiential educational or learning model which fits with SBME and aims to enhance learners' experience. It stipulates that the acquiring of skills by adults relies on their skills of learning instead of their expertise. The argument is that 'skill in its minimal form is produced by following abstract formal rules, but that only experience with concrete cases can account for higher levels of performance'.

Dreyfus (2004) refined the model by Dreyfus and Dreyfus (1980) whose five phases were: novice, competent, proficient, and expert and mastery to beginner, superior learner, expertise, proficiency, and skill. The model was developed based on various functions of the mind including commitment, decision, perspective, and component, the variation of the components in the model. The learners' level of expertise increases as their level of expertise and continuum of five stages increases. People move via the five expertise phases to higher expertise levels by taking advantage of their problem-solving experiences through utilization of the mentioned four mental functions (Neill, 2016). The important components of the adult acquisition five-stage model are context and experience that can also be applied in the training of MLS students.

The first step in real practice requires the reduction of the problem into minute manageable chunks that the learner can solve without knowing the entire condition. The learner relates rules and facts more with situation in the afterward stages, which can be relied upon for the application of the future. Finally, the learner states using diagnostic approaches by considering the past experiences such as taking into consideration the reactions related to emotions to help with decision-making process regarding the significant instances (Neill, 2016). The last stage makes the person to view the steps to getting the solution as well as foreseeing the solution devoid of engaging in analytical process. The learner is thus, completely absorbed in the process of identifying the instance, steps to take to decide on the best solution, and the results that should be achieved.

Neill (2016) and Carraccio, et al., (2008) has applied the model. The researcher herein also applies the model to help with examining the development of competencies and skills of learning in the larger medical education field. Specifically, the model applies to the simulation-based teaching and learning in medical laboratory education.

The study by Owen, (2017) concluded on Kolb's experiential learning model by reporting that this model identifies tangible experience as the major trigger for learning as the learner transacts with the simulation-based activity, engages in reflection, and develops abstract conceptualization, leading to critical manifestation and active testing. Individual and subjective experience as well as environmental and objective experience works together in a multifaceted way to promote learning. Owen's report further concludes that simulation provides a sensed experience based on situations. At the same time, the simulation experiences provide instances where learners can reflect and form abstract concepts that are representative and lead to active testing (Owen, 2017).

Even though critics indicate that Kolb's reflective oversimplifies learning and lacks effectiveness evidence, its application in simulation has been large. (https://crowjack.com/blog/strategy/reflection-models/kolb-reflective-cycle) As such this study, (International Journal of Current Aspects, ISSN 2616-6976, Volume 2, issue 5, 2018, pp. 12-28)., applies it.

In order to enhance the validity of this research, and make it more authoritative, the study was anchored on the above theoretical framework, as well as the following philosophical paradigm, and conceptual framework.

1.11.2 Philosophical Paradigm for the Study

The philosophical paradigm is the framework that one's research is based on. It offers a pattern of beliefs and understandings from which the theories and practices of the research project operate. The Researchers' approaches are influenced by their worldviews which comprise beliefs and philosophical assumptions about the nature of the world and how it can be understood (Gaba & Lincoln, 1994). Research paradigms consist of four philosophical elements: axiology, ontology, epistemology, and methodology, which inform the design and conduct of any research project. The researcher would have to consider the paradigms within which they would situate their work before designing the research (Creswell, 2013).

Ontology is the study of being and it describes how the researcher perceives reality and the nature of human engagement in the world (Scotland, 2012), epistemology is the study of knowledge and belief. It describes the ways knowledge about reality is acquired, understood, and utilized (Babbie, 2020), methodology is the strategy or action plan that informs the choice and use of particular methods within the context of a particular research paradigm. It refers to the study design, methods, and procedures employed in a well-planned investigation to find answers (Kivunja & Kuyini, 2017), axiology refers to the researcher's understanding of values and their role in research. It examines values, deals with issues of right and wrong and measures the level of development and types of perceptual biases (Gaba & Lincoln, 1994).

Epistemology, the branch of philosophy that deals with the study of knowledge and belief, and which describes the ways knowledge about reality is acquired, understood, and utilized, informs this study. In healthcare research, the epistemological stance which is the fundamental beliefs about knowledge and how it can be acquired, can be either of the following; positivism, interpretivism, critical theory, realism and pragmatism (Kivunja & Kuyini, 2017).

The epistemological stance that informed this study was realism, which is seen as the standard philosophical underpinning of mixed methods research. Realism is a philosophy which positions itself between positivism and constructivism. Positivism describes reality as fixed and our knowledge of that reality, which is neutral/value free, can be described by theories that are objective and generalizable. Positivist research aims to discover what exists through prediction and control using mainly quantitative methods with the researcher being an independent observer (Bunniss & Kelly, 2010).

Constructivism views reality and knowledge of that reality as not fixed but socially constructed and this knowledge has both multiple constructions and values. Constructivist researchers are active participants in the research and use both quantitative and qualitative methods (Illing, 2014). The realist view of knowledge is that there is a real world, and through our senses, brains and culture, we process our knowledge of it (Wong, et al., 2012). In relating this to the clinical environment, there is a real world of patients, signs and symptoms (positivism) and these are open to a variety of interpretations which depend on the complex interaction of external influences on the clinician (constructivism).

Realism seeks to answer the question ‘what works for whom, in what circumstances and why? (Pawson, 2013). In answering this question, the realist researcher seeks to identify, test and refine the components of an educational program that work as well as those that which do not work. The three fundamental components that realism philosophy seeks to investigate are context, mechanism and outcome. In other words, educational program work (successful outcome) when they provide appropriate opportunities or resources (mechanisms) to groups under appropriate conditions (context). This is known as the ‘context-mechanism-outcome (CMO) configuration

(Pawson & Tilley, 1997), and can be written as the formula *context* + *mechanism* = *outcome*. There is no set limit on the number of proposed CMO configurations that are constructed for the educational programme under investigation; the key element is the relationship within each CMO (Ogrinc & Batalden, 2009). The researcher gathers data in order to test the proposed CMO configurations.

Simulation is a complex educational intervention with multiple interacting components which can make it challenging to evaluate. However, realist philosophy may provide more useful information about its effectiveness than traditional models of educational philosophy (Moore, 2009). The guiding framework is the realist evaluation cycle which has four key steps (Pawson & Tilley, 1997): formulate a working theory, hypothesis, formulate the hypothetical CMO configurations, i.e. what *might* work for whom in what circumstances and why? Observations; test the theory by gathering data on the CMO configurations using a mixed methods approach (quantitative and qualitative data collection and analysis), program specification, reveals what did work for whom in what circumstances and why. This provides a refined theory which will inform future interventions and program evaluations. The process then continues in an iterative cycle.

Table 1: Proposed context-mechanism-outcome for the innovative simulation-based teaching and learning for final year medical laboratory students

Context		**Mechanism**	**Outcome(student)**
1	Final year medical laboratory students in their last few months of training.	Providing the opportunity to experience and explore the role of a newly qualified laboratory	To foster an understanding of the role of a newly qualified medical laboratory technologist.

		technologist in a simulated setting.	
2	Final year medical laboratory students who have extensive knowledge and laboratory experience but have not had the responsibility of analyzing sputum samples using culture method	Presenting a variety of realistic simulated medical and laboratory emergencies using a high-fidelity manikin.	To collect and analyze the sputum sample using a structured culture method approach.
3	The majority of students have observed the collection of arterial blood sample	Allowing the students to collect (as a team) arterial blood from a simulated actor patient.	To increase understanding of team work and communication.
4	The students have varying levels of confidence.	Providing immediate feedback and exploring the factors that influence when and why the students call for assistance.	To recognize personal limitations and when to call for help.

Adapted from Pawson & Tilley (1997).

The context reflects the reality into which an intervention is introduced and provides the conditions that trigger the mechanisms to produce the desired outcomes and requires that all elements that are relevant to the mechanisms be considered. Just as all social program are introduced into pre-existing social contexts, so simulation based educational programmes are introduced into pre-existing healthcare and or educational contexts. Therefore, researchers should not ignore the contexts of their programmes and to do so is regarded by Pawson and Tilley as one of the 'great omissions as seen in realists' evaluation research'

This epistemological stance is focused on the real and practical application of knowledge and the researchers who adopt a realistic stance aim to create research that is both theoretically sound and applicable to real-world settings (Creswell, et al., 2007). Realism is the view that knowledge is practical, functional and instrumental and is based on the assumption that there is no fixed or final truth, but rather provisional truths that work for specific purposes in specific situations (knowledge not fixed but socially constructed and this knowledge has both multiple constructions and values) (Legg & Hook-away, 2021). Realism states that there is a true reality and things exist whether humans perceive them or not. Real experience in the hospital is amplified with guided experiences in the simulation laboratories. Simulation-based learning is meant to replicate aspects of the real world in an interactive manner that allows learners to be immersed in the learning environment. Learners create their own reality and truth. To support this type of learning, activities include discussion, self-reflection, and questioning so that learners can engage actively in the learning process (Gaba, 2004).

This philosophy offers the researcher methodological descriptions and assistance in the development of techniques that are closer to what is in real practice. Also, the researcher is able to bring together the insights provided by positivists and constructivists' research into a workable solution (Onwuegbuzie & Leech, 2005). Because of its ability to offer logical and practical alternatives as well as its attempt to legitimize the use of multiple approaches in answering research questions, the researcher found it suitable for the research undertaken. Similarly, realism being a liberal system of philosophy and reality is an added advantage to mixed-method research which freely utilizes both quantitative and qualitative approaches. This study adopted a mixed-method approach. In essence, realism opens the door for mixed-method research to access multiple methods, different world views, and different assumptions as well as different forms of data collection and analysis (Creswell & Creswell, 2011).

The realist philosophy of science informs this study because it looks for the answers to the question "what works for medical laboratory students, in what circumstances and why?' It holds the view that knowledge acquired through senses is true and what we observe and perceives through our own senses is real and the true entity of the world. Real experiences are amplified with guided experiences as seen in innovative simulation-based teaching and learning (Maheshwari, 2016). The role of simulation is to interactively mimic the real-world happenings that immerse learners in the surrounding of their learning. Learners are able to develop their individual truth and reality through simulations (Aebersold, 2018).

1.12 Conceptual Framework

The environment of educational learning institution impacts all learners as Miles, et al, (2012) elucidates. The Dundee Ready Education Environment Measure (DREEM) was published in 1997 with the aim of evaluating educational environments of medical schools and other health training settings. The goal of medical education as explained by the above tool is to develop MLS graduates with the necessary knowledge, clinical skills and professional attributes to be successful healthcare professionals. To a certain extent, a medical laboratory scientist level of competence reflects the educational institution they attended and the medical education they received. Therefore, it is vital to appraise the educational environment in which medical lab students learn, including the institutional culture, curriculum, staff competence level and learning climate. Meaningful learning correlates positively with students' perceptions of their educational environment, as this can influence how, why and what students learn (Mayya and Roff, 2004). When the environment of learning, innovation and continuous improvement are taken into account, teaching in medical schools becomes effective (Miles, 2018). The activities that take place between the learner and the teacher constitute the learning environment (Lai, et al., 2009). Curriculum impacts the environment of learning, which Harden (2001), defines as all that is needed for learning to be effective. A study by Jamaia (2008), found a relationship between educational environment and satisfaction, success, and achievement of learners. The mentioned correlation encourages researchers to use this. (adapted from the DREEM model)

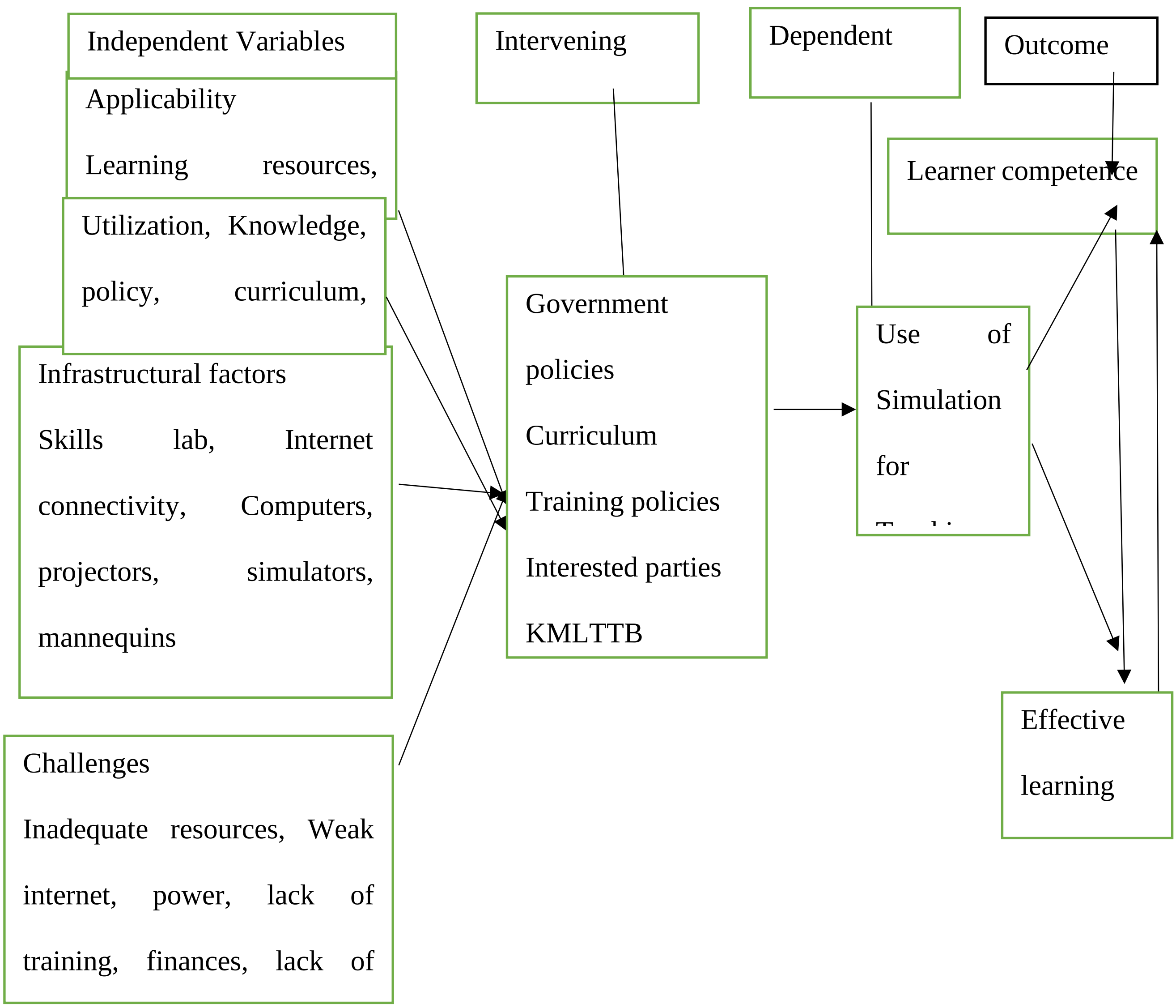

Figure 1: Conceptual framework Source: Lai, et al, (2009).

In this study, several types of variables were used as shown in the diagram above. Eaves (2010) defined a variable as an attribute that a study explores. The independent variables were defined by Gurmu (2011), as those attributes which are thought to influence the dependent variable. In this study independent variables include: Applicability which included learning resources and learning environment; Utilization which included knowledge, policy, curriculum and environment: Infrastructural factors which included skills laboratory, internet connectivity, computers, projectors, simulators and mannequins, Staff training. Challenges which included inadequate resources, weak internet, power, lack of training, finances, lack of support staff, technical/operational challenges. Dependent variable: Use of simulation for teaching and learning. Intervening variables: Government policies: Curriculum, Training policies. Interested parties: KMLTTB (Qualifying body). The outcome of the whole process is learner competence resulting from effective learning.

1.13 Chapter Summary

This chapter introduced the study by discussing the background, the statement of the problem, the objectives of the study both general and specific, the research questions, significance of the study, the justification of the study, scope of the study, assumption of the study, limitations of the study, theoretical framework, philosophical paradigm of the study, conceptual framework the input the study makes to the literature with the main concentration on the utilization of simulation in medical laboratory science education.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview

This chapter reviews empirical and theoretical literature related to the stated objectives outlined in chapter one. It was aimed at establishing the existing knowledge gaps in this area of study. It also looked at the published information about simulation as a learning strategy. The review has been done as a portion of the current study on the use of simulation for teaching and learning in selected KMTC Campuses offering medical laboratory sciences in Kenya.

The literature is discussed under the global historical overview of implementation and conduction of simulation laboratory sessions for their teaching and learning, opportunities for simulation use in teaching and learning, factors influencing the use of simulation in teaching and learning, perspectives and challenges affecting the use of simulation in teaching and learning in relation to similar studies. This chapter provides a scholarly analysis of both general and specific literature related to this study.

2.2 Global Historical overview on the use of simulation in Teaching and Learning

Simulation in its simplest form is the use of imagination to reproduce or imitate that which is real. The definition of simulation-based learning entails an imitation of the reality to help with understanding, changing, or predicting real behavior in a better way (Davis, 2007). Simulation-based teaching and learning is an educational and training method that is used to replace or amplify the real experience with guided experiences (Aebersold, 2018). Simulations can be seen as the instructional scenarios where the learner is placed in a "world" defined by the facilitator to represent a reality within which the learners interact and learn. The facilitator manipulates the parameters of this "world" and uses the same to help students achieve the learning outcomes. The students experience the reality of the scenario and gather meaning from it (https://www.teaching.unsw.edu.au/simulations).

A simulation can be considered a form of experiential learning that fits well with the principles of student-centered learning and constructivist learning and teaching, the learning and teaching that gives students power over what they learn and how they learn it, and that allows students to build on their understanding of what they're learning through their experiences and interactions, rather than just passively receiving information (Wiggins, 2016).

This is an educational approach that is grounded in learning theories and is meant to replicate aspects of the real world in an interactive manner that allows learners to be involved in the learning environment (Gaba, 2004). Various forms of simulations in the literature regarding health are in the form of interactions involving mannequins or plastic body parts, computer-based learning modules, standardized patients, demonstrations, case studies, video tapes, role-play, online activities, and virtual reality applications (Grant, 2007).

Mannequins or plastic body parts is majorly utilized by health care industry to educate learners as indicated by the responses from 80% participants surveyed. Task-specific trainers are also used by 80% of participants as shown by the survey. Standardized patients (actors) account for 62% use. Case reports problem-based learning is utilized by 60% of participants surveyed, virtual environments account for 57%, while flat screen computers cover 57% use (Davis, 2007).

Simulations are characterized by their non-linear nature and by their deliberate ambiguity, which encourages students to think independently as they make decisions.

The inventiveness and commitment of the participants usually determine the success of a simulation (Wiggins, 2016).

Historically, in the nursing education, simulations were used primarily to teach nursing skills and the first mannequin, was named Mrs. Chase, a life-size doll, that was built in 1911 by Martha Jenkins Chase, to train nurses on how to dress, turn, and transfer patients (Aebersold, 2016). Nursing students were also practicing on each other by using various training devices to learn how to administer injections, insert a nasogastric tube, and other basic nursing skills (Nickerson & Pollard, 2010).

A study done by Gaba (2004) reported a significant change in the world of educational simulation that took place in 1990 where companies, such as Laerdal and Medical Education Technologies, Inc. (METI), got an opportunity to developed affordable, high-fidelity simulators for use in teaching and learning. This enabled nursing education to move from a traditional skills laboratory into the world of high-fidelity simulation.

The purpose of simulation-based medical teaching and learning was to support the gaining, preservation and improvement of the clinical skills that health care learners gain. Also, to help students learn both concepts and how to apply them in a nuanced way in an unforeseen situation (Norman, 2018). Medical students who often use simulation finds them more deeply engaging than other activities, as they experience the activity first-hand. Simulations have been advocated for preparing practitioners for unforeseen events (Gaba, 2004); for continuing education and re-credentialing (Van-Kerkhove et al., 2010).

Simulation-based learning is commonly viewed as a way of preparing learners for the clinical surrounding they will encounter and a way of assessing deficiencies (Issenberg, et al., 2005; Kneebone, Nestel, & London 2005).

Simulations also help students in other professional fields apart from medical field to appreciate more deeply the management of the environment, politics, community and culture. Students by participating in a resource distribution activity, might gain an understanding of inequality in society, simulations can reinforce other skills indirectly, such as debating, research skills, and also for enabling students to effectively use and reinforce theoretical knowledge through observation and application of the knowledge obtained (Tüysüz, 2010).

Simulated activities feel real, enables the student to engage with the activity more interactively and enthusiastically, and because they are open-ended, they encourage students contemplate the implications of a scenario, hence promoting the use of critical and evaluative thinking (https://www.teaching.unsw.edu.au/simulations#).

Simulation-based teaching is very key in nursing education and has become its cornerstone (Aebersold, 2018), hence it is important to understand the benefits and policy implications of this shift in medical laboratory science education (Grant, 2007).

In a medical institution, facilitators design simulations around a set of learning objectives which are developed into simulation scenarios, for their students to be engaged in. The following is contained in a simulation scenario; the learning objective, the patient information (background, current condition, medications, and other relevant information), actor scripts as needed, information for the high-fidelity simulator, a timeline for the unfolding of the scenario, cues needed by the facilitator to help the action flow along, as well as other essential information to ensure that the simulation-based learning education experience is successful (Aebersold, 2018).

Mannequins and information technology, simulated patients, and patient volunteers are implemented within the mentioned surrounding that is not risky (Norman, 2018). In this way, the skills laboratories where the simulations mostly take place, provides learners with the required opportunities of gaining knowledge and relevant assessment and feedback prior to them practicing in the real world (Carmichael, & McCall, 2008).

Laboratory medicine, more than any other field of healthcare has witnessed advances and revolutionary growth in new technologies in the recent past. Also, the current upsurge in emerging and re-emerging infectious diseases, HIV/AIDS, have forced a major paradigm shift in the practice of laboratory medicine, emphasizing efficient and effective laboratory services (Donkin, Askew, & Stevenson, 2019).

There is a felt need to re-equip and transform the laboratory professionals with new methods for the future, through training. Some of the new skills set among others, include simulations learning, the increasing use of laboratory information management system for decision making, flagging, assisting and managing of medical data (Gemuhay, et al., 2019).

Simulation-based education which is a more learner-centered approach, and grounded in learning theories based on constructivism, helps the learners create their own reality and truth. Activities that support this type of learning include discussion, self-reflection, and questioning so that the learners can engage actively in the learning process (Kriz, 2010).

Kolb’s Experiential Learning which is most often used to guide and develop SBEs has four steps (concrete experience, reflective observation, abstract conceptualization, and active experimentation) (Aebersold, 2018).

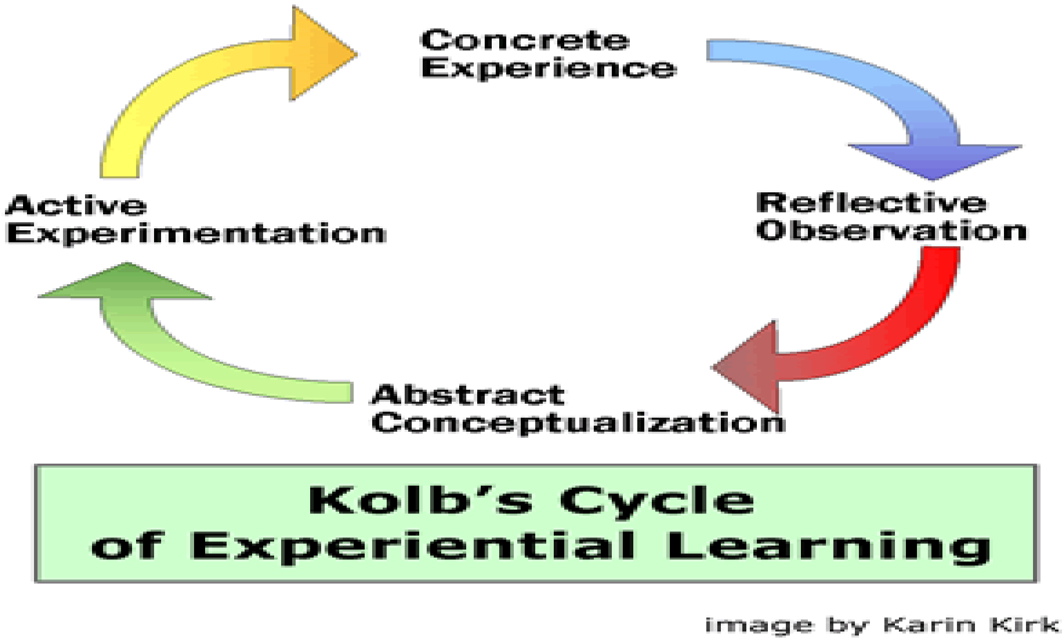

Figure 2: Experiential Learning (Adapted from Owen, (2017)

These steps form a continuous cycle when the theory is applied in SBEs. Concrete experimentation occurs initially when learners engage in a simulation scenario, such as caring for a simulated patient (i.e., a high-fidelity mannequin) who is experiencing a stroke. After the scenario ends, students engage in reflective observation as they debrief and reflect on their performance during the simulation and identify any gaps (Aebersold, 2018). In abstract conceptualization, the facilitator helps learners create or adapt their mental model to incorporate what they have learned in the above scenario. This is where learning is applied and knowledge is transferred into practice when the next opportunity arises. In the active experimentation step, the learners put newly gained mental models into practice (Zigmont, Kappus, &Sudikoff, 2011).

Jeffries, Rodgers, & Adamson, (2015) also discussed yet another additional theory; the NLN/Jefferies Simulation. This theory evolved from the NLN/Jefferies model that talks about context, background, and simulation design characteristics. The simulation elements in this theory led to better experiences such as dynamic interactions between the facilitator and the learner by using the right educational strategies. The system, patient, and participant gave better outcomes (Aebersold, 2018).

For medical laboratory science (MLS) programs, the key elements to positive learning outcomes are the motivation and enthusiasm of students. The two are developed through laboratory simulations rather than the traditional methods of learning where the students are passive learners. In a simulated environment, the learner has an opportunity of controlling the mode and pace of the teaching and learning experience (Conway-Klaassen, et al., 2012).

Medical simulation allows the acquisition of clinical skills through deliberate practice rather than an apprentice style of learning. Experimental and conceptual learning are integrated in that, you do an experiment and then you jump into the equipment and see how the molecules have been affected. There is bridging the gap between the conceptual and the experimental learning (Castillo, 2012). In this way, students can identify bacteria using a microscope and have that bacterium zoomed up for further examination.

In the real clinical laboratory, experiments are only conducted once in a limited time frame, owing to the availability of patient’s samples and working equipment, unlike the simulated environment where the experiment which rarely suffer challenges can be repeated until understanding and learning goals are reached (Bonde, et al., 2014). As a result, simulation increases not only learning outcomes but also students’ motivation and confidence.

Simulation tools serve as an alternative to real patients. One can teach science through virtual reality. For example, carrying out an analysis involving aerosols production can be performed without fear in the virtual laboratory. These laboratories allow the students to be aware of possible consequences arising if they skip or perform incorrectly or incompletely a step in the process. Students acquire competency and are able to prevent errors at any stage while working in a real practical laboratory, performing a similar experiment (Vries & May, 2019). This will make the students more engaged and more confident when they go to physical laboratories. The student trainees can make mistakes and learn from them without the fear of harming the patient because they are not distracted while in virtual laboratories unlike physical ones (Hartfield, 2013).

Historically, animals were used in the training of surgical skills since the Middle Ages throughout modern times (Cooper & Taqueti, 2008). An obstetrical mannequin made of a human pelvis and a dead baby was developed in the USA in the 18th century. This mannequin enabled obstetricians to teach delivery techniques which resulted in a reduction of maternal and infant mortality rates (Rosen, 2008). While 71% of American medical schools in 1999 were using some form of manikin or simulator to teach anesthesia skills to medical students (Morgan and Cleave-Hogg, 2002) and one-third of US medical schools were using human patient simulators by 2003 (Good, 2003), the cost of setting up and maintaining such simulation facilities was prohibitively expensive and beyond the reach of most health science training centers in the developing world (Wennberg, Fisher, & Skinner, 2002).

Patient actors (standardized patients) were used in medical schools in India to teach clinical skills to medical, nursing, and patient actor’s students. Virtual simulators give students, faculty, and medical providers leading-edge tools to investigate and adapt to the advancement in medical training (Aggarwal, et al., 2016). The major hindrance to the development of simulation-based healthcare training in China is resources related to healthcare simulation, like textbooks and published papers, which are relatively few (Li, et al., 2019). The Israel Center for Medical Simulation was established in 2001 in order to lead a nationwide effort to introduce new standards and innovative approaches to health care training and patient-safety education for the benefit of the people of Israel (Ziv, et al., 2006).

In Malawi, simulated learning experiences have been affected by an acute shortage of training instructors, skills labs, and a gross lack of supplies necessary for simulation. These problems negatively impact both clinical teaching and learning (Msiska, Smith, & Fawcett, 2014), and the learners will not be able to perfect their skills because they are not ganging themselves with a previous simulation experience. Beginning students lack manual dexterity and they attain this through regular practice on real patients which can result in undocumented medical errors. (Courtney-Pratt, et al.; 2012; Killam & Heerschap, 2013).

A study carried out by Yaya et al., (2014), found that a maternal mortality ratio of 425 per 100,000 live births and a neonatal mortality ratio of 27 per 1000 live births were recorded in southwest Ethiopia. The MOH in Ethiopia suggested that the midwifery skills of health workers could be upgraded to a safe level through short in-service training which was associated with improved pregnancy outcomes. Thus, there was a need to strengthen the training for SBAs in Ethiopia and build the capacity of healthcare providers to recognize and manage emergency obstetric problems during pregnancy, childbirth, and the postpartum period. They chose to start using the simulation-based training model where the learner is immersed in realistic situations, has the advantage of increasing the frequency of clinical experiences without training on real patients and enables repetitive practice. This has finally demonstrated improvement in the management of emergency obstetric care in Ethiopia.

The simulation lab established in Kijabe mission hospital, Kenya, was aimed at improving Perioperative Anesthesia Care Training in Africa (ImPACT Africa) (https://news.vumc.org/2015/03/05/kenyan-team-trains-in-health-care-simulation-at-vumc/). The University of Nairobi medical school in collaboration with Partnership for Innovative Medical Education in Kenya (prime-k), have constructed a skills laboratory infrastructure that is now fully operational to facilitate faculty training in skills assessment. (https://nursing.uonbi.ac.ke/sites/default/files/chs/nursing/nursing/Clinical%20Skills%20Laboratory%20Development_1.pdf).

A formative evaluation of Simulation-based Training conducted in Pakistan, Tanzania, and Kenya, showed high satisfaction and self-efficacy rating among the participants (Joho et al., 2018) indicating that the strategy was excellent for use in training. Kimeu & Oyucho, (2012) reported that Capacity Kenya, a Non- Governmental Organization, offered a helping hand for the purposes of upgrading the skills laboratory where state of art teaching tools were installed at Kenya Medical Training College, Kitui Campus to improve instructional methods and advance family planning and reproductive skills for the students

According to Jha, et al., (2013), unsafe and harmful health care practices are a major source of morbidity and mortality. World Health Organization (2014), estimates that millions of patients are harmed each year due to unsafe medical practices. The medical errors in many healthcare settings result in either temporary or permanent injuries as well as an increased length of hospitalization or in extreme cases, the death and disability of the patients.

Traditional surgical education is resource-intensive but slowly building surgical competence through trial and error by practicing solely on patients is risky and maximizing patient safety and reducing surgical errors must be prioritized (Martinerie, et al., 2018). Simulation-based education can help address this training need, especially in low-income settings where the disease magnitude is greatest. It is perceived that healthcare students requires clinical learning like never before, and therefore, the idea of using simulations and digital laboratories to complement physical laboratories is to provide training of novel laboratory techniques to students despite the concern of cost, time, and safety issues (Cheung, et al., 2023).

Initially, medical laboratory students were taught theoretical knowledge, to provide them with a foundation that contributes to learning during clinical placements (Warne, et al., 2010), because this helps to develop confidence and competence in these students so as to offer the required services by the health care facilities (Phuma-Ngaiyaye, et al., 2017). In their study, Kapucu & Bulut, (2011) reported that clinical learning practice (clinical setting, clinical staff, patients and their families) gives better abilities in problem-solving, affective, cognitive and psychomotor domains which finally helps the students provide safe and quality patient care.

However, it is very difficult to control conditions present in clinical environments, hence learning objectives may not be successful because students may be confronted with a range of issues, such as difficulties in using medical equipment, managing sudden changes in patients' conditions, dealing with the demands of patients' relatives, maintaining good relationships with clinical staff and instructors, possible criticism from peers, fear of making mistakes, and the negative attitudes and expectations of clinical staff (Kapucu & Bulut, 2011).

A study by Gemuhay, et al., (2019), further reported that negative criticism, limited opportunities for practice, shortage of clinical staff and clinical instructors, and the number of students can affect negatively the performance of students. Ahmad & Anwar, 2018; and Meyer, et al., 2016; had foreseen anxiety and stress among students while in the clinical environment which may result to negative feeling. The effects of stress may result to reduced critical thinking, poor academic performance as well as negative impacts on their professional lives in the future.

A solution to these challenges brought about by the real clinical practice is the use of simulations whose purpose is to prepare students for physical laboratories in safe environments (Santos & Prudente, 2022).

Medical laboratory science students become medical detectives, investigating and determining the presence of a disease process, monitoring response to therapy and aiding in health maintenance causing their knowledge, skills, and attitude acquisition to be taken seriously (Klimas, & Cullen, 2020). Medical laboratory education programs have started adopting simulation in both undergraduate and postgraduate curricula because they have noted that preparing a good course design as well as course content which has a student-centered aspect will increase student engagement and to improve learning outcomes (Davis, Bates, Ellis & Roberts, 2014).

Again, the use of computer-based and gamified applications may provide unlimited training facilities in many methodologies and techniques such as fermentation, spectrometry, PCR, HPLC, Crispr-Cas9, and next-generation sequencing which may contribute to improved learning outcomes also (Blackburn, Villa-Marcos & Williams, 2018). Other reasons cited for this shift include the changes in healthcare delivery, lack of objectivity of clinical examinations (Cleland, Abe, & Rethans, 2009), limited clinical placement positions and the potential of simulation to improve clinical learning (Alinier, Hunt, & Gordon, 2004).

