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# Perceptions of optometry coordinators on eye care services in public hospitals of Limpopo province

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**Background:** Evaluation of eye care services (ECS) is essential for assessing the effectiveness and outcomes of eye care delivery, providing improvements, reducing avoidable vision impairment (VI) and promoting optimal eye health.

**Aim:** This study aimed to determine the perceptions of optometry coordinators on ECS.

**Setting:** Public hospitals in Limpopo province, South Africa.

**Methods:** Qualitative exploratory research was conducted between May and September 2023 to investigate the perceptions of optometry coordinators on ECS. Data collection was facilitated through a structured interview guide. Data obtained from the participants' responses were analysed to assess the outcome of ECS in public hospitals.

**Results:** The study involved four optometry district coordinators aged 48–52 years. Participants found high estimates of VI cases among individuals aged 50 years and older, females in the adult population and males in the paediatric population. Most of the causes of VI were identified as avoidable (perceptions of eye health issues). The findings highlighted the absence of national guidelines, policies and plans for eye health services (perceptions of health policy and infrastructure). Eye care services were primarily delivered by optometrists, ophthalmic nurses and ophthalmologists. There was poor integration of VI services within the health system (perceptions of barriers to care).

**Conclusion:** Provision of comprehensive ECS programmes in public hospitals of Limpopo province is inadequate and constrained. These services are critical to reducing the burden of VI among patients relying on public healthcare for ECS.

**Contributions:** The study describes the perceptions of optometry coordinators on eye care services in Limpopo province.

**Keywords:** eye care services; vision impairment; low vision care; rehabilitation services; service delivery; vision-related quality of life; referral.

## Introduction

Comprehensive eye care services (ECS) are essential to reduce avoidable vision impairment (VI) and ensure optimal eye health.[1] Vision impairment is a major cause of disability worldwide and is regarded as a global public health problem.[1] Approximately 2.2 billion people have VI from various causes, and at least 1 billion of these could have been prevented or are yet to be addressed.[1] Almost 90% of visually impaired individuals live in low- and middle-income countries (LMICs).[2,3] In South Africa, VI accounts for 9.9%.[4]

The presence of VI impacts activities of daily living (ADL), increases morbidity and mortality, poses a higher risk for depression, reduces workplace productivity and educational outcomes, decreases quality of life (QOL), increases risk of falls, causes higher levels of dependency for healthcare and poses a socio-economic burden for the affected individual, healthcare systems and society.[1,2,5] Comprehensive ECS can substantially improve vision-related QOL in affected individuals and optimise the use of their residual vision with assistive devices, medical and surgical interventions, psychological counselling and environmental adaptations.[1,2,5,6,7] However, there are significant inequalities and gaps in the provision and access to comprehensive ECS worldwide.[1,8,9]

Recent studies investigated the prevalence, causes and factors associated with VI,[10] including optometrists' perspectives on the availability of VI services, barriers to provision and uptake in public hospitals of Limpopo province.[11] Findings revealed that their prevalence of VI in Limpopo province

is relatively high, and the main causes of VI are correctable.[10] However, the provision of comprehensive ECS is greatly constrained in public hospitals within Limpopo province.[10,11] A significant proportion of the population in Limpopo province is indigent and relies on public hospitals for ECS.[4,12,13] This study builds on these findings and investigated the effectiveness and outcomes of eye care delivery from the perspective of ECS coordinators. The findings will be valuable for policymakers, eye care personnel and Department of Health authorities to evaluate the outcome of the services provided and facilitate evidence-based planning, effective resource allocation and management of ECS. These efforts are aimed at addressing avoidable VI and enhancing the QOL of affected individuals and their families within Limpopo province. Furthermore, information from this study can also serve as a foundation for future research studies.

# Research methods and design

## Study design and setting

An exploratory qualitative research design was employed to explore the perceptions of optometry district coordinators to gain insights into the patterns and outcomes of ECS in the public hospitals of Limpopo province. This approach was selected to facilitate the collection of rich data to elicit understanding into the experiences, challenges and effectiveness of ECS from the perspective of the optometry district coordinators based on their key roles and responsibilities within each district.

The study was conducted in public health facilities of Limpopo province. As of 2022, Limpopo province[14] had an estimated population of 5.9 million, ranking as the fifth most populous province in South Africa, with a predominantly rural landscape. The province is administratively divided into five district municipalities: Capricorn, Mopani, Sekhukhune, Vhembe, and Waterberg. Each district municipality is served by one secondary-level hospital, which provides support to six or seven primary-level hospitals, health centres and clinics.[12] During the study period, ECS were available across 38 health facilities, comprising 30 primary hospitals, five secondary hospitals, two tertiary hospitals and one health centre. The two tertiary hospitals, including a health centre, were based in the same district.

At the time of the study, eye care services were offered by optometrists, ophthalmic nurses and ophthalmologists. Ophthalmology services were limited to three hospitals comprising one tertiary and two primary-level hospitals, each based in different districts across the province. Optometry services were accessible at all 38 health facilities. This study was conducted at selected public health facilities that had an optometry district coordinator in each district. Each district has one designated optometry district coordinator for ECS, responsible for overseeing and coordinating the delivery of ECS, as well as providing advisory support for ECS at both district and provincial level. This is a common practice across the districts within the country.[15]

## Study population and sampling

During the study period (May 2023 – September 2023), five optometrists were responsible for coordinating ECS across the province, each based at a health facility within their respective district. The concept of 'information power' was applied to guide sampling decisions in this study.[16] The information power concept emphasises that the adequacy of a sample is determined by the richness, relevance and depth of the data it yields rather than the number of participants. This approach is commonly recommended in exploratory qualitative studies.[17,18,19] Aligned with both the study objective and information power concept, a saturated sample comprising all five district coordinators was recruited to participate in this study through purposive sampling strategy. Participants exhibited relative uniformity regarding overseeing and coordinating ECS within their respective districts. The use of purposive sampling strategy ensured that participants were the key informants to provide data that would not be accessible through alternative sampling methods.

Only four district coordinators provided informed consent to participate and were subsequently included in the final sample. Data collected from the four participants were sufficiently rich to address the study objective and generate meaningful insight into the patterns and outcomes of ECS across the districts. Data redundancy was observed after the third participant, as continued data collection yielded no new insights and therefore data saturation. The point of saturation helped to confirm that the dataset was sufficiently rich, and the sample size, albeit small, was adequate for producing data to adequately address the study objective. This approach is recommended in the exploratory qualitative research designs, where the adequacy of the sample is determined based on the achievement of data redundancy than a predetermined number of participants.[17,18]

## Inclusion and exclusion criteria

All five optometry district coordinators were included in the study. One district coordinator declined to provide informed consent and was excluded from participation. The final sample included four district coordinators.

