EVALUATING THE CAPACITY FOR EARLY KERATOCONUS DIAGNOSIS AND MANAGEMENT IN NYANZA AND WESTERN KENYA HOSPITALS

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DEDICATION

I dedicate this thesis to God for enabling me and granting me the grace to complete it, to my family: my mum, dad and my siblings: Agnes, Annet and Godfrey for the support and the encouragement, and to my great friend Catherine Boore for the support and encouragement throughout this period.

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ABSTRACT

Keratoconus is a corneal disorder characterized by progressive thinning. Early detection is often missed due to limited advanced diagnostic equipment, its underutilization and inadequate practitioner knowledge. Few studies have explored the disease. This study aimed to assess the capacity for diagnosis and management of early keratoconus in hospitals across Nyanza and Western Kenya and the specific objectives were: assessment of equipment availability, equipment' working condition, utilization of equipment, and practitioners' knowledge in early keratoconus diagnosis and management. In this study which was conducted across private and public hospitals in Nyanza and Western Kenya, observational cross-sectional design was employed. A total of 143 Eyecare practitioners participated in the study and census approach was used. Data was collected using a questionnaire, and analyzed using SPSS version 29. The study found that the basic equipment was readily available including retinoscopes (95.5%) and ophthalmoscopes (88.1%), compared to advanced equipment such as tomographers (10.4%). Level 6 hospitals had the highest equipment availability. Public hospitals had more basic equipment, while private hospitals had more advanced equipment. Several available equipment was in poor working conditions. These included the contact lens fitting-set (46.1%), corneal topographer (35.2%) and pachymeter (19.1%). The advanced equipment such as contact lens fitting-set depicted low utilization rates (31.0%). However, the basic equipment showed higher utilization rates including distance visual acuity chart (91.8%) and trial lens/phoropter (89.9%). The public hospitals had higher utilization rates for basic equipment, while private hospitals had higher utilization rates for advanced equipment. There was a significant association between equipment availability and its utilization, with distance visual acuity chart p=**0.0333**, trial lens/phoropter p=**0.0029** and slit-lamp p=**0.0028**. Less than half of the eyecare practitioners (36.6%) had good knowledge, (60.4%) fair knowledge and (3.0%) poor knowledge for early keratoconus diagnosis. Equally, (36.6%) had good knowledge, (61.2%) fair knowledge and (2.2%) had poor knowledge for early keratoconus management. There was a significant association (p=**0.006)** between knowledge in the management of early keratoconus and the qualification level of the Eyecare practitioners, and significant difference for knowledge of risk factors (p=**0.0322)**, and progressive keratoconus (p=**0.0186),** between private and public hospitals. In conclusion, the study found that basic diagnostic equipment was widely available, while advanced tools were scarce and underutilized. A significant proportion of practitioners lacked adequate knowledge in diagnosing and managing early keratoconus. The study recommends improving access to advanced diagnostic tools, and training in early keratoconus detection and management, to address this gap.

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LIST OF ACRONYMS AND ABBREVIATIONS

CCT	Central Cornea Thickness
CH	Corneal Hysteresis
CL	Contact Lens
COCS	Comprehensive Ophthalmology and Cataract Surgeons
CRF	Corneal Resistant Factor
CT	Corneal Thickness
CXL	Crosslinking
DALK	Deep Anterior Lamellae Keratoplasty
ECPs	Eye Care Practitioners
ISERC	Institutional Scientific Ethics Review Committee
IOPs	Intra-Ocular Pressures
KC	Keratoconus
NACOSTI	National Commission for Science, Technology and Innovation
OCOs	Ophthalmic Clinical Officers
PGF	Primary Graft Failure
PK	Penetrating Keratoplasty
RE	Refractive Errors
SPSS	Statistical Package for Social Sciences
VA	Visual Acuity
VKC	Vernal Keratoconjunctivitis

OPERATIONALIZATION OF KEY TERMS

Cornea: The front surface of the eye which is normally transparent in colour.

Keratoconus: A condition of the cornea whereby the cornea progressively thins thus forming a conical shape.

Advanced equipment: Equipment that is able to diagnose and detect early stage of keratoconus.

Capacity: Includes equipment availability, their utilization and practitioner knowledge.

Eyecare practitioner: A practitioner was considered an eyecare practitioner if they were ophthalmologist, ophthalmic clinical officer, comprehensive ophthalmology and cataract surgeons or optometrists. Their scope of practice allows them examine, diagnose and manage eyecare patients.

Hospitals: Levels 4, 5 and 6 hospitals that had Eye units, handled eyecare patients and offered eye diagnostic and management services.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Keratoconus (KC) is a bilateral, asymmetric and ectatic corneal abnormality, characterized by the progressive thinning of the cornea (Martínez-Abad & Piñero, 2017; Zhou et al., 2022). This pathological thinning leads to a conical corneal shape, which results in irregular astigmatism and decreased vision (Martínez-Abad & Piñero, 2017). Predominantly, KC affects young individuals in their second and third decades of life, with a higher prevalence in males compared to females (Akowuah *et al.,* 2021; Das *et al.,* 2024).

Globally, KC prevalence is increasing as observed from 0.001% in 2009 (McGhee, 2009) to 0.138% in 2020 (Hashemi *et al.,* 2020). In New Zealand, KC had a prevalence of 0.524% (Papali'i-Curtin *et al.,* 2019), 0.265% in Netherlands (Godefrooij, de Wit, *et al.,* 2017), 0.192% in Norway (Kristianslund *et al.,* 2021) and 0.044% in Denmark (Bak-Nielsen *et al.,* 2019). In most of these studies, the highest KC prevalence was for the mild cases as opposed to the severe cases. In Asia, KC prevalence was higher than in the Western Europe (Hashemi *et al.,* 2013; Hwang *et al.,* 2018).

In a meta-analysis conducted in Africa, which included studies from Egypt, South Africa, Ghana, Nigeria, Sudan and Kenya, the prevalence of KC was 7.913% (Akowuah *et al.,* 2021). Within this meta-analysis, Kenya did not present its prevalence but reported that among those with KC, the males had a higher proportion (59.843%) compared to the females (40.157%) (Rashid *et al.,* 2016). The meta-analysis revealed significantly higher KC prevalence rates in South Africa and Egypt,

(24.215%) and (17.471%) respectively, where most cases were in the severe stages (Rampersad *et al.,* 2020; Saro *et al.,* 2018), contrary to the global developed countries.

In Kenya, limited studies have been conducted on KC. One study estimated the prevalence of KC to be 1.672% (Rashid *et al.,* 2023). Another study, which focused on patients with allergic conjunctivitis, presented significantly higher prevalence of KC (30.894%), indicating a strong association between allergic conjunctivitis and KC (Mugho, 2016). Furthermore, this study revealed that mild KC was diagnosed using corneal topographer.

The diagnosis and management of KC significantly depend on its stage, which includes early, moderate, and severe stages (Santodomingo-Rubido *et al.,* 2022). In the early mild stages, advanced diagnostic equipment such as corneal topographers, tomographers, and pachymeters are essential (Belin & Duncan, 2016; Bevara & and Vaddavalli, 2023; Santodomingo-Rubido et al., 2022). In contrast, basic diagnostic tools like slit-lamps, direct ophthalmoscopes, and keratometers are able to diagnose KC at severe late stages (Mugho, 2016; Ambr & Belin, 2010; Belin & Duncan, 2016; De Stefano *et al.,* 2020; Jesus & Iskander, 2017). Moreover, increasing rates have been observed in USA, whereby earlier studies had lower prevalence (0.007%) (Ljubic, 2009), while recent ones had higher one (0.151%) (Munir et al., 2021), possibly due to the use of advanced equipment presently. This transition, together with good knowledge, enhances timely diagnosis and management of early KC (Bak-Nielsen *et al.,* 2019; Godefrooij *et al.,* 2017). The early diagnosis and management consequently offer numerous advantages including fairer costs and less complications, as opposed to the late stages which are associated with high costs, risks of blindness and complications. Equally, this eventually promote the Sustainable Development Goal (SDG) 3 as it enhances good health, SDG 4 by promoting quality education through

good vision and SDG 8, as once learning and education are improved, this thus enables for decent jobs and economic growth (UN, 2015). Thus, this study aimed to assess the capacity for diagnosis and management of early keratoconus in Nyanza and Western Kenya hospitals.

1.2 Problem Statement

The global KC prevalence has been increasing, with a 2020 study reporting 0.138% (Hashemi et al., 2020) and a more recent one reporting higher rates, 0.241% (Sriranganathan et al., 2022). Moreover, the United States of America (USA) also reported progressive increase, whereby the rates shifted from 0.030% to 0.040% (Singh et al., 2024), with Brazil reporting higher rates (0.730%) (de Azevedo Magalhães et al., 2024). In Europe, Germany equally depicted higher prevalence (0.490%) (Marx-Gross et al., 2023), which was higher than what was earlier on reported. Additionally, Northern Poland demonstrated far higher rates (0.549%) (Kanclerz et al., 2023). Further, Italy reported much higher rates of (2.100%) (Lombardo et al., 2024). For these studies, most of them reported having used the advanced equipment such as corneal topographer to diagnose, possibly, the reason why they elicited higher rates than earlier reported.

In Africa, KC has presented higher rates. In a global study, Africa presented the highest prevalence (2.414%) compared to the global one (0.241%) (Sriranganathan et al., 2022). Ghana reported lower rates (0.053%), which was highly linked to a lack of advanced diagnostic equipment and a lower referral uptake (Kobia-Acquah et al., 2022). Egypt showed a progressive increase, with year 2019 reporting (1.120%) (Elbedewy et al., 2019) and (7.700%) in 2025 (Mousa et al., 2025). A Tanzanian study found higher rates (10.000%) (Maro & Moodley, 2025), and a slightly higher one in South Africa (13.701%) (Gcabashe et al., 2023).

In Kenya, a study of high school population reported a prevalence of (1.672%) (Rashid et al., 2023b), which was more than ten (10) times higher than the global rates (Hashemi et al., 2020). Yego et al reported that most of the KC patients were diagnosed at the late stages, thus showing a lack of early detection (Yego & Chemjor, 2020). Any delay in diagnosis and management leads to significant progression of up to 39.6% in a short span of time, (100-153 days) (Goh et al., 2020), yet this would have been avoided. Crosslinking regimen halts progression (Steinberg et al., 2021), and it is only feasible if it is done early. Moreover, with KC mostly affecting the young population (20-29years) (Sriranganathan et al., 2022), this would affect the country's GDP, as this is the productive age bracket, as their productivity and quality of life declines once affected (Alatawi, 2023; Pinto et al., 2021). Conversely, if KC is diagnosed and managed early, it leads to improved quality of life (Kandel et al., 2020). It is more beneficial when KC is diagnosed and managed early (Galettis, 2018; Godefrooij, Gans, et al., 2016), as opposed to late diagnosis which is characterized by multiple disadvantages (Alio et al., 2014; Choi et al., 2014; Leung et al., 2017; Pinheiro-Costa et al., 2020).

To diagnose early KC, advanced equipment such as corneal topographer and corneal pachymeter, and adequate knowledge are a pre-requisite (Bevara & and Vaddavalli, 2023; Santodomingo-Rubido et al., 2022). If, and when the requisite equipment for early KC lack, are under-utilized, and when practitioners have inadequate knowledge, early KC diagnosis is often missed out. This, consequently delays management, hence lowering the patients' benefits (Baenninger et al., 2021; Bevara & and Vaddavalli, 2023; Santodomingo-Rubido et al., 2022; Shah et al., 2021; Steinberg et al., 2021).

In Kenya, KC prevalence is increasing, and there is limited information on diagnosis and management of early KC. One study reported on general equipment availability

(Rashid et al., 2023a), but did not inform on the utilization rates of the available equipment and their working conditions. Moreover, the Kenyan studies majored on general as opposed to early KC, yet it is at this stage where there is a possibility of numerous advantages, consequently saving on costs and complications associated with the late stages (Espandar & Meyer, 2010). This study thus aimed to evaluate early keratoconus diagnosis and management capacity in Nyanza and Western Kenya hospitals, which eventually informed on the availability of the advanced equipment, its utilization and knowledge levels in early KC diagnosis and management.

1.3 Objectives

1.3.1 Broad Objective

To evaluate the capacity for diagnosis and management of early keratoconus in Nyanza and Western Kenya hospitals.

1.3.2 Specific Objectives

i. To determine the availability of early keratoconus diagnosis and management equipment and consumables in Nyanza and Western Kenya hospitals.

ii. To evaluate the working conditions of the early keratoconus diagnosis and management equipment in Nyanza and Western Kenya hospitals.

iii. To determine the utilization of early keratoconus diagnosis and management equipment and consumables in Nyanza and Western Kenya hospitals.

iv. To assess the level of knowledge of the practitioners in early keratoconus diagnosis in Nyanza and Western Kenya hospitals.

v. To assess the level of knowledge of the practitioners in the management of early keratoconus in Nyanza and Western Kenya hospitals.

1.4 Research Questions

i. What is the available equipment and consumables for diagnosis and management of early keratoconus in Nyanza and Western Kenya hospitals?

ii. What are the working conditions of the available equipment and consumables in Nyanza and Western Kenya hospitals?

iii. What is the degree of utilization of early keratoconus diagnosis and management equipment in Nyanza and Western Kenya hospitals?

iv. What is the level of knowledge of the practitioners in diagnosis of early keratoconus in Nyanza and Western Kenya hospitals?

v. What is the level of knowledge of the practitioners in the management of early keratoconus in Nyanza and Western Kenya hospitals?

1.5 Justification of the Study

The prevalence of KC is increasing (1.191%), with its diagnosis mostly happening at the late severe stages (Chan *et al.,* 2021; Kreps *et al.,* 2021). There are limited number of studies on KC done in Kenya, hence the need for more information regarding KC, particularly early KC, which if not diagnosed and managed early, it progresses to severe stages (Pinheiro-Costa et al., 2020). In a study done in Kenya on contact lens use, it reported that most patients presented with moderate to severe KC, highlighting a lack of early detection in clinical practice (Yego & Chemjor, 2020). The severe KC leads to extreme complications, including going blind, yet this would have been prevented by managing early KC (A. Ferdi *et al.,* 2022; A. C. Ferdi *et al.,* 2019; Olivo-Payne *et al.,* 2019). Nyanza and Western Kenya regions are warm and hot, thus a high prevalence of allergic conjunctivitis which is highly associated with KC (Mugho, 2016; Seth *et al.,* 2023). Moreover, the region is amongst the highest populated

regions, thus having many hospitals to serve the high population. In Kenya, the ophthalmologists, ophthalmic clinical officers (OCOs), comprehensive ophthalmology and cataract surgeons (COCs) and the optometrists are the eye care practitioners (ECPs) involved in patients' examination, diagnosis and management. However, the ophthalmologists were not included in the earlier studies, yet they are at the apex of the referral points. These practitioners work in L4, L5 and L6 hospitals, thus having these as the practitioner and hospital level populations respectively, and eyecare services are offered in these hospitals. The increasing KC prevalence, the dangers in severe KC, including blindness which is possible to avert if KC is diagnosed and managed early, and for the limited information and studies on KC in Kenya, especially the early KC, informed the need for this study. This study sought to evaluate the diagnosis and management capacity for early KC in hospitals in Nyanza and Western Kenya.

1.6 Significance of the Study

The early diagnosis and management will promote sustainable development goal (SDG) 3, ensuring better eye health (UN, 2015). With good eye health, the school going KC patients would perform better in class as promoted by better eye sight, thus promoting SDG 4 on quality education (UN, 2015). With KC patients having an opportunity to be fully and comfortably involved in class work, this promotes good performance academically, thus being able to qualify for decent jobs, consequently promoting economic growth and therefore achieving SDG 8 (UN, 2015).

The ability and capacity to have patients with early keratoconus being diagnosed and managed at lower costs as opposed to having them managed at the late severe keratoconus, highly benefits the patients. This promotes their eye health, therefore achieving the universal health coverage (UHC) goal on lower treatment charges, thus

avoiding draining people into poverty (WHO, 2019). The information on availability of early keratoconus services would guide on where the services can be accessed. This would help patients access the services nearest to them, thus achieving the UHC goal on access of healthcare services where, and when they need them (WHO, 2019). Additionally, with the study aimed at assessing early KC knowledge, it would also guide on knowledge promotion, eventually leading to quality health services, which would help achieve UHC goal on people being able to receive quality services whenever they need them (WHO, 2019).

Previous diagnosis of the KC disease was on general KC without specific stage, thus the literature available in the field is on the general KC equipment for diagnosis. This research on the available equipment, their utilization and knowledge particularly on early KC in the hospitals in parts of Kenya, is an added contribution to the existing literature.

1.7 Scope of the study

This study was conducted in Levels 4, 5 and 6 (L4, L5 and L6) public and private hospitals in Nyanza and Western Kenya, consisting of ten (10) counties. The ECPs working in these hospitals were the participants of the study, who participated by answering a structured questionnaire through an online link that was shared and accessed through their electronic gadgets. The hospitals involved offer eyecare services. They were involved as the population participants because they are involved in eyecare patients' examination, diagnosis and management, and they are equally found in the L4, L5 and L6 hospitals.

1.8 Limitations

There was a possibility of recall bias as the practitioners were required to remember activities involving their keratoconus services. Although some associations of various aspects were found in the study, it was hard to make a causal inference on the same. Additionally, the equipment's working conditions was subjectively determined as it was based on practitioners' perceptions.

1.9 Conceptual Framework

In this conceptual framework, there are intervening (increase or decrease) variables which influence the relationship between independent and dependent variables, these include the age, gender and level of training of the ECPs. There are also control variables which are held constant to prevent their influence on the relationship being studied. The control variable in this study was the level of Hospital. Interveners affect the strength or direction of the relationship, while controls are extraneous factors that could confound the results if not accounted for as illustrated in *figure 1.1*.

In a hospital setting, the conceptual framework could be used to analyze the factors affecting the utilization of an equipment. The framework would help assess the equipment's physical availability (is it always available for use?), its functionality (are there any technical issues? is it actually used?). The maintenance schedule (is it regularly serviced?), the training of the ECPs who use it, among others. By examining these factors and their relationships, the hospital can identify areas for improvement to optimize the equipment's utilization and enhance the quality of patient care (Salawu et al., 2023).