The situations that mimic a clinical setting are referred to as simulations. These are also known as the procedures used in health-care education by students in order to learn the technical skills and competency required for health care (Okuda, et al., 2009), video assisted feedback is an example of such a procedure which is used to capture a 'point of view' recording of the student's attempt to perform a laboratory procedure. Video recording requires minimal operative knowledge and the end product does not require high cognitive load or skills in information literacy to extract and assess the learning objective. This recording allows the student to receive feedback and improve skills while also providing a comparison between how the learner perceives their performance to that given by the expert (Nyström, Pålsson, Hofsten & Häggström, 2014)

The factors thought of motivating and driving the need to apply simulations in the training of healthcare students include desire for patient safety, quality in patient care, safety and hazard avoidance, knowledge of techniques and use of equipment; confidence in performing the procedures without reliance on notes; knowledge as to why and how the technique is performed and the quality of the final product (https://bmchealthservres.biomedcentral.com/articles/10.1186/s12913-022-07467-8).
in the United States and Europe, "See one, do one, and teach one" has been proposed as the principle of clinical practice (Vozenilek, et al., 2004), SBME is an educational tool that is located between "See one" and "Do one", it is a step between a real

laboratory and theory hands-on experience. In this view, virtual labs give the students a little bit of hands-on experience, they are less intimidated when they go to the laboratory, they kind of know what they are already doing and it helps them learn the theory better because they can understand why it is important for a laboratory.

There is growing concerns on how to address pressing issues surrounding medical laboratory education. Some of these issues include limited budgets for equipping the real laboratories, limited laboratory times for the students to learn in the laboratories, a desire to provide equal access for all students with these limited budgets, and review of the training curriculum to incorporate changes in health care delivery (Heuertz, 2011). The MLS curriculum should focus among other aspects, on community-oriented health care with an emphasis on student participation. It should be designed to accommodate the modern education of health professionals that is based on the information revolution (Thompson, & Lowrie, 2017). As a result of this, simulation-based learning has been proposed as a method to bridge the educational gap between conceptual and experimental learning (Heuertz, 2011).

Simulation-Based Medical Education (SBME) can be used not only for the learning of cognitive domains such as knowledge but also for learning the affective domain, for example, communication training of the session with simulated patients. Numerous reports support the introduction of simulation-based medical education as an important step in curriculum development (Al-Elq 2010), especially in training of high-risk disciplines such as resuscitation, airway management, procedural training, trauma, disaster management, mental health, end-of-life care, mass causality situations, anatomy, and interdisciplinary communication (virtual simulation) (Weinberg, Auerbach, & Shah2009).

Virtual lab simulations are being increasingly used to enhance the development of professional skills in various fields, such as healthcare and education, including courses in chemistry biotechnology, and medical genetics. Virtual learning simulations have also been applied to organs virtual dissections, and human patient simulators. The advantages of virtual laboratory simulations include cost-effectiveness, increased engagement of students with learning materials, and elimination of bio-safety concerns. They also allow students to observe otherwise unobservable phenomena by reducing the time required to conduct experiments which require more time if conducted physically.

Learning through simulations provides students an opportunity to engage in inquiry-based learning that enables them to gain conceptual knowledge independently. Simulations also motivate and challenge students by providing continuous feedback in an environment that is tailored to their interests and learning needs (Thisgaard & Makransky, 2017). Positive results in relation to enhancing knowledge, skills, and attitude toward technology-enhanced simulation have been reported in many studies (Weller, et. al., 2012).

In medical education, plastic model for partial task training; Mannequin-type simulators; Dummy type; High-fidelity type; Screen-based virtual-reality simulators; Live or inert animals including isolated organs; Human cadavers for surgical skill training and Simulated or standardized patients as well as student-patient actors on students who are adequately trained to play the role of a patient actor are some of the educational resources used in simulation (Davis 2007).

Partial task trainers acquire partial task training skills by use of plastic model that are not controlled by computer. They use these models to teach basic clinical skills. These include models for teaching diagnostic procedures with shame for patients, such as examination and collection of samples from the rectum, breast or vagina, and non-invasive or invasive clinical procedures, such as suture and ligation of skin, inserting a catheter into the stomach and bladder, catheterization into a peripheral or central vein, and lumbar puncture. They are often believed to be only for personal task training. However, they can also be utilized for training in teamwork or communication with patients by using them in a simulated clinical situation such as an emergency, examination room, or phlebotomy room (Ruddy & Patterson, 2008).

2.3 Appraising the institutions' ability to use simulation laboratory sessions for their teaching and learning

The training of medical laboratory science program previously took place in the physical laboratory classroom where the trainers assisted students through physical interaction. This method of teaching has been challenging and unsustainable and in recent years, it has encouraged innovation in online blended learning. For example, in their institution, Donkin and colleagues taught history lessons through the use of blended learning, which entailed e-learning as well as face-to-face formats. The main content of the lesson included technical processes and morphology (Donkin, et al., 2019), and once evaluation of this innovative teaching method was done, results reviewed that students who participated in the online video format scored better in practical than the control group.

The use of innovative simulation-based teaching and learning strategies became a necessity for the development of medical education in the last years because of the poor performance of most of the medical graduates especially in the clinical skills performance and application of knowledge and problem-solving in critical situations

(Elshama, 2015). Medical students and doctors should be exposed to live patients so that they can acquire the necessary skills. On the other hand, they are also obliged to provide optimal treatment and to ensure patients' safety and well-being.

These becomes two competing needs which can pose a dilemma in medical education. Patient care is becoming more complex which requires medical students to master not only knowledge and procedural skills but also, the ability to effectively communicate with patients, relatives, and other health care providers and coordinate a variety of patient care activities. Healthcare workers need to be good team players and their training programs must systematically inculcate these skills. Simulation has been applied to many different disciplines and type of trainees which include; aviation industry, anesthesiology and the military. It helps to mitigate errors and maintain a culture of safety, especially in these industries where there is zero tolerance for any deviation from the set standards (Jha, Duncan & Bates, 2001).

A study by Webb et al, (2022) reported that traditional methods of learning observed in medical laboratory science training institutions are characterized by inadequate opportunities for practical learning. Lecturers believe that practical learning is not up to par owing to limited time, inadequate demonstrations for skill training, challenges in staff shortages, and insufficient exposure to extensive manual bench work. The students are dissatisfied with the reliance on reading manuals for practical learning, emphasizing that "the experience that you get from hands-on practice is not something that can be replicated by reading books. Also, staff shortages impede their bench-side learning, observing manual bench work due to time constraints: "if our work starts from day 1 for DNA extraction, so first we send PCR, then we send post PCR, then we run electrophoresis. Therefore, if we only have a rotation of 2 days on that bench, we can only see extraction and PCR and not the rest of the process."

A study by Seropian, et al., (2004), reported that issues relating to patient safety and related ethical issues are the major reasons for the implementation of simulations for teaching health professionals. Simulation was mostly used in the training of medical students for emergency room training, anesthesia crisis management, residents in trauma rotations, and first responders for cardiac care (Seropian, Brown, Gavilanes, & Driggers, 2004). Therefore, simulation-based learning is considered an essential part of practical learning. It is an active learning process; it should be involved besides the other teaching methods in medical schools to overcome the problems of using the real patient in the teaching such as his ethical and legal rights, and the lack of critical events that are a source of learning and acquiring of different skills.

Simulation-based medical laboratory education has become a common trend in modern medical education in different medical institutions around the world as a method for development and innovation in the medical curriculum. Simulation-Based Learning provides a controlled, virtual, simulated, and clinical laboratory environment that allows integration of the theory with hands-on skills for practice and mastering the skills, and assessing the applied skills (Datta, Upadhyay & Jaideep, 2012).

This study desired to establish whether KMTC campuses offering medical laboratory program implemented and conducted simulation laboratories for their teaching and learning, considering that in the 21st century, both patients and diseases have changed (Thompson, & Lowrie, 2017). The change has been brought about by factors such as population diversity and the emergence of new, chronic, and lifestyle diseases (Klimas,

& Cullen, 2020). There have also been some changes in healthcare access. These changes including those in the area of technology are of great concern.

Simulation-based learning is an ideal way of prepare all medical students for the real clinical practical site and also as a means of evaluating clinical incompetence. The features considered to be essential for the implementation of relevant simulations include, foundations in educational theory, curricular flexibility and integration, resource support, relevance to practice and appropriate staff development (Grant, 2007).

Simulation-based learning is characterized by pedagogical strategies, technology, task complexity, and task breadth that prepare the students for work in a clinical laboratory with workload and workflow. Before carrying out simulations, the following should be taken into consideration the physical environment, purposes of the tasks, the skills being taught, the characteristics of the participants, and the nature of the learning activities (Fanning & Gaba, 2007). When developing an educational curriculum to accommodate simulation-based learning, the construction of the medical simulation lab should be on a sound foundation with different scientific and logistic aspects that should be considered such as administration, design, technology, instruction, facilitation, and evaluation (Cook, et al., 2013).

Other aspects such as resources, types, applications, and evaluation of simulations should be put into consideration (Loyd, & Greenberg, 2004). It is also important to consider the essential features of simulation-based learning which to a large extend include; defined outcomes or benchmarks feedback, curriculum integration, repetitive practice, range of difficulty levels, multiple learning strategies, individualized learning, representation of clinical variation, and simulator validity (Barry-Isenberg, et al., 2005).

In the process of designing simulations, care should be taken to include guided experiences, instructional features, diagnostic feedback, performance measurement, and a relevant match to the environment being simulated (Salas & Burke, 2002).

Students from University of the Sunshine Coast, Queensland, Australia, in the department of medical laboratory science independently performed histology techniques which included: embedding and mounting samples into paraffin wax and microtome- sectioning tissue samples on a microtome (Donkin, Askew, & Stevenson, 2019).

To supplement their learning, students were provided with several online resources which included online web-based resources and student activities (quizzes, short answer questions, annotated morphology pictures); 24-hour access to virtual slides (e.g., annotated moveable online tissue sections); online tutorial feedback provided by an expert in histology; interactive online learning modules (e-Learning); and expert-led video demonstrations in the histology laboratory. The study showed that a blended learning approach that combines traditional hands-on learning with simulation-based educational technology enhances learning in the laboratory and has benefits for both the student and the academic. Online learning experiences are effective alternatives when the hands-on approach is too complex for early learners, expensive, or inaccessible due to laboratory constraints, or the activity is too time-consuming to complete in the laboratory (Donkin, Askew, & Stevenson, 2019).

In their study on “A Scoping Review of Medical Laboratory Science and Simulation” Webb et al., (2022) concluded that students are more engaged and more motivated when being taught in a blended learning format. They also respond positively to the use of video recordings with expert feedback for the initial learning of hands-on techniques.

Donkin et al., (2019) advised that the academic staff in the Department of Medical Laboratory Sciences should develop a blended learning medical laboratory science program, which includes annotated virtual microscopy, video demonstrations, low fidelity simulations, and online interactive e-Learning activities, which provides an effective and economical approach to learning and teaching.

Although the acquisition of appropriate clinical skills is key to health education, the present curriculum followed in many medical schools is mainly discipline based and knowledge intensive leading to information overload on students with less attention on skills required for the tasks they are expected to perform as healthcare professionals (Lateef, 2008), thus, students most of the time complete their educational programs armed with theoretical knowledge but have inadequate clinical skills vital for their work and hence the graduates produced by this system are not job-ready.

Medical Council of India booklet has indicated that India is moving toward attaining outcomes expected of Indian medical graduates hence improving patient care and management (Aggarwal et al. 2016), because a major challenge for medical undergraduates is the application of theoretical knowledge to the management of patients.

It is in this context that the need for Simulation-Based Medical Education (SBME) and the role that it plays to achieve the graduate outcome competencies needs to be understood better. In addition, after one is convinced about its need and its role, it is important to know what must be done to ensure and maximize the educational benefits of SBME. The type of simulation used and the level of realism needed must be based on the type of thinking processes to be fostered and the extent to which a learning environment must mimic reality and how closely a simulation imitates reality (its ‘fidelity’) is an important consideration (csmls_simulations_final_report) therefore, calls for a change in the instructional methods have resulted in innovative medical curricula of which many are in use today.

SBME includes the use of simulated patient actors (Barrows, 1968) who act like real patients to help mimic a clinical encounter so as to provide a safe learning environment for the learner to do deliberate practice of health-care skills so that it then becomes safe for the patient and for the learner to practice the skills on real patients (Cleland, Abe, & Rethans, 2009).

Simulation-based learning has been publicly recommended for preparing scientists and practitioners for anticipated events and continuing education. It is seen as the ideal way to prepare students for the clinical environment and as a means of evaluating clinical deficiencies (Akaike, et al., 2012). Simulations are used for teaching, research, and for product safety assessment. Some of the simulation strategies for simulation activities include: concept simulation using computer-based animations, virtual patient simulator to reproduce clinical scenarios, part-task training for procedural or psychomotor skills, high-fidelity patient simulations using computerized mannequins for simulating blood collection procedure (Lateef, 2008).

Some of the features essential for implementation of effective simulations include: relevance to practice, foundations in educational theory, curricular flexibility and integration, resource support and appropriate staff development (Davis, 2007).

Some of the driving forces behind use of simulations include: observation that the more complicated and/or invasive the procedure, various interests of stakeholders in health care, educational programs see in simulations an opportunity for improved learning and a competitive edge over other programs or a means of coping with declining clinical education opportunities for their students (Donkin, Askew & Stevenson, 2019). Other cited forces include the fact that professional and licensing associations push for improved practitioner performance, maintenance of competence in response to public pressure and government regulation (Thompson, & Lowrie, 2017).

Health care organizations aim to improve patient care and efficiency, reduce costs, and position themselves well in the health care market. Reduced costs are also sought by funders of medical care, in addition to reduced errors. Liability insurers want to reduce claims and the related payouts (Shih, Velan & Shulruf, 2017), and the fact that the governments are responding to public pressures to reduce costs, and minimize errors. The public advocates for improved patient care and safety, reduced 'training' on patients, and uniform competence and proficiency of health professionals (Klimas, & Cullen, 2020).

Simulation-based teaching modalities are being used in many US colleges and schools of medical laboratory sciences (Grant, 2007) and therefore, there is room for increasing the role of simulation for specific aspects and that it is necessary for colleges and schools of MLS to commit to simulation methodology as a necessary addition to the annual budget and/or to explore opportunities for inter-professional collaborations to share simulation resources. This may alleviate the biggest barrier to the use of simulation within MLS departments (Vyas, Bray & Wilson, 2013).

Simulation in undergraduate education has become one of the new policy areas to which leaders in both MLS education and practice will want to pay careful attention. As the medical laboratory technologist shortage increases due to lack of continuous employment, the number of faculty available to educate new medical laboratory technologists decreases. Also, the number and availability of clinical sites is diminishing (Aebersold, 2018), and hence, the need to rely increasingly on simulation to fill the gaps. In the US, one-third of the medical schools were using human patient simulators by 2003 (Good, 2003).

In Lesotho, simulation-based learning has been implemented to assist nurses and MLS students in learning and practice essential clinical skills. The Ministry of Health developed and equipped simulation laboratories across Lesotho and re-designed curricula, trained faculty in clinical simulation scenarios and student debriefing methods, and developed a plan for sustaining simulation-based education. It also developed and implemented monitoring tools, provided mentoring and supported continued faculty education research in clinical simulation. Through the nursing education partnership initiative, simulation laboratories at nursing schools and MLS departments in Lesotho, Zambia, Malawi, and Ethiopia were also developed (Michaels-Strasser, et al., 2021).

In Rwanda, benefits of simulation-based medical education in healthcare have been recognized in that a Centre for simulation for all the departments was established to address the challenge of shortage of clinical teachers and the importance of non-technical skills. This came about because most skills are difficult to teach in the demonstration labs, operating theatre or in a classroom, but comparatively easy with simulators (Livingston, et al., 2014).

Some nursing schools in Kenya have developed simulation Centre for student training. For instance, Kijabe Hospital through the improving perioperative and anesthesia care training in Africa developed simulation Centre to enhance training of nurse anesthetist through simulation. Capacity Kenya, supported Kenya Medical Training College Kitui campus to upgrade the skills laboratory by setting up teaching tools such as training simulators, mannequins, and other humanistic models to improve instructional methods and build skills for students in Family Planning/Reproductive Health (Kimeu & Oyucho, 2012).

The Kenya Medical Training College, Nairobi campus in partnership with the Ministry of Health and Gradian Health Systems, launched a Kshs 14 million simulation laboratory to train health workers for the country. The laboratory, the first of its kind in a public medical training institution, will help Kenya churn out critical care health workers needed in the fight against emerging diseases like the COVID-19 pandemic of which MLS is key when it comes to sample collection and analysis for the same. The laboratory also includes a classroom set up for lectures and debriefs as well as a full audio-visual suite that allows higher numbers of trainees to observe simulation scenarios as they are being performed, regardless of their location (https://kmtc.ac.ke/2022/kmtc-launches-kshs-14-million-simulation-laboratory/).

Simulation, as a valid and safe adjunct modality in healthcare education, is widely embraced by academic medical centers around the world. It provides a no-risk platform for learners, not only to acquaint themselves with and develop new skills, but also to refine and perfect their skills to achieve expertise and mastery. Simulation-based learning can be applied in MLS and other departments for the training of basic sample collection skills, specimen processing and analysis skills, procedural skills, normal labor management, and conduct of delivery, advanced life support, basic laparoscopic skills, neonatal and pediatric resuscitation skills, microsurgical skills, advanced laparoscopic skills, human patient simulator for anesthesia (Sweet & McDougall, 2008).

Simulation not only enables the trainees to bypass the early error-prone period and reduce the length of the learning curve (Preece, 2015) but also secures the safety of patients (Chin, et al., 2014). Simulation is being used to train and assess all of the domains that are linked to performance in healthcare, including technical and nontechnical skills for both individuals and healthcare teams.

Simulation allows for immersion into the scope of practice. Part of the value of simulation lies in providing hands-on training in the event of shortages or bottlenecks in clinical placements. Simulation is increasingly being considered across all health professions as a way of advancing a number of goals such as bridging the gap between the classroom and the clinic (between theory and practice), whereas there is an integration between basic and clinical sciences because the trainee should learn the related basic sciences to the skill before the starting point of the training session (Harder, 2010), allowing greater practice of skills in simulation before they are tried on real patients, supplementing education models in a way that helps with the clinical placement bottleneck and building innovative models of assessment of competence for practice (https://michener.ca/the-case-for-simulation/).

For a field that is facing personnel shortages due in part to low grade for the learners upon graduation from high school and clinical training challenges, embracing simulation to train more new Medical Laboratory Technologists (MLTs) is a potential game changer. For the national certifying body for MLTs and medical laboratory assistants, simulation may be an opportunity to address specific training needs and staffing shortages.

The application of simulation in medical laboratory science education has different positive impact aspects; it can provide a relaxed, safe and pedagogical environment that is conducive to acquiring good learning experiences and also provide a suitable atmosphere psychologically to make mistakes and its correction leads to reinforcing the quality of the learning environment.

The current medical education training system regarding the clinical care of patients in terms of history taking, physical examination, diagnosis, and management in medical schools has been reported to be inadequate by students even after graduation (Okuda, et al., 2009). Not seeing and practicing on a number of important diagnoses during training periods could pose a significant knowledge gap which eventually gets carried forward to internship and would eventually affect patient care

Medical laboratory errors emanate from the wide range of mechanical, chemical, biological, and environmental hazards that the laboratory practices involve. These errors affect the delivery of the services in the laboratory as well as the patient management either directly or indirectly. The cause of these errors could be as a result of the training given to the medical laboratory practitioners while in their training institutions (Da, 2010).

While some of the errors are caused by inadequate knowledge and skills among the medical laboratory personnel, others are caused by ineffective equipment used in the laboratories. The levels of training for the medical laboratory technicians/technologists also poses some concern (Herbst, et. al., 2008). The training as well as clinical and laboratory practice should be adequate enough to enable them handle complex tests in clinical laboratories and hence, they need to be equipped enough to reduce the errors to zero or the required levels. From the curriculum, the course is designed to take duration of three years distributed as follows: 3780 contact hours where 2100 hours spent on campus (Classroom theory/demonstrations/practical/skills-lab) and 1680 hours are spent on clinical placement. This time allocated for classroom and laboratory demonstrations needs to be increased to enable them learn necessary inter-professional skills and attitudes. The roles and functions of this cadre include; carrying out basic and complex laboratory tests, reporting and dispatching laboratory results, maintaining laboratory apparatus and equipment as well as managing a laboratory (http://kenyalaw.org:8181/exist/kenyalex/sublegview.xql?subleg=No.%2010%20of% 201999).

Some of the errors as documented include; incorrect patient identification, specimen rejection, proficiency test failure, phlebotomy dissatisfaction. Other errors occur as a result of work overload due to staff shortage caused by unemployment and presence of aged officers working in the laboratories (Karkaousos & Evangeloupos, 2011). These medical errors and inadequate confidence, can be witnessed during internship and senior clerkship (Norman, 2018). Newly employed nurses, medical laboratory technologists and clinical officers also found to have similar inadequacies (Okuda, et al, 2009), because the traditional hospital-based clinical instruction is observed not to always provide the same type of patients discussed in the classroom (Sheen, et al., 2021).

The study carried out by Sorensen et al, (2017), reported that outcomes of learning and levels of competence can be enhanced in medical laboratory science student through simulations. Even so, the closing learning phases needs learners to deal with real equipment and patients for competence acquisition.

Although simulation-based medical teaching and learning has been integrated in some of the curricula like in Clinical Medicine and nursing among others, its application is unclear, lacking or inadequate in the department of medical laboratory science education or there is lack in its documentation in literature, which could be because of absence of experts in educational technology who can develop platforms that can be implemented over the internet in case of virtual simulation, the time for technology development, and the training required for staff to easily adopt the technologies. Another reason could be lack of or undocumented scholarly work in this area (Bonde, et al., 2014).

There is need to enhance the medical laboratory science course curricular beyond laboratory skills and diagnostic interpretation competency. Incorporating simulation-based teaching and learning in the curricular presents an opportunity to train and produce medical laboratory scientists and technologists with the skill to communicate and work effectively in an inter-professional healthcare team (Sherwin, 2011).

Traditionally, a skill training such as inserting a catheter, or collecting venous blood was "see one, do one" which was associated with medical errors because of lack of enough exposure on the side of the students, even though by then, students were fewer. This scenario has been reported to be the same to date even with skills laboratory methodology having been introduced (Norman, 2018), and also to some extent, because improved health care systems and information technology have reduced the length of hospital stay for patients thus preventing students to have sufficient time to understudy a particular disease condition and care with real life patients.

The problem of associated medical errors has been increased by the very many students being trained currently versus constrained resources both human and otherwise (Durham, & Alden, 2008). Effective teaching strategies and innovative approaches are critical in producing a competent all-round health care worker in an ever-changing medical field. The use of simulation by computer and internet in skills training is moving in tandem with technology (Norman, 2018).

In the medical laboratory, the student examines the specimen for disease or cancer; provides information about the patient's state of health by testing for diseases and assist the medical practitioner with diagnosis, determination of blood levels of drugs for optimal therapy, tests to determine which antibiotics are the most effective against specific microorganism, tissue sections to determine whether malignancy is present (Rohr, et al., 2016). It is rewarding to see a patient's prognosis get better and hence simulation is advocated for, because it has the advantage of preparing medical students in a better way for their clinical surroundings as well as a method for assessing clinical deficiencies (Grant & Davis, 2007).

A study done by Davis, (2007) reported an alarming deficiency of published work about the use of innovative instructional approaches in the department of medical laboratory sciences and the reverse is the case for other health professions. Understanding that there is a patient at the end of each specimen and that patients' lives matter, hence, it is important to develop competent and qualified laboratory professionals (Nyström, Pålsson, Hofsten, & Häggström, 2014). Davis, (2007) further commented on the specific requirement that medical institutions to come up with an evidence base that enable effective implementation of a teaching and learning strategy based on innovative simulation.

Educators in medical institutions in Kenya need to come up with examples of simulated laboratory learning. For their efforts to be supported, curriculum review, which will incorporate in detail, the content for simulation in every unit is advocated for. This will justify the reasons for educational change in medical institutions as well as identifying directions for further research. The application of innovative Simulation-Based Medical teaching and learning in the medical laboratory science department has scarce documented information in literature hence the researcher's motivation in carrying out the present study. The construction of the evidence base in the application of innovative simulation-based teaching and learning is important for making decisions and developing policies regarding future prospects for medical laboratory education. This innovative teaching strategy can be a rewarding teaching and learning experience when supported with sufficient and appropriate resources (csmls_simulations_final_report).

2.4 Analyzing the educational opportunities brought about by using simulation for teaching and learning.

There is evidence of decreasing reliance on clinical partners and this appears to be a major factor in this shift to simulation-based learning by medical laboratory staff. This has brought in an opportunity for the educators to adopt and show interest in simulation-based learning experiences for their students although the Sim-Center is not intended to be used as a replacement for any clinical rotation (Van-Kerkhove, et al., 2010).

Medical laboratory professionals and educators recognize that simulation-based medical laboratory education can contribute considerably to improving medical care by boosting medical professionals' performance and enhancing patient safety. When developing growth-oriented medical laboratory staff, context is key. Application inside an interactive training environment allows learners to "act through" specific situations to learn. In most cases, hands-on learning gives educators the extra context needed to achieve terminal velocity when it comes to actual work. Most importantly, this hands-on learning is done in a safe, risk-free environment. While a mistake in an on-the-job training situation has real-world consequences on the healthcare system, mistakes and wrong answers in simulation-based teaching and learning are where learning and growth happen (Ziv, Ben-David & Ziv, 2005)

A central characteristic of simulation-based teaching and learning is its unique approach to making (and learning from) mistakes, which is regarded as a powerful educational experience and as an opportunity for professional improvement. Increased practice in learning from mistakes and in error management in a simulated environment will reduce occurrences of errors in real life and will provide professionals with the correct attitude and skills to cope competently with those mistakes that could not be prevented. Simulation is one of the key elements used in continuing education (Khanduja, et al., 2015), aiming to maintain and improve previously acquired skills in conditions similar to the ones present in real environments.

Simulation-based teaching and learning tools can be used to provide immediate feedback to both the educator and the student. When learning is still fresh, feedback, analysis, and debriefing create a real connection between the lecturer and the student. The best part of a simulation session is when feedback isn't delayed for "scoring" or "tabulation." Immediately understanding the "why" behind a right or wrong decision is vastly more valuable than a scorecard delivered days or weeks later. Immediate feedback and debriefing are a vital practice to avoid the effects of forgetting because the memory of learned knowledge begins to fade in a matter of days unless that knowledge is applied and reviewed again (Herrera-Aliaga, & Estrada, 2022).

A simulation-based training program allows administrators to assess and gather a baseline of critical soft skills. The built-in assessment tools also allow teaching staff to increase overall self-awareness of soft skills by comparing their perceived competency with their actual performance. The ability of the administrators to rate the soft skills of their staff who may be technically proficient can be a competitive advantage for the medical training institution in an age with more parity in technical skills and access to innovative technology. Major soft skills, including problem-solving, critical thinking, creativity, and staff-patient/client-student communication, are just a few of the things simulation instructors can improve through these kinds of interactive training programs (Tyng, et al., 2017). Learning through emotion is advantageous to the acquisition of skills compared to other methodologies (Steadman, et al., 2006).

The opportunity for assessment has been seen as the major advantage for medical simulation in medical laboratory education as well as encouraging working into teams; encouraging an environment where education is standardized; ensuring the curricula is uniform; enhancing the capability of students to think critically; encouraging safety of patents; making students be exposed to situations that are common and those that are not; encouraging repeating of tasks to improve performance; possibly promoting expertise acquisition; enabling interpersonal skills and psychomotor skill assessment; and encouraging the students the chance to reflect in a structured manner and engage in debriefing (Huang, Reynolds & Candler, 2007).

Other opportunities includes provision of tools to support students to effectively shift to practice; drawing majorly on human resources that needs continuous support; showcasing a main transition in pedagogical practices and should be based on evidence-based studies that lacks in educators today; allows educators the chance to provide a seamless experience in education that ensure students gain through support of related resources (https://michener.ca/the-case-for-simulation/).

Finally, inside a virtual environment, decisions and consequences are real. When you invest in simulation-based learning, you remove risk from the situation entirely. Instead of forcing learners to acquire skills and knowledge through on-the-job training or by trial and error in the real clinical site, creating a virtual environment gives trainers the flexibility to make mistakes. Unfortunately, on-the-job trial and error costs healthcare facilities hundreds (or even thousands) of dollars for their mistakes. A simulation-based training program reduces the total volume of mistakes made, and by association, the total cost of those mistakes as well as improving the image and reputation of the medical training institution (https://www.capsim.com/blog/advantages-of-simulation-based-learning).

2.5 Establishing the factors considered by implementers in using simulations for their teaching and learning

Full-body mannequin simulators were used in the field of anesthesia in the late 1960's for training in endotracheal intubation and induction of anesthesia. Many of the simulators of the 1980's were utilized in the areas of aviation, military training, nuclear power generation, and space flights. Later, simulations begun to be introduced into anesthesia and other areas of medicine like critical care, obstetrics, emergency medicine, and internal medicine. In the earlier days of medicine, some form of simulation was already being applied in the form of case scenarios and the use of case presentations. These are also being utilized to assess candidates in the objective structured clinical examination (OSCE). Life support courses such as basic and advanced cardiac life support, basic and advanced trauma life support also utilize simulation techniques and principles for learning and testing (Shapiro, et al., 2004).

Medical programs are increasingly adopting simulation in both undergraduate and postgraduate curricula. Cleland, Abe, & Rethans, (2009) and Alinier, Hunt, & Gordon, (2004) cited the many reasons on the use of simulation in clinical teaching which includes and not limited to the changes in healthcare delivery, lack of objectivity of clinical examinations limited clinical placement positions and potential of simulation to improve clinical learning. Also, the shorter hospital stays of patients, staff shortages, and increased number of students to teacher ratio has limited appropriate clinical teaching at clinical sites requiring that the skills be acquired in the skills laboratories (Reese, Jeffries & Engum, 2010). Implementation of simulations in the training of medical professionals is to ensure patients are safe and ethical concerns are addressed. Other factors that has influenced the utilization of simulation based learning by educators include; relating theory to clinical practice, developing a range of core skills, exposing students to the range of medical experiences, dealing immediately with problems, issues and/or speculative events, reproducing practice, enabling practitioners to learn about working in multidisciplinary teams, providing situations for critical reflection and developing capability in real-time critical reasoning (Smith, 2006).

Numerous reports have been given by Weinberg, Auerbach, & Shah, (2009) which support the introduction of simulation based medical education as an important step in curriculum development, especially in training of high-risk disciplines such as resuscitation, airway management, procedural training, trauma, and disaster management.

Positive results in relation to enhancing knowledge, skills, and attitude toward technology-enhanced simulation have been reported in many studies. MLS students beginning their undergraduate studies in histology showed their skills in identification of morphology and techniques of the laboratory. The result showed simulation-based learning approach combined with blended learning with educational technology enhances learning in the laboratory and has benefits for both the student and the academic staff (Donkin, Askew & Stevenson, 2019).

Studies conducted in Saudi Arabia regarding usage of simulators for teaching laparoscopic surgery skills among junior surgical residents and local anesthesia teaching showed significant enhancement and improvement at a cognitive as well as psychomotor level. The technique has been widely used for the acquisition of specific clinical skill in specialties such as pediatrics, emergency medicine, intensive care medicine, obstetrics, anesthesia, radiology, and allied medical sciences (McGaghie, et al., 2011)

Simulation is effective in developing skills in procedures that require eye-hand coordination and in those that call for ambidextrous maneuvers, such as bronchoscopy and other endoscopic procedures (Gupta, Peckler & Schoken, 2008). Medical education has evolved over time and these changes have been oriented towards the incorporation of the use of technology. Many factors have been identified to be responsible for this evolution in medical education namely: societal demand for safety and quality, a need to recreate health professions education, ethical considerations, technological advancements, professional shortages, and a changing landscape for the delivery of patient care. Other factors that hinder the use of simulations could be student centered issue, institutional culture and the learning environment (Donkin, Askew & Stevenson, 2019).

Simulation-based medical education is mostly utilized in the department of nursing, clinical medicine and pharmacy. Simulation-based learning is also adopted by the MLS programs with the aim of lowering the need to highly depend on clinical partners. Even so, the applicability of learning through simulation has not been thoroughly studied in the medical laboratory education. This encouraged the researcher to carry out a study in the area.

2.6 Examining the challenges affecting the use of simulation-based teaching and learning among teaching staff

The role of medical laboratory technologists as key players in ensuring the operational efficiency of clinical laboratories and effective healthcare delivery to the public is crucial and requires serious attention. However, laboratory medicine grapples with the challenge of limited acknowledgment for educational endeavors compared to other medical specialties. In addition, increasing automation of laboratory processes has inadvertently led to a misconception that these professionals merely oversee automated systems without actively being engaged in the analytical process (Waheed et al., 2023). The aim of automation is to streamline routine tasks, but it does not diminish the critical thinking, technical expertise, or troubleshooting skills that medical laboratory technologists bring to the diagnostic process, highlighting their untapped potential for meaningful contributions in integrated clinical management, interpretation of results, research, and discovery (Tyng, et al., 2017).

The primary challenges currently confronting the workforce in medical laboratory technology include lack of opportunities for career advancement, insufficient training and professional development, absence of standardized curricula and assessment, and limited access to continuing education and innovative training (Waheed et al., 2023). Ian & Lowther, (2010) reported that multiple factors influence the implementation of devices into the teaching and learning process. These factors include poor infrastructure, inadequate technology, lack of sufficient technological tools, effective professional development (external factors), low teacher self-efficacy and teacher perceptions (internal factors)

Simulation has gained particular recent momentum in the health/medical area as a way to bridge the gap between theory and clinical practice. It is gaining ground as a medium to deliver a whole range of core skills to aspiring graduates. Simulation is being taken seriously by educators in the healthcare system to a degree seemingly unmatched elsewhere in higher education settings. The challenges likely to impact on simulation initiatives include: learner-focused; educator-focused; situation-focused (inclusive of teamwork); and curriculum focused challenges respectively (Errington, 2010).

