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Optometrist Attitudes towards Keratoconus Patients in the West Bank: A survey-based study.

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Declaration

I declare that, except where explicit reference is made to the contribution of others, this thesis is substantially my own work and has not been submitted for any other degree at the Arab American University or any other institution.

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Dedication

Praise be to Allah — an abundant, pure, and blessed praise — for granting me the strength, patience, and opportunity to complete this academic journey.

To my mother, whose endless love and sacrifice have been my greatest source of strength and inspiration. To my family, for their constant support throughout this journey. To my colleagues and friends, for their companionship and motivation. To my supervisors, for their guidance and belief in me. To the Department of Optometry at the Arab American University, for providing a nurturing environment for learning. And above all, to the martyrs and the injured of Palestine — especially those in Gaza — whose courage and resilience inspire us. This work is dedicated to you with deep gratitude and respect.

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Optometrist Attitudes towards Keratoconus Patients in the West Bank: A survey-based study.

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Abstract

Keratoconus is a progressive corneal ectatic disease which reduces the patient's vision and quality of life. Keratoconus (KC) requires multi-disciplinary approach to diagnose and manage. Optometrists' expertise in detecting and managing KC is crucial for improving patient's outcome. The research aimed to explore the optometrists' attitudes towards patients with keratoconus, in terms of diagnosis, management and referral approaches in the West-Bank. Furthermore, the current study sought to examine the influence of work settings, access to tools such as corneal topography, and years of experience on their practices.

A survey-based, descriptive study was conducted. A validated self-administrated online questionnaire has been used to collect data from Palestinian optometrists about their diagnosis and management methods of keratoconus patients. A total of 160 Palestinian optometrists completed the survey, with 46.9% having 1-5 years of experience in optometry. Approximately 75.6% of optometrists detected 1-10 patients with KC per month. Approximately 33.8% of optometrists considered multiple factors for keratoconus diagnosis. About 38.1% of the optometrists had access to corneal topography. About 70.6% of the participants prescribed glasses for KC at mild stages, and 47.8% prescribed or referred for RGP lenses for moderate cases with keratoconus. About 47.2% of the participants fit or referred for specialized contact lenses for severe cases. Only 25% of the participants reported monitoring progression of keratoconus at all stages. The referral criteria varied among the participants, with signs of progression (71.3%) being the most common reported factor. Chi-square test showed no statistically significance association between the years of experience and RGP lens fitting χ^2 (3, N = 160) = 2.309, p = 0.511, and corneal topography performing and RGP lens fitting χ^2 (1, N = 160) = 0.880, p = 0.348. The most common reported barriers for keratoconus diagnosis and management were the cost of RGP lenses (74.4%), lack of patient educational material (67.5%), and the absence of national guidelines (55%).

Findings showed variations regarding the diagnosis, management and referral approaches of keratoconus among Palestinian optometrists. This study highlights the need for standardized referral guidelines, enhanced interdisciplinary collaboration, and continuous education to improve the diagnosis and management of patients with keratoconus.

Key words: Keratoconus, Optometrist, Diagnosis, Management, Attitudes.

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List of Definitions of Abbreviations

Abbreviations	Title
BCVA	Best corrected visual acuity
CXL	Corneal cross linking
CL	Contact lens
KC	Keratoconus
QoL	Quality of life
RGP	Rigid gas permeable
VA	Visual acuity

1 Chapter One: Introduction

1.1 Background

Keratoconus (KC) is a bilateral asymmetric ocular condition described by degenerative corneal thinning and cone-shaped protrusion, which leads to irregular corneal astigmatism and visual deterioration (Gomes et al., 2015). Typically, corneal thinning occurs in the central or inferotemporal locations (Ferrari& Rama, 2020). Generally, KC affects people during puberty and early adulthood. KC appears among all ethnicities and genders (Gordon-Shaag et al., 2015).

According to a systematic review, the global prevalence of KC has been determined about 1.38 per 1000 population (Hashemi et al., 2020). Epidemiologically, studies demonstrated significant global variation in KC prevalence, with rates ranging from 0.002% to 4.79%, and it is more common in Asian and Middle Eastern populations (Santodomingo-Rubido et al., 2022). A high prevalence of KC has been reported in the Middle East with rates estimated about 4.79% among the Saudi Arabian population (Torres Netto et al., 2018). Furthermore, the prevalence of KC among Palestinian tertiary students is about 1.5% (Shehadeh et al., 2015). In contrast, the prevalence of KC is approximately 0.002% among the Russian population (Gorskova & Sevost'ianov, 1998). Global differences of KC prevalence have been attributed to variation in geographical regions, ethnic groups, KC definition, diagnostic criteria, study design, and the age of the targeted population (Hashemi et al., 2020).

Keratoconus significantly affects vision, which causes visual disturbances due to irregular astigmatism corneal thinning. As KC progresses, higher-order aberrations exacerbate blurring, visual distortions, glares, and difficulties with daily life activities (Santodomingo-Rubido et al., 2022). KC can significantly impact patient's vision and quality of life (QoL). In terms of mental health, near vision, and general vision, patients frequently report lower scores of QoL measures (Mannis et al., 2018). Literature have demonstrated that the severity and duration of the disease are associated with worse outcomes on a range of QoL measures. Previous studies showed that the more severe KC and steep keratometry readings are associated with greater negative impact on overall QoL, involving physical, emotional, and social issues (Al Zabadi et al., 2023; Kymes et al., 2004; Mahdaviazad et al., 2018; Saunier et al., 2017). Moreover, KC imposes a significant

economic burden on individuals and healthcare systems because of its chronic nature, the need for continuous management, and the risk of gradual visual loss necessitating complex and costly treatment (Chan et al., 2020).

Up to date, the cause of KC is not fully understood. However, KC is a multifactorial disease with genetic, environmental, and behavioural factors (Santodomingo-Rubido et al., 2022). Environmentally and behaviourally, the most common reported risk factors contributing to KC etiology are eye rubbing, contact lens wear, and UV exposure (Crawford et al., 2020). Genetically, approximately 6–23.5% of patients with KC report a positive family history (Naderan et al., 2016). Additionally, the occurrence of KC among relatives' patients has been greater than in the general population (Wang et al., 2000). A degree of homogeneity was found between monozygotic twins and dizygotic twins. Most familial KC follows an autosomal dominant inheritance pattern, while autosomal recessive inheritance has been proposed, particularly in remarkably consanguineous populations (Loukovitis et al., 2018). Moreover, KC may associate with other syndromes such as Down's syndrome and Leber congenital amaurosis (Cullent & Butler, 1963; Elder, 1994). Furthermore, literature has identified panels of candidate genes that influence KC development and progression. However, determining the exact genetic predisposition for KC continues to be a significant challenge (Loukovitis et al., 2018). The cooperation between the environment and genes is yet to be understood in the pathogenesis of KC. While more than 80 genes have been identified as potentially associated with KC, the evidence for their involvement in the disease is limited for most (Hao et al., 2022).

Clinically, KC is characterized as an ectatic disease that presents with abnormal posterior ectasia, atypical corneal thickness distribution, and clinical non-inflammatory corneal thinning (Gomes et al., 2015). The early stages of KC are often known as subclinical or form-fruste KC, which refers to topographic signs of KC with normal corneal slit-lamp results (Henriquez et al., 2020). Detecting the earliest stages of KC is challenging but critical for better management and prognosis. Early signs can resemble simple refractive errors, including myopia and irregular astigmatism, making detection doubtful without corneal imaging, even if corrected visual acuity is 20/20 (Almodin Belquiz et al., 2022). Early signs include localized corneal steepening, increased inferior-superior curvature differences, and

anterior corneal aberrations (Henriquez et al., 2020). Several clinical signs are associated with KC, such as scissor reflex, oil-droplet reflex, Fleischer's ring, Vogt's striae, corneal scaring, Munson's sign, and corneal hydrops, which become more common in advanced stages (Santodomingo-Rubido et al., 2022).

Early stages of KC could be asymptomatic. However, as the disease progresses, symptoms may include blurring, visual distortion, visual impairments, glare, and reduced best corrected visual acuity (BCVA) with glasses (Singh et al., 2024).

The development of KC signs and symptoms and their association to the disease severity are significantly variable. Consequently, it has been a challenge to classify the severity of KC. Several classification systems depend on corneal thinning, corneal curvature, and cone position. Typically, the severity of the KC is determined by utilizing visual tests such as visual acuity, and refraction. Moreover, other systems have been introduced based on the anatomical indicators such as Fleischer's ring, Vogt's striae, and corneal scars (Santodomingo-Rubido et al., 2022). The keratometric, Amsler-Krumeich, Hom's classifications, the Keratoconus Severity Score (KSS), the Belin ABCD grading system, and the index-based systems are different classification systems that have been widely used to grade the severity of KC (Amsler, 2010; Belin J. K., 2016; McMahon et al., 2006; Romero-Jiménez et al., 2013; Santodomingo-Rubido et al., 2022; Vega Estrada et al., 2017).

Previously, retinoscopy, keratometry, subjective refraction, and a slit-lamp biomicroscope were employed to detect advanced KC. Since most patients are not diagnosed at the earliest stage of the disease, most patients with KC may not exhibit any remarkable alterations in the corneal structure in the early stages of the disease (Salomão et al., 2018). Recently, advancements in corneal imaging techniques have facilitated the early diagnosis of KC, even at pre-clinical stages. Corneal imaging techniques, including corneal topography and corneal tomography, have been widely used in corneal ectatic diseases, CL fitting, refractive surgeries, and corneal cross-linking (CXL) (Fan et al., 2018). Moreover, advancements in genetic and molecular biology tests have been developed to assess an individual's risk of developing KC (Bui et al., 2023).

Management of KC aims to enhance patient's vision and delay disease progression. Typically, management choices for KC are based on the progression and the severity of the disease, which include surgical and non-surgical approaches (Das, 2022). Traditionally, glasses are prescribed at the mild stage of KC. However, irregular corneal astigmatism can't be corrected with spectacles. Therefore, glasses play a limited role in improving patient vision. (Almodin Belquiz et al., 2022).

Contact lenses (CLs) are an effective and relatively safe choice for visual rehabilitation in KC patients. Different types of CLs are recommended for KC management. Introducing the effective choice of CLs depends on the stage of KC, cone location, and patient's related factors such as intolerance and affordability. Recently, advancements in soft CLs have expanded the scope of refractive error correction for individuals with KC. Spherical soft CLs can be used in the early stages of KC, however, their ability to improve vision is limited (Şengör & Kurna, 2020). Soft CLs are available in high spherical and toric powers, which improve the ability to correct astigmatism in mild and moderate stages of KC, decentred cones, and for cases with hard lenses intolerance (Rico-Del-Viejo et al., 2017).The rigid gas permeable lens (RGP) is considered the gold-standard option of the non-surgical approach of KC management. RGP lenses have been used for refractive error correction that is induced by irregular corneal astigmatism. Moreover, the main advantages of RGP are improving vision, contrast sensitivity, and remarkably enhance visual acuity for individuals with KC (X. H. Zhang & Li, 2020).

In severe stages of KC, scleral CLs are an effective choice. Comparatively, scleral lenses are more comfortable and improve visual acuity other than choices of CLs for KC (Bergmanson et al., 2016; Lim & Lim, 2020). Different options of CLs are available, such as piggyback and hybrid CLs for KC management (Downie & Lindsay, 2015). A hybrid CL combines the optical features of RGP lenses and the comfort of soft CLs, it consists of an RGP lens with a peripheral soft CL skirt (Kloeck et al., 2021). Furthermore, the piggyback system consists of an RGP lens over a soft CL. The implement of soft CL can enhance comfort, stability, and centration of RGP lens (O'Donnell & Maldonado-Codina, 2004).

In another perspective, surgical interventions include CXL to stop the progression of the disease, and corneal transplantation is required in advanced

cases. However, there has been a recent trend toward KC being less common as a keratoplasty indication, most likely due to the availability of CXL (Deshmukh et al., 2023).

1.2 Significance of the study

A multi-disciplinary approach is required for KC management. Effective management of KC aims to early diagnosis, refractive error correction, regular follow ups, and monitoring KC progression. This multi-professional approach includes optometrists, CL practitioners and ophthalmologists, with their ultimate goal to optimize patients' vision and improve their QoL (Garcia-Ferrer et al., 2019).