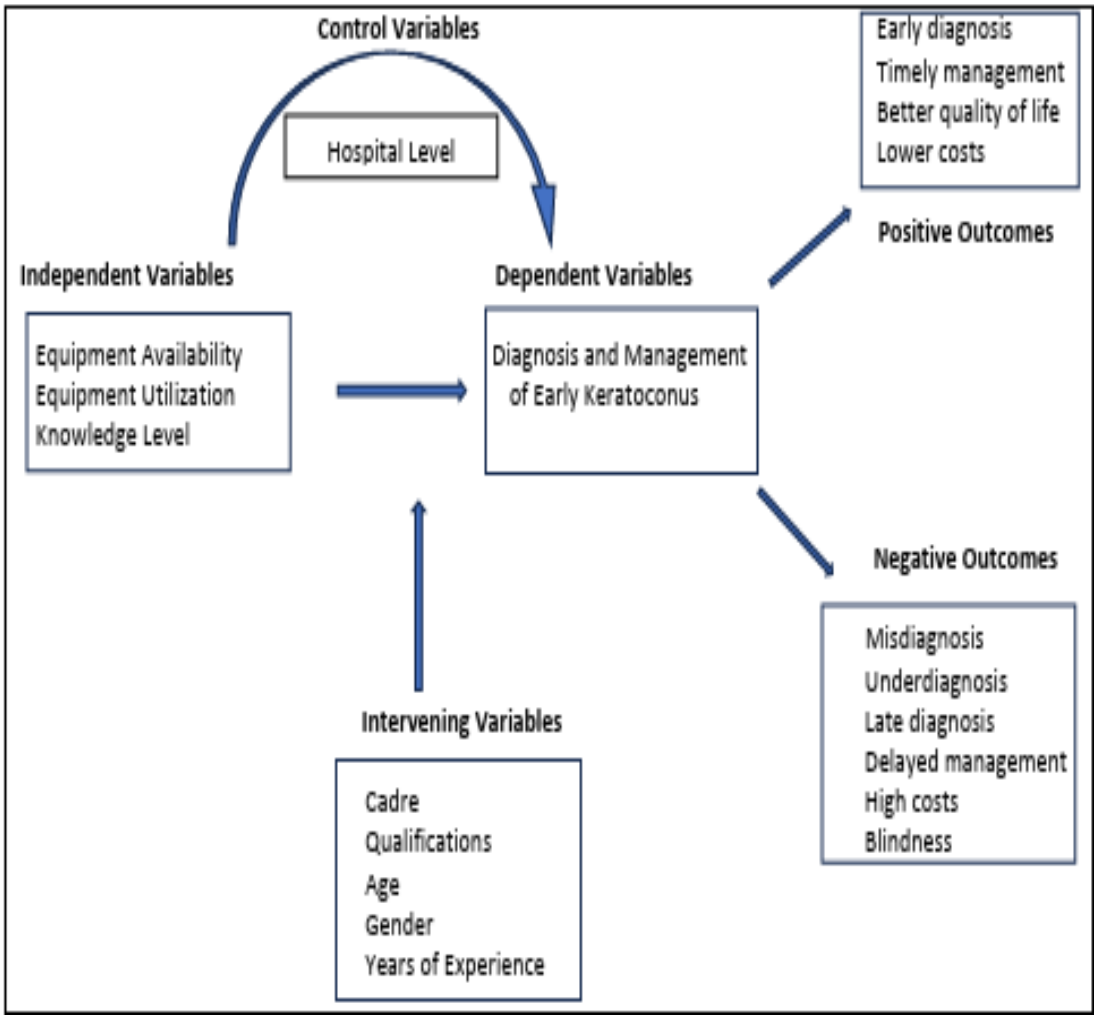

Figure. 1.1 Conceptual framework,

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of the Kenyan Healthcare System

In Kenya, the healthcare system is structured into six hierarchical levels, with the community-based care being the lowest level, while the national referrals are the highest levels. The levels one to three comprise community health services, dispensaries, and health centres respectively. These do not offer eyecare services which are majorly offered at the levels four, five and six, including keratoconus services, consisting of sub-county, county, and the national referral hospitals. The level four healthcare set-ups offer the primary eyecare services, although some offer secondary care. These services include basic ocular assessments and minor surgeries. Level five expand to offer specialized services which include advanced and therapeutic inputs, including medical and surgical management of eye diseases, low vision services, visual rehabilitation, refractive error services and laser interventions. Level six healthcare set-ups comprise of the referral and teaching hospitals, which majorly offer the sub-specialized and more advanced eyecare services in Kenya (Mbindyo et al., 2020; MOH-Kenya, 2020; Nyawira et al., 2022).

The eyecare human-resources, their ability to diagnose and manage keratoconus vary greatly based on their qualification cadres in Kenya. Generally, they comprise of the ophthalmologists, optometrists, comprehensive ophthalmology and cataract surgeons (COCs), ophthalmic clinical officers (OCOs) and the optometry technologists. Ophthalmologists who are medical officers, having an additional 3-year Master's in ophthalmology, are primarily at the referral apex for advanced keratoconus stages, which require surgical management. These are however few in number, about one

hundred and sixty ophthalmologists, who are mostly centralized in the urban area (MOH-Kenya, 2020).

The OCOs and the COCs have a three-year diploma in clinical medicine, and later acquire some additional training in cataract surgery and ophthalmology for three years or one and a half years to become COCs and OCOs respectively (JKUAT, 2025; MOH-Kenya, 2020). Nevertheless, optometrists are trained through a five-year program leading to a Bachelor of Optometry (optometry officers) or through a three-year diploma program to become optometry technologists. The optometry officers carryout refractions, prescribe contact lens and manage a wide range of ocular conditions (KENYA, MOH, 2025; MOH-Kenya, 2020). These cadres are generally able to diagnose and initiate the management of keratoconus.

2.2 Keratoconus Burden, Diagnosis and Management

Keratoconus is a corneal disease that presents with progressive decline in corneal thickness, and a wide range of differences in corneal steepness (Shi, 2016). With a global prevalence of 0.138% (Hashemi et al., 2020), much higher rates in Africa (7.913%) (Akowuah et al., 2021) and equally higher ones in Kenya (1.672%) (Rashid et al., 2023b), it signifies a worrying trend. Moreover, its management modalities and costs vary greatly based on the disease stage. The early stages are managed using spectacles, contact lenses and crosslinking for the progressive KC (Barnett et al., 2023), with these bearing comparatively lower costs and less complications (Godefrooij, van Geuns, et al., 2016; Salmon et al., 2015). Moreover, crosslinking is very effective in reducing progression rates, thus highly avoiding the highly expensive and complicated corneal transplants (Godefrooij, Gans, et al., 2016). However, if crosslinking is delayed, KC progresses to the late stages which are way more expensive to manage in addition to the complications associated (Shah et al., 2021), as it requires

major surgical procedures such as Deep Anterior Lamellar Keratoplasty (DALK) and Penetrating Keratoplasty (PK) (Cursiefen et al., 2016; Musa et al., 2012). These procedures require transplant, which further complicates the process due to delay in getting donor corneas and the high costs (Toro et al., 2020).

The various KC outcomes depend on a number of factors, including advanced equipment availability, their utilization and practitioner knowledge. The lack of these leads to missed or delayed diagnosis and management (Shah et al., 2021), eventually lowering the affected individuals' quality of life (Kandel et al., 2020). The advanced equipment are able to detect KC at the early stages, as opposed to the basic equipment, which are more sensitive at the late severe stages (Belin & Duncan, 2016; Bevara & and Vaddavalli, 2023; Santodomingo-Rubido et al., 2022). Furthermore, the knowledge of early KC clinical features, including the signs and its associated risk factors, are key in diagnosing and managing early KC (Syed et al., 2022; Tojar, 2022).

2.3 Socio-demographics

Some studies have demonstrated more male gender practitioners' participation and representation. A study in Ghana, Africa, reported that more males than the females practitioners participated in the study (Boadi-Kusi et al., 2015). Moreover, another keratoconus knowledge study found out that there were more male practitioners that participated as opposed to the females, in Switzerland, Europe (Baenninger et al., 2021). Another study in India reported that there was a significant association between the qualifications of the eyecare practitioners, and their knowledge level, whereby those with higher qualification levels were found to be more knowledgeable (Arvind et al., 2021).

2.4 Availability of equipment for early keratoconus diagnosis and management

The shift from using basic diagnostic tools to using advanced equipment has led to an increase in diagnosis of early-stage KC, such as in Asia whereby regional studies have had higher rates in the recent times as opposed to earlier ones, (0.037%) in South Korea in 2014 (Hwang et al., 2018) and (2.393%) in Turkey in 2021 (Özalp et al., 2021). Moreover, proper diagnosis of KC requires a combination of both advanced and basic equipment, along with the clinical signs and symptoms associated with KC (Mas Tur *et al.,* 2017; Shi, 2016).

In a study in public health facilities in KwaZulu Natal, South Africa, there was lack of advanced equipment and resources (Gcabashe *et al.,* 2022). Moreover, they found out that the facilities did not have CL fitting sets and CL solutions for KC management, thus lacked advanced equipment. They however had a few consumables for KC management with CL, but they were not individual consumable-specific (Gcabashe *et al.,* 2022). In a related study in South Africa, there was a lack of the advanced equipment which led to lower requisite service levels (Maake & Moodley, 2018). In an evaluation of contact lens practice in private contact lens clinics in Muscat, Oman, there was limited resources for CL services, although it majored on the management aspect (Khandekar & Fahdi, 2009). Moreover, studies in Latin America and Australia reported reduced availability of the advance equipment, whereby topographers were scarcely available (Braga Vieira et al., 2023; Hodge et al., 2015). Furthermore, another study in the Capricorn District in South Africa, reported that the advanced equipment were scarce (Nkoana et al., 2024). Equally, a study in Limpopo, South Africa on diagnosis and management of keratoconus, reported that both the basic and the advanced equipment were lacking (Nkoana et al., 2022a). However, some Saudi Arabian studies reported that the advanced equipment were available (Motowa et al.,

2014; Naidoo et al., 2021), which was similar to a study in India whereby the advanced equipment were available (Arvind et al., 2021).

On the other hand, a study in Limpopo, South Africa on the minimum of care services provided, showed they had basic equipment although the study was not disease specific (Maake & Moodley, 2018). However, there were distribution variations and not zone specific. Additionally, a Kwa Zulu Natal study reported that the basic equipment such as slit lamps were available (86%) (Gcabashe et al., 2022), similar to another Kenyan study which reported that some basic equipment was available (Rashid et al., 2023a). In a study done in India amongst optometrists in the public and private sectors, some instruments were available (Arvind *et al.,* 2021). However, it was reported that basic equipment lacked in South Africa, with slit lamps having only 57% availability (Nkoana et al., 2024). Comparatively, Buthelezi and Staden reported that the tertiary level hospitals were more equipped as opposed to the district hospitals (Buthelezi & Staden, 2020). Moreover, in 2024, Nkoana et al found that the public facilities had more resources than the private ones (Nkoana et al., 2024).

From these studies, there was no consistency on equipment availability, and mostly majored on general disease aspects and not in early KC. The health systems bureaucracy differs in varying aspects including the economic status, and it would be of great importance to assess the actual situation in the public and private health hospital set-up in Kenya.

2.5 Equipment' Working Conditions

A Kenyan study on the maintenance of medical equipment revealed that the equipment had fair standards in the public hospitals and the facilities had no any quality control strategies (Mutia et al., 2012). Comparatively, the study reported that the public

hospitals had a limited priority for servicing equipment, as opposed to the private set-up (Mutia et al., 2012). From another Ethiopian study, the medical equipment were reported as being sub-optimal, which was highly linked to the patients' inaccurate diagnosis and management, and had direct implications to those seeking services (Sewagegn et al., 2025). These studies were not specifically on early keratoconus, and it would therefore be worthwhile seeking information in relation to the early keratoconus equipment.

2.6 Early KC equipment utilization in diagnosis and management of early keratoconus

The use of advanced diagnostic equipment has facilitated the early detection of KC, thus resulting to decrease in severe cases as evidenced in studies conducted in the USA (Espandar & Meyer, 2010; Ljubic, 2009; Munir et al., 2021). Therefore, the use of the advanced diagnostic tools for KC detection and diagnosis is crucial, as it enables timely and more effective management, thereby reducing the risk of severe complications and improving the overall patient outcomes (Uday, 2022).

In a study done in India on knowledge and skills amongst optometrists in the public and private sectors, it showed that some instruments may be available and not in use, although it was not specific on the equipment complexity, role or type (Arvind *et al.,* 2021). Moreover, in a study on the services for refractive error in Kenya, some facilities had a few equipment of which some were not in use, although this majored on refractive error assessment equipment (Morjaria *et al.,* 2013). This showed a similar trend with resources for eyecare in Saudi Arabia (Palmer et al., 2014), although this involved general eyecare equipment. Furthermore, an Australian study reported that the available equipment were not fully utilized (Hodge et al., 2015). Additionally,

South African studies reported that the available equipment were not used (Gcabashe et al., 2022; Nkoana et al., 2024).

On the contrary, a health system dynamics analysis of eyecare services in Trinidad and Tobago, revealed a varying trend in equipment use, with many varied equipment being in use (Braithwaite *et al.,* 2018). In addition, both the advanced and the basic equipment were utilized in India (Arvind et al., 2021). In another study by Maake et al, it revealed that there was a shortage on available equipment and consumables for KC management, of which there was no clear information on which specific ones were being utilized (Maake & Moodley, 2018).

From the above, there is inconsistency on the utilization of the available equipment. The equipment utilization may vary from region to region due to policy differences, and it would therefore be important to consider the use of disease specific equipment in specific coverage. Moreover, it would be fundamental to assess the utilization of advanced early KC equipment in diagnosis and management of early KC in hospitals in Kenya.

2.7 Knowledge level in early keratoconus diagnosis

Keratoconus may generally be detected by observing various signs and paying key attention to its risk factors. Equally, progressive KC may be identified by various indicators. Some of the signs of early KC include: shadow vision in Snellen's optotype, slightly distorted optotype even in good VA, difference in refraction in lighted and dark room, scissor-reflex, mild localized corneal steepening and thinning, increased keratometry readings differences between inferior and superior cornea, increased corneal aberrations, mild changes in refractive error and reduction of spectacles' best corrected visual acuity (BCVA) (Santodomingo-Rubido et al., 2022; Tojar, 2022). The

risk factors of KC include: genetics, systemic diseases, chronic eye allergies, eye rubbing, age, parental consanguinity, family history, asthma and eczema (Almusawi & Hamied, 2021; Debourdeau et al., 2022; Hashemi et al., 2020). Moreover, the indicators of progressive KC include: increase in astigmatism > 1.0D, significant changes in orientation of axes, increase of 1.0 D or more in optical power of the steepest corneal meridian, and decrease of 25 micrometres or more in corneal thickness (Peña-García et al., 2015).

With a minimum keratoconus knowledge (MKK) defined with respect to KC definition, risk factors, symptoms and possible treatment options of KC, a Switzerland study revealed a low recall of symptoms and risk factors (Baenninger *et al.,* 2021). Moreover, a study on self-reported knowledge and skills related to diagnosis and management of KC in Limpopo, South Africa, it showed that a number of optometrists did not have appropriate knowledge and skills regarding KC (Nkoana *et al.,* 2022). Additionally, in a study in Cameroon on keratoconus in the West region of Cameroon, it reported limited knowledge in keratoconus diagnosis, thus poor keratoconus diagnosis (Ayukotang et al., 2024). Baenninger et al reported inadequate knowledge of signs of KC (Baenninger et al., 2021). Additionally, a Limpopo study found low self-reported knowledge on the use of equipment to diagnose KC (Nkoana et al., 2022a).

On the contrary, a study in India revealed that optometrists had knowledge and skills on KC, but still underutilized based on the prevailing policies (Arvind *et al.,* 2021). Besides, majority of optometrists in the public sector in KwaZulu Natal, South Africa, had adequate training and skills to diagnose KC (Gcabashe *et al.,* 2022). These studies were on general KC with no disease specific stage. Moreover, the practitioners were

found to have high knowledge level of the risk factors of KC (62.5%) (Nkoana et al., 2022a).

From the above, there is a broad variation on knowledge and skills on KC diagnosis. Furthermore, the studies dealt with general KC, and so it would be worthwhile considering the early KC which is KC stage specific. With the Kenyan health system being different, there could exist dynamic differences and would be needful to find out the actual situation regarding knowledge in diagnosis of early KC in the public and private hospitals.

2.8 Knowledge level in early keratoconus management

There are varying treatment and management options of KC based on the severity. These include the optical options such as spectacles and contact lens (CL) which are the first line of management (Barnett et al., 2023), including soft, rigid gas permeable (RGP) and the specialty CL (hybrid, piggyback and Rose K) (Saraç et al., 2019). The surgical options include cross-linking (CXL), intracorneal ring segments (ICRS), penetrating keratoplasty (PK) and deep anterior lamellar keratoplasty (DALK) (Deshmukh et al., 2023).

The optical options are the preferred first line of management for KC, with spectacles and contact lenses being favoured due to their cost effectiveness, with an estimated annual cost of $68.8, thus making them more affordable compared to other management options (Leung et al., 2017; Rebenitsch et al., 2011). The CL are used at the early and moderate KC stages, with some recent designs being able to correct irregular astigmatism and improve visual acuity (VA) in most KC patients including in KC progression (Jhanji et al., 2011). The soft toric CLs are effective in correcting myopia and irregular astigmatism in early KC (Barnett et al., 2023). As KC progresses,

specialized CLs such as Rose K, hybrid, piggyback and scleral CL are used for management (Rathi et al., 2013).

The surgical options are majorly used in the moderate to severe stages (Deshmukh et al., 2023). The CXL is commonly used for progressive early KC (Shetty et al., 2015), which significantly halts progression to the severe stages. Technically, ICRS is a more demanding procedure for severe KC management, which is associated with complications including perforation of Bowman's layer, corneal neovascularization, segment extrusion and haziness (Alio et al., 2014; Barbara & Barbara, 2013; Piñero & Alio, 2010). The PK is used in severe stages which requires specialized ECPs and donor corneas, which are usually in limited supply and has numerous complications (Choi et al., 2014; Leung et al., 2017). Additionally, DALK is another surgical option, characterized by numerous disadvantages. These include the longer operation time duration and the potential graft rejection (Coster et al., 2014; Cursiefen et al., 2016).

Gcabashe et al through a study in Kwa Zulu Natal, South Africa, found that the practitioners felt adequately trained and competent in fitting of CL for KC management, although it was not specific on early KC management skills, though they also felt that they needed additional knowledge (Gcabashe *et al.,* 2022).

On the contrary, from a study done in India, the skills and knowledge level varied for various procedures, with lower skills and knowledge levels in the private sector, although this was for general varied services (Arvind *et al.,* 2021). Additionally, a study on keratoconus in the West Region of Cameroon, found out that there was knowledge deficiency in keratoconus management (Ayukotang et al., 2024). On a self-reported study modality in Limpopo, a significant number of practitioners (45%) were found not knowledgeable in the management of KC (Nkoana et al., 2022a). Moreover,

Nkoana et al in a public health sector study reported that the ECPs had low knowledge of KC management (Nkoana et al., 2024).

From this, there is an inconsistency in regard to practitioners' knowledge and skills for KC management. Moreover, the studies were on general KC. This therefore made it fundamental to assess on disease specific knowledge, in management of early KC in public and private hospitals in Kenya.

2.9 Summary of Literature Review

Some studies have been done on equipment in regard to KC, with some reporting that the equipment was available but not utilized. Disparity on knowledge and skills levels was evident, but did not report on utilization (Arvind *et al.,* 2021). Moreover, some were available but their utilization pattern was not clear and informative (Maake & Moodley, 2018), thus no information on what association exists between the two. In India, a study on management outcomes in pediatric KC emphasized on the need to diagnose pediatric KC early due to the high progression risk, yet no specific emphasis for study on the knowledge and equipment to diagnose the early KC (Gupta *et al.,* 2022).

Ayukotang et al in a study in West Cameroon, reported that the majority of eyecare personnel and administrators had limited or no knowledge on KC (Ayukotang et al., 2024). Here, undersupply of KC diagnostic equipment was closely associated with poor diagnosis and management of KC patients. Moreover, in a systematic review and a meta-analysis, Akowuah et al decried the limitation on the shortage of KC studies in Africa and the lack of published researches. They highlighted the need for researches on KC, and that this limitation should be of great concern (Akowuah *et al.,* 2021).

Generally, in Africa, it was found that KC prevalence was high but early KC goes undetected. Some of the studies found out that the advanced equipment was available but not utilized, some practitioners did not have sufficient knowledge and skills to diagnose and manage KC, while others did not have advanced equipment for early KC diagnosis (Gcabashe *et al.,* 2022; Maake & Moodley, 2018; Nkoana *et al.,* 2022), although Kenya was not part of these studies.

In this connection, early KC studies are more limited than the general KC, and hence the dire need for studies in early KC. The study output stands to guide on early KC services, in recognition of the extreme dangers, complications and high costs associated with managing severe KC as a result of unmanaged early KC. Thus, the need for this study which evaluated the diagnosis and management capacity of early keratoconus in hospitals in Nyanza and Western Kenya.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

The study was conducted in hospital facilities offering eyecare services in Nyanza and Western Kenya regions. These included: L4, L5 and L6 hospitals from ten (10) counties namely: Bungoma, Kakamega, Busia and Vihiga in Western region, and Siaya, Kisumu, Homabay, Nyamira, Migori and Kisii in Nyanza region. These included 57 hospital facilities, both private and the public, of which 19 were from Western, and 38 from Nyanza region as shown in (table 3.1). The regions have a high population with Western having 5.02 million and 6.27 million in Nyanza region (Kenya National Bureau of Statistics, 2019), thus increasing the demand for KC services.

Additionally, these regions experience warm and wet climate, thus high prevalence for allergies which is associated with KC (Naderan *et al.,* 2017). With KC being associated with the allergies, the population is at a high risk of the disease (Mugho, 2016). Altogether, these would lead to an increased demand for the KC services. Moreover, these regions are cosmopolitan and thus have people from different ethnicities which is associated with KC (Georgiou *et al.,* 2004; Jonas *et al.,* 2009), including both the rich and the poor. Besides, the area is convenient for the researcher because the two regions are adjacent to each other.

