

Prevalence and distribution of visual impairment, refractive error and their impact on quality of life among school-going children aged 6-18 years in Sekhukhune district (Limpopo), South Africa

TSHUBELELA SELLO SIMON MAGAKWE (218074043)

Ukuvama kanye Nokusabalala Kwezinga Lokungaboni Kahle, kanye nomthelela wakho ezingeni lempilo ezinganeni zesikole eziphakathi kweminyaka eyi-6 kuya kweyi-18, Esifundeni SaseSikhukhuni (Limpopo) Eningizimu Afrika



Supervisor: Mrs ZNQ Xulu-Kasaba

Co-Supervisor: Prof R Hansraj

Submitted in fulfillment of the requirement for the degree of Master of Optometry in the School of Health Sciences, University of KwaZulu-Natal.

Submission date: 30 July 2020

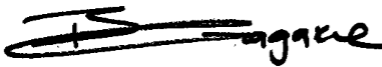
DECLARATION

I, Mr Magakwe Tshubelela Sello Simon, declare as follows:

1. That the work described in this thesis has not been submitted previously to University of KwaZulu Natal or other tertiary institute for purposes of obtaining an academic qualification, whether by myself or any other party.
2. That my contributions to the project were as follows: Drafting proposal for the project, applying for authorization (from the Limpopo Department of Education, schools included and UKZN BREC for ethical clearance), data collection, analysis (with a help of a Statistician) and writing. I was the first author for the manuscripts submitted to the African Vision and Eye Health Journal (AVEH) and British Medical Journal (BMJ).

3. Contribution of others:

Mrs Xulu-Kasaba and **Prof Hansraj** were the supervisors and were the link during the submission of ethical clearance application to the UKZN Biomedical Research Ethical committee. They equally contributed with the conception and editing of manuscripts, added to the content and approved the final versions submitted to journals.

Sign:  Date: 23 July 2020

As the candidates supervisors we agree to the submission of this thesis:

Mrs ZNQ Xulu-Kasaba  Date: 23 July 2020

Prof R Hansraj  Date: 23 July 2020

DEDICATION

I dedicate this work to my late mother Hlagudi Selina Magakwe who against all odds encouraged me to focus on my schoolwork. You might not have lived long enough Moekadi, but your legacy lives in us forever. To my two children Letlotlo and Mosa, thank you for always giving me a meaning to life.

ACKNOWLEDGEMENTS

I thank the Almighty God for this life and strength throughout this project. I acknowledge my supervisors Mrs. Xulu-Kasaba and Prof Hansraj for all support they gave to me throughout. Sammy, London and Tshepisho for assisting me with data collection. The university of KwaZulu Natal CHS for their funding assistance. I would like to send my gratitude also to the Principals and the learners from the participating schools. Finally, I would like to acknowledge Mrs EN Xulu for translating my abstract into Isizulu language.

TABLE OF CONTENTS

DECLARATION	i
DEDICATION	ii
ACKNOWLEDGEMENTS	iii
TABLE OF CONTENTS	iv
List of Acronyms	vi
List of Tables	vii
ABSTRACT	ix
IQQQA	x
CHAPTER 1	1
Introduction	1
1.1 Background	1
1.2 Literature review.....	1
1.3 Justification for this study.....	3
1.4 Research questions	3
1.5 Aim & Objectives.....	3
1.6 Methods.....	4
i. Sample Size	5
ii. Sampling Method.....	6
1.7 Study instruments:.....	6
1.8 Study Procedure.....	7
i. Vision Assessment.....	7
ii. Binocular Motor Function.....	8
iii. Cycloplegic Dilation:.....	9
iv. Cycloplegic Autorefraction.....	9
v. Media and Fundus Examination	9
vi. Assessment of visual impairment	10

1.9 Pilot study	10
1.10 Data Management and Analysis	11
1.11 Reliability and Validity.....	11
1.12 Ethical, Legal considerations and Permission	12
1.13 Dissemination of results:	12
1.14 Chapters presented in this thesis.....	12
1.15 Conclusion.....	13
References	14
CHAPTER 2 – First Manuscript	20
CHAPTER 3 – Second Manuscript	29
CHAPTER 4 - Synthesis Chapter	55
4.1 General discussion	55
4.2 Conclusion.....	57
4.3 Recommendations into future research.....	57
4.4 Limitations of this study.....	58
References	59
APPENDICES	61
<i>Appendix 1-</i> Information document (detailing the overall study)	61
Appendix 2- Certificate of consent	63
Appendix 3- Assent form	65
Appendix 4- Ethical clearance.....	68
Appendix 5- Approval letter from Limpopo Department of Education	69
Appendix 6- Approval letters from the principals of the selected schools.....	70
Appendix 7- National Eye Institute Visual Functioning Questionnaire – 25	78
.....	79
.....	80
.....	81
.....	83

.....	84
.....	85
Appendix 8- Examination Record Card	86
.....	88
.....	89
.....	90
.....	91
Appendix 9- Class (Cluster) Enumeration Form	92
Appendix 10- Ethical certificates	93

List of Acronyms

CI: Confidence Interval

D: Dioptre

HRQoL: Health Related Quality of Life

LogMAR: The logarithmic of minimum angle of resolution

NEI-VFQ: National Eye Institute Visual Function Questionnaire

QoL: Quality of Life

RE: Refractive error

RESC: Refractive Error Study in Children

SD: Standard Deviation

SPSS: Statistical Package for Social Sciences

UKZN: University of KwaZulu-Natal

URE: Uncorrected Refractive Error

UVA: Unaided visual acuity

VA: Visual Acuity

VI: Visual impairment

VFQ: Visual Function Questionnaire

WHO: World Health Organisation

List of Tables

Tables within the First manuscript

Table 1: Distribution of participants according to age

Table 2: Distribution of participants according to grade

Table 3: Distribution of Uncorrected Visual Acuity (UVA) in LogMAR for right and left eyes

Table 4: Prevalence of Visual Impairment according to with gender, age and grade.

Table 5: Prevalence of refractive error according to gender, age and grade

Table 6: Demonstrating the prevalence of refractive errors in African countries

Tables within the Second Manuscript

Table 1: Demographics of the respondents

Table 2: Participants with and without RE and/ VI based on age and gender

Table 3: Prevalence of refractive error according to types, gender and age

Table 4: Comparison of the mean and standard deviation of the sub scores of the items on the VFQ-25 between learners without RE and/VI or those with

Table 5: The mean and standard deviation of sub scores of the items on the VFQ-25 for participants with RE and/ VI based on age groups.

Table 6: The mean and standard deviation of sub scores of the items on the VFQ-25 for participants with RE and/ VI based on gender.

Table 7: The mean and standard deviation of sub scores of the items on the VFQ-25 according to refractive status

Table 8: Correlations between the items of VFQ

ABSTRACT

Background: Refractive error (RE) and visual impairment (VI) remain major problems affecting school going children worldwide and impacting their quality of life.

Aim: To determine the prevalence and distribution of RE and VI, and their impact on quality of life (QoL) of school-going children.

Setting: This school-based study was conducted on school-going children residing within the borders of greater Sekhukhune district, Limpopo (South Africa).

Methods: A multistage random sampling method was used to select schoolchildren aged between 6 and 18 years from Grades R to 12. A total of 400 learners were invited to participate in this study and 326 (81.5% [95% CI, 77.7-85.3]) learners underwent an eye examination. The examination assessed unaided and aided visual acuity using a LogMAR chart, binocular motor function, autorefractometry under cycloplegia, media and fundus examination, and QoL measured with the National Eye Institute visual function questionnaire (NEI-VFQ-25).