Optometrists, as primary eye care professionals, play a crucial role in reducing blindness and visual impairments globally and regionally through early detection, management, and referrals. The World Council of Optometry (WCO) defines an optometrist as "an independent, educated, and regulated (licensed or registered) healthcare practitioner. Optometrists provide comprehensive eye and vision care, such as refraction, dispensing, disease identification, diagnosis, and management, as well as vision rehabilitation" (World Council of Optometry, n.d.). Optometrists play an essential role in the diagnosis and management of KC. Their proficiency in diagnosing and managing KC is pivotal for preventing visual impairment and enhancing patients' Qol (Song et al., 2022).

Particularly, optometrists have a pivotal role in KC diagnosis and management as primary eye care professionals and CL practitioners in Palestine. Their role in early KC diagnosis, non-surgical management approaches such as prescribing glasses and CLs specialized for patients with KC, monitoring disease progression, and patient education. Moreover, optometrists play a vital role in coordinating a multidisciplinary approach by referring patients with KC to ophthalmologists when required.

Understanding optometrists' behaviours towards patients with KC shed the lights for improving patients vision care, and arranging opportunities for co-management and future training.

1.3 Problem Statement:

Previous studies have explored optometrists' attitudes regarding KC diagnosis and management in different countries such as Australia, India, the United Kingdom, Spain, Portugal, Latin America, New Zealand, South Africa, and Kenya (Braga Vieira, 2023; Hodge et al., 2015; Nkoana et al., 2022a; Ortiz-Toquero & Martin, 2017; Rahmani et al., 2022; Rashid et al., 2024; Usgaonkar et al., 2023). However, there is a gap of research evidence regarding optometric attitudes towards KC in the Middle East, particularly, in Palestine (Song et al., 2022).

There is a consensus in the literature about the importance of early KC diagnosis (Santodomingo-Rubido et al., 2022). However, studies showed notable variations among optometrists in the global rates of KC diagnoses (Braga Vieira, 2023; Hodge et al., 2015; Ortiz-Toquero & Martin, 2017). The diagnostic standards for KC remain constant in spite of these variations. Early diagnosis using characteristics such as family history, visual acuity, scissor reflex in retinoscopy, corneal topography, and slit-lamp symptoms is pivotal, according to both optometrists and ophthalmologists (Song et al., 2022). The diagnosis, management, and referral approaches of KC vary among optometrists and ophthalmologists internationally. The variability in KC diagnosis among different geographical regions contributes to varied management and referral approaches (Braga Vieira, 2023; Hodge et al., 2015; Rahmani et al., 2022; Usgaonkar et al., 2023).

Patterns of diagnosis and management of KC differ internationally, with variations rising from personal preferences of optometrists and multiple challenges for specific management approaches (Song et al., 2022). The differences were mostly in the rates of prescribing RGP lenses and the timing of referral, leading to varied indications for surgical intervention (Hodge et al., 2015; Rahmani et al., 2022; Rashid et al., 2023). Literature highlighted the need for standardized referral guidelines, enhanced interdisciplinary collaboration, and continuous education to improve the diagnosis and management of KC patients (Song et al., 2022).

Understanding the diagnostic, management, and referral patterns of optometrists can provide valuable insights for improving patient care and

organizing chances for co-management and future training. Several studies explored optometrists' attitudes regarding KC diagnosis and management in different countries; however, there is a lack of data in the Middle East, particularly in Palestine (Song et al., 2022).

In order to fill the gap in the literature, this study represents the first investigation of optometric practices related to KC diagnosis, management, and referral approaches in Palestine.

1.4 Study objectives

This study aims to survey a representative sample of optometrists in Palestine in order to understand their practices and attitudes toward KC diagnosis, management, and referral approaches, as well as to describe how infrastructure, such as corneal topographers, and years of experience influence these attitudes.

1.5 Study Questions

Meeting the objectives of this study would answer the following the research questions:

- What are the optometrist attitudes towards patients with KC in the West Bank in terms of diagnosis, management, and referral?
- How different factors such as the availability of corneal topography, and years of experience could affect these attitudes?
- What are the main barriers that optometrists face regarding diagnosis, management, and referral KC patients?

1.6 Study Scope

1.6.1 Spatial and Temporal scope:

A validated self-administrated online questionnaire has been distributed through different social media platforms such as Facebook and WhatsApp (Meta Platforms, Inc., Menlo Park, CA, USA). The current study was conducted between August 2024 to March 2025.

1.6.2 Population and sample:

The study population included optometrists in the West Bank. A total of 160 optometrists from different provinces in the West Bank have participated in the current study.

1.6.3 **Study Variables: Table (1) shows the key variables of this study.**

Table 1.1 Study variables

	Dependent variables	**Independent variables**
1	Awareness of keratoconus diagnosis and management	Gender
2	Important investigation for keratoconus diagnosis	Qualification
3	Management of keratoconus patients	Highest qualifications
4	Lower limit of binocular best corrected visual acuity requires management or referral.	Years of experience
5	Lower limit of binocular best corrected visual acuity for referral to an ophthalmologist.	Work setting
6	Management approach of contact lenses.	Accessible tools for keratoconus diagnosis
7	Stage of referring to ophthalmologist.	Number of patients per month
8	Recommend for corneal cross-linking.	Independent variable
9	Co-management with ophthalmologists after surgical treatment	Number of patients with keratoconus per month
10	Access to professional collaboration and education	
11	Methods to update knowledge and skills in eye care	
12	Confidence in using tools/performing assessments (Retinoscopy, Subjective Refraction, Keratometry, etc.)	
13	Interest for further training in specific areas (Keratoconus diagnosis & management, Retinoscopy, etc.)	
14	Factors hindering knowledge and skills acquisition in eye care	
15	Factors hinder opt from diagnosing keratoconus early and managing patients effectively	

2 Chapter Two: Literature review

2.1 Introduction

Keratoconus (KC) is an asymmetric bilateral ectatic corneal disease that leads to gradual visual deterioration and reduces the patient's QoL (Gomes et al., 2015). KC requires a multi-disciplinary approach between optometrists and ophthalmologists to diagnose and manage, with optometrists considered as primary eye care clinicians. Their expertise in detecting and managing KC is crucial for preventing vision loss and improving patients' QoL (Song et al., 2022)**.** Understanding the diagnostic, management, and referral patterns of optometrists can provide valuable insights for improving patient care and organizing chances for co-management and future training. Several studies explored optometrists' attitudes regarding KC diagnosis and management in different countries, however, there is a lack of data in the Middle East, particularly, in Palestine (Song et al., 2022). This review aims to investigate the approaches and attitudes of optometrists towards patients with KC in terms of diagnosis, management, and referral approaches, Moreover, this literature review seeks to explore the barriers that hinder optometrists from effective KC diagnosis and management.

2.2 Literature review strategy

The literature review was carried out electronically with a comprehensive search of published articles about the optometrist attitudes, behaviours, and knowledge towards KC patients. This review included full original articles in English-language publications from 2014 to 2024, that reported data on the diagnosis and management approaches of KC by optometrists. The demographic group was not limited by age, gender, or ethnicity. Articles that did not meet the objectives of the review and existed in the grey literature were excluded. This review excluded studies that investigated the patient's attitudes towards KC.

The identification process involved searching for articles and including their citations, screening the title and abstract for relevancy, and including full texts of eligible articles. Data extracted included the title, authors, date, location, sample size, study design, diagnosis and management approaches of KC by optometrists. The databases searched were Google Scholar, PubMed, MEDLINE, and Scopus, and relevant articles were identified using MESH keywords such as "Keratoconus'', "corneal ectasia'', "keratoectasia", ''attitudes'', "diagnosis'', ''management'', "treatment", ''practices'', ''opinion'', ''protocol'', ''behaviours'', "barriers'', "challenges".

Eight studies that aligned with the aims of this review were included. All of the studies have used questionnaire formats to collect data about optometrists' various practices or knowledge of KC. Table (2) summarizes the included studies. Studies from Australia, the United Kingdom, Spain, India, and New Zealand investigated the diagnosis, management, and referral approaches of patients with KC by optometrists (Angelo et al., 2024; Hodge et al., 2015; Ortiz-Toquero & Martin, 2017; Usgaonkar et al., 2023) . Moreover, studies from Portugal and 15 countries from Latin America compared their results with UK and Spain study (Braga Vieira, 2023; Rahmani et al., 2022). While there were similarities between countries, variations emerged in diagnosis and RGP lens prescriptions. A study from South Africa reported the knowledge and skill of optometrists in the public sector regarding KC diagnosis and management (Nkoana et al., 2022b) While a Kenyan study highlighted the barriers that optometrists face in KC diagnosis and management (Rashid et al., 2024).

Table 2.1 Summary of studies investigating optometrists' practices in diagnosing, managing, and referring patients with keratoconus

Study\ Country	**Study design**	**Sample size**	**Diagnosis of KC**	**Management approaches of KC**	**Referral pattern to ophthalmologists**
Australia (Hodge et al., 2015)	Cross-sectional, survey- based	n=71	46.4% of participants had a corneal topography.	35.4%, 9.2% prescribed SCL and RGP lenses every-day, respectively.	34.4% of optometrists refer with progression of corneal biomicroscope and topographic signs.
The UK & Spain (Ortiz-Toquero & Martin, 2017)	Cross-sectional, survey- based	n=464	38.1% and 60% from the UK and Spain had corneal topography, respectively.	55% from the UK, 28% from Spain prescribed RGP per month.	50% from each country refer upon initial diagnosis. The majority didn't participate in co-management with ophthalmologists after surgical procedure.
Portugal (Rahmani et al., 2022)	Cross-sectional, survey- based.	n= 119.	75.1% of participants considered multiple factors to diagnose KC.	Fitting RGP in more complicated in keratoconic eyes.	31.6% refer with signs of progression. 10% refer with reduction of VA.
South Africa (Nkoana et al., 2022b)	Cross-sectional, survey- based	n=24.	None of the hospitals had corneal topography or pachymetry.	46% of optometrist required training in RGPCL fitting.	Not reported
India (Usgaonkar et al., 2023)	Cross-sectional, survey- based	n= 159.	45.3% of participants had corneal topography.	55% of participants prescribed RGPCL	50.9% refer with progression of corneal signs. 54% co-managed with ophthalmologists after surgical treatment.

Latin America (Braga Vieira, 2023)	Cross-sectional, survey- based	n= 977.	23% of participants had corneal topography.	66% of participants prescribed RGP	36.9% refer with progression of corneal signs.
Kenya (Rashid et al., 2024)	Cross-sectional, survey- based	n= 151.	80% lack of retinoscope, slit lamp and keratometry.	25.2% of participants were confident in performing RGP fitting.	Not reported
New Zeeland (Angelo et al., 2024)	Cross-sectional, survey- based	n=168	34.5% of participants had a corneal topography.	22% and, 6.4% of participants prescribed SCL and RGP daily, respectively	41% of participants refer on progression of corneal parameters.
Abbreviations: KC: keratoconus, n= sample size SCL: soft contact lens, RGP: rigid gas permeable, VA: visual acuity.					

2.3 Diagnosis Pattern

There is a consensus in the literature about the importance of early KC diagnosis. However, the variability in diagnosis KC contributes to varied management and referral approaches. Literature showed that there are notable variations in the global rates of KC diagnoses. Rahmani *et al.* showed that about 70.6%,78.6%, and 76.3% of optometrists in the UK, Spain, and Portugal, respectively, diagnosed less than five cases of KC per year (Rahmani et al., 2022). While Braga Vieira *et al* reported just 44.4% of optometrists from 15 countries in Latin America reported this poor diagnostic rate (Braga Vieira, 2023). The low diagnostic rate of KC in these countries can be attributed to the lower prevalence of the disease in these regions. For instance, the prevalence of KC in the UK is about 0.057% among white population (A.R. PEARSON, 2000). Which likely contributes to the reduced number of cases diagnosed by optometrists annually.