Learner focused challenges are challenges mostly centered on the learner and if they are not met then simulation is most unlikely to facilitate educational intentions. Laboratory practices enable students to transform learned concepts and methods into practical skills through experience. For effective learning to take place, students should be divided into small groups when conducting experiments, increasing the number of simulation instructors required. In addition, the students have to practice with a variety of hazardous materials such as biological (e.g., blood, saliva, urine, and stool), chemical (e.g., strong acids), and physical (e.g., fire), which may increase the risk of laboratory incidents (Ali & Ullah, 2020).

To gain the required competence, medical laboratory student is required to gain experience in hospitals through performing procedures by practicing under the supervision of hospital advisors. It is difficult to perform these procedures such as blood collection, peripheral blood smear, or urinalysis without previous experience, therefore, such applications require demonstrations using mannequins, models, and/or virtual computer applications. These challenges cause inequalities of opportunity in the education of medical laboratory technicians worldwide (Miyamoto, et al., 2019).

Simulation-based teaching and learning and in particular, virtual laboratories overcome the challenges of real (practical) laboratories (Jones, 2018), wherein the practical laboratory, experiments are conducted once in a limited time frame, but in the virtual laboratory, these experiments can be repeated until understanding and learning goals are reached. Simulation-based teaching and learning can simplify complex and confusing experimental processes and also the fact that an experiment involving a dangerous substance can be performed safely in the virtual laboratory (Ali & Ullah, 2020).

Other learner focused challenges include: lack of psychological fidelity/realism which is "the degree to which the trainee perceives the simulation to be a believable surrogate for the trained tasks; clear understanding of the aims/purposes of the simulation. The purposes of the simulation should be express clearly, its scope, and the realistic roles to be assumed by participants in the simulation experience. Communicating to students the aims, purposes, processes and intended outcomes of the simulation would also seem to be at the heart of achieving psychological realism; lack of productive interaction with simulated patients-simulators and lack of opportunities for staged critical reflection (Van-Wissen, 2003).

In clinical and science courses, laboratory practices enable students to effectively use and reinforce theoretical knowledge through observation and application. Medical laboratory education has an important role in providing effective learning in the fields of microbiology, biochemistry, molecular biology, and genetics. Many institutions are facing growing challenges in laboratory training and are unable to provide adequate laboratory facilities to the students of medical laboratory sciences (Tüysüz, 2010). These challenges focus on the shared context of the simulations and the respective part of educators and students in influencing the success or failure of learning processes. They include establishing near-life situations, constructing and sustaining the scene, drawing on people and situations from a broad vision of society, providing inter-positional opportunities and enabling knowledge transfer to real patients.

Medical laboratory not having specialized equipment and a working area for laboratory education poses a situational challenge. If this is to be provided, it will cause a significant financial burden on the institutions. Simulation-based activities make high demands on educational resources. These resources entail support given to ensure effective administration, scheduling and space, specimens, and equipment. The cost of operation in this regard, is high considering the required expendables and reagents. Program coordinators receive a lot of pressure from learners that they should implement up-to-date technologies to encourage the use of simulation in the laboratories (Jones, 2018). If these challenges are not met then the simulation will not be shared and the experience will be relegated to a discussion-only approach.

Simulation-based teaching and learning activities are demanding for instructional staff. The time commitment by the simulation instructors, the increased accountability levels, and the nature by which simulation laboratories are unpredictable can increase the level of anxiety. At the same time, educators are anxious about the quality and safety of students when the latter engage in simulation is the absence (Donkin, Askew & Stevenson, 2019). There is the requirement for students working with bio-hazardous materials as well as risky electrical and mechanical equipment to be highly supervised. In addition, the expensive laboratories may be at risk when students are not supervised during the simulation process.

Activities such as reading hematology slides by the students are a task where they would like to have one-on-one instruction from their instructors. Students are always not supervised when the educator has multiple responsibilities that make them leave the laboratory, enhancing students' safety risks. The lack of backup personnel is a real concern for instructors (Grant, 2007).

A study carried out by Jones, (2018) reported that challenges such as lack of an academic background in technologists, managing excessive work burdens, and cultivating teaching skills in experienced instructors were also noted. In this study, a trainee noted that "not everyone can be a teacher," while an alumni had a similar opinion, with one highlighting how "it's important to know how to conduct a class." Supervisors echoed similar sentiments, with one saying: "The way we train technologists, it is important that the instructors are trained too." Another said, "A very skilled technologist doesn't need to be a good teacher." To improve on the ability of the instructors, Al-Nakhle, (2022), recommended conducting training sessions and workshops, providing incentives to trainers, and developing a skill lab.

There is high demand when preparing for laboratory especially because of the need to carefully handle specimen during transportation, prepare and test specimen, maintain and test equipment, document laboratory processes, and develop curriculum. While some institutions can manage to employ support employees, others are not, leading to burnout of educators. As such, simulated laboratories can sometimes lead to stress when workers are not adequate (Jones, 2018).

These challenges focus on the sole role of the simulation instructor. Other challenges include: making practice deliberate and engaging students consciously in professional identity formation. This helps in the development of students' professional identity as aspiring health/medical professionals; providing students with timely feedback, creating a risk-free environment and actual life situations are invariably laden with risks. Simulated learning is likely to fail if educators do not put the above challenges into consideration (Larew, et al., 2006).

There are also curriculum-specific factors which are likely to foster or inhibit simulated-based learning. They include: faculty members viewing their own part of the curriculum for which they may have responsibility for delivery; integrating traditional knowledge, simulation, and being with real patients; incorporating students' lived experiences into the simulation process and broadening the curriculum to include team-based simulations (Voelker, 2009), when looking at the curriculum design, Waheed et al., (2023), reported that most of the time there is an opportunity for hands-on practice included in the curriculum, but there is a disconnect between theory and practice of quality control, and disconnect between lectures and bench side teaching as well as limited focus on practical learning. This can be solved by enhancing focus on clinical correlation and integrating professionalism in the curriculum. This can be hindered by time constraints in implementing curriculum.

Some stakeholders in health care are skeptic about the suitability of simulation in the medical laboratory education (Grant & Davis, 2004), relying on the study by (Lemery, 2001), which lists areas of concern to include the ability to transfer technical skills obtained through simulation, inability to socialize in a physical surrounding which is essential for employability (Grant & Davis, 2004).

Working together by people with knowledge and skills in various aspects of medical laboratory develop numerous learning opportunities in clinical education. For example, working together makes learners and educators work as a team, feel that they contribute to promoting the health of the patient, appreciate challenges that real life brings, and experience non-routine aspects of laboratory procedure and patient specimens, and work with current instrumentation (Jones, 2018). The simulated environment may not address the mentioned opportunities thus, researchers should consider examining it to bridge the gap in simulation is medical laboratory education.

The challenge lies in medical laboratory science educators and simulation coordinators in constructing realistic, goal-based simulations that afford team building opportunities and reflect the workings of the real medical profession. The emphasis is on the 'building' of teams with specific, clear roles and purposes, understood by all players (Errington, 2010).

To overcome these challenges, the following ways will help if put in place; being guided by learning intentions not technology/media; enhancing psychological realism/fidelity; providing opportunities for repetition; aligning immersion with opportunities for situation analysis and self/peer critical reflection; connecting with students' lived experiences; communicating clear roles and responsibilities; maintaining a helicopter view of the curriculum (an overview of the curriculum without going into details) where simulation events may be viewed as timely interventions within a transparent curriculum; tolerating student failure (rehearsal and opportunity for learning not failed performance and moving from individual skills acquisition to team building and performing capability (Donkin, Askew & Stevenson, 2019). Labuschagne, Nel & Van –Zyl (2014) said "it doesn't matter which school they're from, the experience they lack, there's always something new, always something to learn, until you're in the middle of it and being pulled in three directions, that's the only way you're going to learn". There is need for the students to experience the simulation to encourage them to prioritize. While simulation assists in learning, it is not similar to the real world.

Simulations precede any form of touching real humans as learning apparatus for health care students undergoing education and training. According to Reese, Jeffries & Engum (2007), Simulations have been found to provide a good learning opportunity to health care provisional learning prior to exposing them to real humans (patients).

While the applications of human body simulation are diverse (Gaba, 2004) and the educational benefits have been documented (McGaghie, Isenberg, Petrusa & Scalese, 2010), the question that needs to be considered is; ‘Should simulation-based training be an essential, non-negotiable component of training for a career in MLS? Important reasons why clinical simulation training Centers are essential, include: (i) concerns about patient safety; (ii) risk of injury to trainees; (iii) medico-legal consequences of procedural errors; (iv) need for a ‘safe’ learning environment where errors can be made and remediated without dire consequences; (v) reduction in time needed to become proficient in the requisite skills; and most recently (vi) need for additional appropriate training opportunities in circumstances where the clinical teaching platform has become overloaded with both patients and students, and the combined epidemics of tuberculosis, HIV/AIDS, Covid-19 and trauma have inappropriately skewed the case mix from a training perspective (Ali & Ullah, 2020).

Simulation has begun to change much of the ways in which medicine is taught and how trainees and junior doctors acquire the relevant skills. Medical, nursing, and other health care staff also have the opportunity to develop and refine their skills, repeatedly if necessary, using simulation technology without putting patients at risk. Simulation training centers, with their new techniques and equipment, offer unique opportunities for dynamic, complex, and unanticipated medical situations to be practiced and managed (Errington, 2010).

In both aviation and health care domains, human performance is strongly influenced by the situational context, i.e., the interaction between the task, the environment, and the behavior of team members. In aviation, more than 50 years of research has shown that superior cognitive and technical skills are not enough to ensure safety: effective teamwork skill is a must. Similar observations are also now being made in the practice of medicine (Lateef, 2010).

Simulation-based learning can be the answer to developing health professionals' knowledge, skills, and attitudes, whilst protecting patients from unnecessary risks. Simulation-based medical education can be a platform for learning to mitigate ethical tensions and resolve practical dilemmas. Simulation based training techniques, tools, and strategies can be applied in designing structured learning experiences, as well as be used as a measurement tool linked to targeted teamwork competencies and learning objectives. Simulation-based learning itself is not new. It has been applied widely in the aviation industry also known as Crew Resource Management (CRM), anesthesiology, as well as in the military. It helps to mitigate errors and maintain a culture of safety, especially in these industries where there is zero tolerance for any deviation from set standards (McGaghie, Isenberg, Petrusa & Scalese, 2009).

Simulation-based training gives healthcare providers a new, enlightening perspective on how to handle real-life clinical situations. The experience helps participants develop preparedness to both prevent and respond to critical events. Simulation is poised to help fundamentally change healthcare to meet the challenges of our times. Courses for simulation coordinators, educators and researchers who seek to develop and maintain high-quality healthcare simulation programs within training institutions is paramount. The training package entails developing teamwork behaviors and communication, collaboration and crisis management skills. These skills are best learned experientially under realistic conditions. The courses address both the clinical and behavioral aspects of performance, focusing on crisis management and error prevention. Course topics include leadership, teamwork, effective communication, resource management and performance enhancement (https://harvardmedsim.org/training/).

A crucial component of Medical Laboratory Science (MLS) student training is clinical experience. This can be delivered through clinical rotations or by clinical laboratory simulation. The department of Medical Laboratory Sciences at KMTC utilizes a combination of both to provide clinical experience to MLS students. At KMTC Nairobi campus, simulated laboratory short course was re-designed to enhance student customer service, communication skills, workflow and time management, instrument maintenance and troubleshooting, data entry, and result reporting. The course is to be taught for two weeks and evaluated by a pre/post survey related to the main educational outcomes, a mock certification exam, and a comprehensive practical exam. The goal of this exposure is to reduce hospital errors when time comes and produce more marketable experienced graduates. A typical day at the KMTC simulation training Centre is filled with experiences in simulated clinical situations, punctuated with debriefings supported by videotaped scenarios.

2.7 Chapter Summary

The literature review has synthesized the current practices in the medical laboratory learning so as to identify what is known and unknown about simulation-based learning and teaching. The literature allows for development of the foundation upon which the study bases as well as pinpoint directions for further research. The review of the literature found that simulation-based teaching and learning can support the achievement of effective learning among medical laboratory learners. The learning method assists students to easily transition from education to practice. However, it cannot replace clinical experience. The method as well encourages educators to provide a seamless experience of education. Even so, the implementation of simulation-based teaching and learning declines in the medical laboratory program because of limited resources as well as inadequate evidence supporting its use. The simulation laboratories are thus, dealing with demanding issues.

CHAPTER THREE

3.0 RESEARCH DESIGN AND METHODOLOGY

3.1 Overview

This chapter highlights the research design, the study site, study population, inclusion and exclusion criteria, sample size, sampling procedure, research instruments, data collection procedures, and methods of data analysis. The chapter gives the framework of how the study was conducted. The purpose of this chapter is to provide proper procedures that were followed in conducting the study.

3.2 Research approach and design

3.2.1 Research approach

A research approach is a plan and procedure for conducting research that spans the decisions from broad assumptions to detailed methods of data collection and analysis. Research design is the conceptual blueprint within which research is conducted. A research design is informed by research approaches, as well as the type of evidence required to answer the problem which the research seeks to proffer solutions (Creswell, 2014).

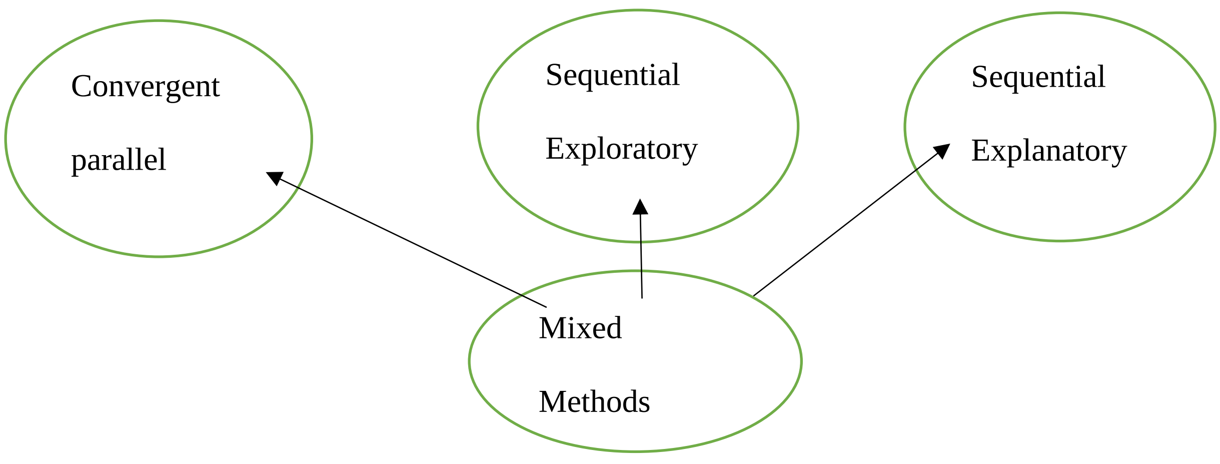

Figure 3: Mixed Methods Approach and Research Designs: Adapted from Zerger (2014).

Convergent parallel design

Convergent parallel design consists of taking qualitative and qualitative data collection and analysis and comparing or relating the two and then interpreting them. This design requires that the data collection timing be done concurrent, with emphasis placed on quantitative and qualitative research approaches being equal (Zerger, 2014).

The quantitative and qualitative research approaches are integrated from and during the time of studying results. The number of phases required in the implementation of convergent research design is one. The researcher obtains complementary data on the same topic and compare datasets. The areas of convergence or divergence between the qualitative and quantitative results should be discussed (Maxwell & Loomis, 2003).

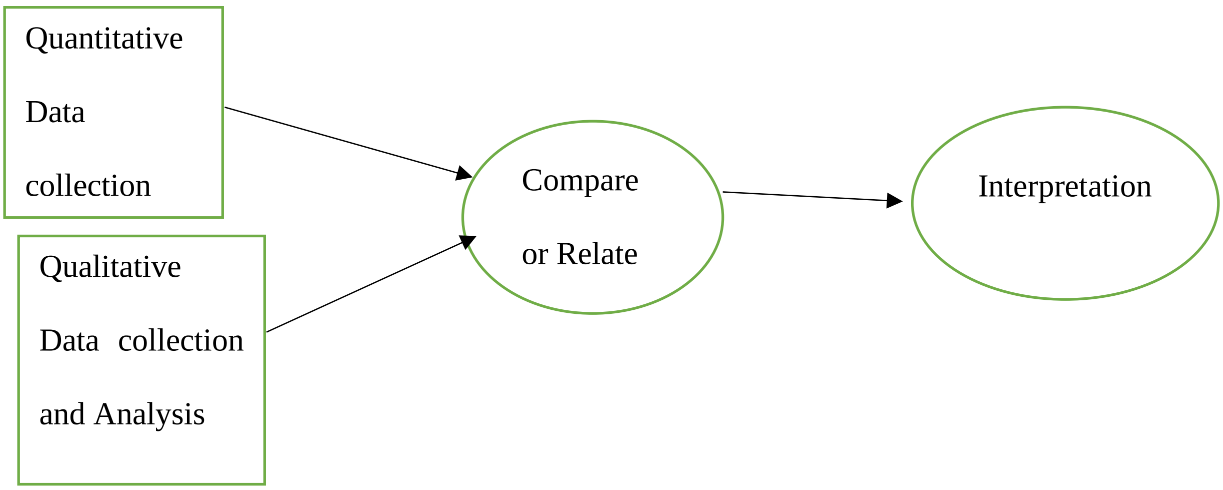

Figure 4: Exploratory sequential design

Exploratory sequential design starts with qualitative data collection and analysis and builds to quantitative data collection and analysis, which leads to interpretation. This design requires that the data collection timing be done first with qualitative research approach. Emphasis is placed on qualitative research approach. In this design, the qualitative results are used to develop a new instrument or taxonomy for quantitative strand. The researcher is required to explain qualitative findings and further use qualitative findings to enhance determination of reality quantitatively. The integrated starting point is during the time when the researcher collects data for the study (Johnson

& Onwuegbuzie, 2004). Furthermore, the number of phases required in the implementation of sequential exploratory research design is three.

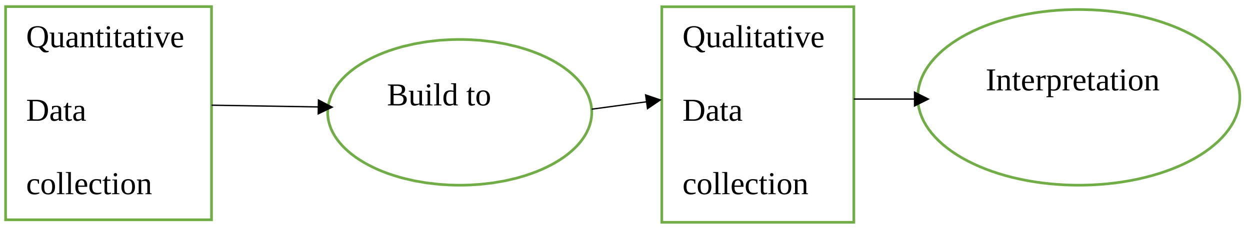

Figure 5: Explanatory sequential design 2

Explanatory sequential design starts with quantitative data collection and analysis and then follows up with qualitative data collection and analysis, which leads to interpretation. This design requires that the data collection timing be done first with quantitative research approach. Emphasis is placed on quantitative research approach. The researcher is required to explain quantitative results and further use quantitative results to enhance determination of reality qualitatively. This helps determine what quantitative results need further explanation. The integrated stating point is during the time when the researcher collects data for the study (Ortiz, et al., 2012). The number of phases required in the implementation of sequential explanatory research design is two.

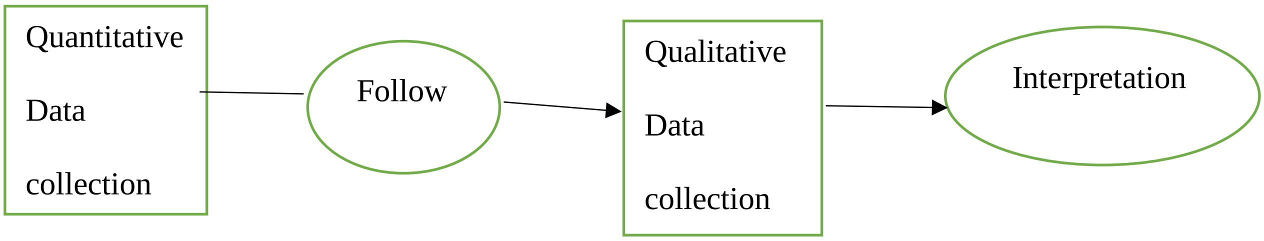

Figure 6: Explanatory sequential design 3

From the definition above, the literature gathered and the chosen philosophical paradigm, the most suitable research approach for this study was the mixed methods approach. The mixed-method type of research combines both qualitative and quantitative designs and is defined as a procedure for collecting, analyzing, and "mixing" both quantitative and qualitative data in a single study in order to better the understanding of a research problem (Creswell, Fetters, & Ivankova, 2004).

The mixed-methods approach is a class of research where the researcher mixes or combines quantitative (positivists) and qualitative (constructivists) research techniques, methods, approaches, concepts, or language into a single study (Johnson & Onwuegbuzie, 2004). The mixed-methods approach identifies three different approaches to mixed methodology; concurrent parallel design, explanatory sequential design and exploratory sequential design as discussed above. This study utilized convergent parallel design which consisted of taking quantitative and qualitative data collection and analysis and comparing or relating the two and then interpreting them. Mixed methods study combines both qualitative and quantitative designs thus, considers the two paradigms to find a middle solution that works best (Johnson, Onwuegbuzie et al., 2007).

The mixed-methods design are usually utilized to inspect the reasons and ways by which things happen so as to deeply understand phenomenon and the level of their connection (Ortiz, et al., 2012). The quantitative and qualitative research approaches are integrated from and during the time of studying results, the quantitative phase was followed by the qualitative phase (personal experiences). Both quantitative and qualitative data collection were done concurrently (Creswell, 2007), then integrated in order to provide a comprehensive analysis of the application and opportunities for innovative Simulation-Based Medical Teaching and Learning among staff in selected KMTC Campuses offering Medical Laboratory Sciences in Kenya.

3.2.2 The Convergent Parallel Design

This design occurs when the researcher uses concurrent timing to implement the quantitative and qualitative strands during the same phase of the research process, weighs the methods equally and keeps the strands independent during analysis, and then mixes the results during the overall interpretation (analyses the two components independently, and interprets the results together) (Creswell, Plano Clark, et al., 2003). As a result of this, the researcher chose to use both research questions and hypotheses in the study. In the quantitative data collection stage, a structured cross-sectional questionnaire was used (survey questionnaire).

The survey questionnaire was used to gather numeric descriptions of the level of application of innovative simulation-based learning and issues that determine the decision of the program to execute simulation-based learning by use of questionnaires, document analysis, interviews, and structured observations. The qualitative research study design/ strategy (phenomenological research) was used to identify lecturers' opportunities, perspectives, and challenges about the use of simulation-based learning. The qualitative strategy complemented the quantitative strategy. The triangulation of all data, both qualitative and quantitative led to a credible understanding of the study (Mertens, 2010).

The research was analytic and employed cross-sectional approach (Schneider, et al., 2007). Cross-sectional styles are usually implemented at a particular point in time or spread within a short time span to examine the relationship between variables (Levin, 2006). Across-section of a population is usually obtained by researchers with the aim of getting a sample that represents the entire population (Sedgwick, 2014), but for this study, the whole population was taken and hence, it was representative.

An analytic study of a cross-sectional nature can implement inferential statistics to identify the variable that causes the other to change (Schneider, et al., 2007), and indicate in case there is high probability that the alternative hypothesis can be true so as to reject or confirm the predictions (Field, 2009). A survey is usually administered in cross-sectional analytic studies to determine the relationship between variables under testing (Levin, 2006). As such,

Chapter 4 presents models of statistics that investigate this research's simulation survey data and the inferences used to elucidate the findings.

A cross-sectional style was beneficial in this research because it reduced follow-up loss because of the short duration required to collect data (Levin, 2006; Sedgwick, 2014). The cross-sectional style as well was advantageous as it did only look at the relationship and inferences between variables that were examined and the results but not absolute causal. The researcher analyses the questionnaire data quantitatively and the checklist, the open-ended questions contained in the interview schedule as well as the document analysis data qualitatively and then merges the two sets of results to assess in what ways the results about the application of innovative simulation-based teaching and learning among teaching staff converge and diverge. This design was chosen as its overall strength is greater than either qualitative or quantitative research (Creswell, et al., 2007).

Mixed methods also mirror the way individuals naturally collect information by integrating quantitative and qualitative data (Mertens, 2010). Mixed-method design is important in this study because it enabled the researcher to collect rich and comprehensive data.

The purpose of the convergent parallel design is "to obtain different but complementary data on the same topic" to best understand the research problem. The intent in using this design is to bring together the differing strengths and non-overlapping weaknesses of quantitative methods (large sample size, trends, generalization) with those of qualitative methods (small sample, details, in depth). This design is used when the researcher wants to triangulate the methods by directly comparing and contrasting quantitative statistical results with qualitative findings for corroboration and validation purposes. Other purposes for this design include illustrating quantitative results with qualitative findings, synthesizing complementary quantitative and qualitative results to develop a more complete understanding of a phenomenon, and comparing multiple levels within a system (Patton, 1990).

In addition to matching the design to the study's purpose, the researcher felt that there is equal value for collecting and analyzing both quantitative and qualitative data to understand the problem better. There are four major steps in the convergent parallel design. First, the researcher collects both quantitative data and qualitative data about the topic of interest. These two types of data collection are concurrent but separate, that is, one does not depend on the results of the other. They also typically have equal importance for addressing the study's research questions. Second, the researcher analyzes the two data sets separately and independently from each other using typical quantitative and qualitative analytic procedures (Mertens, 2010).

Once the two sets of initial results are at hand, the researcher reaches the point of interface and works to merge the results of the two data sets in the third step. This merging step may include directly comparing the separate results or transforming the results to facilitate relating the two data types during additional analysis. In the final step, the researcher interprets to what extent and in what ways the two sets of results converge, diverge from each other, relate to each other, and/or combine to create a better understanding in response to the study's overall purpose (Patton, 1990).

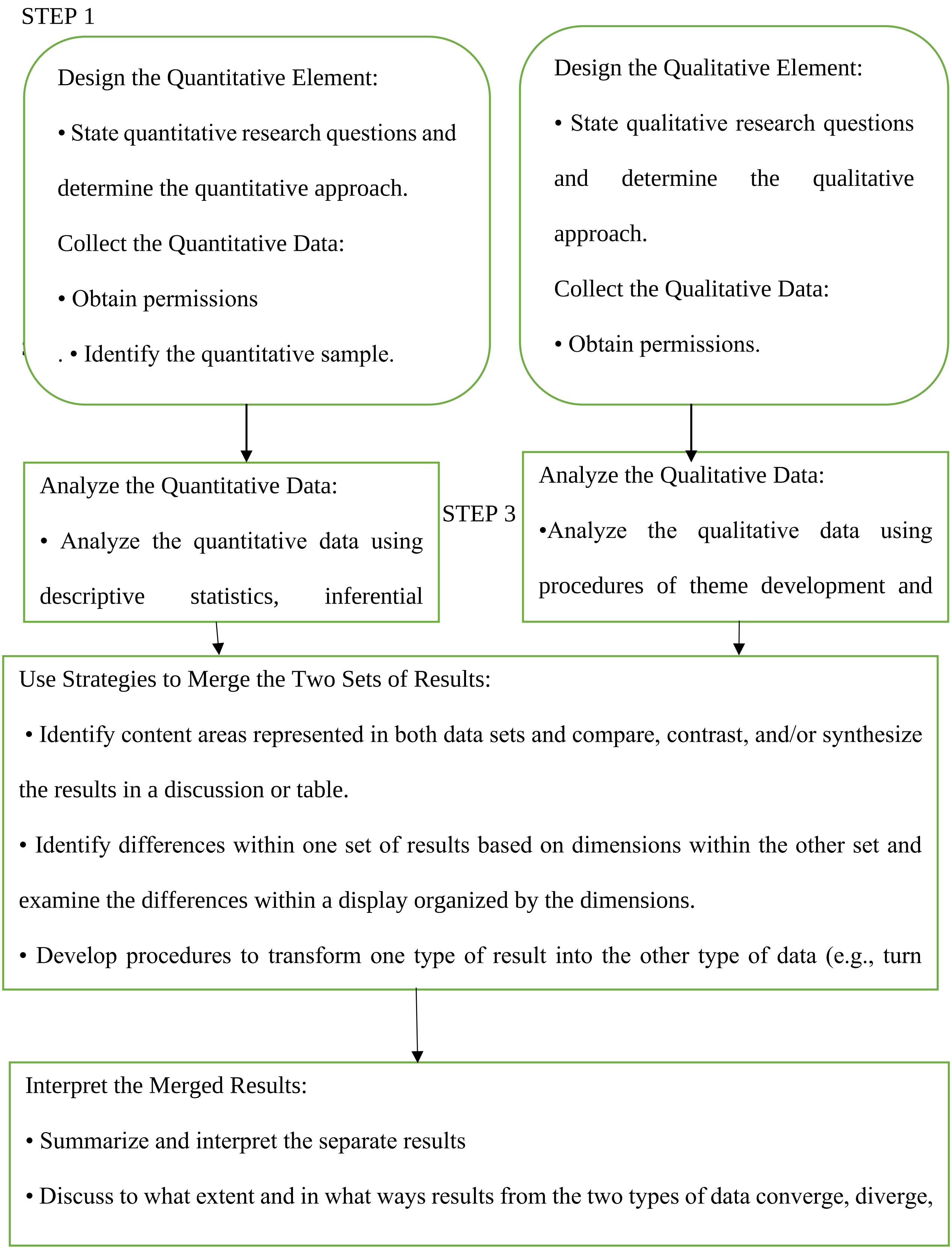

Figure 7: Flowchart of the Basic Procedures in Implementing a Convergent Design adapted from (Maxwell, & Loomis, 2003).

3.3 Location of the Study

This study was carried out in selected KMTC campuses. KMTC is currently made up of 74 constituent medical training campuses distributed countrywide. However, only the campuses offering MLS program were involved in this study. These included: Lake Victoria, Porteriz, Nairobi, Nakuru, Nyeri, Embu, Kakamega, Kombewa, Meru, Kisii and Machakos.

3.4 Study Population

Lecturers teaching in the Department of Medical Laboratory Sciences in the various campuses and the principals in these campuses were involved in this study. The projection of the study was also that the two groups' exclusive elements (lecturers and principals) could be captured to enable broadening of the possible results. Their level of education was not considered because the minimum entry requirement for one to be academic staff at KMTC particularly for medical laboratory sciences is a bachelor of science in medical laboratory sciences. All the lecturers in the MLS department have this qualification.

All the lecturers from the sites selected were part of the study sample considering inclusion and exclusion criteria. This study was targeting KMTC and particularly the campuses offering medical laboratory course program which is a diploma program that takes 3 years of study. Once the students graduate, they are ready for the job market and do not go for internship after qualifying from KMTC because the skills they acquired in the simulation laboratory as well as the clinical sites was deemed adequate. Again, this bit about the internship is not there in the curriculum for diploma in medical laboratory sciences. The study was not done in collaboration or in comparison with other departments, institutions or organizational bodies.

The study targeted the teaching staff. In order for students to learn and apply what they have learned, they must first be taught in detail the principles and concepts required for them to become qualified medical laboratory health professionals who can be able to discharge their work of collecting patient's specimen samples, analyze, interpret and dispatch the results to the relevant destination.

Clinical instructors and laboratory in-charges are qualified medical laboratory staff with added short course training given as an on-job training to enable them serve in the capacity delegated effectively. Campus principals are the overall managers in these campuses who are charged with the responsibility of coordinating all the academic matters in the campuses. The minimum qualification for one to be a campus principal is at least a Master's degree in a particular specialty.

3.5 Inclusion and Exclusion Criteria

This is a thorough description of the study population such that the subject population have the attributes that make it possible to accomplish the purpose of the research. Defining inclusion and exclusion criteria increases the likelihood of producing reliable and reproducible results, minimize the likelihood of harm to the subjects, and guards against exploitation of vulnerable persons.

3.5.1 Inclusion Criteria

The study included all Lecturers from the campuses which use simulation-based medical teaching and learning for their students and utilize minimum laboratory simulation even if it is for demonstration purposes to the students. Campus principals, clinical instructors, and laboratory in-charges drawn from these 12 KMTC campuses were included in the study.

3.5.2 Exclusion Criteria

Lecturers, campus principals, clinical instructors, and laboratory in-charges who did not consent based on their own reasons.

Lecturers, campus principals, clinical instructors, and laboratory in-charges from the institutions not having any form of medical laboratory simulation for they could not understand the application and opportunities for innovative simulation-based teaching and learning in MLS.

This exclusion criterion ensured that only lecturers who actively use simulation-based teaching methods are included in the study, as they are the target population for investigating the effectiveness and impact of such methods.

3.6 Data Collection Instruments

The research instruments that were used included; a questionnaire, interview, document analysis, site visits, and checklist. The tools chosen enabled the researcher to collect mixed data because the research method was a mixed-method type of research. The questionnaire contained both open-ended and closed-ended questions. The interview was both qualitative and quantitative meaning that it contained both open-ended and closed-ended interview questions. Quantitative interviews are similar to qualitative interviews in that they involve some researcher/respondent interaction. But the process of analyzing findings from quantitative interviews differs from that of qualitative interviews. The respondent for the interview was the campus principal in each campus. Observation was carried out by the researcher during the site visits as well as administering the checklist as explained under each tool.

3.6.1 Questionnaire

A questionnaire is an investigation tool that consists of inquiries designed in line with the study objectives to help the researcher collect data for analysis and thereafter guide in writing of the findings. The questionnaire was designed as per the DREEM model discussed in chapter one. Advantages of using questionnaires include; they are economical to use in terms of time and money, they permit a greater depth of response, and are simple to formulate. Some of the disadvantages of using questionnaires include; closed-ended questions are difficult to construct because categories must be well thought out, and responding to open-ended questions is time-consuming (Frels, et al., 2011). This may put off some respondents. This tool was administered to the lecturers by the researcher who was assisted by the research assistants.