Results: The prevalence of uncorrected, presenting and best corrected visual acuity of 0.30 or worse in the better eye was 12.3% (95% CI, 8.7-15.8), 12.3% (95% CI, 8.7-15.8) and 2.1% (95% CI, 0.6-3.7) respectively. Refractive error accounted for 81% of all causes of VI. Myopia was the most prevalent RE (50.7% [95% CI, 38.8-62.7]), followed by astigmatism (36% [95% CI, 24.3-47.3]), and hypermetropia (13.6% [95% CI, 5.30-21.6]). There was no significant difference in the prevalence of RE and VI between males (50.7% [95% CI, 38.8-62.7]) and females (49.3% [95% CI, 37.3-61.2]). Refractive error and VI were highest among children aged between 14 and 18 years. Moreover, the highest prevalence of RE was observed in Grades 9 to 12 learners (46.3% [95% CI, 34.3-58.2]). Children with RE and or VI scored low on NEI-VFQ-25.

Conclusion: The prevalence of RE and VI among schoolchildren in greater Sekhukhune district was high. This calls for attention from policymakers and all stakeholders responsible for eye care to devise strategies to address these conditions as they decrease the children's QoL.

Keywords: Refractive Error, Visual Impairment, school-going children, Impact and Quality of Life

IQQQA

Isingeniso:- Izinga Lokungaboni Kahle lihlezi liyinselela enkulu ekhathaza izingane ezihamba isikole emhlabeni wonke, futhi linomthelela ezingeni lempilo ephilwa yilezo zingane. Ukuhlonza ukuvama nokusabalala kwalesi sifo, kanye nomthelela waso ezingeni lempilo ephilwa yizingane ezihamba isikole

Indawo Yocwaningo:- Lolu cwaningo lwenzelwe esikolweni kubantwana abafundayo abahlala ngaphakathi kwemingcele Yesifunda Sase Sikhukhune (Limpopo) Eningizimu Afrika

Izindlela Zokwenza Ucwaningo:- Indlela yokwenza ucwaningo elandelwe, kube yileyo yokuqoka abantwana besikole ababaphakathi kweminyaka eyi-6 kuya kweyi-18, kusukela ku-Grade R kuya ku-12, ngokubadumba nje kulandelwe imidiyo ethize. Bangama-400 sebebonke abantwana besikole ababemenyelwe ukubamba iqhaza kulolu cwaningo, kwathi abangama-326 (81.5% [95% CI, 77.7-85.3]) kulaba bafundi bahlololwa amehlo. Abafundi baxilongwa bengazifakile izibuko, baphinda futhi bahlolwa izinga lokubona bezifakile. Izinga lokubona lahlolwa nge LogMAR chart, kwabhekwa ukesebenzisana kwemisipha yamehlo, kwabhekwa ungwengwezi kwase kuhlolwa impilo yawo amehlo phakathi (phecelezi kwi fundus). Imibuzo ye National Eye Institute Visual Function Questionnaire (NEI-VFQ-25) nayo yasetshenziswa ukuze kuhlolwe izinga lempilo yabafundi egcina ingumthelela wawo amehlo.

Imiphumela: Abafundi abatholakala bangaboni ngokwenelisayo batholakala bengu 12,3% (95% CI, 8.7-15.8). Ababengaboni kakhulu babe ngu 2.1% (95% CI, 0.6-3.7). Ababenenkinga yamehlo angaboni kahle (phecelezi Refractive Error) babe ngu-81%, iningi labahluleka ukubona into uma iqhelile kubona. Abesilisa babengu 50.7% (95% CI, 38.8-62.7), abesifazane bengu 49.3% (95% CI, 37.3-61.2) kulaba ababehloliwe. Iningi lababenenkinga yokubona babe neminyaka kwe-4 kuya kweyi-18, befunda u grade 9 to 12 (46.3% [95% CI, 34.3-58.2]). Izinga lempilo yabo nalo lathokala liphansi uma kuhlolwa nge NEI-VFQ-25

Isiphetho: Izinga lokungaboni kahle nokukhubazeka ngamehlo liphezulu eSikhukhune. Abengamele ezempilo nabaphathiswa emkhakheni wamehlo kumele bangenelele balekelele ngezindlela zokusiza abantwana ukuze nezinga labo lempilo libe ngconywan

CHAPTER 1

Introduction

1.1 Background

Refractive error (RE) and subsequent visual impairment (VI) in some cases, has its onset much earlier in life thus affecting individuals for many years and on many levels including social, psychological and financial (1,2). The management of RE and subsequent VI has been a priority of the World Health Organization (WHO) as it is the second leading cause of avoidable blindness globally (3). It is also known that RE and VI have an impact on the quality of life of school-going children (4). Refractive error is a visual disorder caused by irregularity in the shape, and or size of the eye, resulting in difficulty when attempting to focus objects clearly and leading to blurred vision (5). Linked to RE is VI which results when the RE cannot be corrected by conventional spectacles, contact lenses, surgery or medical intervention (6). In addition, in some instances, RE remains uncorrected for a variety of other reasons including inaccessibility and unaffordability which further contributes to the statistics on VI. Uncorrected refractive error (URE) and VI remain major problems affecting school-going children worldwide, leading to broader negative social and economic impacts (7).

1.2 Literature review

1.2.1 Prevalence

Refractive errors, particularly myopia, can pose a serious challenge to an individual and society. Hashemi Hassan *et al.* (8) recently indicated that globally, 11.7% of children are myopic with a further 4.6% and 4.9% having hypermetropia and astigmatism, respectively. The prevalence of RE differs from region to region, with the highest prevalence in the Asian populations where China has a prevalence of 33.9% (9), followed by India with 18.6% (10), Indonesia 15.9% (11), and Iraq 47% (12). The African continent has a prevalence ranging from 2 - 12% (13-16). However, in some African countries the prevalence of RE differs slightly as it was found to be 26.9% and 25.6% for Egypt and Ghana, respectively (17,18). South Africa has a prevalence of 20.1% (19).

The leading type of RE, with a serious impact on the lives of children, was found to be myopia (8,20-22). Myopia was also associated with differing prevalences with respect to gender (14,15,23), age (14,24,25) and parents' level of education (26-28). Several studies have indicated that people living in urban areas have a higher prevalence of RE than people living in rural areas (23,29-31). On the contrary, Al Wadaani *et al.* (32) reported that children coming from rural areas have a higher prevalence of RE compared to their urban counterparts.

The higher prevalence of myopia in children in recent years has been attributed to urbanization (30, 31, 33) and subsequently less exposure to sunlight due to increased indoor activities including watching television and playing computer games. Myopia was also found to be associated with an older child, while hyperopia, with a younger age group (24,26,27). While in South Africa, Wajuihian and Hansraj (20) did not find any evidence of an association between RE, gender and/or age, elsewhere myopia has been associated with gender, with some cases reporting a higher prevalence in girls than boys (14,15,34) and others a higher prevalence in boys than girls (35-37). As it is known that parents' level of education is also associated with myopia as children of people with post-matric qualifications have been found to be more myopic than children whose parents only have a high school qualification or lower (26-28).

1.2.2 Visual Impairment

Refractive error that remains uncorrected leads to VI (37,38). Global statistics reveal that there are about 19 million visually impaired children in the world, most residing within the African continent, with URE as the leading cause of their VI (39). A study done by Pascolini and Mariotti (40) indicated that the global prevalence of VI amongst children is 18.9 million (6.6%). Moreover, the prevalence of VI also differs from region to region with Sub-Saharan Africa being at the top of the list (40). The reported prevalences of VI on school-children also differs from region to region like 14% in Indonesia (11), 39.9% in Iraq (12), 12.2% in Vietnam (21), 21.6% in Pakistan (36), 12.4% in Ethiopia (40), 3.66% in Ghana (13) and 2.74% in South Africa (25). Visual impairment prevalences also differ between genders and age groups (41).

1.2.3 Quality of life

Refractive error and/ VI can have detrimental impacts on an individual's quality of life (QoL) (42). According to the WHO, QoL can be defined as a personal perception of someone's position in life in a context of culture and value systems in which he lives and in relation to his goals, expectations, standards and concerns (43). Therefore vision-related QoL can be defined in the context of VI (44). Unlike with cataract and glaucoma which have a later onset, the number of years of life that RE, and/ or VI, affects one is significant (1,2). In the United States of America, the medical expenditure of a person with RE and/or VI was estimated around \$4000 per annum, excluding the cost of loss of productivity, anxiety and distress (45,46).

