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Prevalence and socio-demographic distribution of uncorrected refractive errors in school-going adolescents in Kakamega County, Kenya

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ABSTRACT

BACKGROUND: Efforts to mitigate vision loss due to uncorrected refractive errors (UREs) in Africa remain unpredictable. This study investigated the prevalence and socio-demographic distribution of UREs in school-going adolescents of Kakamega County in Kenya.

MATERIAL AND METHODS: A cross-sectional study was conducted with randomly selected secondary school adolescents. Participants were screened and clinically examined for URE types and dioptric strength and were administered questionnaires designed to elicit socio-demographic, socioeconomic, and perceived well-being information.

RESULTS: 165 students, aged 17.50 ± 1.576 years, were included in the study. The prevalence of URE was found to be 8.65%, for which 27% of all UREs were significant. URE types were classified as astigmatism (52%), myopia (25%), and hyperopia (23%). Astigmatism and hyperopia were more common among males (59% and 61%, respectively) than females, while myopia occurred slightly more among females (51%) than males. Most participants (72%) were from large families, 92% had parents who were poorly educated, 85% had poor occupational statuses, and 89% were from rural settings. The interclass differences in all the pre-defined socio-demographic statuses were not significant ($p > 0.05$), including the within-group interaction with UREs. The distributions were significantly different ($p < 0.05$) for well-being, with over two-thirds of the participants reporting poor-to-fair perceived well-being, with a recent known history of poor eye health.

CONCLUSIONS: URE is highly prevalent among school-going adolescents in Kakamega County. The study recommends intensified strategies to increase spectacle uptake among learners in rural settings and of low socioeconomic means.

KEY WORDS: school-going adolescents; sociodemographic; uncorrected refractive error; vision function; well-being

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INTRODUCTION

Uncorrected refractive error (URE) is a significant cause of vision loss in children [1], with estimates of two to five percent being of a significant nature [2]. Africa accounts for over 6 million of the global population, primarily children and persons living in poor and rural communities, having vision impairment (VI) resulting from URE [3]. VI in children and adolescents resulting from URE can be easily corrected with a pair of spectacles,

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even though this carries a direct cost of spectacle provision, estimated to be about USD 3.8 billion [4]. In various studies, spectacles have been shown to improve vision to within normal limits for 95% of vision-impaired persons due to URE [5]. Still, the challenges with mitigating vision loss in children and adolescents are disproportionately worse in low-to-middle-income countries. Efforts towards eliminating VI challenges resulting from URE in Africa remain unpredictable, often due to complexities of uncontrollable socioeconomic, cultural and political factors [6].

Blindness in children resulting from URE may interfere with education [7], which could further lead to lowered future earnings, reduced employment opportunities, and social stigmatization [7, 8]. Therefore, the impact of UREs on children cannot be over-emphasized, with a broader consequence of increased economic burden on the larger society [8]. Moreover, URE can have psychosocial implications and far-reaching consequences on children as they grow older, with the number of blind-person-years in children lost to disability and future productivity loss [8]. Thus, the need for early detection of URE in children, both in their homes and in schools, is crucial and has also been proven to be very useful in not only averting their impact [9] but also in providing a clearer understanding of the pattern and distribution of these REs [2].

Studies conducted among children on the prevalence of RE in Kenya [10, 11] have provided some understanding of the pattern and distribution of REs in Kenya. However, these studies, which mainly concentrated in the central and eastern region of Kenya, on the prevalence and distribution of significant REs in children have found the range of UREs to be as low as 5.2% [10] to as high as 17.2% [11]. Overall, the prevalence of refractive error (RE) is reported to account for more than two-thirds of all causes of VI in children in Kenya [10]. As a result of the limitations in the existing knowledge of URE in Kenya, this study aimed to investigate the prevalence and distribution of sociodemographic, socioeconomic, and well-being factors in school-going adolescents with UREs of Kakamega County, in the western region of Kenya.

