African Vision and Eye Health
ISSN: (Online) 2410-1516, (Print) 2413-3183

Keratoconus management at public sector facilities in KwaZulu-Natal, South Africa: Practitioner perspectives

Authors:
Nonkululeko Gcabashe[1]
Vanessa R. Moodley[1]
Rekha Hansraj[1]

Affiliations:
[1]Discipline of Optometry, School of Health Science, University of KwaZulu-Natal, Durban, South Africa

Corresponding author:
Nonkululeko Gcabashe,
thwala@ukzn.ac.za

Dates:
Received: 12 Aug. 2021
Accepted: 23 Dec. 2021
Published: 30 Mar. 2022

How to cite this article:
Gcabashe N, Moodley VR, Hansraj R. Keratoconus management at public sector facilities in KwaZulu-Natal, South Africa: Practitioner perspectives. Afr Vision Eye Health. 2022;81(1), a698. https://doi.org/10.4102/aveh.v81i1.698

Background: Keratoconus (KC) is a non-inflammatory, self-limiting corneal ectasia that causes reduced visual acuity and if left undiagnosed and/or untreated may lead to visual impairment. Optometrists remain the first point of contact for affected patients, making appropriate timeous care essential.

Aim: To investigate keratoconus management in the public sector in KwaZulu-Natal, South Africa.

Setting: Public sector eye care facilities in KwaZulu-Natal, South Africa.

Methods: In a quantitative, cross-sectional study, a questionnaire was distributed to optometrists employed by the Department of Health in KwaZulu-Natal (DoH-KZN). Data on practitioner demographic profile and clinical competence, facility attendance statistics, resources available and KC clinical protocols were collected.

Results: The response rate was 36 (71%). The optometrists' mean age was 30.19 ± 4.53 years, and 80% of them had work experience of less than 10 years. The majority of the health facilities (63.9%) reported a monthly attendance of 51–300 patients, and, of these, 72% of the respondents reported seeing only between 1 and 10 keratoconic patients. A lack of equipment and/or fitting of contact lenses being disallowed by the DoH-KZN were cited by the majority (61%) as the reason for routinely referring KC patients to optometrists in private practice.

Conclusion: This study highlights a deficiency in the minimum standard of optometric care for KC in the public sector in KZN, primarily because of a lack of equipment and resources. It is recommended that the management of KC at all levels of the public health system be reviewed to improve the quality of service for keratoconic patients.

Keywords: keratoconus; keratoconus services; practitioner perspectives; vernal keratoconjunctivitis; public sector, health facilities.

Introduction

Keratoconus (KC) is a chronic, non-inflammatory, generally bilateral, asymmetric disease characterised by thinning of the cornea.[1,2] The development of the disease involves complex interactions between genetic, environmental and hormonal factors.[3] While the exact aetiology is still unclear,[4] risk factors for KC include, amongst others, eye rubbing, atopy and exposure to ultraviolet radiation.[5,6] Analysis of clinical parameters such as corneal thickness, corneal radii and transparency of the cornea, refractive errors and cone morphology inform the classification as mild, moderate or severe or as stages I–IV.[7,8]

Keratoconus has an early onset, usually at puberty, with continued progression up to around 40–50 years of age. However, being a self-limiting disease, progression of KC may halt at any stage between mild and severe.[9] In many instances, for reasons such as a lack of access or unaffordability of treatment options, it remains undiagnosed until later in life when it has already progressed to an advanced stage.[10] The negative impact of this delayed diagnosis on the quality of life (QoL) of affected individuals has been reported in several studies.[11,12] The disease is reported to impact education, economic, social and family life.[13] Early diagnosis and management are therefore key in ensuring optimal QoL for keratoconic patients.

While KC has been noted in populations worldwide, varied prevalence, ranging from 2.3% in India and Jerusalem to 0.3 per 100 000 in Russia, has been reported.[14,15,16] The different prevalence rates are attributed to diverse geographical locations, gender, ethnicities and diagnostic tools. A higher prevalence has frequently been reported in males, certain ethnic groups such as South Asians,

Eastern Mediterranean and North Africans, as well as in areas with dusty, dry and hot climates.[4,15,16,17,18,19,20] The prevalence of KC in the Middle East and North Africa has been reported to range from 2.3% to 3.3%, while in other parts of Africa and South Africa (SA), the prevalence remains largely unknown. Noting the warm subtropical climate in KwaZulu-Natal (KZN) in SA, the prevalence in this province is expected to be similar to that in Asian and Middle Eastern countries.[15,21,22]