The diagnostic standards for KC remain constant in spite of these variations. Early diagnosis using characteristics such family history, visual acuity, scissor reflex in retinoscopy, corneal topography, and slit-lamp symptoms is important, according to both optometrists and ophthalmologists (Song et al., 2022). While many optometrists prioritize these factors, access to essential diagnostic tools is limited. In spite of the importance of corneal topography in KC diagnosis, studies showed the lack of this technique in different optometric practices. Only about 23% of optometrists from 15 countries in Latin America had corneal topography (Braga Vieira, 2023). Moreover, 38.1%, 46.4%, and 60% from the UK, Australia, and Spain had corneal topography, respectively (Hodge et al., 2015; Ortiz-Toquero & Martin, 2017). In regions like South Africa and Kenya, studies reported the lack of basic tools for KC diagnosis, such as retinoscopes, slit lamps, and keratometers (Nkoana et al., 2022b; Rashid et al., 2024).

2.4 Non-surgical management pattern

There is consensus in the literature that the main goals of management for KC are to stop disease progression and provide visual rehabilitation (Deshmukh et al., 2023). A stepwise approach to optical correction is suggested, starting with glasses, then soft contact lenses, RGP lenses, and progressing to specialized keratoconus contact lenses such as hybrid, piggy-back, scleral, and miniscleral lenses (Lim & Lim, 2020). While contact lenses provide visual rehabilitation, they do not halt disease progression (Rico-Del-Viejo et al., 2017). Usgaonkar *et al* reported that practitioners consider fitting RGP lenses challenging in keratoconic eyes, highlighting the complexity of managing this condition in India (Usgaonkar et al., 2023). Furthermore, Ortiz-Toquero & Martin compared optometric practices and attitudes in managing patients with KC in the UK and Spain through an online survey distributed to optometrists in both countries. Results showed similarities in practices and attitudes but differences in the use of corneal topography and RGP prescriptions, with higher prescriptions in the UK (Ortiz-Toquero & Martin, 2017). Additionally, about half of the optometrists prescribe RGP lenses for KC management in Latin American and Indian studies (Braga Vieira, 2023; Usgaonkar et al., 2023). In contrast, Hodge *et al.* reported that most optometrists in Australia frequently prescribe soft contact lenses, while fewer prescribe RGP lenses (Hodge et al., 2015). Furthermore, Angelo *et al.* reported a low prescribing rate of RGP for KC in New Zealand (Angelo et al., 2024).

Management of KC usually requires surgical and non-surgical approaches, subsequently, interdisciplinary collaboration between optometrists and ophthalmologists is significant to improve patients' QoL (Deshmukh et al., 2023). However, optometrists from the UK and Spain reported low ophthalmologists' com-management (Ortiz-Toquero & Martin, 2017). Moreover, about half of the optometrists in India co-managed KC patients with ophthalmologists (Usgaonkar et al., 2023).

2.5 Referral criteria

Previous studies emphasized the importance of early diagnosis of KC, the literature revealed significant variation in the referral practices for KC to ophthalmologists (Song et al., 2022). This is likely due to the lack of national consensus about KC management, which leads to variable referral approaches. There were no specific criteria for referral to ophthalmologists, while the most common reported factors for referral were signs of corneal progression, decreased best corrected visual acuity, upon initial diagnosis of KC, and patient request.

Hodge *et al*, showed that about 34.5% of the optometrists in Australia refer patients with KC to ophthalmologists in the presence of signs of corneal progression (Hodge et al., 2015). Comparatively, Rahmani *et al*, revealed that about 31% of the participants in Portugal refer KC patients to ophthalmologists in the existence of corneal progression signs (Rahmani et al., 2022). However, Usgaonka *et al*, reported that the about half of the optometrists consider signs of corneal progression as a major factor for referral to ophthalmologists (Usgaonkar et al., 2023).

Ortiz-Toquero *et al* showed that about half of the optometrists in both the UK and Spain refer patients with KC upon initial diagnosis (Ortiz-Toquero & Martin, 2017). In contrast, initial diagnosis of KC, reduced visual acuity, and patient requests are not frequent factor for referral to ophthalmologists in optometric practices in Australia, India, and Portugal (Hodge et al., 2015; Rahmani et al., 2022; Usgaonkar et al., 2023). In Australia, optometrists refer patients with KC based on the visual acuity, the majority of optometrists refer patients with KC to ophthalmologists for surgical procedures when the visual acuity of the patient is between 6/9 and 6/12, suggesting a collaborative management approach between optometrists and ophthalmologists (Hodge et al., 2015). However, a minority of optometrists would refer based on the visual acuity in Latin America, Spain, and the UK (Braga Vieira, 2023; Rahmani et al., 2022).

2.6 Associations:

Literature suggested the availability of corneal topography is associated with early diagnosis of KC and RGP lens fitting, such as in Australian, British, Spanish, and Indian studies (Hodge et al., 2015; Ortiz-Toquero & Martin, 2017; Usgaonkar et al., 2023). However, the years of experience of practitioners showed various effects on KC management and diagnosis. In Australia, Hodge *et al* reported that optometrists with more years of experience were more likely to prescribe RGP lenses (Hodge et al., 2015). In contrast, Usgaonkar *et al* reported that practitioners with fewer years of experience in optometry were more likely to prescribe RGP lenses than those with more years of experience (Usgaonkar et al., 2023). Moreover, the years of experience in optometry for participants were not clinically relevant to KC diagnosis and management in the UK and Spain (Ortiz-Toquero & Martin, 2017).

2.7 Challenges and Barriers:

Globally, optometrists face challenges and barriers that hinder them from effective KC diagnosis and management. Braga Viera *et al.* showed that optometrists from 15 countries in

Latin America reported the lack of access to corneal topography, which has been considered challengeable for early diagnosis of KC and RGP lens fitting (Braga Vieira, 2023). Furthermore, studies conducted in Portugal, the UK, and Spain revealed that the primary barriers for diagnosis and management of KC are low market demand, practice cost, and time restrictions (Rahmani et al., 2022).

Additionally, Nkoana *et al.* revealed that most public sector optometrists in South Africa lacked the necessary training and expertise to diagnose and manage individuals with KC. The main barriers to CLs fitting were a lack of corneal imaging techniques and inadequate training and experience (Nkoana et al., 2022b). Moreover, Rashid *et al.* found that the cost of corneal topographers, limited experience with RGP fitting, lack of professional development opportunities, high conference expenses, lack of diagnostic tools, lack of national guidelines, and patient-related factors like affordability and compliance are the main barriers to effective KC diagnosis and management among optometrists in Kenya (Rashid et al., 2024).

Enhancing KC diagnosis and management internationally requires establishing common recommendations, improving optometric education, establishing standardized guidelines, and identifying affordable diagnostic tool options. Addressing these issues and improving patient care require improved co-management techniques and chances for professional growth (Song et al., 2022).

2.8 Literature Gap:

Several studies explored optometrists' attitudes regarding KC diagnosis and management in different countries, however, there is a lack of data in the Middle East, particularly, in Palestine (Song et al., 2022).Understanding the diagnostic, management, and referral patterns of optometrists can provide valuable insights for improving patient care and organizing chances for co-management and future training.

This study aims to fill the gap in the literature, which provides data regarding optometric practices towards KC in the West Bank. The findings offer valuable insights into KC patient management optometric practices and attitudes in the West Bank. This study is the first to explore the optometrists' attitudes towards patients with KC in Palestine.

2.9 The conceptual framework of the study

This study surveyed a representative sample of optometrists in Palestine through an online validated questionnaire. The current study has explored the attitudes, practices, and challenges faced by Palestinian optometrists in KC diagnosis and management. Moreover, the

current study investigated the influence of work settings, access to tools such as corneal topography, and years of experience on their practices. In order to fill the gap in the regional literature by providing data specific to the West Bank. The findings offered valuable insights into KC patient management optometric practices and attitudes in the West Bank. This study represents the first investigation of optometric practices related to KC in Palestine.

2.10 Conclusion:

Global variations in KC diagnosis, management, and referral patterns could be attributed to optometrist's personal preferences and multiple barriers with particular management strategies. The differences were mostly in the rates of prescribing RGP lenses and the timing of referral, leading to varied indications for surgical intervention. In order to improve the diagnosis and management of individuals with KC, these results emphasize the necessity of standard referral criteria, improved interdisciplinary collaboration, and continuous education.

3 Chapter Three: Materials and Methods

A quantitative survey-based, descriptive study design was carried out involving a total of 160 optometrists from different provinces in the West Bank. Prior to the study, the questionnaire underwent a validation process with a pilot sample of 20 participants to ensure clarity, reliability, and relevance of the questions. Feedback from this pilot phase was used to make necessary revisions before distributing the final version of the survey to the larger group. The validated self-administered online questionnaire aimed to explore attitudes of Palestinian optometrists towards KC diagnosis and management. This study included 160 licensed Palestinian optometrists who were actively practicing at the time of the research. Participants who did not complete all questions of the survey, and optometrists who did not work in Palestine were excluded from final the data analysis. The study was conducted between August 2024 to March 2025.

3.1 Sample size calculation:

According to the Palestinian Optometrists Syndicate and the Palestinian Ministry of Health, the number of Palestinian optometrists was 500, distributed across 13 hospitals and 145 optometric practices in 11 cities in the West Bank. These cities include Hebron, Bethlehem, Ramallah, Nablus, Jericho, Tubas, Tulkarem, Jenin, Qalqilya, Salfit, and East Jerusalem, with the majority practicing in urban areas and working in the private sector.

A sample size calculation with a confidence interval of 95% and a margin of error of 5% was performed using an online sample size calculator (Sample Size Calculator by Raosoft, Inc.). The sample size was set at 218. The total number of responses was 160, yielding a response rate of 32% out of the total number of Palestinian optometrists.

3.2 Questionnaire design:

An anonymous, self-administered online survey was developed and tailored to Palestinian optometrists to explore their practices and attitudes toward the diagnosis and management of KC patients. The survey included a series of questions designed to capture the participants' perspectives on KC management. These questions were developed based on a comprehensive review of the existing published literature (Angelo et al., 2024; Braga Vieira, 2023; Hodge et al., 2015; Nkoana et al., 2022b; Ortiz-Toquero & Martin, 2017; Rahmani et al., 2022; Rashid et al., 2024; Usgaonkar et al., 2023). The final version of the survey was created

using Google Docs Forms (https://docs.google.com/forms/d/e/1FAIpQLSexfSx57RWcuE6-fvl4vc6xxhMCbUFaF8OC54h-wUozjrFRjw/viewform), as shown in appendix (1). It was developed in English, as all optometrists in the West Bank received their education in this language.

A series of closed-ended questions about participant demographics, professional background, clinical practices, knowledge of guidelines, patient management, barriers, and needs for extra training. The questionnaire contained 29 closed-ended questions and one open-ended question. The open-ended question asked about the barriers that may hinder optometrists from effective diagnosis and management of patients with KC. The estimated time to fill out the survey was about 5-10 minutes. The questionnaire begins with questions about gender, age, city of work, qualifications, years of experience, work setting, and the number of patients and patients with KC seen on a monthly basis, which provide context on the respondents' backgrounds.

The questionnaire included questions about the availability of diagnostic tools such as distance visual acuity charts, retinoscopes, trial lenses, lens-meters, autorefractometers, slit lamp biomicroscopes, keratometers, corneal topography, pachymetry, corneal tomography, fluorescein, contact lens fitting trial sets, and contact lens care solutions. Moreover, the questionnaire included questions about the frequency of using specific assessments like retinoscopy, subjective refraction, slit lamp examination, keratometry, corneal topography, and corneal tomography. Furthermore, the questionnaire included questions regarding awareness of national guidelines and key factors influencing KC diagnosis, such as family history, visual acuity, retinoscopy, keratometry, slit lamp findings, and corneal topography or tomography. These questions aimed to assess the knowledge base guiding optometrists' clinical decisions.

The questionnaire also included questions about management approaches for KC, focusing on the frequency of fitting various contact lenses and managing complications such as allergic conjunctivitis. The patient management section focused on how optometrists manage KC at different stages, including referral criteria to ophthalmologists and the use of specialized lenses such as RGP, scleral, and hybrid lenses. Questions addressed the minimum binocular visual acuity for referrals, whether optometrists personally fit lenses or refer patients to others, co-management with ophthalmologists, and criteria for referring patients for CXL.