MATERIAL AND METHODS

We employed an observational study design, using cross-sectional sampling methodologies to determine URE's prevalence and socio-demographic distribution in school-going adolescents. The research investigation included two phases: Phase one (clinical aspect), detailed clinical examinations, and patient refractions to determine the participants' RE magnitude and type classification. Classification of RE magnitude was predefined as significant (enough to cause VI) for myopia ≥ |–1.00D|, hyperopia ≥ +3.00D, and astigmatism ≥ |–1.00D|[12]. In addition, RE, resulting in a reduced presentation of Snellen's distance visual acuity (VA) of ≥ 6/12, equivalent to ≥ 0.3 logarithms of the minimum angle of resolution (logMAR), was considered significant. Phase two employed structured pre-validated questionnaires administered to the selected participants to elicit their socio-demographic, socioeconomic, and other well-being factors influencing the distribution of UREs amongst the study participants.

The study sample was selected from a population of school-going adolescents aged 14 to 25 attending mixed (male and female) secondary schools in Kakamega County. Learners (forms one to four) who met all pre-defined criteria were selected for inclusion and screened for the presence of URE by pre-trained secondary school teachers – pre-trained by the principal investigator (PI) to rapidly screen for URE and supervised by research assistants, who were optometrists, each assigned to a selected school. Cross-check by the PI of all persons identified by the school teachers to have any type of URE showed 100% correct identification of URE by trained and supervised school teachers. A multi-stage technique was used to select the study sample. One-third (4 sub-counties), as a representative sample, of the 12 sub-counties of Kakamega County were randomly selected as four (4) clusters [13] using a computer-generated random system [14]. The four sub-counties had 138 secondary schools and comprised a total of 40,577 students, most of whom were in boarding and single-gender schools. Schools that included both day scholars and boarding facilities and gender mix were identified. This ensured that each selected school maintained homogeneity and that participants' characteristics of interest to this study, including sociodemographic and socioeconomic factors, were present within the same school. Only 19 schools met this criteria, from which seven schools were randomly selected from the four clusters by simple balloting. Over one month, all students (2,821) from the 7 selected schools were screened for URE by trained teachers supervised by optometrists. Children identified with URE were assessed for URE types

and dioptric values by the Principal Investigator (PI) of the study and then included in the study. Participants also completed structured questionnaires that contained self-reported general eye health questions and questions relating to long-standing visual disability, previous eye problems, or any previous general medical condition(s) that affected their ability to see well. Additionally, a list of sociodemographic questions and a validated socioeconomic status assessment tool adjusted and pre-validated to suit the socioeconomic context of the study area [Family Affluence Scale (FAS-Kenya)] were included [15]. Data collected during the study were captured into MS Excel (2013), cleaned, coded, and exported into Statistical Package for Social Sciences (SPSS) (v.25). The within-groups relationships of the identified sociodemographic, socioeconomic, and well-being variables were compared using the Pearson Chi-square test, conducted at α = 0.05 and 95% confidence interval (CI).

All ethical guidelines, consistent with the Helsinki Declaration, including participants' rights to refuse or withdraw further participation in the study, were adhered to. For all participants, in addition to written and verbal consent elicited prior to the study, participants' legal caregivers equally gave assent. These were sent and received through the schools' heads two weeks before the data collection process began.

RESULTS

Of the 2,821 learners screened by the trained school teachers, 244 were identified as having any form of URE. The prevalence of URE among school-going adolescents in Kakamega County was, therefore, 8.65%, of which only 165 of the 244 screened students presented for detailed refraction and clinical examination by the PI. The findings of the 165 students included in this study were normally distributed and elicited from 94 male students (57%) and 71 female students (43%) (Tab. 1), with a mean age of 17.50 ± 1.576. The study found astigmatism (52%) to be most common among the participants, followed by myopia (25%) and hyperopia (23%) (Tab. 2), although only about 27% of all participants' REs were significant (Tab. 3). Details of the distribution of hyperopia, astigmatism, and myopia amongst female and male participants are shown in Figure 1.