Most children with RE and/or VI complain of having difficulties copying what is written on the blackboard at school (44). Further to this is that they cannot participate in most sporting codes that require good vision (47). A study done by Pan *et al.* (48) among adolescents in rural China found that healthy adolescents with reduced vision had lower health-related quality of life (HRQoL) scores including social and school function, as compared with those with normal vision. Some studies show

that correcting RE or VI can increase the QoL of an individual (49). Vision impairment is also associated with poor physical performance (4). In addition, children with worse VI are reported to experience more difficulty in life as compared to those with average VI (50), and children with VI in one eye could still score better on the QoL assessment, than those with bilateral VI (51).

1.3 Justification for this study

There was a need for this study to be done to determine the current prevalence of RE and VI and their impact on the QoL among school-going children inclusive of all age groups, which could guide intervention strategies in dealing with this global issue. Moreover, a study like this was not done in this area.

1.4 Research questions

The research questions addressed by this study included:

1.4.1 What is the prevalence and distribution of RE and VI among schoolchildren aged 6-18 years, in the greater Sekhukhune district in Limpopo Province, South Africa?

1.4.2 What is the impact, if any, of RE and VI on the QoL of school-children aged 6-18 years, in the greater Sekhukhune district in Limpopo Province, South Africa?

1.5 Aim & Objectives

The aim of this study was to determine the prevalence and distribution of RE and VI, and their impact on QoL among school-children aged 6 – 18 years, in the greater Sekhukhune district in Limpopo Province, South Africa.

The objectives more specifically were to:

1.5.1 measure the RE and VI on a sample of school-children using the modified Refractive Error in School Children (RESC) protocol and visual acuity measured with a log MAR chart in greater Sekhukhune district.

1.5.2 report on the prevalence and distribution of RE and VI on a sample of school-children based on age, gender, level of schooling and geographical location.

1.5.3 assess the QoL of school-children with RE and/or VI using a QoL questionnaire (NEI-VFQ-25).

1.6 Methods

1.6.1 Study design

This was a quantitative, cross sectional, school-based study to determine the prevalence of RE, VI, and their impact on QoL among school-children residing within the borders of Greater Sekhukhune district, Limpopo province, South Africa.

1.6.2 Study setting

Greater Sekhukhune is one of the five districts in Limpopo province, the northernmost province of South Africa. It is the smallest district of the province of Limpopo making up 11% of the geographical area (i.e. 13 528km²) with a population of 1 169 762. Greater Sekhukhune district is made up of four local municipalities which are Ephraim Mogale (greater Marble Hall), greater Tubatse (Feta Kgomo), Makhuduthamaga and Elias Motsoaledi. It also has few towns and cities namely Burgersfort, Groblersdal, Marble Hall, Ohrigstad, Roosenekal, Schuinsdraai Nature reserve, and Steelpoort. From the northern side, Sekhukhune is surrounded by Capricorn and Mopani on the East, Ehlanzeni on the South East, Nkangala to the South and Waterberg to the North West.

Eighty-three percent of the population in greater Sekhukhune are Sepedi speaking with 98.6% of the population being black African, followed by Caucasians (1.1%), mixed race (0.2%) and Indians (0.1%). Fifty-five percent of the population are female and 44.50% are male (52). Greater Sekhukhune district municipalities are made up of many homelands and its main economic sectors are mining (20%), trade (17%), financial and business services (12%) and agriculture (9.7%). This is a low socio-economic area with an unemployment rate of 64%, and many people living on an income of less than R1500 per month per household (52,53). Greater Sekhukhune district has 932 schools: 547 primary schools, 326 secondary schools, 28 combined schools, 25 private schools and six special schools. The population in greater Tubatse/ Feta Kgomo is 489 902 with 343 schools, population in Makhuduthamaga is 284 435 with 324 schools, Elias Motsoaledi has a population of 268 256 with 204 schools and Ephraim Mogale is populated at 127 168 with 61 schools (54).

1.6.3 Study population

The study population comprised school-children aged 6-18 years in Greater Sekhukhune district, Limpopo Province, South Africa. The targeted population were learners residing in the rural area of Makhuduthamaga municipality which has been selected by convenience due to access to this municipality by the researcher. This municipality is representative of greater Sekhukhune district. In 2016, STATS SA indicated that 105 023 children were enrolled at various schools in Makhuduthamaga (53). This number was used as the total population size for this study. Makhuduthamaga municipality

has 197 primary schools, 117 secondary schools, four combined schools, three special schools and three private schools.

1.6.4 Sample size and sampling method

i. Sample Size

The baseline sample size was determined by using the equation outlined below (55):

$$N = (Z)^2 (1.0-p)(p) / (b)^2$$

N = min sample size

p = anticipated prevalence (7%)

b = desired error bound considered as 3,5% (prevalence divided by 2)

Z = 1.96, for a 95% confidence interval

The value for p was 7% which is the assumed prevalence of RE in accordance with the recent study in South Africa on a sample of black high schoolchildren (56).

$$N = (1.96)^2 \times (1.0 - 0.07) (0.07) / 0.035^2$$

$$N = 3,8416 \times (0,0651) / 0,001225$$

$$= 204$$

The sample size determined was however multiplied by 1.5 to compensate for the design effect, therefore,

$$\text{Adjusted for design effect: } 204 \times 1,5 = 306$$

Finally, another 10% was added to the calculated value as a contingency factor, therefore:

Adding 10% of 306 give us a required sample size of 337. This was rounded off to 400 to allow an equal distribution of grades and genders.

ii. Sampling Method

A total of 400 learners were invited to participate in this study, the total number of learners to be enrolled for the study per school was obtained by dividing the total sampling frame (from the 271 schools) by the tentative sample size to obtain the sample interval and total of ten schools (Appendix 7) which included five primary schools and five secondary schools which were randomly selected. The total number of learners per school was then divided by the sample interval to obtain the total number of learners to be enrolled per school, as a result 40 learners were randomly selected to represent each school.

Five grades were randomly selected from each school between Grades R to Grade 12. In every grade the class register was used as a sampling frame to randomly select eight participants from the rest of the class, both males and females equally represented.

All the learners selected to participate in this study were given the information document (Appendix 1) detailing the purpose and nature of the study, parental consent forms (Appendix 2) for their parents to read and sign confirming that they are allowing their children to take part in the study and a child assent form (Appendix 3).

Participants were selected based on the following criteria:

Inclusion

Children aged 6-18 years who returned signed parental consent forms, assent forms and were present at school on the days of the examination for data collection, were included in this study.

Exclusion

All children with any systemic or ocular diseases and/or on any systemic or ocular medication were excluded from this study.

1.7 Study instruments:

1.7.1 A Log MAR chart with the tumbling E' optotype to accommodate the younger children that may have been unfamiliar with letters or numbers was used to measure visual acuity at distance.

1.7.2 An ophthalmoscope (Keeler) was used for media and fundus examination and to check the corneal reflex.

1.7.3 The paddle occluder was used for cover test and occlusion during visual acuity assessment.

1.7.4 The autorefractor (Topcon RM-8000B) was used to measure the refractive error under cycloplegia.

1.7.5 A penlight torch was used for the Hirschberg assessment.

1.7.6 Trial lenses and a trial frame were used to measure visual impairment.

1.8 Study Procedure

Data collection commenced after ethical approval was obtained from the Biomedical Research and Ethics Committee at the University of KwaZulu Natal [(BE080/19) (Appendix 4)], authorization was granted from Limpopo Department of Education (Appendix 5), and permission granted by the principals of the selected schools (Appendix 6). The data collection took place in the afternoon to minimize disruption of the childrens' academic program due to cycloplegia. The study was conducted in accordance with the Declaration of Helsinki regarding research on human subjects.