The management of KC varies, depending on disease severity. Incipient cases are managed with spectacles, mild-to-moderate cases with specialised soft and rigid gas permeable (RGP) contact lenses (CLs), while severe cases may require surgical interventions such as keratoplasty.[23] Spectacles are used in cases where the cornea is still regular and thus visual acuity of 20/40 or better may be achievable with correction; however, they have limited use as the disease progresses. Soft CLs and corneal RGP lenses are utilised to treat the mild-to-moderate cases with scleral and hybrid lenses generally being fitted in more advanced stages.[24,25,26,27]

Surgical management of KC can include intrastromal corneal segments (INTACS) and corneal cross-linking (CXL), which attempts to strengthen the cornea with bonds between collagen fibres and corneal transplants (keratoplasty).[27,28] Early diagnosis and intervention with CXL have made a positive impact on retarding the disease progression.[29,30] This is expected to reduce the need for corneal transplants, a management option that is out of the financial reach of the majority of patients in low-income contexts.[18] The management of KC with spectacles and CLs is performed primarily by optometrists while CXL, INTACS and keratoplasty remain within the clinical domain of ophthalmologists.

The South African health system is designed on the District Health System model, which is based on the primary health care (PHC) approach.[31,32] The country has a population of approximately 59 million people, the majority (84%) of whom access their healthcare from the public sector clinics and hospitals. This results in the private sector, within which the majority of practitioners work, serving only approximately 16% of the population.[33] In KZN, 9.5 million of the 11.1 million people seek eye care services at public sector facilities, a possible indication that the overwhelming majority fall within the lower socioeconomic strata.[34]

As KC is a progressive disease, diagnosing and treating mild-to-moderate cases early enough may result in fewer cases progressing to the advanced or severe stages. As eye care service providers in the public sector, optometrists are expected to also play a key role in the early detection and management of mild-to-moderate KC. In many remote areas of SA, optometrists serve as the primary eye care service providers, as other eye care personnel are not easily accessible to those populations.

Anecdotal evidence suggests that patients presenting to public sector facilities at the early stages (mild) of KC are often not diagnosed and where the diagnosis is made, they are managed with spectacles. Those presenting with later stages of KC (moderate, advanced and severe) are referred either to non-governmental organisations (NGOs) or private sector optometrists and/or ophthalmologists. However, many of these patients may not present to their referred site because of financial constraints, poor knowledge about the condition, fear of the outcome of surgical interventions or cultural and social barriers. These barriers to the necessary clinical care may be mitigated if the appropriate clinical protocols are administered at their first point of entry into the healthcare system. The rationale as to why spectacles remain the only mode of correction for KC in the public sector has also not been established. This study therefore set out to ascertain the practitioners' perspectives and experiences in relation to the diagnosis and management of KC within the public-sector facilities in KZN.

Methodology

This study utilised a quantitative, cross-sectional, descriptive design. Data collection commenced once gatekeeper approvals were obtained from the Department of Health in KwaZulu-Natal (DoH-KZN) and the National Health Research Ethics Council (NHREC). Saturated sampling was used to select the study participants that included 51 consenting optometrists representing all 11 KZN public-sector districts at the time of data collection. The districts were represented as follows: six rural, two urban and three mixed (rural and urban).

A structured questionnaire was designed, piloted, modified and administered via email or hand delivery, to the study sample between December 2019 and May 2020. This questionnaire obtained data on the demographic profile of respondents, patient's monthly attendance statistics, clinical competency levels of the respondents, KC treatment options and equipment availability at each of the different facilities. Data were captured using the Statistical Package for Social Sciences (SPSS version 27) and analysed using descriptive and inferential statistics.

Ethical considerations

Ethical clearance to conduct the study was obtained from the Biomedical Research and Ethics Committee at the University of KwaZulu-Natal (number: BE332/19). The study adhered to the tenets of the Declaration of Helsinki.

Results

Demographic profile of respondents

Of the 51 optometrists recruited for participation in this study from 11 districts of KZN, 36 (71%) completed and returned their questionnaires. The majority (61%) of the respondents were female, as well as black Africans (92%) with only 8% being Indian. The ages of the respondents ranged between 22 years and 40 years with a mean

and standard deviation of 30.19 ± 4.53, respectively. The respondents median age is 29.00 with a skewness of 0.641. The majority of the respondents (69.4%) were employed at district level facilities, followed by community health centres (CHC) (13.9%) with very few at regional (8.3%) and provincial hospitals (8.3%).

