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RESEARCH

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Frequency and causes of visual impairment in people attending outreach clinics in Zambia

Cheralynn Saunders, Neema Ghorbani-Mojarrad, Brendan T Barrett, Alexander G Swystun and Christopher J Davey

School of Optometry and Vision Sciences, University of Bradford, Bradford, UK

ABSTRACT

Clinical relevance: Preventable visual impairment and blindness represent significant global public health challenges. Expanding access to high-volume eye care services in underserved areas may reduce visual impairment and blindness.

Background: Visual impairment negatively impacts quality of life, education, and employability, but is often treatable with management following a basic eye examination. Access to basic eyecare in Zambia is limited. Vision Action, a UK-based non-governmental organisation, facilitates eyecare services in Zambia to reduce rectifiable visual impairment by supporting government outreach clinics in underserved communities. This study examines the frequency of presenting visual impairment, uncorrected refractive error, and ocular pathology among outreach clinic attendees in Zambia.

Methods: A retrospective analysis of outreach clinic records between 2012 and 2015 was performed. The available data include patient demographics, presenting symptoms, presenting level of vision, and classification of any ocular pathology present. Levels of visual impairment were categorised according to the World Health Organization's classification for blindness and visual impairment.

Results: Data from 5809 patients were collected (58.5% female, mean age = 41.9 years, SD = 20.7 years). Presenting vision, in the better eye, was classified as 'moderate visual impairment' in 14.2% (*n* = 766), 'severe visual impairment' in 0.3% (*n* = 15) and 'blind' in 4.3% (*n* = 234) of individuals. Uncorrected refractive error was responsible for 62.4% and 57.0% of blindness and severe visual impairment, respectively. Cataract, corneal scarring, and glaucoma were the most common non-refractive ocular pathologies associated with visual impairment.

Conclusion: Uncorrected refractive error is the leading cause of blindness and visual impairment in patients presenting to outreach clinics in Zambia and is particularly significant in a predominantly working-age population. Outreach clinics are an effective method of detecting and treating correctable visual impairment in this population. However, there is a need to expand and enhance primary eyecare services to reduce the burden of visual impairment, through management of uncorrected refractive error.

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Introduction

The World Health Organization estimates that globally 2.2 billion people are living with a visual impairment (VI), and half is estimated to be preventable or rectifiable.[1] Due to increasing life expectancy and improved socio-demographic factors around the world, the global population is ageing, with an associated increase in the prevalence of disability, disease, and VI.[2,3] Specifically, global predictions estimate that the population over 60 years of age will double from 11% to 22% of the total population by 2050.[4]

Alongside this ageing global population, the World Health Organisation has also reported that the leading causes of VI in adults are as follows: age-related macular degeneration, cataract, diabetic retinopathy, glaucoma, and uncorrected refractive error (URE).[1] In Africa, several studies have found cataract, glaucoma, corneal scarring, and uncorrected or under-corrected refractive error to be the leading causes of blindness and severe VI.[2,5–7]

CONTACT Christopher J. Davey c.j.davey1@bradford.ac.uk School of Optometry and Vision Sciences, University of Bradford, Bradford, UK
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Reduced vision caused by URE can be easily managed with appropriate refractive correction.[8,9] However, in cases where refractive error is not corrected, or is inadequately corrected, the resulting poor vision can have a considerable impact. Persons may suffer a loss of educational or employment opportunities and a resultant poorer quality of life.[8] On an international level, it has been reported that annually, up to US $202 billion of global income (~20% of the Gross World Product) is lost solely due to reduced vision caused by URE.[10] Similarly, it has been suggested that URE also contributes towards reduced household income and lower economic gain at a national level.[8,9,11]

Low- and middle-income countries, such as those in sub-Saharan Africa, have a disproportionate health care service demand; 90% of global disease is found in low- and middle-income countries despite having access to only 10% of the global health care resources.[12] Eyecare is no exception and, therefore, URE is a significant obstacle to economic growth in the developing world.[5,8,9,11]

Located in sub-Saharan Africa, Zambia is a lower-middle-income country,[13] with a rapidly growing population, having increased from approximately 13 million in 2010, to more than 18 million in 2021.[14] Zambia has high levels of socio-economic deprivation,[13] and some of the lowest levels of eyecare globally.[5,11] Reports from the Zambian Ministry of Health in 2017 (https://www.moh.gov.zm/?wpfb_dl=3) suggest existing eyecare programs within the country at the time were inadequate and largely confined to selected localities. Health services within Zambia are largely limited due to infrastructure and human resource deficiency, relative to other similar lower- middle-income countries.[11,14–16] This indicates that there is a critical need for additional healthcare facilities, to enable service delivery, and proper coordination, of eye health services across the country.[17]

In 2011, it was reported that Zambia had only one health care worker per 1000 population,[15] compared to a global recommendation of 2.3 health care workers per 1,000.[16] In ophthalmology at the same time, there was a ratio of only one ophthalmologist to 556,000 people in the population.[14,16] These low numbers of health care workers in Zambia are attributed to several potential causes: emigration, death of staff, and inadequate training of health care workers.[16]