The survey asked participants about their agreement on several barriers to the effective diagnosis and management of KC, such as the lack of diagnostic equipment, insufficient patient educational materials, lack of knowledge and skills, highcost of spectacles and contact lenses, and limited access to national guidelines in KC management. Moreover, participants rated their confidence in using specific diagnostic tools such as subjective refraction, retinoscopy, corneal topography, and RGP lenses fitting on a Likert scale and expressed interest in further training, particularly in KC management and corneal cross-linking. The survey also asked about factors that limit access to professional development, including time constraints, the cost of resources, and the availability of mentors, which hinder optometrists' ability to update their knowledge and skills.

3.3 Validity and reliability of the questionnaire:

Based on the previous studies, the questionnaire has been piloted by the primary author, and reviewed by the secondary authors (Angelo et al., 2024; Braga Vieira, 2023; Hodge et al., 2015; Nkoana et al., 2022b; Ortiz-Toquero & Martin, 2017; Rahmani et al., 2022; Rashid et al., 2024; Song et al., 2022; Usgaonkar et al., 2023). To ensure the validity and reliability of the questionnaire used in this study, a systematic, multi-step approach was implemented. This process included evaluation of the questionnaire by four experts specializing in optometry and KC, including academics and practitioners. By evaluating the questionnaire validity, these professionals verified the questions were relevant, comprehensive, and matched with the aims of the study. Their suggestions were thoughtfully incorporated into the questionnaire, ensuring clarity and appropriateness in investigating optometrist’s attitudes in term of KC diagnosis, management, and referral.

Subsequently, a pilot study was conducted to assess the reliability of the questionnaire. The pilot study included 20 optometrists, who have been re-surveyed after 10 days of the first administration. The pilot study consisted of a small group of optometrists who were not included in the final sample of the study. The collected data from the pilot study were analysed to determine Cronbach’s alpha, a statistical measure of internal consistency.

High level of reliability among the questionnaire items was signified by the calculated **Cronbach’s alpha coefficient of 0.85.** This result confirms the questionnaire’s validity and reliability as a tool for evaluating optometrist’s attitudes regarding patients with KC in the West-Bank.

3.4 Data collection

Data were collected using a self-administered online survey distributed through WhatsApp and Messenger (Meta Platforms, Inc., Menlo Park, CA, USA). The survey link was shared with members of the Palestinian Optometrists Syndicate group on Facebook who were randomly selected. Potential participants were contacted individually via private messages to request their permission to participate in the study, and those who agreed were sent the survey link. A reminder message was sent to participants to encourage survey completion. Optometrists who completed the survey sent a confirmation message upon submission.

3.5 Data Analysis

The statistical analysis of the collected data has been conducted using the SPSS software. Descriptive analysis has been used to illustrate the study sample's characteristics. Cross-tabulations have been used to describe the frequencies and confidence intervals of associations between variables. Subsequently, the Chi-square with a significance level of $p < 0.05$ has been considered as statistically significant associations.

3.6 Ethical consideration:

This study adhered to the principles outlined in the Declaration of Helsinki. Ethical approval to conduct this study has been obtained from the Institutional Review Board (IRB) committee at the Arab American University of Palestine (AAUP) (no “R-2024/A/130/N”). All participants have been provided with an online consent form. The researchers responsibly managed all information for scientific research purposes, ensuring proper data handling post-research.

4 Chapter Four: Results

4.1 Demographic Characteristics:

A total of 160 Palestinian optometrists responded to the survey, with 74.4% of respondents were female. The mean age of participants was 29.5 years old (SD ± 6.56), ranging from 22 to 60. The geographical distribution of the sample varied, with the majority in the three main cities in the West Bank, Hebron (29.4%), Ramallah (26.9%), and Nablus (20%). Moreover, the years of experience varied across the sample, about 46.9% had 1-5 years of experience, as shown in table (3). Educationally, about 83% of participants held bachelor's degrees in optometry, 7.5% had diplomas, and 8.75% of the participants had master's degrees. About 76.25% of the optometrists worked in the optical shops, while others were employed in public/private hospitals, clinics, or universities.

Table 4.1 Demographic profile of the study population (N=160)

Category	Details	Percentage (Number of participants)
Gender	Female	74.375% (119)
	Male	25.625% / (41)
Years of experience	Less than one year	4.375% (7)
	1-5 years	46.875% (75)
	6-10 years	28.125% (45)
	11-15 years	14.375% (23)
	16-20 years	1.875% (3)
	More than 21 years	4.375% (7)
Qualification	Diploma	7.5% (12)
	Bachelor's degree	83.125% (133)
	Master degree	8.75% (14)
	PhD	0.625% (1)
City	Hebron	29.375 % (47)
	Bethlehem	4.375% (7)

	Ramallah	26.875% (43)
	Nablus	20% (32)
	Jenin	8.125% (13)
	Tulkarem	5% (8)
	Jericho	0.625% (1)
	Qalqilya	5.625% (9)
Work setting	Optical shops	76.25% (122)
	Public Hospital/Clinic	3.75% (6)
	Private Hospital/Clinic	13.75% (22)
	University/ College	3.125% (5)

4.2 Diagnosis Pattern:

On a monthly basis, about 75.6% of optometrists detected 1-10 patients with KC, while 11.3% diagnosed 11-20 patients with KC, and 4.4% diagnosed more than 21 patients with KC. About 38.12% of the optometrists had access to corneal topography, while 34.4% used corneal topography to diagnose KC. Table (4) shows the accessibility and performance of clinical procedures among respondents. About 33.8% of optometrists consider multiple diagnostic factors for KC, such as family history, visual acuity, scissor reflex in a retinoscope, keratometry, slit lamp signs, and corneal topography. While the most common reported factors of KC diagnosis were history and visual acuity (93.8%), followed by corneal topography or tomography (86.3%), keratometry (83.8%), slit lamp signs (63.7%), and retinoscopy (45.6%).

Table 4.2: Accessibility and Performance of clinical procedures

Clinical procedures	**Access to tools**	**Performing assessments regularly**
Retinoscopy	72.50%	50%
Subjective refraction	99%	99%
Keratometry	63.70%	65%
Slit lamp exam	71.90%	52%
RGP fitting set	48.10%	36.80%

Corneal topography	38.10%	34.40%
Corneal tomography	15%	15%

4.3 Management approach:

The findings showed that 70.6% of the respondents prescribe spectacles for KC at mild stages. While 20% of the participants prescribe glasses for mild and moderate cases. Moreover, about 47.8% of the optometrists fit or refer for RGP lenses for moderate cases with KC. About 29.8% fit or refer RGP for moderate and severe cases of KC. However, about 8.7% of the participants fit RGP with severe cases of KC. In another prospective, about 47.2% of the participants fit or refer for specialized CL (hybrid, scleral) for severe cases of KC, and 24.2% of the participants fit or refer for specialized CLs for moderate and severe cases. The stage of monitoring the progression of the diseases varied among this sample, while 29.8% answered that they monitor the progression of KC for mild cases, 24.2% of the participants monitor the progression of KC at moderate stages, and 25.5% of the respondents monitor at all stages, as figure (2) shows.

In terms of co-management with ophthalmologists after keratoplasty for contact lens fitting, about 40% of optometrists answered they do not co-manage, while 27.3% stated co-managing occasionally, and about 31.7% of the participants reported that they co-manage KC patients with ophthalmologists. Moreover, about half of the participants (52.5%) refer to another optometrist for CL fitting, while 45% of the participants fit CL for KC patients by themselves. Moreover, about 60% of the participants stated that the lower limit of binocular BCVA to fit or refer for KC specialized CLs is between 6/9 and 6/12.

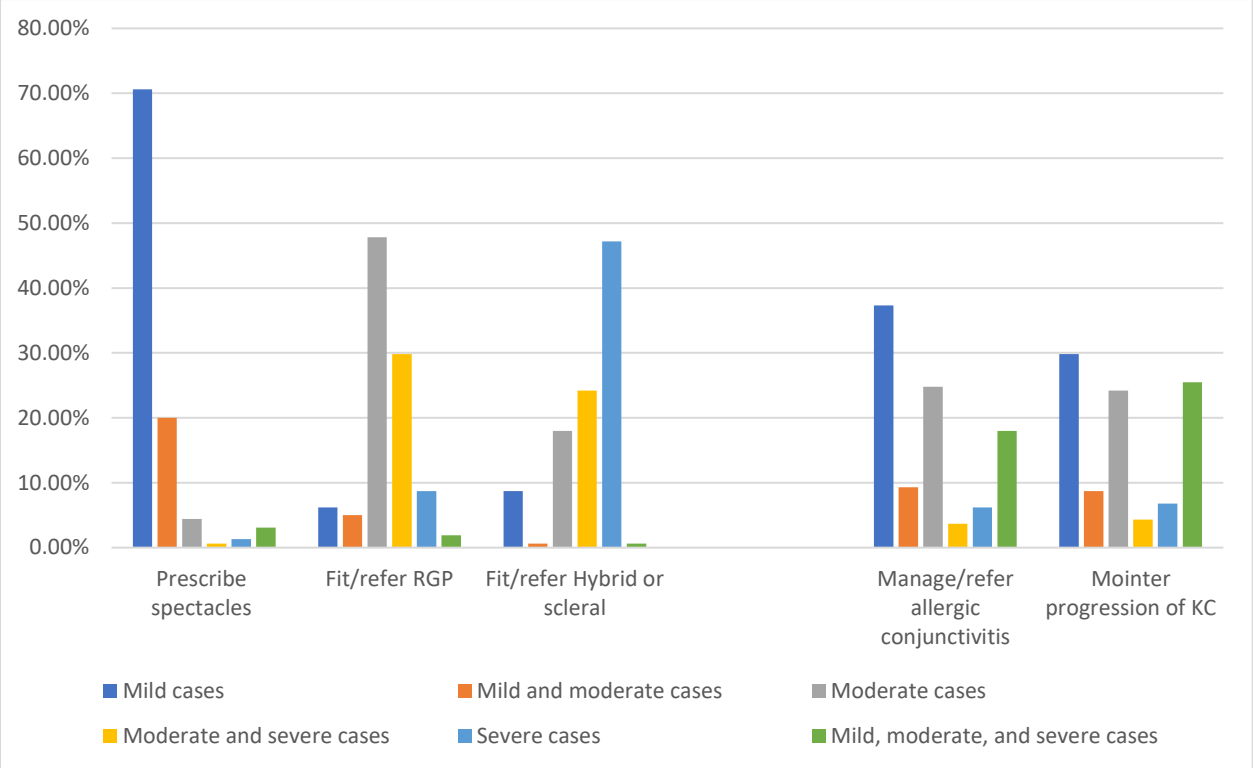

Figure 4.1 Management approaches of KC at different stages

4.4 Referral approach:

Regarding the stages of KC patients' referral to ophthalmologists, about 30% of the optometrists stated that they refer patients to ophthalmologists at all stages, while 35% of the respondents refer severe cases, and about 11.3% and 15.6% refer mild and moderate cases, respectively. The referral criteria varied among the participants, with the most common factors were signs of progression (71.3%), reduction of BCVA (60.6%), signs and symptoms of moderate to severe allergic conjunctivitis (50%), and upon initial diagnosis (50.6%), as shown in figure (2). Moreover, about 70.6% of the optometrists recommended CXL for patients with KC when the disease is likely to progress according to the patient's age and signs of progression, while 22.5% of the participants recommended CXL for all KC patients, irrespective of their age or progression signs.