The field staff included an optometrist who has diagnostic privileges and three research assistants. A training and standardization workshop was held for all study personnel prior to commencement of the study. A pilot study was conducted in the Elias Motsoaledi municipality (Groblersdal Academy) to validate the data collection procedures and recording forms.

A modified RESC protocol was employed to determine the prevalence values of RE and VI. Refractive error was determined with autorefraction under cycloplegia, and not with subjective refraction.

A validated tool (NEI VFQ-25 questionnaire) was modified to be relevant to the current study sample and used to assess the QoL of the learner (Appendix 7).

1.8.1 Clinical Assessment

The clinical examination was done by the optometrist and the research assistant, at the stations set-up at the selected schools in an allocated classroom and it followed the modified RESC protocol as per sequence below (20):

- i. Vision Assessment: Distance VA was measured with a retro illuminated LogMAR chart using the tumbling E optotype. The chart was placed four meters in front of the participant. The top line on the chart is 1M. The participant was asked to close one eye with a paddle occluder and not to put pressure on it. The research assistant started with the large E at the top the chart, showing them the three parallel fingers of the E and asked them to show him with their hand which direction the finger on the Es were pointing. The research assistant pointed to each E on successively smaller lines to test visual acuity, while reminding the learner not to peer with the unoccluded eye and ensuring occlusion of the other eye.

Each letter had a score value of 0.02 log units. The formula that was used in calculating the score is:

$$\text{LogMAR VA} = 0.1 + \text{LogMAR value of the best line read} - 0.02 X (\text{number of letters read})$$

The right eye was tested first, then the left eye, each time occluding the fellow eye. Unaided acuity was measured first, followed by aided, where applicable. This procedure was done by same person all the time.

- ii. **Binocular Motor Function:** All ocular alignment assessments were performed without spectacles as only habitual binocular motor function was reported upon. Initially ocular alignment was assessed using corneal reflections (Hirschberg test). In this test we asked each child to fixate on the penlight binocularly rather than monocularly and observed the symmetry of the corneal light reflections. If there was strabismus or eye turn in which only one eye focused on the target and the other eye would deviate nasally or temporally, the corneal light reflex of the turned eye was seen displaced from the pupil centre. If the eye deviated towards the nose (esotropia) the reflex was displaced temporally and if the eye deviated away from the nose (exotropia) the reflex was displaced nasally. This was followed by a cover/uncover test using an occluder and performed with the fixation target at distances of 50 cm and four metres. The left eye was covered first, and the right eye was observed to detect any corrective movement while the child fixated on an accommodative target, which was a line above the VA of the poorer eye with both eyes open. The cover was then removed and then the right eye was covered to detect any movement in the left eye. The heterotropia was classified as an esotropia (outward movement of the uncovered eye), exotropia (inward movement), or vertical tropia (upward or downward movement and the recording was made of the eye with the hypertropia). If a heterotropia was detected it was measured using a prism bar. It was classified as constant if it was present at all times for both fixation distances. If detected at only one fixation distance or not present at all times, it was classified as periodic.

In the absence of a heterotropia, the cover test was then used to assess for the presence of a heterophoria. The right eye was covered, and then as it was being uncovered, it was observed for any movement (just uncovered eye) which, if present, indicated a phoria. An inward movement represented an exophoria, an outward movement an esophoria, upward movement a hypophoria and downward movement a hyperphoria. The left eye was then covered, and as above, observed as it was being uncovered to confirm any phoria detected in the right eye. If no movement of the “just uncovered eye” was observed, then only was the alternating cover test (movement of the cover from the right to left eye and back to right eye without allowing fusion) be performed to assess whether there was a phoria approx. less than four prism dioptres which was not necessarily observable to the naked eye.

The amount of tropia or phoria was measured using the alternating cover test in combination with a prism bar. The prism bar was placed in front of the non-tropic eye (in the case of a tropia) and before any eye (in the case of a phoria) with the participant fixating on a relevant target. One eye was covered and then after a few seconds the occluder was moved directly to the other eye, again after 1-2 seconds, the occluder was moved back to the original eye. The sequence was repeated a number of times (minimum 2-3) and one eye being covered for the duration of the alternate cover test. If corrective re-fixation movement of the eye (without the prism) was detected, then the prism power was increased until no movement of the eye (without the prism) was observed. The amount of prism that results in no further movement of the eye/s was regarded as the magnitude of deviation. Base-in prisms were used to measure exo deviations, base-out prisms for eso deviations, base-up prism for hypo deviations and base-down prism for a hyper deviation.

- iii. **Cycloplegic Dilation:** Pupillary dilation and cycloplegia (in both eyes) was attained by using one drop of Novesin Wander in both eyes and then after two minutes of achieving ocular surface anaesthesia, two drops of 1% cyclopentolate were administered five minutes apart in each eye. After an additional 15 minutes, if a pupillary light reflex was still present when observed with a bright torch light without magnification, then a third drop was administered as required. After a further 15 – 20-minute interval cycloplegia was considered complete if the pupillary light reflex was absent and pupil diameter was 6mm or more. In some children both dilation and cycloplegia could not be achieved: dilation may be less than six millimetres but cycloplegia complete, or dilation six millimetres with incomplete cycloplegia. The achievement of cycloplegia was necessary irrespective of the extent of dilation. This procedure was performed by the optometrist.
- iv. **Cycloplegic Autorefraction:** In eyes with successful cycloplegia, refraction was performed with an autorefractor (Topcon RM-8000B). Autorefraction was carried out according to the manufacturer instruction manual, including daily calibration. A minimum of five readings with valid confidence rankings as per the manufacturer's instructions were obtained for each eye. The RESC protocol defines myopia in one or both eyes of at least -0.50 diopter (D), hypermetropia at least +2.00 D in one or both eyes and astigmatism at 0.75 cylindrical refraction or more.
- v. **Media and Fundus Examination:** Examination of the anterior segment, lens, vitreous and fundus was performed using a direct ophthalmoscope in all children. The recording of abnormal

findings was important as documentary evidence to support the assignment of a principal cause of impairment. Any abnormal fundus findings were recorded.

- vi. **Assessment of visual impairment:** The cycloplegic autorefractor prescription was put up in a trial frame for any significant RE as defined above, and the aided VA measured as per procedure described above for VA for all children who attained an initial unaided or aided VA worse than LogMAR = 0 (20/20). In those cases where the aided VA was worse than LogMAR = 0.30 (20/40) the child was categorized as having VI.

1.8.2 Quality of life assessment

The modified National Eye Institute (NEI) visual functioning questionnaire-25 (NEI-VFQ-25) version 2000 was used as an instrument to measure the QoL (Appendix 7) (57). This was administered to children 14 years and older because older children were able to understand the questions better. This was administered in a structured interview format consisting of 23 questions which were compulsory. The trained research assistant read the questions/statements about vision problems or difficulties that the child might experience due to his/her vision condition. After each question/statement the field worker read the list of possible answers and the child had to verbally express a response, after which the research assistant recorded the response. The questions were categorized into sub-scales like global vision rating (1), difficulty with near vision activities (3), difficulty with distance vision activity (3), limitation in social functioning due to vision (2), dependency on others due to vision (4), limitation with peripheral vision (1) and ocular pain (2).

The maximum score was 100, indicating a good quality of life. A poor QoL was indicated by scores closest to zero. The questionnaire was presented in English and the results were collected and analysed as low or high QoL.

1.9 Pilot study

The pilot study was conducted outside the main area of study on 40 school-children attending Groblersdal Academy, following the protocol outlined above. This was done procedurally to identify all possible problematic areas in the study procedures or data collection in order to modify prior to the implementation of the main study. Subjects recruited for the pilot study were excluded from the main study. During pilot study we discovered that some learners could not understand English well, then for the main study we use a field worker who was proficient in both English and Sepedi in order to translate the questions should need arise.

1.10 Data Management and Analysis

All data was captured and entered onto a MS Excel spreadsheet. Data was cleaned and analyzed using the Statistical Package for Social Sciences (SPSS v 25) in consultation with a statistician. Data back-up was done daily, and the back-up copies were stored in a password protected file. Descriptive statistics including frequencies, percentages, means and standard deviations were computed. Data back-up was done daily, and the back-up copies were stored in a password protected file.