Currently, non-governmental organisations support ophthalmic, refractive, and optical educational service provision within Zambia, and in other socio-economically deprived countries.[11] One such organisation, working in Zambia, is Vision Action (https://www.visionaction.org.uk/).[18]

Vision Action is a United Kingdom-based charity working predominantly to give people living in poverty access to affordable eyecare services.[18] In recent years, this has expanded to training and education of eyecare workers, establishing eye examination centres and supporting community outreach services, facilitated by professionally trained optical volunteers from the United Kingdom.[18] At outreach centres, the focus of this study, volunteers aim to examine and supply spectacles to as many patients as possible, during short-duration, high volume eye camps.[19]

When reporting on the characteristics of poor vision, authors may describe VI as the impairment of best-corrected distance visual acuity, that is whilst using the most appropriate refractive correction and defined in the International Classification of Diseases, 11th Revision.[20] Alternatively, one can define VI using the *presenting* distance visual acuity, including the use of the habitual spectacles of an individual, where a person has these, or unaided where no glasses are worn. To assess and account for VI due to refractive error, it is suggested that the latter approach is more appropriate, particularly in areas like sub-Saharan Africa, to accurately assess functional levels of vision.[8,9] This is because presenting visual acuity is more indicative of the actual impairment individuals face daily, compared to best corrected visual acuity.

The present study examines the frequency of VI observed in Vision Action-supported outreach clinics in Zambia, from eye examinations carried out by volunteers, between 2012 and 2015. The aims of the study are to determine the extent and magnitude of VI based on the presenting levels of visual acuity, to reveal the variety and frequency of ocular pathology in the sample, and to quantify the extent to which the VI is due to URE.

Methods

This study was a retrospective analysis of all eye examination records, completed by United Kingdom-qualified examining optometrists, of patients who self-presented to every Vision Action outreach clinic in Zambia between 2012 and 2015. These records were taken from a range of locations and volunteer teams, working within Zambia during this time (Figure 1).

Figure 1. Map of Zambia illustrating the primary provinces and the locations of vision outreach clinics, with clinic positions mapped to the nearest town.

Clinics at a particular location were typically conducted in clusters over several consecutive days. However, at three locations, clinics were repeated with intervals of more than 12 months between them. This project is a case record audit and did not require formal ethical approval, and no patient identifiable data were recorded by the research team.

Vision Action volunteers were advised to document, for each eye, 'vision', 'prescription', 'distance visual acuity', 'reading addition' (or near prescription), 'near visual acuity', and 'all eye pathology detected' on the record of each patient reviewed in the audit.[19] There were no standardised tests or testing conditions, and all assessments were conducted at the discretion of the optometrist performing the eye examination. Consequently, not all patients underwent refraction; for example, individuals who presented with normal visual acuity and reported no overt symptoms, may not have in fact been refracted.

Furthermore, in cases where refraction was performed, it may not have been cycloplegic (in either adults or children) unless it was deemed explicitly necessary by the practitioner performing the examination. Additionally, testing locations varied, with some conducted outdoors in natural light and others indoors, either with or without artificial lighting, depending on the available facilities at the outreach centre. Occasionally, outreach volunteers utilised hand-held torches to illuminate the vision charts if required.

Predominantly, only hand-held optometric equipment was available at outreach clinics.[21] Equipment available included ophthalmoscopes, retinoscopes, trial case lenses, trial frames, Perkins tonometers, and Snellen vision charts with illiterate E charts overleaf. Some ophthalmic drugs were also routinely available, such as cyclopentolate and tropicamide.

Outreach clinics are high volume facilities as patients self-presented in large numbers. Practitioners, therefore, were required to work quickly, and were expected on average, to examine as many as 50 patients per day.[21] The location, date, and time of outreach clinics were generally publicised by word of mouth.

Procedure

Initially, 100 records were randomly selected from this sample and were used for an exploratory review by authors CS and CD. This initial review involved a discussion to determine what information was routinely available on most of the eye examination records. Following this, a standardised data collection table was developed, and this was used to capture the information recorded on the case record sheets.

The remaining records were then transcribed into a spreadsheet by one member of the team (CS). Any illegible or hard-to-read records were discussed with members of the wider research team, until a consensus about their meaning was reached. If members of the team were unable to reach a consensus about a particular record, the record was excluded from analysis.

Data analysis

Descriptive statistical analyses were performed to evaluate the frequency and distribution of the most commonly reported symptoms by patients attending outreach clinics. The analysis also examined the frequency of presenting (with habitual correction, when available) and best-corrected visual acuity using the International Classification of Diseases, 11th Revision[20] categories of VI; mild or no VI (presenting vision better than 6/18 in the better seeing eye), Moderate VI (≥6/18 to 6/60), severe VI (≥6/60 to 3/60), and blindness (≥3/60). This was further stratified by age.