Table 3.1 Summary of the Study Site Data

HOSPITAL LEVEL	REGION		
	Nyanza	**Western**	**Total number of Hospitals per Level**
L4	29	14	43
L5	8	5	13
L6	1	0	1
Total Number of Hospitals per Region	38	19	57

Table showing the hospital levels and regional distribution of the study area

3.2 Study Design

In this study, an observational cross-sectional design was employed. The required data was obtained from the practitioners in regard to their hospital of practice at one point in time using a questionnaire.

3.3 Study Population

The target population for this study were the ECPs working in public and private hospitals in Nyanza and Western Kenya regions. These were ECPs working in L4, L5 and L6 hospitals, comprising of ophthalmologists, COCs, optometrists and OCOs.

3.3.1 Inclusion Criteria

All ECPs working in Eye units in L4, L5 and L6 public and private hospitals were included. The practitioners were trained in a certified higher learning institution in Kenya, with a study period of at least three years of training. This was because according to the scope of practice based in Kenya, these cadres are certified to examine, diagnose and manage patients.

3.3.2 Exclusion Criteria

The ECPs on attachment or internship were excluded because these were working under supervision. The practitioners who did not give consent to the study were also excluded.

3.4 Study Variables

This comprised both the dependent and the independent variables, which were derived from the specific objectives.

3.4.1 Dependent Variables

The dependent variables were derived from the various specific objectives. The specific objective one was to determine the availability of the equipment for early KC diagnosis and management in Nyanza and Western Kenya hospitals. In this objective, the dependent variables were the equipment. Specific objective two was to evaluate the working conditions of the equipment for diagnosis and management of early keratoconus. From this objective, the dependent variables were the available equipment. Specific objective three was to determine the utilization of early KC diagnosis and management equipment in hospitals in Nyanza and Western Kenya. The dependent variables in this objective were the equipment. The fourth specific objective was to assess practitioners' level of knowledge in early KC diagnosis. The dependent variables were knowledge on various risk factors for KC, ability to use equipment to diagnose and the signs of early KC. Specific objective five was to assess practitioners' knowledge in early KC management, whereby the dependent variables were knowledge on use of various equipment, indicators for progressive KC and the management strategies for early KC.

3.4.2 Independent Variables

In specific objective one, the independent variables were the hospitals. Regarding specific objective two, the independent variables were the hospitals. For specific objective three, the independent variables were the practitioners and the hospitals. In regard to specific objective four and five, the independent variable was the practitioners.

3.5 Sampling Design

3.5.1 Sampling Strategy

Purposive sampling was used as only specific eyecare practitioners participated in the study. The ECPs were specifically those who examine, diagnose and manage eyecare patients. These included the Ophthalmologists, Comprehensive Ophthalmology and Cataract surgeons (COCs), Optometrists and Ophthalmic Clinical Officers (OCOs) working in the Eye units in the public and private hospitals. It is only the hospitals having either of the ECPs practicing that were involved. The ECPs working in the public and private hospitals which included L4, L5 and L6 hospitals participated. This is because this is where eye unit hospital set-ups are likely found currently in the Kenyan public and private hospitals.

3.6 Sample size determination

For the sample size, a census of the practitioners' population in Nyanza and Western Kenya region was done. Leading information on the ECPs was obtained from their respective professional associations including Optometrists Association of Kenya (OAK), Clinical Officers Council of Kenya (COC-K) and Kenya Medical Practitioners, Pharmacists and Dentists Union (KMPDU). There were one hundred and forty-three (143) ECPs. This comprised the ECPs in the public and private hospitals

for L4, L5 and L6. All the ECPs in L4, L5 and L6 hospitals were invited to participate in the study, thus a census was used.

3.7 Data and Information Collection

3.7.1 Data Collection Procedure

The data for this study was collected between August, 2024 and September, 2024. A questionnaire was developed and reviewed based on, and in relation to other questionnaires from studies done on KC. An online questionnaire was then piloted in Kiminini constituency and modified before data collection. Every participant, via electronic media including WhatsApp, Facebook Messenger and Email, received a link to the questionnaire.

Below is an illustration for data collection process:

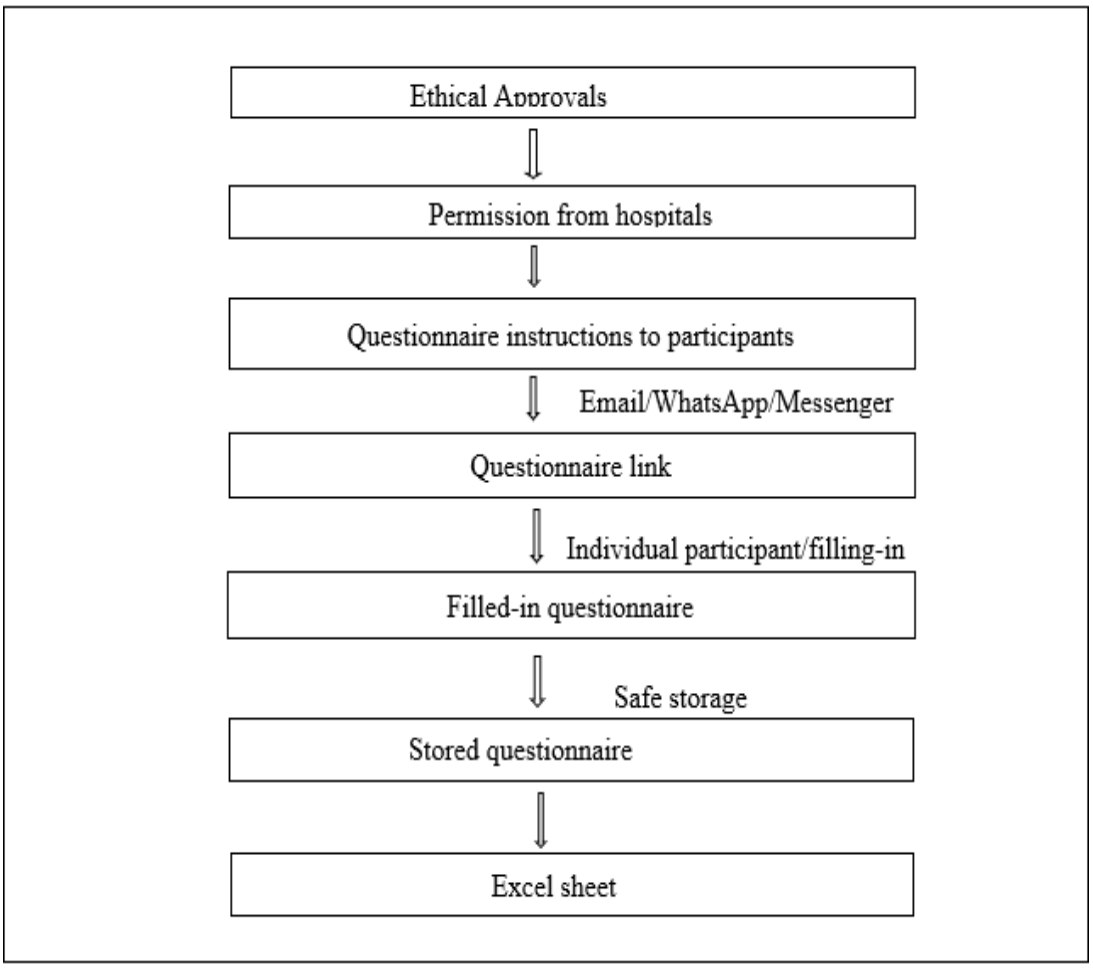

Figure 3.1 Data collection process

3.7.2 Data Collection Instruments

A questionnaire was used for data collection. The questionnaire was derived and set in relation to other questionnaires in KC related studies (Baenninger *et al.,* 2021; Khandekar & Al Fahdi, 2009; Usgaonkar *et al.,* 2023). It consisted of different sections including the biodata of the participants, equipment availability and their working conditions, equipment utilization and early KC knowledge. The Biodata included both open-ended and close-ended questions including: age, gender, years of experience, county of practice, level of facility of practice, institution of qualification, the highest achieved qualification, whether in private or public hospital, and the specific qualification in regard to eyecare. The section on early KC presented close-ended

questions involving three (3) questions, which had sub-sections on knowledge of early KC diagnosis involving a five (5)-likert scale, three (3) questions with sub-sections on knowledge of early KC management involving a five (5)-likert scale, and a question on the available equipment and their working condition based on a five (5)-likert scale. There was a question on the frequency of utilization of the available equipment pegged on a five (5)-likert scale, and finally a question on how the participants upgraded their knowledge on KC, which involved the knowledge sources. See Appendix III (research questionnaire).

3.7.3 Reliability

The internal consistency was tested and computed for knowledge questions to find the correlation between questions within the section. This gave Cronbach's alpha co-efficient 0.75, which was within the acceptable ranges (Sharma, 2016). The questions were then further checked for accuracy, as the Cronbach's alpha may not be relied on alone (Taber, 2018).

3.7.4 Techniques for validation of data collection tools

The feedback obtained from the pilot study was used to refine the questionnaire, which enhanced its ability to optimally answer to the objectives of the study. Face validation was done on the questionnaire before, and after piloting and modification. This was in consultation with eyecare experts ranging from research institutions, academic institutions, public and private hospital practices. These included Ophthalmologists, Comprehensive Ophthalmology and Cataract surgeons, Optometrists and Ophthalmic Clinical Officers who were invited to review the questionnaire. Modification was done to enhance the accuracy of the questionnaire and its ability to satisfactorily answer the research questions. Besides, the correct use of language, early KC and KC content were inspected, including the alignment of the objectives and the questions.

3.8 Pilot Study

An online questionnaire was developed and piloted in Kiminini constituency, which included ten eye care practitioners. The questionnaire was then modified based on the responses received. Some of the modifications included standardizing the scaled questions to a five-likert scale, changing the yes or no answer questions and instead, provided likert scale options, and gave answer choices to the questions that required ECPs to write down the answers, thus avoiding ambiguity.

3.9 Data Management, Analysis and Presentation

There was a structured process in which the data collected in the study was managed, protected in line with the ethical provisions, stored and retrieved, and how it was analyzed for interpretation and presented in the results chapter.

3.9.1 Data Management and Storage

The data collected from the study was automatically entered into Excel sheet from the questionnaire. It was then cleaned, coded and entries made into the statistical package for social sciences (SPSS) V 29 software. This involved converting quantitative and qualitative data into numerical codes. The data was then protected using a password in the computer in such a way that, only the researcher can access the information. The participants' details were anonymized during analysis, while the email addresses through which they responded to the questionnaire, were, and will not be shared with third parties during and after the research. The data was then stored based on the university policy regarding data storage and protection (Mmust, 2022).

3.9.2 Data Analysis and Presentation

The already cleaned data was entered into SPSS software V 29 for analysis. The dependent and the independent variables were derived from each specific objective for analysis and data presentation based on the variables' type.

The first objective was to determine the availability of equipment for early KC diagnosis and management in hospitals in Western and Nyanza Kenya. From this objective, the dependent variables were the equipment while independent variables were the hospitals. Analysis was done using descriptive statistics: percentages and frequencies, then presented using bar-charts and tables as shown in *table 3.2*.

The second objective was to evaluate the working conditions of the available equipment for keratoconus. The dependent variables were the equipment, while the independent variables were the hospitals. These were analyzed using descriptive statistics: percentages and frequencies, and subsequently presented using tables (table 3.2).

The third objective was to determine the utilization of early keratoconus diagnosis and management equipment in hospitals in Nyanza and Western Kenya. In this, the dependent variables were equipment and independent variables were the practitioners and the hospitals. Analysis was done using descriptive statistics: percentages and inferential statistics: Chi-square, then presented using bar graphs and tables (table 3.2).

The fourth objective was to assess the practitioners' knowledge level in early KC diagnosis. In this, the dependent variables were knowledge on the various KC risk factors, the ability to use the equipment to diagnose and the signs of early KC, while the independent variables were the practitioners. The analysis was done using descriptive statistics: percentages, and inferential statistics: Chi-square and independent t-tests, then presented using tables and pie-chart as shown in *table 3.2*.

The fifth objective was to assess the practitioners' knowledge level in early KC management. In this, the dependent variables were knowledge on the use of various equipment, indicators for progressive KC and management strategies for early KC,

whilst the independent variables were the practitioners. These were analyzed using descriptive statistics: percentages, and inferential statistics: Chi-square and independent t-tests, and presented using tables and pie-chart (table 3.2).

The questions testing on knowledge (objectives four and five), had a 5-Likert scale, whereby the highest score was five (5) and the least was one (1). For the positive questions, those that strongly agreed scored 5 points, while the ones that strongly disagreed scored 1 point. For the negative questions, those who strongly disagreed scored 5 points, while the ones that strongly agreed scored 1 point. The knowledge score was classified such that, a score below 50% was regarded as poor knowledge, 50% to 75% was regarded as a fair knowledge, and above 75% was regarded as good knowledge level.

The summary of analysis and presentation is as shown in *table 3.2.*

Table 3.2. Summary of Data Analysis and Presentation Procedures

S/NO	OBJECTIVE	DEPENDENT VARIABLES	INDEPENDENT VARIABLES	TOOL FOR DATA ANALYSIS	TOOL FOR DATA PRESENTATION
1	Determining the availability of early KC diagnosis and management equipment	Equipment	Hospital Hospital levels	Percentages Frequency	Bar-chart Tables
2	Evaluating the working conditions of the equipment	Equipment	Hospital Hospital levels	Percentages Frequency	Tables
3	Determining the utilization of early KC equipment in early KC diagnosis and management	Equipment	Hospital Practitioners	Percentages Chi-square	Tables Bar-chart
4	Assessing the level of knowledge in early KC diagnosis	Various KC risk-factor knowledge Various early KC signs knowledge Knowledge on use of various equipment for diagnosis of early KC	Practitioners Age Qualification/ Level of education Cadre	Percentages Chi-square Independent t-test	Pie-chart Tables
5	Assessment of knowledge in early KC management	Various equipment knowledge in management of early KC Various early KC management strategies knowledge Knowledge on various indicators of progressive KC	Practitioners Age Qualification/ Level of education Cadre	Percentages Chi-square Independent t-test	Pie-chart Tables

A table showing a summary of the specific objectives, dependent and independent variables, tools for analysis and data presentation.

3.10 Logistical and Ethical Considerations

The researcher obtained institutional ethical clearance from the ethical committee of Masinde Muliro University of Science and Technology, Institutional Scientific and Ethics Review Committee (MMUST-I.S.E.R.C.), with clearance bearing approval number: MMUST/ISERC/074/2024 as shown in (appendix vi). Additionally, the National Commission for Science, Technology and Innovation (NACOSTI) approval was sought, bearing License Number: NACOSTI/P/24/39382 as shown in (appendix vii). In addition, permission was sought from the hospitals through the eye unit in-charge of the selected hospitals before data collection (appendix iv).

Informed consent. The participants signed consent forms before responding to the questionnaire (appendix ii). It gave a brief description of the research and intentions for the data, and any potential risks or benefits. During the questionnaire filling-in and data collection, the participants were able to seek clarification from the researcher or research assistant. Participation was voluntary and optional, and the participants received information regarding the voluntary nature of the research participation.

In data compilation, the participants were kept anonymous for the purposes of confidentiality and data protection. Moreover, the questionnaire was anonymous and so no identifiable data was obtained, and records were retrieved by the codes assigned to each questionnaire for ease of identification. Each participant was identified using the code number allocated to their questionnaire. There were no confidential details that were collected from the participants.

The researcher would ensure that the information obtained from the study is disseminated to the relevant authority to help inform future policies that will be of help

to KC patients, and enhance early diagnosis and management of KC, thus ensuring and enhancing beneficence.

There was no any direct form of harm from the study, hence enhancing non-maleficence.

Anyone within the inclusion criteria had equal chances of participation in the study, thus ensuring justice prevailed in participation.

The study ensured transparency towards participants and ensured that the right information was delivered. The participants' responses were held as they were, without construing their intended feedback. This enhanced quality and transparency.

For the respect of participants' autonomy, they were allowed to voluntarily withdraw from the study at any point in time, without any consequences. Any participant willing to withdraw at any stage of the study was free to withdraw without any consequence.

There was no any financial gain and the research was conducted independently. For the participants, there were no any incentives accruing from the participation. All this information was disclosed, thus there was no conflict of interest.

CHAPTER FOUR

RESULTS

4.1 Introduction

In this study, a total of 143 ECPs received the questionnaire whereby 134 responded, yielding a response rate of 93.7%. From among the respondents, 80 (59.7%) were males and 54 (40.3%) females as shown in *table 4.1.* Most of the practitioners were from the private hospitals, with L4s, the optometrists and those aged 30-39 years having the highest representation as shown in *table 4.1.* The highest achieved qualification for most respondents was a Bachelor's degree, followed by Diploma, with very few having Master's.

Table 4.1: Demographic Distribution of the practitioners

Socio-demographics		n	%
Gender	Female	54	40.3
	Male	80	59.7
Age	20-29	40	31.3
	30-39	62	48.4
	40-49	21	16.4
	50 and above	5	3.9
Qualifications	OCO	25	18.7
	Optometrists	78	58.2
	COCs	24	17.9
	Ophthalmologists	6	4.5
Hospital level	Level 4	86	64.2
	Level 5	40	29.9
	Level 6	6	4.5
Hospital set-up	Private	71	53.0
	Public	58	43.3

A table showing the socio-demographic data of the practitioners in frequencies (n) and percentages (%)

4.2 Availability of keratoconus diagnosis and management equipment in hospitals

4.2.1 Overall Equipment/Consumables Availability

The equipment availability across the hospital levels varied. Overall, some of the basic equipment was highly available, with distance VA chart at 100%, trial lens/phoropter 96.3% and retinoscope at 95.5%. However, the advanced equipment had limited availability, with corneal topographers (12.7%) and corneal tomographers (10.4%) as shown in *figure 4.1.*

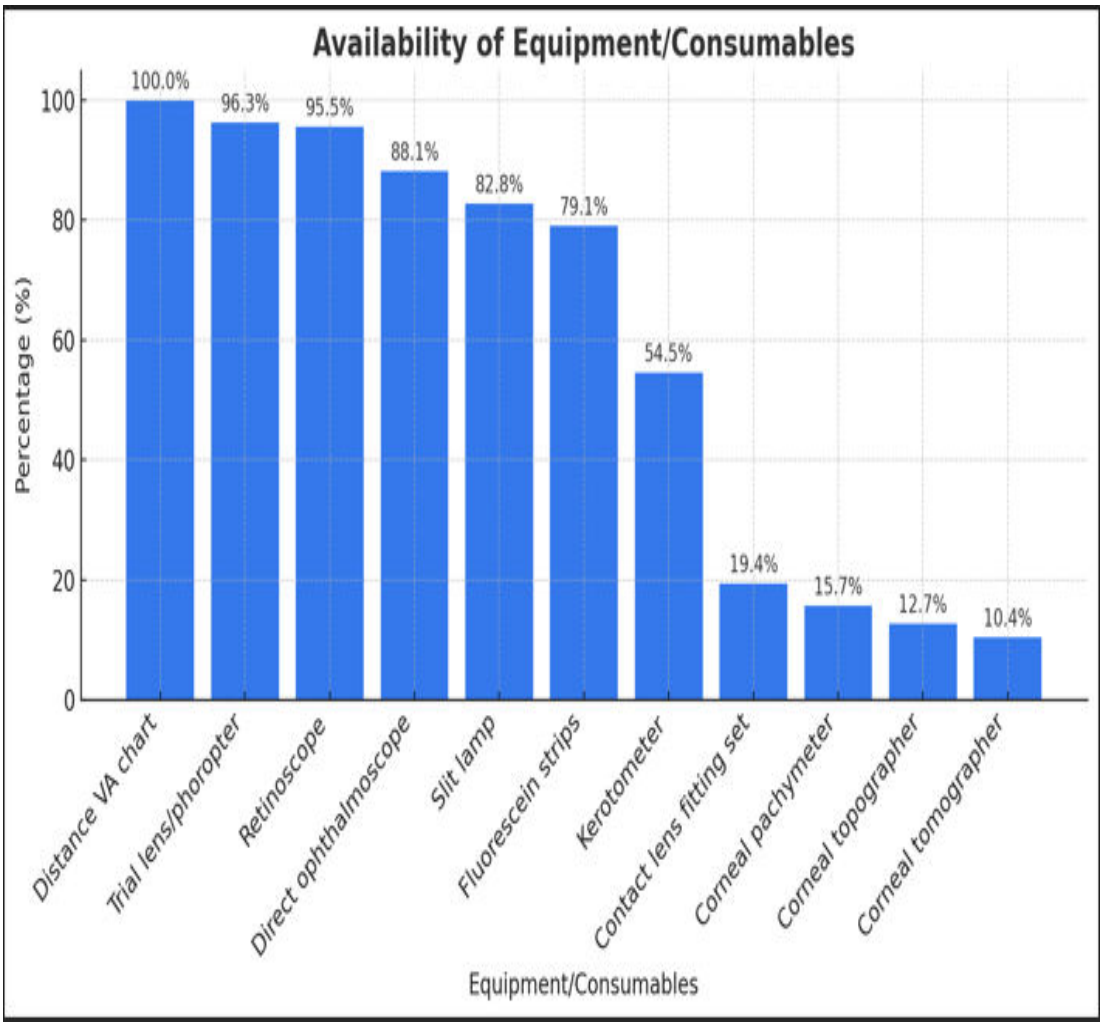

Figure 4.1 Equipment/consumables availability in place of practice.