The study had slightly more male (57%) than female participants. However, this was not significant (p = 0.073). For age distribution, grouped into those below 18 years (minors) and those 18 years and older (young adults), we found that although there were more participants (53.3%) below 18 years of age, the difference was not significant (p = 0.195). Concerning the interclass interactions of all socio-demographic factors defined for this study, with URE, we found no significant differences (p > 0.05). A detailed presentation of

Table 1. Sociodemographic distribution of participants in the study

Socio-demographic variables	Distribution (n = 165)	
	N (%)	p-value
Age		
Below 18 years	88 (53.3)	0.195
18 and above years	77 (46.7)	
Gender		
Male	94 (57.0)	0.073
Female	71 (43.0)	
Parents' marital status		
Single	11 (6.7)	0.846
Separated	15 (9.1)	
Married	120 (72.7)	
Widowed	19 (11.5)	
Family size (children)		
Less than 5 children	46 (27.9)	0.101
5–8 Children	107 (64.8)	
9 or more children	12 (7.3)	
Parent education		
Never been to school	8 (4.8)	0.695
Primary	49 (29.7)	
Secondary	94 (57.0)	
College	11 (6.7)	
Tertiary	3 (1.8)	
Parent occupation		
Unemployed	69 (41.8)	0.681
Artisan	16 (9.7)	
Self-employed	27 (16.4)	
Professional but self–employed	3 (1.8)	
Trading	28 (17.0)	
Professional in public service	0 (0.0)	
Public Services	12 (7.3)	
Paid/private-company employed	10 (6.1)	
Domiciliation		
Rural	146 (88.5)	0.861
Urban	19 (11.5)	

N — frequency; % — percentage; Chi square test (X^2) significant at α = 0.05

Table 2. Sociodemographic distribution with uncorrected refractive errors (URE) sub-types

Sociodemographic variables	Distribution of URE types (n = 165)			p-value
	M (24.85%)	H (23.03%)	A (52.12%)	
	N (%)	N (%)	N (%)	
Age				
Below 18 years	23 (26.1)	24 (27.3)	41 (46.6)	0.258
18 and above years	18 (23.4)	14 (18.2)	45 (58.4)	
Gender				
Male	20 (21.3)	23 (24.5)	51 (54.3)	0.470
Female	21 (29.6)	15 (21.1)	35 (49.3)	
Parents' marital status				
Single	4 (36.4)	4 (36.4)	3 (27.3)	0.333
Separated	3 (20.0)	4 (26.7)	8 (53.3)	
Married	26 (21.7)	27 (22.5)	67 (55.8)	
Widowed	8 (42.1)	3 (15.8)	8 (42.1)	
Family size (children)				
Less than 5 children	13 (28.3)	9 (19.6)	24 (52.2)	0.613
5–8 children	25 (23.4)	28 (26.2)	54 (50.5)	
9 or more children	3 (25.0)	1 (8.3)	8 (66.7)	
Parent education				
Never been to	1 (12.5)	1 (12.5)	6 (75.0)	0.419
Primary	16 (32.7)	10 (20.4)	23 (46.9)	
Secondary	23 (24.5)	23 (24.5)	48 (51.1)	
College	1 (33.3)	0 (0.0)	2 (66.7)	
Tertiary	0 (0.0)	4 (36.4)	7 (63.6)	
Parent occupation				
Unemployed	20 (29.0)	16 (23.2)	33 (47.8)	0.710
Artisan	3 (18.8)	5 (31.3)	8 (50.0)	
Self-employed	6 (22.2)	9 (33.3)	12 (44.4)	
Professional but self-employed	1 (33.3)	0 (0.0)	2 (66.7)	
Trading	7 (25.0)	6 (21.4)	15 (53.6)	
Professional in public service	0 (0.0)	0 (0.0)	0 (0.0)	
Public services	2 (16.7)	2 (16.7)	8 (66.7)	
Paid/private-company employed	2 (20.0)	0 (0.0)	8 (80.0)	
Domiciliation				
Rural	40 (27.4)	33 (22.6)	73 (50.0)	0.105
Urban	1 (5.3)	5 (26.3)	13 (68.4)	

M — myopia (percentage of participants with myopia); H — hyperopia (percentage of participants with hyperopia); A — astigmatism (percentage of participants with astigmatism); N — frequency; % — percentage; Chi square test (X2) significant at $\alpha = 0.05$

the socio-demographic findings of the study is shown in Table 1. Furthermore, in the interaction with the URE sub-types for all socio-demographic factors defined for this study, we found that participants with astigmatism occurred most frequently (Tab. 2) than those with myopia and hyperopia.