1.10.1 Prevalence of RE and VI in the sample

The distribution of uncorrected, presenting and best corrected VA was reported in visual acuity categories. Values of at least - 0.50 dioptre, + 2.00 dioptre and -0.75 cylindrical power and above for myopia, hyperopia and astigmatism, respectively were considered significant. The distribution of spherical equivalent RE among those with VI was tabulated by age and gender. The association of myopia or hyperopia with a child's age and gender was explored with multiple logistic regression. Principal causes of VI (visual acuity 20/40 or worse) were summarized.

1.10.2 Effect of RE and VI of quality of life

Correlations were used to look at the strengths of the relationship between QoL scores. The independent sample t-test or ANOVA analysis was used to compare the mean QoL scores between the categories of RE and/ VI. All the tests were two tailed and statistical significance was set at $\alpha=5\%$.

1.11 Reliability and Validity

Reliability is a term used when assessing the consistency of the measure or techniques used, while validity focuses on the accuracy of the measuring technique. For this study to be consistent and accurate, it was done following the below procedure.

- i. The study procedures followed the modified RESC protocol.
- ii. A pilot study was done to finalise the data collection procedures and recording.
- iii. A standardization workshop was held with all personnel involved in the data collection prior to commencement of the study.
- iv. All equipment was calibrated prior to commencement of data collection, and thereafter on a daily basis, before data collection.
- v. Multiple readings were taken for determining the refractive error.
- vi. The principal investigator was a qualified optometrist, skilled to perform all the tests with over ten years' experience.
- vii. All distances were measured using a tape measure.

- viii. Standard room lighting was used for measurement of VA and assessment of binocular vision function.

1.12 Ethical, Legal considerations and Permission

- i. Ethical clearance for the study was obtained from the Biomedical Research and Ethics Committee (**BE080/19**) at the University of KwaZulu-Natal.
- ii. Permission was obtained from the Department of Education in Limpopo Province (Appendix 5).
- iii. Permission was obtained from the respective school principals (Appendix 6).
- iv. Informed consent was signed by the parents of the children, and assent was approved by the children.
- v. Data back-up was done daily, and the back-up copies were stored in a password protected file. The only person with access to this data is the principal investigator.

Any child that was found to have reduced vision, significant refractive error and/or ocular pathology was given a referral to their chosen eye care practitioner.

1.13 Dissemination of results:

Findings were reported in manuscripts that have been submitted to peer-reviewed, accredited journals and presented to other stakeholders including Department of Education and Department of Health in Limpopo.

1.14 Chapters presented in this thesis

1.14.1 Chapter 1

This chapter details the introduction of this study, its background, literature review, research question, objectives and detailed methodology.

1.14.2 Chapter 2

This is the chapter that addressed the research question about the prevalence of RE and VI among school-children aged 6-18 years residing within the borders of Sekhukhune district. It further outlines the distribution of RE and VI based on gender, age, and grade. It is an original research manuscript, submitted and published on African Vision and Eye Health Journal (AVEH) .

1.14.3 Chapter 3

This chapter addresses the research question pertaining to the impact of RE/VI on the QoL of school-children within greater Sekhukhune district. It is an original research manuscript, to submitted for publication on BMJ journal.

1.14.4 Chapter 4

This is the synthesis chapter, it outlines all the results and critically discusses them, including conclusions and recommendations from the study.

1.15 Conclusion

In overall chapter 1 outlines the detailed background of this study, literature view, the aims and objectives of this study, methodology with study procedure and the main questions to be answered by this study.

References

1. Kocur I, Resnikoff S. Visual impairment and blindness in Europe and their prevention. Vol. 86, British Journal of Ophthalmology. BMJ Publishing Group Ltd; 2002. p. 716–22.
2. Kandel H, Khadka J, Goggin M, Pesudovs K. Impact of refractive error on quality of life: a qualitative study. Clin Exp Ophthalmol. 2017 Sep 1;45(7):677–88.
3. WHO | Priority eye diseases. WHO. 2018;
4. Elsmann EBM, van Rens GHMB, van Nispen RMA. Quality of life and participation of young adults with a visual impairment aged 18–25 years: comparison with population norms. Acta Ophthalmol. 2019 Mar 1;97(2):165–72.
5. Sieving PA. Facts about Refractive Errors | National Eye Institute. National Eye Institute. [cited 2018 Nov 12]. p. 1–2. Available from: <https://nei.nih.gov/health/errors/errors>
6. DeCarlo DK, Woo S, Woo GC. Patients with low vision. In: Borish's Clinical Refraction. 2006.
7. Rahi JS, Solebo AL, Cumberland PM. Uncorrected refractive error and education. BMJ (Online). 2014 Oct 6;349.
8. Hashemi H, Fotouhi A, Yekta A, Pakzad R, Ostadimoghaddam H, Khabazkhoob M. Global and regional estimates of prevalence of refractive errors: Systematic review and meta-analysis. J Curr Ophthalmol. 2018 Mar 1 [cited 2018 Jun 19];30(1):3–22. Available from: <https://www.sciencedirect.com/science/article/pii/S2452232517300227>
9. Xie Z, Long Y, Wang J, Li Q, Zhang Q. Prevalence of myopia and associated risk factors among primary students in Chongqing: multilevel modeling. Springer. [cited 2020 May 6]; Available from: <https://doi.org/10.1186/s12886-020-01410-3>
10. BEG S, Diagnostic SL-J of C&, 2020 undefined. Prevalence of Refractive Errors and Colour Blindness in School Going Children of Wardha Tehsil: A Prospective Study. search.ebscohost.com.[cited2020May6];Availablefrom: <http://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=0973709X&AN=142268596&h=gisf1O%2B6CE6IuT9x85iJd9%2FuVRzc7wFI1xlDWbc4HNma8UEPnkMxGSEieggf40Z0uIynblCBuAXtvaLuGeHnBQ%3D%3D&crl=c>
11. Halim A, Suganda R, Natalya Sirait S, Karfiati Memed F, Rini M, Ratnaningsih N. Prevalence and associated factors of uncorrected refractive errors among school-children in suburban areas in Bandung, Indonesia. cogentia.com. 2020 [cited 2020 May 6]; Available from: <https://doi.org/10.1080/2331205X.2020.1737354>
12. Hatow MHU, ... AM-F and D, 2018 undefined. The Prevalence of Refractive Errors Among