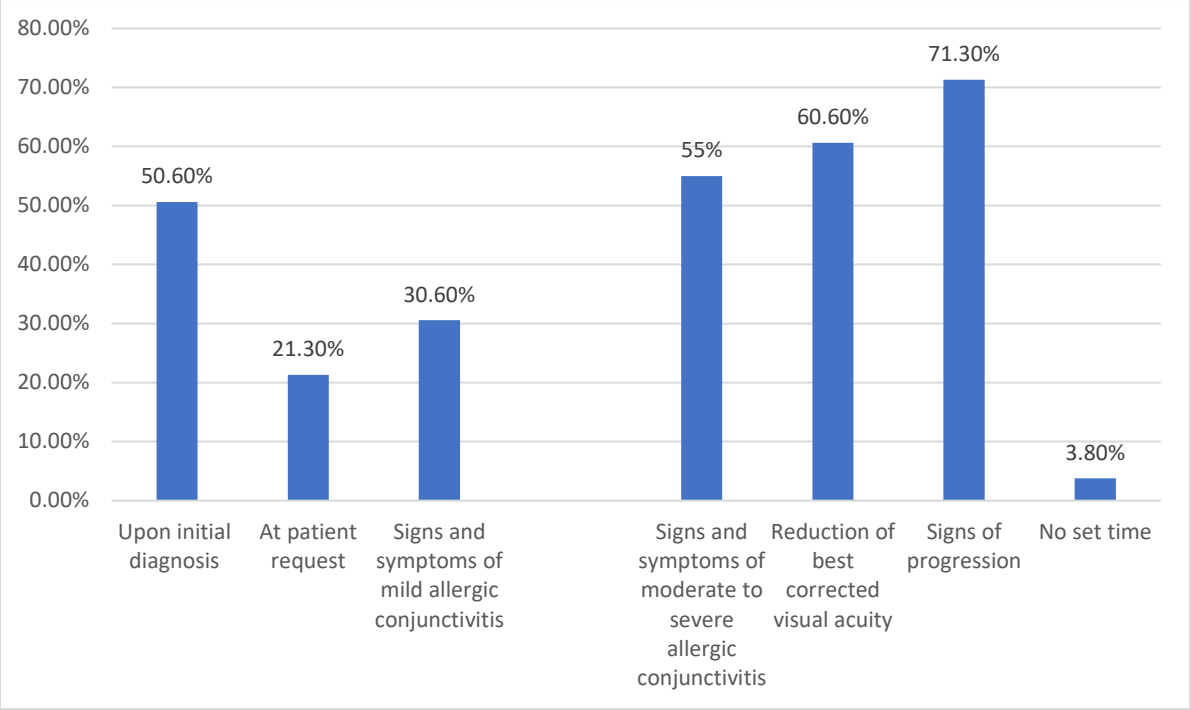

Figure 4.2 Referral criteria for KC patients

4.5 Bivariate analysis:

The result of the association between work setting and fitting RGP lenses indicated a statistically significant association, $\chi 2(1, N=155) = 7.43$\chi^2 (1, N = 155) = 7.43$\chi 2(1, N=155) = 7.43$, $p = 0.006$. Fisher's exact test also supported this association with a 2-sided $p = 0.008$, further confirming the significance. About 41.7% of the optometrists who work in the optical shops reported that they fit RGP lenses, while 85.7% of the optometrists who work in hospitals reported that they don't fit RGP lenses. The findings suggest that optometrists in optical shops are more likely to fit RGP lenses compared to those working in hospitals.

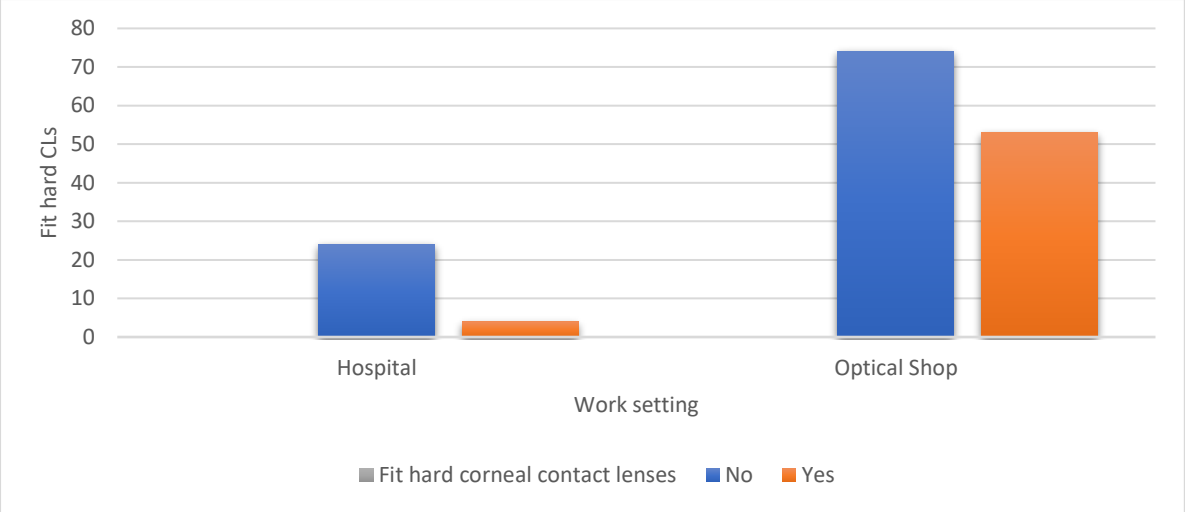

Figure 4.3: The association between hard contact lens fitting and work setting

Additionally, the Chi-square test results showed a statistically significant association between work setting and corneal topography performance, χ^2 (1, N = 155) = 10.682, p = 0.001. The Continuity Correction also indicated significance, χ^2 (1) = 9.292, p = 0.002, as did the Likelihood Ratio Chi-square (χ^2 = 10.162, p = 0.001) and Fisher's Exact Test (p = 0.002). Additionally, the linear-by-linear association test showed a significant linear relationship, χ^2 (1) = 10.613, p = 0.001. About 60.7% of hospital-based optometrists performed corneal topography, compared to only 28.3% of optometrists in optical shops. These findings indicate that optometrists working in hospitals are significantly more likely to perform corneal topography compared to those in optical shops.

The results of the Chi-square test between corneal topography performing and fitting of special CLs for CK (hybrid and scleral) showed a statistically significant association, χ^2 (1, N = 160) = 4.347, p = 0.037. The Likelihood Ratio Chi-square (χ^2 = 4.210, p = 0.040) and Fisher's Exact Test (p = 0.048) further supported this finding. Additionally, the linear-by-linear association test showed a significant linear relationship between the variables, χ^2 (1) = 4.320, p = 0.038. These results revealed that optometrists who use corneal topography are significantly more likely to fit special contact lenses for KC patients.

Moreover, the results showed that there is no statistically significant correlation between corneal topography performing and RGP lenses fitting using the Chi-square test χ^2 (1, N = 160) = 0.880, p = 0.348. As well as, the findings showed that there is no statistically significant correlation between the years of experience and RGP lens fitting using the Chi-square test χ^2 (3, N = 160) = 2.309, p = 0.511. This suggests that years of experience do not significantly influence the likelihood of optometrists fitting hard contact lenses in this sample.

Table 4.3: Variable associations and the results of their statistical tests

Variable Association	Statistical Test(s)	Results
Work setting and RGP lens fitting	Chi-square	χ^2 (1, N = 155) = 7.43, p = 0.006;
	Fisher's Exact Test	(2-sided) p = 0.008
Work setting and corneal topography performance	Chi-square	χ^2 (1, N = 155) = 10.682, p = 0.001;
	Fisher's Exact Test	p = 0.002
	Continuity Correction	χ^2 = 9.292, p = 0.002
	Likelihood Ratio	χ^2 = 10.162, p = 0.001
	Linear-by-Linear Association	χ^2 = 10.613, p = 0.001
Corneal topography and special CL fitting	Chi-square	χ^2 (1, N = 160) = 4.347, p = 0.037;
	Likelihood Ratio,	χ^2 = 4.210, p = 0.040z
	Fisher's Exact Test,	p = 0.048
	Linear-by-Linear Association	χ^2 = 4.320, p = 0.038
Corneal topography and RGP lens fitting	Chi-square	χ^2 (1, N = 160) = 0.880, p = 0.348
Years of experience and RGP lens fitting	Chi-square	χ^2 (3, N = 160) = 2.309, p = 0.511

4.6 Knowledge and skills:

The majority of optometrists (92%) were aware of the national guidelines of KC diagnosis and management, while 74.4% of the optometrists were aware of the national guidelines of allergic conjunctivitis diagnosis and management. About 82.5% of the respondents reported that they share knowledge and experience with their colleagues, while 60% of the participants had access to continuous medical education in their eye care specialty. Moreover, participants reported that the main sources for updating their knowledge regarding eye care were online sources and journal publications (75.6%), followed by attending conferences (44.4%), registering for courses (30%), and attending continuous medical education sessions (25.6%).

The participants felt most confident in subjective refraction (mean = 4.03, SD=1.07)), followed by keratometry (mean = 3.98, SD =1.03) and corneal topography (mean = 3.79, SD = 1.23). Furthermore, tasks such as retinoscopy (mean = 3.15, SD = 1.30) and RGP lens fitting (mean = 3.15, SD=1.27) have a moderate confidence rating. In contrast, managing allergic conjunctivitis had the lowest confidence scores, with the average yielding 2.67 (SD= 1.08). Techniques with high interest for further training included KC diagnosis and management (mean = 3.88, SD= 1.12), RGP fitting (mean = 3.81, SD= 1.18), and corneal topography (mean = 3.68, SD= 1.25). While subjective refraction (mean = 3.56, SD=1.37), managing allergic

conjunctivitis (mean = 3.47, SD= 1.17), and CXL (mean = 3.41, SD= 1.39) indicate above-average interest but slightly lower than the top areas. With a mean of 3.26 (SD= 1.35), retinoscopy showed the lowest interest in further training.

4.7 Key barriers:

The most common barriers reported for KC diagnosis and management were the cost of RGP lenses (74.4%), lack of patient educational material (67.5%), and the absence of national guidelines (55%). Moreover, about half of the participants agreed that the lack and cost of diagnostic tools, lack of facilities that provide KC services in the same region, lack of hard CL supply, and poor communication with secondary eye facilities hinder the optometrists from diagnosing and managing patients with KC, as figure (5) shows.

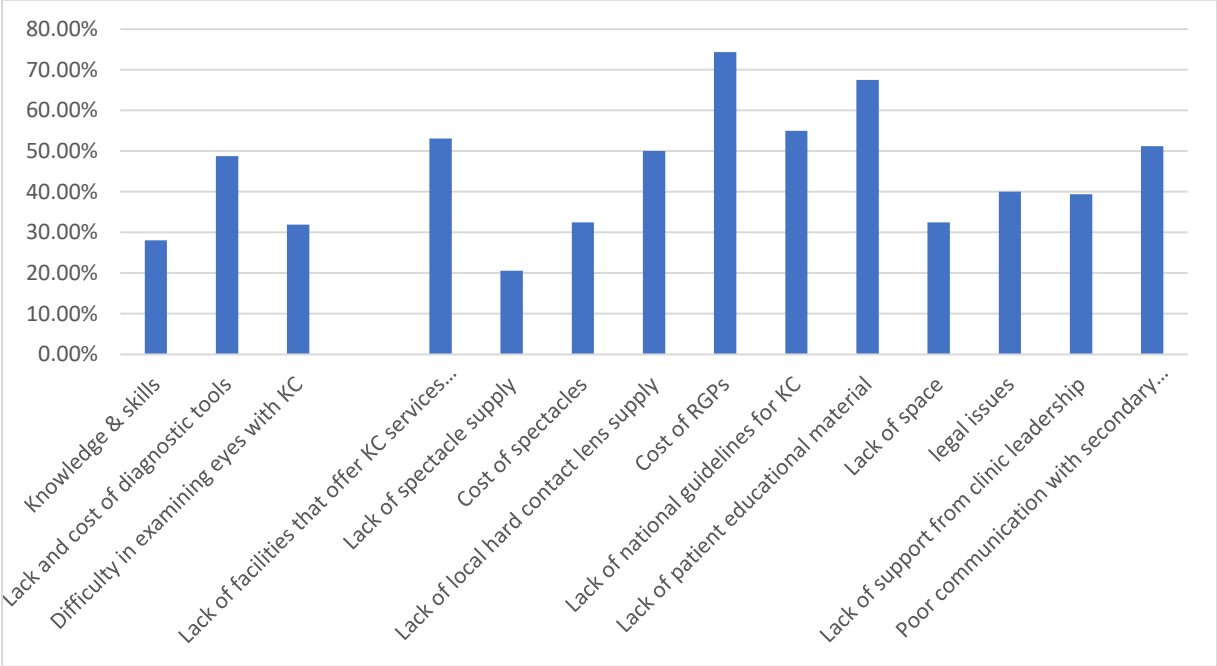

Figure 4.4 Barriers for KC diagnosis and management

5 Chapter Five: Discussion

Keratoconus is a bilateral asymmetric corneal ectatic disease described by degenerative corneal thinning and cone-shaped protrusion, which lead to irregular astigmatism and visual impairment (Gomes et al., 2015). Delayed diagnosis of KC negatively impacts the patient's QoL, in terms of mental health, near vision, and general vision, patients with KC frequently report lower scores of QoL measures (Mannis et al., 2018). Therefore, the key to preventing visual loss and stopping disease progression is the early diagnosis of KC (Bui et al., 2023).