Table 1 summarises the rank, qualification and work experience of all the respondents. The majority (61.1%) were currently employed at the level of junior optometrist and had obtained their degrees from the University of KwaZulu-Natal (UKZN) (88.9%). While 50.0% of the respondents indicated having up to five years of experience, only 2.8% had more than 15 years of experience.

Number of patients at each site per month including patients diagnosed with keratoconus

Twenty-three of the facilities (64.0%) reported that the number of patients who visited their sites varied from 51 to 300 per month, with one (2.8%) reporting that they see 50 patients or less per month (Table 2). Two of the facilities reported attending to more than 1000 patients per month. Of the total number of monthly attending patients, most health facilities (72.0%) reported 10 or less to be keratoconic with only one site reporting 21–50 keratoconic patients per month.

TABLE 1: Level of experience, employment and academic qualifications.

Rank	Number	%
Senior Optometrist	14	38.9
Junior Optometrist	22	61.1
Highest qualification		
B. Optometry	33	91.67
M. Optometry	2	5.56
MBA	1	2.77
Undergraduate institution		
University of KwaZulu-Natal	32	88.9
University of Limpopo	2	5.55
University of Johannesburg	2	5.55
Post qualification experience (years)		
0–5	18	50.0
6–10	12	33.3
11–15	5	13.9
16–20	1	2.8

MBA, Master of Business Administration; B. Optometry, Bachelor of Optometry; M. Optometry, Master of Optometry

TABLE 2: Number of total patients and keratoconic patients per site monthly.

Variable	Frequency	Percentage
Average number of patients per site per month		
1–50	1	2.8
51–300	23	63.9
301–400	7	19.4
401–500	0	0.0
501–1000	3	8.3
> 1000	2	5.6
Patients with KC per site per month		
0	9	25.0
1–10	26	72.2
21–50	1	2.8

KC, keratoconus.

Available equipment to diagnose and manage keratoconus

Just over half of the participants (56%) responded that they have access to a keratometer, 86% to a slit lamp biomicroscope, 75% to a tonometer and 2.8% to an optical coherence tomography (OCT) and corneal topographer to enable them to diagnose KC (Figure 1). However, none of the facilities had contact lens fitting sets, radiuscopes, shadowgraphs, V-gauges, contact lens solutions and suction holders. All the sites had access to one or more consumables such as fluorescein, Schirmer strips, saline and tear supplements.

Management of keratoconus patients

The protocols for the management of keratoconic patients needing CLs attending the different sites are illustrated in Figure 2. Some of the patients (44.4%) are managed at the facility by the prescription of spectacles, while the rest are referred to external sites. The most commonly used strategy is referral to a private optometrist (61.1%) or to the UKZN (51.4%) contact lens clinic. The least utilised approach was referring to an ophthalmologist (2.8%) with no site reporting referral to any NGO (Figure 2).

Table 3 outlines possible reasons as to why the sites are unable to fit patients who need CLs with the main reason being that it is not permitted by the Department of Health or that the eye facility does not have the necessary equipment to facilitate the fitting (60%).

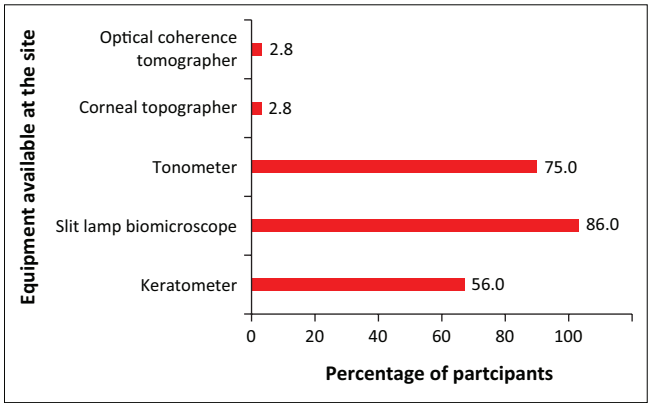
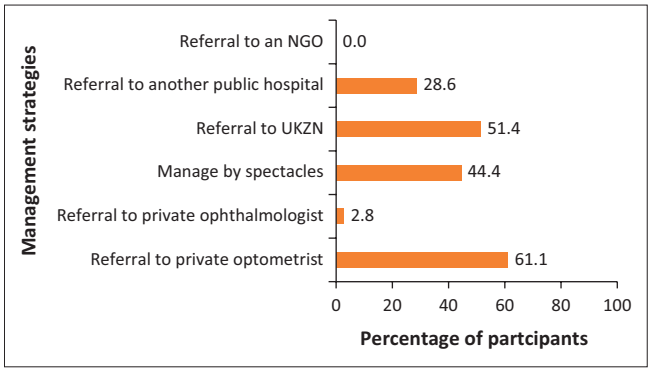


FIGURE 1: Equipment available to diagnose and manage keratoconus.