## Data collection

A semi-structured interview guide was used for data collection. The development of the interview guide was guided by a comprehensive review of relevant literature[20,21,22,23] to ensure methodological consistency and reproducible findings. A pilot study assessed content validity and the suitability of the interview guide for the intended study context. The pilot study was conducted in two phases, in public hospitals within Limpopo province. Conducting a pilot study in a similar setting to the main study enhances the validity of the data collection tool and its appropriateness for use within similar context.[24,25] During the first phase, two optometrists who were serving at supervisory levels in their respective hospitals from

different districts within the province participated. Feedback from this phase informed adjustments to the interview guide, specifically re-organising and aligning three sub-questions with the pre-determined section items to enhance information coherence. Subsequently, the second phase involved one optometrist who often served as acting district coordinator, who was not part of the main study sample. Feedback from this phase indicated no need for further modifications to the interview guide or data collection procedures. Data obtained from the pilot study were excluded from the final analysis. The interview guide was designed to elicit participants' perceptions of ECS within their respective districts.

The final interview guide was structured into nine sections addressing the following topics: (1) demographic information; (2) description, distribution and causes of VI; (3) leadership and governance; (4) service delivery and access; (5) eye care workforce; (6) technology, assistive devices and funding; (7) information management; (8) awareness and health promotion services and (9) barriers to accessing ECS. Face-to-face interviews were conducted using the interview guide. The participants were interviewed independently to allow for open, in-depth exploration of their personal experiences and perspectives without influencing one another and to ensure confidentiality during data collection. The researcher adopted an open and receptive approach during the interviews, actively engaging with participants' reported experiences and perspectives.

All participants provided consent for the interviews to be audio-recorded, with their responses concurrently documented in written form. Data saturation was observed in the third participant, as responses became increasingly repetitive, indicating redundancy. However, all four participants were interviewed to enhance the credibility of the findings. All participants opted to be interviewed in English. The same interview guide was used across all study sites to maintain consistency in data collection processes and enhance comparability of participants' responses.

## Data analysis

The verbatim transcription of all audio-recorded interviews was conducted using the Microsoft 365 transcription programme, which incorporated verbal cues. Participants' gestures during the interviews were noted and diarised. Following the transcription and data-cleaning process, the transcripts were meticulously reviewed. To ensure methodological rigour and accuracy, the interview transcripts were cross-referenced with the diarised responses, and participants were contacted to verify and clarify specific statements made during the interviews. Subsequently, the researcher applied Braun and Clarke's six-phase framework for inductive thematic analysis: (1) familiarisation with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes and (6) producing the final report.[26] Consequently, data were analysed using thematic analysis, a method involving identifying, analysing and reporting themes within the dataset to elucidate participants' perceptions and uncover patterns of ECS in the public hospitals in Limpopo province. This approach was selected for its methodological rigour and alignment with the study objective. Participants' responses served as the primary data source for this analysis.

To enhance the trustworthiness of the findings, Lincoln and Guba's criteria for credibility, transferability, dependability and confirmability, as outlined by Stahl and King,[27] were applied. Specifically, district coordinators were purposefully sampled to facilitate data source triangulation across districts, to enhance the credibility of the study. The study setting and participants were described in detail. Investigator triangulation was achieved through the independent analysis and interpretation of data by the research team comprising the principal investigator and supervisors. This process was further strengthened by peer debriefing and the integration of diverse perspectives and viewpoints from the research team, to reduce potential bias associated with a single-researcher interpretation. Coding frameworks were developed and subjected to inter-coder verification among the research team to ensure transferability and dependability. These codes and categories were iteratively refined in response to emerging data and feedback from debriefing sessions. Illustrative quotes from participant interviews were incorporated to maintain a clear linkage between the findings and the raw data. A blended approach of deductive and inductive data analysis was employed to facilitate a nuanced understanding of the patterns and outcomes associated with ECS in the public hospitals within Limpopo province. The study's findings and recommendations will be made available upon request to promote confirmability.

## Ethical considerations

Ethical approval for this study was obtained from the Humanities and Social Science Research Ethics Committee of the University of KwaZulu-Natal (Reference: HSSREC/00004472/2022). Gatekeeper permission was granted by the Limpopo Provincial Department of Health (Reference: LP_2022-12-004), authorising the use of departmental facilities for data collection. To ensure participants' anonymity, unique identification codes were assigned to each participant.

# Results

## Demographic characteristics

Three female and one male district coordinators participated in this study. Their ages ranged between 48 and 52 years. All participants had a Bachelor's degree in optometry and a post-graduate diploma in related fields. In addition, two participants had completed Master's degrees in disciplines related to their work, although not specifically in optometry. The three female participants each had a minimum of 16 years of professional experience as district coordinators, while the male participant had 9 years of experience in the same role. Their primary responsibilities included coordinating clinical optometry services and providing ongoing support to ECS within their respective districts.

Furthermore, all participants served as the primary provincial advisors for ECS, contributing to the planning, management and distribution of eye care resources.

## Relationships and patterns within themes

The findings were organised into eight primary themes, each with corresponding subthemes, as detailed in Table 1: (1) description, distribution and causes of VI; (2) leadership and governance; (3) service delivery and access; (4) eye care workforce; (5) technology, assistive devices and funding; (6) information management; (7) awareness and health promotion services and (8) barriers to eye care services.