3.6.2 Interview

The face-to-face interviews aimed to ensure the interaction between the researcher and the participant was interactive as they share their experiences with learning through simulation (van-Manen, 1997). The interviews provided the interviewees with the chance to narrate their learning experiences with the simulation. The interview schedule for the campus principals consisted of two segments. Section one consisted of general information on the designation of the respondent and the number of years served in that position. The subsequent section had both closed-ended and open-ended questions for use in collecting information from the interviewees based on the objectives of the study. Campus principals were interviewed on one-on-one basis to obtain more information that helped the researcher to understand the concept of application and opportunities of innovative simulation-based teaching and learning.

Semi-structured interview helps the researcher to gain information about a specific issue through a list of predetermined questions even though the questions may have varied wordings and order (Merriam, 1998). As such, the responses received from participants guided the interview process as they determined the kind of questions asked. Advantages of using interviews include; they provide in-depth data which is not possible to get using questionnaires, interviews guard against confusing the questions since the interviewer can clarify the questions thereby helping the respondent give relevant responses. Disadvantages of interviews include; they are more expensive to conduct. Researchers have to travel to meet the respondents, and sometimes interviewers need to be trained to avoid bias (Frels & Onwuegbuzie, 2013).

3.6.3 Observation

Observation is a way to gather data by watching people, events, or noting physical characteristics in their natural setting. Observations can be overt (subjects know they are being observed) or covert (do not know they are being watched) participant observation. The researcher sought for permission from the CEO of Kenya Medical Training College (KMTC) in writing to be allowed to carry out research in a portion of KMTC campuses as well as use the teaching staff and campus principals as research participants. This request indicated the various data collection tools which included the researcher physically visiting the institutions in order to observe simulation operations in the simulation laboratories or classes, collect evidence of the teaching strategy implementation and outcomes, and interview staff and teaching strategy supervisors, the campus principals. Simulation teachers observed the scenarios after the simulation as well as debriefs after the simulation so as the researcher could see the aspects of behavior portrayed by the simulators when the simulation learning was being undertaken.

The researcher either allows the observation to take place while participating in the simulation or just watched (Angrosino, 2005). As such, the researcher asked the simulators on how they go about their simulation sessions, their preparations, adequacy of the equipment, any challenges they encounter during their simulations as well as a simple demonstration of their choice. Advantages of site visits include; one is able to collect accurate information. Disadvantages of site visits include; being time-consuming and expensive (Frels, et. al., 2011).

3.6.4 Checklists

The checklists had one section with five items to collect information on the type of physical facilities, location of facilities, adequacy of facilities, condition of facilities, and appropriateness of the facilities. Advantages of using a checklist include; helping to produce a higher degree of awareness of the activity in question, helping people in responsible positions to become more aware of what they should be looking for. Disadvantages of using a checklist; Descriptive checklists may be exhaustive, inability to relate individual activities to environmental components affected by these activities. Laboratory in-charges were required to fill the checklists whereby the researcher once on site, gave the checklist to the laboratory in-charges, the checklist was self-explanatory and the officers had easy time going through them and attending to the checklist (Creswell, et al., 2007).

3.6.5 Document Analysis

Document analysis is a method of data collection which involves analysis of content from written documents in order to make certain deductions based on the study parameters. It is the study of recorded human communications, such as books, websites, paintings and laws. The process involves evaluating electronic and physical documents to interpret them, gain an understanding of their meaning and develop upon the information they provide (Babbie, 2010).

There are three main types of documents in their research; Public records which are official records of the activities of an organization, usually a government agency or educational institution, that anyone can access. Examples include handbooks, census information, birth and death records and court records, Personal documents which refers to accounts of an individual's own experiences, examples include diaries, journals, emails, blogs and social media posts, and physical evidence which includes objects found within the research setting, examples include flyers, posters and training materials (Bowen, 2009).

The documents analyzed included; course curriculum, course outlines, and sample of test items for qualifying students after the end of the three (3) years of their study having the component of simulation. All these were availed to the lead researcher by the Head of the Department in each campus visited.

Document analysis is important because it allows researchers to make sense of their resources and select the appropriate pieces for their studies. It allows researchers to conduct studies that they might not be able to complete through field research, due to resources or time constraints. Reduces some of the ethical concerns associated with other qualitative methods. Can provide a rich source of supplementary data and help researchers recover suppressed narratives. Can also corroborate findings and other evidence sources, adding credibility to research (Goldstein & Reiboldt, 2004).

A number of limitations inherent in documents analysis include; insufficient detail: documents are produced for some purpose other than research; they are created independent of a research agenda, they usually do not provide sufficient detail to answer a research question, low retrievability: documentation is sometimes not retrievable, or retrievability is difficult, it relies on pre-existing texts, which may not always be available or comprehensive, it can also be associated with issues such as data redundancy and maintainability if the choice of data representation is neglected, documents that seem objective can contain biased information, and challenges in interpretation. (Rapley, 2007).

3.7 Target population

The population targeted was all the teaching staff and campus principals from the 12 campuses offering diploma in medical laboratory sciences of the KMTC

3.8 Census Method

The method used was census. It is also known as complete enumeration. A census method is that process of the statistical list where all members of a population are analyzed. It is a statistical investigation in which data is collected for each and every element/unit of the population. It is useful when case intensive study is required or the area is limited. The population has a particular set of characteristics such as; specific attributes/traits, experience, knowledge, skills, and exposure to events (Bowen, 2009).

Advantages of this method include; it provides intensive and in-depth information covering many facets of the problems, useful for small populations or when detailed information is needed about the whole population, in this type of investigation, every item of the universe is taken into account hence the conclusions are more accurate and reliable, the margin of error is typically very small as it covers the whole population. Disadvantage of this method include that since the data are obtained for or from each and every unit of the population, it is a very expensive method of investigation, especially in case of a large population size, since a large volume of data is to be collected, more time and manpower is required for its collection, analysis, and interpretation. This method is meaningless in the case of an infinite universe where the number of items is unlimited (Frels & Onwuegbuzie, 2013).

3. 9. Census Procedure

This refers to the steps followed in using the census method. The first step was to define the unit characteristics, units are the things that make up the population. These units can be people, cases (e.g., organizations, institutions, countries, etc.), and pieces of data. The specific characteristics of the population that made it appropriate to be used as a total population were defined. Such characteristics included specific attributes/traits, experience, knowledge, skills, exposure to events. All the campuses offering medical laboratory course and had a laboratory with basic simulations such as simple clinical laboratory simulation laboratory rooms, simple manikins and some simple equipment were included in the study. A list of the population of interest was created. The list focused on the units that had the specific characteristics that the researcher was interested with. To achieve this, a gatekeeper was used. The researcher was interested in determining the application of innovative simulation-based teaching and learning among staff in selected Kenya medical training colleges offering medical laboratory sciences in Kenya, and hence she used the secretary to the Head of the Department (HOD), medical laboratory sciences, Nairobi campus, as the gatekeeper to ensure that she had access to the list of all campuses offering diploma in medical laboratory science technology and staffing. A sample frame (see appendix 6) for all the campuses offering medical laboratory program was generated and used to eliminate the campuses without a basic demonstration laboratory for simulations. This helped the researcher to eliminate any human bias and ensure representativeness.

3.10. Sample Size and Sampling Procedures

The sample size is defined as a portion of the target population that is selected for the study. Normally, it should be representative of the target population. According to Connelly (2008), extant literature suggests that a pilot study sample should be 10% of the sample projected for the larger parent study. The total population of the participants: campus principals, lecturers, clinical instructors, and laboratory in-charges were sixty-four (64) (of whom, 6 participants participated in the pilot study (10% of 64) and hence excluded in the actual study). The remaining 58 participants participated in the study and hence considered to be a small number giving the justification to take the whole population as the sample hence census method was used. The clinical instructors and laboratory in-charges are medical laboratory professionals only that they have been given this designation to ensure smooth flow of work and to assign responsibility, hence form part of the total population. The campus principals may not be graduates of MLS (see appendix 10) but it should be understood that they are the in-charges (managers) in these campuses and it is their responsibility to monitor teaching and learning and suggest innovative teaching and learning strategies to the CEO and the Board of management for their campuses. This justifies the reason as to why they should be part of the population involved in the study.

3. 11. Data Collection Procedure

Questionnaires, interviews, checklists, document analysis and site visits for observations were used. The questionnaires were administered to the staff selected by the researcher who was assisted by the research assistant. The questionnaire items were made very clear so that the participants only gave the right and valid information while document analysis and site visit checklist were done by the lead researcher upon carrying out the observations and on-site visits. The interview was conducted by the lead researcher to the respective campus principals. Reliability and validity testing had been done prior to collecting the data through pilot study, discussion with the supervisors and statistician.

3.12. Validity and Reliability of instruments

The data collection tools were pre-tested in KMTC Kitui Campus to help the researcher to know if the questions were appropriate and assess how long it took to administer the tools. The testing was also done to verify the level of suitability of the questions to answer the research question, achieve the aims and objectives of the study, thus, a tentative model. The pilot study comprised of several components which included: determining the feasibility of the study protocol, recruitment of subjects, testing the measurement instruments (questionnaire, observation checklist, document analysis and interview) and data entry and analysis. The approach ensured easy understandability of the tools used to collect data and the required data could be gathered.

A small study carried out by the researcher to test research protocols is called a pilot study, and it tests; data collection instruments, sample recruitment strategies, and other research techniques in preparation for a larger study. Before a pilot study begins, researchers must fully understand the clear purpose and question of the study, they should also become aware of the procedures involved in the main study through the pilot study, which aids in the selection of the research method most suitable for answering the research question in the main trial (Thabane et al., 2010). It is one of the important stages in a research project and is conducted to identify potential problem areas and deficiencies in the research instruments and protocol prior to implementation during the full study. It assists in planning and modification of the main study, it can also help members of the research team become familiar with the procedures in the protocol and can help them decide between two competing study methods, such as using interviews rather than a questionnaire (Kraemer, Mintz, Noda, Tinklenberg & Yesavage, 2006).

Extant literature (text that has survived from the past to the present time, as opposed to lost work) suggests that a pilot study sample should be 10% of the sample projected for the larger parent study (Connelly, 2008). A sample size of 6 staff was used in the pilot study. This was arrived at by applying the recommendations by Connelly, (2008)

Pilot process

Observe

Researcher observed

-Recruitment of subjects

-Subjects' response

-Subjects' comments

-Any disruption in the process

Research assistant observed

-Subjects' understanding

-Subjects comments'

-Time taken to fill the

To determine the feasibility of the

1) Followed study protocol closely

To test recruitment and consent rate

Researcher tested respondent recruitment

Give eligible respondents

1) Explanatory statement

2) consent form

To pilot the measurement instrument (questionnaire)

To test data entry and analysis.

Researcher

1) Template for data entry

2) Analysis

3) Dummy table (of results)

Researcher

Any difficulties arising with data entry and

Figure 8: flow chart of the pilot study: Adopted from Thabane et al., (2010).

To determine the feasibility of the study protocol, a pilot study was conducted at Kitui MTC campus from 1st July to 30th September 2022. In this pilot, the provisional study protocol was strictly adhered to, that is, a small-scale version of the complete questionnaire, document analysis, observation, and interview were tested, from staff recruitment to data analysis. The researcher enrolled 5 teaching staff from the department of Medical Laboratory Sciences as well as the campus principal as previously indicated. Training of the research assistants had been conducted to establish their understanding of the research aims and protocol and to determine the number of research assistants needed for the study.

For recruitment of the study subjects, a participation invitation letter from the researcher was sent prior, to the campus principal requesting the invitee to kindly take part in the research study. The principal of Kitui MTC campus invited the staff for a meeting with the researcher who in turn explained the aim and the process of participating in the study.

The researcher gave adequate time to the staff to consider whether they wish to participate or not. Respondents who demonstrated their desire to participate signed the consent form which was distributed to them by the researcher assisted by the research assistants. All the said staffs demonstrated interest to participate. Afterwards, the participants who consented to participate were given the questionnaire to fill by the research assistant. The response rate was recorded by the researcher which was 100% and the research assistant observed the filling of the questionnaire process of data collection which also progressed smoothly. At this point, the campus principal was with the lead researcher carrying out the interview, which was followed by document analysis and observation of the physical facilities available in the campus.

Documents analyzed included; program curriculum, course outlines per subject, sample practical papers for final qualifying examinations for the last three (3) years, and individual subject score sheet for the practical examination. All this work was done in order of priority so as to save on time and also allowing freedom to the participants as well as the researcher and research assistants to finish the process of counter checking the questionnaires.

The measurement instrument required self-completion by the staff with the assistance from research assistants. An important factor was to ensure that the questionnaire items accurately addressed the research questions. The pilot study also tested whether the questionnaire and checklist were comprehensive and appropriate, and that the questions were well defined, clearly understood and presented in a consistent manner. Respondent information, statements and consent forms were also tested for comprehension.

The questionnaire was divided into 5 sections which were related to: a) Socio-demographic characteristics of respondents; b) application of simulation-based learning in various sections in the departments of medical laboratory sciences; c) opportunities for innovative Simulation-Based Medical Teaching and Learning to the staff; d) factors that influence the utilization of simulation-based training, and e) challenges affecting the applicability of simulation-based training. All the comments from the respondents were taken into consideration and errors if any amended accordingly

Validity is defined by Brennen (2021), as the general and reasonable level of accepting the instrument to perform a task. Two approaches of content validity and face validity were used. Content validity refers to how accurately a measuring tool captures the various aspects of the concerned study while face validity refers to the extent to which a test is subjectively viewed as covering the concept it is to measure (Keter, 2021). The questionnaire designed to collect information on application of innovative simulation-based teaching and learning in Medical Laboratory Sciences program was content and face validated through pre-testing as well as by the supervisors. Thereafter, modification and necessary adjustment was done to the questionnaire in order to suit the content validity. The suitability of the items and appropriateness of the language was determined by the supervisors' advice and input. To provide means of validation during the work of data collection and analysis, triangulation was employed (multiple sources of data, different data collection methods, and multiple methods of analysis).

According to Tenenbaum & Eklund (2007), reliability is the degree to which an instrument is dependable. To test for the reliability of the research questionnaire that was used in the study on use of simulation-based teaching and learning in Medical Laboratory Sciences program, the questionnaire was administered to some lecturers at Kitui MTC for pilot study as indicated above. Cronbach's Alpha test for reliability was done and an alpha coefficient was 0.91was obtained. The necessary adjustments were made on the questionnaire, following the responses collected to ensure that the tool was equally dependable.

3.13. Data Analysis

The data obtained included both quantitative and qualitative that was integrated sequentially. A fully mixed sequential equal status design model by Leech and Onwuegbuzie (2009) informed the design of this study. The research entailed sequential occurrence of qualitative and quantitative phases in the entire study process and with every separate participant group. Both the phases were weighted in the same way. The primary data collected was sorted and organized for ease of analyzing. All responses were edited and coded as per the various objectives before data entry.

The cohorts and their different response times were in line with the utility of the sequencing design adapted by the study. The initial phase of the study used quantitative study so as to match the first research question and related objective. The quantitative study was the starting point and the results of the data were integrated with the qualitative research data, which aimed to address the other research questions and objectives. The quantitative phase was foreseen to measure depth of the definition, construction, and implementation of simulation in colleges offering laboratory science programs. At the same time, qualitative approach was considered to help with deep investigations that allowed understanding of innovative simulation-based medical teaching and learning in laboratory science in a deeper way. In the various participant cohorts, gathering of quantitative simulation questionnaire survey, document analysis and checklist was initially done then face-to-face interviews. The implemented strategy was good for this study as it collected data that mirrored on the diverse nature of the innovative simulation-based teaching and learning. As such, a cross-sectional outlook of the analysis and interpretation that followed was obtained.

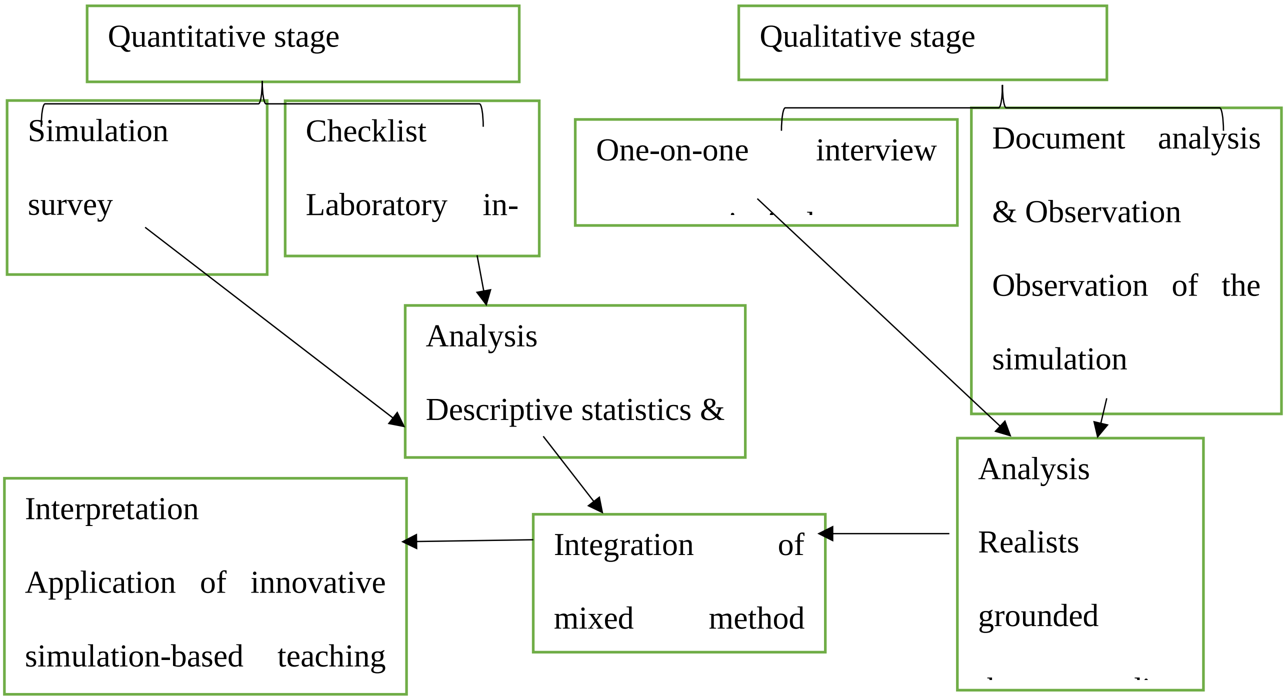

Figure 9: Study stage sequencing

The survey questionnaires contained both closed and open-ended statements which formed the quantitative data acquisition method used. Questions about demographics were used. Other questions allowed participants to explain their experiences with simulation-based teaching and learning. Qualitative data collection was done through the use of observation as well as face-to-face interviews. The interview developed a conversation that was interactive regarding the experiences of the participants with the use of simulation-based teaching and learning. As such, the interview was the main tool for qualitative design in the study. The participants were able to be deeply immersed in the interview process as a result of the interactive conversation created. The first step in the analysis was analytical coding which was expansive and immersed into participants' stories as anticipated.

The five data types were entered into a computer by a research assistant who was not involved in data collection assisted by a statistician as well as the lead researcher. Data entry was direct into the Statistical Package for Social Sciences (SPSS) program, with specific codes used for questionnaire, checklist, document analysis, interview, and observation items. Data was then analyzed using SPSS version 25. The analysis was descriptive as well as inferential, with data from all the sections being analyzed. A p-value of < 0.05 was considered statistically significant.

3.13.1 Quantitative data analysis

The quantitative data analysis frame work involved: 1) quantification of how well respondents understood and defined simulated medical laboratory experiences both actual and anticipated, 2) examination of the perspectives and opportunities for innovative simulation-based teaching and learning chosen by respondents, and 3) the factors that shaped the programs decision to implement simulation-based teaching and learning experience. The data collected was then coded accordingly in order to facilitate analysis. Descriptive statistics formed the basis of quantitative data analysis and informed the use of non-parametric statistical tests used such as Pearson chi-square ($\chi 2$) and estimation of association, Phi and Cramer's V correlation coefficients. The strength and effect size of determined correlations were also quantified. Statistical analysis provided the ‘bones’ which formed the ‘skeleton’ of this study’s iteratively evolving theoretical model which were ‘fleshed-out’ by qualitative findings.

3.13.2 Qualitative Data Analysis

The aim of qualitative analysis was to extend and build upon the quantitative findings to gain further insight into the application of innovative simulation-based teaching and learning. This analysis addressed the narrated data. The realist grounded theory methods (coding) used in this study for all qualitative data comprised three iterative and inductive phases – initial-coding (or open-coding), focused-coding, and theoretical-coding (Charmaz, 2006). Initial-coding represented the first level of analysis applied to each questionnaire open-ended questions, interview transcript, observation memo, and checklist. This involved defragmenting data through line-by-line analysis to uncover themes or concepts, and so represented initial immersion into participants’ stories (Charmaz, 2006) and observational data. At this early stage of qualitative data analysis, deeper insight and meaning of participants’ stories began to emerge.

Focused coding followed, which involved merging open-codes with collective meanings into larger categories, which gave further substance and form to participants’ stories. Focused coding also facilitated further questions about the data to gain further meaning and make analytical interpretations or abstractions (Walker & Myrick, 2006; Charmaz, 2008).

Theoretical-coding was the final stage of data analysis, and represented an advanced level of integration of the developed conceptual categories and their theoretical links. Therefore theoretical-coding was focused on specifically identified issues which represented gaps in the emerging theoretical schema which had to be filled, in order to gain substantive understanding of participants' simulation-learning experiences. Grounded theory methods enabled analysis to move away from description, and towards theory construction. Merger of mixed-methods findings was the final analytical stage.

3.13.3 Merging Quantitative and Qualitative Findings

Triangulation was a central process of this mixed-methods integration as it converged findings from both study stages through corroboration (Nastasi, Hitchcock et al., 2010; Nilsen & Brannen, 2010). Thus, triangulation represented the simultaneous display of multiple and refracted realities (Denzin & Lincoln, 2005) to result in a dense and rich (Fielding, 2012) understanding the use of innovative simulation-based teaching and learning.

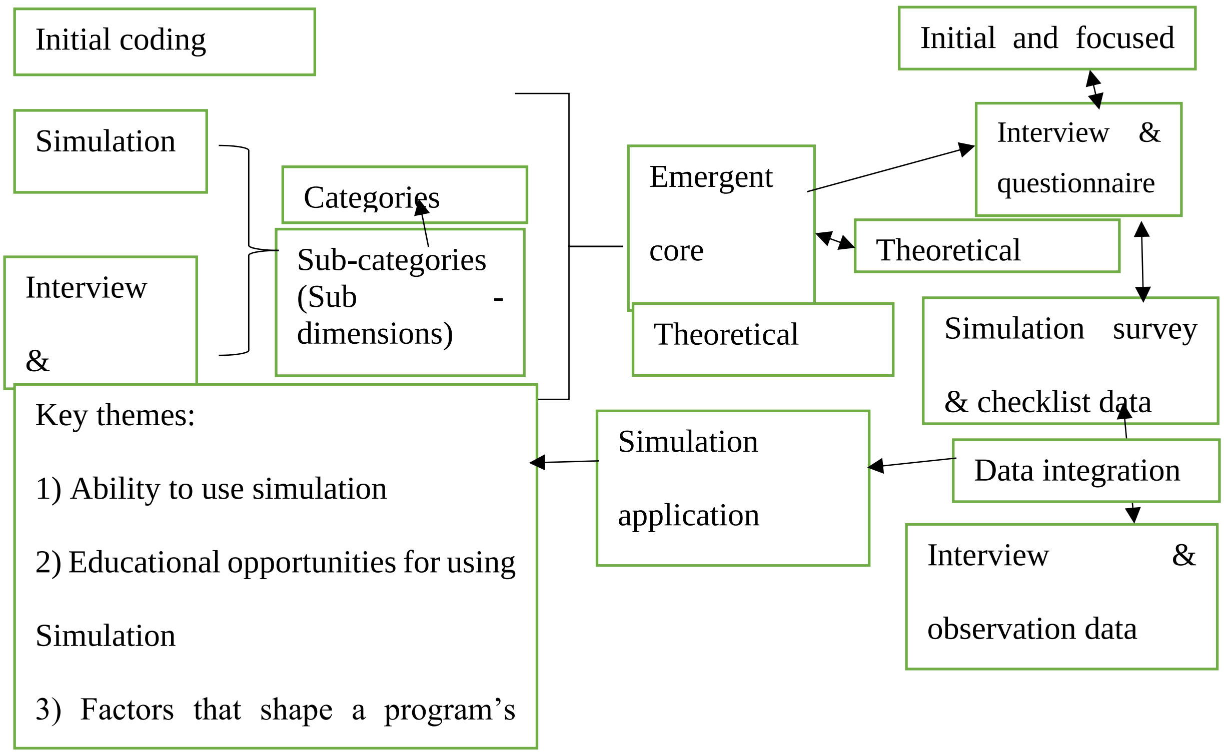

Figure 10: understanding the use of innovative simulation-based teaching and learning.

Quantitative data was further summarized using frequency counts and tables then analyzed using Pearson chi-square statistical method. The mentioned statistical analysis provided the 'bones' which formed the 'skeleton' of this study's iteratively evolving theoretical model which was 'fleshed-out' by qualitative findings. Qualitative data (which is non-numerical and unstructured) for this study was generated through text, such as open-ended responses from one-on-one interviews with campus principals, questionnaire surveys for lecturers and observational notes. Qualitative data analysis is a process of gathering, structuring and interpreting qualitative data to understand what it represents (https://getthematic.com/insights/qualitative-data-analysis/).

The method of qualitative data analysis for this study was content analysis. This method of analysis was used to identify the patterns that emerged from text, by grouping content into words, concepts, and themes. Content analysis is useful to quantify the relationship between all of the grouped content. The collected data was plotted into a spreadsheet in the SPSS software which assisted in organizing the data, grouping into broader categories and content coding. The different themes were uncovered also. Coding is the process of labeling and organizing data in such a way that one can then identify themes in the data and the relationships between these themes. To code means to identify key words or phrases and assign them to a category of meaning and analyze using descriptive statistics. All these were done using the SPSS software. Qualitative analysis was to extend and build upon the questionnaire survey and checklist findings to gain further insight into the nature of participants' application of innovative simulation-based teaching and learning experiences.

3.13.4 Mixed Methods Research - Quality Principles

Mixed-methods research attracts the study-strength determinants of both quantitative and qualitative research approaches. Janneke, Frambach et al., (2013) provided the following quality principles as a framework to assess the quality of quantitative and qualitative research in medical education: true value of evidence, applicability of evidence, consistency of evidence, and neutrality of evidence. All these quality principles were achieved in this study.

3.14. Data Presentation

After analysis, data was summarized and presented in form of frequency tables, percentages and bar graph. Non-parametric statistical tests were also used such as Pearson chi-square ($\chi 2$) and estimation of association as described in chapter four.

3.15. Ethical Considerations.

This refers to the precautions undertaken to ensure anonymity of the respondents and confidentiality of the research. Approval to carry out the study was sought from Moi University College of Health Sciences, Moi Teaching and Referral Hospital (MTRH) - Institutional Research and Ethics Committee (MU/MTRH-IREC), NACOSTI, the KMTC Research Ethics Committee, the institutions management, various offices and departments. Respondent's consent was sought prior to the study. Here, a consent form was presented to the respondents to sign if they agree to take part in the study. Consenting information included purpose of the study, benefits of the study and rights of non-participation. The respondents were also assured of their confidentiality and anonymity. All raw data was treated as confidential and availed only to the research team. The study did not involve any invasive procedures and there were no health risks involved. No individuals were identified in dissemination of findings or in any report related to this study. There were no incentives and benefits awarded to any participant enrolled in the study. The study entailed ones' voluntary participation and one was free to decline or withdraw from the study any time without victimization. The full contacts of the researcher were also included.

3.17 Chapter Summary

This chapter explained the frame-work of the study by discussing the research design, the study site, study population, sampling procedure, sample size, inclusion and exclusion criteria, research instruments, data collection procedures and methods of data analysis

CHAPTER FOUR

4.0 DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Overview

This chapter consists of data analysis, presentation and interpretation of the study findings. The chapter first presents the research results on the demographic characteristics of the respondents. This is then followed by the presentation of the data analysis according to the objectives of the study. The findings are discussed under the following titles: the institutions' ability to apply and conduct simulation laboratory sessions for their teaching and learning; the opportunities for innovative Simulation-Based Medical Teaching and Learning among teaching staff; the factors that shape a program's decision to implement simulation-based teaching and learning and what influences its application among teaching staff; and the challenges affecting the application of innovative simulation-based teaching and learning among teaching staff.

Participant demographics were first presented in section 4.2 followed by descriptive and non-parametric statistical findings in section 4.3 for the various objectives. SPSS version 25 statistical software package was used for all analysis. In total, forty-seven (n=47) Simulation Surveys were received. These contained both quantitative and qualitative data. Eleven (n=11) structured interview schedules were received which contained both quantitative and qualitative data. Eleven (n=11) checklists were received which contained qualitative data. Eleven (n=11) observation data were received which contained qualitative data and document analysis data from the campuses were obtained which were uniform across all the campuses. There was no missing data and hence none was excluded from analysis. This high response rate can be due to the fact that the lead researcher was monitoring every step and equally involved in the data collection process.

4.2. Demographic characteristics of respondents

The study included forty-seven (47) lecturers who took take part in the study. All the forty-seven (47) lecturers participated by filling the questionnaire. None of the respondents failed to avail their questionnaires back. This gave a response rate of 100% among the lecturers. To begin with, the study sought to establish the demographic characteristics of lecturers. The characteristics sought were details like gender, age, MTC Campus they are working, position they held in the department and their teaching experience in years. The findings of the study as regards to gender of the respondents were as shown in Table 2 below.

Table 2: Frequency distribution for gender among Lecturers

Gender	N	Percent	Valid Percent	Cumulative Percent
Male	35	74.5	74.5	74.5
Female	12	25.5	25.5	100.0
Total	47	100.0	100.0	

As indicated in Table 1, 35(74.5%) of the lecturers were male while 12(25.5%) were female. As such there were more male than female lecturers in the various MTC Campuses at the time of the study. From the findings, it appears that men are approximately three times as likely as women to have interest of teaching in this profession. What implication do these observations have for educational change and the application of simulations in the department of medical laboratory sciences? The findings could be attributed to applicants who apply for vacant teaching positions when advertised in the department of medical laboratory sciences. Possibly, more men expressed interest for teaching in this department and hence applied for the positions and therefore more were hired than the female. Female candidates should be encouraged to apply for gender balance among the staff within the campuses offering MLS or to at least 2/3 gender rule as stipulated in the Kenyan constitution. The mean was 1.26 with a standard deviation of 0.441.

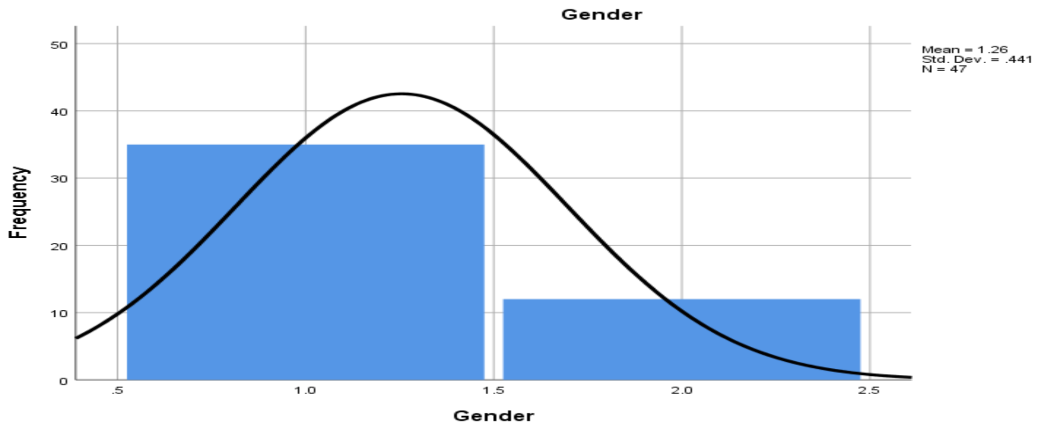

Figure 11: Distribution for gender among Lecturers

The study also sought to establish the age distribution among lecturer – respondents. Their responses were as indicated in Table 3 below.

Table 3: Frequency distribution for Age among lecturers

Age	N	Percent	Normality of Data	
32-38	1	2.1	Mean	4.30
39-45	9	19.1	Std. Deviation	.858
46-52	12	25.5	Skewness	-.845
53 and above	25	53.2	Std. Error of Skewness	.347
Total	47	100.0	Kurtosis	-.477
			Std. Error of Kurtosis	.681

As indicated by Table 3, majority, 25(53.2%), of the lecturers were aged 53 years and above.

This was followed by 46- 52 (25.5%) age bracket. This was followed by 39-45 (19.1%) age bracket and finally followed 32-38 (2.1%). The ages are well spread from 32-38 to 53 and above. Majority 53.2% are at their peak working age. This group has wealth of experience to share with the other staff. However, only 2.1% represents 32-38 years of who are relatively young and can immensely contribute to the growth of the institution although they are very few. This big percentage of the lecturers who are 53 years and above (53.2%) could advantage the institutions as they may be so much willing to share their vast experience with the other members of the academic staff because of their age and also before they retire as the retirement policy of the institution for academic staff is at 65 years.

The age of the respondents was not normally distributed but had a positive skewness of 0.845

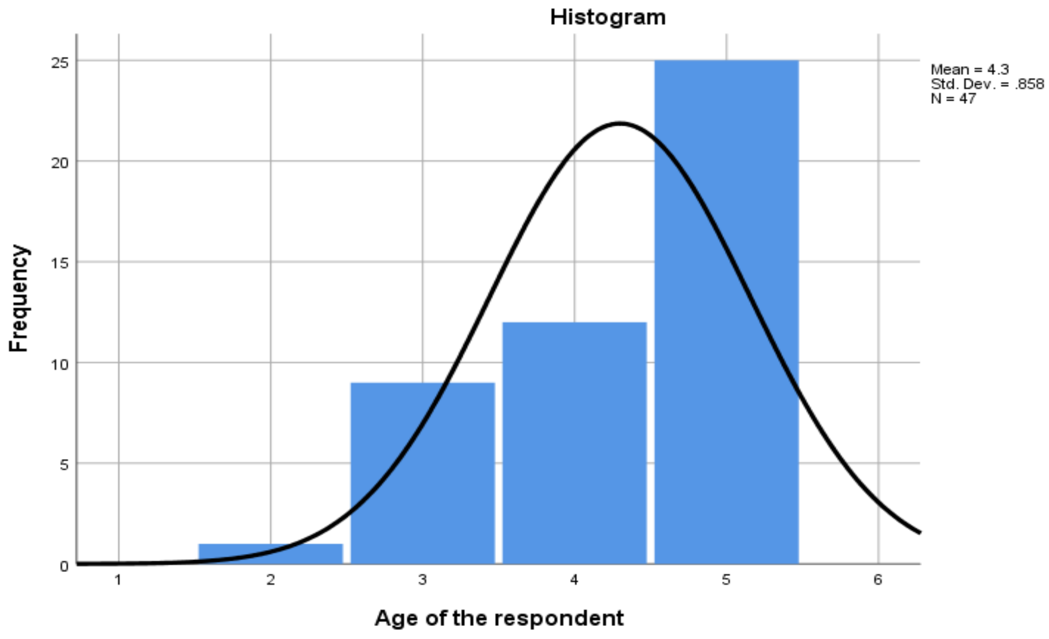

Figure 12: Age distribution of lecturers

A cross tabulation of the same was performed in order to see the picture and comparison between the gender and the age of the respondent as seen in Table below.