NGO, non-governmental organisations; UKZN, University of KwaZulu-Natal.

FIGURE 2: Management strategies of patients needing contact lenses.

Perceived competency and knowledge on keratoconic contact lens fittings of respondents

Table 4 shows the respondents' perceptions of their competency and knowledge regarding CLs fitting for keratoconic patients. The study showed that most of the respondents (86.1%) feel that it is essential to fit CLs in the public hospitals, that they are adequately trained for the fitting of CLs (84.8%) and that they are competent (83.3%) in fitting CLs.

Figure 3 shows practitioner responses on activities undertaken in order to keep themselves up to date with advancements within the field of CLs. The most common method used was reading of journals (58.3%), and the least common was attending seminars (2.7%).

Discussion

The study revealed that there were more females (61%) than male optometrists currently employed by the DoH-KZN within an age range of 22–40 years old. The profile of predominantly female and young adult optometrists being in employment within the public sector in the province remains relatively stable as indicated by previous studies conducted in the same province by Ramson et al.,[35] and Maake and Moodley.[35,36] The current profile is contrary to that which was expected by Oduntan et al., who suggested that males were more likely to prefer working in a hospital as compared to females, who were more inclined towards working in a private practice post-graduation.[37] The higher number of females than males might be related to the intake of more female student optometrists in universities in SA and that there are more female optometrists registered with the Health Professional Council of South Africa (HPCSA).[38] Pre-democracy statistics (1930–1994) in SA revealed more males than females within the profession.[39] As per our study, the previous studies also found that the majority of public sector optometrists had working experience of less than five years. Ramson et al.[35] found that there is a high mobility of optometrists within the public sector, influenced by poor salary scales as compared to other allied health professionals and a lack of recognition at their respective workplaces.[35] This could contribute to reasons why, in the current study, the majority of respondents have work experience of less than five years. Another possible reason may include public sector posts only becoming available in the previous five years at specific facilities. Furthermore, because of a lack of posts, graduates may not be placed in a public-sector facility immediately after graduating and might have to wait for a long period for a vacancy to arise before placement. The lower work experience could also be because of them entering immediately following graduation but then leaving after about five years as a result of non-competitive public-sector salaries.

The current study also revealed that there were more black African respondents compared to other races and respondents predominantly obtained their undergraduate degrees from the UKZN. This could be because of UKZN being the only university that offers a programme in optometry in the province. The university's intake policy promotes access to students from poor/impoverished schools, classified as quintile one and two. These students are mostly black African and from rural areas,[40] with most being funded by the DoH bursary scheme or the National Student Financial Aid Scheme (NSFAS). Post-graduation that had been funded by the DoH is expected to return and serve within the public sector. There were no mixed-race optometrists or white optometrists employed within the public sector, which is similar to the 2016 situation found by Ramson et al.[35] Universities and funders should explore strategies to improve the demographic representation of students funded to work within the public sector.

In most facilities (64%), the number of patients who attended ranged between 51 and 300 per month which

TABLE 3: Reasons cited for not fitting contact lenses.

Reasons	Frequency (*n*)	Percentage (%)
Not allowed by the Department of Health	7	17.5
Not allowed by the hospital	3	7.5
Allowed but the hospital does not have the necessary equipment	24	60.0
Allowed but the site does not have the necessary contact lens consumables	2	5.0

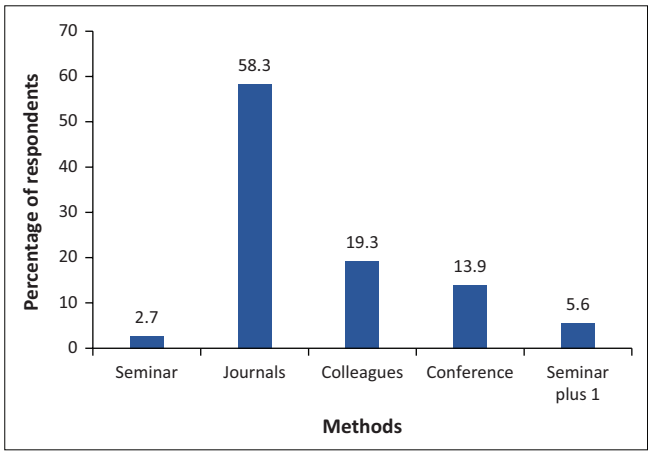


FIGURE 3: Methods used by the participants to keep engaged, maintain knowledge and competency in contact lens fitting.