- First Grade of Primary School in Amara, South of Iraq. *fdj.iums.ac.ir*. [cited 2020 May 6]; Available from: http://fdj.iums.ac.ir/browse.php?a_code=A-10-26-3&slc_lang=en&sid=1
13. Kumah BD, Ebri A, Abdul-Kabir M, Ahmed A-S, Koomson NY, Aikins S, et al. Refractive Error and Visual Impairment in Private School-children in Ghana. *Optom Vis Sci*. 2013 Dec [cited 2019 Mar 31];90(12):1456–61. Available from: <http://content.wkhealth.com/linkback/openurl?sid=WKPTLP:landingpage&an=00006324-201312000-00016>
 14. Mehari ZA, Yimer AW. Prevalence of refractive errors among schoolchildren in rural central Ethiopia. *Clin Exp Optom*. 2013 Jan [cited 2018 Jun 19];96(1):65–9. Available from: <http://doi.wiley.com/10.1111/j.1444-0938.2012.00762.x>
 15. Ekpenyong BN, Naidoo K, Ahaiwe K, Ezenwankwo O, Ndukwe O, Ogar E, et al. Visual status and prevalence of eye disorders among school-age children in southern Nigeria. *African Vis Eye Heal*. 2017 Jan 30 [cited 2018 Jun 19];76(1):1–6. Available from: <http://www.avehjournal.org/index.php/aveh/article/view/377>
 16. Arafa AEE-D, Ewis AAE, Mahran WM, Mohamed AAE, El-Shabrawy EM. Prevalence and risk factors of refractive errors among preparatory school students in Beni-Suef, Egypt. *J Public Health (Bangkok)*. 2018 May 26 [cited 2018 Jun 19];1–5. Available from: <http://link.springer.com/10.1007/s10389-018-0930-8>
 17. Yamamah GAN, Talaat Abdel Alim AA, Mostafa YSED, Ahmed RAAS, Mahmoud AM. Prevalence of Visual Impairment and Refractive Errors in Children of South Sinai, Egypt. *Ophthalmic Epidemiol*. 2015 Jul 4 [cited 2018 Jun 19];22(4):246–52. Available from: <http://www.tandfonline.com/doi/full/10.3109/09286586.2015.1056811>
 18. Ovenseri-Ogbomo GO, Omuemu VO. Prevalence of refractive error among school-children in the Cape Coast Municipality, Ghana. *Clin Optom*. 2010;2:59–66.
 19. Baloyi V, Akinsola H, Physical JM-AJ for, 2018 undefined. Pattern of distribution of refractive error among primary school-children in Malamulele community of Limpopo province, South Africa. *journals.co.za*. [cited 2020 Apr 16]; Available from: <https://journals.co.za/content/journal/10520/EJC-132839854a?crawler=true&mimetype=application/pdf>
 20. Wajuihian SO, Hansraj R. Refractive Error in a Sample of Black High School-children in South Africa. *Optom Vis Sci*. 2017 Dec [cited 2019 Mar 15];94(12):1145–52. Available from: <http://insights.ovid.com/crossref?an=00006324-201712000-00010>
 21. Paudel P, Ramson P, Naduvilath T, Wilson D, Phuong HT, Ho SM, et al. Prevalence of vision

- impairment and refractive error in school-children in Ba Ria - Vung Tau province, Vietnam. *Clin Experiment Ophthalmol.* 2014 Apr [cited 2018 Jun 19];42(3):217–26. Available from: <http://doi.wiley.com/10.1111/ceo.12273>
22. Sewunet SA, Aredo KK, Gedefew M. Uncorrected refractive error and associated factors among primary school-children in Debre Markos District, Northwest Ethiopia. *BMC Ophthalmol.* 2014;14(1).
 23. You QS, Wu LJ, Duan JL, Luo YX, Liu LJ, Li X, et al. Prevalence of myopia in school-children in greater Beijing: the Beijing Childhood Eye Study. *Acta Ophthalmol.* 2014 Aug [cited 2018 Jun 19];92(5):e398–406. Available from: <http://doi.wiley.com/10.1111/aos.12299>
 24. French AN, Morgan IG, Burlutsky G, Mitchell P, Rose KA. Prevalence and 5- to 6-Year Incidence and Progression of Myopia and Hyperopia in Australian Schoolchildren. *Ophthalmology.* 2013 Jul 1 [cited 2018 Jun 19];120(7):1482–91. Available from: <http://linkinghub.elsevier.com/retrieve/pii/S0161642012011992>
 25. Naidoo KS, Raghunandan A, Mashige KP, Govender P, Holden B a., Pokharel GP, et al. Refractive Error and Visual Impairment in African Children in South Africa. *Investig Ophthalmology Vis Sci.* 2003;44(9):3764. Available from: <http://iovs.arvojournals.org/article.aspx?doi=10.1167/iovs.03-0283>
 26. Caca I, Cingu AK, Sahin A, Ari S, Dursun ME, Dag U, et al. Amblyopia and Refractive Errors Among School-Aged Children With Low Socioeconomic Status in Southeastern Turkey. *J Pediatr Ophthalmol Strabismus.* 2013 Jan 1 [cited 2019 Mar 30];50(1):37–43. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/22966784>
 27. Atowa UC, Munsamy AJ, Wajuihian SO. Prevalence and risk factors for myopia among school-children in Aba, Nigeria. *African Vis Eye Heal.* 2017 Jan 30 [cited 2018 Jun 19];76(1):1–5. Available from: <http://www.avehjournal.org/index.php/aveh/article/view/369>
 28. Li Z, Xu K, Wu S, Lv J, Jin D, Song Z, et al. Population-based survey of refractive error among school-aged children in rural northern China: the Heilongjiang eye study. *Clin Experiment Ophthalmol.* 2014 May [cited 2018 Jun 19];42(4):379–84. Available from: <http://doi.wiley.com/10.1111/ceo.12198>
 29. Barria Fernando, Conte Francisco, Munoz Sergio. Prevalence of refractive error and spectacle coverage in schoolchildren in two urban areas of Chile. *Pan American Journal of Public Health.* 2018, Vol. 42, p1-8. 8p. 2018 [cited 2019 Mar 10]. Available from: <http://web.a.ebscohost.com.ukzn.idm.oclc.org/ehost/detail/detail?vid=25&sid=372efe76-7c2c-4138-b571->

ae13dd03c1f2%40sessionmgr4008&bdata=JnNpdGU9ZWwhvc3QtbGl2ZQ%3D%3D#AN=134551776&db=a9h

30. Gao Z, Meng N, Muecke J, Chan WO, Piseth H, Kong A, et al. Refractive error in school-children in an urban and rural setting in Cambodia. *Ophthalmic Epidemiol.* 2012 Feb [cited 2019 Feb19];19(1):16–22. Available from: <http://www.tandfonline.com/doi/full/10.3109/09286586.2011.632703>
31. Wu JF, Bi HS, Wang SM, Hu YY, Wu H, Sun W, et al. Refractive Error, Visual Acuity and Causes of Vision Loss in Children in Shandong, China. *The Shandong Children Eye Study.* Barnes S, editor. *PLoS One.* 2013 Dec 23 [cited 2018 Jun 19];8(12):e82763. Available from: <http://dx.plos.org/10.1371/journal.pone.0082763>
32. Al Wadaani FA, Amin TT, Ali A, Khan AR. Prevalence and pattern of refractive errors among primary school-children in Al Hassa , Saudi Arabia. *Glob J Health Sci.* 2012 Nov 11 [cited 2018 Jun 19];5(1):125–34. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/23283044>
33. Wu PC, Tsai C-L, Wu H-L, Yang Y-H, Kuo H-K. Outdoor Activity during Class Recess Reduces Myopia Onset and Progression in School-children. *Ophthalmology.* 2013 May [cited 2019Mar6];120(5):1080–5. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0161642012010755>
34. Lim HT, Yoon JS, Hwang S-S, Lee SY. Prevalence and associated sociodemographic factors of myopia in Korean children: the 2005 third Korea National Health and Nutrition Examination Survey (KNHANES III). *Jpn J Ophthalmol.* 2012 Jan 6 [cited 2018 Jun 19];56(1):76–81. Available from: <http://link.springer.com/10.1007/s10384-011-0090-7>
35. Parmar A, Kartha G, Baria M. A study on the prevalence of refractive errors among school-children of 10-16 years in Surendranagar district, Gujarat. *Int J Community Med Public Heal .* 2017Aug23[cited2018Jun19];4(9):3376. Available from: <http://www.ijcmph.com/index.php/ijcmph/article/view/1779>
36. Awan AR, Jamshed J, Khan MM, Latif Z. Prevalence and causes of visual impairment and blindness among school-children in Muzaffarabad, Pakistan. *Int J Sci Reports [Internet].* 2018 Mar 27 [cited 2018 Jun 19];4(4):93. Available from: <http://www.scirep.com/index.php/scirep/article/view/410>
37. Ezinne NE, Mashige KP. Refractive error and visual impairment in primary school-children in Onitsha, Anambra State, Nigeria. *African Vis Eye Heal [Internet].* 2018 Sep 11 [cited 2019 Mar 30];77(1):1–8. Available from: <http://www.avehjournal.org/index.php/AVEH/article/view/455>
38. Kedir J, Girma A. Prevalence of Refractive Error and Visual Impairment among Rural School-