Participants' vision function (VF) was defined as presenting and final visual acuity (VA), post refraction. More than half (59%) of the participants, with any form of URE in any eye, presented with an entry VA 0.3 LogMAR (Snellen 6/12) or worse in the worse eye (Tab. 3). However, after optical correction, nearly all (91%) participants had their VA improved to better than 0.3 LogMAR. Three-quarters (75%) of the study participants presented with an entry VA of 0.0 LogMAR to 0.5

Table 3. Participants' vision function (VF) and refractive status distribution

VF and refractive status variables	Distribution (n = 165)	
	N (%)	p-value
VF (VA in LogMAR)		
Entry VA worse eye		
> 0.3	67 (40.6)	0.000
0.3–0.5	57 (34.6)	
< 0.5–1.0	40 (23.0)	
< 1.0	3 (1.8)	
Final VA worse eye (post refraction)		
≥ 0.0	91 (55.2)	0.000
0.0 to > 0.3	59 (35.7)	
0.3 to 0.5	6 (3.6)	
< 0.5	9 (5.5)	
Refractive error status (type)		
Myopia	41 (24.9)	0.000
Hyperopia	38 (23.0)	
Astigmatism	86 (52.1)	
Refractive error significance		
Significant URE	44 (26.7)	0.000
Non-Significant URE	121 (73.3)	

N — frequency; % — percentage; Chi square test (X^2) significant at $\alpha = 0.05$; where > implies "better than"; < implies "worse than"; ≥ implies "at worse"; ≤ implies "at best"; VA — visual acuity; LogMAR — logarithm of minimum angle of resolution

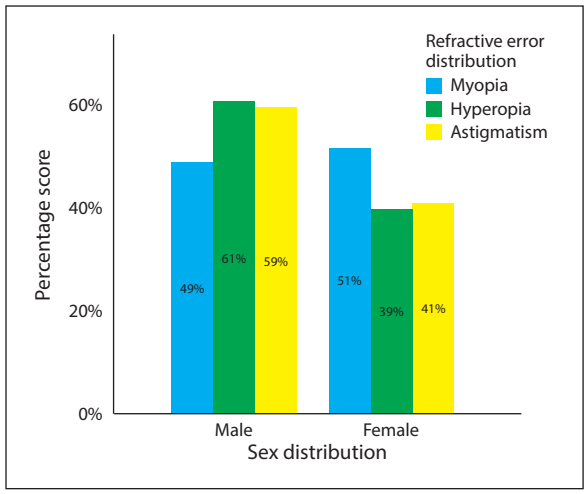

FIGURE 1. Gender distribution of refractive errors (RE) according to gender (n = 165)

LogMAR (Snellen 6/18), regardless of the type of RE or significance of the URE.

The participants' socioeconomic status in this study was measured using the adjusted family affluence status scale (FAS Kenya). The scale found

Table 4. Participants' socioeconomic and well-being distribution

Socioeconomic and well-being Variables	Distribution (n = 165)	
	N (%)	p-value
Family affluence status (FAS)		
Low FAS (0 to 3 scores on FAS Kenya)	109 (66.1)	0.000
Middle FAS (4 to 7 scores on FAS Kenya)	50 (30.3)	
High FAS (8 to ≥ 10 scores on FAS Kenya)	6 (3.6)	
General eye well-being		
Very poor	5 (3.0)	0.000
Poor	59 (35.8)	
Fair	77 (46.7)	
Good	12 (7.3)	
Very good	10 (6.1)	
Excellent	2 (1.2)	
Duration of previous eye problem		
None	44 (26.7)	0.000
Yes (not sure)	13 (7.9)	
Yes (0–5 years)	51 (30.9)	
Yes (6–10 years)	30 (18.2)	
Yes (since birth)	27 (16.4)	
Duration of previous medical condition		
None	93 (56.4)	0.000
Yes (not sure)	38 (23.0)	
Yes (0 to 5 years)	15 (9.1)	
Yes (6 to 10 years)	12 (7.3)	
Yes (since birth)	7 (4.2)	