Ocular pathologies were analysed to identify the most common diagnoses. Further analysis was performed to determine the levels of VI, according to the type of ocular pathology observed, adopting the International Classification of Diseases, 11th Revision[20] classification categories.

In this study, adults (19 years and above) were classified based on their refractive error in the better seeing eye as follows: emmetropia was defined as mean spherical equivalent greater than or equal to −0.50D, but less than or equal to +0.50D, myopia as mean spherical equivalent of less than −0.50D and hypermetropia as mean spherical equivalent greater than +0.50D.

By contrast, in children (18 years or less), emmetropia was defined as mean spherical equivalent greater than or equal to −0.50D, but less than or equal to +2.00D, and hypermetropia as mean spherical equivalent of greater than +2.00D, while the definition of myopia was unchanged, in keeping with prevalence studies conducted in sub-Saharan Africa.[22,23]

All statistical analyses were conducted using R version 4.2.0.[24]

Results

Data were collected from 5809 (58.5% female) eye examination records of individuals who self-presented to outreach clinics. A total of 346 records (5.6% of the overall sample) were excluded from the study. Exclusion of case records was largely due to damage of paper records ($n = 68$, 19.7%) resulting in illegibility, with an additional portion being inherently illegible ($n = 241$, 69.6%), when vital information, such as date or location, was missing ($n = 34$, 9.8%) or when no consensus could be reached ($n = 3$, 0.8%).

The ages of participants ranged between 1 and 105 years (mean = 41.9 years, SD = 20.7) (Figure 2). For 119 participants, age could not be established. The most commonly reported symptoms were 'poor or blurred near vision' ($n = 2708$, 52.5%), 'poor or blurred distance vision' ($n = 1333$, 25.8%), and 'irritation, discomfort, and redness' of the eyes ($n = 1257$, 24.4%) (Figure 3). Most individuals ($n = 5159$, 88.8%) presented with multiple symptoms ($n = 9207$). Only 188 participants (3.23%) presented to outreach clinics with existing spectacles.

In line with International Classification of Diseases, 11th Revision,[20] 81.2% ($n = 4380$) of individuals had either mild or no VI (Figure 4). Moderate VI, severe VI, and blindness in the better seeing eye were found, respectively, in 14.2% ($n = 766$), 0.3% ($n = 15$), and 4.2% ($n = 234$) of participants (Table 1).

Refractive error, measured by either retinoscopy or subjective refraction, was recorded for a total of 5057 (87.05%) persons. From this, the mean spherical equivalent was calculated using the standard formula. 3920 (77.5%) participants, from the entire sample were emmetropic, 701 (13.9%) myopic and 436 (8.6%) hypermetropic in the better seeing eye.

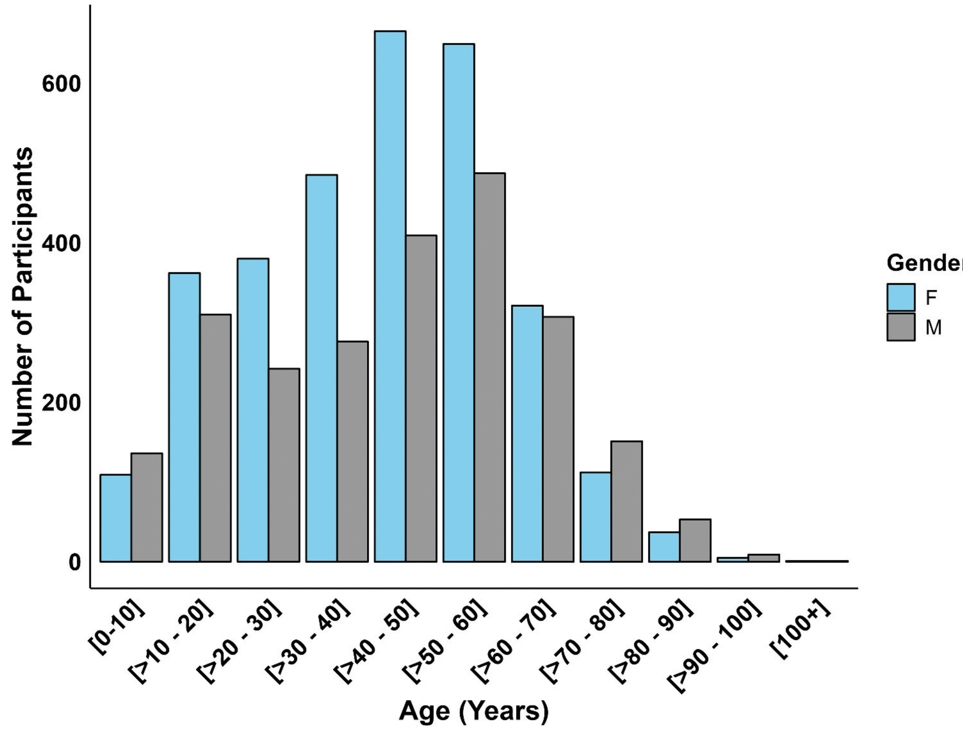

Figure 2. Distribution of age by gender in patients attending outreach clinics in Zambia ($n = 5506$, female (F) = 3126, male (M) = 2380).