## Description and interpretation of findings

### Theme 1: Description, distribution and causes of vision impairment

**Sub-theme 1.1:** Description of vision impairment: Participants characterised VI as a partial or complete loss of vision that significantly affects the ability to perform ADL. Participants described VI as a condition characterised by reduced VA that limits an individual's ability to function effectively in daily life. Participants' shared accounts reflected both a quantified VI (based on visual acuity) and its impact on an individual's capacity to perform daily activities, regardless of the severity of vision loss. These perspectives are illustrated in the excerpt provided as follows:

> 'Vision impairment is when one cannot see well at far and/or near, with visual acuity (VA) worse than 6/18. When you can't function … due to eyesight. So, it's about functioning relying on your eyesight.' (Participant 1 (P1), District A (DA), 48 years old)

> 'My understanding of VI is when a person is unable to carry out their daily activities due to the compromised eyesight, with VA worse than 6/18, it could be partial vision loss or complete blindness.' (Participant 2 (P2), District B (DB), 50 years old)

> 'One can define vision impairment as VA less than 6/12, which includes mild VI. But again, it will depend on the type of work or activities that the person does. So for me, work and daily activities should be considered for VI.' (Participant 4 (P4), District C (DC), 52 years old)

**Sub-theme 1.2:** Distribution and causes of vision impairment: Participants' responses from self-reports based on the district's monthly data records revealed notable variations in the number of individuals presenting with VI cases across different age groups. Among children aged 0–18 years, the monthly number of uncorrected VI cases ranged between 50 and 90, whereas adults aged 19 years and older accounted for 500–700 cases per month across the districts. Based on the best-corrected vision, the number of VI cases decreased to 20–40 cases for children, and between 120 and 150 cases for adults, per month across the districts. The reported cases include both initial consultations and follow-up visits. Vision impairment was notably more prevalent among individuals aged 50 years and older across the districts. Regarding gender distribution, VI was more common among females in the adult population and males in the paediatric population.

The causes of VI varied distinctly between children and adults. Among children, the main causes of VI were oculocutaneous albinism, retinal disorders, corneal disorders, congenital and/or hereditary conditions and complications arising from vernal keratoconjunctivitis (VKC). These conditions, often manifesting early in life, if left untreated, lead to irreversible VI that affects growth development, learning and social interaction. Among adults, participants reported cataract and glaucoma as the main causes of VI – conditions which they attributed to age-related factors. Additional causes among adults included oculocutaneous albinism, corneal disorders, retinal diseases, sequelae of ocular trauma and complications arising from systemic diseases such as diabetes and hypertension. Across both age groups, participants found the use of traditional medicines for eye disease treatment and refractive errors as a common cause of VI across all districts. Participants' responses revealed epidemiological trends, patterns and socio-cultural factors that shape eye health and outcomes within the province. The distribution and causes of VI based on participants' responses are illustrated in Table 2.

### Theme 2: Leadership and governance

**Sub-theme 2.1:** District plan on prevention and management of vision impairment: Participants consistently emphasised the absence of national or district-level plans on the prevention and management of VI. Eye care services were largely fragmented, unequal and characterised by hospital-developed plans. Eye health initiatives vary across facilities depending on available resources and practitioners' discretion. Eye care campaigns, clinic- and school-based outreach visits are being implemented to facilitate vision screening, early detection and timely management of ocular conditions to promote eye health awareness in the absence of

**TABLE 1:** Themes and sub-themes from the data.

| Theme number | Themes | Subthemes |
|---|---|---|
| 1 | Description, distribution and causes of vision impairment | 1.1 Description of vision impairment<br>1.2 Distribution and causes of vision impairment |
| 2 | Leadership and governance | 2.1 District plan on prevention and management of vision impairment<br>2.2 Guidelines for vision impairment management and implementation monitoring at the hospital level<br>2.3 Barriers to implementation of the guidelines |
| 3 | Service delivery and access | 3.1 Existing intervention strategies for vision impairment management<br>3.2 Overview of clinics that offer low vision and rehabilitation services<br>3.3 Existing guidelines on referral systems for patients with vision impairment |
| 4 | Eye care workforce | 4.1 Eye care staff complement<br>4.2 Integration of low-vision services |
| 5 | Technology, assistive devices and funding | 5.1 Equipment complement<br>5.2 Availability of visual assistive devices and funding |
| 6 | Information management | 6.1 Data collection on the distribution of vision impairment<br>6.2 Planning and resource allocation |
| 7 | Awareness and health promotion services | 7.1 Awareness of vision impairment services and health promotion |
| 8 | Barriers to eye care services | 8.1 Barriers to the provision of eye care services<br>8.2 Barriers to access and uptake of eye care services |

**TABLE 2:** The distribution and causes of vision impairment across districts based on participants' reflections from monthly data records.

| District | Age group (years) | Estimated VI (Based on PVA) | Estimated VI (Based on CVA) | Gender distribution | Causes of VI |
|---|---|---|---|---|---|
| District A, Participant 1 | 0–18 | 90 | 40 | Males | Refractive errors, complications of eye allergies, use of traditional medicine, eye injuries and congenital and/or hereditary disorders |
| | ≥ 19 | 700 | 150 | Females | Refractive errors, cataracts, glaucoma, corneal diseases, eye injuries, complications of systemic diseases and the use of traditional medicine |
| District B, Participant 2 | 0–18 | 50 | 20 | Males | Refractive errors, corneal diseases, oculocutaneous albinism, eye injuries and congenital and/or hereditary disorders |
| | ≥ 19 | 500 | 50 | Females | Refractive errors, cataracts, glaucoma, corneal diseases, eye injuries, complications of systemic diseases and the use of traditional medicines |
| District C, Participant 4 | 0–18 | 70 | 20 | Males | Refractive errors, corneal opacities and hereditary conditions such as oculocutaneous albinism |
| | ≥ 19 | 600 | 120 | Females | Cataracts, refractive errors, glaucoma, complications of systemic diseases and corneal opacities |
| District D, Participant 3 | 0–18 | 80 | 30 | Males | Refractive errors, complications arising from VKC, oculocutaneous albinism, congenital anomalies and the use of traditional medicines |
| | ≥ 19 | 600 | 150 | Females | Refractive errors, cataracts, glaucoma, retinal disorders secondary to systemic diseases, corneal diseases and the use of traditional medicine |

VI, vision impairment; PVA, presenting visual acuity; CVA, corrected visual acuity; VKC, vernal keratoconjunctivitis.

a national or district plan. The management of VI included the provision of eye medications, the provision of corrective spectacles and referrals to ophthalmologists for surgical interventions and advanced care. Participants identified gaps in low vision and rehabilitation services and expressed concerns about the lack of support for individuals who might benefit from low vision and rehabilitation services across all surveyed districts. The management of low vision was limited to the provision of high-power lenses and referrals to external institutions such as university eye clinic or specialised schools for individuals with VI for further support. Some participants expressed uncertainty regarding referral pathways in hospitals within their districts, reflecting inconsistencies in patient care and eye health service delivery. These perspectives are illustrated in the narratives as follows:

> 'We don't have a national or district plan on prevention for VI. We conduct clinic and school outreach services for screening and early detection of eye diseases. For eye disease management, we recommend eye medications, provide spectacles, and refer them to an ophthalmology center in the district for further management. We are struggling with the provision of low vision devices and rehabilitation services [*as*] we never had those services in the district. So, for those who might benefit from the low vision care services, we advise them to visit the university eye clinic for assistance.' (P1, DA, 48 years old)

> 'We just use self-developed hospital plans, as we do not have anything from the national or head office. Hence, you will find that it is not uniform and not reflected at the provincial level. Concerning preventative care, we conduct school and clinic outreach services for vision screening, health education and referral. For management, we provide spectacles, recommend eye medications, and referrals to the ophthalmologist for those who need further management. For individuals who might benefit from low vision care services, we advise them to visit the university eye clinic for management, but this is based on the practitioner's discretion.' (P3, DD, 48 years old)

> 'We don't have a district plan. We aligned our services to other professions within the hospital on prevention, where we conduct school and clinic outreach services … We refer eye pathology cases to the ophthalmic medical registrar and provide spectacles for those who might benefit from refractive error correction. We do not provide low vision care services; however, we advise individuals with low vision to visit a special school for people with VI for support. I'm not sure if other hospitals in the district use the same approach!' (P4, DC, 52 years old)

**Sub-theme 2.2:** Guidelines on vision impairment management and monitoring implementation at the hospital level: Participants' responses showed that protocols primarily designed to guide the initial assessment of individuals presenting for ECS were distributed to hospitals across the districts. However, their implementation was incomplete and inconsistent. Participants attributed this gap to resource constraints, particularly for the management of specific conditions such as low vision cases. This resulted in variations in adherence to assessment guidelines between facilities and among practitioners. This further hinders the delivery of coordinated ECS across the districts. In addition, participants found a lack of monitoring mechanisms for adherence to protocols at the hospital level across districts. There were no formalised or standardised guidelines documented regarding the management of VI cases. Emergency eye cases were referred to ophthalmologists or the ophthalmic medical registrar, while non-emergency cases were managed at the hospital level, with some patients placed on waiting lists for further care, which often delays access to care. This is illustrated in the excerpts as follows:

> 'We only have a protocol on patient assessment, and not management. And, again, implementation is a challenge due to a lack of equipment and trial devices. We refer emergency cases to the ophthalmologist and use waiting lists for non-emergency cases. So management is based on [*the*] practitioner's discretion, but we encourage practitioners to consult for a second opinion when in doubt.' (P1, DA, 48 years old)

> 'We just have protocols for patient assessment only, but again it is not fully implemented because of a lack of resources… there are no guidelines for management of specific conditions. Yes, some protocols for assessment are there, but you just end up being frustrated due to a lack of equipment and trial devices, especially for low vision cases. We refer emergencies to tertiary hospitals, and use waiting lists for non-emergency cases.' (P3, DD, 48 years old)

**Sub-theme 2.3:** Barriers to implementation of the guidelines: Participants' responses reflect the lack of support, professional recognition, established guidelines for the management of eye diseases and opportunities for continuous professional development as barriers that hindered the implementation of protocols. Additional barriers included insufficient equipment and human resources, limited access to low-

vision devices and a loss of interest among eye care professionals. The absence of adequate financial support was perceived as a key barrier that eroded staff motivation. Their responses are illustrated as follows:

> '… Remember, we are resource-constrained, both in the districts and the province. You know, when you don't have the budget, almost everything will just fall out. I think we lost interest and courage because all our efforts seemed fruitless due to a lack of recognition and support from management, including national health. We do not have support from the national, as other professions, it's that bad. Other than that, we just use our discretion on referral to the ophthalmologist in the district.' (P1, DA, 48 years old)

> 'The main problem is education and knowledge. Some colleagues are unaware of existing protocols for patient assessment, so implementation becomes an issue, as you cannot implement what you don't know. Again, we do not have protocols for the management of eye diseases, not that I know. Our challenge is the lack of support and resources like budget, low vision devices, and equipment.' (P2,DB, 50 years old)

> 'Lack of support from the national level for ECS. Now, the structure of ECS is compromised somewhere, somehow, from up there. Yes, ECS are not getting the expected support from the national level, and this has demoralised us. Lack of equipment, budget, and manpower. As you know, low vision services are expensive.' (P3, DD, 48 years old)

### Theme 3: Service delivery and access

**Sub-theme 3.1:** Existing intervention strategies for vision impairment management: Participants' responses revealed that the intervention strategies for managing VI encompassed a combination of spectacle provision, treatment of eye diseases and referral for specialised and emergency cases. An ophthalmology waiting list system was implemented for non-emergency cases, allowing facilities to manage patient flow with limited resources. Children and individuals with bilateral vision loss are given priority, reflecting the awareness of the significant functional impact of visual loss on daily functioning and QOL. Participants showed that patients with low vision were encouraged to seek support and care from external dedicated low vision centres elsewhere. Participants' accounts collectively depicted a resource-constrained and adaptive pattern of care, where decisions were shaped by the severity and urgency of the condition, affordability of services and access to other levels of care:

> 'So, our management include: referral of emergency cases to the ophthalmologist, the use of waiting lists for non-emergency cases, recommendation of eye medications, provision of spectacles, and referral to the keratoconus clinic at [**hospital]. We also encourage low vision patients who can afford it to visit the university optometry department. So, we prioritise the children and emergencies for referral to the ophthalmologist.' (P1, DA, 48 years old)

> 'Concerning the management of VI, we refer emergencies to a tertiary hospital, recommend eye medications, issue spectacles, refer keratoconus to [**hospital] and use a non-emergency waiting list. We refer children with low vision to special schools, and those who are 18 years and older, we advise them to visit the centre for vocational training for visually impaired people for support. I'm not sure if other colleagues in the district are referring their patients.' (P2, DB, 50 years old)

> 'So far, our management includes provision of spectacles… We refer low vision cases to the special school nearby. The medical registrar performs some surgeries, and manages pathologies…' (P4, DC, 52 years old)

**Sub-theme 3.2:** Overview of clinics that offer low vision and rehabilitation services: Participants revealed a pattern of limited services within districts. Only one hospital provided contact lens services. In addition, no clinics within the province's public hospitals provided low vision devices or rehabilitation services as part of their routine eye care service offerings. Participants relied on referral to external centres for low vision and rehabilitation services. Participants' accounts reflected a fragmented referral system and service delivery shaped by limited resources:

> 'We have eight hospitals providing eye care services, but no low vision care services. We refer those who can benefit from contact lenses to [**hospital]. We do not have a low vision centre or special school for low vision rehabilitation services in the district. We advise interested patients to visit the university's low vision department for assistance.' (P1, DA, 48 years old)

> '… Only [**hospital] offers keratoconus services at the moment … it's a tertiary hospital and serves the whole province. Otherwise, some of the patients are advised to visit the university optometry department for low vision care services since there's no hospital offering low vision care services.' (P3, DD, 48 years old)

> '… There is no hospital that offers low vision rehabilitation and/or keratoconus services in our district … We refer low vision cases to a special school for individuals with visual impairment.' (P4, DC, 52 years old)

**Sub-theme 3.3:** Existing guidelines on the referral system for patients with vision impairment: Participants' responses revealed variations in referral practices for patients with VI. Districts equipped with ophthalmology services allocated specific days for referrals to the district ophthalmology centre, whereas other districts referred patients directly to tertiary hospitals. Participants noted the absence of standardised referral guidelines as a hindrance to the effective management of individuals with VI. Referrals to ophthalmologists or low vision care centres were determined based on the clinical discretion of the referring clinician and the preferences of the patients in the absence of standardised referral guidelines. This is illustrated in the following excerpts:

> 'Ok, we have allocated days for referrals to the ophthalmologist in the district. Emergency cases are referred immediately in consultation with the ophthalmologist. For non-emergency cases, we use the waiting list [*system*], but there are no guidelines for all referrals.' (P1, DA, 48 years old)

> 'There are no guidelines on referral, per se! But, with referral to a tertiary hospital, we use a register book for the waiting list of non-emergency conditions. For emergencies, we refer immediately … and for low vision cases, we advise patients to visit the university eye department, but it is the clinician's discretion and patient's interest as well.' (P3, DD, 48 years old)

### Theme 4: Eye care workforce

**Sub-theme 4.1:** Eye care staff complement: Participants' accounts revealed an uneven distribution of the eye care workforce across the districts. The eye care workforce comprises optometrists, ophthalmic nurses and ophthalmologists. The number of optometrists varied from 19 to 24 per district, while the number of ophthalmic nurses ranged from 6 to 11 per district, reflecting limited staffing levels relative to service demand. Participants' responses showed that ophthalmology services were available at only three public hospitals, comprising one tertiary and two primary-level hospitals in different districts. Optometry services were delivered at 37 public hospitals and one health centre. There was a notable shortage of staff in remote areas, and a lack of other allied healthcare staff, such as mobility and orientation officers. Table 3 provides an overview of the eye care workforce across districts as reported by participants.

**Sub-theme 4.2:** Integration of vision impairment services: Participants' accounts revealed a fragmented pattern of multidisciplinary collaboration in the management of VI. Vision impairment services were partially integrated into the multidisciplinary team, with the involvement of other healthcare practitioners determined at the clinician's discretion in the absence of established guidelines. This is illustrated in the excerpt as follows:

> 'The services are not really integrated due to a lack of guidelines. We just use clinician's discretion to refer to other practitioners … and mostly refer to the general practitioner … But with referral for psychological counselling and other vision rehabilitation services, that is where we still lack.' (P3, DD, 48 years old)

> 'The services are not really integrated due to a lack of standardised guidelines. We just use the clinician's discretion for referral to other practitioners. In our facility, optometrists manage refractive errors, and the medical registrar manages all pathology cases. Concerning referral for psychological counselling and other vision rehabilitation services, that is where we are still experiencing challenges, because there are no guidelines.' (P4, DC, 52 years old)

### Theme 5: Technology, assistive devices and funding

**Sub-theme 5.1:** Equipment complement: Participants' responses revealed a limited and uneven distribution of resources across the districts. While hospitals generally possessed similar basic eye care equipment for routine eye assessments, such as a diagnostic set, Snellen visual acuity chart, tonometer and trial lens and frame sets, the absence of more advanced or specialised equipment limited the range of clinical services that could be offered. Additionally, all hospitals faced significant challenges in maintaining an adequate supply of consumables required for the proper functioning of the available equipment. Participants' responses are illustrated as follows:

> 'We only have the, basic equipment like Snellen acuity charts, trial case and frames, tonometer and diagnostic sets. We have a serious challenge with the procurement of consumables and the maintenance of equipment.' (P2, DB, 50 years old)

> '… All optometry clinics are basically equipped with Snellen acuity chart, tonometer, diagnostic set, trial cases and frame … procurement of consumables is still a challenge at some hospitals… Of course, the tertiary hospitals are better equipped with latest technologies such as fundus camera, including ocular coherence tomography machine at [***hospital*] … and that's why we are able to refer keratoconus patients to them…' (P3, DD, 48 years old)

**TABLE 3:** Eye care workforce overview based on categories across the districts.

| Staff category | District | | | | Facility level |
|---|---|---|---|---|---|
| | A | B | C | D | |
| Ophthalmologists and/or medical registrar | 3 | 0 | 1 | 9 | Tertiary and primary |
| Optometrists | 20 | 22 | 19 | 24 | Tertiary, secondary, primary and health centre |
| Ophthalmic nurses | 6 | 6 | 10 | 13 | Tertiary, secondary and primary |

**Sub-theme 5.2:** Availability of visual assistive devices and funding: Participants consistently highlighted the persistent insufficient budget allocation for spectacles, consumables and the absence of assistive devices and technologies for low vision care across the districts. Their responses reflect the impact of insufficient budget allocations on the continuity of spectacle provision, with primary-level hospitals mainly constrained because of recurrent budget cut-offs. The provision of assistive devices across the districts was predominantly limited to spectacles, reflecting a systemic gap in the availability of low vision devices within public hospitals. At times, the districts depended on frequent donations of lenses from non-profit organisations (NPOs) to meet the patients' eye health needs, highlighting the significant contributions of external organisations to service delivery. Participants emphasised that the lack of funding for low vision devices constituted a critical gap in the district's capacity to provide comprehensive care. Specialised services, such as contact lens services, were available exclusively at one of the tertiary-level hospitals. The funding for spectacles and contact lenses was derived from the Department of Health, donations from NPOs and, in some cases, through out-of-pocket co-payments by patients:

> 'We provide spectacles funded by the department and those donated by the NPO. Otherwise, we are struggling with funding for assistive devices, and the experience is worse at primary-level hospitals due to budget constraints.' (P1, DA, 48 years old)

> 'The only funding we have is for spectacles from the department, but it's never enough. At times, we receive donations of spectacle lenses from the NPOs, which assist us a lot. But we do not provide low vision devices.' (P2, DB, 50 years old)

> '… Only one tertiary hospital provides contact lens services. The services are funded by the Department of Health, and at times, patients have to contribute out of pocket to purchase contact lenses.' (P3, DD, 48 years old)

### Theme 6: Information management

**Sub-theme 6.1:** Data collection on the causes of vision impairment: Participants' responses demonstrated a consistent reliance on multiple data sources to monitor the trends of causes VI and service demand across districts.