A graph showing equipment/consumables overall availability in percentages (%)

4.2.2 Equipment/Consumables availability per hospital level

In terms of the hospital levels, the equipment and consumables available varied. The L6 hospitals reported the highest rates of equipment and consumables availability as shown in *table 4.2*. Generally, L6 had more equipment available, followed by L5 and L4.

Table 4.2 Equipment/consumables available per hospital level and type

Equipment/Consumable Available per Hospital Level and type						
Equipment/ Consumable	**Availability**	**Level 4 N %**	**Level 5 N %**	**Level 6 N %**	**Public N %**	**Private N %**
Slit lamp	Available	66 (75.0)	39 (97.5)	6 (100)	54 (93.1)	57 (75)
	Not available	22 (25.0)	1 (2.5)	0 (0.0)	4 (6.9)	19 (25)
Distance VA Chart	Available	88 (100)	40 (100)	6 (100)	58 (100)	76 (100)
	Not available	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.)
Direct ophthalmoscope	Available	74 (84.1)	38 (95.0)	6 (100)	55 (94.8)	63 (82.9)
	Not available	14 (15.9)	2 (5.0)	0 (0.0)	3 (5.2)	13 (17.1)
Retinoscope	Available	86 (97.7)	36 (90.0)	6 (100)	55 (94.8)	73 (96.1)
	Not available	2 (2.3)	4 (10.0)	0 (0.0)	3 (5.2)	3 (3.9)
Trial lens set/phoropter	Available	85 (96.6)	39 (97.5)	5 (83.3)	55 (94.8)	74 (97.4)
	Not available	3 (3.4)	1 (2.5)	1 (16.7)	3 (5.2)	2 (2.6)
Contact lens solution	Available	31 (35.2)	8 (20.0)	1 (16.7)	6 (10.3)	34 (44.7)
	Not available	57 (64.8)	32 (80.0)	5 (83.3)	52 (89.7)	42 (55.3)
Fluorescein strips	Available	62 (70.5)	38 (95.0)	6 (100)	58 (100)	48 (63.2)
	Not available	26 (29.5)	2 (5.0)	0 (0.0)	0 (0.0)	28 (36.8)
Contact lens fitting set	Available	19 (21.6)	7 (17.5)	0 (0.0)	7 (12.1)	19 (25)
	Not available	69 (78.4)	33 (82.5)	6 (100)	51 (87.9)	57 (75)
Corneal Tomographer	Available	7 (8.0)	6 (15.0)	1 (16.7)	2 (3.4)	12 (15.8)
	Not available	81 (92.0)	34 (85.0)	5 (83.3)	56 (96.6)	64 (84.2)
Corneal Pachymeter	Available	10 (11.4)	8 (20.0)	3 (50.0)	8 (13.8)	13 (17.1)
	Not available	78 (88.6)	32 (80.0)	3 (50.0)	50 (86.2)	53 (82.9)
Keratometer	Available	39 (44.3)	29 (72.5)	5 (83.3)	36 (62.1)	37 (48.7)
	Not available	49 (55.7)	11 (27.5)	1 (16.7)	22 (37.9)	39 (51.3)
Corneal Topographer	Available	10 (11.4)	6 (15.0)	1 (16.7)	5 (8.6)	12 (15.8)
	Not available	78 (88.6)	34 (85.0)	5 (83.3)	53 (91.4)	64 (84.2)

Data showing equipment and consumables available per hospital level and set-up in frequency (n) and percentages (%)

4.2.3 Equipment/Consumable availability per hospital set up (public/private)

The equipment and consumables availability rates equally varied between the public and the private hospitals. While basic equipment and consumables generally showed

higher availability than the advanced equipment, there was a marked difference based on the hospital set up. The public hospitals were more equipped with the basic equipment including slit lamp (93.1%), direct ophthalmoscope (94.8%) and the fluorescein strips (100%) than the private hospitals as shown in *table 4.2*. On the contrary, even though the advanced equipment had overall low availability, the private hospitals demonstrated higher availability as compared to the public hospitals including contact lens fitting set (25%), corneal tomographer (15.8%), corneal pachymeter (17.1%) and corneal topographer (15.8%) as shown in *table 4.2*

4.3 Working conditions of the equipment/consumables in hospitals

A number of the available equipment was in a poor working condition, whereby some were far below standards and others below standards. In respect to the basic equipment, these included the slit lamp (13.5%), direct ophthalmoscope (14.4%) and retinoscope (16.4%), for the basic equipment as shown in table 4.2. Moreover, a number of the advanced equipment equally had poor working conditions including corneal topographer (35.2%), contact lens fitting set (46.1%) and corneal pachymeter (19.1%) (table 4.3).

Table 4.3 Working conditions of the equipment in percentages (%) and frequencies *(n)*

	Far above standards	Above standards	Meets standards	Below standards	Far below standards	Overall poor standards
Corneal Topographer	11.8% (2)	17.6% (3)	35.3% (6)	17.6% (3)	17.6% (3)	35.2% (6)
Corneal Tomographer	42.3% (6)	14.3% (2)	28.6% (4)	0.7% (1)	0.7% (1)	1.4% (2)
Keratometer	9.6% (7)	15.1% (11)	56.2% (41)	15.1% (11)	4.1% (3)	19.2% (14)
Direct ophthalmoscope	12.7% (15)	15.3% (18)	57.6% (68)	5.1% (6)	9.3% (11)	14.4% (17)
Slit lamp	10.8% (12)	16.2% (18)	59.5% (66)	4.5% (5)	9.0% (10)	13.5% (15)
Distance VA chart	9.7% (13)	17.2% (23)	61.2% (82)	3.0% (4)	9.0% (12)	12.0% (16)
Retinoscope	12.5% (16)	11.7% (15)	56.3% (72)	7.0% (9)	9.4% (12)	16.4% (21)
Trial lens set/phoropter	10.9% (14)	15.5% (20)	57.4% (74)	5.4% (7)	10.9% (14)	16.3% (21)
Contact lens fitting set	23.1% (6)	7.7% (2)	23.1% (6)	26.9% (7)	19.2% (5)	46.1% (12)
Corneal Pachymeter	28.6% (6)	14.3% (3)	38.1% (8)	4.8% (1)	14.3% (3)	19.1% (4)

A table showing the working conditions of the equipment in percentages (%) and frequency (n)

4.4 Utilization of early keratoconus diagnosis and management equipment in hospitals

The frequency of use of the equipment varied based on the equipment. The utilization rates of some of the basic equipment were high, including distance VA chart 91.8%, trial lens/phoropter 89.9%, slit lamp 78.4% and retinoscope 75.0% as shown in *figure 4.2*. The advanced equipment available had lower utilization rates including contact lens fitting set 31.0%, corneal pachymeter 52.4% and corneal topographer 52.9% as shown in *figure 4.2.* Chi-square tests showed a significant association between equipment availability and its utilization, including distance VA chart (**0.0333)**, trial

lens/phoropter (**0.0029)**, slit lamp (**0.0028)** and keratometer (**0.00001)** as shown (table 4.4).

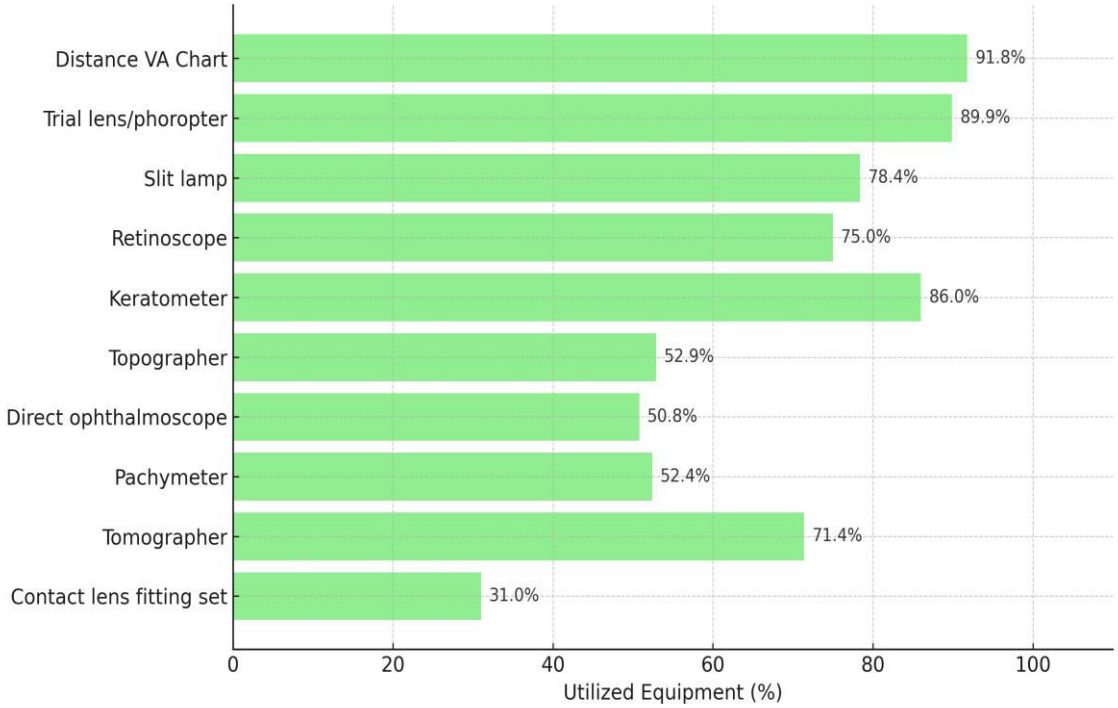

Figure 4.2 Equipment/consumable utilization rates in percentages (%).

A bar graph showing the utilization rates of the available equipment in percentages (%)

4.4.1 Utilization rates of early keratoconus diagnosis and management equipment based on type of hospital set up (public/private)

Generally, the public hospitals reported higher utilization rates for the basic equipment including slit lamp (83.3%) and direct ophthalmoscope (57.7%), than the private hospitals as shown in *table 4.4*. On the other hand, the private hospitals demonstrated higher utilization rates for the advanced equipment including corneal topographer (61.3%), corneal pachymeter (74.2%) and corneal tomographer (79.7%) as shown in *table 4.4*

Table 4.4 Cross-tabulation of Equipment availability and their utilization

		Overall Availability, Utilization and p-value			Utilization Per Hospital Set-up	
	Equipment	**Available Overall**	**Utilized Overall**	**p-**value	**Public (%)**	**Private (%)**
1	Distance VA Chart	134 (100%)	123(91.8)	**0.0333**	91.4	92.1
2	Trial lens/phoropter	129(96.3%)	116(89.9%)	**0.0029**	85.5	93.2
3	Slit lamp	111(82.8%)	87 (78.4%)	**0.0028**	83.3	73.7
4	Retinoscope	128(95.5%)	96(75%)	0.0625	70.9	78.1
5	Keratometer	73(54.5%)	63(86%)	**0.00001**	86.1	86.5
6	Corneal Topographer	17(12.7%)	9(52.9%)	0.8148	43.0	61.3
7	Direct ophthalmoscope	118(88.1)	60(50.8%)	0.9322	57.7	43.9
8	Corneal Pachymeter	21(15.7)	11(52.4%)	0.9845	30.0	74.2
9	Corneal Tomographer	14(10.4%)	10(71.4%)	0.1189	63.0	79.7
10	Contact lens fitting set	26(19.4%)	8(31%)	0.0632	17.3	45.1

Data showing utilization rates (%) as an overall and per hospital set up of the available equipment in frequency (n), and the categorical variables compared using Chi-square test with significance at $p \leq 0.05$ and CI of 95%.

4.5 Assessment of knowledge level of practitioners in diagnosis of early keratoconus in hospitals

The knowledge level of the practitioners in diagnosis of early KC was assessed using three parameters. These included KC risk factors knowledge, signs of early keratoconus knowledge and self-reported knowledge on the use of various equipment to diagnose early KC.

4.5.1 Risk factors for keratoconus knowledge assessment

Keratoconus risk factor assessment involved various factors including genetics, systemic disorders, eye allergies, eye rubbing, age, eczema and asthma. From the responses on KC risk factors' knowledge, only 39.3% of the respondents had good knowledge level, 51.1% had a fair knowledge level while 9.6% had a poor knowledge. This was based on factor agreement for various risk factors for KC. All the factor options given were right answers and so, for those that strongly agreed that they were risk factors for KC, obtained the highest score, while those that strongly disagreed scored the least.

4.5.2 Signs of early keratoconus knowledge level

From the responses on knowledge of signs of early KC, 80.0% of the practitioners had fair knowledge, 15.6% had a good knowledge level, while 4.4% had poor knowledge of the signs of early KC. This was based on various signs of keratoconus, with some of the options being signs of early KC stage, while other options were signs of other KC stages. For those that strongly agreed with the right signs of early KC and strongly disagreed with the wrong signs of early KC, they scored the highest. On the contrary, those that strongly disagreed with the right signs of early KC and strongly agreed with the wrong signs of early KC, they scored the least.

4.5.3 Knowledge level on the use of various equipment in diagnosing early keratoconus

This was self-reported knowledge on equipment use for early KC diagnosis. Out of the 134 respondents, 45.9% had good knowledge, 48.1% had fair knowledge while 5.9% had a poor level of knowledge on a cumulative percentage. This involved knowledge assessment on the use of various equipment for early KC diagnosis.

4.5.4 Overall knowledge for early keratoconus diagnosis

This involved the three aspects of early KC diagnosis knowledge assessment, that included recognizing the risks factors of KC, signs of early KC and knowledge on equipment use in diagnosis of early KC. On average, 36.6% had good knowledge, 60.4% had fair knowledge, while 3.0% had a poor knowledge level in early KC diagnosis as shown in *figure 4.3.*

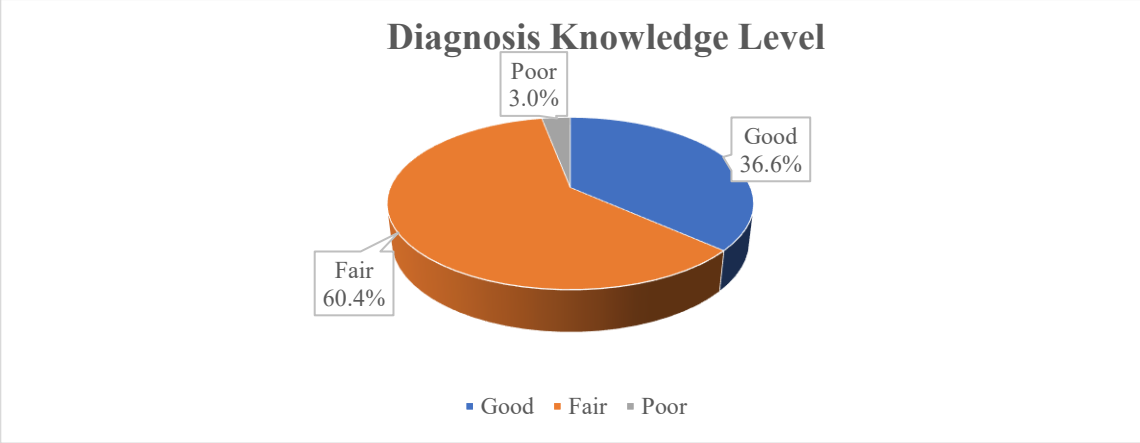

Figure 4.3 Knowledge level for early KC diagnosis.

A pie-chart showing knowledge level in percentages (%) of the practitioners in the diagnosis of early keratoconus

4.6 Assessment of practitioners' knowledge in management of early keratoconus in hospitals

Practitioners' knowledge in the management of early KC was assessed based on three aspects. This involved the assessment of knowledge on the ability to use equipment to manage early KC, various management strategies of early KC and on the indicators of progressive KC.

4.6.1 Knowledge of early keratoconus management strategies

This involved various management strategies of KC whereby some of the options given were strategies for early KC, while others were strategies for other KC stages.

The various strategy options given included were spectacles, corneal CL, corneal-scleral CL, piggy-back CL, soft CL, hybrid CL and referral to CL specialists. Those that strongly agreed with the right options and strongly disagreed with the wrong options for early KC management, scored the highest. On the contrary, those that strongly disagreed with the right options and strongly agreed with the wrong options, scored the least. From the study, 18.5% of the practitioners had good knowledge, 78.5% had fair knowledge, while 3.0% had poor knowledge level in the management strategies of early KC on a cumulative percentage.

4.6.2 Knowledge of use of various equipment in management of early keratoconus

The knowledge level of the practitioners varied for different equipment on a self-reported basis. From among the practitioners, 45.9% had good knowledge, 48.1% had fair knowledge while 5.9% had a poor knowledge level on the use of various equipment in the management of early KC.

4.6.3 Knowledge of indicators of progressive keratoconus

The knowledge of the indicators of progressive KC was tested on specific corneal astigmatism dioptric changes, specific changes in refractive axis orientation, specific dioptric power changes on the steepest meridian and specific magnitude changes in corneal thickness. All the choice options given were correct and right indicators of progressive KC and therefore, all those that strongly agreed with the given options scored the highest, while those that strongly disagreed scored the least. 61.5% of the practitioners had good knowledge, 34.1% had a fair knowledge, while 4.4% had a poor knowledge level of the indicators of progressive KC.