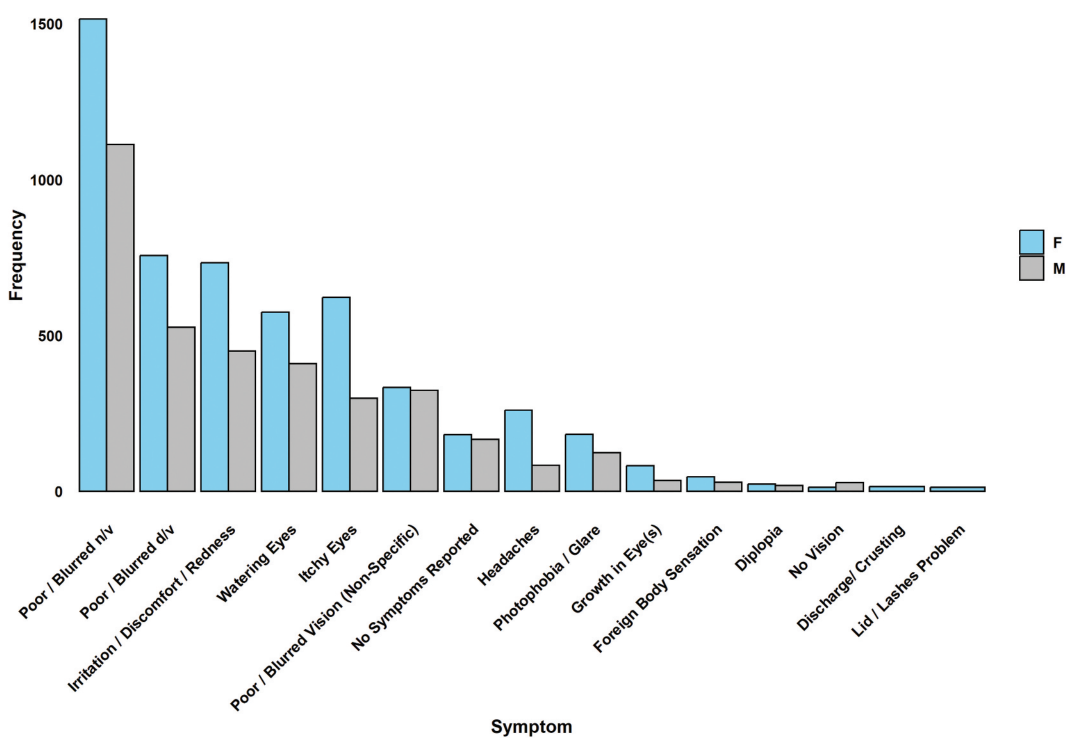

Figure 3. Most common self-reported presenting symptoms ($n = 9207$) of patients attending outreach clinics, stratified by gender (male = M and female = F) (conditions appear here if the count reached ≥10). Most individuals ($n = 5159$, 88.8%) presented with multiple symptoms.

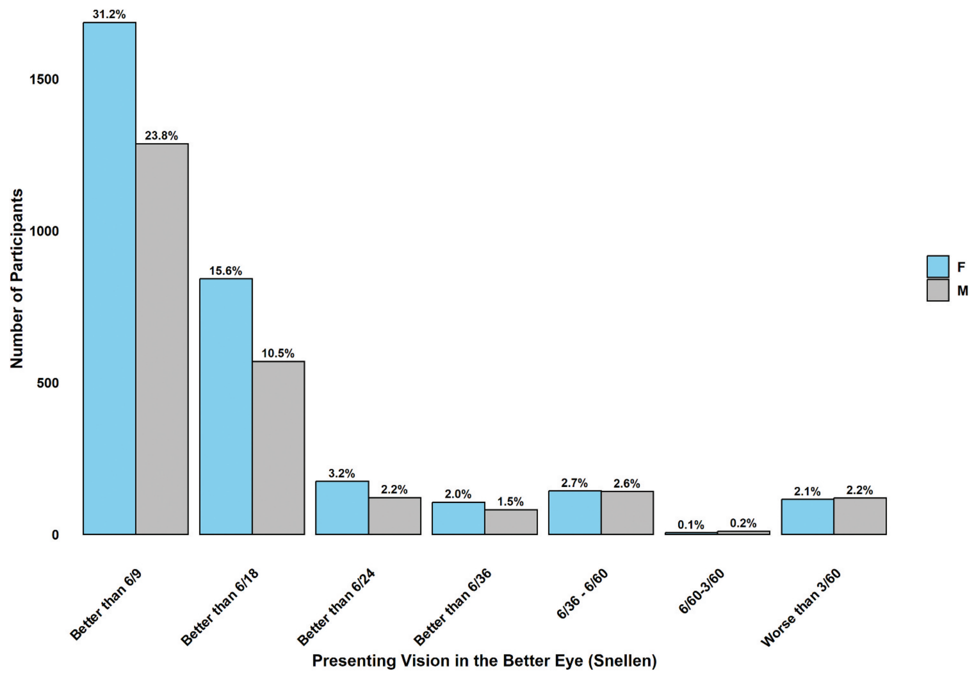

Figure 4. Presenting vision, in the better eye (*n* = 5395), stratified by gender (male = M and female = F), for people attending outreach clinics (recorded using Snellen notation) using the glasses of the participant, if they wore them for distance viewing.