N — frequency; % — percentage; Chi-square test (X^2) significant at $\alpha = 0.05$.

that most (66%) participants were from a background whose family affluence status fell within the low-income status while 30% fell within the Middle FAS (Tab. 4). The difference in the participants' FAS Kenya scores was significant (p = 0.000).

While almost half (47%) of the participants reported that their "general eye well-being" was fair, over one-third (36%) of them reported poor general eye well-being (Tab. 4). Additionally, 31% of participants reported having had a previous eye problem in the last five years, while most (79%) either reported that they had no previous medical condition (56%) or were not sure for how long (23%). Furthermore, while 18.2% reported a recent history of eye problems in the last six to ten years, 16.4% reported having had the same since birth. Only a few (4%) reported having had any disabling med-

ical condition since birth. The differences in the responses to well-being measures were all significant (p = 0.000) (Tab. 4).

DISCUSSION

The prevalence of URE (8.65%) found in this study is of particular interest, considering that it contributes to the already inconsistent findings for UREs in some studies conducted among school-going children and adolescents elsewhere [10, 11, 16, 17]. These inconsistent findings, as observed from previous Kenyan studies, may be due to variations in the age of study participants [10] or in study settings [10, 11]. Other studies with comparable participant characteristics had prevalence findings within a range of 2% to 3% below or above the finding of this study [10, 16, 17]. Furthermore, while we found that more than half of the participants of this study had astigmatism, which occurred more frequently than any other RE, only about a quarter of all UREs were significant (Tab. 3). The prevalence of significant REs among school-going adolescents in this study was nonetheless more than in previous studies [10, 11]. In addition, unlike other Kenyan studies where myopia was most prevalent [10, 11], we found astigmatism occurred more than any other type of URE. The increased prevalence of astigmatism among the study participants may be attributed to the participant's presentation of symptoms of frequent eye rubbing, which was outside the scope of this present study.

Conversely, but consistent with two previous studies [16, 17], we found hyperopia was least prevalent amongst school-going adolescents. The general gender distribution of URE in this study was inconsistent with previous similar studies elsewhere [11, 16], and may have been influenced by the gender imbalances in these studies. With regards to place of regular domiciliation, our finding showed higher URE prevalence amongst participants from rural settings, particularly astigmatism and myopia [Tab. 2]. This was inconsistent with previous Kenyan studies [10, 11]. This finding, therefore, suggests and supports previous reports elsewhere [18] for the urgent need for increased public health interventions to mitigate UREs amongst persons from rural settings.

As shown in Table 1, while participants below the age of 18 years were more in this study, males were slightly more than females. As much as these findings may indicate an increased need for URE interventions among younger male students in the study area, our findings further showed that the difference in need was not significant compared to their older counterparts and females within similar settings. More so, we did not find it surprising that the findings of the interclass differences in the socio-demographic attributes of participants in this study (Tab. 1) were not significantly different. These findings were expected for a County such as Kakamega, which is known to have done very well in maintaining socio-demographic parity — particularly for gender parity in school enrolments [19]. Nonetheless, our findings add to the inconsistency in literature on socio-demographic distributions and, in particular, non-consensus for gender distribution for studies conducted amongst school-going children in many African studies, with some having more males [11, 16, 17] and more females [20].

Additionally, while over two-thirds of the participants' parents were married, nearly three-quarters were from homes with large family sizes (Tab. 1). These were exciting results considering that nearly 9 of every 10th participant's parent(s) were poorly educated, mostly either unemployed or engaged in personal local trading, and regularly resided in areas designated as rural settings. These findings indicate a population group from families with minimal economic means. As noted elsewhere [21], poverty is closely associated with an inability to afford simple spectacles and is a common factor associated with the increasing prevalence of UREs worldwide [6, 8].