4.6.4 Overall knowledge in early keratoconus management

For the overall knowledge in the management of early KC, which comprised of the management strategy, the use of the equipment and the indicators of progressive KC knowledge, cumulative percentages were obtained. 36.6% of the practitioners had good knowledge level, 61.2% had a fair knowledge, while 2.2% had a poor knowledge level in the management of early KC as shown in *figure 4.4.*

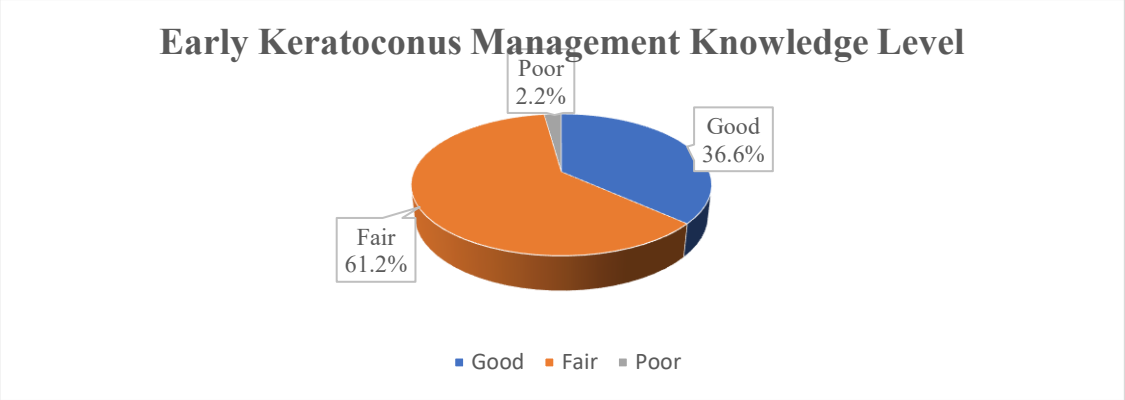

Figure 4.4 Knowledge level for early keratoconus management

A pie-chart showing the overall percentage (%) knowledge level of the practitioners in early keratoconus management

4.7 Differences in knowledge of diagnosis and management of early keratoconus between public and private hospitals

The ECPs' knowledge level mean scores between the public and private hospitals were relatively similar. There was however a slight variation, whereby the ECPs in the public hospitals demonstrated a minimally higher knowledge of the risk factors of KC. On the other hand, the private hospitals had slightly higher knowledge of progressive KC as shown in *table 4.5*

Table 4.5 Comparing Private and Public Hospitals Knowledge of Diagnosis and Management of Early Keratoconus

	Hospital type	Mean	Std. Deviation	Std. Error Mean
Knowledge on diagnosis				
Risk factors for keratoconus	Public	71.3793	17.30615	2.27241
	Private	68.4737	16.32869	1.87303
Signs of early keratoconus	Public	68.1724	9.92805	1.30362
	Private	67.5395	9.52392	1.09247
Ability to use equipment to diagnose early keratoconus	Public	73.3276	17.12533	2.24867
	Private	72.7237	13.14798	1.50818
Knowledge on Management				
Indicators of progressive keratoconus(management)	Public	76.5517	18.14191	2.38215
	Private	80.1316	13.03773	1.49553
Management strategies for early keratoconus	Public	69.2069	8.90448	1.16922
	Private	69.3684	6.91634	.79336
Ability to use equipment to manage early keratoconus	Public	73.3276	17.12533	2.24867
	Private	72.7237	13.14798	1.50818
Overall Knowledge of diagnosis	Public	72.3276	11.72400	1.53944
	Private	72.2105	8.97451	1.02945
Overall knowledge of management	Public	71.2586	10.72554	1.40833
	Private	71.0263	8.07131	.92584

Table showing mean scores comparisons for keratoconus diagnosis and management knowledge between public and private hospitals

On testing ECPs' knowledge levels differences between the public and the private hospitals, an Independent Samples t-test showed no statistically significant differences for most knowledge test domains. However, there was a significant difference in the knowledge levels of risk factors of KC and the indicators of progressive KC as shown in *table 4.6*

Table 4.6 Independent Samples t-Test for Public and Private Hospitals Knowledge of Diagnosis and Management of Early Keratoconus

Variable	t	df	p	Mean Diff.	95% CI (Lower, Upper)
Risk Factors for Keratoconus	0.99	132	**0.0322**	2.91	[-0.25, 5.57]
Signs of Early Keratoconus	0.37	132	0.709	0.63	[-2.71, 3.98]
Equipment use to Diagnose Early Keratoconus	0.23	132	0.818	0.60	[-4.57, 5.78]
Indicators of Progressive Keratoconus	-1.33	132	**0.0186**	-3.58	[-6.78, -0.37]
Management Strategies for Early Keratoconus	-0.12	132	0.906	-0.16	[-2.86, 2.54]
Use of Equipment to Manage Early Keratoconus	0.23	132	0.818	0.60	[-4.57, 5.78]
Overall Diagnosis Knowledge	0.07	132	0.948	0.12	[-3.42, 3.65]
Overall Management Knowledge	0.14	132	0.886	0.23	[-2.98, 3.44]

Knowledge mean score differences between public and private hospitals were assessed using an Independent Samples t-Test. Results were considered statistically significant at $p < 0.05$. df = Degrees of Freedom.

4.8 Analysis for Socio-demographics across groups

A Chi-square test analysis revealed significant association, χ^2 (78, N=134) =112.88, p=**0.006**, regarding qualification level and knowledge in management. However, there were no significant differences for gender, years of experience, the cadre affiliation, and age in regard to knowledge in diagnosis and management of early KC as shown in *table 4.7*

Table 4.7 Chi-square (χ^2) results for Demographic Characteristics' Associations with Keratoconus Diagnosis and Management Knowledge

Variable		df	Pearsons (χ^2)	p
Respondents gender	Knowledge in diagnosis	40	46.52	0.222
	Knowledge in management	39	36.02	0.607
Age	Knowledge in diagnosis	1160	1070.81	0.970
	Knowledge in management	1131	1124.54	0.549
Experience	Knowledge in diagnosis	840	851.38	0.385
	Knowledge in management	819	860.04	0.153
Cadre	Knowledge in diagnosis	80	53.51	0.990
	Knowledge in management	78	90.56	0.157
Qualification	Knowledge in diagnosis	80	94.48	0.128
	Knowledge in management	78	112.88	**0.006**

A table showing results of test for associations between groups on knowledge in diagnosis and management of keratoconus, with CI of 95% and significance at $p \leq 0.05$

CHAPTER FIVE

DISCUSSION

5.1 Socio-demographics of the practitioners

From the study, there were more males than female practitioners. This may be due to the African tradition set up, whereby more males have predominance for higher education as opposed to the females, with the results being similar to a study in Ghana, Africa, where there were more males than the females in practice (Boadi-kusi et al., 2015). Equally, this finding was also similar to a study in Switzerland, Europe, whereby there were more male practitioners as opposed to the females (Baenninger et al., 2021). The level 4s had the highest representation, which may be due to higher numbers of the practitioners working in private hospital set up, which had higher representation as opposed to public hospital set up. There was a significant association between the qualification level and knowledge in early KC management. This could be due to the higher knowledge gained with higher academic qualification of the practitioner. This result was similar to a study in India, whereby the ECPs with postgraduate qualifications were more knowledgeable, possibly due to more enhanced achievements with higher education levels (Arvind et al., 2021).

5.2 Availability of keratoconus diagnosis and management equipment in hospitals

From this study, there was a variation in equipment availability, with the advanced equipment being unavailable, while more basic equipment was available. The advanced equipment had limited availability, including corneal topographer, corneal pachymeter, contact lens fitting set and the corneal tomographer. This could be due to the high costs of the equipment, the limited early KC services in Kenya, and the knowledge limitation on the use of the advanced tools as found out in this study. The result was similar to a study in Latin America, where topographers had low availability

(23%) (Braga Vieira et al., 2023), which also aligns with a study in Australia, where topographers had limited availability, possibly due to the low demand of the services (Hodge et al., 2015). Moreover, these results were similar to a study in South Africa whereby advanced KC tools lacked, reporting only 2.8% topographer availability, possibly because these services were not offered in the public health sector (Gcabashe et al., 2022), and due to low funding (Nkoana et al., 2024). However, the finding was contrary to studies in India and Saudi Arabia, whereby the advanced equipment was available, could be due to the high industrialization levels in the country (Motowa et al., 2014; Naidoo et al., 2021). The study revealed a higher availability of the basic equipment, which is likely as a result of the wider range of use of this equipment and its applications for different investigations. These findings were similar to a study done in KwaZulu, South Africa, where slit-lamp availability rate was 86% (Gcabashe et al., 2022) and in another study in Kenya (Rashid et al., 2023a). However, this was contrary to a study in South Africa where slit-lamp were unavailable, with only 57% availability (Nkoana et al., 2024).

The tertiary L6s had the highest availability for both the basic and the advanced equipment as compared to the L5 and L4 hospitals, which could be due to the high demand of the services, the wide range and specialized services offered, with it being the highest level in the hospital hierarchy. This result was similar to a study in South Africa whereby the tertiary hospitals were more equipped as opposed to the district hospitals (Buthelezi & Staden, 2020), may be due to the specialized services offered at this level.

A number of the available equipment were in a poor working condition, with some being of far below standards and below standards. Interestingly, some of the equipment were still being utilized despite their poor working condition. This would likely lead

to errors in diagnosis, a possibility of overestimation or underestimation, or these altogether.

5.2.1 Equipment and Consumables availability per hospital set-up (public/private)

Most of the basic equipment was available in the public hospitals as opposed to the private hospitals, possibly because most of the primary essential services are offered at the public hospitals. Additionally, it could be because most of the rural community seeks health services from the public hospitals, therefore requiring them to have the basic equipment for eyecare. The finding is similar to a study by Nkoana et al, which reported that the public sector may have more resources because most of the populace sought healthcare services from the public facilities (Nkoana et al., 2024).

5.3 Evaluating the working conditions of the equipment in hospitals

A number of the available equipment had poor working conditions and state. This finding was similar to the result of an Ethiopian study, whereby the functionality of the equipment was sub-optimal, and this was linked to poor patient outcome and indefinite diagnosis and management (Sewagegn et al., 2025). Moreover, the results were similar to another study in Kenya on maintenance of hospital equipment, where the public hospitals were only ranked as having a fair standard, lacked quality control systems and did not prioritize servicing the equipment (Mutia et al., 2012). In Kenya, could be that there is a shortage of the biomedical engineers that are skilled in servicing the advanced equipment such as corneal tomographer, as these are fairly new in the country. Additionally, with these three studies being all from the developing countries, it may be that the governments have a limited budget for maintenance, or even no viable allocation at all.

5.4 Determining the utilization of early keratoconus diagnosis and management equipment in hospitals

The study revealed a mismatch between the available equipment and their utilization, whereby the utilization varied depending on the equipment. Even though some of the equipment were scarcely available, the available ones were not fully utilized including retinoscope, trial lens set/phoropter, direct ophthalmoscope, keratometer, contact lens fitting-set, corneal pachymeter, corneal topographer and corneal tomographer. This was likely due to the practitioners' limited knowledge on the use of the equipment as found out in this study. These results were similar to studies by Motowa and Morjaria, where the available tools were not utilized (Morjaria et al., 2013; Motowa et al., 2014), which concurred with the results of studies in South Africa, where the available equipment was not put in use as a result of the practitioners not being allowed to offer some services by the Department of Health (Gcabashe et al., 2022). The finding was also similar to a study in Australia, where the tools were not used due to limited practitioner knowledge and experience (Hodge et al., 2015). Moreover, the results concurred with the findings of a South African study by Nkoana et al, whereby the available equipment was not used due to a lack of consumables, time and working space (Nkoana et al., 2024), although, with them having considered utilization regardless of the availability, this meant that the utilization rates could be slightly higher than the reported. The outcome was however different from a study in Trinidad and Tobago on health system dynamics analysis of eyecare services, which reported that the available equipment were put in use (Braithwaite et al., 2018).

Even though some of the equipment were not fully utilized, there was a significant association between equipment availability and their utilization, as depicted in the study. Therefore, when the equipment is available, the ECPs will be able to use them

for the diagnosis and the management of early KC. The failure to use the equipment may consequently lead to missing out on the diagnosis of the early KC. To bridge this gap, it is imperative that the practitioners fully utilize the already available equipment, thus ensuring timely, accurate diagnosis and better patient outcomes.

5.4.1 Equipment utilization between public and private hospitals

The public hospitals demonstrated a higher utilization rate for the basic equipment as opposed to the private hospitals, possibly due to higher demand of the primary eyecare services by the community. It could also be due to the lower knowledge levels required in the use of the basic equipment. This was similar to a study in India, where the basic equipment was highly utilized possibly because of the limited skills needed for their use (Arvind et al., 2021). On the other hand, the private hospitals had higher utilization rates for the advanced equipment than the public hospitals. This was possibly due to the higher knowledge levels on the use of the advanced equipment in the private hospitals as reported in this study. This was similar to a study by Arvind et al, where the results showed that the advanced equipment was highly utilized, possibly because of the higher levels of specialized services offered in the private hospitals (Arvind et al., 2021).

5.5 Assessment of practitioner knowledge level in diagnosis of early keratoconus in hospitals

In terms of the risk factors for KC, less than a half proportion of the ECPs had good knowledge level. This is likely because KC practice is generally uncommon in Kenya. The findings were similar to a study in Switzerland where very few ECPs (9%) had good knowledge on KC risk factors, possibly because the practitioners involved were general ophthalmologists as opposed to corneal specialists (Baenninger et al., 2021). Interestingly, this study by Baenninger et al used the exact tool as for the patients'-

based study, meaning it tested on the lowest level of knowledge, which may not indicate a true practitioner' picture, thus the actual knowledge level could even be worse than the reported. These results were contrary to a study in Limpopo on risk factors of KC, which reported that the ECPs had good knowledge (62.5%), although this may have been overrated as what was regarded as good knowledge was a score of 50% and above (Nkoana et al., 2022b), whereas in this current study, good knowledge was considered to be from above 75% score.

Regarding self-reported knowledge on use of equipment in diagnosis of early KC, a fair proportion of the ECPs had good knowledge level with a slightly higher proportion having a fair knowledge level. The highest proportion of the ECPs only scored a fair knowledge level in their ability to use equipment to diagnose early KC, meaning most of them could not effectively use them. This may be due to the complex nature of the advanced equipment, as the advanced equipment used for early keratoconus diagnosis requires heightened skills. The findings were similar to a study in Limpopo, South Africa, whereby the practitioners reported having no adequate knowledge for diagnosis of keratoconus as only 41.7% had good knowledge, and with the methodology being equally similar, as they were both on self-reported knowledge levels (Nkoana et al., 2022a).

For the signs of early KC, the study found out that the ECPs had inadequate knowledge, with only 15.6% of the ECPs having good knowledge on the signs of early KC. Most of the ECPs had a fair knowledge level of the signs of early KC. Possibly, because early keratoconus is more specific and there exists a thin line of variability between the early and the moderate KC. These findings were similar to a study in Switzerland on signs of KC, whereby the practitioners had no adequate knowledge (Baenninger et al., 2021). Interestingly, in the current study, the number of the ECPs

that scored good knowledge on the signs of early KC was quite low as compared to the number that self-reported having good knowledge level on the ability to use equipment to diagnose early KC. Most of these signs are identified by use of the equipment.

For the self-reported knowledge on the use of the equipment to diagnose KC, a high number of ECPs (45.9%) reported having good knowledge. However, on the assessment for knowledge on signs of early KC as observed using the equipment, only a few ECPs (15.6%) scored good knowledge. Therefore, even though many ECPs self-reported that they had good knowledge on the use of the equipment in diagnosis of early KC, only a few of them scored good knowledge on the signs of early KC.

5.6 Assessment of practitioner knowledge level in management of early keratoconus in hospitals

Regarding management strategies of early KC majoring on contact lens in this study, only 18.5% of the ECPs had good knowledge level. This is likely due to the fact that contact lens practice is still fairly new in Kenya, thus practitioners may not have fully sharpened their knowledge in contact lens practice, especially for special CL practice. These findings were contrary to a study in KwaZulu-Natal, South Africa, whereby the practitioners reported having adequate knowledge (83.3%) in management of keratoconus using contact lenses, although in regard to the methodology, this was self-reported, thus a possibility of over estimation (Gcabashe et al., 2022).

In self-reported knowledge on the use of equipment in the management of early keratoconus, most of the ECPs had a fair knowledge level as opposed to good knowledge. This may be associated with the lack of the advanced equipment for early KC management, which in turn limits experience as brought about by knowledge and

skills application. These findings were similar to a study in Limpopo, South Africa, on a self-reported knowledge assessment in keratoconus management, whereby 45% of the practitioners were found not knowledgeable (Nkoana et al., 2022a).

In regards to the indicators of progressive KC, most of the ECPs had a good knowledge level. This is likely because KC progresses across most stages, although this equally applies to early KC.

From the study, on overall, most ECPs had only a fair knowledge level in the management of early KC, followed by those with good knowledge level and those with a poor knowledge level. The findings on ECPs having low knowledge level in early KC management could be due to limited post-graduate qualifications, as a few ECPs had Masters and Degree education level, which showed a significant association with knowledge in this study. The results were similar to a study in India, whereby the practitioners were reported as being not knowledgeable in managing keratoconus, possibly due to limited clinical exposure and limited qualification levels (Arvind et al., 2021). Additionally, this outcome was similar to a study in the West Region of Cameroon, whereby the eyecare practitioners were found to have inadequate knowledge and skills regarding keratoconus management, which could have been due to inadequate training (Ayukotang et al., 2024). Moreover, the results concurred with a public sector study in South Africa where the practitioners had limited knowledge for KC management, possibly because there was no keen attention to KC earlier on (Nkoana et al., 2024).

5.7 Knowledge Differences in early keratoconus diagnosis and management between the public and private hospitals

Even though there were minimal differences in knowledge mean scores of risk factors and on indicators of progressive KC between the public and the private hospitals, most of the knowledge domains indicated almost similar mean scores. This is possibly due to the almost equal distribution of qualification levels between the public and private hospitals, which was a significant socio-demographic feature for knowledge. This finding was contrary to a study in India whereby the practitioners in the private sector were found more knowledgeable on equipment use, possibly because of the higher availability of the advanced equipment in the private sector, which thus help them gain experience through practice (Arvind et al., 2021). There was however a significant difference for knowledge of risk factors of KC and the indicators of progressive KC between the public and the private hospitals. This could mean that the private hospitals could better detect progressive KC, while the public hospitals could better identify the risk factors of KC. These results concurred with a study by Arvind et al which reported different knowledge levels between the private and the public hospitals (Arvind et al., 2021). Even though there was no statistically significant association between knowledge and cadres, the ophthalmologists and the Degree level optometrists scored higher than the other cadres.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

1. The basic equipment and consumables such as slit-lamp, distance VA chart and trial lens/phoropter were highly available. The advanced equipment for early keratoconus diagnosis and management had limited availability. The L6s had the highest availability for both basic and advanced equipment, as compared to the other hospital levels. The public hospitals had more basic equipment available than the private hospitals, while the private hospitals had more advanced equipment.

2. Some of the available equipment such as corneal topographer, contact lens fitting-set and topographer had poor working conditions.

3. Most of the available equipment was not fully utilized, and the public hospitals utilized the basic equipment more, while the private hospitals had higher utilization rates for the advanced equipment.

4. Most practitioners had only a fair knowledge level in the diagnosis of early KC, a moderate number had good knowledge level, while few had poor knowledge level. Moreover, there was almost equal knowledge mean scores between the public and private hospitals.

5. On the management of early KC, most practitioners had only a fair knowledge level, a moderate number had good knowledge, with few having a poor level of knowledge. There were almost equal knowledge mean scores between the public and private hospitals.

6.2 Recommendations

6.2.1 Recommendations for Action

The hospitals should consider procuring the advanced equipment to facilitate early keratoconus diagnosis and management, especially the public hospitals that had much less availability. Moreover, the private hospitals should also ensure that they acquire the basic equipment as proper diagnosis and optimum KC care requires a combination of both the advanced and the basic equipment. This would be important as there was a significant association between equipment availability and its utilization. Additionally, the available equipment should be regularly serviced, to ensure that they are of good quality, as a number of the equipment available were found to have poor working conditions.

With a significant proportion of the practitioners found not fully utilizing the equipment that was already available, then, the hospital management and the practitioners should ensure that the equipment is put to use once already availed, to improve on keratoconus diagnosis and management. The public hospitals should ensure use of the advanced equipment as it is essential in KC diagnosis, while the private hospitals should ensure that they equally utilize the basic equipment as both the advanced and the basic equipment are a necessary combination for optimum KC services. Additionally, Standard Operating Procedures (SOPs) for KC should be established and followed accordingly for both the public and private facilities, which would thus help leverage and harmonize services across all set-ups.

A high percentage of the practitioners lacked good knowledge in early keratoconus diagnosis and management. Therefore, a possible guideline policy document on early keratoconus should be considered, prepared and provided to the hospitals, ECPs and

MoH-Eye Health Division to enhance diagnosis and management of the early keratoconus, including the follow-up mechanisms.

The institutions of higher learning, at the University levels offering eyecare training, should consider a module specifically on keratoconus or early keratoconus to enhance good knowledge level, as very many practitioners lacked good knowledge in early KC in many varying areas. Detection of early KC and its management training should be prioritized, as this would also facilitate for referrals. Additionally, with the significant association between knowledge levels and academic qualifications, the practitioners should be encouraged to further their education to promote knowledge.

6.2.2 Recommendations for Further Research

With this study including ten counties, it would be important to have a nation-wide coverage to help give a national picture of the same.

It would be worthwhile considering a study on practitioner skills in early KC, as the study assessed on knowledge levels. Knowledge needs to be applied appropriately to facilitate early KC diagnosis and management.