- Age Children of Goro District, Gurage Zone, Ethiopia. *Ethiop J Health Sci* [Internet]. 2014 Nov 4[cited2018Jun19];24(4):353. Available from:
<http://www.ajol.info/index.php/ejhs/article/view/109429>
39. Resnikoff S. Assessment of the prevalence of visual impairment attributable to refractive error or other causes in school-children. *PROTOCOL AND MANUAL*. World Heal Organ. 2007;
 40. Pascolini D, Mariotti SP. Global estimates of visual impairment: 2010. *Br J Ophthalmol*. 2012 May1[cited2018Jun19];96(5):614–8. Available from:
<http://www.ncbi.nlm.nih.gov/pubmed/22133988>
 41. Dhanesha U, Polack S, Bastawrous A, Banks LM. Prevalence and causes of visual impairment among schoolchildren in Mekelle, Ethiopia. *Cogent Med*. 2018 Dec 6;5(1).
 42. Dandona L, Dandona R, Srinivas M, Giridhar P, Vilas K, Prasad MN, et al. Blindness in the Indian state of Andhra Pradesh. *Investig Ophthalmol Vis Sci*. 2001;
 43. Skevington SM. Measuring quality of life in Britain: Introducing the WHOQOL-100. *J Psychosom Res*. 1999;47(5):449–59.
 44. Kumaran SE, Balasubramaniam SM, Kumar DS, Ramani KK. Refractive error and vision-related quality of life in South Indian Children. *Optom Vis Sci*. 2015 Mar 6;92(3):272–8.
 45. Frick KD, Gower EW, Kempen JH, Wolff JL. Economic impact of visual impairment and blindness in the United States. *Arch Ophthalmol*. 2007 Apr;125(4):544–50.
 46. Lin JC, Yu JH. Assessment of quality of life among Taiwanese patients with visual impairment. *J Formos Med Assoc*. 2012 Oct 1;111(10):572–9.
 47. Hopkins S, Narayanasamy S, Vincent SJ, Sampson GP, Wood JM. Do reduced visual acuity and refractive error affect classroom performance? *Clin Exp Optom*. 2020 May 22 [cited 2020 May 5];103(3):278–89. Available from: <https://onlinelibrary.wiley.com/doi/abs/10.1111/cxo.12953>
 48. Pan CW, Wu RK, Wang P, Li J, Zhong H. Reduced vision, refractive errors and health-related quality of life among adolescents in rural China. *Clin Exp Optom*. 2018 Nov [cited 2019 Mar 15];101(6):758-63. Available from: <http://doi.wiley.com/10.1111/cxo.12680>
 49. Scott IU, Smiddy WE, Schiffman J, Feuer WJ, Pappas CJ. Quality of life of low-vision patients and the impact of low-vision services. *Am J Ophthalmol*. 1999 Jul;128(1):54–62.
 50. Kinengyere P, Kizito S, Kiggundu JB, Ampaire A, Wabulembo G. Burden, etiology and predictors of visual impairment among children attending Mulago National Referral Hospital eye clinic, Uganda. *Afr Health Sci*. 2017;17(3):877–85.

51. Hsieh M-H, Lin J-C. Association of refractive error with vision-related quality of life in junior high school students. *Taiwan J Ophthalmol*. 2016 [cited 2018 Jul 30];6(1):32–5. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/29018707>
52. Adrian Frith S. Census 2011 — Local Municipality “Makhuduthamaga. [cited 2018 Sep 3]. Available from: <https://census2011.adrianfrith.com/place/985>
53. South African, Lehohla AP, Statistics South Africa. The state of basic service delivery in South Africa: In-depth analysis of the Community Survey 2016 data. Statistics South Africa. Pretoria: Statistics South Africa. 2016.
54. Final IDP/Budge Review 2017-2018 by The executive mayor: Councillor Keamotsng Stanly Ramaila. Polokwane; [cited 2018 Oct 23]. Available from: [http://www.sekhukhunedistrict.gov.za/sdm-admin/documents/IDP Final 2017-2018\(2\) \(2\).pdf](http://www.sekhukhunedistrict.gov.za/sdm-admin/documents/IDP%20Final%202017-2018(2)(2).pdf)
55. Arya R, Antonisamy B, Kumar S. Sample Size Estimation in Prevalence Studies. [cited 2018 Oct11]; Available from: https://doc-0s-5c-apps-viewer.googleusercontent.com/viewer/secure/pdf/562uvjhkdj3scanoqq20he550i1ojjua/9njl18282queajqva8gjlvfdbv1lrkl/1539235875000/gmail/08250884207869853936/ACFrOgBhnsTdfFmoG0KgExsM9FdhYXUS20Qko1m_1K6ECPeVpiopBMs8Sq1uIZQWT0PYmgWMe87H0U
56. Alrasheed SH, Naidoo KS, Clarke-Farr PC. Prevalence of visual impairment and refractive error in school-aged children in South Darfur State of Sudan. *African Vis Eye Heal*. 2016;75(1):9 pages. Available from:
57. Mangione, C. M., Lee, P. P., Gutierrez, P. R., Spritzer, K., Berry, S., & Hays RD. Visual Function Questionnaire (VFQ-25) from RAND Health | RAND. *Archives of Ophthalmology*, 119, 1050-1058. 2001 [cited 2018 Aug 20]. Available from: https://www.rand.org/health/surveys_tools/vfq.html

CHAPTER 2 – First Manuscript

Chapter 2 is a manuscript ; this is the manuscript that addressed the research question about the prevalence of RE and VI among school-children aged 6-18 years residing within the borders of Sekhukhune district. The results were obtained after a full optometric examination was administered to learners and data was captured and analyzed using SPSS software. It further outlined the distribution of RE and VI based on gender, age, and grade. This manuscript is titled “Visual Impairment and refractive error among school-going children in Sekhukhune district (Limpopo) South Africa”. It was submitted and published in the African Vision and Eye Health (AVEH) journal as manuscript number: **551**.

Visual impairment and refractive error amongst school-going children aged 6–18 years in Sekhukhune District (Limpopo, South Africa)



Authors:
Tshubelele S.S. Magesiwe¹
Zamedondo N.Q.
Xulu-Kasabe¹
Rekha Hansraj¹

Affiliation:
¹Department of Optometry,
Faculty of Health Sciences,
University of KwaZulu-Natal,
Durban, South Africa

Corresponding author:
Zamedondo Xulu-Kasabe,
XuluKasabeZ@ukzn.ac.za

Dates:
Received: 07 Jan. 2020
Accepted: 23 July 2020
Published: 03 Oct. 2020

How to cite this article:
Magesiwe TSS, Xulu-Kasabe
ZNQ, Hansraj R. Prevalence
and distribution of visual
impairment and refractive
error amongst school-going
children aged 6–18 years in
Sekhukhune District
(Limpopo, South Africa).
Afr Vision Eye Health.
2020;79(1), e3551. <https://doi.org/10.4102/aveh.v79i1.3551>

Copyright:
© 2020. The Author(s).
Licensee: AOSIS. This work
is licensed under the
Creative Commons
Attribution License.

Read online:



Scan this QR
code with your
smart phone or
mobile device
to read online.

Background: Refractive error (RE) and visual impairment (VI) remain major problems affecting school-going children worldwide.

Aim: To determine the prevalence and distribution of VI and RE in school-going children aged 6–18 years.

Setting: The study was conducted in Sekhukhune District, Limpopo, South Africa.

Methods: A multistage random sampling method was used to select school-going children aged 6–18 years from Grades 1 to 12. A total of 326 learners went through eye examinations, which included visual acuity (VA) measurement using a logarithm of the minimum angle of resolution chart, autorefractometry under cycloplegia and ocular health assessment.