Table 4: Gender vs. Age of the respondents Cross-tabulation

		Age of the respondent				Total
		32-38	39-45	46-52	53 and above	
Gender	Male	1	4	7	23	35
	Female	0	5	5	2	12
Total		1	9	12	25	47

From the table, majority 37(78.7%) of the respondents were forty-six years and above. This implies that majority of the workforce in this department were of good age and able to share their extensive wealth of experience. A chi-square test was carried out to see whether there was any significant relationship between the gender and the age of the respondent which is given in Pearson Chi-Square as 0.016 ($p<0.05$) now that the female gender was seen to have less representation in this department.

Table 5: Chi-Square results on gender and age of the respondent

		Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square		10.294[a]	3	.016
Nominal by Nominal	Phi	.468		.016
	Cramer's V	.468		.016

The results showed that there was a significant relationship between gender and the age of the respondents involved in this study as given by 0.016 ($p<0.05$).

The Phi and Cramer's V model was used to test the normality of the spread of ages, and its statistics showed that these ages were normally distributed: D(47) = 0.016, $p < 0.05$, with the median of 5 years, a mean of 4.30 and a standard deviation of 0.850. This age distribution also had a positive skewness (lack of symmetry) of 0.845, which indicated ages clustered slightly towards the upper-end (slightly away from 0).

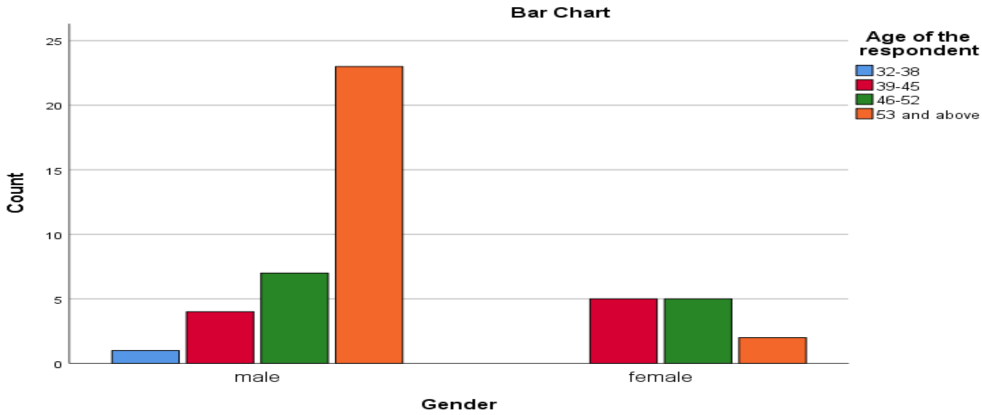

Figure 13: Comparison of the gender as well as the age of the respondents

From the bar chart, it is clearly seen that more men than females work as lecturers in the department of medical laboratory sciences and these men are of advanced age. Again, there was no female lecturer aged between 32-38 years. This may be that there was no female applicant during that time who applied or those who applied were not successful.

The research study also sought to establish the distribution of lecturer respondents according to their respective campuses. The findings were as indicated in Table 6 below.

Table 6: Distribution of lecturers across KMTC Campuses

Campus		Frequency	Percent
	Embu	4	8.5
	Nyeri	4	8.5
	Meru	4	8.5
	Machakos	5	10.6
	Nairobi	7	14.9

Nakuru	4	8.5
Kisii	4	8.5
Kakamenga	4	8.5
Lake Victoria	4	8.5
Porteritz	4	8.5
Kombewa	3	6.4
Total	47	100.0

The results in Table 6 indicate that majority, 7(14.9%), of the lecturers who took part in this study came from Nairobi campus. This was followed by Machakos campus with a percentage of 10.6%. Campuses like Embu, Nyeri, Meru, Nakuru, Kisii, Kakamenga, Lake Victoria and Porteritz had the same number of lecturers 4(8.5%) while Kombewa MTC had the least with a percentage of 6.4%. The mean, median and standard deviation for this distribution was 5.66, 5.0, and 3.192 respectively. The distribution of the staffing across campuses is relatively normal as a slight skewness of 0.215 was obtained. The slight skewness is as seen in the histogram below

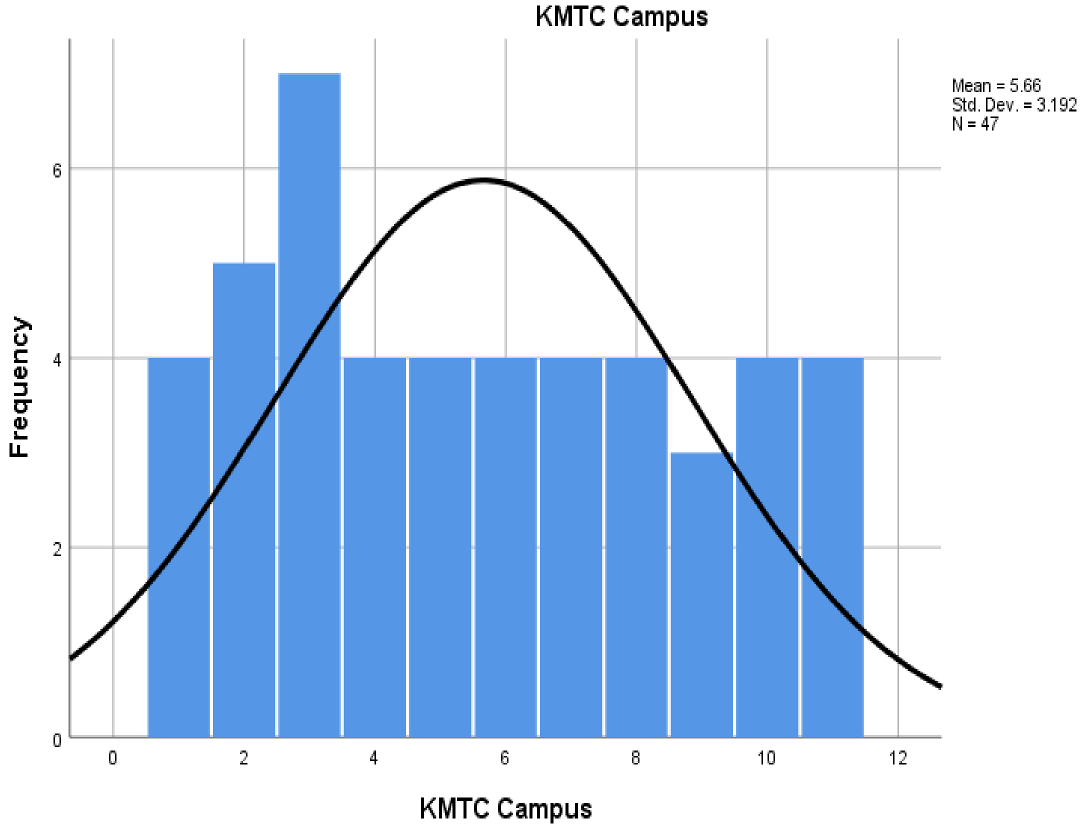

Figure 14: Staff population per KMTC Campus

Nairobi campus has a relatively big population of the lecturers. This can be attributed to the fact that it is the coordination Centre for the other campuses and hence justifies its big population. Kombewa campus is relatively young in terms of when it was started hence her infrastructure is still growing.

Having established the gender, age and staffing in various campuses, the study also sought to identify the teaching experience in years of the lecturers. Their responses to this item were as indicated in Table 7. below.

Table 7: Teaching experiences of lecturers in years

No. of years teaching experience	Frequency	Percent
5-10	6	12.8
11-15	2	4.3
16-20	7	14.9
21-25	5	10.6
26-30	9	19.1
31-35	9	19.1
36-40	9	19.1
Total	47	100.0

From the results presented in the Table 4.4, the majority, 9(19.1%), of the lecturers had served in their present positions for 26-30 years, 31-35 years and 36-40 years. In addition, 7(14.9%) of the lecturers had served for 16-20 years; 6(12.8%) had served in various campuses for 5-10 years; 5(10.6%) had served for 21-25 years. Lastly 2(4.3%) lecturers had served for 11-15 years. All the lecturers had a teaching experience of more than 3 years, therefore all KMTC Campuses offering a program in medical laboratory sciences had an experienced academic staff who were in a better position to apply innovative simulation-based medical teaching and learning as an instructional method. With thirty-two (32) out of the forty-seven (47) lecturers having served for more than 20 years is a good indication that the department of medical laboratory sciences in the KMTC campuses involved in the study has a wealth of experienced academic staff members.

The researcher sought to determine whether there was any relationship between the teaching experience of lecturers in years and their actual age. The report below was generated

Table 8: No. of years teaching experience vs. Age of the respondent Cross-tabulation

		Age of the respondent				Total
		32-38	39-45	46-52	53 and above	
No. of years teaching experience	5-10	1	5	0	0	6
	11-15	0	2	0	0	2
	16-20	0	2	4	1	7
	21-25	0	0	5	0	5
	26-30	0	0	2	7	9
	31-35	0	0	1	8	9
	36-40	0	0	0	9	9
Total		1	9	12	25	47

From the table above, majority of the respondents aged 53 years and above had worked for 26 years and above 24(51%) while those who were between 46-52 years and had worked for the same period of time were 3(6.4%). This is an indication that there was a relationship between the number of years spend in teaching experience and the age of the respondent. This was confirmed by the Chi-Square test results of 0.000 ($p<0.05$).

Table 9: Chi-Square tests

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	67.526[a]	18	.000
Likelihood Ratio	67.182	18	.000
Linear-by-Linear Association	35.169	1	.000

N of Valid Cases	47

The number of years served by the principals was not considered as an important factor because the position of the principal is a special assignment given by the Board of Directors of KMTC for a period of 3 years renewable once upon exemplary performance. By the time the study was carried out, many of the principals were serving their second year in their first term.

4.3 Data analysis as per the Specific Objectives

4.3.1 Appraising the institutions' ability to apply simulation laboratory sessions for their teaching and learning.

The first objective of the study was to appraise the institutions' ability to implement and conduct simulation laboratory sessions for their teaching and learning. To achieve this objective, the respondents were first asked how well they understood and defined simulated medical laboratory experiences both actual and anticipated and why they thought so. The scores from their responses were as indicated in Table below.

Table 10: How well do you understand, define and use simulated medical laboratory experiences both actual and anticipated

How well do you understand and define simulated medical laboratory experiences both actual and anticipated	Frequency	Percent
somehow	8	17.0
very well	38	80.9
excellent	1	2.1
Total	47	100.0

Based on the results presented in Table 3, 39(83.0%) of the lecturers indicated that they understood and defined simulated medical laboratory experiences both actual and anticipated (very well plus excellent), while 8(17.0%) of the lecturers indicated they somehow understand and define simulated medical laboratory experiences both actual and anticipated.

A cross tabulation of the same was done where an understanding of the simulated laboratory experiences and the definition of simulated medical laboratory experiences was done to compare and see whether there was a significance relationship on the two.

Table 11: How well did you understand simulated medical laboratory experiences * How well did you define simulated medical laboratory experiences Cross tabulation

		How well did you define simulated medical laboratory experiences			
		excellent	very well	somehow	Total
How well did you understand simulated medical laboratory experiences	Excellent	1	0	0	1
	Very well	0	38	0	38
	Somehow	0	0	8	8
Total		1	38	8	47

From the table above, 1 respondent reported to have excellent understanding and definition of simulated medical laboratory experiences, 38 respondents reported to very well understand and define simulated medical laboratory experiences, while 8 respondents reported to somehow understand and define simulated medical laboratory experiences. This is an indication that there was a significant relationship between understanding simulated medical laboratory experiences and defining simulated medical laboratory experiences as it was confirmed by the Chi-Square test results of 0.000 ($p<0.05$). This rejects the null hypothesis that teaching staff in the department of medical laboratory sciences do not understand and define simulated medical laboratory experiences both actual and anticipated and hence accepts the alternative hypothesis that teaching staff in the department of medical laboratory sciences understand and define simulated medical laboratory experiences both actual and anticipated. This is represented in the table below.

Table 12: Chi-Square Test results

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	94.000[a]	4	.000
Likelihood Ratio	52.186	4	.000
Linear-by-Linear Association	46.000	1	.000
N of Valid Cases	47		

The lecturers were asked why they thought they had good understanding and definition of simulated medical laboratory experiences. Their responses were: *it is outlined in the teaching curriculum and course outlines, it is a useful teaching strategy, it is an important requirement by the regulatory body (KMLTTB)*. This was also transformed into quantifiable results to be compared with the quantitative finding. The results of the transformed qualitative data were represented as shown in the table below.

Table 13: Why do you think you very well understand and define simulated medical laboratory experiences both actual and anticipated?

Why do you think so	Frequency	Percent
It is outlined in the teaching curriculum and course outlines	29	61.7
It is a useful teaching strategy	7	14.9
It is an important requirement by the regulatory body (KMLTTB)	11	23.4
Total	47	100.0

As indicated in the research findings, majority 29(61.7%) of the respondents said they thought so because simulation was well outlined in the teaching curriculum and in all their course outlines. These were followed by 11(23.4%) who reported that they thought so because simulation-based teaching and learning was an important requirement by the regulatory body (KMLTTB) for all medical laboratory students before they go to the clinical site and handle the actual patients during their clinical experience. Lastly, 7(14.9%) of the respondents indicated that simulation-based teaching and learning was a useful teaching strategy that they used after they had done the theory so that they can reinforce student understanding.

This was confirmed during document analysis where the teaching curriculum and the course outlines were seen to contain the aspect of simulation "*this course is designed to enable the student acquire appropriate knowledge, skills and attitudes to enable the learner perform effectively as a medical laboratory technologist at all levels of the universal Health care system. The technologist will be empowered to promote health, prevent illness, manage and rehabilitate the individual, the family and community that may be afflicted by ill health.*

The teaching/learning methods include those most appropriate for adult learners. Such methods are community-based problem solving, participatory methods which are student centered, which include: small group discussion, overview and illustrated lectures, problem solving, role play, simulations, demonstrations, independent study, assignments, class/practical's, projects, tutorials, field/clinical attachment, field visits". From the course curriculum, page 1, (Kiptoo, 2020, page 4)

The study also wanted to know whether medical laboratory educators and current practices in simulation-based learning were considered to be a valuable resource for this study. The responses from the lecturers were documented as shown in the table below.

Table 14: Medical laboratory educators and current practices in simulation-based learning are considered to be valuable resources

Medical laboratory educators and current practices in simulation-based learning are considered to be valuable resources for this study. What is your take?	Frequency	Percent
True	47	100.0

The respondents reported that educators as well as current practices were of value.

All the forty-seven (47) lecturers reported that according to them, medical laboratory educators and current practices in simulation-based learning were valuable resources for this study. This was so because of the changes observed in technology as well as the current patient care practices in the hospital. When asked whether they had simulation laboratories where they have medical laboratory educators, and apply current practice, their responses were as indicated below:

Table 15: Simulated laboratories as part of curriculum for use in teaching and learning

Do you have simulated laboratories in your institution as part of your curriculum which you use for teaching and learning

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	45	95.7	95.7	95.7
No	1	2.1	2.1	97.9
Not sure	1	2.1	2.1	100.0
Total	47	100.0	100.0	

As seen in this table, 45(95.7%) of the lecturers said they had simulated laboratories in their institutions as part of their curriculum which they use for teaching and learning, while 1(2.1%) reported of not having simulated labs as part of their curriculum and 1(2.1%) reported of not being aware whether they had simulated laboratories as part of their curriculum for use in their teaching and learning. When asked what type of activities were simulated in the simulation labs, their responses were as follows *"I simulate sample collection process such as venous blood sample collection, analysis of samples such as thick and thin blood smear, analysis of sputum using GeneXpert technology, preparation of peripheral blood smear for blood cell count"*. This was quantitatively analyzed to see the counts for each category and presented as follows in the table below

Table 16: Activities simulated in the medical laboratory simulation center

What types of activities are simulated in the simulation medical laboratory?

	Frequency	Percent	Valid Percent	Cumulative Percent
sample collection	42	89.4	89.4	89.4
analysis of samples	5	10.6	10.6	100.0
Total	47	100.0	100.0	

It is seen from their findings that 42(89.4%) of the respondents said that simulation is mainly used in collecting various samples from the patients while 5(10.6%) mentioned analysis of samples in the laboratory. The researcher was also interested in knowing whether there was a significant difference or significant association among those who said they understood and defined simulated medical laboratory experiences both actual and anticipated as well as those who said that they had simulated laboratories in their institution as part of their curriculum which they used for teaching and learning, and it was found out that there was a statistically significant association as it was confirmed by the Chi-Square test results of 0.000 ($p<0.05$) as presented in the tables below

Table 17: Chi-Square Tests results for association

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	51.961[a]	4	.000
Likelihood Ratio	13.286	4	.010
Linear-by-Linear Association	.368	1	.544
N of Valid Cases	47		

This further helped the researcher to reject the null hypothesis and accept the alternative hypothesis.

When asked how these experiences or activities were constructed in the laboratory for their effective use, their responses were as follows *"they are constructed by a simulation instructor, they are constructed by following standard operating procedures, am not aware"*. This was quantitatively analyzed to see the counts for each category and presented as follows in the table below

Table 18: Construction of simulated laboratory experiences

How these simulated lab experiences were constructed	Frequency	Percent
By a simulation instructor	30	63.8
SOP	12	25.5
not aware	5	10.6
Total	47	100.0

There were varied reaction as to how the simulated laboratory experiences were constructed. From the above table, 30(63.8%) of the respondents said that these experiences were constructed by the simulation instructor who is an individual who plans, prepares and implements student simulation laboratories according to the curriculum and the course outlines in use by the lecturers while 12(25.5%) said that the simulated experiences were constructed according to the standard operating procedures. Of the forty-seven lecturers involved in this study, 5(10.6%) reported that they were not aware of how these simulated experiences were constructed. These may be the academic instructors who may be involved in the students' lectures and classes but not directly involved in the simulation laboratories. The same dilemma was also not clear from the curriculum and the course outline as the two documents did not show or explain who is responsible for constructing the simulated laboratory experiences.

The form/s in which simulation-based learning experiences take during teaching and learning process as reported by the respondents is as shown in the table below.

Table 19: Form/s simulation-based learning experiences take during teaching and learning

What form/s does your simulation-based learning experiences take during your teaching and learning?	Frequency	Percent
all of the above	31	66.0
role play, case studies, demonstrations actors, mannequins,	16	34.0
Total	47	100.0

Based on the results presented on table 13, 31(66.0%) reported that all the listed simulation-based learning experiences listed were applicable during their teaching and learning. The listed forms included; role play, videotaped interactions, case studies/problem-based learning, demonstrations, computer-based learning modules, online activities, standardized patients (actors), virtual reality applications and mannequins or plastic body parts. The rest of the respondent 16(34.0%) reported that, during their teaching and learning, the simulation-based experiences they used included role play, case studies, demonstrations, actor patients as well as mannequins. At least all the respondents used some form of simulation-based learning experience.

When asked what they used the experiences for, the respondents reported that simulations have been advocated for preparing the students for anticipated events such as the ones indicated in the table below.

Table 20: Uses of simulated medical laboratory experiences

What do you use these simulated medical laboratory experiences for?	Frequency	Percent
teaching and assessing students	34	72.3
research, assessment and teaching of students	13	27.7
Total	47	100.0

This table represents reports from the respondents on simulated experiences.

From this table, 34(72.3%) reported that they used simulated laboratory experiences *for "teaching and assessing student learning".* This is to mean that they see simulation-based learning as an ideal way to prepare students for the clinical environment and also as a means of evaluating student's clinical deficiencies.

Another group of respondents 13(27.7%) reported that they used simulated laboratory experiences *for "research, assessment and teaching of the students"*. From the responses given in the table, it can also be said that all the respondents use simulated laboratory experiences for teaching and assessing student learning to enable them give the students credentials or grades. Even though assessment of student learning was widely mentioned by the respondents, the lecturers highlighted several inconsistencies and inadequacies regarding the assessment methods used in the program.

In contrast to the current six-monthly assessment, one lecturer noted, "It (assessment) can be held after 2 months, or it can be divided department-wise. Furthermore, laboratory in-charges emphasized the importance of providing comprehensive feedback "rotating students in each department should be allowed to evaluate that department once their rotation ends," a laboratory in-charge remarked.

The features considered to be essential for the implementation of effective simulation in the department of medical laboratory were listed for the respondents to rate whether they were not essential, essential, essential to some extent or very essential. Their responses are given in the table below.

Table 21: Outlined features to be considered for the implementation of effective simulations.

Essential feature	Not essential	Essential	Essential to some extent	Very essential	Overall mean	SD
Relevance to practice		6(12.8)	18(33.3)	23(48.9)	3.36	0.705
Foundations in educational theory	1(2.1)	8(17.0)	5(10.6)	33(70.2)	3.49	0.856
Resource support		4(8.5)	26(55.3)	17(36.2)	3.64	0.640
Curricular flexibility and integration		4(8.5)	9(19.1)	34(72.3)	3.28	0.615
Appropriate staff development	3(6.4)	4(8.5)	20(42.6)	20(42.6)	3.21	0.858
Repetitive practice		4(8.5)	20(42.6)	23(48.9)	3.40	0.648

Range of difficulty levels		5(10.6)	29(61.7)	13(27.7)	3.17	0.601
Multiple learning strategies		4(8.5)	8(17.0)	35(74.5)	3.66	0.635
Representation of clinical variation		4(8.5)	10(21.3)	33(70.2)	3.62	0.644
Individualized learning	1(2.1)	6(12.8)	8(17.0)	32(68.1)	3.51	0.804
Defined outcomes or benchmarks		2(4.3)	8(17.0)	37(78.7)	3.74	0.530
Simulator validity		7(14.9)	19(40.4)	21(44.7)	3.3	0.720
Overall mean and SD					3.465	0.688

The outlined features were considered for the implementation of effective simulations. They included; relevance to practice, foundations in educational theory, resource support, curricular flexibility and integration, appropriate staff development, repetitive practice, range of difficulty levels, multiple learning strategies, multiple learning strategies, representation of clinical variation, Individualized learning, defined outcomes or benchmarks and simulator validity. Majority the respondents reported that all these features were essential to some degree in their institutions and hence they considered them to be essential for the implementation of effective simulation. A small percentage, 1(2.1%), 3(6.4%) and 1(2.1%) reported that Foundations in educational theory, Appropriate staff development as well as Individualized learning features were not essential for the implementation of effective simulation.

Descriptive statistics for essential features for the implementation of effective simulations revealed an overall mean score of 3.465 (SD = 0.688). This shows a positive perception on the application of simulations among the lecturers. Defined outcomes, as an essential feature, had the highest mean value (3.74) indicating that simulations brought about well-defined outcomes to the lecturers as well as to the students.

When the respondents were asked whether simulations should be carefully crafted to include instructional features, guided experiences, performance measurement, diagnostic feedback, and a relevant match to the environment being simulated, they respondent as tabulated in the table below

Table 22: Other features to be considered when crafting simulations

Feature	True n (%)	False n (%)	Not sure n (%)	Undecided n (%)	Total
Instructional feature	47(100)				47
Guided experiences	47(100)				47
Performance measurement	44(93.6)	1(2.1)	2(4.3)		47
Diagnostic feedback	44(93.6)	1(2.1)	2(4.3)		47

A relevant match to the environment being simulated	40(85.1)	2(4.3)	4(8.5)	1(2.1)	47

The respondents also reported on how they prepared the simulated experiences.

When the respondents were asked whether simulations must be carefully crafted to include instructional features, guided experiences, performance measurement, diagnostic feedback, and a relevant match to the environment being simulated, forty-seven 47(100%) reported that it was true that simulations were well crafted in their institution to cater for instructional features as well as guided experiences. Forty-four 44(93.6%), 1(2.1%) and 2(4.3%) reported true, false and not sure for performance measurement and diagnostic feedback respectively. The respondent also agreed to the fact that simulations should be crafted to include a relevant match to the environment being simulated where 40(85.1%), 2(4.3%), 4(8.5%) and 1(2.1%) reported true, false, not sure and undecided respectively. From the results, it can clearly be concluded that the respondents agreed with the view that simulations must be carefully crafted to include instructional features, guided experiences, performance measurement, diagnostic feedback, and a relevant match to the environment being simulated with a very small fraction having a different view.

4.4 Analyzing the opportunities brought about by simulation as an innovative strategy as used for teaching and learning.

The second objective of the study was to determine the opportunities for innovative simulation-based medical teaching and learning among teaching staff.

Table 23: Perspectives and learning opportunities for innovative simulation-based teaching and learning among teaching staff

Perspectives and opportunit	Strongly agree	Agree	Strongly disagree	disagree	SD	Total
Fostering team-based approaches and opportunities for longitudinal monitoring	12(25.5)	35(74.5)			1.26	0.441
Providing a platform for standardized education and assessment of learners	18(38.3)	28(59.6)		1(2.1)	1.43	0.542
Promoting uniformity of curricula	23(48.9)	22(46.8)		2(4.3)	1.57	0.580
Helping to develop critical thinking	23(48.9)	23(48.9)		1(2.1)	1.53	0.546
Promoting patient safety	28(59.6)	16(34.0)		3(6.4)	1.72	0.579
Ensuring exposure to both rare and common events	24(51.1)	18(38.3)		5(1.6)	1.72	0.649
Promoting task repetition for performance improvement	7(14.9)	40(85.1)			1.15	0.360

Potentially accelerating acquisition of expertise over time	16(34.0)	31(66.0)	1.34	0.479
Allowing assessment of psychomotor and interpersonal skills	38(80.9)	9(19.1)	1.81	0.398
Providing opportunity for structured reflection through debriefing	37(78.7)	10(21.3)	1.79	0.414
Opportunity for assessment	35(74.5)	12(25.5)	1.74	0.441
Potential for capturing behaviors in contexts similar to actual practice	31(66)	16(34)	1.66	0.479
Setting is reproducible	27(57.4)	20(42.6)	1.57	0.500
Simulation allows measurement of skills such as communication and professionalism	30(63.8)	17(36.2)	1.64	0.486
Opportunities to improve technical, motor, communication, diagnostic and decision-making skills	15(31.9)	32(68.1)	1.32	0.471

Cumulative Mean and SD	1.55	0.491

These were the educational opportunities identified by the lectures.

To achieve this objective, the respondents were first asked to tick in the relevant box, the perspectives and opportunities brought about by innovative simulation-based medical teaching and learning among teaching staff in medical laboratory sciences. The scores from their responses were as indicated in Table below.Almost all the respondents agreed that the suggested opportunities above had been brought about by innovative simulation-based learning. Only very few disagreed on a few of some opportunities as seen from the table 23 above.

The opportunity for assessment is seen as one of the major advantages for medical simulation. It is also noted in particular that simulation-based learning has the potential for capturing behaviors in contexts similar to actual practice. Other distinct opportunity is in the fact that the setting is reproducible and that simulation allows measurement of skills such as communication and professionalism, which are otherwise difficult to evaluate.

Other positive features for simulation-based learning in medical laboratory sciences as reported by the respondents are the fact that it enables them to earn *Continuous Professional Development (CPD)* points as well as enabling them to use *case scenarios* in their facilitation.

The narrative on what some respondents said include: “Provision of an opportunity to practice rare practices like animal dissection, inoculations, a culturing method for viruses”, “preservation of parasites such as trypanosomes”, “use clinical scenarios”, “opportunity for making teaching and learning easier and more efficient”.

Some respondent said that simulation-based learning helps in facilitating ongoing integration of theory and practice, creating opportunities for learning professional language and participating in

Inter-professional and teamwork-based activities as well as provision of feedback as alluded by a respondent who said that; *"simulation-based teaching and learning makes the whole process of teaching skills and attitude easier".*

Descriptive statistics for perspectives and learning opportunities for innovative simulation-based teaching and learning among teaching staff reveal an overall mean score of 1.55 (SD = 0.41). This shows a positive perception because the overall mean is towards agreement for the staff agreed that these were true concerning the perspectives and learning opportunities for innovative simulation-based teaching and learning among teaching staff. The perspective on allowing assessment of psychomotor and interpersonal skills had the highest mean value, indicating that the lecturers saw this perspective as an important opportunity for using simulations.

When the respondents were asked on the perspectives of which simulations in health professions education and in MLS in particular have been criticized, they had all this to say as seen in the table below

Table 24: The negative side of Simulations

Critiques	True	False	Total
Their use of costly resources	47(100)		47(100)
Faculty may be resistant to new teaching strategies required for simulation	39(83.0)	8(17.0)	47(100)

Simulations create high demands for infrastructure support in terms of implementation and sustainability	45(95.7)	2(4.3)	47(100)
participants may find simulated environments intimidating and stressful	35(74.5)	12(25.5)	47(100)
There is also the danger of fragmentation of tasks	42(89.4)	5(10.6)	47(100)

From their response, the respondents agree that simulations in health professions education have their negative sides as shown by several pros and cons indicated above. From their responses, 47(100%) of the respondents agreed that simulations are criticized due to their use of costly resources and the lack of a research foundation to validate their use; 45(95.7%) of the respondents reported that simulations create high demands for infrastructural support in terms of implementation and sustainability; 42(89.4%) of the respondents reported that, there is also the danger of fragmentation of tasks; 39(83.0%) of the respondents reported that faculty may be resistant to new teaching strategies required for simulation; while 35(74.5%) of the respondents reported that the participants (students) may find simulated environments intimidating and stressful. From their responses, it is true that simulation-based teaching and learning has been criticized from a number of perspectives even in the department of MLS across all the KMTC campuses offering medical laboratory sciences.

Table 25: Perspectives affecting the use of simulations

	Their use of costly resources	Faculty may be resistant to new teaching	Simulations create high demands for infrastructure support in	participants may find simulated environments	There is also the danger of fragmentation of tasks

		strategies required for simulation	terms of implementation and sustainability	intimidating and stressful	
N	Valid	47	47	47	47	47
	Missing	0	0	0	0	0
Mean		1.00	1.17	1.04	1.26	1.11
Std. Deviation		.000	.380	.204	.441	.312
Variance		.000	.144	.042	.194	.097
Std. Error of Skewness		.347	.347	.347	.347	.347
Std. Error of Kurtosis		.681	.681	.681	.681	.681

The use of simulation experiences were extensively criticized by the staff in this department.

Although simulations were really applied in the department of medical laboratory sciences, their negative side as seen and perceived by the same staff seems to outweigh their significance for their application as a teaching and learning strategy as shown from the table above, because there was a positive skewness (0.347) and kurtosis (0.681) on the critics of simulations use. So, the question in the mind of the researcher is, what was motivating these staff to still apply a strategy which seems to have nothing to write home about. This led to the question as to what was the driving force behind their use in this department as it is explained below.

4.4.4 Driving forces behind the use of simulations

When the respondents were asked what they thought was the driving force behind the use of simulation-based teaching and learning in the department of medical laboratory sciences or the major reasons for the implementation of simulations for teaching in health professions education, they gave the responses as presented in the table below: -

Table 26: Driving forces behind the use of simulation-based learning in MLS

Driving forces	Frequency	Percent
Safety of students and patients	6	12.8
New technology, changing trends in disease occurrence, public awareness on the need for true diagnosis	8	17.0
Medical lab science is dynamic, need for higher skills and automation	10	21.3
Emerging technologies, keeping abreast of global trends in MLS	2	4.3
Limited hospital staff, demand from regulatory bodies and prospective employers	9	19.1
Shift from long hospital stay by patients to short or no hospitalization, new pandemics	12	25.5
Total	47	100.0

These were the driving forces justifying the use of simulation in this department.

The results in table 26 indicated that 12(25.5%) said their driving force was mainly due to shift from long hospital stay by patients to short or no hospitalization, new pandemics; 10(21.3%) was due to Medical lab sciences is dynamic, need for higher skills and automation; 9(19.1%) was due to limited hospital staff, demand from regulatory bodies and prospective employers, new technology, changing trends in disease occurrence, public awareness on the need for true diagnosis; 6(12.8%) was due to safety of students and patients and 2(4.3%) was due to emerging technologies as well as keeping abreast of global trends in MLS

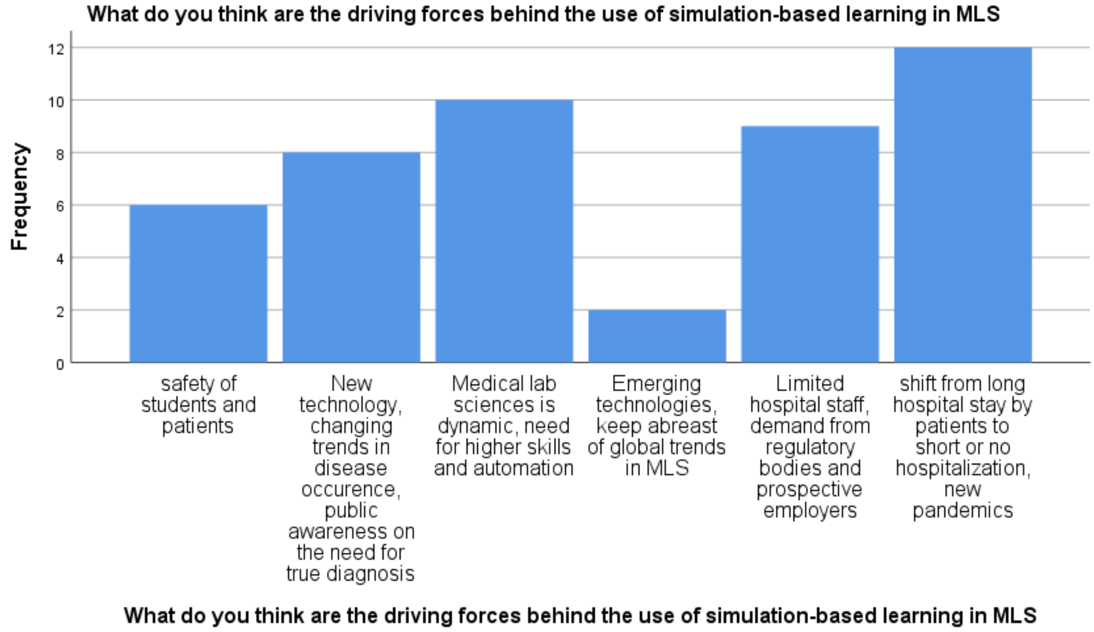

Figure 15: Driving forces behind the use of simulation-based learning in MLS

This figure explains further the distribution of the driving forces from the most key downwards.