TABLE 4: Participant responses regarding contact lens fittings.

Probing questions	Yes (%)	No (%)
Do you feel that is it essential to fit contact lenses in the public sector?	86.1	13.9
Do you feel adequately trained to fitting contact lenses?	83.3	16.7
Do you feel competent in fitting contact lenses?	83.3	16.7
Are you aware of the latest developments in contact lenses?	36.1	63.9
Do you think you will benefit from refresher and/or advanced course in contact lenses fitting and management?	97.2	2.8
Would you make yourself available to attend refresher and/or advanced course in fitting contact lenses?	97.2	2.8
Have you attended any CPD activities on contact lenses in the last 2 years?	30.6	69.4

CPD, continuous professional development.

translates to between 600 and 3600 per year. However, two of the sites indicated that they see more than a 1000 patients per month (equivalent to 12 000 per year), one of which is the only eye hospital in the province, based in the eThekwini district. All the patients seen at three district hospitals within the catchment area are referred to this facility because those hospitals did not have an optometrist employed at the time of the study.

The number of patients with KC who attend each of the facilities, per month varied, with most respondents reporting that they see between 1 and 10 keratoconic patients monthly with only two indicating that they see 21–51 keratoconic patients per month. Interestingly, all the respondents indicated that they see patients with vernal keratoconjunctivitis (VKC), seven of whom reported that they see more than 100 patients with VKC per year. Vernal keratoconjunctivitis is a severe, inflammatory, ocular allergic disease of the cornea and conjunctiva, which is more prevalent in children and adolescents.[41] It causes visual impairment and normally resolves around puberty. Similar to KC, VKC is more frequent in warmer, windy climatic countries such as the Mediterranean region, Middle East, Africa and Indian subcontinent and unusual in North America and Western Europe.[42,43] Totan et al.[44] using video keratography to determine the incidence of KC in subjects with VKC revealed a higher incidence (26.8%) of KC as compared to studies that have been previously done. The high incidence found could be attributed to the use of diagnostic instrumentation with a high sensitivity for KC detection, as compared to traditional methods of using a keratometer or slit lamp biomicroscope. Cingu et al.[45] using a topographer in a retrospective study to ascertain the effect of vernal and allergic conjunctivitis on the severity of KC revealed that most of the patients with VKC were found to have severe KC, despite their age. The lack of appropriate diagnostic equipment, such as corneal topographers, at many study facilities may contribute to patients who present with or without VKC not being diagnosed. In the current study, most of the health facilities revealed that they have keratometers; however, it is not routinely conducted on patients presenting with VKC and/or KC. This may be because of the general protocol of patients with VKC initially treated by ophthalmologists and ophthalmic nurses and optometrists being limited to conducting refractions only. This protocol prevents effective co-management of patients, which could additionally suggest that the number of patients being undiagnosed might be higher than currently revealed in this study.

The HPCSA has a list that outlines the basic minimum equipment and procedures needed for any site or practitioner to fit CLs. These include an objective and subjective refraction, slit lamp biomicroscopy, corneal curvature measuring equipment, internal ocular health assessment, binocular status, corneal diameter, tear stability/function tests and appropriate trial lenses such as soft and RGP lenses. This study revealed that most of the facilities have the required minimum equipment to diagnose KC such as a keratometer, slit lamp biomicroscope (86.0%), tonometer (75.0%) and OCT/corneal topographer (2.8%). However, none of the sites have the necessary CL trial lens fitting sets, even though they may have consumables such as fluorescein. Eighty six percent of the sites have slit lamp biomicroscopes; however, practitioners indicated that they do not assess the anterior surface of the eyes or perform keratometry as a preliminary test for patients who visit the site. This shortcoming in clinical care is of concern and may be the reason why patients needing to be fitted with CLs are not appropriately diagnosed and managed at the public hospitals. A contributing factor may be that optometrists within the public health sector are largely limited to conducting refractions only, missing key clinical signs of KC that might have been picked up using a slit lamp biomicroscope and topographer. The reason could be shortage of equipment. Furthermore, the screening team consists of ophthalmic nurses who do medical evaluation and refer to an optometrist for refraction only and to an ophthalmologist or medical officer for evaluation and management of pathology. Subsequently, most patients who need CLs, which in KC is one of the primary management options, are being treated with spectacles until vision is severely compromised with the negative impact on the QoL of the patient. Kurna et al.,[11] in evaluating vision-related quality of life (VRQoL) in patients with KC, revealed VRQoL was low in this grouping. As the majority of optometrists self-reported being adequately trained and competent in fitting CLs (Table 4), the other factors preventing CLs being prescribed will need to be identified by the DoH to improve the quality of care administered to KC patients. The underutilisation of the full clinical competencies that fall within the scope of practice of optometrists may contribute to such compromises in patient care.