Typically, KC affects individual during puberty and early adulthood, and it appears among all ethnicities and genders (Barbara Editor, 2018). According to a systematic review, the prevalence of KC is about 0.381% in the general population (Hashemi et al., 2020). Epidemiological studies showed significant global variation in KC prevalence, with rates ranging from 0.002% to 4.79%, and it is more common in Asia and Middle East regions (Santodomingo-Rubido et al., 2022). The high prevalence of KC has been rated at about 4.79% among the Saudi Arabian population (Torres Netto et al., 2018). Furthermore, the prevalence of KC among Palestinian tertiary students is approximately 1.5% (Shehadeh et al., 2015). In contrast, the prevalence of KC was approximately 0.002% among Russian population (Gorskova & Sevost'ianov, 1998). Variations between studies have been attributed to differences in geographical regions, ethnicity, the definition of KC, diagnostic criteria, study design, and the age of the targeted population (Barbara Editor, 2018).

Moreover, KC imposes a significant economic burden on individuals and healthcare systems because of its chronic nature, the need for continuous management, and the risk of progressive visual loss necessitating complex and costly treatment (Chan et al., 2020). Furthermore, economic disparities significantly affect diagnostic and management approaches. The cost of eye care services and diagnostic tools is relatively high in comparison to average income in low-resource countries (Yego & Moodley, 2020). For example, Palestinian territories are considered a low-income region (Giacaman et al., 2009).

Optometrists, as primary eye care professionals, play a crucial role in reducing blindness and visual impairments globally and regionally through early detection, management, and referrals. The World Council of Optometry (WCO) defines an optometrist as "an independent, educated, and regulated (licensed or registered) healthcare practitioner" (World Council of Optometry, n.d.). Optometrists play an essential role in the diagnosis and management of KC.

Their proficiency in diagnosing and managing KC is pivotal for preventing visual impairment and enhancing patients' Qol (Song et al., 2022). Understanding optometrists' behaviours towards patients with KC shed the lights for improving patients vision care, and arranging opportunities for co-management and future training.

A multi-disciplinary approach is required for KC management. Effective management of KC aims to early diagnosis, refractive error correction, regular follow ups, and monitoring KC progression. This multi-professional eye health care involves optometrists, CL practitioners and ophthalmologists, all working to optimize patient's vision and improve their QoL (Garcia-Ferrer et al., 2019). Particularly, optometrists have a pivotal rule in KC diagnosis and management as primary eye care professionals and CL practitioners in Palestine.

The detection of KC at early stage is challenging but pivotal for effective management plan and prognosis. Earlier, retinoscopy, keratometry, subjective refraction, and a slit-lamp biomicroscope have been used to detect KC (Salomão et al., 2018). KC is diagnosed by keratometry readings and the occurrence of slit-lamp biomicroscopic signs such as corneal thinning, Munson's sign, Fleischer's ring, Vogt striae, corneal hydrops and localized inferior paracentral protrusion. Moreover, scissor reflex could be visualised via retinoscopy. Advancements in corneal topography and the gold standard technique corneal tomography has facilitated the ability to diagnose patients with KC even at sub-clinical stage (X. Zhang et al., 2021).Therefore, early and accurate diagnosis of KC by optometrists is essential for introducing timely management and enhancing visual outcomes.

Previous studies have explored optometrists' attitudes regarding KC diagnosis and management in different countries such as Australia, India, the United Kingdom, Spain, Portugal, Latin America, New Zealand, South Africa, and Kenya (Braga Vieira, 2023; Hodge et al., 2015; Nkoana et al., 2022a; Ortiz-Toquero & Martin, 2017; Rahmani et al., 2022; Rashid et al., 2024; Usgaonkar et al., 2023). However, there is a gap of research evidence regarding optometric attitude towards KC in the Middle East, particularly, in Palestine.

This study surveyed a representative sample of optometrists in Palestine through an online validated questionnaire. The aims of this study were to explore the attitudes, practices, and challenges faced by Palestinian optometrists in KC diagnosis and management. Moreover, the current study sought to examine the influence of work settings, access to tools such as corneal topography, and years of experience on their practices. In order to fill the gap in the regional literature by providing data specific to the West Bank. The findings offered valuable

insights into KC patient management optometric practices and attitudes in the West Bank. This study represents the first investigation of optometric practices related to KC in Palestine.

The response rate of this study was 35%, which is generally considered acceptable for research studies. Conversely, previous researches in similar field have demonstrated relatively lower response rates. Comparatively, the estimated response rates in similar context were 1.5% in Latin America, less than 1% in the UK, 15% in Australia, 2% in Spain, and approximately 3% in Portugal (Braga Vieira, 2023; Hodge et al., 2015; Ortiz-Toquero & Martin, 2017; Rahmani et al., 2022).

Globally, optometrists are mainly employed in the private section, with limited integral into the public healthcare system. In some regions, public sector jobs for optometrists are entirely not exist, restricting access to affordable eye care for many communities, such as in Central Asia (Naidoo et al., 2023). Likewise, the present study found most optometrists worked in the private sector, such as optical shops, private hospitals, and clinics. This similar to the trend seen in developing countries such as Kenya and South Africa (Muma et al., 2024; Prasidh et al., 2016). These results emphasize the need for policies and initiatives that would improve optometrist's integration into the public sector to ensure equitable access to eye care services.

5.1 Diagnosis Pattern

Literature has showed that there are notable differences in the global rates of KC diagnoses. Optometrists in the West Bank reported relatively higher diagnostic rate of KC. This study revealed that about 75% of optometrists diagnose from one to ten KC cases monthly. Conversely, most optometrists in the UK, Spain, and Portugal stated that they diagnose less than five patients with KC annually (Rahmani et al., 2022). Moreover, about 44.4% of Latin American optometrists reported poor KC diagnostic rate (Braga Vieira, 2023).

The relatively higher KC diagnostic rate among Palestinian optometrists likely reflects the higher prevalence of the KC in the Middle East. For example, the KC prevalence among Palestinian population is about 1.5%, which may contribute to higher detection rate of KC among optometrists (Shehadeh et al., 2015). In contrast, the prevalence of KC in the UK is about 0.057% among white population (A.R. PEARSON, 2000). The relatively high diagnostic rate of KC warrants the need for accessible diagnostic tools and trained eye health care professionals to achieve efficient management strategy for individuals with KC in Palestine.

Moreover, the findings of this study align with the global trend that KC involves multiple diagnostic standards, including family history, visual acuity, scissor reflex in a retinoscope, keratometry, slit lamp biomicroscope signs, and corneal topography (Song et al., 2022). A comprehensive ocular examination is required to detect KC. Detailed patient history is critical to detect any KC risk factors. KC has been considered as a multifactorial condition with genetic, environmental, and behavioural. Genetically, the occurrence of KC among relatives 'patients is significantly higher than in the general population. Moreover, eye rubbing, UV exposure, and CL wear has been demonstrated as the most common behavioural and environmental factors to develop KC (Mousa et al., 2017).

In the absence of corneal imaging techniques, basic diagnostic tools such as retinoscopes, slit lamps, and keratometers can still play a significant role in early KC detection. Scissor reflex is a typical sign in KC patients which can be observed using retinoscopy. Additionally, keratometers show irregular mires and steep corneal power in keratoconic corneas. Key signs of KC such as Munson's sign, Fleischer's ring, Vogt striae, corneal hydrops and localized inferior paracentral protrusion could be observed using the slit lamp biomicroscope (Almodin Belquiz et al., 2022).

The majority of optometrists in the West Bank reported access to basic tools like retinoscopes, slit lamps, and keratometers as shown in the current study. Conversely, Nkoana *et al* and Rashid *et al* reported a lack of basic diagnostic tools for KC such as retinoscopes, slit lamps, and keratometers in South Africa and Kenya (Nkoana et al., 2022b; Rashid et al., 2024). Moreover, prior studies have showed significant variations for accessible diagnostic tools and management options for KC between low-income and high-income countries. The basic clinical tools for KC diagnose KC are still slit lamps, retinoscopes and keratometers in low-income countries (Yego & Moodley, 2020).

The principle of corneal topography is based on the Placido disk-base that reflect off the tear film, which observe the morphology of the anterior cornea. Furthermore, the principle of the corneal tomography is based on the scheimpflug image, which assess the anterior and posterior cornea, and corneal thickness (X. Zhang et al., 2021).

Corneal topography has a crucial role in early diagnosis and determine appropriate management option for patients with KC (Fan et al., 2018). However, only about 38.1% of optometrists in Palestine had access to it. This trend aligns with previous studies, about 38.1%, 46.4%, 60% of optometrists from the UK, Australia, and Spain had access to corneal

topography, respectively (Hodge et al., 2015; Ortiz-Toquero & Martin, 2017). Moreover, only about 23% of optometrists from 15 countries in Latin America reported access to corneal topography (Braga Vieira, 2023). Therefore, the accessibility of corneal imaging techniques potentially contributed to the higher diagnostic rate of KC in Palestine compared to Latin America and Europe.

In Palestine, improved access to diagnostic tools such as corneal topography and corneal tomography could enhance KC diagnosis rates, timely management options. These improvements would include subsidized diagnostic equipment, implanting training programmes for the optometrists to early diagnosis and effective management of KC, and establishing shared diagnostic centres. These recommendations could improve patent's vision and enhance their QoL, decrease the burden on the Palestinian optometrists, and achieve a high quality of eye care services in Palestine.

5.2 Management Approach

There is consensus in the literature that the main goals of management for KC are to stop disease progression and provide visual rehabilitation (Deshmukh et al., 2023). A stepwise approach to optical correction is suggested, starting with glasses, then soft contact lenses, RGP lenses, and progressing to specialized CLs for KC such as hybrid, piggy-back, scleral, and miniscleral lenses (Lim & Lim, 2020). The results of this study are consistent with global standards. Most respondents reported prescribing glasses at mild stages. However, only 20% extended their use of glasses to moderate cases, indicating a transition to more specialized management, such as CLs, as the disease progresses.

Furthermore, about half of the participants reported fitting RGP lenses to address moderate KC, while one third of optometrists extended their practice to severe cases. Interestingly, a minority of respondents reported fitting RGP lenses exclusively for severe cases, possibly reflecting resource limitations or personal preference for less complex management strategies. These observations are consistent with studies from Latin America and India, in which more than half of practitioners prescribed RGP lenses for KC treatment (Braga Vieira, 2023; Usgaonkar et al., 2023). In contrast, the findings highlight disparities from optometric practices in Australia and New Zealand, where soft CLs are more commonly prescribed for patients with KC (Angelo et al., 2024; Hodge et al., 2015). Variations of the management strategies of KC could be due to differences in optometric education programmes, patient's preferences, and accessibility to specialized CLs for KC.

About half of the Palestinian optometrists considered specialized CL for severe cases of KC, with 24.2% expanded their usage to moderate and severe cases of KC. Literature have highlighted the importance of hybrid and scleral CLs for management of severe KC. These findings may indicate optometrist's awareness of the advanced visual rehabilitation options in KC management such as hybrid and scleral lenses. Nevertheless, the low percentage of optometrists who fit specialized CLs for KC suggest a lack of accessibility to these lenses or lack of optometrist's training in their fitting.

Specialized CLs for KC such as hybrid or scleral lenses required training and advanced diagnostic tools such as corneal topography. Gaps in training and diagnostic tools aggravate the difficulty of specialized CLs fitting (Deshmukh et al., 2023). The lack of corneal imaging topography, limited training of specialized CLs fitting procedures, and the lack of continues educational courses hinder optometrists in Palestine to achieve optimum eye care for patients with KC. It is necessary to improve training programs, initiate continues educational courses, and facilitate the access of advanced diagnostic technologies. These recommendations aim eventually to enhance eye care services in the West Bank, which could optimize patient's outcome.