Participants' VF in this study, defined as VA cut-offs, showed that of all participants refracted, nearly two-thirds of them presented with an entry VA of 0.3 logMAR or worse in the worse eye. Following spectacle correction, post-refraction, over 90% of the participants had their final VA improved to better than 0.3 logMAR. Additionally, while over a quarter of all participants presented with an entry VA worse than 0.5 logMAR, they all had varying levels of improvement, following issuance with spectacle correction, regardless of their URE type or magnitude. This finding is helpful as it justifies the important role of spectacle uptake in alleviating the burden of URE on school-going adolescents and children, thus strengthening existing knowledge on the same [22].

The study found that most participants, regardless of their URE type, were from a background whose family socioeconomic status fell within the low-income status (Low FAS). Furthermore, most participants were from families with low eco-

nomic means, had parents with minimal education, and were either unemployed or engaged in informal petty trading and living in rural settings. Socioeconomic status and family affluence have previously been described as solid determinants of willingness to take up interventions for alleviating UREs and VI [6, 18]. In the same context, these findings may thus provide sufficient reasons why, despite the high URE prevalence amongst our study participants, many had never used spectacles.

The study also noted that while most participants felt their general eye health was fair, many others reported poor eye health. Additionally, while most participants reported having some form of eye problems in the preceding five years, they also reported either not having any previous medical condition or being unsure of the duration (Tab. 4). Well-being has been shown to be a good indicator for quality of life measures [23]. Poorer responses to eye well-being usually result in reduced scoring on a quality of life index [23]. Participants' responses to well-being indices defined for this study showed significant differences, thus corroborating similar reports on the negative impact of well-being on the quality of life of persons in health states considered less than usual [24].

CONCLUSION

This study aimed to bridge the knowledge gap for prevalence and the socio-demographic factors influencing URE among school-going adolescents in Kakamega County. The findings revealed a high prevalence of URE in the county, with most participants largely astigmatic, while males were mainly hyperopic and females were mostly myopic. Furthermore, the study showed that participants from families of lower family affluence and living in rural settings had increased URE presence. Contrary to other research findings, where URE was mostly found among those in urban and affluent settings [11], the converse was confirmed in this study. Our findings report that as much as about two-thirds of the study participants, regardless of their presenting URE states, had less than normal vision function; these significantly affected their general eye well-being. However, we also found that participants' vision function improved significantly following the use of spectacle corrections. The results from this study can support efforts outlined in the Kenya National Strategic Plan for Eye Health and Blindness Prevention [25] and highlight the intensified need for strategies to alleviate URE, particularly astigmatism and myopia, through increased spectacle uptake among school-going adolescents in rural settings and of low socioeconomic means.

Conflict of interest

The authors declare no conflict nor competing interest in the publication of this paper.

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This manuscript has neither been published anywhere previously nor being simultaneously considered for any other publication.

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Data availability statement

The datasets used and analyzed for this paper can be made available from the corresponding author upon reasonable request.

Ethics statement

Approval for this study was obtained from the Biomedical Research Ethics Committee (BREC) of the University of KwaZulu-Natal (UKZN) (BE359/15); the Institutional Ethics Review Committee of Masinde Muliro University of Science and Technology (MMUST) (MMU/COR: 403009 (VOL. 62); and the Kenyan National Commission for Science, Technology and Innovation (NACOSTI) (Permit no. NACOSTI/P/17/33921/18996).

Author contributions

E.E.O.V. — conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, software, validation, visualization, writing — original draft, writing — review and editing; J.N. — conceptualization, formal analysis, funding acquisition, investigation, metho-

dology, project administration, resources, software, supervision, validation, visualization, writing — original draft, writing — review and editing; P.C.C.F. — conceptualization, data curation, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing — original draft, writing — review and editing.

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