Patients who need CLs are managed mostly by being referred to private optometrists (61.1%) or to the UKZN eye clinic. However, most of these patients might not present to the referral site because of transportation costs, poor knowledge about the condition, costs of corrective devices, fear of outcome of the surgery if needed and cultural and social barriers.[46] Treating these patients at the public-sector facilities will help overcome the barriers to care that the referrals may cause.

The respondents when self-reporting on their competency with regard to fitting CLs revealed that felt competent and were willing to fit the lenses, despite the lack of equipment at their facilities. They, however, indicated a need for refresher courses on basic and advance fitting of RGPs, corneal, scleral and hybrid lenses. It is recommended that the DoH facilitate the attendance of relevant clinical training workshops as part of their continuous professional development.

Conclusion

Visual impairment has been reported to affect the quality of life in patients who live with conditions that can be treated. Uncorrected refractive error is one of the major causes of avoidable visual impairment and blindness globally. The study highlights that there are more female optometrists within the public sector in KZN. However, most of them have less than five years of experience, warranting a need for

better retention plans to be developed. There is a concern about the sub-optimal quality of care received by KC patients attending many of the study facilities. A turnaround strategy to improve patient care could include re-skilling of the optometrists in KC diagnosis and management, redefining clinical protocols to enable optometrists to practice the full scope of optometric practice and equipping facilities with the minimum equipment and consumables needed for CL fitting.

Acknowledgements

The authors thank Zelalem Getahun Dessie for assistance with statistical analysis.

Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

N.G., V.R.M. and R.H. conceptualised the project and designed the methodology. N.G. drafted the initial manuscript and wrote the manuscript. V.R.M. and R.H. supervised the project, guided and reviewed drafts up to the final article.

Funding information

The University of KwaZulu-Natal (UKZN) College of Health Sciences funded the fieldwork.

Data availability

New and original data were collected, analysed and available upon request from the corresponding author, N.G.

Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

References

1. Cheng EL, Maruyama I, SundarRaj N, Sugar J, Feder RS, Yue BY. Expression of type XII collagen and hemidesmosome-associated proteins in keratoconus corneas. Curr Eye Res. 2001;22(5):333–340. https://doi.org/10.1076/ceyr.22.5.333.5491
2. Touri AJ, Virtanen I, Kalluri R, Miner JH, Uusitalo HM. The immunohistochemical composition of corneal basement membrane in keratoconus. Curr Eye Res. 1997;16(8):792–801. https://doi.org/10.1076/ceyr.16.8.792.8989
3. Georgiou T, Funnell CL, Cassels-Brown A, O'Conor R. Influence of ethnic origin on the incidence of keratoconus and associated atopic disease in Asians and white patients. Eye. 2004;18:379–383. https://doi.org/10.1038/sj.eye.6700652
4. Weed KH, MacEwen CJ, McGhee CNJ. The variable expression of keratoconus within monozygotic twins: Dundee University Scottish Keratoconus Study (DUSKS). Cont Lens Anterior Eye. 2006;29(3):123–126. https://doi.org/10.1016/j.clae.2006.03.003
5. Najmi H, Mobarki Y, Mania K, Altowairqi. The correlation between keratoconus and eye rubbing. A review. Int J Ophthalmol. 2019;12(11):1775–1781. https://doi.org/10.18240/ijo.2019.11.17
6. Gordon-Shaag A, Millodot M, Shneor E. The epidemiology and etiology of keratoconus. Int J Keratoco Ectatic Corneal Dis. 2012;1(1):7–15. https://doi.org/10.5005/jp-journals-10025-1002
7. Orucoglu F. Incidence and tomographic evaluation of unilateral keratoconus. Turkish J Ophthalmol. 2013;43(2):83–86.
8. Krumeich JH, Daniel J, Knulle A. Live-epikeratophakia for keratoconus. J Cataract Refract Surg. 1998;24(4):456–463. https://doi.org/10.1016/S0886-3350(98)80284-8
9. Mungo SN, Ilako D, Nyenze EM. Prevalence of keratoconus in patients with allergic conjunctivitis attending Kenyatta National hospital eye clinic. J Ophthalmol East Cent S Afr. 2020;22(1):18–23.
10. Olivo-Payne A, Abdala-Figuerola A, Hernandez-Bogantes E, Pedro-Aguilar L, Chan E, Godefrooij D. Optimal management of pediatric keratoconus: Challenges and solutions. Clin Ophthalmol. 2019;13:1183–1191. https://doi.org/10.2147/OPTH.S183347
11. Kurna SA, Altun A, Gencaga T, Akkaya S, Sengor T. Vision related quality of life in patients with keratoconus. J Ophthalmol. 2014;2014:694542. https://doi.org/10.1155/2014/694542
12. Yildiz EH, Cohen EJ, Virdi AS, Hammersmith KM. Quality of life in keratoconus patients after penetrating keratoplasty. Am J Ophthalmol. 2010;149(3):416–422. https://doi.org/10.1016/j.ajo.2009.10.005
13. Rabinowitz YS. Keratoconus. Surv Ophthalmol. 1998;42(4):297–318. https://doi.org/10.1016/S0039-6257(97)00119-7
14. Jonas JB, Nangia V, Matin A, Kulkarni M, Bhojwani K. Prevalence and associations of keratoconus in rural Maharashtra in central India: The central India eye and medical study. Am J Ophthalmol. 2009;148(5):760–765. https://doi.org/10.1016/j.ajo.2009.06.024
15. Millodot M, Shneor E, Albou S, Atlani E, Gordon-Shaag A. Prevalence and associated factors of keratoconus in Jerusalem: A cross-sectional study. Ophthalmic Epidemiol. 2011;18(2):91–97. https://doi.org/10.3109/09286586.2011.560747
16. Gorskova EN, Sevost'ianov EN. Epidemiology of keratoconus in the Urals. Vestn Oftalmol. 1998;114(4):38–40. https://doi.org/10.1016/S0294-3506(98)80026-4
17. Pearson AR, Soneji B, Sarvananthan N, Sandford-Smith JH. Does ethnic origin influence the incidence or severity of keratoconus? Eye. 2000;14:625–628. https://doi.org/10.1038/eye.2000.154
18. Yego WK, Moodley VR. Visual acuity and refractive error improvement in keratoconic patients: A low-income context management perspective. Clin Optom. 2020;12:113–122. https://doi.org/10.2147/OPTO.S258905
19. Gillian W. Keratoconus: A clinical exposé. S Afr Optom. 2013;72(1):4–45. https://doi.org/10.4102/aveh.v72i1.40
20. Mahadevan R, Arumugam AO, Arunachalam V, Kumaresan B. Keratoconus – A review from a tertiary eye-care center. J Optom. 2009;2(4):166–172. https://doi.org/10.3921/joptom.2009.166
21. Ziaei H, Jafarinasab MR, Javaddi MA, et al. Epidemiology of keratoconus in an Iranian population. Cornea. 2012;31(9):1044–1047. https://doi.org/10.1097/ICO.0b013e31823f8d3c
22. Waked N, Fayad AM, Fadlallah A, EL Rami H. Keratoconus screening in a Lebanese students' population. J Fr Ophalmol. 2012;35(1):23–29. https://doi.org/10.1016/j.jfo.2011.03.016
23. Kanski JJ, Bowling B, Nischal KK, Pearson A. Clinical ophthalmology: A systematic approach. 8th ed. Amsterdam: Elsevier, 2016; p. 213.
24. Mohammadpour M, Heidari Z, Hashemi H. Updates on managements for keratoconus. J Curr Ophthalmol. 2018:30;110–124. https://doi.org/10.1016/j.joco.2017.11.002
25. Rupnarain S, Madlala N, Memela N, et al. Clinical characteristics of keratoconus patients at the University of KwaZulu-Natal eye clinic. Afr Vision Eye Health. 2020;79(1):a528. https://doi.org/10.4102/aveh.v79i1.528
26. Wagner H, Barr JT, Zadnik K. Collaborative longitudinal evaluation of keratoconus (CLEK) study: Methods and findings to date. Cont Lens Anterior Eye. 2007;30(4):223–232. https://doi.org/10.1016/j.clae.2007.03.001
27. Khor WB, Wei RH, Lim L, Chan CM, Tan DT. Keratoconus in Asians: Demographics, clinical characteristics and visual function in a hospital-based population. Clin Exp Ophthalmol.2011;39(4):299–307.https://doi.org/10.1111/j.1442-9071.2010.02458.x
28. Chunyu T, Xiujun P, Fan Zhengjun F, Xia Z, Feihu Z. Corneal collagen cross-linking in keratoconus: A systematic review and meta-analysis. Sci Rep. 2014;4:5652. https://doi.org/10.1038/srep05652
29. Kelly T, Willaims KA, Coster DJ. Corneal transplantation for keratoconus: A registry study. Arch Ophthalmol. 2011;129(6):691–697. https://doi.org/10.1001/archophthalmol.2011.7
30. De Bernardo M, Capasso L, Lanza M, et al. Long-term results of corneal collagen crosslinking for progressive keratoconus. J Optom. 2015;8(3):180–186. https://doi.org/10.1016/j.optom.2014.05.006
31. Blumenthal D, Mort E, Edwards J. The efficacy of primary care for vulnerable population groups. Health Serv Res. 1995;30(1):253–273.
32. Dookie S, Singh S. Primary health services at district level in South Africa: A critique of the primary health care approach. BMC Fam Pract. 2012;13:67. https://doi.org/10.1186/1471-2296-13-67
33. Naidoo S. The South African national health insurance: A revolution in health-care delivery. J Public Health. 2018;34(1):149–150. https://doi.org/10.1093/pubmed/fds008
34. South Africa. Department of Health White Paper: National health insurance policy: Towards universal health coverage [document on the Internet]. 2017 [cited 2019 June]. Available from: http://www.health.gov.za/
35. Ramson P, Govender P, Naidoo K. Recruitment and retention strategies for public sector optometrists in KwaZulu-Natal province, South Africa. Afr Vision Eye Health. 2016;75(1):a349. https://doi.org/10.4102/aveh.v75i1.349
36. Maake ME, Moodley VR. An evaluation of the public sector optometric service provided within the health districts in KwaZulu-Natal, South Africa. Afr Vision Eye Health. 2018;77(1):a407. https://doi.org/10.4102/aveh.v77i1.407-1