Table 1. Presenting vision and best-corrected visual acuity per the International Classification of Diseases, 11th Revision[20] visual category of patients attending outreach clinics.

The International Classification of Diseases, 11th Revision[20] Visual Category[20]	Presenting Vision (Habitual spectacles worn when available) (*n* = 5395)	Best Corrected Visual Acuity (*n* = 5260)
No VI to Mild VI (< 6/18)	81.2% (*n* = 4380)	89.5% (*n* = 4707)
Moderate VI (≥6/18 to 6/60)	14.2% (*n* = 766)	6.9% (*n* = 362)
Severe VI (≥6/60 to 3/60)	0.3% (*n* = 15)	0.6% (*n* = 32)
Blindness (≥3/60)	4.3% (*n* = 234)	3.0% (*n* = 159)

VI, visual impairment.

Mean spherical equivalent in the better seeing eye was then stratified by age, for individuals where data were recorded (Table 2, Figure 5). Seventy-two (1.4%) individuals had refractive data available but not age. In adult participants, most were emmetropic (78.6%), while myopia (13.2%) was more common in this sample than hypermetropia (8.2%). Both refractive and age data were available for a total of 724 child participants, and of those, emmetropia, myopia, and hypermetropia were present in 82.9%, 16.3%, and 0.8%, respectively.

By comparison with presenting vision, the best corrected visual acuity in the better seeing eye, with optimal refractive correction (Table 1), resulted in 4901 (89.5%) patients with little to no VI, 362 (6.9%) with moderate VI, 36 (0.6%) with severe VI, and 159 (3.0%) classified as 'blind'. The biggest difference was observed in the moderate VI category, where VI at this level was halved (from 14.2% to 6.9%).

Following refraction 30.13% (*n* = 1753) of the whole cohort were dispensed with spectacles, and of those recorded, 1471 pairs were for near vision, while 282 pairs were for distance use. Although near refractive data and prescription were not always reliably recorded for participants requiring presbyopic refractive correction, it is estimated that, based solely on age and presenting symptoms, as many as 37.0% (*n* = 2154) of

Table 2. Classification of mean spherical equivalent refractive error in the better seeing eye, by age, in participants attending outreach clinics. In the combined cohort and adult sample emmetropia, myopia, and hypermetropia, in the better seeing eye were defined as −0.50D ≤ mean spherical equivalent ≤+0.50D, mean spherical equivalent <−0.50D and mean spherical equivalent >+0.50D, respectively. In children, emmetropia, myopia, and hypermetropia in the better seeing eye were defined as −0.50D ≤ mean spherical equivalent ≤+2.00D, mean spherical equivalent <−0.50D and mean spherical equivalent ≥+2.00D, respectively.[23,24] There were 72 (1.4%) individuals who had refractive data available but not age and were therefore excluded. See supplementary document S1 for additional data information.

	Emmetropia	Myopia	Hypermetropia
Entire cohort (*n* = 5057)	n = 3920 (77.5%)	n = 701 (13.9%)	n = 436 (8.6%)
Adults (≥19 years) (*n* = 4261)	n = 3348 (78.6%)	n = 563 (13.2%)	n = 350 (8.2%)
(Children (≤18 years) (*n* = 724)	n = 600 (82.9%)	n = 6 (0.8%)	n = 118 (16.3%)