4.5 Establishing the factors considered by implementers in using simulations for their teaching and learning

The third objective of the study was to establish the factors that shape and influence a program’s decision to implement and apply simulation-based teaching and learning. Their responses were as shown in table 27 below: -

Table 27: Factors that shape a program’s decision to implement simulation-based teaching and Learning

Factors that shape and influence a program's decision to implement and apply simulation-based teaching and learning	Strongly agree	Agree	Strongly disagree	Disagree	Total
Educational validity	37(78.7)	10(21.3)			47
A means of remedying deficiencies in troubleshooting skills	34(72.3)	12(25.5)	1(2.1)		47
For assessing competency among practitioners	34(72.3)	11(23.4)	1(2.1)	1(2.1)	47
Valuable tool for permitting students to become familiar with the clinical environment	23(48.9)	22(46.8)	1(2.1)	1(2.1)	47
As a means to decrease teaching costs and increase access to laboratories	20(42.6)	20(42.6)	3(6.4)	4(8.5)	47
Difficulties in finding and retaining clinical sites that will train our students	7(14.9)	29(61.7)	3(6.4)	8(17.0)	47
The relevance of skills gained in a simulation at the educational institution	27(57.4)	13(27.7)	2(4.3)	5(10.6)	47
Loss of opportunities for professional socialization that	19(40.4)	18(38.3)	3(6.4)	7(14.9)	47

occur within the authentic environment					
For employers and students mutual 'sizing up' prior to employment	28(59.6)	12(25.5)	2(4.3)	5(10.6)	47
Working with up-to-date techniques and instrumentation	23(48.9)	22(46.8)	2(4.3)		47
Appreciating the rhythm and challenges of real-life laboratory workflow and the strategies for addressing them	11(23.4)	34(72.3)	1(2.1)	1(2.1)	47
Gaining a sense of contributing to patient well-being	8(17.0)	38(80.9)		1(2.1)	47
The transferability of technical skills gained through simulation to the workplace	33(70.2)	12(25.5)	1(2.1)	1(2.1)	47
The growing construction of clinical education is a 'burden' that must be shifted from clinical sites	17(36.2)	21(44.7)	3(6.4)	6(12.8)	47

These were the significant factors that made the staff use simulations.

From the results obtained, most respondents agreed that the listed factors really shape and influence program's decision to implement and apply simulation-based teaching and learning indicating that they were part of the considerations they put in place when they thought of implementing simulations in their various institutions with a few having different opinion as seen from the table.

Educational validity seems to have been an afterthought in the adoption of simulation-based learning, because 100% of the respondent agreed to it with 37 out of 47 respondents strongly agreeing. The respondents also reported that simulation-based learning effectively helps students learn skills they can apply on real patients or real-life situations, helps increase self-confidence on the students and lecturers as well as making teaching and learning easy. The respondents highlighted key program features, including strengths such as a balance between theoretical and practical exposure.

One lecturer articulated, "This is a very balanced program; it includes both theoretical and practical exposure." while a principal said, “I don’t think any other organization here is doing this on a similar level where student technologists get to rotate in all sections and receive specialized training.”

Principals noted the program’s dual benefits for both students and the organization, as one of them remarked, "When we train our students according to our standards, protocols, and policies, they benefit a lot from everything they have learned here, and our organization benefits in the way that when these students get fixed, they already know everything." One of the HoD highlighted that “the academic background of the faculty is also a source of innovative ideas”.

The respondents were also asked about the simulated activities that are directly applicable to MLS and particularly in their institution, the following was a list of simulated activities they voiced out:-*“sample collection, analysis of specimen, drug sensitivity testing and culture, media preparation, teaching on internal organs especially anatomy and physiology, dissection, cancer cell and their staging, tissue* *processing, during practical examination, patient's response during sample collection, dispatch of results, hands-on practice on any theory given, and simulation of vectors and parasites pathogenic to humans" (Respondent, 2022).*

One respondent said "the simulated activities directly applicable in my institution include: - formal ether concentrate method to the slides, getting mosquitoes and demonstrating its parts for the purposes of identification" (Respondent, 2022).

The respondents also reported on the increased use of simulation in MLS education and they alluded that their use was mostly driven by *"accreditation of educational programs and standardization of graduate competence"*. Other reasons they highlighted included *"changes in the medical field, national portability of credentials and economic concerns" (Respondent, 2022)*. The study also sought to understand whether the respondents used simulation models in their departments. Their responses were as tabulated in the table below: -

Table 28: Simulation models used in MLS

Simulation models	Frequency	Percent
mannequins, lab equipment and patient actors	32	68.1
lab equipment	4	8.5
Computers	1	2.1
mannequins only	8	17.0
no model	2	4.3
Total	47	100.0

Respondent reported that they had used some form of simulations in their department. From the table, 32(68.1%) of the respondents reported using mannequins, laboratory equipment and patient actors, 1(2.1%) of the respondents reported using computerized virtual simulators. 2(4.3%) of the respondents reported of not using any form of simulation model. This can be seen as a lack in the standardization and uniformity in teaching and learning by the lecturers.

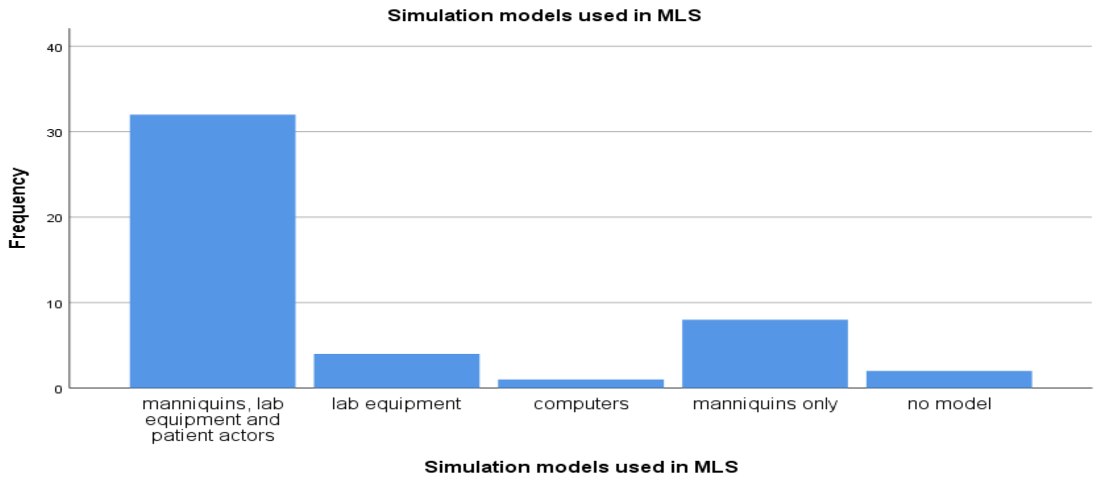

Figure 16: Simulation models used in MLS

Mannequins, lab equipment and patient actors are the most common simulation models used in medical laboratory science department.

4.6 Examining the challenges affecting the application of innovative simulation-based teaching and learning among teaching staff

The fourth objective of the study was to examine the challenges affecting the application of innovative simulation-based teaching and learning among teaching staff. To achieve this objective, the respondents were given the example of challenges suggested to influence simulation-based teaching and learning. They were required to tick those that were applicable to their institutions. Their responses were as shown in the table below: -

Table 29: Challenges affecting the application of innovative simulation-based teaching and learning.

Challenges affecting the application of simulation-based teaching and learning	Strongly agree	Agree	Strongly disagree	Disagree	Total
Issues of professionalism and certain skills	32(68.1)	11(23.4)		4(8.5)	47
Simulations are demanding for instructional staff	23(48.9)	23(48.9)		1(2.1)	47
Simulations are resource-intensive (funding, equipment, specimens, space and scheduling and administrative support	34(72.3)	12(25.5)		1(2.1)	47
Some aspects of laboratory work are difficult or impossible to simulate	19(40.4)	25(53.2)	2(4.3)	1(2.1)	47
The quality of the learning experience may be uneven	15(31.9)	28(59.6)		4(8.5)	47

From the results obtained, the respondents agreed that all the challenges suggested also applied in their institutions as far as simulation-based teaching and learning is concerned. Their responses were as follows: issues of professionalism and certain skills 43(91.5%), simulations are demanding for instructional staff 46(97.9%), simulations are resource-intensive (funding, equipment, specimens, space and scheduling and administrative support 46(97.9%), some aspects of laboratory work are difficult or impossible to simulate 44(93.6%) and the quality of the learning experience may be uneven 43(91.5%). The respondents were also requested to list any other challenge that they encountered in their institution.

Some of the challenges cited were: "untrained staff on simulation-based teaching in MLS, lack of adequate infrastructure, poor internet strength, lack of enough models for simulation, lack of standard specimens due to complex specimen collection procedures for some specimens as well as instability of analytes when specimens are stored for long and Instability of power (electricity)" (Respondent, 2022).

The respondents were asked to rate the factors considered when selecting activities to be simulated which are viewed as solutions to the challenges of simulation-based teaching and learning application. Their responses were documented as shown below:

Table 30: Factors considered when selecting activities to be simulated which are seen as solutions to the challenges of simulation-based learning application

Factors considered when selecting activities to be simulated in MLS	Strongly agree	Agree	Strongly disagree	Disagree	Total
The complementarity of academic/clinical setting: for example, activities that cannot be carried out in the clinical site	24(51.1)	19(40.4)	3(6.4)	1(2.1)	47
Commonality: routine procedures with relevance to all clinical sites	32(68.1)	14(29.8)	1(2.1)		
Program priorities: for example, established competency-based objectives	32(68.1)	15(31.9)			

Repetition: activities that need time for students to practice repeatedly	22(46.8)	25(53.2)			
Availability of resources: equipment, samples, supplies, space, instructors, support & education for staff	10(21.3)	34(72.3)	3(6.4)		
The needs of clinical partners for students with specific skills	35(74.5)	11(24.4)		1(2.1)	
The validity of the learning experience: its potential for authenticity, the likelihood of minimal compromise to quality of the student experience, evidence of effectiveness relative to the effort and cost involved	31(66)	12(25.5)	1(2.1)	3(6.4)	47

Solutions to the challenges encountered when using simulation for teaching and learning.

From the results obtained, the respondents agreed that the suggested factors should be considered when selecting activities to be simulated because they are also solutions to the challenges of simulation-based teaching and learning application. A small percentage 11(24.4%) of the respondent had a different opinion on some of the factors. All the respondents agreed that Program priorities: for example, established competency-based objectives as well as Repetition: activities that need time for students to practice repeatedly were important factors to consider when selecting activities to be simulated in MLS.

The respondents were also asked how they evaluate the effectiveness of simulated laboratory experiences in their institutions. The respondents alluded to the following: "*We give questionnaires (google forms) to the MLS graduates to evaluate the effectiveness of the whole process of simulation since they joined the institution and also internal audit", "Checklist for program evaluation is given to the educators and* students *at the end of the course" (Respondent, 2022).*

Majority of the respondents just said that simulated laboratory experiences in their institutions can "be very effective if fully implemented and done well, very effective due to the opening of the phlebotomy laboratory, when assessing our students on the practical bit of our course, the student fill the student feedback on learning checklist and also end of program evaluation by students and lecturers, return demonstration by students, use of observed practice forms as well as standard operating procedures" (Respondent, 2022).

It can be well concluded that the effectiveness of simulated laboratory experiences is evaluated in most of the institutions offering medical laboratory sciences even though some lamented of limited utilization due to lack of resources. This brings about lack of uniformity in teaching and learning. The clinical instructors/lab in-charges were as well given their checklist to fill regarding the state of their simulation laboratories in their various institutions and their response is as given below:

Table 31: Checklist for clinical instructors and lab in-charges

Physical facilities					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	All (1-4)	3	27.3	27.3	27.3
	2-4	7	63.6	63.6	90.9
	1 & 2	1	9.1	9.1	100.0
	Total	11	100.0	100.0	

The physical facilities included 1. Phlebotomy lab, 2. Demonstration lab, 3. Skills lab, 4. Computer lab. Majority of the respondents 7(63.6%) said that the physical facilities present in their institutions included demonstration lab, skills lab and computer lab. None of the respondents reported having no physical facility. This is to mean that some form of simulation-based teaching and learning was already taking place in their institutions.

One of the laboratory in-charge added to the discussion by stating "Ideally, we should have a skill lab because the technologist who is responsible for patient reporting is also responsible for teaching the trainee, so it is understandable that they prioritize the patient." (Laboratory in-charge, 2022). They were also asked about the location of the physical facilities and these were their responses

Table 32: Location of the Physical Facilities in the Institution

Location of the physical facilities					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MLS dept.	2	18.2	18.2	18.2
	All (1-3)	9	81.8	81.8	100.0
	Total	11	100.0	100.0	

These facilities were located in 1. MLS department, 2. Nursing department, 3. ICT department.

From the results obtained, 9(81.8%) of the respondents reported that the physical facilities were located in MLS, nursing as well as ICT department. This was a clear indication that almost all the institutions embraced inter-professional interactions which helps them to foster team-based approaches and opportunities for longitudinal monitoring as well as providing a platform for standardized education and assessment of learners. Simulation is an innovative alternative for conducting inter-professional education with healthcare professionals. From the results, it is true that medical students grow beyond theoretical knowledge and application as a result of this inter-professional interaction.

Table 33: Adequacy of the facilities

Adequacy of the facilities

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Adequate	4	36.4	36.4	36.4
	Insufficient	7	63.6	63.6	100.0
	Total	11	100.0	100.0	

Physical facilities were located in various departments and were working, not in good condition.

Majority 7(63.6%) of the respondents reported that they were inadequate and needed more.

The reasons given as to why they saw the physical facilities inadequate is that "simulation-based teaching and learning is demanding for instructional staff, resource intensive, some aspects of laboratory work are difficult or impossible to simulate without high fidelity simulators otherwise it is possible to simulate all aspects of medical laboratory work and if these facilities are not looked at, the quality of learning experience may be uneven for the many students being admitted" (Respondent, 2022). A relatively small 4(36.4%) percentage reported that they were just adequate. These results were similar to the one obtained by the researcher during the observation carried out when site visits were done. There was no relationship between the presence of physical facilities and their adequacy. This is because the physical facility may be present and not necessarily be adequate.

4.7 The emergent themes from qualitative data

The general concepts (themes) and specific concepts (sub-themes) which emerged from the data were fully described in the previous chapter and are summarized in the table below: -

Table 34: Key identified themes

Themes	Sub-themes
Level of simulation definitions, construction, and implementation	Understanding and definition of simulation experiences The range of skills emphasized Type of simulator and use Essential features for the implementation of effective simulations Crafting good simulation activities
Perspectives and opportunities for innovative simulation-based teaching and learning	Positive perspectives and opportunities Critics of simulation-based teaching and learning

	Driving force behind simulation-based teaching and learning
Factors shaping and influencing a program's decision to apply simulation-based teaching and learning	List of factors Effectiveness of simulated laboratory activities- brings about innovation and up-to-date technology Simulated activities directly applicable in Medical Laboratory Science Education Drivers of simulations in MLS Specific models in the department of MLS
Challenges with simulation-based teaching and learning	List of challenges Specific challenges in MLS Solutions to the challenges Evaluation of the effectiveness of simulation-based teaching and learning in MLS
Facilities	Location Physical Adequacy Appropriateness Condition

4.8 Chapter Summary

In summary, the results from the lecturer respondents and those from the laboratory in-charge respondents were presented concurrently. Similarly, results drawn from the interview schedule and observation as well as document analysis were incorporated into the presentation. The first data showed the demographic characteristics of the respondents. This was followed by an analysis and presentation of the results based on the objectives of the study. This chapter demonstrated that participants had a wide range of experiences in applying innovative simulation-based teaching and learning for their students, with some having had a great deal of exposure to simulation-based learning and other groups had experienced relatively little.

Participants expressed a range of perspectives on the value of their experiences. There were many positive value perspectives of simulation experiences, which corresponded to the published literature, describing the benefits of simulation. These included the opportunity for repeated practice in a circumstance that has no risk of harm to patients, the provision of an opportunity to experience otherwise rare situations or conditions, the provision of effective feedback leading to reflection, the opportunity to work with and learn from a team, and simulation learning as fun. There were also negative perspectives expressed by participants. The negative experiences were more on the critics of simulation-based teaching and learning. A key negative feature was that simulations bring about anxiety created in participants' actual and anticipated simulation experiences.

The participants also considered simulation to be a very important part of their continuing education. The simulation also appeared to have a wider acceptance in the role it plays in the development of both technical and non-technical skills as well as a relevant contribution to their knowledge or skill development. There was a the challenge of not having well trained simulator instructors. Finally, themes and sub-themes which emerged were identified.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Overview

The discussion of research findings was conducted in accordance with the stated objectives that guided the study. It showed how the study answered the unanswered questions, identified in the literature review and related the findings to the current theory. The discussion also explained how this study made an original contribution to the current perspectives and practices of using simulation-based teaching and learning in medical laboratory science education.

5.1.1 Appraise the institutions' ability to use simulation-based laboratory sessions for their teaching and learning

The study focused on the application of innovative simulation-based teaching and learning extent, definition, construction and implementation in the institutions offering medical laboratory science program. The findings were that simulations were well defined, constructed and implemented to a greater extent due to the challenges with clinical placement for their students and also in order to ensure pedagogical validity of the training.

To establish a common definition for simulations in medical laboratory education, the findings agreed that medical laboratory programs have offered some degree of simulations since they were first brought into the college-based didactic environment from their hospital origins. 39(83.0%) of the respondents indicated that they very well understand and define simulated medical laboratory experiences both actual and anticipated while 8(17.0%) of the lecturers indicated they somehow understand and define simulated medical laboratory experiences both actual and anticipated.

A study by done in Canada by Bauer & Newman, (1989) agrees with finding of this study and reported that satisfactory performance of medical laboratory technicians trained using only simulation were obtained as compared to programs where students were trained in affiliate hospitals. Fraser (1986) also described and recommended computer-based case study simulations for medical laboratory students.

Anderson, (1984), disagrees with the findings of this study where they noted that the introduction of written simulations into a medical laboratory program produced no discernible difference in students' professionalism as measured by error rates in performance of diagnostic tests. This implies that Institutions implemented and conducted simulation laboratory sessions for their teaching and learning only that they did not get any difference from what was previously done. The respondents also indicated that they used the simulations during their teaching and that it was well incorporated in their teaching curriculum as well as the course outlines.

The Ministry of Health (2014), indicated that variation in commitment to the approaches and teaching strategies as observed with the simulation-based medical teaching and learning is an indication of lack of standards and harmonization in training. The study findings agreed with MoH observation where 8(17.0%) indicated that they somehow understood and defined simulation experiences even though they did not indicate to what extent, but they are not ignorant that they do not know.

This it is a clear indication that the management has tried to ensure that there is no variation in commitment to the teaching and learning approaches and strategies used in the department of medical laboratory sciences as shown by 39(83.0%) of the lecturers who reported having good understanding as well as definition of the same in their institutions.

This was confirmed by the fact that there was a significant relationship between understanding simulated medical laboratory experiences and defining simulated medical laboratory experiences as it was shown by the Chi-Square test results of 0.000 ($p<0.05$). This rejects the null hypothesis that teaching staff in the department of medical laboratory sciences do not understand and define simulated medical laboratory experiences both actual and anticipated and hence accepts the alternative hypothesis that teaching staff in the department of medical laboratory sciences understand and define simulated medical laboratory experiences both actual.

According to Grant, & Davis, (2004), all medical laboratory courses have traditionally been accompanied by laboratory sessions in which students conduct analyses, like those performed in clinical laboratories, on ‘doctored’ or ‘mock’ specimens. Such laboratory sessions are typically limited in duration (two to three hours) and scope (one procedure at a time in one subject area at a time, such as chemistry or microbiology). The procedures may not necessarily represent state-of-the-art technology, but are considered to impart the necessary foundations for theoretical understanding and manual skills. These were considered ‘low level simulations during then.

From this study, majority 29(61.7%) of the respondents said they thought there was some form of simulation taking place in their institutions because simulation was well outlined in the teaching curriculum and in all their course outlines, followed by 11(23.4%) who reported that they thought so because simulation-based teaching and learning was an important requirement for all medical laboratory science students before they go to the clinical site and handle real patients as well as 7(14.9%) of the respondents who indicated that simulation-based teaching and learning was a teaching strategy that they used after they had done the theory so that they can reinforce student understanding.

Oermann, (2004) agrees with these findings as he reported that medical laboratory programs have used simulations for decades, therefore, it is important to keep in mind that simulations are not a new development in medical laboratory education. In this report, the traditional low-level simulations are considered to be part of the basic academic laboratories used by all medical laboratory programs, and are referred to as 'academic' laboratories.

All the respondents reported that according to them, medical laboratory educators and current practices in simulation-based learning were valuable resources for this study because of the changes observed in technology as well as patient care practices in the hospital.

The findings agreed with a reported by Lemery, (2001), who said "because initial examination of the literature suggests that there is limited published data on simulations in medical laboratory education, medical laboratory educators and current practices in simulation-based learning were considered to be valuable resources".

From the study findings, 45(95.7%) of the lecturers said they had simulated laboratories in their institutions as part of their curriculum which they used for teaching and learning, assessment of student as well as research. They also added that they used these simulation labs for activities such as specimen collection and analysis.

A study by Grant, & Davis, (2004), had similar findings where respondents reported that all medical laboratory courses have traditionally been accompanied by laboratory sessions in which students conduct analyses, like those performed in clinical laboratories, on ‘doctored’ or ‘mock’ specimens, which were considered ‘low level simulations.

In a study by Elshama, (2015), it was reported that simulation-Based Learning is considered an essential part of practical learning as well as active learning process which should be used besides other teaching methods in medical laboratory sciences to overcome the problems of using real patient in the teaching because of ethical and legal rights, and the lack of critical events that are a source of learning and acquiring of different skills. Simulation-based learning activities take place in the educational institution but recreate the environment and experiences of the clinical site as closely as possible with the available resources.

The respondents gave their responses on the question requiring some explanation on how these simulated laboratory experiences are constructed where majority 30(63.8%) of the respondents said that these experiences were constructed by the simulation instructor who is an individual who plans, prepares and implements student simulation laboratories according to the curriculum and course outlines in use by the lecturers while 12(25.5%) said that the simulated experiences were constructed according to the standard operating procedures.

The findings agreed with a study carried out by Grant (2005), which reported that most simulated laboratories take place in fully-equipped student laboratories in the educational institution guided by the simulation instructor. The students may begin the day with a mini-lecture, video or demonstration by the instructor, new or review material on theory related to the procedures of the day, or orientation to particular technical aspects of the day’s activities. The construction of the simulations varies according to what the simulation instructor has constructed or prepared according to the curriculum.

The forms of simulation-based learning used in the medical laboratory department may be classified into human simulation such as role-play and standardized patient or non-human simulation such as manikin and the computer-based simulation. Based on the findings of this study, 31(66.0%) reported that all the listed simulation-based learning experiences were applicable during their teaching and learning.

The listed forms included; role play, videotaped interactions, case studies/problem-based learning, demonstrations, computer-based learning modules, online activities, standardized patients (actors), virtual reality applications and mannequins or plastic body parts. The rest of the respondent 16(34.0%) reported that, during their teaching and learning, the simulation-based experiences they used included role play, case studies, demonstrations, actor patients as well as mannequins. At least all the respondents used some form of simulation-based learning experience.

These findings disagreed with the findings obtained in a study carried by Stevens (2015), which reported that laboratory simulations in medical laboratory science are very different from those in medicine and nursing, where the term ‘high fidelity’ indicates use of sophisticated computerized patient simulators. Since medical laboratory work does not involve extended patient contact, medical laboratory programs may make use of ‘high technology’ and a great deal of authenticity without fitting the commonly accepted definition of the term ‘high fidelity’.

The respondents were asked to list the reasons as to why they used the simulated medical laboratory experiences where 34(72.3%) reported that they used simulated laboratory experiences for teaching and assessing students learning. This is to mean that they see simulation-based learning as an ideal way to prepare students for the clinical environment and also as a means of evaluating student's clinical deficiencies. Another group of respondents 13(27.7%) reported that they used simulated laboratory experiences for research, assessment and teaching of the students.

Davis (2007), agreed with these findings to a greater extent where their survey results showed that more than 90% of respondents among educators reported that they used simulations for testing, evaluating and credentialing; 86% use them for teaching; 60% for research; and 29% for product safety assessment.

Isenberg (2006), reported that Simulation-based medical laboratory education provides a controlled virtual, or simulated environment that reproduces the clinical laboratory environment to some extent in order to permit learners to integrate theory with hands-on skills, to practice and master skills, and to be assessed applying these skills. Isenberg's findings agreed with the finding of this study.

Grant (2005) also reported that E-learning systems, online tests, computer simulations, digitized media (i.e., microscopic slides) and other learning management systems are used to introduce students to laboratory safety, quality management, interpretation of microscopy slides, and data entry skills. Kneebone, et al, (2005) utilized online learning tools as part of the workstation activities through which students rotate during their simulation laboratories. Their findings agreed with the findings of this study.

The respondents of this study were asked to tick the features they considered essential for the implementation of effective simulations in their department. From the finding, Majority of the respondents reported that all these features were essential to some degree in their institutions and hence they considered them to be essential for the implementation of effective simulation. A small percentage, 1(2.1%), 3(6.4%) and

1(2.1%) reported that foundations in educational theory, appropriate staff development as well as individualized learning features were not essential for the implementation of effective simulation.

The features considered by a number of authors to be essential for the implementation of effective simulations which were consistent to the findings of this study included: relevance to practice, foundations in educational theory, curricular flexibility and integration, resource support, appropriate staff development, repetitive practice, range of difficulty levels, multiple learning strategies, representation of clinical variation, individualized learning, defined outcomes or benchmarks, and simulator validity (Bradley & Postlethwaite, 2003; Isenberg et. al., 1999; Kneebone, Scott, Carzi, &Horrocks,2004; McLaughlin, Doezema, & Sklar, 2002; Oermann, 2004); Barry-Isenberg et al., (2005).

Kolb (2014), also reported that educators need to extend beyond the psychomotor and fundamental cognitive domains of learning in the process of implementing effective simulations and help students prepare for intricate, patient-centered discussions with team members. The overall goals of the simulation laboratories as seen in the findings of this study appear to be expanding and refining students' technical skills as well as encouraging them to demonstrate an increasing degree of autonomy, professionalism, and discretionary judgment in their laboratory tasks.

Salas & Burke (2002) maintain that simulations activities must be carefully defined and constructed before being implemented to include important aspects such as instructional features, guided experiences, performance measurement, diagnostic feedback, and a relevant match to the environment being simulated. This was clearly seen in this study where 47(100%) reported that it was true that simulations were well crafted in their institution to cater for instructional features as well as guided experiences.

Forty-four 44(93.6%), reported that it was true that simulations were well crafted in their institution to cater for performance measurement and diagnostic feedback. The respondents 40(85.1%) also agreed to the fact that simulations should be crafted to include a relevant match to the environment being simulated. From the results, it can clearly be concluded that the respondents agreed with the views that simulations must be carefully crafted to include instructional features, guided experiences, performance measurement, diagnostic feedback, and a relevant match to the environment being simulated with a very small fraction having a different view.

According to Mookherjee, et al., (2013), simulation activities to be implemented may progress from manual to semi-automated to fully-automated procedures, or from single-technique to multiple-technique and sequential processes. Their report agreed with the findings of this study.

Rudman, Lunz, & Summers, (1995) suggested Computer simulations as a possible means of remedying deficiencies in troubleshooting skills observed in new graduates of medical laboratory programs while Schwabbauer, (2000) suggested them to be good for assessing competency among the qualified practitioners as well as being a valuable tool for permitting students to becoming familiar with the clinical environment and for assessment of student performance. Chiasera and Rudman (2003) found no difference in student performance on tests following use of computer modules for a single analytical procedure and suggested simulated learning as a means to decrease teaching costs and increase access to laboratories.

5.1.2 Determine the opportunities brought about by simulation as an innovative strategy as used for teaching and learning.

This objective dealt with the perspectives and opportunities for innovative simulation-based medical teaching and learning among the teaching staff. Perspective is a particular way of thinking about something, especially one that is influenced by beliefs or experiences. For this case, the “something” here is the simulation-based medical teaching and learning.

All the respondents, 47(100%) reported on their perspectives concerning Simulation-based teaching and learning as they were involved in the simulated learning and agreed that; the type of simulation used and the level of realism needed must be based on the type of thinking processes to be fostered (procedural, psychomotor or decision-making); Realism should enhance the learning experience; Simulation should offer opportunity to gain transferable skills/knowledge and Simulations should not operate in isolation from the clinical context but should operate alongside it through integration of simulation with clinical experience.

The perspectives and learning opportunities brought about by innovative simulation-based medical teaching and learning among teaching staff for this study included: Fostering team-based approaches and opportunities for longitudinal monitoring, providing a platform for standardized education and assessment of learners, promoting uniformity in curricula, helping to develop critical thinking, promoting student and patient safety, ensuring exposure to both rare and common events, promoting task repetition for performance improvement, potentially accelerating acquisition of expertise overtime, allowing assessment of psychomotor and interpersonal skills, providing opportunity for structured reflection through debriefing, opportunity for assessment, potential for capturing behaviors in contexts similar to actual practice, setting is reproducible, simulation allows measurement of skills as well as opportunities to improve technical, motor, communication, diagnostic and decision-making skills.

44 (93.6%) of the respondents in this study agreed that the suggested opportunities above have been brought about by innovative simulation-based learning in their department. Only very few 3(6.4%) of the respondents disagreed on a few of the opportunities. The opportunity for assessment is seen as one of the major opportunities for medical simulation. It is also noted in particular that simulation-based learning has the potential for capturing behaviors in contexts similar to actual practice. Poeggel, (2006) report agrees with these finding and reported that simulated laboratory experiences have been described as a valuable tool for permitting students to becoming familiar with the clinical environment and for assessment of student performance. Other distinct learning opportunities are the fact that the setting is reproducible and that simulation allows measurement of skills such as communication and professionalism, which are otherwise difficult to evaluate.

Other positive features for simulation-based learning in medical laboratory sciences as reported by the respondents are the fact that it enables them to earn *continuous professional development (CPD)* points as well as enabling them to use *case scenarios* in their facilitation.

The respondent 47(100%) said that simulation-based learning helps in facilitating ongoing integration of theory to practice, creating opportunities for learning professional language and participating in Inter-professional and teamwork-based activities as well as provision of feedback. They also alluded that "*Simulation-based teaching and learning in our institutions promotes and encourages inter-professional* *learning in that, to transform healthcare education, medical laboratory students, due to inter-professional learning, will grow beyond theoretical knowledge and application. It will also foster professional relationship and collaborative behaviors".*

The study finding agreed with Rudman, Lunz, & Summers, (1995) findings who reported that Simulations in medical laboratory science is perceived as a possible means of remedying deficiencies in troubleshooting skills observed in new graduates of medical laboratory programs and for assessing competency among practitioners (Schwabbauer, 2000). Simulated laboratory experiences have been described as a valuable tool for permitting students to becoming familiar with the clinical environment and for assessment of student performance. To reduce diagnostic error, Peterson, (2003) recommended increasing collaboration among medical professionals to improving diagnosis in healthcare. In addition, simulation can be used for skill attainment such as phlebotomy and cardiopulmonary resuscitation and to extend into more complex objectives such as teamwork, interpersonal communication, and professional role clarity (Peterson, 2003). All these studies were in agreement with the study findings.

Poore, Cullen, & Schaar, (2014) maintained that simulation is an innovative alternative for conducting inter-professional education with healthcare professionals. Through the incorporation of other educational strategies such as simulation, learners are able to engage themselves in real-time simulated healthcare events that emphasize teamwork among healthcare professionals, hence agreeing with the study finding. An increasing number of schools worldwide are turning to simulation to increase opportunities for hands-on experiences. (Fuglsang, Bloch, & Selberg, 2022; Mulyadi, Tonapa, Rompas, Wang, & Lee, 2021)

The respondents 47(100%) also reported that simulations and real clinical placements are related in that simulation is an innovative alternative to real clinical placement and cannot replace clinical experiences. The overall goals of the simulation laboratories appear to be expanding and refining students' technical skills as well as encouraging them to demonstrate an increasing degree of autonomy, professionalism, and discretionary judgment in their laboratory tasks as reported by the respondents.

Factors that go into selecting activities to be simulated according to Grant (2005) include: the complementarity of academic/clinical settings: for example, activities that cannot be carried out in the clinical site; commonality: routine procedures with relevance to all clinical sites; program priorities: for example, established competency based objectives; repetition: activities that need time for students to practice repeatedly; availability of resources: equipment; samples; supplies; space; instructors; support & education for staff; the needs of clinical partners for students with specific skills; the validity of the learning experience: its potential for authenticity; the likelihood of minimal compromise to quality of the student experience and evidence of effectiveness relative to the effort and cost involved. The same factors were still reported in the study and came clear in the study findings. This is a clear indication that simulations and real clinical sites are closely related. According to Kneebone, Scott, Darzi, & Horrocks, (2004), simulation should not operate in isolation from the clinical context, but should operate alongside it through integration of simulations with clinical experience, hence agreeing with the study findings.