Monthly statistics, non-emergency patient registers and spectacle waiting lists were routinely used to assess the patterns of VI. The manual registers and electronically captured data served as key sources for interpreting patients' eye health needs and monitoring both service backlogs and overall demand. Collectively, the accounts underscore the significant function of these data sources in monitoring trends in VI and the demand for ECS across districts. This is illustrated in the excerpt as follows:

> 'We use monthly statistics and the register for the cataract waiting list and other non-emergency cases, including those who need spectacles.' (P1, DA, 48 years old)
>
> '… So we use monthly statistics, spectacle and non-emergency waiting lists to collect information on the causes of VI. Yeah, that's what we are doing so far …' (P3, DD, 48 years old)
>
> 'We use the monthly statistics, non-emergency registers, and spectacle waiting lists …' (P4, DC, 52 years old)

**Sub-theme 6.2:** Distribution and allocation of resources: Participants' responses showed reliance on monthly statistical data, spectacle order records and reports to understand the emerging trends in eye diseases and the demand for ECS within their districts. The data were actively interpreted to guide strategic planning, strengthen advocacy for improved ECS provision and inform decisions on the distribution of resources. Participants' responses are reflected in the excerpt as follows:

> 'Ok, the monthly statistics assist with prioritisation during planning and resource distribution. We are able to check disease trends in the district and prioritise during allocation of resources.' (P2, DB, 50 years old)
>
> 'So, the statistics reflect what is happening at the ground level. So the statistics provide a snapshot of eye disease distribution in various subdistricts, their patient intake and demands for eye care services. So, we can distribute resources looking at that.' (P3, DD, 48 years old)

### Theme 7: Awareness and health promotion services

**Sub-theme 7.1:** Awareness of vision impairment and health promotion services: Participants' responses revealed that hospitals frequently organise routine eye care awareness initiatives to promote eye health education and provide vision screening services. Furthermore, some colleagues secure radio slots with their community radio stations to deliver eye health education. Collectively, these responses illustrate a commitment to community engagement as a key component for eye health promotion. Their responses are illustrated in the excerpts as follows:

> 'We regularly conduct eye care awareness campaigns for vision screening and eye health education. Other colleagues get slots at their local radio stations for presentations on eye health and care.' (P1, DA, 48 years old)
>
> 'We conduct regular clinic and school outreach services, awareness campaigns, and some do presentations at local community radio stations for community empowerment.' (P4, DC, 52 years old)

### Theme 8: Barriers to eye care services

**Sub-theme 8.1:** Barriers to the provision of eye care services: Participants' responses revealed a system constrained by persistent underfunding and inadequate support for ECS. The limited budget allocations interrupt the supply of spectacles and hinder the procurement of essential equipment and assistive devices, leaving staff to improvise and contribute to the loss of clinical skills. Additional barriers include a shortage of assistive devices, transportation, necessary equipment, inadequate working space and the eye care workforce, particularly ophthalmic nurses and orientation and mobility trainers. Participants also highlighted erosion of professional skills and interest, inadequate training opportunities, limited knowledge, scarcity of educational materials and the overburdening of ophthalmology centres. Overall, these accounts illustrate a system constrained by budget limitations, workforce shortages, inadequate infrastructure and a weak support system for ECS. Their responses are illustrated in the excerpts as follows:

> 'I'll say lack of budget; the budget is always limited for spectacles and is shared with the audiology section for hearing devices. So, lack of assistive devices, equipment, and working space. We just improvise in most instances, and this demoralises our staff because they end up losing skills due to a lack of frequent practice. Lack of knowledge, workshops and support, including from the national department. There is a shortage of ophthalmic nurses, a lack of mobility and orientation training officers, and overburdened referral of ophthalmology centres.' (P1, DA, 48 years old)
>
> '… The main barriers include: the lack of prioritisation of eye care services from the national and provincial governments. Lack of budget, equipment, eye care personnel, lack of assistive devices, demoralised personnel, lack of recognition and transport.' (P4, DC, 52 years old)

**Sub-theme 8.2:** Barriers to access and uptake of eye care services: Participants' responses reflect multiple barriers to accessing ECS, shaped mainly by poverty and insufficient financial support. Additional challenges included limited transportation, low literacy levels and inadequate eye-health-seeking behaviours. The uptake of VI services is further hindered by a lack of awareness, denial of VI and minimal family support. Additional barriers include cultural beliefs, such as attributing vision loss to witchcraft, prompting some patients to seek help from traditional healers before visiting hospitals. Overall, financial constraints and limited eye health knowledge significantly hinder the timely use of ECS. This is illustrated in the following excerpts:

> 'Most barriers for patients are cultural beliefs. Patients delay hospital consultation and present when their eyes are complicated. Another thing is the issue of finance because not everybody can afford to come to the hospital and make spectacles payments due to poverty. Lack of awareness, poor eye-care seeking behaviour, and poor literacy level.' (P2, DB, 50 years old)
>
> 'We conduct eye care awareness campaigns for continuous eye health education. Others give presentations at their local community radio stations during eye care awareness month.' (P3, DD, 48 years old)

# Discussion

The provision of comprehensive ECS is essential to reduce avoidable VI and promote optimal eye health. Consequently, the services enable affected individuals to achieve optimal independence, increase vision-related QOL concerning psycho-social well-being and physical health, improve educational achievements and better participate in social, economic, political and cultural aspects of life.[1,5,6,7,9] This study reports on the perceptions of district coordinators on ECS to gain insights into the patterns and outcomes of these services in the public hospitals within Limpopo province, South Africa.