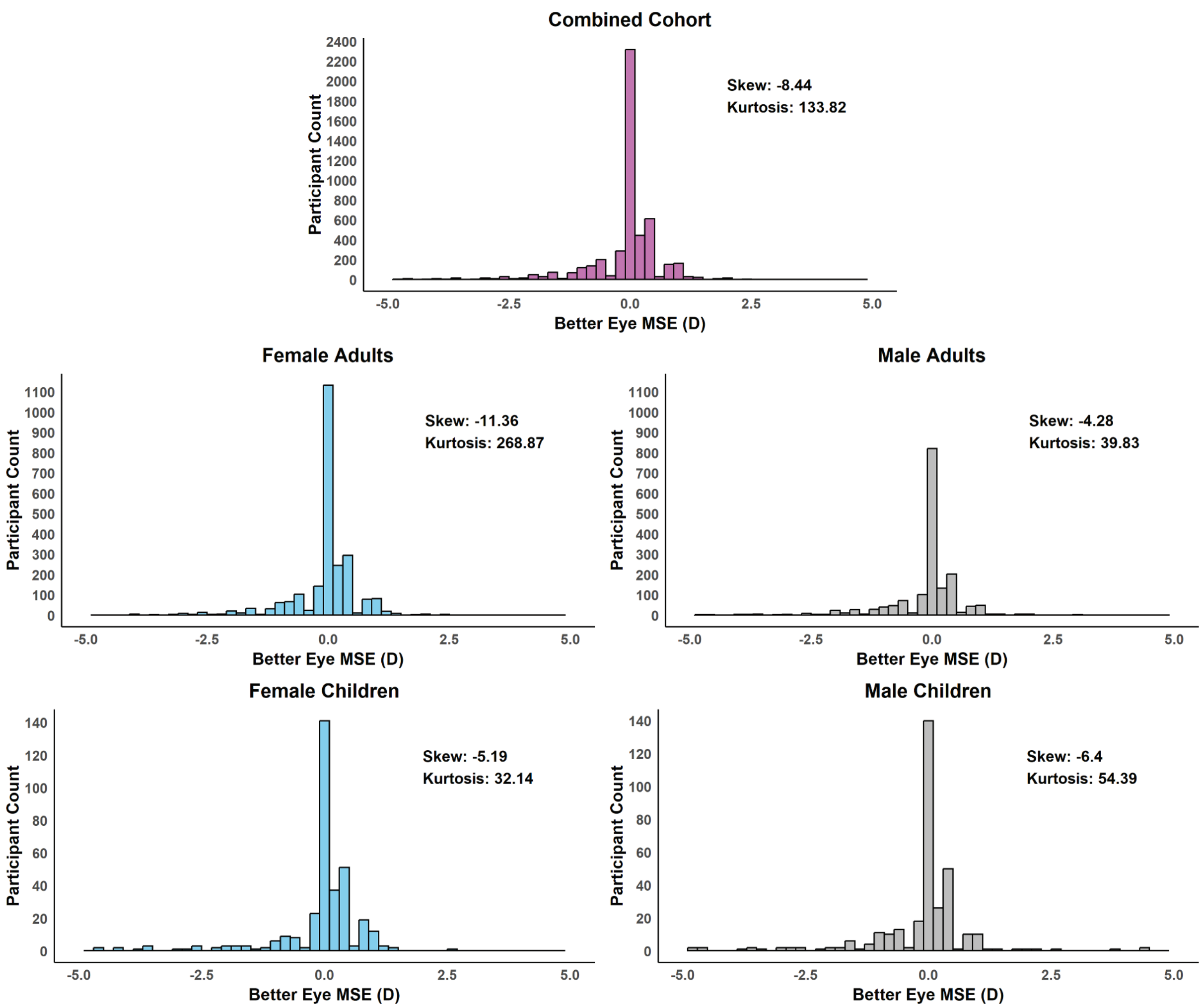

Figure 5. Histograms of the mean spherical equivalent refractive error in the better seeing eye, of patients attending outreach clinics, stratified by age group and gender, with the skew and kurtosis displayed in each sub-figure.

individuals, over the age of 35 years[25–27] were suffering from some form of near vision problem. However, due to the limited data available, it is not possible to determine if this was due to presbyopia or hyperopia.

URE, as a result, contributed to 62.4% of presenting blindness, 57.1% of severe VI, and 56.1% of moderate VI (within individuals examined).

Within the study cohort, cataract (*n* = 939, 16.2% of the entire sample) was the most observed ocular pathology (Figure 6) causing VI, despite optimal refractive correction. This was followed by corneal scarring