Interestingly, optometrists reported differences in monitoring the disease progression in the West Bank. Nearly one third of participants reported that they monitor the disease at the mild stage, whereas 24.2% and 25.5% monitored KC progression at the moderate and all stages, respectively. Palestinian optometrists reported inconsistent approach for monitoring KC progression, which may indicate variations in optometrists or institutional protocols, availability of advanced diagnostic tools such corneal imaging techniques. Moreover, these results encourage the need for polices and initiatives to establish standard national guidelines for KC management, improve the availability of advanced diagnostic tools, and provide training programmes for optometrists in the West Bank. These recommendations would ensure consistent and efficient KC management approach at all stages.

The findings of this study indicate significant variability in the co-management practices of KC patients with ophthalmologists among optometrists in the West Bank. Similarly, optometrists in the UK and Spain also reported limited co-management with ophthalmologists, highlighting that this challenge (Ortiz-Toquero & Martin, 2017). In contrast, these findings reflect a lower rate of collaboration compared to India, where half of optometrists reported co-managing KC patients with ophthalmologists (Usgaonkar et al., 2023).

The low rate of co-management with ophthalmologists may results from barriers such as lack of formal referral process, inadequate interdisciplinary collaboration, or geographical differences in the availability of ophthalmologists, and financial constraints. Establishing a formal and clear referral criterion and providing joint training would overcome these barriers. An interdisciplinary approach is recognized as critical for improving patient outcomes in KC management, especially after surgical interventions such as CXL and corneal transplantation (Song et al., 2022). Enhanced co-management practices can facilitate timely interventions, optimize post-surgical outcomes, and improve QoL for patients with KC.

In Palestine, the private optometry practices mainly provide RGP lens fitting for patients with KC. However, this study shows that about half of the optometrists referred patients with KC to other optometrists for RGP fitting. These findings may indicate the complexity of fitting specialized CLs for KC and potential gaps in training. Similarly, Usgaonkar et al. highlighted the challenges faced by Indian practitioners in fitting RGP lenses for KC, including limited access to training and resources (Usgaonkar et al., 2023). Referrals for RGP fitting are critical for KC management to ensure optimum visual outcome. RGP lenses are considered the gold standard visual correction for patients with KC. RGP lenses have long been used to correct refractive errors induced by an irregular corneal surface, improve the patient's vision, contrast sensitivity, significantly enhance visual quality, and comfort (Rico-Del-Viejo et al., 2017).

However, this study found that 60% of participants identified a BCVA threshold of 6/9 to 6/12 as the lower limit to fit or refer for KC-specific CLs. Globally, low rates of referral between optometrists for contact-lens fitting have been observed, possibly due to gaps in collaboration, training, or access to resources (Song et al., 2022).

5.3 Referral criteria

The management of KC typically involves both surgical and non-surgical approaches. Consequently, interdisciplinary collaboration between optometrists and ophthalmologists is essential to improve patient's outcome (Deshmukh et al., 2023). While ophthalmologists are in charge to manage patient with KC in surgical methods such as CXL and corneal transplantation. Optometrists manage patients with KC through glasses prescriptions, RGP and specialized CLs fitting for KC patients.

This study found variations in the referral criteria among Palestinian optometrists for KC patients. The results showed that about 30% of optometrists refer patients with KC to ophthalmologists at all stages. The absence of standard guidelines for management of KC

imposes a global challenge, which lead to inconsistent referral criteria in optometric practices (Song et al., 2022).

Authors agree about the importance of early diagnosis of KC. However, the literature revealed significant variation in the referral optometric practices for KC to ophthalmologists (Song et al., 2022). This is likely due to the lack of national consensus about KC management, and clinician's preference for CLs or surgical management approach, which leads to variable referral criteria. There is no specific criterion for referrals, factors such as signs of corneal progression, decreased visual acuity, upon initial diagnosis, and patient request all play a role.

The current study showed that respondents consider multiple factors for referral to ophthalmologists. This study revealed that the most commonly reported factor for referral to ophthalmologist is the presence of progression signs. Similarly, the most frequently reported factor for referral to ophthalmologists was progression signs of KC among Indian, Australian, and Portuguese, Kenyan optometric workforce. (Hodge et al., 2015; Rahmani et al., 2022; Rashid et al., 2024; Usgaonkar et al., 2023).

Furthermore, the majority of Palestinian optometrists stated that they refer patients with KC in case of reduced visual acuity. Similarly, Rashid *et al* reported that reduced vision is a common factor for referring patients with KC to ophthalmologists in Kenya. Moreover, Hodge *et al* revealed that optometrists in Australia refer patients with KC based on the visual acuity (Hodge et al., 2015). In contrast, decreased vision has not been commonly stated among British, Spanish, Latin American, and Indian optometrists (Braga Vieira, 2023; Rahmani et al., 2022; Usgaonkar et al., 2023).

This study shows about half of the optometrists refer patients with KC upon initial diagnosis. Similarly, Ortiz-Toquero *et al* revealed that half of the optometrists from the UK and Spain refer KC patients to ophthalmologists upon initial diagnosis. In contrast, referring patients with KC upon initial diagnosis is less common among optometry practices in Australia, India, and Portugal. These results may indicate a proactive management approach among Palestinian optometrists.

Additionally, about half of the optometrists refer KC patients with KC in the presence of moderate and severe allergic conjunctivitis. These results may indicate an awareness of KC risk factors such as vernal keratoconjunctivitis among Palestinian optometrists. Moreover, rules and regulations for optometrists in Palestine have restriction, as they are not allowed to

prescribe therapeutic eye drops. Therefore, management of allergic conjunctivitis is considered challenging by optometrists in the West-Bank.

The current study revealed that consensus on a timeline for referral to ophthalmologists has not been found among optometrists. The respondents would differ in referral approach from initial diagnosis to the presence of progression signs.

Moreover, the majority of Palestinian optometrists stated that they recommend CXL for KC patients based on age and progression signs. This behaviour aligns with Australian optometrists, as they recommend CXL based on KC progression threshold of VA (Hodge et al., 2015). Subsequently, these results highlight the global consensus about the importance of early management to limit the disease progression, particularly among younger patients. These results underscore the significance of promoting standard national guidelines for KC management, for the sake of consistent referral criteria and improve patient's vision and QoL.

5.4 Associations:

This study showed that participants who work in optical shops are more likely to prescribe RGP lenses for KC patients compared to hospital-based optometrists, likely because of variations in patient demographic, practice priorities, or access to diagnostic tools. However, studies have not widely investigated the influence of work setting on RGP lenses prescription (Song et al., 2022). Moreover, the results showed that optometrists who work in hospitals are more likely to use corneal topography compared to those work in optical shops. Typically, hospitals have access to advanced diagnostic techniques, which may explain the availability of corneal topography in hospitals compared to optical shops.

Furthermore, the results of this study showed that optometrists who fit specialized CL for patients with KC are more likely to use corneal topography. Literature have showed the importance of corneal topography in determining the suitable management approach for patients with KC, including the prescription of specialized CLs such as hybrid or scleral lenses (Fan et al., 2018).

Interestingly, no statistically significant association was determined between corneal topography use and prescribing RGP lenses. In contrast, Literature suggested the availability of corneal topography is associated with early diagnose of KC and prescribe RGP lenses, such as in Australian, British, Spanish, and Indian studies (Hodge et al., 2015; Ortiz-Toquero & Martin, 2017; Usgaonkar et al., 2023).

Additionally, the results showed no clinically relevant between years of experience for participants and KC diagnosis and management. However, the years of experience of practitioners showed various effects on KC management and diagnosis in previous studies. Similarly, Ortiz-Toquero et al reported no statistically significant association between years of experience and RGP lens prescription in British and Spanish optometric practices (Ortiz-Toquero & Martin, 2017). In Australia, Hodge *et al* reports that optometrists with more years of experience were more likely to prescribe RGP lenses (Hodge et al., 2015). In contrast, Usgaonkar *et al* reported that practitioners with less years of experience would prescribe RGP lenses than those with more years of experience in India (Usgaonkar et al., 2023). These variations underscore the need for further research to investigate contextual factors affecting KC management.

5.5 Key Barriers:

The current study explored the barriers that hinder optometrist from effective diagnosis and management of KC patients. The most common reported barrier was the cost of RGP lenses. As a developing country with low to moderate income, Palestinian's patients and optometrists may consider that the cost of RGP lenses is relatively expensive. Moreover, the lack of patient educational material was reported as a main barrier, addressing this challenge involves the development of accessible and culturally proper educational material tailored the demands of patients with KC in Palestine. Additionally, the absence of national guidelines for KC diagnosis and management was reported as a key barrier. Despite the consensus about the importance of early diagnosis of KC in the literature, practice patterns vary globally (Song et al., 2022). Generating national guidelines by the Palestinian Optometrists Syndicate and Palestinian Ophthalmologists Syndicate would standardize the clinical approach to diagnose, refer, and manage patients with KC in the West Bank. Furthermore, optometrists reported that the lack of facilities that provide KC services in the same region, lack of hard CL supply, and poor communication with secondary eye facilities hinder the optometrists from diagnosing and managing patients with KC. In Palestine, there is no CLs manufacture, as the available one exists in Israel, which considered challenging due to language and time constrains.

Additionally, participants reported that the lack and cost of diagnostic tools as a key barrier to effective diagnosis and management of KC. Similarly, previous studies reported such barriers to effective KC diagnosis and management. Braga Vieira et al reported that optometrists in Latin America face challenges in managing KC due to limited access to corneal

topography, with only 23% reported its accessibility, which affect the fitting of RGP lenses (Braga Vieira, 2023). Moreover, studies in Portugal, the United Kingdom, and Spain reported the main challenges of KC diagnosis and management are the lack of experience, low market demands, cost to practice, and time constraints (Rahmani et al., 2022). Furthermore, Nkoana *et al* reported that a significant number of South African optometrists in the public sector lacked the appropriate knowledge and skills to diagnose and manage KC patients. Lack of equipment, poor knowledge and expertise were the main barriers to contact lens fittings in KC management (Nkoana et al., 2022b). Additionally, Rashid *et al* reported the key barriers to effective KC diagnosis and management include the cost of corneal topographers, the lack of experience in RGP fitting, limited professional development opportunities, high costs of conferences, the lack of diagnostic tools, the lack of national guidelines, and patient- related factors such as compliance and affordability in Kenya (Rashid et al., 2024).

5.6 Limitations of the study

This study highlighted the optometrist's rules and attitudes in KC diagnosis and management. However, authors faced challenges to conduct this study. Initially, the nature of self-reported online survey may introduce a level of data bias. However, using of validated online questionnaire to collect the data could overcome this limitation. Future studies should consider the objective evaluation of the optometrists' attitudes towards patients with KC.

Moreover, the characteristics of the participants, authors noted that a limited number of responses from males and optometrists with more years of experience. This uneven participation may be due to technology issues to access the survey, or low-level interest of KC diagnosis and management.

Furthermore, this study did not investigate the optometrists' attitudes across all the occupied Palestinian territories. Optometrists from Gaza strip were excluded from this study due to the massive destruction and ongoing Israeli war. Therefore, the results do not represent the optometrists' attitudes in Gaza, who may encounter different challenges due to the destruction of the infrastructure and poor healthcare services.

5.7 Recommendations

The current study highlighted the vital role of optometrists in diagnosis, management, and referral patients with KC. However, optometrists in the West-Bank encounter challenges to approach effective KC diagnosis and management, therefore, it is pivotal to encourage

policymakers and professional associations to overcome these challenges such as the lack and cost of diagnostic tools. Moreover, providing accessible and culturally proper educational materials such as videos, brochures, could improve patients' knowledge about their condition.

In another prospective, enhancements of multidisciplinary approach between optometrists and ophthalmologists could optimize patient's outcome and improve their QoL. Moreover, the difference among optometrists' behaviours suggests the need for standardized guidelines for KC diagnosis, management, and referral criteria. Consequently, there is a compelling need to establish rules and regulations by policy makers and professionals from the Palestinian Ministry of Health, Palestinian Syndicate of Ophthalmologist, and Palestinian Syndicate of Optometry, to standardize referring criteria, and enhance collaboration.