REFERENCES

Abdalla, Y. F., Elsahn, A. F., Hammersmith, K. M., & Cohen, E. J. (2010). SynergEyes Lenses for Keratoconus. *Cornea*, *29*(1), 5. https://doi.org/10.1097/ICO.0b013e3181a9d090

Akowuah, P. K., Kobia-Acquah, E., Donkor, R., Adjei-Anang, J., & Ankamah-Lomotey, S. (2021). Keratoconus in Africa: A systematic review and meta-analysis. *Ophthalmic and Physiological Optics*, *41*(4), 736–747. https://doi.org/10.1111/opo.12825

Alatawi, S. K. (2023). Quality of life of a sample of people with keratoconus in KSA. *Journal of Taibah University Medical Sciences*, *18*(5), 1157–1169. https://doi.org/10.1016/j.jtumed.2023.03.008

Alio, J. L., Vega-Estrada, A., Esperanza, S., Barraquer, R. I., Teus, M. A., & Murta, J. (2014). Intrastromal Corneal Ring Segments: How Successful is the Surgical Treatment of Keratoconus? *Middle East African Journal of Ophthalmology*, *21*(1), 3–9. https://doi.org/10.4103/0974-9233.124076

Almusawi, L. A., & Hamied, F. M. (2021). Risk Factors for Development of Keratoconus: A Matched Pair Case-Control Study. *Clinical Ophthalmology*, *15*, 3473–3479. https://doi.org/10.2147/OPTH.S248724

Ambrósio, R., & Belin, M. W. (2010). Imaging of the Cornea: Topography vs Tomography. *Journal of Refractive Surgery*, *26*(11), 847–849. https://doi.org/10.3928/1081597X-20101006-01

Arvind, A., Clarke-Farr, P. C., & Naidoo, K. S. (2021). Knowledge and skills amongst optometrists in public and private sectors in India. *African Vision and Eye Health*, *80*(1), Article 1. https://avehjournal.org/index.php/aveh/article/view/643

Ayukotang, E. N., Moodley, V. R., & Mashige, K. P. (2024). Keratoconus in the West Region of Cameroon: Stakeholder knowledge and management. *African Vision and Eye Health*, *83*(1), Article 1. https://doi.org/10.4102/aveh.v83i1.905

Baenninger, P. B., Bachmann, L. M., Iselin, K. C., Pfaeffli, O. A., Kaufmann, C., Thiel, M. A., & Gigerenzer, G. (2021). Mismatch of corneal specialists' expectations and keratoconus knowledge in general ophthalmologists—A prospective observational study in Switzerland. *BMC Medical Education*, *21*(1), 297. https://doi.org/10.1186/s12909-021-02738-0

Bak-Nielsen, S., Ramlau-Hansen, C. H., Ivarsen, A., Plana-Ripoll, O., & Hjortdal, J. (2019). Incidence and prevalence of keratoconus in Denmark – an update. *Acta Ophthalmologica*, *97*(8), 752–755. https://doi.org/10.1111/aos.14082

Barbara, R., & Barbara, A. (2013). Intacs Intracorneal Ring Segments Complications in Patients Suffering from Keratoconus. *International Journal of Keratoconus and Ectatic Corneal Diseases*, *2*(3), 121–128. https://doi.org/10.5005/jp-journals-10025-1064

Barnett, M., Lee, K., & Mannis, M. (2023). Chapter 21 - Keratoconus: Diagnosis and Management With Spectacles and Contact Lenses. In L. Izquierdo, M. Henriquez, & M. Mannis (Eds.), *Keratoconus* (pp. 303–316). Elsevier. https://doi.org/10.1016/B978-0-323-75978-6.00021-2

Belin, M. W., & Duncan, J. K. (2016). Keratoconus: The ABCD Grading System. *Klinische Monatsblätter Für Augenheilkunde*, 701–707. https://doi.org/10.1055/s-0042-100626

Bevara, A., & and Vaddavalli, P. K. (2023). The Evolution of Diagnostics for Keratoconus: From Ophthalmometry to Biomechanics. *Seminars in*

Ophthalmology, *38*(3), 265–274. https://doi.org/10.1080/08820538.2022.2152716

Boadi-Kusi, S. B., Ntodie, M., Mashige, K. P., Owusu-Ansah, A., & Antwi Osei, K. (2015). A cross-sectional survey of optometrists and optometric practices in Ghana. *Clinical & Experimental Optometry*, *98*(5), 473–477. https://doi.org/10.1111/cxo.12291

Boadi-kusi, S. B., Ntodie, M., Mashige, K. P., Owusu-ansah, A., & Antwi osei, K. (2015). A cross-sectional survey of optometrists and optometric practices in Ghana. *Clinical and Experimental Optometry*, *98*(5), 473–477. https://doi.org/10.1111/cxo.12291

Braga Vieira, S., Rivadeneira-Bueno, D., Ortiz-Toquero, S., & Martin, R. (2023). Optometric practices and attitudes in keratoconus patient management in Latin America. *Clinical and Experimental Optometry*, *106*(4), 386–394. https://doi.org/10.1080/08164622.2022.2048997

Braithwaite, T., Winford, B., Bailey, H., Bridgemohan, P., Bartholomew, D., Singh, D., Sharma, S., Sharma, R., Silva, J. C., Gray, A., Ramsewak, S. S., & Bourne, R. R. A. (2018). Health system dynamics analysis of eyecare services in Trinidad and Tobago and progress towards Vision 2020 Goals. *Health Policy and Planning*, *33*(1), 70–84. https://doi.org/10.1093/heapol/czx143

Buthelezi, L. M., & Staden, D. van. (2020). Integrating eye health into policy: Evidence for health systems strengthening in KwaZulu-Natal. *African Vision and Eye Health*, *79*(1), Article 1. https://avehjournal.org/index.php/aveh/article/view/549

Chan, E., Chong, E. W., Lingham, G., Stevenson, L. J., Sanfilippo, P. G., Hewitt, A. W., Mackey, D. A., & Yazar, S. (2021). Prevalence of Keratoconus Based on

Scheimpflug Imaging: The Raine Study. *Ophthalmology*, *128*(4), 515–521. https://doi.org/10.1016/j.ophtha.2020.08.020

Choi, J. A., Lee, M. A., & Kim, M.-S. (2014). Long-term outcomes of penetrating keratoplasty in keratoconus: Analysis of the factors associated with final visual acuities. *International Journal of Ophthalmology*, *7*(3), 517–521. https://doi.org/10.3980/j.issn.2222-3959.2014.03.24

Coster, D. J., Lowe, M. T., Keane, M. C., & Williams, K. A. (2014). A Comparison of Lamellar and Penetrating Keratoplasty Outcomes: A Registry Study. *Ophthalmology*, *121*(5), 979–987. https://doi.org/10.1016/j.ophtha.2013.12.017

Cursiefen, C., Schaub, F., & Bachmann, B. (2016). Update: Tiefe anteriore lamelläre Keratoplastik (DALK) bei Keratokonus. *Der Ophthalmologe*, *113*(3), 204–212. https://doi.org/10.1007/s00347-015-0204-6

Das, A. V., Deshmukh, R. S., Reddy, J. C., Joshi, V. P., Singh, V. M., Gogri, P. Y., Murthy, S. I., Chaurasia, S., Fernandes, M., Roy, A., Das, S., & Vaddavalli, P. K. (2024). Keratoconus in India: Clinical presentation and demographic distribution based on big data analytics. *Indian Journal of Ophthalmology*, *72*(1), 105–110. https://doi.org/10.4103/IJO.IJO_1190_23

de Azevedo Magalhães, O., Pagano, B. N., Grellmann, L. V., Zago, V. S., & Kronbauer, C. L. (2024). Prevalence of Keratoconus Among High School Students in Southern Brazil: A Community-Based Study. *Eye & Contact Lens*, *50*(3), 117. https://doi.org/10.1097/ICL.0000000000001066

De Stefano, V. S., Ford, M. R., Seven, I., & Dupps, W. J., Jr. (2020). Depth-Dependent Corneal Biomechanical Properties in Normal and Keratoconic Subjects by

Optical Coherence Elastography. *Translational Vision Science & Technology*, *9*(7), 4. https://doi.org/10.1167/tvst.9.7.4

Debourdeau, E., Planells, G., Chamard, C., Touboul, D., Villain, M., Demoly, P., Babeau, F., Fournie, P., & Daien, V. (2022). New Keratoconus Risk Factors: A Cross-Sectional Case—Control Study. *Journal of Ophthalmology*, *2022*(1), 6605771. https://doi.org/10.1155/2022/6605771

Deshmukh, R., Ong, Z. Z., Rampat, R., Barrio, J. L. A. del, Barua, A., Ang, M., Mehta, J. S., Said, D. G., Dua, H. S., Renato Ambrósio, J., & Ting, D. S. J. (2023). Management of keratoconus: An updated review. *Frontiers in Medicine*, *10*. https://doi.org/10.3389/fmed.2023.1212314

Edelstein, S. L., DeMatteo, J., Stoeger, C. G., Macsai, M. S., & Wang, C.-H. (2016). Report of the Eye Bank Association of America Medical Review Subcommittee on Adverse Reactions Reported From 2007 to 2014. *Cornea*, *35*(7), 917–926. https://doi.org/10.1097/ICO.0000000000000869

Elbedewy, H. A., Wasfy, T. E., Soliman, S. S., Sabry, M. M., Awara, A. M., El Emam, S. Y., Shafik, H. M., & Alam, M. R. (2019). Prevalence and topographical characteristics of keratoconus in patients with refractive errors in the Egyptian delta. *International Ophthalmology*, *39*(7), 1459–1465. https://doi.org/10.1007/s10792-018-0965-4

Espandar, L., & Meyer, J. (2010). Keratoconus: Overview and Update on Treatment. *Middle East African Journal of Ophthalmology*, *17*(1), 15–20. https://doi.org/10.4103/0974-9233.61212

Ferdi, A. C., Nguyen, V., Gore, D. M., Allan, B. D., Rozema, J. J., & Watson, S. L. (2019). Keratoconus Natural Progression: A Systematic Review and Meta-

analysis of 11 529 Eyes. *Ophthalmology*, *126*(7), 935–945. https://doi.org/10.1016/j.ophtha.2019.02.029

Ferdi, A., Nguyen, V., Kandel, H., Tan, J. C. K., Arnalich-Montiel, F., Abbondanza, M., & Watson, S. (2022). Predictors of progression in untreated keratoconus: A Save Sight Keratoconus Registry study. *British Journal of Ophthalmology*, *106*(9), 1206–1211. https://doi.org/10.1136/bjophthalmol-2020-317547

Fernandez-Velazquez, F. J. (2012). Kerasoft IC compared to Rose-K in the management of corneal ectasias. *Contact Lens and Anterior Eye*, *35*(4), 175–179. https://doi.org/10.1016/j.clae.2012.02.005

Flockerzi, E., Xanthopoulou, K., Goebels, S. C., Zemova, E., Razafimino, S., Hamon, L., Jullien, T., Klühspies, U., Eppig, T., Langenbucher, A., & Seitz, B. (2021). Keratoconus staging by decades: A baseline ABCD classification of 1000 patients in the Homburg Keratoconus Center. *British Journal of Ophthalmology*, *105*(8), 1069–1075. https://doi.org/10.1136/bjophthalmol-2020-316789

Galettis, R. (FMC). (2018). *Australian Corneal Graft Registry Report 2018*.

Gcabashe, Moodley, V. R., & Hansraj, R. (2023). Prevalence and clinical profile of keratoconus in patients presenting at a provincial hospital in KwaZulu, Natal, South Africa: A case study. *Journal of Public Health in Africa*, *14*(9), 2356. https://doi.org/10.4081/jphia.2023.2356

Gcabashe, N., Moodley, V. R., & Hansraj, R. (2022). Keratoconus management at public sector facilities in KwaZulu-Natal, South Africa: Practitioner perspectives. *African Vision and Eye Health*, *81*(1), Article 1. https://avehjournal.org/index.php/aveh/article/view/698

Georgiou, T., Funnell, C. L., Cassels-Brown, A., & O'Conor, R. (2004). Influence of ethnic origin on the incidence of keratoconus and associated atopic disease in Asians and white patients. *Eye*, *18*(4), 379–383. https://doi.org/10.1038/sj.eye.6700652

Godefrooij, D. A., de Wit, G. A., Uiterwaal, C. S., Imhof, S. M., & Wisse, R. P. L. (2017). Age-specific Incidence and Prevalence of Keratoconus: A Nationwide Registration Study. *American Journal of Ophthalmology*, *175*, 169–172. https://doi.org/10.1016/j.ajo.2016.12.015

Godefrooij, D. A., Gans, R., Imhof, S. M., & Wisse, R. P. L. (2016). Nationwide reduction in the number of corneal transplantations for keratoconus following the implementation of cross-linking. *Acta Ophthalmologica*, *94*(7), 675–678. https://doi.org/10.1111/aos.13095

Godefrooij, D. A., van Geuns, P., de Wit, G. A., & Wisse, R. P. L. (2016). What Are the Costs of Corneal Cross-linking for the Treatment of Progressive Keratoconus? *Journal of Refractive Surgery (Thorofare, N.J.: 1995)*, *32*(5), 355. https://doi.org/10.3928/1081597X-20160318-01

Goh, Y. W., Gokul, A., Yadegarfar, M. E., Vellara, H., Shew, W., Patel, D., McGhee, C. N. J., & Ziaei, M. (2020). Prospective Clinical Study of Keratoconus Progression in Patients Awaiting Corneal Cross-linking. *Cornea*, *39*(10), 1256. https://doi.org/10.1097/ICO.0000000000002376

Gupta, Y., Saxena, R., Jhanji, V., Maharana, P. K., Sinha, R., Agarwal, T., Titiyal, J. S., & Sharma, N. (2022). Management Outcomes in Pediatric Keratoconus: Childhood Keratoconus Study. *Journal of Ophthalmology*, *2022*(1), 4021288. https://doi.org/10.1155/2022/4021288

Hashemi, H., Beiranvand, A., Khabazkhoob, M., Asgari, S., Emamian, M. H., Shariati, M., & Fotouhi, A. (2013). Prevalence of Keratoconus in a Population-based Study in Shahroud. *Cornea*, *32*(11), 1441. https://doi.org/10.1097/ICO.0b013e3182a0d014

Hashemi, H., Heydarian, S., Hooshmand, E., Saatchi, M., Yekta, A., Aghamirsalim, M., Valadkhan, M., Mortazavi, M., Hashemi, A., & Khabazkhoob, M. (2020). The Prevalence and Risk Factors for Keratoconus: A Systematic Review and Meta-Analysis. *Cornea*, *39*(2), 263. https://doi.org/10.1097/ICO.0000000000002150

Hodge, C., Chan, C., Zantos, S., Kokkinakis, J., Stapleton, F., & Sutton, G. (2015). Therapeutic treatment of keratoconus: A survey of local optometric practice criteria. *Clinical and Experimental Optometry*. https://doi.org/10.1111/cxo.12233

Holopainen, J. M., & Krootila, K. (2011). Transient Corneal Thinning in Eyes Undergoing Corneal Cross-Linking. *American Journal of Ophthalmology*, *152*(4), 533–536. https://doi.org/10.1016/j.ajo.2011.03.023

Hwang, S., Lim, D. H., & Chung, T.-Y. (2018). Prevalence and Incidence of Keratoconus in South Korea: A Nationwide Population-based Study. *American Journal of Ophthalmology*, *192*, 56–64. https://doi.org/10.1016/j.ajo.2018.04.027

Jesus, D. A., & Iskander, D. R. (2017). Assessment of corneal properties based on statistical modeling of OCT speckle. *Biomedical Optics Express*, *8*(1), 162–176. https://doi.org/10.1364/BOE.8.000162

Jhanji, V., Sharma, N., & Vajpayee, R. B. (2011). Management of keratoconus: Current scenario. *British Journal of Ophthalmology*, *95*(8), 1044–1050. https://doi.org/10.1136/bjo.2010.185868

JKUAT. (2025). BSc. Comprehensive Ophthalmology and Cataract Surgery. *Jomo Kenyatta University of Agriculture and Technology*. https://www.jkuat.ac.ke/bsc-comprehensive-ophthalmology-and-cataract-surgery/

Jonas, J. B., Nangia, V., Matin, A., Kulkarni, M., & Bhojwani, K. (2009). Prevalence and Associations of Keratoconus in Rural Maharashtra in Central India: The Central India Eye and Medical Study. *American Journal of Ophthalmology*, *148*(5), 760–765. https://doi.org/10.1016/j.ajo.2009.06.024

Kanclerz, P., Przewłócka, K., Toprak, I., & Alio, J. (2023). The prevalence of keratoconus in northern Poland: A cross-sectional study of patients from a primary healthcare practice. *Contact Lens and Anterior Eye*, 101846. https://doi.org/10.1016/j.clae.2023.101846

Kandel, H., Pesudovs, K., & Watson, S. L. (2020). Measurement of Quality of Life in Keratoconus. *Cornea*, *39*(3), 386. https://doi.org/10.1097/ICO.0000000000002170

Kasbekar, S. A., Jones, M. N. A., Ahmad, S., Larkin, D. F. P., & Kaye, S. B. (2014). Corneal Transplant Surgery for Keratoconus and the Effect of Surgeon Experience on Deep Anterior Lamellar Keratoplasty Outcomes. *American Journal of Ophthalmology*, *158*(6), 1239–1246. https://doi.org/10.1016/j.ajo.2014.08.029

KENYA, MOH. (2025). *Career Guidelines For Optometry Personnel 2024 WD | PDF | Optometry | Ophthalmology*. Scribd.

https://www.scribd.com/document/908799387/Career-Guidelines-For-Optometry-Personnel-2024-wd-2

Kenya National Bureau of Statistics. (2019). 2019 Kenya Population and Housing Census Volume I: Population by County and Sub-County. *Kenya National Bureau of Statistics*. https://www.knbs.or.ke/download/2019-kenya-population-and-housing-census-volume-i-population-by-county-and-sub-county/

Khandekar, R., & Fahdi, M. (2009). Evaluation of resources for contact lens practice in private contact lens clinics of Muscat, Oman. *Oman Journal of Ophthalmology*, *2*(1), 19–22. https://doi.org/10.4103/0974-620X.48417

Kobia-Acquah, E., Senanu, E. N., Antwi-Adjei, E. K., Appiah, D. P., Kumah, D. B., Abdul-Kabir, M., & Donkor, R. (2022). Prevalence of keratoconus in Ghana: A hospital-based study of tertiary eye care facilities. *European Journal of Ophthalmology*, *32*(6), 3185–3194. https://doi.org/10.1177/11206721221113197

Kodavoor, S. K., Sarwate, N. J., & Ramamurhy, D. (2015). Microbial keratitis following accelerated corneal collagen cross-linking. *Oman Journal of Ophthalmology*, *8*(2), 111. https://doi.org/10.4103/0974-620X.159259

Kreps, E. O., Claerhout, I., & Koppen, C. (2021). Diagnostic patterns in keratoconus. *Contact Lens and Anterior Eye*, *44*(3), 101333. https://doi.org/10.1016/j.clae.2020.05.002

Kristianslund, O., Hagem, A. M., Thorsrud, A., & Drolsum, L. (2021). Prevalence and incidence of keratoconus in Norway: A nationwide register study. *Acta Ophthalmologica*, *99*(5), e694–e699. https://doi.org/10.1111/aos.14668

Labiris, G., Kaloghianni, E., Koukoula, S., Zissimopoulos, A., & Kozobolis, V. P. (2011). Corneal melting after collagen cross-linking for keratoconus: A case report. *Journal of Medical Case Reports*, *5*(1), 152. https://doi.org/10.1186/1752-1947-5-152

Leung, V. C., Pechlivanoglou, P., Chew, H. F., & Hatch, W. (2017). Corneal Collagen Cross-Linking in the Management of Keratoconus in Canada: A Cost-Effectiveness Analysis. *Ophthalmology*, *124*(8), 1108–1119. https://doi.org/10.1016/j.ophtha.2017.03.019

Liu, H., Chen, Y., Wang, P., Li, B., Wang, W., Su, Y., & Sheng, M. (2015). Efficacy and Safety of Deep Anterior Lamellar Keratoplasty vs. Penetrating Keratoplasty for Keratoconus: A Meta-Analysis. *PLOS ONE*, *10*(1), e0113332. https://doi.org/10.1371/journal.pone.0113332

Ljubic, A. D. (2009). Keratoconus and Its Prevalence in Macedonia. *Macedonian Journal of Medical Sciences*, *2*(1), 58–62. https://doi.org/10.3889/MJMS.1857-5773.2009.0034

Lombardo, M., Alunni Fegatelli, D., Serrao, S., Vestri, A., & Lombardo, G. (2024). Estimated prevalence of keratoconus in the largest metropolitan area of Italy. *European Journal of Ophthalmology*, *34*(3), 649–655. https://doi.org/10.1177/11206721241235984