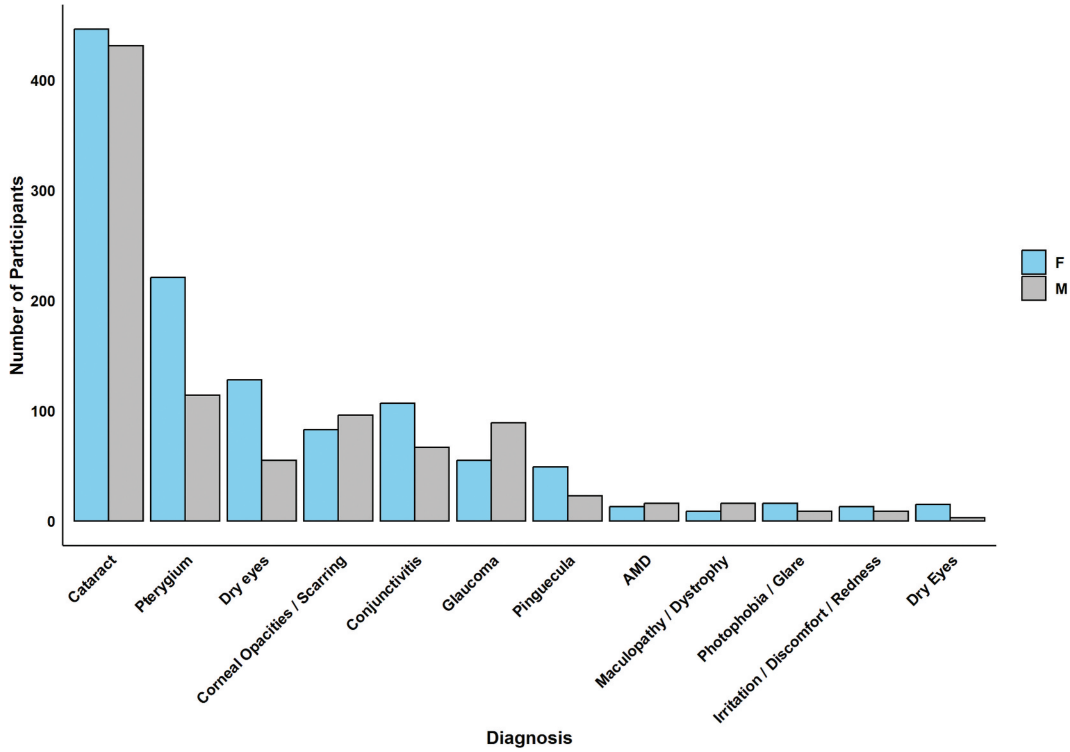

Figure 6. Distribution of the most common ocular pathologies per gender (male = M and female = F) group identified in patients attending outreach clinics. Many individuals were diagnosed with more than one ocular pathology (*n* = 347, 17.9%).

Table 3. Leading causes of visual impairment (VI), per World Health Organization category of VI,[20] with optimal refractive correction.

Diagnosis	Blindness (*n* = 245)	Severe VI (*n* = 16)	Moderate VI (*n* = 486)
Cataract	177 (72.2%)	3 (18.8%)	238 (50.0%)
Corneal Opacities/Scarring	29 (11.8%)	3 (18.8%)	32 (6.5%)
Glaucoma	27 (11.0%)	1 (6.2%)	22 (4.5%)
Other	12 (5.0%)	9 (56.2)	194 (40.0%)

(*n* = 189, 3.3%) and glaucoma (*n* = 151, 2.6%). Cataract, as seen in Table 3, accounted for 72.2% of blindness, 18.8% of severe VI, and 50.0% of moderate VI.

Discussion

In order of frequency, URE, cataract, glaucoma, and corneal opacification, were the leading causes of VI and blindness in people attending outreach clinics in Zambia. Crucially, once URE was corrected, the remaining blindness was most commonly caused by cataract: specifically, ~70% of blindness and half of moderate VI was attributable to cataract.

A total of 234 people (4.3%), who presented to outreach clinics, were functionally blind, a further 766 (14.2%) had moderate VI and 15 (0.3%) had severe VI, in the better seeing eye. With appropriate refractive correction, approximately two-thirds of presenting blindness could be improved. Specifically, with spectacles, nearly a quarter of people within the sample, or 1137 individuals, would have had improved functional distance vision.

This study comprises predominantly a working-age population with the mean age of participants approximately 42 years. In this population, the high levels of VI reported, particularly from preventable or treatable causes like URE, cataracts, and corneal scarring, may negatively impact quality of life, education, and employment opportunities. The long-term consequences of high numbers of VI individuals are also noteworthy, such as reduced household income and ultimately less economic gain at a national level.[8,9,11,28]

Few studies have reported the prevalence of refractive error in adults in sub-Saharan Africa, with none having utilised outreach data such as that analysed in the present study. Nevertheless, the reports that are available described a similar occurrence of myopia to the present study (13.9%).[29,30] Conversely, the prevalence of hypermetropia in sub-Saharan Africa has been reported to be between 37.7% and 50.7%,[29,30] compared to only 8.6% in the present study. One reason for this might be that hypermetropia was underestimated in this current report, since tests carried out during the eye examinations were done at the discretion of the optometrist performing the exam, it is possible that persons with good presenting vision were not in fact refracted.

Alternatively, the studies by Ezelum et al.[29] in Nigeria and Mashige et al.[30] in South Africa, reported on typically older cohorts, including only participants over the age of 40 and 35, respectively, in their cluster samples. Self-presenting patients in the present study, however, were typically younger, reflecting that patients had to be well enough to travel to the outreach clinics. Additionally, hypermetropic patients may be less likely to present to eyecare clinics, since young hyperopes may be asymptomatic, even in the presence of significant amounts of hyperopia.[31]

Presenting blindness, within the study sample, was twice as high as was reported by Lindfield et al.[32] in their cross-sectional survey in Southern Zambia. It is likely that the occurrence of blindness in the present report is deceptively high, since other reports in sub-Saharan Africa, like that of Lindfield et al.[32] have estimated presenting blindness to be between 1.1% and 2.4%.[33–38] It is likely that the higher proportion of blindness in the present sample, could be due to the self-presentation of symptomatic participants, because the study sample does not constitute a true cross-section of the population.