37. Oduntan AO, Louw A, Moodley VR, Richter M, Von Poser P. Perceptions, expectations, apprehensions and realities of graduating South African optometry students (PEAR study, 2006). S Afr Optom. 2007;66(3):94–108. https://doi.org/10.4102/aveh.v66i3.241

38. Mashige KP, Oduntan OA, Rampersad N. Perceptions and opinions of graduating South African optometry students on the proposed community service. S Afr Optoms. 2013;72(1):11–18. https://doi.org/10.4102/aveh.v72i1.43

39. Nirghin U, Ebrahim Khan N, Mashige KP. Institutional, gender and racial profiles of South African optometrist. S Afr Optom. 2011;70(3):123–128. https://doi.org/10.4102/aveh.v70i3.107

40. Van Dyk H, White CJ. Theory and practice of the quintile ranking of schools in South Africa: A financial management perspective. S Afr J Edu. 2019;39(1):a1820. https://doi.org/10.15700/saje.v39ns1a1820

41. Bonini S, Coassin M, Aronni S, Lambiase. Vernal keratoconjunctivitis. Eye. 2004;18(4):345–351. https://doi.org/10.1038/sj.eye.6700675

42. Leonardi A. Management of vernal keratoconjunctivitis. Ophthalmol Ther. 2013;2(2):73–88. https://doi.org/10.1007/s40123-013-0019-y

43. Bremond-Gignac D, Donadieu A, Leonardi A, Pouliquen P, Doan S, Chiambarretta F. Prevalence of vernal keratoconjunctivitis: A rare disease? Br J Ophthalmol. 2008;92(8):1097–1102. https://doi.org/10.1136/bjo.2007.117812

44. Totan Y, Hepsen F, Cekic O, Gunduz A, Aydin E. Incidence of keratoconus in subjects with vernal kerotoconjunctivitis: A video keratographic study. Ophthalmology. 2001;108(4):824–827. https://doi.org/10.1016/S0161-6420(00)00664-3

45. Cingu AK, Cinar Y, Turkcu FM, et al. Effects of vernal or allergic conjunctivitis on severity of keratoconus. Int J Ophthalmol. 2013;6(3):370–374.

46. Sacharowitz HS. Visual impairment in South Africa: Achievements and challenges. S Afr Optom. 2005;64(4):139–149. https://doi.org/10.4102/aveh.v64i4.239