## Description, distribution and causes of vision impairment

In this study, VI was described as a partial or complete loss of vision that significantly impacted ADL. Participants' shared responses reflected both a quantified understanding of VI, described in terms of visual acuity, and its impact on an individual's ability to participate in daily activities, regardless of the severity of vision loss. The use of visual acuity to characterise VI aligns with the World Health Organization (WHO)-recommended classification standards.[6] This description of VI encompasses functional vision, which relates to how an individual functions when performing ADL.[28,29] Participants reported a high number of VI cases among individuals aged 50 years and older, females in the adult population and males in the paediatric population. Similar findings were reported in an earlier study conducted in the province, where individuals aged 50 years and older showed a higher risk of VI.[10] This may be attributed to the increased risk of age-related eye diseases associated with increasing age among this population.[1,2,6,30] In addition, VI was perceived as more common among females in the adult population, a finding consistent with the reports of other studies.[1,2,31,32,33] The higher prevalence of VI among females might be attributed to their higher life expectancy, predisposing them to increased risk of developing age-related eye diseases, lack of prioritisation of women's health because of cultural beliefs, limited access to ECS for women and poverty.[34] The increased number of VI among the males for the paediatric population may be because of complications associated with ocular surface diseases such as VKC that commonly affect male children.[1,35,36,37]

The main causes of VI among children were refractive errors, corneal disorders, complications associated with eye allergies, albinism and retinal diseases. Among adults, the main oculocutaneous of VI included refractive error, cataracts, glaucoma, albinism, corneal disorders, retinal diseases, sequelae oculocutaneous trauma and complications arising from systemic diseases. The causes of VI among children and adults in this study are similar to those reported earlier within the country[38] and in LMICs.[1,9] The majority of the causes of VI reported by participants were avoidable or treatable. Some of the factors that explain the high prevalence and causes of VI in LMICs include poor access, availability and affordability of comprehensive ECS, low eye care literacy levels, high poverty rates, limited access to ophthalmology services and a lack of sustainable refractive error coverage in public hospitals in these regions.[1,9] The use of traditional medicine for treatment of eye diseases was reported as a common occurrence in both children and adults. This finding is similar to those reported in other African countries, including South Africa.[39,40,41] The use of traditional medicines to treat eye diseases was attributed to cultural factors, a lack of eye health education, poor access, affordability and failure of the healthcare system to deliver comprehensive ECS.[22,23,42,43,44]

## Leadership and governance

Findings from this study highlight gaps in the prevention and management of VI at the national level, emanating from limited eye health guidelines, policies and plans. The absence of such policies, plans, coupled with partial implementation of the guidelines, and the lack of monitoring mechanisms likely contribute to compromised ECS delivery in the public hospitals of the province. These factors further highlight underlying health system weaknesses that hinder efforts to eliminate avoidable blindness. Similar findings of fragmentation and lack of integration of ECS within health policy documents in South Africa that accounted for the lack of comprehensive ECS in public hospitals in the country were reported.[15,45,46] The gaps in the national policies, programmes and plans may have hindered effective implementation of the recommended strategies, including guidelines aimed at preventing avoidable blindness at provincial and district levels.[38] The development, implementation and monitoring of integrated national eye health policies, plans and programmes into health systems to enhance eye health outcomes are necessary to reduce the burden and impact of VI.[22,23,47] The inadequate integration of ECS into national health policies adversely impacts the majority of individuals who rely on public hospitals for ECS.

## Service delivery and access

Findings from this study showed that the management of VI in Limpopo province included the provision of spectacles, disease management and referrals for further management to the ophthalmologists, schools for individuals with low vision, and the university. However, prolonged waiting lists for cataract surgery services, poor access, non-sustainable provision of spectacles and lack of low vision and rehabilitation care centres may contribute to the poor uptake of ECS in the public hospitals within the province. Similar factors were reported as barriers to the utilisation of ECS in other studies.[48,49] The variations in patient referral practices may be attributed to the absence of standardised referral guidelines, undermining continuity of patient care. Consequently, patients may be prompted to seek alternative or informal care such as unregulated medicines, which may worsen their eye health outcomes. Other factors contributing to the variations in referral practices and inadequate management of patients with irreversible VI may be the lack

of recognition of specialised services, such as low vision rehabilitation care, and the lack of equipment for diagnosis and management of certain eye conditions, such as keratoconus cases. These factors may hinder practitioners' ability to provide appropriate diagnostic and therapeutic interventions for optimal outcomes.[48] There are persistent gaps for low vision and rehabilitation services access across the public hospitals within Limpopo province despite early recommendations for the establishment of such clinics at primary and/or secondary hospital levels.[38] Strengthening the partnership between governmental departments, NPOs and academic institutions may provide a better strategy for improving the provision of comprehensive ECS and referral pathways, particularly in resource-constrained settings.[50]

## Eye care workforce and integration of services

Findings from this study showed that ECS in public hospitals of Limpopo province were mainly provided by optometrists, ophthalmic nurses, ophthalmic medical registrars and ophthalmologists. Participants found a shortage of staff, such as ophthalmic nurses, and the absence of other essential eye care personnel, such as mobility orientation officers, whose roles are critical for vision rehabilitation. These findings are consistent with those reported earlier in the province.[11,46] The existing shortages of eye care staff may be attributed to the growing population size, increased service demand and expanded geographical coverage. Despite that Limpopo province has commendable coverage of optometrists in public hospitals compared with other provinces in the country,[51] the severe shortage of ophthalmic nurses in the surveyed districts may compel optometrists to assume ophthalmic nurse duties, thereby limiting their ability to focus on key optometry services such as low vision care, orthoptics vision therapy and keratoconus management. Similar findings of shortage of eye care staff were reported as barriers to increasing cataract surgery rates in the country, with surgeons mostly performing non-surgical services such as screening, refractions and administration.[52] The shortage of practitioners in public hospitals, including remote areas, may be because the majority of eye care practitioners opt for employment in the cities or the private sector, and this results in inadequate coverage in public hospitals.[53] The shortage of ophthalmic nurses might be because of a lack of continuous training, the replacement of those who exit the health system because of retirement and misallocated ophthalmic nurses in pursuit of flexible working conditions in hospitals.[46] The number of eye care practitioner-to-population in this study is below the national health recommended targets, with this being 1: 100 000 for ophthalmic nurses, 1:250 000 for optometrists and 1:1 000 000 for ophthalmic medical registrar or ophthalmologist in South Africa.[38] This suggests the need to re-evaluate the recommended human resource targets for ECS per population size in health facilities within the country, considering population growth and eye care service demand, as the majority of the population in the country relies on public hospitals for healthcare services.[13,38] It also hints a broader challenge in eye healthcare in the country, likely emanating from inadequate integration of eye health policies within the overall health system. The shortage of eye care staff has been associated with high magnitude of VI, suggesting the need for health authorities to increase the staff compliment and integrate ECS within the health system to reduce the burden of VI.[53]