Clinically, optometrists in the West Bank are recommended to improve their diagnostic and management capabilities with patients with KC through continuous education, training programs. Furthermore, optometrists are encouraged to look for alternatives, such as facilitating collaboration between optical centres which allow the accessibility to advance diagnostic tools like corneal topography, and using of empirical fitting through software in cases of lack of RGP trials sets. Moreover, optometrists are suggested to conduct screening programs for early diagnosis of KC. Additionally, optometrists should increase awareness in among Palestinian population about KC, its risk factors, and the importance of early diagnosis through social medias, local media like radios, and events.

Moreover, the current study could not find a statistically significant association between the availability of corneal topography and fitting RGP, neither between the optometrist's years of experience and fitting RGP lenses. Therefore, further studies are needed to explore the contextual factors that may affect the prescribing RGP lenses.

This study explored the optometrists' perspectives in KC diagnosis and management. Further studies are required in ophthalmologist and patients' perspectives to obtain a complete view of the current situation for KC diagnosis and management. Ophthalmologists also play a crucial rule in KC diagnosis and advanced management such as CXL and keratoplasty. Moreover, patients experiences and satisfaction with care may reveal gaps in service delivery and accessibility. These viewpoints will contribute to the development of more efficient, team-based, and patient-focused methods for the diagnosis and management of KC.

5.8 Conclusion

The current study shed the light on optometrists' attitudes towards patients with KC and highlighted the key barriers for effective diagnosis and management for patients with KC. Despite the importance of early diagnosis for KC. The results of this study showed variable practices of optometrist, especially relating the management, and referral criteria for patients with KC. Moreover, variations haves been observed between hospital-based optometrists and those who work in optical shops in term of RGP fitting and the use of corneal topography. Optometrists encounter key barriers that hinder them from effective KC diagnosis and management such as the cost of RGP lenses, the lack and the cost of diagnostic tools. This study underscores the need for for standardized referral guidelines, enhanced interdisciplinary collaboration, and continuous education to improve the diagnosis and management of patients with KC which led to optimize patient's outcome and enhance their QoL.

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7 Appendices

Appendix 7.1 Questionnaire investigating the optometrist's attitudes towards patients with keratoconus

1. What is your gender?
    - Male
    - Female

2. What is your age?

_____ Years old

3. What city do you work in?

4. What is the highest qualification in eye care that you have achieved?
    - Diploma
    - Bachelor degree
    - Masters' degree
    - PhD

5. How long have you been practicing since you qualified as an Eye Care Practitioner?
    - Less than 1 year
    - 1-5 years
    - 6-10 years

- 11-15 years
- 16-20 years
- More than 21 years

6. In which setting do you work?
    - Optical Shop
    - Public Hospital/Clinic
    - Private Hospital/Clinic
    - University/ College
    - Other: _____

7. Which of the following equipment and consumables do you have access to at your place of work? Please select all that apply:
    - Distance visual acuity charts
    - Retinoscope
    - Trial lens set and trial frame
    - Lens meter\ Focimeter
    - Cross-cylinder
    - Auto-refractor
    - Slit lamp
    - Keratometry

• Corneal topographer • Pachymeter • Corneal tomographic • Local anaesthetic drops • Fluorescein • Contact lens fitting sets for keratoconus • Contact lens care solutions		
8. Do you perform the following assessments regularly? • Retinoscopy • Subjective refraction • Slit lamp exam • Keratometry • Pachymetry • Corneal topography • Corneal tomography	✓ Yes	✓ No
9. Do you perform the following tasks regularly? • Fit hard corneal contact lenses • Fit hybrid/scleral contact lenses	✓	✓

• Manage mild allergic conjunctivitis • Manage moderate severe allergic conjunctivitis • Corneal cross-linking			
10. Are you aware of national guidelines on the diagnosis and management of the following eye conditions? • Keratoconus • Allergic conjunctivitis	✓ Yes		✓ No
11. On average, how many patients do you see on a monthly basis? • Less than 50 • 51-100 • 101-150 • 151-200 • More than 201			
12. When you see a patient with allergic conjunctivitis do you perform or recommend the following investigations? • Refraction • Slit lamp exam • Keratometry • Corneal topography	Always	Sometimes	Never

13. How do you therapeutically manage patients with allergic conjunctivitis?

- Counsel against eye rubbing
- Prescribe a lubricant
- Prescribe an anti-allergy eye drop
- Prescribe a steroid eye drop
- I am not allowed to prescribe

14. On average, how many patients on average with keratoconus do you see in a month?

- None
- 1-10
- 11-20
- More than 21

15. Which of the following assessments do you consider important for diagnosing keratoconus? (Please select all that apply)

- History and visual acuity
- Retinoscopy
- Keratometry
- Slit lamps signs
- Corneal topography/tomography
- Other: _____

16. How do you manage your keratoconus (KC) patients at different stages? • Prescribe spectacles • Fit/refer corneal hard contact lenses • Fit/refer hybrid/scleral contact lenses • manage/refer allergic conjunctivitis • monitor progression • Refer to ophthalmologist	Mild cases	Moderate cases	Severe cases
17. What is the lower limit of binocular best corrected visual acuity in glasses that you would fit/refer a patient with keratoconus for specialized contact lenses? • 6/6 • 6/9 • 6/12 • 6/18 • 6/24 • 6/60			
18. What is the lower limit of binocular best corrected visual acuity with contact lenses that you would refer a patient with keratoconus to an ophthalmologist for possible surgical interventions such as corneal cross-linking? • 6/6 • 6/9			

- 6/12
- 6/18
- 6/24
- 6/60

19. How do you manage Keratoconus patients who require contact lenses?

- Fit the contact lenses yourself
- Refer to an optometrist
- Don't refer

20. At what stage would you consider referring a patient with keratoconus to an ophthalmologist?

- Upon initial diagnosis
- At patients request
- Signs and symptoms of mild allergic conjunctivitis
- Signs and symptoms of moderate to severe allergic conjunctivitis
- Reduction of best corrected visual acuity
- Signs of progression
- No set time

21. Which patients do you recommend for corneal cross-linking?

- All keratoconus patients, irrespective of their age or the stability of their condition
- Only those keratoconus patients whose condition is progressing

• I don't know • Other: _____					
22. Do you currently co-manage patients with ophthalmologists after surgical treatment, for example: corneal cross-linking or contact lens fitting following intra-stromal corneal rings or penetrating keratoplasty? • Yes • No • Occasionally					
23. At the Practice/Hospital/Clinic where you work: • Do you have colleagues in eye care with whom you can share knowledge and experiences? • Do you have access to continuous medical education in eye care?	Yes	No			
24. Which of the following options do you use to update your knowledge and skills in eye care? • Journals/publications/online resources • Attending continuous medical education sessions • Registering for courses • Attending conferences • Other: _____					
25. On a scale of 1-5 on how confident do you feel at using the following tools or performing the following assessments when screening, diagnosing and managing patients with keratoconus (1-not confident, 5- very confident)	1	2	3	4	5

• Retinoscopy • Subjective Refraction • Keratometry • Corneal Topography • Hard contact lens fitting • Managing mild allergic conjunctivitis • Managing moderate allergic conjunctivitis					
26. Please rate your interest for further training in the following areas (1- not interested, 5 very interested) • Keratoconus diagnosis & management • Retinoscopy • Subjective Refraction • Corneal topography • Hard contact lens fitting • Managing allergic conjunctivitis • Corneal cross-linking	1	2	3	4	5
27. How often do the following factors hinder you from increasing your knowledge and skills in eye care? • Not knowing where to access it	Always	Sometimes			Never

• No mentor at work • Lack of diagnostic tools • Lack of professional development opportunities • Cost of conferences • Cost of journal subscriptions • Lack of motivation / incentive • Time constraints			
28. Do the following factors hinder you from diagnosing keratoconus (KC) early? • Lack of knowledge & skills • Lack of useable equipment • Cost of diagnostic equipment • Difficulty in examining eyes with KC • Lack of facilities that offer keratoconus services in the same city where you work	Yes	NO	
29. Do the following factors hinder you from managing patients with keratoconus (KC) effectively? • Lack of spectacle supply • Cost of spectacles • Lack of local hard contact lens supply • Cost of hard contact lenses	Yes	NO	

• Lack of national guidelines on managing KC • Lack of patient educational material • Lack of space • Fear of litigation • Lack of support from clinic leadership • Poor communication with secondary eye care facilities		
30. Please list any barriers not covered in the questions above that hinder you from providing quality eye care services to your keratoconus patients		

توجهات أخصائي البصريات تجاه مرضى القرنية المخروطية في الضفة الغربية: دراسة استقصائية.

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8 ملخص

القرنية المخروطية هي مرض تدريجي يصيب قرنية العين ويؤدي الى تدهور نظر المريض ويقلل جودة حياته. تتطلب القرنية المخروطية نهجاً متعدد الاختصاص من أجل التشخيص والعلاج, ومن ضمن هذه الاختصاصات أخصائي البصريات. تُعد خبرة أخصائي البصريات في تشخيص وعلاج القرنية المخروطية مهمة من أجل تحسين نظر وجودة حياة المريض. هدفت هذه الدراسة الى استكشاف تصرفات والعوائق التي تواجه أخصائي البصريات في الضفة الغربية تجاه مرضى القرنية المخروطية من ناحية التشخيص والعلاج والتحويل. وكذلك دراسة العلاقة بين متغيرات مختلفة وتأثيرها على تشخيص وعلاج القرنية المخروطية مثل سنوات الخبرة وإمكانية توافر الصور الطبقية للقرنية. تم استخدام دراسة وصفية من خلال استبيان الكتروني موثوق ومعتمد لجمع البيانات من أخصائي البصريات الفلسطينين حول طرق تشخيص وعلاج وتحويل المرضى المصابين بالقرنية المخروطية.

حوالي مئة وستون اخصائي بصريات شارك في هذه الدراسة وقام بتعبئة الاستبيان, حيث كانت نسبة 46.9% من اخصائي البصريات لديهم خبرة من سنة الى خمس سنوات. حوالي 75.6% من اخصائي البصريات يشخصون من مريض الى عشرة مرضى بالقرنية المخروطية بشكل شهري. تقريباُ 33.8% من الأخصائيين يأخذون بعين الاعتبار عدة عوامل لتشخيص القرنية المخروطية. حوالي 38.1% من اخصائي البصريات لديهم القدرة صور متقدمة لفحص سطح القرنية. ما يقارب 70.6% من الأخصائيين يعالجون القرنية المخروطية بوصف نظارات طبية في مراحله المبكرة, بينما حوالي 48% من المشاركين يعالجون المرض عن طريق وصف عدسات لاصقة صلبة في مراحله المتوسطة. وأيضاُ حوالي 47% من أخصائي البصريات يوصفون أو يحولون مرضى القرنية المخروطية في مراحله المتقدمة العدسات اللاصقة المخصصة لضعف القرنية. حوالي ربع المشاركين أبلغوا عن متابعة تطور المرض في جميع مراحله. هناك اختلاف في معايير الإحالة إلى طبيب العيون, حيث كانت التطور في المرض (71%) هو المعيار الأكثر توثيقاً. وضح اختبار كاي–تربيع عدم وجود علاقة ذات دلالة إحصائية بين سنوات الخبرة ووصف العدسات اللاصقة χ^2 (3, N = 160) = 2.309, p = 0.511, وأظهر الاختبار عدم وجود علاقة ذات دلالة

إحصائية بين توفر أجهزة التصوير الطبقي للقرنية وتركيب العدسات اللاصقة = χ^2 (1, N = 160) 0.880, p = 0.348. اعتبرت تكلفة العدسات اللاصقة (74.4%), و نقص المواد التعليمية للمرضى عن القرنية المخروطية (67.5%), وغياب الارشادات (55%) هي العوائق الأكثر شيوعاُ التي تواجه أخصائي البصريات. تبرز هذه الدراسة الحاجة إلى توجيهات موحدة بين أخصائي البصريات لتحويل مرضى القرنية المخروطية, وتعزيز التعاون بين مختلف الاختصاصات, والتعليم المستمر من أجل تحسين تشخيص وعلاج المرضى المصابين بالقرنية المخروطية, الذي من دوره أن يؤدي الى تحسين نظر وجودة حياة المريض.

الكلمات المفتاحية: القرنية المخروطية, أخصائي البصريات , تشخيص, علاج, توجهات.