Simulations in health professional education and in medical laboratory sciences in particular have been criticized from a number of perspectives among which include: their use of costly resources and the lack of a research foundation to validate their use

(Huang et al., 2007), faculty being resistant to new teaching strategies required for simulations, simulations creating high demands for infrastructural support in terms of implementation and sustainability, participants finding simulated environments intimidating and stressful as well as the danger of fragmentation of tasks.

The respondents of this current study reported that simulations in health professional education have been criticized from a number of perspectives. 47(100%) agreed that simulations use of costly resources and lack of a research foundation to validate their use; 45(95.7%) they create high demands for infrastructure support in terms of implementation and sustainability. If the cost of consumables is reduced and institutions ensure sharing among various departments to optimize use of the simulation facilities, then, the costs can be reduced drastically. 42(89.4%) there is also the danger of fragmentation of tasks; 39(83.0%) faculty may be resistant to new teaching strategies required for simulation; 35(74.5) participants may find simulated environments intimidating and stressful. From their responses, it is true that simulation-based teaching and learning has been criticized from all these perspectives even in the department of MLS across all the kmtc institutions offering mls. Ward-Cook, Simpson, & Brito, (2000) disagrees with these findings and reports that this relative paucity of supporting research notwithstanding and that there is a growing interest in use of simulated laboratories among medical laboratory programs in the United States due to difficulties in finding and retaining clinical sites that will train their students.

Kneebone, (2006) agrees on some of the critiques such as the danger of task fragmentation in simulation-based learning and said that the students can lose the big picture or confuse crises and unusual situations as well as the fact that not all students can learn effectively through simulations. This calls for support to both educators and students during the transition to simulation-based learning. From this discussion, it important that prior planning be done before implementation to ensure that simulations address the need and mitigate the critiques. The study by Kneebone (2006), agreed with the findings of this study in that critiques are valid and needs to be addressed.

Despite the critique, there are some driving forces behind the use of simulation-based learning in medical laboratory. These includes interests of stakeholders in health care, maintenance of competence in response to public pressure and government regulation, to reduced errors as well as reduced 'training' on patients (Mookherjeeet al.2013).

When the respondents were asked about what they thought as the driving forces behind their use of simulation-based learning in medical laboratory sciences, their responses were: 12(25.5%) said their driving force was mainly due to *shift from long hospital stay by patients to short or no hospitalization* and *new pandemics*; 10(21.3%) was due to *Medical lab sciences is dynamic, need for higher skills and automation*; 9(19.1%) was due to *Limited hospital staff, demand from regulatory bodies and prospective employers, new technology, changing trends in disease occurrence, public awareness on the need for true diagnosis*; 6(12.8%) was due to *safety of students and patients* and 2(4.3%) was due to *emerging technologies as well as keeping abreast of global trends in medical laboratory science training*. These findings agreed with the study by Mookherjee et al., (2013).

Similar results were obtained by Davis (2007), who reported that simulations have been linked to various interests of stakeholders in the United States health care system, as professional and licensing associations push for improved practitioner performance, maintenance of competence in response to public pressure and government regulation and the public advocates for improved patient care and safety, reduced ‘training’ on patients, and uniform competence and proficiency of health professionals.

5.1.3 Establishing the factors considered by implementers in using simulations for their teaching and learning

The factors considered to influence and shape a program’s decision to implement and apply simulation-based teaching and learning in the department of medical laboratory sciences for this study included:

it’s educational validity, as a means of remedying deficiencies in troubleshooting skills, for assessing competency among practitioners, a valuable tool for permitting students to become familiar with the clinical environment, as a means to decrease teaching costs and increase access to laboratories, difficulties in finding and retaining clinical sites that will train our students, the growing construction of clinical education is a ‘burden’ that must be shifted from clinical sites (Ayaz, 2022), the transferability of technical skills gained through simulation to the workplace, the relevance of skills gained in a simulation at the educational institution (as institutions maybe using out-of-date equipment), loss of opportunities for professional socialization that occur within the authentic environment, employers and students for mutual ‘sizing up’ prior to employment, working with up-to-date techniques and instrumentation, experiencing non-routine aspects of procedures and patient specimens, appreciating the rhythm and challenges of real-life laboratory workflow and the strategies for addressing them and gaining a sense of contributing to patient well-being.

From the results obtained, most respondents agreed that the listed factors really shaped and influenced their decision to implement and apply simulation-based teaching and learning indicating that they were part of the considerations they put in place when they thought of implementing simulations in their various institutions with a few having different opinion as seen from the table in the previous chapter.

Educational validity seemed to being key in the adoption of simulation-based learning, because 47(100%) of the respondent agreed to it with 37 out of 47 respondents strongly agreeing. The respondents also reported that simulation-based learning effectively helps students learn skills they can apply on real patients or real-life situations, helps increase self-confidence on the students and lecturers as well as making teaching and learning easy.

Huang, et al., (2009), categorized simulations along the following lines: concept simulation using computer-based animation; virtual patient simulation to reproduce clinical scenarios; part-task training for procedural or psychomotor skills and high-fidelity patient simulation using computerized mannequins which may have limited use in the training of medical laboratory students. The study findings reported that simulation effectively addressed learning activities such as sample collection, analysis of specimen, drug sensitivity testing and culture, media preparation, teaching on internal organs especially anatomy and physiology, dissection, cancer cell and their staging, tissue processing, during practical examination, patient’s response during sample collection, dispatch of results, hands-on-practice on any theory given, and simulation of vectors and parasites pathogenic to humans. These findings agreed with Huang, et al., (2009), report.

A study by Kilgour, et al., (2015) disagreed with these findings and reported that simulated experiences are more realistic than some other techniques and they can be so engaging and absorbing that students forget the educational purpose of the exercise.

The studies done on simulation in medical laboratory sciences reported computer simulations as a possible means of remedying deficiencies in troubleshooting skills observed in new graduates of medical laboratory programs (Rudman, Lunz, & Summers, 1995), and also in assessing competency among Medical Laboratory Science practitioners (Schwabbauer, 2000). Simulated laboratory experiences are a valuable tool for permitting students to become familiar with the clinical environment and for the assessment of student performance.

There is a growing interest in the use of simulated laboratories among medical laboratory programs in the U.S. due to difficulties in finding and retaining clinical sites for their students (Ward-Cook, Simpson, & Brito, 2000).

The use of simulations in medical laboratory science education appears to be driven by economic concerns, workplace constraints, accreditation of medical programs, standardization of graduate competence and national portability of credentials (Van-Kerkhove, et al., 2010); all the respondents of this study reported on the use of simulation in MLS education and maintained that their use is majorly driven by accreditation of medical programs and standardization of graduate competence. Other reasons they highlighted included changes in the medical field, national portability of credentials and economic concerns respectively. Keskitalo, et al, (2014) disagreed with these findings and reported that developing well-designed simulation-based training can provide a complex model of reality, leading to some challenges. The challenges here are from the learner's side and the instructors' perspective, and even from health care The driving forces behind the use of simulations in health professions according to Smith (2006), include: Patient safety and related ethical issues, interests of stakeholders in healthcare, minimization of diagnostic errors, as well as professional and licensing associations pushing for improved practitioner performance, maintenance of competence in response to public pressure and government regulation.

The form simulations take in the department of medical laboratory sciences as reported by the respondents was that, those who use mannequins, lab equipment and patient actors were (68.1%), lab equipment (8.5%), computers (2.1%), mannequins only (17%), no model (4.3%) respectively. In a survey carried out by Davis (2007), reported that the form of simulations used by health professional educators include: full mannequin patient simulation (used by 80% of the survey participants); almost 80% of participants use task-specific trainers; 62% utilize standardized patients (actors); 60% make use of case reports/problem-based learning; 57% employ virtual environments; and 57% use flat screen computers. This report agreed with the findings of this study but reported higher figures for the models used. All the laboratory in-charges 11(100%) reported that "*I feel like a member of a team in a collegial health care environment, experiencing non-routine aspects of laboratory procedure and patient specimens and working with up-to-date techniques and instrumentation in a virtual simulation laboratory"* implying that these learning opportunities are no longer evidence gaps on simulations in medical laboratory education as previously reported by Davis, (2007).

A study carried out at the College of Applied Medical Sciences at Taibah University, Saudi Arabia, reported that knowledge acquired from simulation brought about improvement in scientific writing skills and allowed students to construct knowledge, relate it to prior information, and generate new findings, which can then be recorded in the scientific report. Furthermore, the use of virtual simulations allows students to apply creativity and critical thinking to find solutions to issues, including real-world problems. The study further reported that gamified laboratory simulations may facilitate better learning outcomes as compared to traditional teaching. Virtual learning simulations were found to provide positive learning experiences and were reported to be valuable tools for developing cognitive and non-cognitive skills (Al-Nakhle, 2022). The finding of Al-Nakhle study agrees with the findings of this study.

5.1.4 Examining the challenges affecting the application of innovative simulation-based teaching and learning among teaching staff

Study participants identified a number of concerns about simulation-based teaching and learning activities in medical laboratory science programs. These challenges were placed in the following categories: professionalism and certain skills; simulations are demanding for instructional staff; simulations are resource intensive; some aspects of laboratory work are difficult or impossible to simulate; the quality of the learning experience may be uneven.

From the findings, 43(91.5%) of the respondents reported that professionalism and certain skills was a challenge to them because of lack of training particularly on simulations and majority said they were only applying the knowledge and experience they obtained during their professional training as medical laboratory technologists. These findings agrees with a report by Ren at al., (2017), who maintains that having a good understanding of medicine is not enough to cope competently with real-life sensitive situations but having the relevant clinical skills, problem-solving abilities, and the ability to apply the knowledge obtained to patient care, particularly in unanticipated circumstances is key.

The findings also agree with a study by de-Smale, et al, (2016) who reported that resources and time are required to develop a quality learning experience that uses simulations and that assessment of student learning through simulation is often more complex than with other methods. They further reported that simulation allows students to gain valuable experience in areas where resources are scarce but technological skills are essential. With an emphasis on problem-based learning, the educator’s aim is to establish a long-term, predetermined improvement in the learner's behavior, acquired skills, and attitudes.

Majority of the study participants 46(97.9%), reported that simulations were demanding for instructional staff because their work was too much and yet they did not have relevant training on the same. Similar findings were obtained by Grant and Davis, (2004) who reported that simulation instructors maintain a hectic pace of early mornings, missed lunch breaks, late evenings, marking assignments at home, specimen pick-up from clinical sites, and all-day interactions with students.

The time commitment, level of responsibility, physical demands, setting up role play scenarios, unexpected need for remediation, and unpredictability of simulation laboratories can be anxiety-provoking and unsustainable.

Several simulation instructors 9(82%) in this study reported that they had to forego or postpone other responsibilities and possibly family or social commitments while they are conducting simulation laboratory experiences to students. From the findings of this study and also cited findings, it is clearly seen that preparation for simulation laboratories is demanding because it involves a great deal of specimen handling (including picking up and transporting samples from local hospitals), specimen preparation and testing, equipment testing and maintenance, paperwork, creation of documentation associated with laboratory procedures and quality control as well as curriculum development.

These findings agree with a study by Caniglia, (2019) who reported that although instructional simulations can be very effective in encouraging student's engagement, many simulations require intensive pre-simulation lesson preparation where the preparation varies with the type and complexity of the simulation.

The presence of other support personnel (such as laboratory assistants, teaching assistants, and technicians) to assist with some of these duties is very essential which is not the case with the institutions involved in this study. Burnout and fatigue among the simulation instructors were major source of concern expressed by the campus principals in discussing their experiences. The principals expressed major concerns about the educational value of simulation laboratories when staffing levels and staff training on simulation-based teaching and learning are not adequate.

From the results of this study, 46(97.9%) of the participants recognized the high demands that simulation-based activities make on educational resources in terms of funding, equipment, specimens, space and scheduling and administrative support. In effect, the principals proposed the construction of fully equipped hospitals whose laboratories can be equipped with simulation equipment at the educational site at least one hospital in each region. This appears to be a dream because of very harsh economic times but their hopes were still alive. The resources which the principals' expressed difficulties were funding; equipment; specimens; space and scheduling because of other competing activities, and administrative support, in the order of importance and frequency of mention.

Viggers, Østergaard and Dieckmann (2020), agreed with the above findings in that the costs of simulation laboratories were built into the costs of running the program in general and that simulation laboratories are expensive. They also noted that, medical laboratory program is the most expensive program to be offered by any institution in areas such as funding for the curriculum revision; operating expenses for reagents, media, and expendables for the automated and manual testing procedures; replacement of microscopes because they are used very frequently; diagnostic technology due to its short lifespan and rapid obsolescence; instruments, whether purchased or donated, require service contracts and repairs; pressure to purchase and maintain up-to-date technologies and pressures from students and clinical partners for educational programs to maintain relevant and current technologies and to increase the authenticity of simulation laboratories.

Grant and Davis (2004), further agreed with the study findings in that, the majority of simulation instructors in their survey felt the need to shift the emphasis of their simulation laboratories to manual and small automated methodologies and leave the high-technology to the clinical environment and therefore simulation laboratories cannot be implemented without a significant and an ongoing investment on equipment, reagents, media, and expendables.

Yang et al, (2017), summarized these challenges into four (4) categories; Increased experimental costs: As the number of students increases, more experimental materials, instruments, and animals are needed, which results in increased costs; Medical ethics and environmental protection requirements: There is a need to reduce the consumption of experimental materials and animals as much as possible to meet the requirements of medical ethics and environmental protection; Biosafety limitations: Some experiments with pathogenicity, infectivity or trauma cannot be carried out due to legislation and regulations related to safety and security of biological materials and demand for knowledge integration: Medicine is a comprehensive subject emphasizing the integration and application of interdisciplinary knowledge, but experiments involving knowledge integration are difficult to carry out in the classroom.

From the study, the campus principals also said that it is more expensive to run simulated laboratories than to send students out to a clinical site for the same length of time because it is not possible to recover the costs by charging students. Options for integration of medical laboratory programs with other programs (for example, in inter-professional or core health sciences curricula) may be the possible way to go. A study by Didemet. al, (2022) disagreed with the principals' comments and reported that simulation laboratories overcome several disadvantages of real (practical) laboratories, for example, in the practical laboratory, experiments are conducted once in a limited time frame, but in the simulation laboratory, these experiments can be repeated until understanding and learning goals are reached. Also, simulation laboratories can simplify complex and confusing experimental processes. More importantly, an experiment involving a dangerous substance can be performed safely in the simulation laboratory. The simulation laboratory allows us to understand possible consequences that may arise if one of the steps in the process is performed incorrectly or incompletely. In these circumstances, students can become more confident and more aware of possible dangers while performing the same experiment in the practical laboratory. In the same vein, de-Vries & May, (2019), said "*Furthermore, since no ethical approval is needed, these simulations provide the opportunity to conduct various experiments in simulated animals and human beings".*

The majority of the respondents 44(93.6%) reported that some aspects of laboratory work were difficult or impossible to simulate due to unavailability of resources and the unique characteristics of the laboratory environment which includes wet laboratories, computer laboratories, instruments, write-up spaces, office areas, and other spaces with varying degrees of chemical use and hazards. Maintaining a positive safety culture and at the same time meeting the safety and comfort needs of laboratory personnel can be challenging as well as placing constrains on what can be simulated.

The findings of this study further agree with Grant (2007), regarding resource intensiveness of Medical Laboratory Science simulations.

The same findings were generated by Lamé & Dixon-Woods (2020), who reported that, some risky situations are unsafe or impossible to observe directly, and some theories and interventions can't be tested ethically in real-world settings. That's when simulation can be a valuable research tool. Simulation enables one to observe what might otherwise be impossible by replicating real-word scenarios in a controlled environment. For example, when simulating the impact of sleep deprivation on anesthetists' skills couldn't do so in a hospital without putting people at risk.

The participants 43(91.5%) of this study also agreed that the quality of the learning experience may be uneven during simulations. To support their argument, the respondents gave the following reasons; insufficient staffing of laboratories making it difficult to supervise large groups of students and insufficient numbers of instructors are also a safety issue, as simulations often involve many students carrying out differing activities at the same time, all of which require supervision.

The findings from the principals reported that, some areas required attention in order to improve the quality of the learning experience in simulation laboratories. These areas were: *untrained simulator instructor staff in MLS, lack of adequate infrastructure, poor internet strength*, as well as *instability of power (electricity)*

The study by Sonja-Chamberlin & Heather-Gray (2007), was consistent with the findings of this study where they pointed out the reasons that may cause the quality of the learning experience to become uneven. These reasons were; the use of expired quality control materials, although it is cost-effective, it sets a poor example for good laboratory practice, as do the short-cuts and 'make-do' quick-fixes that are often necessitated when appropriate resources are not available. Sonja-Chamberlin & Heather-Gray (2007), also reported that students' express frustration when they encounter lack of attention in understaffed laboratories, laboratories that are not staffed with knowledgeable and experienced instructors, insufficient equipment, and outdated methodologies.

Clinical instructors in this study expressed their challenges and said that "most of the times, the students are aware that the environment is not 'real' and that there are no patients depending on their work; it is difficult to encourage them to attach appropriate meaning to their simulation activities or to take appropriate precautions with bio-hazardous materials; it is sometimes difficult to assess students: small group work is not always appropriate for assessing individuals; it is a challenge to maintain confidentiality of student assessments when they are carried out in an open and crowded learning environment; instructors observe inappropriate sharing of work and a tendency for strong students to 'carry' the other members in their group by doing a disproportionate amount of the work and it has not been established whether simulations provide the same quantity or quality of experience as students would have in the same amount of time in a clinical setting". These findings agreed with the cited published work.

The factors that should go into selecting activities to be simulated and which can be considered as solutions to the challenges of simulation-based teaching and learning application include: the complimentary of academic/academic setting; for example, activities that cannot be carried in the clinical site; commonality: routine procedures with relevance to all clinical sites; program priorities: for example, established competency based objectives; repetition: activities that need time for students to practice repeatedly; availability of resources: equipment, samples, supplies, space, instructors, support and education for staff; the needs of clinical partners for students with specific skills and the validity of the learning experiences: its potential for authenticity, the likelihood of minimal compromise to quality of the student experience, evidence of effectiveness relative to the effort and cost involved. The respondents agreed that the suggested factors should be considered when selecting activities to be simulated because they are also solutions to the challenges of simulation-based teaching and learning application. A small percentage of the respondent had a different opinion on some of the factors. All the respondents 47 (100%) agreed that program priorities: for example, established competency-based objectives as well as repetition: activities that need time for students to practice repeatedly were important factors to consider when selecting activities to be simulated in MLS.

The study by Grant (2005) agrees with the findings of this study concerning the factors that should be considered while selecting activities to be simulated. They also added that the breadth of experience to be simulated was valuable, suggesting that learning different principles was more important than seeing variations of the same thing. Grant (2007), also agreed with the findings of this study and cited existing practitioner- and program-based expertise as the most widely-utilized source of guidance and information for implementing simulated laboratories. To prepare for and support their simulated laboratories, Ren at al., (2017), reported consulting competency based objective documents as well as other programs that are already using simulations because they believed that the recent industry experience of those involved in setting up a simulation laboratory and collaboration with clinical partners were particularly crucial to the success of their simulated laboratory projects. This was not evident in these study findings.

From the findings of this study, it was reported that the simulation experiences were often positioned as alternatives to learning at the clinical sites but could not fully address the issues of students' safety. When selecting activities to be simulated, the respondents reported having bench marked with those having advances in simulations such as Kijabe Mission Hospital as well as following the standard operating procedures for simulations. They also considered those procedures relevant to clinical sites, availability of resources as well as considering the validity of the learning experiences to be obtained. The study findings showed that the respondents had indicated evaluating the effectiveness of simulated laboratories and reported that it was an effective teaching and learning strategy as evidenced by student satisfaction surveys, student practical assessments and theoretical exams, graduate employment uptake statistics and audit reports provided.

Similar findings were obtained in a study done by Grant (2005), whose participants reported the following evaluation strategies for evaluating their simulated laboratory experiences which were fairly general in nature: employer satisfaction surveys; student surveys; graduate satisfaction surveys; student success on CSMLS certification examinations; student practical assessments and theoretical exams; comments from preceptors and clinical instructors; graduate employment uptake statistics.

The study findings from laboratory in-charges reported learning experiences in simulated laboratories being very beneficial to the students. They felt that simulations were valuable opportunities for them to offer an integrated case-based perspective as well as to identify weaknesses in students' skills and to institute remedial action. However, instructors expressed concerns over inadequacy of the facilities in many institutions and insufficient numbers of instructional staff. This was an area of concern across board.

Findings from a study carried out by Herbst, et al., (2008) reflected that, based on their experiences with simulated laboratories, they would like to see more resources provided for implementing the experiences, including instrumentation, staff, budget, and time, opportunities for inter-professional interactions, more time for simulated laboratories introduced. Findings of this study indicated all respondents reporting a great deal of pleasure at seeing students benefiting from simulation-based activities. They say that students enjoy the hands-on practical application in the simulation laboratories of what they have learned theoretically.

Because of the paucity of empirical studies related to the determination of the extent to which innovative simulation-based learning is applied in medical laboratory science technology, there is a need for a robust study that critically appraises the institutions' ability to implement and conduct simulation laboratory sessions for their teaching and learning. This study addresses this need by being theoretically underpinned, methodologically concordant and broader than the few previous studies (Brown & Bostic, 2016, Grant, & Davis, 2004, Miyamoto, et al., 2019) which were later shown to be too narrow in focus, simplistic or not related to theoretical considerations. The original aspects of this thesis are that; it is a mixed-methods study exploring the extent innovative simulation-based learning is applied in medical laboratory science technology, it includes participants at various stages of medical training from institution managers to experienced lecturers in the department of medical laboratory sciences and it includes clinical instructors who are directly involved in the simulation laboratories and have diverse experiences and expectations for simulations.

There is hope that the use of simulation as a robust, evidence based and cost effective learning tool in a competitive and litigious healthcare climate might offer part of the solution to the huge challenges faced in contemporary healthcare education, and this thesis has contributed to the robust analysis of simulation-based teaching and learning in medical laboratory science education, not just in helping answer the question ‘Does it work’?, but with utility in answering the questions ‘For whom does it work?’ and ‘How can we make it even better?’.

From the study findings, it is true that simulation-based teaching is working in the department of medical laboratory sciences at KMTC; it is working for the trainers, trainees, prospective employers as well as the accrediting bodies. This is true because it facilitates consistency in teaching, learning, and student assessment. Simulation-based teaching and learning can be made even better by training the clinical instructors because this was reported as one of the challenges encountered with simulations in medical laboratory science education.

The issues uncovered during this research’s survey and interview-based inquiries are similar to those identified in the literature. The need for research that helps the academic community and practitioners in simulation to identify robust evidence for the application of innovative simulation-based teaching and learning is addressed in this thesis.

A detailed understanding of what it is about medical laboratory science programs which make application of simulations experiences possible is explained to a greater extent. In other words, in the highly complex and variable world of medical laboratory education, what in simulation 'works,' and what is the 'magic ingredient'. Sustainability and the need for evidence-based educational practices in simulation-based learning appear repeatedly as themes throughout this study.

The literature identified some research revealing barriers to engagement with simulation but did not come up with solutions for the same. This research found out the issue of sustainability which relates to funding and provision of sufficient resources and instructional staff for simulation laboratories. It is apparent that simulation laboratories are demanding undertakings. Medical laboratory science programs are already the most expensive program in many educational institutions. Simulations only increase the costs further but this research suggested solutions for it.

Simulations offer an opportunity to bring students closer to the reality and culture of the healthcare system and to foster their development as medical laboratory technologists, rather than as a student as seen in their transition from their learning institutions to the laboratory setting. The theoretical underpinning crosses academic disciplinary boundaries of medicine, medical education, and psychology, particularly in the area of application to bring about opportunities for inter-professional interactions. In addition, this research makes a further contribution to knowledge by identifying a clear relationship between the driving force for simulation and their critiques. The author is not aware of any other presentations or publications drawing a link between application and driving forces for simulation-based teaching and learning and its criticism.

This thesis offers an original contribution and also a challenge to simulation designers in medical laboratory science which on average provides more than 70% of the information required by clinicians and doctors to manage a patient to attend to the internal consistency of the simulation, rather than focusing and dedicating continued efforts on creating closer (physical) approximations to the real world.

5.2 Implication of the study

The issues uncovered during this research's survey and interview-based inquiries are similar to those identified in the literature. Application and the need for evidence-based educational practices in simulation-based learning appear repeatedly as themes throughout this study. The gradual shift over time of medical laboratory science education from one sector (healthcare) into another (education) has implications for funding, as the essentially 'invisible' costs associated with clinical education in the workplace are now becoming clear in educational institutions' attempts to re-create the clinical environment in their simulation laboratories. This prompts a question about the duplication of resources involved in re-creating a hospital laboratory environment in an educational institution. It appears that simulations can definitely play a constructive role in medical laboratory science education. The question is, given the restraints posed by funding, technology, and other resources, will it not be far more cost-effective and pedagogically grounded to provide more support to clinical sites for facilitating the clinical education that experienced educators and students regard as the 'first choice for learning about medical laboratory practice? If it should be established that simulations offer a superior learning experience, this places programs that cannot afford to offer simulations in a disadvantageous position.

It is worth asking how effectively the costs of simulations can be rationalized given the relatively sparse research supporting the use of simulations in medical laboratory education. The implementation of simulation laboratories in medical laboratory science education appears to have followed the implement-first-validate-later model evident in the medical literature about simulations. Reports obtained from the respondents are that they can effectively rationalize simulations by having many campuses utilize one well-equipped simulation laboratory regionally.

There is no evidence base for determining the length of time (in simulation laboratories or clinical placements) or the learning environment that is needed to produce a medical laboratory graduate who is sufficiently competent to enter the workforce but only that which is contained in the curriculum for the medical laboratory science program. Given the centralizing tendencies in evidence for lengths of clinical placements, it might seem that the medical laboratory education industry itself is establishing a default length for clinical placements.

It is important to stress, though, that there is no research to establish the average time for clinical placements is the right amount of time; this is simply a length of time that has been determined to be tolerable given the pressures on educational institutions and hospitals to work with increasingly limited resources and expanding professional, regulatory, and workplace expectations. Nor is there any indication of an optimum length for simulation laboratories, although there are assumptions that using simulation laboratories permits decreasing time spent in clinical placement. Despite any evidence base for the use of simulation laboratories, their use (or cessation) appears to figure into decisions about clinical placements.

Do simulation laboratories fully address the issues of student safety raised peripherally in this report? Patient safety may not be a driving factor in implementing simulations in medical laboratory education but the immersive and extended exposure of students and instructors to bio-hazards in simulation laboratories (particularly where supervision is inadequate) did not appear to generate the concern it merits. The respondents also reported that simulation-based learning experiences are often positioned as alternatives to learning at a clinical site or interactions with real patients/clients but do not address the issue of student safety fully.

It is also unclear whether the use of simulations actually helps to address health human resources shortages. This is because simulations create high demand for human resource support. If simulations are to succeed as a strategy for increasing class size or doubling student intake, the medical laboratory programs must be financially supported and with appropriate staff development to carry through on this promise. Interestingly, employers seem to be regarding medical laboratory programs differently now that they are experiencing difficulties hiring technologists and there is also some decline in prospective students of medical laboratory science. Educational institutions can capitalize on their new attractiveness to employers by encouraging their support for simulation-based learning as well as clinical placements.

Simulations may offer an opportunity to bring students closer to the culture of the health care system and to foster their development as medical laboratory technologists, rather than as a student. They may also make a move for improved collaboration between academic and clinical settings. Simulations could be interpreted as a natural progression of a historical trend.

The shift of academic portions of health professions programs out of the hospital settings in the 1960s and 1970s set the stage for a noticeable divide between the theory and practice of medical laboratory science; the ‘two solitudes’ continue to function in many programs as two different worlds. This is evident in the comments from the campus principals in this and a previous study about what it is like to make the transition from their school to the laboratory setting. There appears to be some value in former hospital-based apprenticeship-oriented models in terms of the proximity and immediacy of the clinical environment to which students were once exposed right from the start. Implementing simulation laboratories may necessitate that this divide is bridged to create a more seamless and holistic learning experience for students.

5.3 Chapter Summary

This chapter presented and discussed the key findings embedded throughout this study’s application of simulation-based teaching and learning which was aimed at answering the research questions of the study. The presented discussion is on how the research objectives and the study findings addressed the research questions. The study findings from the all the respondents responses were discussed indicating how they addressed the study questions1) Institutions’ ability to implement and conduct simulation laboratory sessions, 2) Opportunities for innovative Simulation-Based Medical Teaching and learning 3) Factors that shape a program’s decision to implement simulation-based teaching and learning and what influences its application, and 4) Challenges affecting the application of innovative simulation-based teaching and learning. This finding have introduced new insights to further understand instructors’ simulation-based teaching and learning experiences, and so adds to the broader canvas of already identified research by adding on the aspect of SBME learning with a nexus to the application of simulated medical laboratory experiences, both actual and anticipated in Medical Laboratory Science Program.

This thesis' insights are informed by the experiential Learning theory. Here, the experiences of a learner occupy the central place in their teaching and learning process. This theory shows *how* and *why* SBME plays a central role in the formation of a professional medical laboratory technologist. This study offers new theoretical understandings of application of simulation-based teaching and learning which further facilitates the preparation of medical laboratory students for the demands of contemporary medical laboratory practice, and for functioning effectively in a complex and changing healthcare environment, together with the increasing focus on multidisciplinary interaction.

This chapter has shown that the application of innovative simulation-based teaching and learning can be viewed as an educational space which provides legitimate opportunities for learners to develop and acquire competences necessary for the job market. This thesis' notion of application of innovative simulation-based teaching and learning resonates with Kneebone, (1984) and the suggestion that simulation-based teaching is feasible and perceived by participants to be educationally useful.

The original contributions of this thesis to the academic community and practitioners in simulation as well as more current literature were addressed in this study. The contribution aimed at presenting empirical research in the application of innovative simulation-based teaching and learning in Medical Laboratory Sciences which was theoretically underpinned.

The implications of this study were also looked at. It was found out that simulations can definitely play a constructive role in medical laboratory science education, but given the restraints posed by funding, technology, and other resources, it may be far more cost-effective and pedagogically grounded to provide more support to clinical sites for facilitating the clinical education that experienced educators and students regard as the ‘first choice for learning about medical laboratory practice.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Overview

This chapter presents the conclusions and recommendations of the research finding based on the study objectives. The chapter first states the conclusions, then the recommendations. The conclusions and recommendations are as per the research findings.

6.2 Conclusions

The study sought to determine the use of simulations in teaching and learning among staff in the department of medical laboratory sciences of Kenya Medical Training College. In particular, the study chose to appraise the institutions' ability to implement and conduct simulation laboratory sessions for their teaching and learning, analyze their educational opportunities, establish the factors that shaped a program's decision to implement simulation as well as examining the challenges affecting the use of simulations.

6.2.1 Appraising the institutions' ability to implement and conduct simulation laboratory sessions for their teaching and learning

This study sought to explain the extent in which simulations are defined, constructed and implemented in their institution especially in the department of medical laboratory sciences. From the findings, it can be concluded that simulations were defined, constructed and implemented to a greater extent due to the challenges with clinical placement for their students and also in order to ensure pedagogical validity of the training in the selected KMTCs in Kenya. To establish a common definition for simulations in medical laboratory education, it is true from the results obtained that medical laboratory programs have offered some degree of simulations since they were first brought into the college-based didactic environment from their hospital origins. Further, it was found out that simulations are used during their teaching and that it was well incorporated in their teaching curriculum.

6.2.2 Analyzing the educational opportunities for innovative simulation-based medical teaching and learning among teaching staff

This objective was dealing with the perspectives and opportunities for innovative simulation-based medical teaching and learning among the teaching staff. The perspectives and learning opportunities brought about by innovative simulation-based medical teaching and learning among teaching staff includes: fostering team-based approaches and opportunities for longitudinal monitoring, providing a platform for standardized education and assessment of learners, promoting uniformity in curricula, helping to develop critical thinking, promoting student and patient safety, ensuring exposure to both rare and common events, promoting task repetition for performance improvement, potentially accelerating acquisition of expertise overtime, allowing assessment of psychomotor and interpersonal skills, providing opportunity for structured reflection through debriefing, opportunity for assessment, potential for capturing behaviors in contexts similar to actual practice, setting is reproducible, simulation allows measurement of skills as well opportunities to improve technical, motor, communication, diagnostic and decision-making skills.

It was concluded that almost all the respondents in this study agreed that the suggested opportunities above have been brought about by innovative simulation-based learning in their department. Only very few disagreed on a few of some opportunities as seen from the table. The opportunity for assessment is seen as one of the major opportunities for medical simulation. It is also noted in particular that simulation-based learning has the potential for capturing behaviors in contexts similar to actual practice. Other distinct learning opportunities are the fact that the setting is reproducible and that simulation allows measurement of skills such as communication and professionalism, which are otherwise difficult to evaluate. Other positive features for simulation-based learning in medical laboratory sciences as reported by the respondents are the fact that it enables them to earn *continuous professional development (CPD)* points as well as enabling them to use *case scenarios* in their facilitation.

Further, some respondent said that simulation-based learning helps in facilitating ongoing integration of theory and practice, creating opportunities for learning professional language and participating in

Inter-professional and teamwork-based activities as well as provision of feedback. The respondents also reported that simulation-based learning promotes and encourages inter-professional learning in that, to transform healthcare education, medical laboratory students, due to inter-professional learning, will grow beyond theoretical knowledge and application. It will also foster professional relationship and collaborative behaviors.

6.2.3 Establishing the factors that shape a program's decision to implement simulation-based teaching and learning and what influences its application among teaching staff

The factors considered to influence and shape a program's decision to implement and apply simulation-based teaching and learning in the department of medical laboratory sciences for this study include: it's educational validity, as a means of remedying deficiencies in troubleshooting skills, for assessing competency among practitioners, a valuable tool for permitting students to become familiar with the clinical environment, as a means to decrease teaching costs and increase access to laboratories, difficulties in finding and retaining clinical sites that will train our students, the growing construction of clinical education is a 'burden' that must be shifted from clinical sites, the transferability of technical skills gained through simulation to the workplace, the relevance of skills gained in a simulation at the educational institution (as institutions maybe using out-of-date equipment), loss of opportunities for professional socialization that occur within the authentic environment, employers and students for mutual 'sizing up' prior to employment, working with up-to-date techniques and instrumentation, experiencing non-routine aspects of procedures and patient specimens, appreciating the rhythm and challenges of real-life laboratory workflow and the strategies for addressing them and gaining a sense of contributing to patient well-being. From the results obtained, most respondents agreed that the listed factors really shaped and influenced their decision to implement and apply simulation-based teaching and learning indicating that they were part of the considerations they put in place when they thought of implementing simulations in their various institutions with a few having different opinion as seen from the table. Educational validity seemed to being key in the adoption of simulation-based learning, because 100% of the respondents agreed to it with 37 out of 47 respondents strongly agreeing. The respondents also reported that simulation-based learning effectively helps students learn skills they can apply on real patients or real-life situations, helps increase self-confidence on both the students and lecturers as well as making teaching and learning easy.