## Technology, visual assistive devices and funding

The majority of public hospitals from surveyed districts were equipped with basic eye care equipment; however, hospitals faced significant challenges regarding equipment maintenance, including maintaining an adequate supply of consumables required for their proper functioning. As a result, the lack of adequate and functional equipment means that many hospitals fail to meet the minimum equipment standards for comprehensive eye examinations recommended by the Professional Board for Optometry and Dispensing Opticians.[54] Similar findings have been reported in the country,[46,55] where minimum standards of optometric care were not practised because of outdated technology and a lack of equipment. These could be attributed to poor prioritisation of eye health services by the health authorities.[6,19]

An early report[10] showed a substantial decrease in VI after optical correction, and an increased presence of cataracts, suggesting that the majority of causes of VI among patients in the Limpopo province were treatable through optical and surgical intervention. Despite these findings, this study highlights that the provision of spectacles was often interrupted because of constraints in the procurement processes, contact lens care services were limited to only one tertiary-level hospital, and there were prolonged cataracts waiting lists. Additionally, no health facility offered low vision care. This suggests the need for health authorities to prioritise the provision of optical devices such as spectacles, contact lenses, low vision devices and increase cataract surgery coverage.

## Awareness of vision impairment services and eye health promotion

The eye care awareness initiatives were frequently organised to promote ocular health education and provide vision screening services in Limpopo province. This assertion is supported by Masemola et al.,[46] wherein it was also found that eye care practitioners in Limpopo province actively engaged in outreach services for vision screening and eye health promotion. Such initiatives are notable as early identification and intervention of ocular diseases and injuries may prevent the development of complications and impairments.

## Barriers to eye care services

The barriers to ECS were attributed to the lack of support and national policies for eye health, limited budgetary allocation, lack of assistive devices, inadequate equipment, consumables and working space and insufficient personnel,

particularly low vision rehabilitation professionals. Other barriers included erosion of professional skills and interest, inadequate training opportunities, limited knowledge, scarcity of educational materials, limited optometry services and insufficient ophthalmologists. These findings are similar to those reported in South Africa.[45,46,52,55] The main barriers to access and uptake of services were poverty, lack of financial support, limited transportation, low literacy levels, inadequate eye health–seeking behaviours, a lack of awareness, cultural beliefs, denial of VI and insufficient family support. These socio-demographic characteristics have been shown to impact access and uptake of ECS in previous studies.[1,2,10,22,56,57,58]

### Strength and limitations

The strength of this study includes use of an interview guide that was designed based on review of relevant literature to ensure methodological consistency, reproducible findings and comparability with other studies. Furthermore, the inclusion of participants with relevant experiences provided richer insights on ECS in public hospitals within the Limpopo province. While the study may be susceptible to information bias because of participants being optometrists, ECS in the province are primarily coordinated by optometrists, making them apt sources of information regarding these services and outcomes thereof. Nevertheless, these findings should be interpreted with caution, as they may not be representative of the other district coordinator's perceptions, particularly in district not included in the study. In addition, the researcher works as an optometrist at a public hospital and, therefore, participants' responses may have been influenced by the researcher's subjective perspective. Although this is possible, the interpretation and analysis of the study findings were performed by a research team to reduce potential bias associated with a single-researcher interpretation. Additionally, adherence to the interview guide may have limited the extent of the exploration on certain topics. Despite these limitations, this study provides valuable insights for policymakers, health authorities and eye care professionals, facilitating the effective planning of comprehensive ECS. This study also offers a foundation for future research.

## Conclusion

The provision of comprehensive ECS in public hospitals of Limpopo province is constrained and inadequately integrated into the health system. The prevalence of VI reported in this study was high, and the majority of causes of VI were avoidable. There is a paucity of national policies, guidelines for eye health, a shortage of eye care personnel, inadequate equipment and limited provision of assistive devices. Comprehensive ECS programmes that focus on eye health promotion, prevention, treatment and rehabilitation services in the public hospitals of Limpopo province are necessary to reduce the burden of VI. Such programmes will improve the ECS and improve the experiences of patients who utilise public hospitals for these services.

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Related work has addressed complementary aspects of this research area. Specifically:

- The prevalence, causes and factors associated with vision impairment in Limpopo province were investigated through a retrospective chart review, with findings published in the *African Vision and Eye Health* journal. https://doi.org/10.4102/aveh.v83i1.956

- Optometrists' perspectives on the availability of vision impairment services, barriers to provision and uptake in public hospitals of Limpopo province, with findings published in the *African Journal of Disability*. The study population for this work comprised optometrists employed in the public sector within the province. https://doi.org/10.4102/ajod.v14i0.1559

This article builds on these foundations but addresses a distinct research question. It focuses on the perspectives of optometry district coordinators regarding the provision of eye care services in public hospitals of Limpopo province. Accordingly, the study population consists of district-level optometry coordinators working within the province's public hospitals.

### Competing interests

The author reported that they received funding from the University of KwaZulu-Natal's College of Health Sciences Scholarship, which may be affected by the research reported in the enclosed publication. The author has disclosed those interests fully and has implemented an approved plan for managing any potential conflicts arising from their involvement. The terms of these funding arrangements have been reviewed and approved by the affiliated university in accordance with its policy on objectivity in research.

### CRediT authorship contribution

Modjadji M. Leshabane: Conceptualisation, Formal analysis, Investigation, Methodology, Project administration, Resources, Visualisation, Writing – original draft. Nishanee Rampersad: Data curation, Formal analysis, Funding acquisition, Supervision, Visualisation, Writing – review & editing. Khathutshelo P. Mashige: Conceptualisation, Data curation, Formal analysis, Funding acquisition, Project administration, Supervision, Validation, Writing – review & editing. All authors reviewed the article, contributed to the

discussion of results, approved the final version for submission and publication, and take responsibility for the integrity of its findings.

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## Data availability

The data that support the findings of this study are available from the corresponding author, Modjadji M. Leshabane, upon reasonable request.

## Disclaimer

The views and opinions expressed in this article are those of the authors and are the product of professional research. It does not necessarily reflect the official policy or position of any affiliated institution, funder, agency or the publisher. The authors are responsible for this article's results, findings and content.

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