Maake, M. E., & Moodley, V. R. (2018). An evaluation of the public sector optometric service provided within the health districts in KwaZulu-Natal, South Africa. *African Vision and Eye Health*, *77*(1), 1–9. https://doi.org/10.4102/aveh.v77i1.407

Mangioris, G. F., Papadopoulou, D. N., Balidis, M. O., Poulas, J. L., Papadopoulos, N. T., & Seiler, T. (2010). Corneal Infiltrates After Corneal Collagen Cross-

Linking. *Journal of Refractive Surgery*, *26*(8), 609–611. https://doi.org/10.3928/1081597X-20100326-01

Maro, F. P., & Moodley, V. R. (2025). Keratoconus in Northern Tanzania: A hospital-based prevalence and clinical profile study. *African Vision and Eye Health*, *84*(1), 1026. https://doi.org/10.4102/aveh.v84i1.1026

Martínez-Abad, A., & Piñero, D. P. (2017). New perspectives on the detection and progression of keratoconus. *Journal of Cataract & Refractive Surgery*, *43*(9), 1213–1227. https://doi.org/10.1016/j.jcrs.2017.07.021

Marx-Gross, S., Fieß, A., Münzel, T., Wild, P. S., Beutel, M. E., Schmidtmann, I., Lackner, K. J., Pfeiffer, N., & Schuster, A. K.-G. (2023). Much higher prevalence of keratoconus than announced results of the Gutenberg Health Study (GHS). *Graefe's Archive for Clinical and Experimental Ophthalmology*, *261*(11), 3241–3247. https://doi.org/10.1007/s00417-023-06132-y

Mbindyo, R., Kioko, J., Siyoi, F., Cheruiyot, S., Wangai, M., Onsongo, J., Omwoyo, A., Kisia, C., & Miriti, K. (2020). Legal and institutional foundations for universal health coverage, Kenya. *Bulletin of the World Health Organization*, *98*(10), 706–718. https://doi.org/10.2471/BLT.19.237297

McGhee, C. N. (2009). 2008 Sir Norman McAlister Gregg Lecture: 150 years of practical observations on the conical cornea – what have we learned? *Clinical & Experimental Ophthalmology*, *37*(2), 160–176. https://doi.org/10.1111/j.1442-9071.2009.02009.x

Mmust. (2022). *Research_and_Consultancy_Policy_2_1_REVISED_DECEMBER.docx*. Policy. https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fmmust

.ac.ke%2Fimages%2FResearch_and_Consultancy_Policy_2_1_REVISED_DECEMBER.docx&wdOrigin=BROWSELINK

MOH-Kenya. (2020). *National_Eye_Health_Strategic_Plan-_2020-2025.pdf*. MOH-Kenya. http://guidelines.health.go.ke:8000/media/National_Eye_Health_Strategic_Plan-_2020-2025.pdf

Morjaria, P., Minto, H., Ramson, P., M, G., Naidoo, K., & Gilbert, C. (2013). Services for refractive error in Kenya: Extent to which human resources and equipment are meeting VISION 2020 targets. *Journal of Ophthalmology of Eastern Central and Southern Africa*, *17*(2), Article 2. https://researchonline.lshtm.ac.uk/id/eprint/2551559/

Motowa, S., Khandekar, R., & Al-Towerki, A. (2014). Resources for Eye Care at Secondary and Tertiary Level Government Institutions in Saudi Arabia. *Middle East African Journal of Ophthalmology*, *21*(2), 142–146. https://doi.org/10.4103/0974-9233.129761

Mousa, R. M., Saif, M. Y. S., Said, M. A. E., & Mohamed Taher, R. M. (2025). Prevalence of Keratoconus and Characteristics of Refractive Errors in First-Degree Relatives of Patients With Keratoconus Among Egyptians. *Cornea*, *44*(1), 86. https://doi.org/10.1097/ICO.0000000000003593

Mugho, S. N. (2016). *Prevalence of Keratoconus in Patients with Allergic Conjunctivitis Attending Kenyatta National Hospital Eye Clinic* [Thesis]. http://erepository.uonbi.ac.ke/handle/11295/99080

Munir, S. Z., Munir, W. M., & Albrecht, J. (2021). Estimated Prevalence of Keratoconus in the United States From a Large Vision Insurance Database. *Eye & Contact Lens*, *47*(9), 505. https://doi.org/10.1097/ICL.0000000000000812

Musa, F. U., Patil, S., Rafiq, O., Galloway, P., Ball, J., & Morrell, A. (2012). Long-term risk of intraocular pressure elevation and glaucoma escalation after deep anterior lamellar keratoplasty. *Clinical & Experimental Ophthalmology*, *40*(8), 780–785. https://doi.org/10.1111/j.1442-9071.2012.02796.x

Mutia, D., Kihiu, J., & Maranga, S. (2012). *Maintenance Management of Medical Equipment in Hospitals*. *2*.

Naderan, M., Rajabi, M. T., Zarrinbakhsh, P., & Bakhshi, A. (2017). Effect of Allergic Diseases on Keratoconus Severity. *Ocular Immunology and Inflammation*, *25*(3), 418–423. https://doi.org/10.3109/09273948.2016.1145697

Naidoo, K., Arvind, A., Abesamos-Dichoso, C., Tan, K. O., & Govender-Poonsamy, P. (2021). Optometry in South-East Asia. In T. Das & P. D. Nayar (Eds.), *South-East Asia Eye Health: Systems, Practices, and Challenges* (pp. 303–311). Springer. https://doi.org/10.1007/978-981-16-3787-2_18

Nkoana, Mashige, K. P., & Moodley, V. R. (2024). Strengthening keratoconus management systems in South African public sector facilities. *African Vision and Eye Health*, *83*(1), 1–11. https://doi.org/10.4102/aveh.v83i1.832

Nkoana, Moodley, V. R., & Mashige, K. P. (2022a). Self-reported knowledge and skills related to diagnosis and management of keratoconus among public sector optometrists in the Limpopo province, South Africa. *African Journal of Primary Health Care & Family Medicine*, *14*(1), e1–e9. https://doi.org/10.4102/phcfm.v14i1.3668

Nkoana, P. M. W., Moodley, V. R., & Mashige, K. P. (2022b). Self-reported knowledge and skills related to diagnosis and management of keratoconus among public sector optometrists in the Limpopo province, South Africa.

African Journal of Primary Health Care & Family Medicine, *14*(1), 1–9. https://doi.org/10.4102/phcfm.v14i1.3668

Nyawira, L., Tsofa, B., Musiega, A., Munywoki, J., Njuguna, R. G., Hanson, K., Mulwa, A., Molyneux, S., Maina, I., Normand, C., Jemutai, J., & Barasa, E. (2022). Management of human resources for health: Implications for health systems efficiency in Kenya. *BMC Health Services Research*, *22*(1), 1046. https://doi.org/10.1186/s12913-022-08432-1

Olivo-Payne, A., Abdala-Figuerola, A., Hernandez-Bogantes, E., Pedro-Aguilar, L., Chan, E., & Godefrooij, D. (2019). Optimal management of pediatric keratoconus: Challenges and solutions. *Clinical Ophthalmology*, *13*(null), 1183–1191. https://doi.org/10.2147/OPTH.S183347

Özalp, O., Atalay, E., & Yıldırım, N. (2021). Prevalence and risk factors for keratoconus in a university-based population in Turkey. *Journal of Cataract & Refractive Surgery*, *47*(12), 1524. https://doi.org/10.1097/j.jcrs.0000000000000669

Palmer, J. J., Chinanayi, F., Gilbert, A., Pillay, D., Fox, S., Jaggernath, J., Naidoo, K., Graham, R., Patel, D., & Blanchet, K. (2014). Mapping human resources for eye health in 21 countries of sub-Saharan Africa: Current progress towards VISION 2020. *Human Resources for Health*, *12*(1), 44. https://doi.org/10.1186/1478-4491-12-44

Papali'i-Curtin, A. T., Cox, R., Ma, T., Woods, L., Covello, A., & Hall, R. C. (2019). Keratoconus Prevalence Among High School Students in New Zealand. *Cornea*, *38*(11), 1382. https://doi.org/10.1097/ICO.0000000000002054

Peña-García, P., Sanz-Díez, P., & Durán-García, M. L. (2015). Keratoconus Management Guidelines. *International Journal of Keratoconus and Ectatic Corneal Diseases*, *4*(1), 1–39. https://doi.org/10.5005/jp-journals-10025-1095

Piñero, D. P., & Alio, J. L. (2010). Intracorneal ring segments in ectatic corneal disease – a review. *Clinical & Experimental Ophthalmology*, *38*(2), 154–167. https://doi.org/10.1111/j.1442-9071.2010.02197.x

Pinheiro-Costa, J., Correia, P. J., Pinto, J. V., Alves, H., Torrão, L., Moreira, R., Falcão, M., Carneiro, Â., Madeira, M. D., & Falcão-Reis, F. (2020). Increased choroidal thickness is not a disease progression marker in keratoconus. *Scientific Reports*, *10*(1), 19938. https://doi.org/10.1038/s41598-020-77122-x

Pinto, R. D. P., Abe, R. Y., Gomes, F. C., Barbisan, P. R. T., Martini, A. F., de Almeida Borges, D., Fernandes, A. G., Arieta, C. E. L., & Alves, M. (2021). Quality of life in keratoconus: Evaluation with Keratoconus Outcomes Research Questionnaire (KORQ). *Scientific Reports*, *11*(1), Article 1. https://doi.org/10.1038/s41598-021-92346-1

Rampersad, N., Gcabashe, N., Memela, N., Rupnarain, S., Simjee, N., Ngcobo, S., Shabalala, N., & Madlala, N. (2020). Clinical characteristics of keratoconus patients at the University of KwaZulu-Natal eye clinic. *African Vision and Eye Health*, *79*(1), 1–7. https://doi.org/10.4102/aveh.v79i1.528

Rashid, Z. A., Millodot, M., & Evans, K. S. E. (2016). Characteristics of Keratoconic Patients Attending a Specialist Contact Lens Clinic in Kenya. *Middle East African Journal of Ophthalmology*, *23*(4), 283–287. https://doi.org/10.4103/0974-9233.194074

Rashid, Z. A., Moodley, V. R., & Mashige, K. P. (2023a). Diagnosis and management of keratoconus by eye care practitioners in Kenya. *BMC Ophthalmology*, *23*(1), 37. https://doi.org/10.1186/s12886-023-02792-w

Rashid, Z. A., Moodley, V. R., & Mashige, K. P. (2023b). *Prevalence and demographic profile of keratoconus among high school students in Kenya*. https://doi.org/10.21203/rs.3.rs-3697729/v1

Rathi, V. M., Mandathara, P. S., & Dumpati, S. (2013). Contact lens in keratoconus. *Indian Journal of Ophthalmology*, *61*(8), 410. https://doi.org/10.4103/0301-4738.116066

Rebenitsch, R. L., Kymes, S. M., Walline, J. J., & Gordon, M. O. (2011). The Lifetime Economic Burden of Keratoconus: A Decision Analysis Using a Markov Model. *American Journal of Ophthalmology*, *151*(5), 768-773.e2. https://doi.org/10.1016/j.ajo.2010.10.034

Salawu, R., Shamsuddin, A., Bolatitio, S., & Masibo, S. (2023). Theoretical and conceptual frameworks in research: Conceptual clarification. *European Chemical Bulletin*, *12*(12), 2103–2117. https://www.researchgate.net/profile/Aina-Obe-Shamsuddin/publication/374081258_THEORETICAL_AND_CONCEPTUAL_FRAMEWORKS_IN_RESEARCH_CONCEPTUAL_CLARIFICATION/links/650c631a82f01628f0361553/THEORETICAL-AND-CONCEPTUAL-FRAMEWORKS-IN-RESEARCH-CONCEPTUAL-CLARIFICATION.pdf

Salmon, H. A., Chalk, D., Stein, K., & Frost, N. A. (2015). Cost effectiveness of collagen crosslinking for progressive keratoconus in the UK NHS. *Eye*, *29*(11), Article 11. https://doi.org/10.1038/eye.2015.151

Santodomingo-Rubido, J., Carracedo, G., Suzaki, A., Villa-Collar, C., Vincent, S. J., & Wolffsohn, J. S. (2022). Keratoconus: An updated review. *Contact Lens and Anterior Eye*, *45*(3), 101559. https://doi.org/10.1016/j.clae.2021.101559

Saraç, Ö., Kars, M. E., Temel, B., & Çağıl, N. (2019). Clinical evaluation of different types of contact lenses in keratoconus management. *Contact Lens and Anterior Eye*, *42*(5), 482–486. https://doi.org/10.1016/j.clae.2019.02.013

Saro, A. S., Radwan, G. A., Mohammed, U. A., & Abozaid, M. A. (2018). Screening for keratoconus in a refractive surgery population of Upper Egypt. *Delta Journal of Ophthalmology*, *19*(1), 19. https://doi.org/10.4103/DJO.DJO_39_17

Seth, I., Bulloch, G., Vine, M., Outmezguine, J., Seth, N., Every, J., & Daniell, M. (2023). The association between keratoconus and allergic eye diseases: A systematic review and meta-analysis. *Clinical & Experimental Ophthalmology*, *51*(4), O1–O16. https://doi.org/10.1111/ceo.14215

Sewagegn, N., Tilahun, T., Dessie, G., & Bezabih, B. (2025). Assessment of the operational status of medical equipment in public hospitals in the Amhara region, Ethiopia: A sub-national study. *Discover Health Systems*, *4*(1), 131. https://doi.org/10.1007/s44250-025-00312-9

Shah, H., Pagano, L., Vakharia, A., Coco, G., Gadhvi, K. A., Kaye, S. B., & Romano, V. (2021). Impact of COVID-19 on keratoconus patients waiting for corneal cross linking. *European Journal of Ophthalmology*, *31*(6), 3490–3493. https://doi.org/10.1177/11206721211001315

Sharma, B. (2016). A focus on reliability in developmental research through Cronbach's Alpha among medical, dental and paramedical professionals.

Asian Pacific Journal of Health Sciences, *3*(4), 271–278. https://doi.org/10.21276/apjhs.2016.3.4.43

Shetty, R., Kaweri, L., Pahuja, N., Nagaraja, H., Wadia, K., Jayadev, C., Nuijts, R., & Arora, V. (2015). Current review and a simplified "five-point management algorithm" for keratoconus. *Indian Journal of Ophthalmology*, *63*(1), 46–53. https://doi.org/10.4103/0301-4738.151468

Shi, Y. (2016). Strategies for improving the early diagnosis of keratoconus. *Clinical Optometry*, 13. https://doi.org/10.2147/OPTO.S63486

Singh, R. B., Parmar, U. P. S., & Jhanji, V. (2024). Prevalence and Economic Burden of Keratoconus in the United States. *American Journal of Ophthalmology*, *259*, 71–78. https://doi.org/10.1016/j.ajo.2023.11.009

Sriranganathan, A., Chan, C. C., Dhillon, J., & Felfeli, T. (2022). Global Incidence and Prevalence of Keratoconus: A Systematic Review and Meta-Analysis. *Cornea*, 10.1097/ICO.0000000000003973. https://doi.org/10.1097/ICO.0000000000003973

Steinberg, J., Bußmann, N., Frings, A., Katz, T., Druchkiv, V., & Linke, S. J. (2021). Quality of life in stable and progressive 'early-stage' keratoconus patients. *Acta Ophthalmologica*, *99*(2), e196–e201. https://doi.org/10.1111/aos.14564

Syed, Z. A., Meghpara, B. B., & Rapuano, C. J. (2022). Clinical Diagnosis of Keratoconus. In S. Das (Ed.), *Keratoconus: Diagnosis and Treatment* (pp. 45–57). Springer Nature. https://doi.org/10.1007/978-981-19-4262-4_5

Taber, K. S. (2018). The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education*, *48*(6), 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

Tojar, M. B. (2022). Early Diagnosis of Keratoconus: When Should One Suspect It? In E. Almodin, B. A. Nassaralla, & J. Sandes (Eds.), *Keratoconus: A Comprehensive Guide to Diagnosis and Treatment* (pp. 47–56). Springer International Publishing. https://doi.org/10.1007/978-3-030-85361-7_6

Toro, M., Choragiewicz, T., Posarelli, C., Figus, M., & Rejdak, R. (2020). Early Impact of COVID-19 Outbreak on the Availability of Cornea Donors: Warnings and Recommendations. *Clinical Ophthalmology*, *14*, 2879–2882. https://doi.org/10.2147/OPTH.S260960

Uday, B. (2022). *Clinical Keratoconus Management: Avoiding the Slippery Slope* [MiVision Education]. https://www.mieducation.com/pages/clinical-keratoconus-management-avoiding-the-slippery-slope

UN. (2015). *THE 17 GOALS | Sustainable Development*. UN. https://sdgs.un.org/goals

Usgaonkar, U., Chodankar, S., & Shetty, A. (2023). Online survey about keratoconus management by optometrists. *Indian Journal of Ophthalmology*, *71*(1), 86–90. https://doi.org/10.4103/ijo.IJO_525_22

WHO. (2019). *Universal health coverage (UHC)*. https://www.who.int/news-room/fact-sheets/detail/universal-health-coverage-(uhc)

Yego, W. K., & Chemjor, H. (2020). Profile and Performance of Rigid Gas Permeable and Scleral Lenses on Keratoconic Patients in the Developing Contact Lens Practice Settings. *Open Journal of Ophthalmology*, *10*(03), Article 03. https://doi.org/10.4236/ojoph.2020.103021

Zhang, Y., Wu, S., & Yao, Y. (2013). Long-term comparison of full-bed deep anterior lamellar keratoplasty and penetrating keratoplasty in treating keratoconus. *Journal of Zhejiang University SCIENCE B*, *14*(5), 438–450. https://doi.org/10.1631/jzus.B1200272

Zhou, W., Yu, H., & Feng, Y. (2022). Decrease in Tear Film Lipid Layer Thickness in Patients with Keratoconus. *Journal of Clinical Medicine*, *11*(18), Article 18. https://doi.org/10.3390/jcm11185252

APPENDICES

Appendix I: Map of Kenya Showing Nyanza and Western Kenya Regions

Map of Kenya Showing Nyanza and Western Kenya Regions

Appendix II: Sample Consent Document for Eyecare Practitioners

INFORMATION DOCUMENT

STUDY TITLE: DIAGNOSIS AND MANAGEMENT OF EARLY KERATOCONUS- PRACTITIONER PERSPECTIVES

RESEARCHER: MILLICENT M. NJERU

INSTITUTION; MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY

Date:

Dear Eye care practitioner,

I am Millicent Njeru, a Master's student, carrying out a research study.

You are being invited to participate in a research study on early keratoconus. The study aims to evaluate the diagnosis and management of early keratoconus on a practitioner's perspective.

If you agree to participate in the study, you will be requested to fill-in a questionnaire in a google form, via electronic gadget shared through a link. The questionnaire will take about 10 minutes to answer and the researcher or the research assistant will be present to help you with any information regarding the study and the questionnaire. Your decision to participate will be voluntary and you will be allowed to withdraw at any point even after commencing the study and there will be no any consequences on thereof.

The study does not involve any risks or harm. On completion of the study, we hope to inform on how to improve and enhance on diagnosis and management of early keratoconus.