Another reason may be because a threshold measurement of vision (unaided) or visual acuity (i.e., with glasses) was not obtained, since clinicians examining participants in outreach clinics faced a lack of time, language barriers, and the use of fixed Snellen vision charts, with only a few large letters available.[39] Therefore, some individuals recorded as having vision worse than 6/60 may have been inaccurately reported as 3/60 or worse, leading to their classification as 'blind'. This potential misclassification suggests that certain individuals may have been capable of achieving better vision than reported. Therefore, some individuals that were categorised as 'blind' may have been misclassified and have been capable of better vision than reported.

Another possible explanation for the higher occurrence of presenting blindness in the present sample, compared to the relatively urban sample of Lindfield et al.[32] could be due to some of the locations of the outreach clinics from which data were collected. Several of the outreach clinics were located in more rural areas of Zambia, which are chronically under-served by eye health services. Equally, a study of this nature, examining only outreach data, has not been carried out before, and comparisons with cross-sectional population-based studies should be viewed in the context of potential bias associated with this recruitment method.

Individuals who self-presented to outreach services exhibited issues that were also observed in general population reports from within sub-Saharan Africa and Zambia alike. In this report, as in other population-based studies in sub-Saharan Africa, cataract, URE, posterior-segment disease, and/or glaucoma are consistently the main causes of blindness and VI.[32–38,40]

It is also important to take into consideration that in some studies, glaucoma is grouped into 'posterior-segment disease', while in others it is not, depending on examination technique. For example, some clinicians only have access to a direct ophthalmoscope for diagnosis.[32] Accordingly, the relatively low frequency (2.6%) of glaucoma in the present study may be attributed to only those showing signs of advanced glaucoma, being documented. Thus, because of the limitations of the clinical data from these outreach clinics,[41] some pathology, particularly glaucoma, may have been misclassified or misdiagnosed.

Robust cross-sectional prevalence data are required to get a true indication of the current levels of VI, URE, and ocular pathology within Zambia. At both the community and national level, eye health promoting activities, the provision of adequate training facilities for eyecare practitioners and sufficient infrastructure are needed for the long-term and sustainable reduction of VI and blindness within the country, to improve self-sufficiency and to reduce the reliance on non-governmental organisations.

Limitations of the study

This study has several limitations due to the retrospective nature of data collection. The self-selection bias associated with participants who attended clinics based on word-of-mouth recommendations is likely to contribute to a higher observed prevalence of symptomatic individuals. Additionally, it is possible that some of the participants may have presented on multiple occasions within the study period, introducing the potential for duplication in the dataset.

The aim of the outreach clinics was not research, which can impact the approach in which data collection occurred; the principal objective of the examination was detecting possible VI that would require treatment, not necessarily a formal diagnosis, and to resolve URE.

There was no robust standardised protocol and procedures for the assessments performed. During the eye examinations, the clinical investigations performed were at the discretion of the individual practitioner, with no mandatory tests conducted. This is particularly relevant in the context of cycloplegia in children, as there was no standardised protocol or rationale governing its use. This can further be extrapolated to the testing conditions, since there were no standardised conditions employed. Most noteworthy, is lighting, as this could potentially have had a significant impact on the vision and visual acuity results.

Some vision testing, at outreach clinics, took place outdoors, in bright natural sunlight, while refraction and subsequent visual acuity assessments were often conducted indoors, in a darker environment.

This report could not determine the levels of VI and refractive error at near, due to some missing data, as for many case records ($n = 3919$, 67.5%) presenting and best corrected near visual acuity, alongside near refractive data and/or final prescription were either not recorded at all, or not recorded in full.

All researchers involved in this study are based in the United Kingdom. Consequently, this report may have benefited from local expertise to enhance the contextualisation of the results and provide a more nuanced understanding of the patterns and behaviours associated with participant attendance at each outreach clinic location within Zambia.

Conclusion

Despite limitations outlined above, the results reported here offer an insight into the demographic characteristics of individuals attending outreach clinics and the frequency of their VI, URE, and ocular pathology. The data suggest that the high occurrence of avoidable blindness and VI found in individuals who attend outreach clinics is of particular importance. High frequency of poor vision and URE are indicative of a larger systemic issue and suggest an urgent need to improve and develop access to affordable primary eyecare services within Zambia.

Previous reports have found that the current ophthalmic service delivery in Zambia, is inadequate, largely because of insufficient staffing levels, a lack of necessary equipment for examination, and a disproportionally low rate of spectacle dispensing. These problems are compounded by a lack of eyecare infrastructure within the country.[11] Alongside affordability issues, there is a major problem regarding the accessibility of eye health services by individuals from low-income groups in Zambia. Ophthalmic outreach services, however, provide access to eyecare that addresses some of the gaps in service delivery.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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ORCID

Cheralynn Saunders http://orcid.org/0009-0007-2822-0565
Neema Ghorbani-Mojarrad http://orcid.org/0000-0001-9171-3070
Brendan T Barrett http://orcid.org/0000-0003-4159-4223
Alexander G Swystun http://orcid.org/0000-0003-1394-3027
Christopher J Davey http://orcid.org/0000-0002-9050-379X

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