6.2.4 Examining the challenges affecting the application of innovative simulation-based teaching and learning among teaching staff

From the findings, 43(91.5%) of the respondents reported that professionalism and certain skills was a challenge to them because of lack of training particularly on simulations and majority said they were only applying the knowledge and experience they obtained during their professional training as medical laboratory technologists. Majority of the study participants 46(97.9%), reported that simulations were demanding for instructional staff because their work was too much and yet they did not have relevant training on the same. From the results of this study, 46(97.9%) of the participants recognized the high demands that simulation-based activities make on educational resources in terms of funding, equipment, specimens, space and scheduling and administrative support. In effect, campus principals are proposing the constructions of fully equipped hospitals whose laboratories can be equipped with simulation equipment at the educational site. This appears to be a dream because of very harsh economic times. The resources about which campus principals expressed difficulties were funding; equipment; specimens; space and scheduling, and administrative support, in the order of importance and frequency of mention. The campus principals also said that it is more expensive to run simulated laboratories than to send students out to a clinical site for the same length of time because it is not possible to recover the costs by charging students. Options for integration of medical laboratory programs with other programs (for example, in inter-professional or core health sciences curricula) may be the possible way to go.

The majority of the respondents 44(93.6%) reported that some aspects of laboratory work were difficult or impossible to simulate due to unavailability of resources and the unique characteristics of the laboratory environment which includes wet laboratories, computer laboratories, instruments, write-up spaces, office areas, and other spaces with varying degrees of chemical use and hazards. Maintaining a positive safety culture and at the same time meeting the safety and comfort needs of laboratory personnel can be challenging as well as placing constrains on what can be simulated.

Simulations may take place either in dedicated simulation centers or in situ, in real-life clinical settings. The participants 43(91.5%) of this study also agreed that the quality of the learning experience may be uneven. To support their argument, the respondents gave the following reasons; insufficient staffing of laboratories making it difficult to supervise large groups of students and insufficient numbers of instructors are also a safety issue, as simulations often involve many students carrying out differing activities at the same time, all of which require supervision.

The campus principals reported that, some areas required attention in order to improve the quality of the learning experience in simulation laboratories. These areas were: *untrained simulator instructor staff in MLS, Lack of adequate infrastructure, Poor internet strength,* as well as *Instability of power (electricity)*

6.3 Recommendations

From the study, the following recommendations were made: -

1. The institutions' ability to implement and conduct simulation laboratory sessions for their teaching and learning.

   The KMTC management to ensure there is standardization and harmonization of training of Medical Laboratory Science program across all KMTCs offering the program in Kenya. This is because some respondents 8(17.0%) of the lecturers indicated they somehow understand and define simulated medical laboratory experiences both actual and anticipated. Educators should understand the curriculum areas, success aspects regarding the design and interaction stages and also be flexible in their roles.

2. The opportunities for innovative simulation-based medical teaching and learning among teaching staff. Although the opportunity for assessment was seen as one of the major opportunities for medical simulation, assessment of student learning through simulation has been reported in other published studies to be more complex than with other methods. Therefore, KMTC management to create more opportunities for staff and more infrastructural support to promote implementation and sustainability of the reported opportunities. This may call for the government of Kenya to increase funding to KMTC to improve on the infrastructure. Each simulation centre should create a procedure or policy in which faculty members can register for a chosen number of slots per academic year. This technique can assist instructors in identifying simulation activities that are appropriate for their professional practice area. The repetition of structured activity to improve performance is deliberate practice therefore, educators should be encouraged to participate in deliberate practice in order to address the perspectives criticizing simulations. Additionally, workplace mentorship by experienced instructor also helps educators to master newly acquired educational skills hence addressing the aspects that faculty may be resistant to new teaching strategies required for simulation, participants may find simulated environments intimidating and stressful and the danger of fragmentation of tasks by simulation instructors.

3. **Establishing the factors that shape a program's decision to implement simulation-based teaching and learning and what influences its application among teaching staff**

   The KMTC management to prepare schedules for updates especially continuing professional development programs for medical laboratory staff on simulation-based teaching and learning to enable simulation instructors use follow-up activities such as discussions, journal entries or other reflective activities to determine how well the students understood what the simulation was designed to teach. These schedules may call for off-site training which may require more funding to aid financial support to the simulation instructors as well as facilitation to the trainers. Using reflection as the assessable component of the activity, rather than participation in the simulation itself, can be a useful way of determining students' understanding.

4. **Examining the challenges affecting the application of innovative simulation-based teaching and learning among teaching staff**

   Human resources in simulation centres must meet both professional and quantity requirements, therefore, KMTC management should recruit, train, use, and compensate simulation instructors. In order to address the issue of scheduling conflicts, educators should emphasize the importance of advanced planning at least one semester in advance. This will help them solve the issue of lack of enough models for simulation, lack of standard specimens due to complex specimen collection procedures for some specimens as well as instability of analytes when specimens are stored for long. The government of Kenya to provide adequate quality infrastructure for simulation training across all Medical Laboratory Science departments of Kenya Medical Training campuses.

6.4 Suggestions for Further Research

Further research may address:

i. Perceptions on simulation use among MLS students

ii. Comparisons of simulated and non-simulated activities,

iii. Specific cost analyses for implementing a simulation laboratory.

6.5 Chapter Summary

This chapter concludes this thesis. The subject of this research was on the use of simulation for teaching and learning among teaching staff in the department of medical laboratory sciences of KMTC. This is an important area because simulation is being used increasingly in other medical professions in both undergraduate and post graduate education. Simulation has a significant potential to provide an additional medium for teaching and learning the complex skills needed for the delivery of safe, patient-centered healthcare which ‘does no harm’ (Ziv et al., 2006). This research project has examined current literature, practices, and expertise in order to begin constructing a much-needed evidence base for simulated learning in medical laboratory science programs in Kenya, to provide educators with exemplars of simulated laboratory learning, and to identify directions for further research. The construction of this evidence base is essential for decision- and policy-making about future directions for medical laboratory education. Although the benefits have been widely stated, like in any educational intervention, it is complex to evaluate in terms of effectiveness particularly in considering the impact on patient outcomes. This work is situated in the scholarly traditions of medicine and education and is underpinned by contemporary theoretical perspectives on experiential learning. The work relates to other contributions to the field of simulation research as there is a quest to identify what works, for whom and in what circumstances (Dieckmann et al., 2011).

Introduction of the study on simulations in medical laboratory programs has provided the foundations for an informed and relevant definition of simulated laboratory learning in the professional preparation of medical laboratory technologists. It has also highlighted a number of commonalities in implementing these learning experiences. The study contributes to the body of literature by arguing that in order to generate robust evidence that simulation is important to be used as a teaching, learning, and assessment strategy to prepare students for clinical practice, the position of educators in terms of the ability to understand and apply innovative simulation-based teaching and learning must be understood and taken account of.

This work appraised the institutions' ability to apply simulation laboratory sessions for their teaching and learning, determined the opportunities for innovative simulation-based medical teaching and learning, established the factors that shaped a program's decision to implement simulation-based teaching and learning, and examined challenges affecting the application of innovative simulation-based teaching and learning among teaching staff.

Through the use and integration of the theoretical perspectives, deeper understanding of what happens in a simulation laboratory was unveiled. Educators' simulation experiences and the meaning and value they attach to their teaching and learning was also unveiled.

The findings of this study suggest that, simulations in medical laboratory education can be an effective and supportive tool to enhance student transition into the clinical environment, but cannot replace clinical experience; simulations are a major draw on resources (human and otherwise) and must be adequately supported both at startup and on an ongoing basis; simulations represent a significant shift in pedagogical practices and must be grounded in educational resources and research-based evidence which are not currently available to educators; simulations offer opportunities for academic and clinical educators to foster a more seamless educational experience; and simulations must be complemented with effective and well-supported clinical education resources and practices.

Attention has been given to addressing the strengths and limitations of the work, and recommendations for practice have been made. The opportunities for further research have also been outlined.

In conclusion, this thesis answers the questions ‘to what extent are simulations defined, constructed, and implemented in the institutions offering medical laboratory science course?, are there opportunities for those directly involved in simulated-based learning in MLS?, what factors shaped a program’s decision to implement simulations?, and what challenges did they encounter while implementing innovative simulation-based teaching and learning?’ and so has contributed to greater understanding of the application of innovative simulation-based teaching and learning.

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APPENDICES

Appendix 1: Study Information Sheet

Study information sheet

Dear participant,

Ref: Introduction

You have been invited to participate in a research work being conducted by Prominah Kavinya Muia, a student at Moi University undertaking Doctor of Philosophy in Medical Education in Partial Fulfilment of the Requirement for the Award of the Degree of Doctor of Philosophy (Medical Education) in the School of Medicine on the use of simulated laboratory learning activities in medical laboratory education.

Study title: Application of innovative Simulation-Based Medical Teaching and Learning among staff in selected KMTC Campuses offering Medical Laboratory Sciences in Kenya

This study is for academic purposes and hence not funded. The study will inform educators and policy-makers on relevant issues in the educational preparation of medical laboratory technologists and more specifically on simulation-based teaching and learning. The final research report will be made available to Moi University, School of Medicine, study participants, the CEO KMTC, and will be presented in professional venues such as the MLS national Congress, KMTC scientific conference, the KMTC Journal of Medical Laboratory Science, stakeholder workshops and discussion groups.I hope you will consent to a 10- to 20-minute of your time with the research principal investigator, Prominah Muia or the research assistants. Your participation will help to create a current and valid picture of the implementation and value of simulated laboratories and to provide KMTC management with a full appreciation of the resources and outcomes for these types of learning experiences.

The data to be collected will not contain any personal information about you. All information gathered as part of this research either through questionnaires, checklist, site visits (observation) and interviews will be confidential. Participants will be anonymized in all data, for example Participant number 1 etc. The interview data will use participant codes. The interview data will be kept as digital files or transcribed documents on a password protected computer, in a locked room at all times. Any associated written data will be stored in a locked filing cabinet. Raw data may be made available for monitoring in relation to the professional doctorate degree only. Anonymized data may be used in quotations in the thesis or for peer reviewed journal publication. Only the principal researcher will have access to the raw data. The data will be destroyed 10 years after participation in the project. This study entails your voluntary participation and so you may withdraw or decline from the study at any time without any victimization.

The study will not involve any invasive procedures and there is no health risk involved, therefore, there will be no incentives and benefits awarded to the participants enrolled in the study. Your name will not be used in the analysis and writing of the reports or in any publications or presentations but your institution will be.

If you have any questions or concerns about this research or your participation in it, please contact Prominah Kavinya Muia, 0721422778, muiakav1@gmail.com.

Appendix 2: Consent Form

Consent of participant

I have read or the researcher has read and explained to me the description of the research study from the participant information sheet. The researcher has also explained to me the nature of the study and my involvement has been explained and all the questions I asked have been answered satisfactorily. I have been told of the possible benefits (if any) and been informed of the confidentiality of the study. I freely volunteer to participate in this study.

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Signature of participant Date

I have explained this study to the above participant and have sought his/her understanding for informed consent.

Prominah Kavinya Muia -------------------------------- ----------------

Name of researcher Signature of researcher Date

Appendix 3: Questionnaire for Lecturers

Date: --

You have been selected to participate in this study through filling in this questionnaire. This questionnaire contains of several sections. Section A contains background information concerning the participant.

Section (A): socio-demographic data

Please tick √ or cross in the appropriate box what applies to you

1. Gender of the respondent Female ☐ Male ☐
2. Age of the respondent 25-31 ☐ 32-38 ☐
   39-45 ☐ 46-52 ☐
   53 and above ☐
3. MTC campus: --
4. Position in the department: ---
5. No. of years teaching experience: --

Section 2: level of simulations definition, construction, and implementation at KMTC medical Laboratory Department. Answer the following questions by ticking the appropriate choice for you and kindly give a supporting explanation as per your choice of answer.

1. How well do you understand and define simulated medical laboratory experiences both actual and anticipated

   Not at all ☐

   Somehow ☐

   Very well ☐

   Excellent ☐

Why do you think so?

Medical laboratory educators and current practices in simulation-based learning are considered to be valuable resources for this study. What is your take?

Do you have simulated laboratories in your institutions as part of your curriculum which you use for teaching and learning? Yes. No. Not aware

What type of activities are simulated in the simulation medical laboratory?

How do you construct simulated lab experiences? ---------------------------------

----

What form/s does your simulation-based learning experiences take during your teaching and learning? Tick all that apply.

Role play

Videotaped interactions

Case studies/problem-based learning

Demonstrations

Computer-based learning modules

Online activities,

Standardized patients (actors)

Virtual reality applications ☐

Mannequins or plastic body parts ☐

All of the above ☐

What do you use these simulated medical laboratory experiences for?

------------------------------ (testing, evaluating and credentialing; use them for teaching; research; and for product safety assessment)

2. Please √ the outlined features that you consider to be essential for the implementation of effective simulations.

Essential feature	not essential	essential	Essential to some extent	Very essential
Relevance to practice				
Foundations in educational theory				
Curricular flexibility and integration				
Resource support				
Appropriate staff development				
Repetitive practice				
Range of difficulty levels				
Multiple learning strategies				
Representation of clinical variation				
Individualized learning				
Defined outcomes or benchmarks				
Simulator validity				

3. For the following statement indicate True/False

Simulations must be carefully crafted to include	True	False	Not sure	undecided
Instructional features				
Guided experiences				
Performance measurement				
Diagnostic feedback				
A relevant match to the environment being simulated				

Section C: Perspectives and opportunities for innovative Simulation-Based Medical Teaching and learning among teaching staff

1. Please √ in the relevant box the perspectives and opportunities brought about by innovative Simulation-Based Medical Teaching and learning among teaching staff in MLS

Perspectives and Opportunities	agree	Strongly agree	disagree	Strongly disagree
Fostering team-based approaches and opportunities for longitudinal monitoring				
Providing a platform for standardized education and assessment of learners				

Promoting uniformity of curricula				
Helping to develop critical thinking				
Promoting patient safety				
Ensuring exposure to both rare and common events				
Promoting task repetition for performance improvement				
Potentially accelerating acquisition of expertise over time				
Allowing assessment of psychomotor and interpersonal skills				
Providing opportunity for structured reflection through debriefing				
Opportunity for assessment				
Potential for capturing behaviors in contexts similar to actual practice.				
Setting is reproducible				
Simulation allows measurement of skills such as communication and professionalism				
Opportunities to improve technical, motor, communication, diagnostic and decision-making skills				

2. Indicate other positive features for simulation-based learning in Medical Laboratory Sciences apart from the ones indicated above

----

----

3. Indicate true/false for the following statements

Simulations in health professional education and in MLS in particular have been criticized from a number of perspectives:

i. Their use of costly resources (True/False)

ii. Faculty may be resistant to new teaching strategies required for simulations (True/False)

iii. Simulations create high demands for infrastructure support in terms of implementation and sustainability (True/False)

iv. Participants may find simulated environments intimidating and stressful (True/False)

v. There is also the danger of fragmentation of tasks (True/False)

4. What do you think are the driving forces behind use of simulation-based learning in MLS

Section D: Factors that shape and influence a program's decision to implement and apply simulation-based teaching and learning. You have been given four choices to choose from. Only one choice applies. Kindly tick appropriately.

1. Factors considered as afterthought in the adoption of simulation-based learning	Strongly agree	agree	Strongly disagree	disagree
Educational validity				
A means of remedying deficiencies in troubleshooting skills				
For assessing competency among practitioners				
Valuable tool for permitting students to become familiar with the clinical environment				
As a means to decrease teaching costs and increase access to laboratories				
Difficulties in finding and retaining clinical sites that will train our students				
The growing construction of clinical education is a ‘burden’ that must be shifted from clinical sites				
The transferability of technical skills gained through simulations to the workplace				
The relevance of skills gained in a simulation at the educational institution (as institutions maybe using out-of-date equipment)				

Loss of opportunities for professional socialization that occur within the authentic environment				
For employers and students for mutual 'sizing up' prior to employment				
Working with up-to-date techniques and instrumentation				
Experiencing non-routine aspects of laboratory procedure and patient specimens				
Appreciating the rhythm and challenges of real-life laboratory workflow and the strategies for addressing them				
Gaining a sense of contributing to patient well-being				

2. Explain how effectively simulated laboratory activities can address these types of learning opportunities as indicated above according to the choice of your answer

----

----

3. List the simulated activities that are directly applicable to medical laboratory education and particularly in your institution

----

----

4. Increased use of simulations in MLS education appears to be driven by economic concerns, workplace constraints, accreditation of educational programs, standardization of graduate competence, and national portability of credentials. What is your take in this?

----

5. Do you use models for simulation in your department? Yes ☐ No ☐

If yes, list them and their use

Model Its use in the department

--------------------------------- --------------------------------------

Section E: Challenges with simulation-based learning. This section highlights the challenges suggested to influence simulation-based teaching and learning. Tick the choice that applies to your institution.

1. challenges affecting the application of simulation-based teaching and learning	Strongly agree	agree	Strongly disagree	disagree

Issues of professionalism and certain skills				
Simulations are demanding for instructional staff				
Simulations are resource-intensive (funding; equipment; specimens; space and scheduling, and administrative support)				

Some aspects of laboratory work are difficult or impossible to simulate.				
The quality of the learning experience may be uneven				

2. List the challenges you encounter in your institution

----

3. The following are some of the factors that go into selecting activities to be simulated

Some solutions to the challenges	Strongly agree	agree	Strongly disagree	disagree

of simulation-based learning application				
The complementarity of academic/clinical settings: for example, activities that cannot be carried out in the clinical site				
Commonality: routine procedures with relevance to all clinical sites				

Program priorities: for example, established competency -based objectives				
Repetition: activities that need time for students to practice repeatedly				
Availability of resources: equipment; samples; supplies; space; instructors; support &				

education for staff				
The needs of clinical partners for students with specific skills				
The validity of the learning experience: its potential for authenticity; the likelihood of minimal compromise to quality of the student experience; evidence of				

effectiveness relative to the effort and cost involved				

4. How do you evaluate the effectiveness of simulated laboratories in your institution?

-----------------Thank you for completing this Questionnaire. Your responses are respected and valued. For more information do not hesitate to send your SMS to 0721422778.

Appendix 4: Checklist for Clinical Instructors and Laboratory In-charge

Date: --

The researcher to assist the campus principals fill and comment on the following components of the research study.

Part 1: facilities

The type, nature, condition, quality, quantity and their appropriateness for simulation in the department of Medical Laboratory sciences

Area/ Item

1. Physical facilities (type)

   ----

2. Location of facilities

   ----

3. Adequacy of facilities

   ----

4. Condition of facilities

   ----

5. Appropriateness of facilities

---------------------------Thank you for your participation

Appendix 5: Site Visits (Observation)

Date ---

The researcher to observe and write comments on the following components of the research study during the site visits

Part 1: facilities

The type, nature, condition, quality, quantity and their appropriateness for simulation in the department of Medical Laboratory sciences

Area/ Item

1. Physical facilities (type)

   ----

2. Location of facilities

   ----

3. Adequacy of facilities

   ----

4. Condition of facilities

   ----

5. Appropriateness of facilities --

Appendix 6: Interviews with Campus Principals

Researcher to explain the objectives of the research study and seek views on the following:

General information

Designation of the respondent---

Number of years served in that position---

For the following interview, the interviewer is to tick (√) appropriately against the items listed below based on the interviewee responses

1. To what extent are simulations defined, constructed, and implemented in your institution?

   ----

2. Are you able to adequately address student needs during the simulated laboratory session?

Yes ☐ No ☐

Not aware ☐

Give reasons for your response

----

3. What are your perspectives now that you are most directly involved in simulated learning?

   ----

4. What motivated and influenced you to decide and apply simulation-based teaching and learning in your institution?

-

5. Do you feel it would be valuable to introduce opportunities for inter-professional interactions?

Yes ☐

No ☐

Explain why

----

6. What do you think are the relationships between simulations and real clinical placements

----

----

7. Is your simulation-based teaching and learning facing any challenges in your institution?

Yes ☐

No ☐

If yes, mention some of these challenges

----

8. Which more resources would you like to see provided for implementing simulation-based experiences

----

----

9. How effectively can the costs of simulations be rationalized

----

----

10. Do simulation laboratories fully address the issues of student safety

----

----

11. Do you think simulations offer an opportunity to bring students closer to the culture of the health care system and to foster their development as a medical laboratory technologist, rather than as a student?-----------------------------------

----

----

12. Why is your program using simulations? ---

----

13. What is involved in the development and preparation for simulation laboratories? ---

14. How did you decide which activities to simulate? ----------------------------------
----

15. Can you give us any information about the costs involved in your simulation laboratories? ---
----

16. What happens in a simulation laboratory on a typical day? ------------------------
----

17. Could you show me the laboratory where the simulations take place? ----------
----

18. How do you assess your students' learning in the simulation laboratory? -------
----

19. How do you know that the students are learning what they're supposed to be learning? --

20. How do your students respond to being in a simulation laboratory? --------------
----

21. What was the best/worst thing about your simulation laboratories? --------------
----

22. Are you aware of any research or studies that have been conducted within or outside of your institution on simulation-based learning? --------------------------
----

23. Do you have any plans to change the way you implement your simulations? ---
----

24. If you could change your simulations and money was no object, what would you do? -

Thank you for your time and participation. Your responses are highly valued and respected.

Appendix 7: A Sample Frame for All the Campuses Offering Medical Laboratory Program and the staff therein

No.	KMTC campus	No. of staff	County	Simulation lab: Yes/No
1	EMBU	5	EMBU	
2	KITUI	6	KITUI	
3	MACHAKOS	6	MACHAKOS	
4	NAIROBI	8	NAIROBI	
5	NAKURU	5	NAKURU	
6	KISII	5	KISII	
7	KAKAMENGA	5	KAKAMEGA	
8	LAKEVICTORIA	5	KISUMU	
9	PERTRITZ	5	MOMBASA	
10	KOMBEWA	4	KISUMU	
11	NYERI	5	NYERI	
12	MURAN’GA	5	MURANG’A	
	Total	64		

Appendix 8: Designation of the various campus principals

	Campus	Designation of the principal
1	Meru	Nursing
2	EMBU	Pharmacist
3	MACHAKOS	Nursing
4	NAIROBI	Health Records and Technology (HR&I)
5	NAKURU	Nursing
6	KISII	Nursing
7	KAKAMENGA	Nursing
8	LAKEVICTORIA	Public Health
9	PERTRITZ	Pharmacist
10	KOMBEWA	Nursing
11	NYERI	Clinical Officer
12	MURAN'GA	Nursing

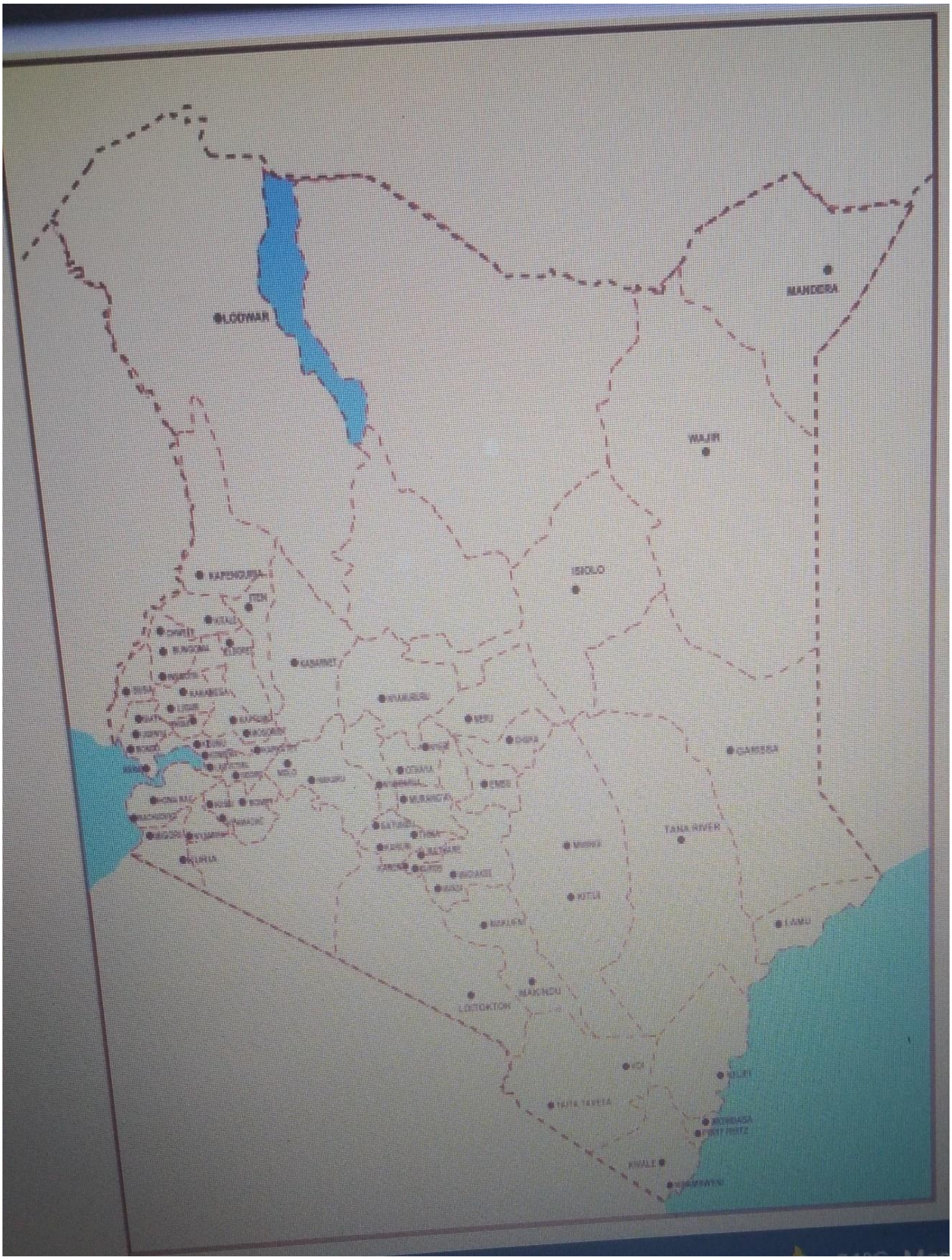
Nb: Kitui KMTC was used for pilot study. The principal here has a specialty in nursing

Appendix 9: Recruitment procedure for potential research participants and communication

The sample will be recruited from all the twelve (12) KMTC campuses offering medical laboratory course and has a laboratory with basic simulations by use of census sampling method. This method involves the use of the total enumeration of the study population which will include the lecturers in the MLS department and the campus principals in these campuses. To qualify for the study, the lecturer participant must be teaching clinical simulation in their respective units while the principals will be included because they are the managers in these campuses and are expected to lead the staff under them in terms of teaching and learning among other managerial roles. The recruitment process will begin with the campus principal informing the faculty members of a request done by Prominah Muia, through the CEO, KMTC Nairobi to carry out data collection in their department for a study titled: Application of innovative Simulation-Based Medical Teaching and Learning among staff in selected KMTC Campuses offering Medical Laboratory Sciences in Kenya, then the principal will give them the invitation letter done by the researcher inviting them to participate in the study. This participation invitation letter from the researcher will be sent prior to the campus principals requesting the invitee to kindly take part in the research study. The letter will also notify them of the date and the purpose of the study in advance. The invitation will clearly state that participating in the study will be voluntary and confidential and that the participants can withdraw from the study without any penalty. A description and explanation of the data collection procedure will be also be stated. The contact information of the researcher will be included. The participants will demonstrate their desire to participate by signing the consent form which will also be attached for their attention.

On the action day (the day for the data collection), the principal of the respective campus will invite the staff for a meeting with the researcher who in turn will explain the aim and the process to participate in the study. The researcher will give adequate time to the staff to consider whether they wish to participate or not. Respondents will demonstrate their desire to participate by signing the consent form which will be distributed to them by the researcher assisted by the research assistants. Afterwards, the participants who consent to participate will be given the questionnaire to fill by the research assistant. The response rate will be recorded by the researcher and the research assistant will observe the filling of the questionnaire process of data collection to progress smoothly. Once the principal is done with the welcoming and opening remarks, he/she will be free to remain or leave at his/her pleasure hence allowing freedom to the participants as well as the researcher and research assistants to continue with the exercise. The researcher together with the research assistants will collect the filled questionnaires, verify whether there are corrections to be done then finally thank the participants for their time and dedication. The team will pack the questionnaires well for safe custody and then leave.

Appendix 10: Map of Kenya showing distribution of KMTC campuses



Appendix 11: Participation Invitation Letter

Dear Invitee,

My name is Prominah Muia. I am a doctoral student at Moi University's Medical Education Program. I am kindly requesting your participation in a doctoral research study that I am conducting titled: Application and opportunities for innovative Simulation-Based Medical Teaching and Learning

The intention is to determine the extent of application and opportunities for innovative Simulation-Based Medical Teaching and learning among staff in selected KMTC Campuses offering Medical Laboratory Sciences in Kenya. The study involves completing a questionnaire by the teaching staff, designed to contain both open and closed-ended questions, interview to the 12 campus principals conducted by the researcher. Other tools include site visits for the purposes of observation done by the researcher and checklist to be filled by the clinical instructors and Lab in-charges in the campuses. Participation is completely voluntary and you may withdraw from the study at any time. The study is completely anonymous; therefore, it does not require you to provide your name or any other identifying information. If you would like to participate in the study, please read the Informed Consent letter below. Your participation in the research will be of great importance to assist in constructing a much-needed evidence base for simulation-based teaching and learning in medical laboratory science program in Kenya and to provide educators with exemplars of simulated laboratory learning, and to identify directions for further research. Thank you for your time and participation.

Sincerely,

Prominah Muia, BSc. MSc, Doctoral Student, Moi University

Appendix 12: IREC Approval Letter

MTRH/MU-INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471/2/3

MOI UNIVERSITY
COLLEGE OF HEALTH SCIENCES
P.O. BOX 4606
ELDORET
Tel: 33471/2/3

Reference: IREC/132/2022
Approval Number: 0004137

26th May, 2022

Phominah K. Muia,
KMTC Chwele Campus,
P.O. Box 112-50202,
KABUCHAI-CHWELE.

Dear Ms. Muia,

APPLICATION OF INNOVATIVE SIMULATION-BASED MEDICAL TEACHING AND LEARNING AMONG STAFF IN SELECTED KMTC CAMPUSES OFFERING MEDICAL LABORATORY SCIENCES IN KENYA

This is to inform you that ***MTRH/MU-IREC*** has reviewed and approved the above referenced research proposal. Your application approval number is ***FAN: 0004137.*** The approval period is **26th May, 2022- 25th May, 2023.**
This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, Material Transfer Agreements (MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***MTRH/MU-IREC.***
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***MTRH/MU-IREC*** within 72 hours of notification.
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to ***MTRH/MU-IREC*** within 72 hours.
v. Clearance for export of biological specimens must be obtained from ***MOH at the recommendation of NACOSTI*** for each batch of shipment.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to ***MTRH/ MU-IREC.***

Prior to commencing your study; you will be required to obtain a research license from the National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and other relevant clearances from study sites including a written approval from the CEO-MTRH which is mandatory for studies to be undertaken within the jurisdiction of Moi Teaching & Referral Hospital (MTRH) and its satellites sites.

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
26 MAY 2022
APPROVED
P. O. Box 4606-30100

Sincerely,

PROF. E. WERE
CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc	CEO	-	MTRH	Dean	-	SOP	Dean	SOM
	Principal	-	CHS	Dean	-	SON	Dean -	SOD

Appendix 13: NACOSTI Research License

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Ref No: 683148

Date of Issue: 13/June/2022

RESEARCH LICENSE

This is to Certify that Ms.. prominah kavinya muia of Moi University, has been licensed to conduct research in Embu, Kakamega, Kisii, Kisumu, Kitui, Machakos, Meru, Mombasa, Muranga, Nairobi, Nakuru, Nyeri on the topic: application of innovative simulation-based medical teaching and learning among staff in selected kmtc campuses offering medical laboratory science in kenya for the period ending : 13/June/2023.

License No: **NACOSTI/P/22/18001**

683148

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Verification QR Code

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Appendix 14: Kenya Medical Training College Permission for Research Letter

Telegrams: "MEDTRAIN" Nairobi
TELEPHONE: NAIROBI 2725191, 2725711/14
Fax:2722907 Email: info@kmtc.ac.ke
Please address all correspondence to:
The Director
When replying please quote

Ref: No. KMTC/ADM/74/VOL.VI /211

KENYA MEDICAL TRAINING COLLEGE
P.O. BOX 30195-00100
NAIROBI

Date 27/6/2022

Prominah K. Muia
KMTC Chwele Campus
P.O Box 112-50202
KABUCHAI-CHWELE

Dear Ms. Muia

PERMISSION TO COLLECT DATA IN SELECTED KMTC CAMPUSES

Reference is made to your letter dated 4th February, 2022 requesting for authorization to carry out a study titled '**Application of innovative simulated-based medical teaching and learning among staff in selected KMTC campuses offering Medical Laboratory Sciences in Kenya: A case of Kenya Medical Training College'** (Embu, Kakamega, Kisii, Kisumu, Kitui, Machakos, Meru, Mombasa, Muranga, Nairobi, Nakuru, Nyeri Campuses).

It is noted that the study protocols have received the necessary ethical clearance from the relevant institutions and the required research license by NACOSTI.

The KMTC Research and Ethics Review Committee has also reviewed the proposal and is satisfied that no ethical issues will be violated in the data collection process.

Permission is therefore granted for data collection; should any unanticipated issues arise, please contact the College Research Office.

Upon completion of the study, you are requested to submit one (1) hard and soft copy of the research report to the KMTC Chief Executive Officer's office.

Thank you.

Eglah J. Kiplagat
FOR: CHIEF EXECUTIVE OFFICER