In case of any query or information, you can contact the researcher through mobile: +254 715 867 693 or email: mmnjeru16@gmail.com

Appendix III: Questionnaire

Section 1

QUESTIONNAIRE

Patterns of Diagnosis and Management of early Keratoconus: A survey of primary eye care practice in Kenya

INFORMATION DOCUMENT

Dear Eyecare practitioner,
I am Millicent Njeru, a Master's student from Masinde Muliro University of Science and Technology (MMUST), department of Optometry and Vision Sciences. I am doing a research study as a partial requirement for my Master's. My phone number is: +254715867693 and email address is: mmnjeru16@gmail.com
You are being invited to participate in the research study. The study aims to evaluate the patterns of diagnosis and management of early keratoconus on a practitioners' perspective.
This study is intended for Eyecare practitioners (Ophthalmologists, Ophthalmic Clinical Officers, Comprehensive Ophthalmology and Cataract Surgeons and Optometrists) practicing in Western and Nyanza Kenya regions.
If you agree to participate in the study, you will be requested to fill-in a questionnaire in a google form, shared through a link via electronic gadget. The questionnaire will take about 10 minutes to answer and the researcher or the research assistant will be present to help you with any information regarding the study and the questionnaire. Your decision to participate will be fully voluntary and you will be allowed to withdraw at any point in time even after commencing the study and there will be no any consequences on this. There will be no confidential data that will be collected but any information collected will be confidentially stored. This information will only be accessible to the researcher and for research data analysis purposes only. No personal information such as contacts information including the email address will be accessible by the researcher from the data.
The study does not involve any risks or harm. However, on completion of the study, we hope to inform on how to improve and enhance on diagnosis and management of early keratoconus. This will be of great benefit for it will lead to a decrease in late severe keratoconus diagnosis and the many disadvantages and complications that come with late keratoconus diagnosis and management.
If you agree to participate in this study, you will be required to sign a consent form/agreement.
Your participation in this study is highly appreciated.
In case of any query, clarification or information, you can contact the researcher through mobile: +254 715 867 693 or email: mmnjeru16@gmail.com

Do you consent to the study? _____

After section 1, continue to next section.
BIODATA OF RESPONDENT

i) Please indicate your age(in years) _____

ii) Gender

Male	Female	Other

iii) Please indicate your years of experience (in years) ___

iv) Please indicate the county where you practice _

Kisumu	
Siaya	
Homabay	
Migori	
Nyamira	
Kisii	
Busia	
Bungoma	
Kakamega	
Vihiga	
Trans Nzoia	
Other ……	

v) Please indicate the level of your facility of practice

Level 4	Level 5	Level 6	Other…

vi) Please indicate your Institution of qualification

University of Nairobi	MMUST	KMTC	JKUAT	Other…..

vii) Please indicate your highest achieved qualification

Diploma	Higher diploma	Bachelors	Masters	PhD	Other……

viii) Please indicate your qualifications

Ophthalmologist	Comprehensive Ophthalmology/Cataract Surgeon	Ophthalmic Clinical Officer	Optometrist	Other……

ix) Please indicate the type/set-up of your work facility

Public hospital	Private hospital	Other……

After section 2, Go to section 3 (Equipment availability)

SECTION 3

Equipment availability

1a) Please indicate the equipment/consumables available in your place of practice (tick all that applies)

i)Distance VA Chart	Available	Not Available
ii)Slit lamp		
iii)Direct ophthalmoscope		
iv)Retinoscope		
v)Trial lens set/phoropter		
vi)Contact lens solution		
vii)Fluorescein strips		
viii)Contact lens fitting set		
ix)Tomographer		
x)Pachymeter		

Continuation ……1a)

1a) ….Please indicate the equipment/consumables available in your place of practice [keratometer] (tick as applies)

i)Keratometer ☐ available
[Go to section 4 (Equipment- Keratometer available)]

ii)Keratometer not ☐ available
[Go to Section 5 (Equipment availability- topographer)]

(After section 3, Continue to next section)

SECTION 4
Equipment – Keratometer available (is available)

(go to section 5)

SECTION 5

1a) Cont'….

1a) ……Please indicate the type of keratometer available in your place of practice (tick all that applies)

Manual keratometer	
Automatic keratometer	
Other ……	

(After section 5 continue to next section)

SECTION 6

Equipment Availability- Topographer

Continuation 1a)……

1a)…..Please indicate the equipment/consumables (topographer) available in your place of practice [tick as applies]

i)Topographer available	

(If available, then go to section 7 Equipment- Topographer available)

ii)Topographer not available	

(If not available, then go to section 8, -Working state/condition of the equipment/consumables available)

SECTION 7

Equipment-Topographer available

Cont'….. 1a)

1a) Please indicate the type of topographer available in your practice (tick all that applies)

i)Slit-scan topographer	
ii)Placido-based topographer	
iii)Scheimpflug topographer	
iv)Other topographer	

(Continue to next section)

SECTION 8

Working state/condition of the equipment/consumable available

1b) Please indicate the working state/condition of the equipment/consumables that are available in your place of practice (tick as applies)

	Far below standards	**Below standards**	**Meets standards**	**Above standards**	**Far above standards**
Distance VA Chart					
Slit lamp					
Direct ophthalmoscope					
Retinoscope					
Trial lens set/phoropter					
Tomographer					
Pachymeter					
Contact lens fitting set					
Fluorescein strips					
Contact lens solution					

Continuation ….1b)

1b)…..Please indicate the working state/condition of the equipment/consumables (keratometer) that you have in your place of practice (tick as applies) ***[If available]***

	Far below standards	**Below standards**	**Meets standards**	**Above standards**	**Far above standards**
i)Manual keratometer					
ii)Autokeratometer					
iii)Other keratometer					

Continuation……1b)

1b)…….Please indicate the working state/condition of the equipment/consumables (topographer) that you have in your place of practice (tick as applies) ***[If available]***

	Far below standards	**Below standards**	**Meets standards**	**Above standards**	**Far above standards**
i)Slit-scan topographer					
ii)Placido-based topographer					
iii)Sheimpflug topographer					
iv)Other topographer					

(After Section 8, continue to next section)

SECTION 9

Frequency of utilization

2a) How often do you do the following assessment in your place of practice? (tick as applies)

	Never	Rarely	Sometimes	Often	Always
i)Distance VA test					
ii)Slit lamp examination					
iii)Topography					
iv)Tomography					
v)Pachymetry					
vi)Keratometry					
vii)Direct ophthalmoscopy					
viii)Retinoscopy					
ix)Trial lens/phoropter test					
x)Fit hard contact lens					
xi)Fit hybrid contact lens					
xii)Corneal crosslinking					

Continuation…..2a)

2a) How often do you do the following assessment[keratometry] in your place of practice? (tick as applies)

	Never	Rarely	Sometimes	Often	Always
i)Manual keratometry					
ii)Automatic keratometry					
iii)Other keratometry					

Continuation …..2a)

2a)…How often do you do the following assessment in your place of practice? (tick as applies)

	Never	**Rarely**	**Sometimes**	**Often**	**Always**
i)Slit-Scan Topography					
ii)Placido-based topography					
iii)Scheimpflug topography					
iv)Other topography					

SECTION 10

3a) Please indicate your level of agreement of the following as risk factors for keratoconus (please tick as applies)

	Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
i)Genetics					
ii)Systemic disorders					
iii)Eye allergies					
iv)Eye rubbing					
v)Age					
vi)Asthma					
vii)Eczema					

3b) Please indicate your level of agreement on the following as signs of early keratoconus (tick as applies)

	Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
i)Scissor reflex					
ii)Charlouex's reflex					
iii)Vogt's striae					
iv)Increased corneal nerve visibility					
v)Reduction of spectacles BCVA					
vi)Mild localized corneal steepening					
vii)Mild changes in refractive error					
viii)Increased keratometric readings difference between inferior and superior cornea					
ix)Increased corneal aberration					
x)Fleisher's ring					
xi)Shadow vision in Snellen's optotype					
xii)Slightly distorted optotype even in good VA					
xiii)Difference in refraction in lighted or in dark room					
xiv)Keratometry values <45D					
xv)Keratometry values 46-52D					

3c) Please indicate how often you perform/recommend the following investigations, when attending to allergic conjunctivitis patients in your place of practice (tick as applies)

	Never	Rarely	Sometimes	Often	Always
i)Refraction					
ii)Slit lamp exam					
iii)Keratometry					
iv)Corneal topography					

3d) Please indicate on your level of agreement on the following as indicators of progressive keratoconus (tick as applies)

	Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
i) Increase in astigmatism > 1.00D					
ii)Significant changes in orientation of refractive axes					
iii)Increase of 1.00D or more in optical power of the steepest corneal meridian					
iv)Decrease of 25µm or more in corneal thickness					

3e) Please indicate your level of agreement on your knowledge on the use of the following equipment (tick as applies)

	Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
i)I have sufficient knowledge on slit lamp for diagnosing and managing keratoconus					
ii)I have sufficient knowledge in diagnosing and managing early keratoconus using corneal topographer					
iii)I have sufficient knowledge in diagnosing early keratoconus using pachymeter					
iv) I have sufficient knowledge in diagnosing early keratoconus using manual keratometer					
v) I have sufficient knowledge in diagnosing early keratoconus using retinoscope					
vi)I have sufficient knowledge in diagnosing and managing early					

keratoconus using direct ophthalmoscope					

4a) Please indicate your level of agreement of below listed as management strategy for early keratoconus (tick as applies)

	Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
i)Spectacles					
ii)Corneal-contact lens					
iii)Corneal-scleral contact lens					
iv)Piggy-back contact lens					
v)Soft contact lens					
vi)Hybrid contact lens					
vii)Referral to contact lens specialist					

4b) In your place of practice, which patients do you recommend for corneal crosslinking? (tick as applies)

	Recommend	Do not recommend
i)Those with progressive keratoconus		
ii)Those with non-progressive keratoconus		
iii)Not sure		

4c) Please indicate which of the following options that you use to upgrade your knowledge and skills on keratoconus (tick all that applies)

i)Journal	
ii)CME	
iii)Articles	
iv)Text books	
v)Optometry school/medical school	
vi)Other	

Appendix IV: Sample Information Document: Permission to carry out a Research Study

INFORMATION DOCUMENT

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF OPTOMETRY AND VISION SCIENCES
P.O. BOX 190-50100
KAKAMEGA, KENYA

DATE……

TO:
(THE INCHARGE EYE-UNIT,)
(HOSPITAL FACILITY)

Dear Sir/Madam,

RE: REQUEST FOR PERMISSION TO COLLECT DATA FOR A RESEARCH STUDY

I am a Master's student at Masinde Muliro University of Science and Technology, department of Optometry and Vision Sciences. I write to request for permission to collect data from your facility, involving the practitioners.

The study aims to evaluate the diagnosis and management of early keratoconus in hospitals in Nyanza and Western Kenya- Practitioner Perspectives. The study further seeks to promote on diagnosis and management of early keratoconus. The information obtained will guide towards enhancing early diagnosis of keratoconus. The study will involve a questionnaire, which will be filled-in by the practitioner if they agree to the study by signing a consent form. The study will not involve any confidential information, have any risks or cause any harm. The data to be collected will only be for research purposes and all the information will be treated confidentially.

Your assistance in this regard will be highly appreciated.

Thanking you in anticipation of your approval of this kind request.

Yours Faithfully,
Millicent M. Njeru
+254 715 867 693, mmnjeru16@gmail.com
Department of Optometry and Vision Sciences.

Appendix V: MMUST DPS Approval

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

Tel: 056-30870
Fax: 056-30153
E-mail: directordps@mmust.ac.ke
Website: www.mmust.ac.ke

P.O Box 190
Kakamega – 50100
Kenya

Directorate of Postgraduate Studies

Ref: MMU/COR: 509099

9th August, 2024

Millicent Muthoni Njeru
HOV/G/01-54114/2019
P.O. Box 190-50100,
KAKAMEGA.

Dear Ms. Muthoni

RE: APPROVAL OF PROPOSAL

I am pleased to inform you that the Directorate of Postgraduate Studies has considered and approved your Masters Proposal entitled: ***"Evaluation of Early Keratoconus Diagnosis and Management Patterns in Nyanza-Western Kenya Hospitals"*** and appointed the following as supervisors:

1. Prof. Hussein Golicha - MMUST
2. Dr. Sheilah Nangena - MMUST

You are required to submit through your supervisor(s) progress reports every three months to the Director of Postgraduate Studies. Such reports should be copied to the following: Chairman, School of Public Health Biomedical Sciences and Technology Graduate Studies Committee and Chairman, Department of Optometry and Vision Sciences and Graduate Studies Committee. Kindly adhere to research ethics consideration in conducting research.

It is the policy and regulations of the University that you observe a deadline of two years from the date of registration to complete your Master's thesis. Do not hesitate to consult this office in case of any problem encountered in the course of your work.

We wish you the best in your research and hope the study will make original contribution to knowledge.

Yours Sincerely,

Prof. Stephen O. Odehero, PhD, FIEP
DIRECTOR, DIRECTORATE OF POSTGRADUATE STUDIES

Appendix VI: MMUST Ethical Clearance Letter

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY

Tel: 056-31375
Fax: 056-30153
E-mail: ierc@mmust.ac.ke
Website: www.mmust.ac.ke

P. O. Box 190,
50100.
Kakamega,
KENYA

Institutional Scientific and Ethics Review Committee

To: Ms. Millicent Muthoni Njeru

Date: August 14th 2024

Dear Ms. Muthoni

RE: EVALUATION OF EARLY KERATOCONUS DIAGNOSIS AND MANAGEMENT PATTERNS IN NYANZA – WESTERN KENYA HOSPITALS.

This is to inform you that the ***Masinde Muliro University of Science and Technology Institutional Scientific and Ethics Review Committee (MMUST-ISERC)*** has reviewed and approved your above research proposal. Your application approval number is **MMUST/ ISERC/074/2024.** The approval covers for the period ***August 14th, 2024*** *to* ***August 14th,2025.***

This approval is subject to compliance with the following requirements;

i. Only approved documents including informed consents, study instruments, MTA will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***MMUST-ISERC.***
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 ***MMUST-ISERC*** 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 ***MMUST-ISERC*** within 72 hours
v. Clearance for export of biological specimens must be obtained from relevant institutions.
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 ***MMUST-ISERC***.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://research-portal.nacosti.go.ke and also obtain other clearances needed

Yours Sincerely,

Prof. Gordon Nguka (PhD)
Chairperson, Institutional Scientific and Ethics Review Committee

Copy to:
- The Secretary, National Bio-Ethics Committee
- Vice Chancellor
- DVC (PR&I)

APPENDIX VII: Nacosti License Approval

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 306348

Date of Issue: 30/August/2024

RESEARCH LICENSE

This is to Certify that Ms.. Millicent Muthoni Njeru of Masinde Muliro University of Science and Technology, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Bungoma, Busia, Homabay, Kakamega, Kisii, Kisumu, Migori, Nyamira, Siaya, Transnzoia,
Vihiga on the topic: EVALUATION OF EARLY KERATOCONUS DIAGNOSIS AND MANAGEMENT PATTERNS IN NYANZA-WESTERN KENYA HOSPITALS for the period ending : 30/August/2025.

License No: NACOSTI/P/24/39382

306348

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

See overleaf for conditions

APPENDIX VIII: Research Publication I

Clinical Optometry

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Assessing Access to and Utilization of the Advanced Diagnostic and Management Equipment for Early Keratoconus in Public and Private Healthcare Facilities Across Nyanza and Western Kenya

Millicent Muthoni Njeru[1], Sheilah Nangena Maina[1]*, Isabel Signes-Soler[1,2]*, Hussein Adams Golicha[3]*

[1]Department of Optometry and Vision Sciences, Masinde Muliro University of Science and Technology, Kakamega, Kenya; [2]Department of Optics and Optometry and Vision Sciences, Research Group in Preventive Optometry and Visual Treatments (OPTV), Universitat de València, Valencia, Spain; [3]Department of Physics, Masinde Muliro University of Science and Technology, Kakamega, Kenya

*These authors contributed equally to this work

Correspondence: Millicent Muthoni Njeru, Masinde Muliro University of Science and Technology, Department of Optometry and Vision Sciences, P.O. BOX 190 – 50100, Kakamega, Kenya, Tel +254715867693, Email mmnjeru16@gmail.com

Purpose: To evaluate the availability and utilization of the advanced equipment for the diagnosis and management of early keratoconus in the public and private healthcare facilities in Nyanza and Western Kenya.

Methods: A cross-sectional study design was applied. An online questionnaire was sent to the eyecare practitioners. Data on socio-demographics, equipment availability, and utilization for early keratoconus diagnosis and management were obtained and analyzed using SPSS V 29.

Results: A total of 134 eyecare practitioners (out of 143), with the majority 80 (59.7%) being males, responded to the questionnaire. The study found that advanced equipment were scarcely available, such as Tomographer 14 (10.4%), Topographer 17 (12.7%) and Pachymeter 21 (15.7%) as compared to basic equipment: distance VA chart 134 (100%), trial lens/phoropter 129 (96.3%), retinoscope 128 (95.5%) and slit-lamp 111 (82.8%), with level 6 having the highest availability. Additionally, the available advanced equipment had working conditions far below standards and below standards: topographer 6 (35.2%) and contact lens fitting set 12 (46.1%). The utilization rates of the advanced equipment were low as follows: contact lens fitting set 8 (31.0%), pachymeter 11 (52.4%) and topographer 9 (52.9%). A chi-square test found a significant association between equipment availability and their utilization, VA chart ($p=0.03333$), trial lens/phoropter ($p=0.00292$), slit-lamp ($p=0.00283$) and keratometer ($p=0.00001$).

Conclusion: The study revealed a lack of advanced diagnostic equipment, with some existing tools falling below standard and underutilized. It recommends that healthcare institutions prioritize the acquisition and maintenance of essential equipment. Additionally, the Ministry of Health should collaborate with stakeholders to incorporate early keratoconus detection into national eyecare guidelines.

Keywords: eyecare practitioners, advanced equipment, equipment utilization, early keratoconus diagnosis and management, Kenya

Introduction

Keratoconus (KC) is a progressive corneal disease that leads to irregular astigmatism, reduced visual acuity, and cornea thinning.[1,2] Keratoconus primarily affects young individuals in their second and third decades of life,[3] often leading to significant visual impairment if not diagnosed and managed early.[4] Timely diagnosis of KC requires competent eye care professionals and advanced diagnostic tools, as early signs of the disease may be missed with basic diagnostic tools.[5] Advanced diagnostic tools such as corneal topographers, tomographers and pachymeters are a higher sensitivity and specificity equipment that are able to detect and diagnose KC at the sub-clinical stages, even before the clinical signs

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APPENDIX IX: Research Publication II

The Open Ophthalmology Journal
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ISSN: 1874-3641
1

RESEARCH ARTICLE OPEN ACCESS

Knowledge of Early Keratoconus Diagnosis and Management in Nyanza and Western Kenya: Practitioners' Perspective

Millicent Muthoni Njeru[1,*], Isabel Signes Soler[2], Sheila Nangena Maina[1] and Hussein Adams Golicha[3]

[1]*Department of Optometry and Vision Sciences, Masinde Muliro University of Science and Technology, Kakamega, Kenya*
[2]*Department of Optics, Optometry and Vision Sciences, Research Group in Preventive and Visual Treatments- OPTV, University of Valencia, Valencia, Spain*
[3]*Department of Physics, Masinde Muliro University of Science and Technology, Kakamega, Kenya*

Abstract:

Introduction: Keratoconus is a bilateral, progressive corneal ectasia characterized by thinning and conical protrusion of the cornea. Its global prevalence is increasing, with higher rates reported in Africa, including Kenya. In Kenyan studies, most patients are diagnosed at advanced stages, where management is often costly, and complications are severe. Early detection enables more effective and affordable interventions with reduced risks. However, accurate early diagnosis requires advanced equipment and clinical expertise. In many low-resource settings, these factors are lacking, resulting in delayed diagnosis and poor outcomes. Strengthening early diagnostic capacity is essential to reduce the burden of advanced keratoconus and prevent avoidable visual impairment. The objective of this study was to assess the level of knowledge among eye care practitioners in the diagnosis and management of early-stage keratoconus in Nyanza and Western Kenya.

Methods: A cross-sectional study was conducted across hospitals in Nyanza and Western Kenya. A census sampling technique was employed to include all eligible eye care practitioners. Data were collected using a structured questionnaire and analysed using both descriptive and inferential statistical methods to evaluate knowledge levels and associated factors.

Results: A total of one hundred and thirty-four practitioners completed the questionnaire. Regarding early keratoconus diagnosis, 36.6% demonstrated good knowledge, 60.4% had fair knowledge, and 3.0% exhibited poor knowledge. For early keratoconus management, 36.6% had good knowledge, 61.2% had fair knowledge, and 2.2% reported poor knowledge. A statistically significant association was observed between practitioners' qualifications and knowledge in early keratoconus management (p=0.006).

Discussion: A substantial number of practitioners demonstrated limited knowledge of early keratoconus, possibly due to the low rates of keratoconus services, which may ultimately limit their experience.

Conclusion: Most practitioners demonstrated only fair knowledge in the diagnosis and management of early keratoconus. Practitioners' qualifications were significantly associated with knowledge in early keratoconus management.

Keywords: Early keratoconus, Diagnosis, Management, Knowledge, Eye care practitioners.