Results: The prevalence of uncorrected, presenting and best-corrected VA of 0.30 M or worse in the better eye was 12.3% (95% confidence interval [CI], 8.70–15.80), 12.3% (95% CI, 8.70–15.80) and 2.1% (95% CI, 0.60–3.70), respectively. Refractive error accounted for 80% (95% CI, 67.6–92.4) of all causes of VI. Myopia was the most prevalent RE (50.7%; 95% CI, 38.8–62.7), followed by astigmatism (36%; 95% CI, 24.3–47.3) and hypermetropia (13.6%; 95% CI, 5.30–21.6). There was no significant difference in the prevalence of RE and VI between males (50.7%; 95% CI, 38.8–62.7) and females (49.3%; 95% CI, 37.3–61.2). Refractive error and VI were higher amongst children aged 14–18 years: 56.7% (95% CI, 44.9–68.6) and 60% (95% CI, 44.8–75.20), respectively.

Conclusion: The prevalence of RE and VI amongst school-going children in Sekhukhune District was high, highlighting the need for school visual screening and strategies to address these conditions in that area.

Keywords: refractive error, visual impairment, myopia, hypermetropia, school-going children, learner eye health

Introduction

The World Health Organisation (WHO) has made a call to all nations to prioritise the management of refractive error (RE) and visual impairment (VI) as they are the second leading cause of avoidable blindness globally.¹ Refractive error is a visual disorder caused by irregularity in the shape and/or size of the eye, resulting in difficulty when attempting to focus objects clearly leading to blurred vision.² Linked to RE is VI, which results when the RE cannot be corrected by conventional spectacles, contact lenses, surgery or medical intervention.³ In addition, in some instances, RE remains uncorrected for a variety of other reasons including inaccessibility and unaffordability, which further contributes to the statistics on VI. Uncorrected refractive error (URE) and VI remain a major problem affecting school-going children worldwide, and this has broader social and economic negative impacts.⁴

Refractive errors, particularly myopia, pose a serious challenge on the individual and society. Hashemi Hassan et al.⁵ recently indicated that globally, 11.7% of children are myopic, whilst a further 4.6% and 4.9% have hypermetropia and astigmatism, respectively.⁵ Moreover, the prevalence of RE differs from region to region, with the highest prevalence in the Asian populations, where China has a prevalence of 20.6%,⁶ followed by India with 10.2%,⁷ Saudi Arabia with 18.6%,⁸ and Vietnam with 19.4%.⁹ Several studies conducted in Chile, the United States and Cambodia reveal RE prevalence values of 18.7%,¹⁰ 13.1%,¹¹ and 6.5%,¹² respectively. In Africa, Ghana had an RE prevalence value of 3.7%,¹³ Nigeria 11.5%,¹⁴ Ethiopia 6.3%,¹⁵ Egypt 2.2%,¹⁶ and South Africa 7.1%, as shown in Table 1.¹⁷ The African continent has shown a comparatively low

prevalence of RE between 2% and 12%.^{33,34,35,36,37} However, this does not suggest that there is no prevalence of RE, because the prevalence from all regions of Africa is not readily available. Several studies have indicated that people living in urban areas have a higher prevalence of RE than people living in rural areas.^{30,32,38,39} On the contrary, Al Wadaani et al.²⁰ reported that children coming from rural areas have a higher prevalence of RE compared to their urban counterparts.

The leading type of RE with a serious impact on the lives of children was found to be myopia.^{5,16,37,21,22} Myopia was also associated with different prevalences with respect to gender,^{14,15,38} age^{15,23,24} and parents' level of education.^{25,26,27} The higher prevalence of myopia in children in recent years has been attributed to urbanisation and subsequently from increased indoor activities, watching television and playing computer games.^{30,32,28} Myopia was also found associated with older children, while hyperopia was associated with the younger age group.^{25,25,26} Although in South Africa, Wajuthian et al.³⁷ did not find any evidence of an association between RE, gender and age, elsewhere myopia has been associated with gender, in some cases with a higher prevalence in girls than boys^{14,15,29} and in others a higher prevalence in boys than girls.^{30,31,32} As it is known that parents' level of education is also associated with myopia, children of people with post-matric qualifications have been found to be more myopic than children whose parents only have a high school qualification or lower.^{26,27}

Refractive error is also associated with VI if it remains uncorrected.^{20,24} Global statistics reveal that there are about 19 million visually impaired children in the world, most residing within the African continent, and with URE as the leading cause of their VI.² A study done by Pascolini and Mariotti²⁰ indicated that the global prevalence of VI amongst children is 18.9 million (6.6%). Moreover, the prevalence of VI also differs from region to region, with sub-Saharan Africa being at the top of the list.²⁰ The reported prevalence of VI

amongst schoolchildren is 12.77% in Chile,⁶ 1.9% in Southern Asia,⁷ 12.2% in Vietnam,²⁴ 21.6% in Pakistan,²¹ 7.7% in China,²⁰ 6.22% in India,²⁶ 1.8% in Ethiopia,²⁷ 3.66% in Ghana²⁸ and 2.74% in South Africa.²⁴

The African continent has the highest prevalence of VI in children after Asia;²⁰ however, there is insufficient data available in South Africa in this respect.²⁰ More studies are needed to determine the current prevalence of RE and VI on school going children inclusive of all age groups that could guide intervention strategies in dealing with this global issue.²⁷ The aim of this study therefore was to determine the prevalence and distribution of RE and VI amongst school-going children aged 6–18 years in the greater Sekhukhune District in Limpopo Province, South Africa.

Methods

A quantitative, cross-sectional, school-based study was conducted. Participants underwent vision testing at their respective schools in Sekhukhune District, which is one of the five districts in Limpopo Province, the northernmost province of South Africa. It is the smallest district of the Limpopo Province, making up 11% of the geographical area (i.e. 13 528 km²) with a population of 1 169 762 (Final IDP/Budget Review, 2017–2018 by the Executive Mayor KS Ramaila, 2018).⁴⁶ Greater Sekhukhune District is further divided into four local municipalities.

The study population comprised school-going children aged 6–18 years in the chosen district and residing in the rural area of Makhuduthamaga municipality which was selected by convenience sampling. This municipality is representative of greater Sekhukhune District. In 2016, 105 023 children were enrolled at various schools in Makhuduthamaga.⁴⁷

A sample size of 337 was decided upon in consultation with a statistician. Multistage random sampling was used to select the participants. A total of 400 learners from

TABLE 1: Prevalence of refractive errors in African countries.

Author	Country/region	Year	Age (years)	Sample size	Prevalence of RE (%)	Prevalence of myopia (%)	Prevalence of hypermetropia (%)	Prevalence of astigmatism (%)	Ethnicity
This study	South Africa/Limpopo	2019	6–18	326	12.3	10.4	2.8	7.4	Black/African
Wajuthian et al.	South Africa/KwaZulu-Natal	2017	15–18	1558	7.1	7.0	5.0	5.0	Black/African
Naidoo et al.	South Africa/KwaZulu-Natal	2005	5–15	4890	1.4	3.0	2.0	0.0	Black/African
Koomson et al.	Ghana/Ashanti	2015	12–15	2455	5.7	5.2	0.5	9.5	Black/African
Dvornack et al.	Ghana/Cape Coast	2010	5–19	1103	25.6	6.9	4.6	14.1	Black/African
Ngosika et al.	Nigeria/Anambra State	2018	5–15	928	9.7	4.5	1.7	3.5	Black/African
Ekeonyang et al.	Nigeria/Cross River State	2017	6–17	2110	11.5	NK	NK	NK	Black/African
Wedner et al.	Tanzania/Mwanza	2000	7–19	1358	0.7	0.1	0.5	0.1	Black/African
Muma et al.	Kenya/Makueni District	2009	12–15	1459	5.2	1.7	3.2	0.5	Black/African
Masika et al.	Malawi/Mochu	2009	12–15	1278	2.4	1.4	0.8	0.1	Black/African
Kedir et al.	Ethiopia/Goro District Gurgu	2014	7–15	570	3.5	2.8	0.9	NK	Afro-Asian
Mehari et al.	Ethiopia/Woreda Sub-district	2015	7–15	4255	6.5	6.0	0.55	0.78	Afro-Asian
Margrita et al.	Equatorial Guinea/Malabo	2015	6–16	425	15.5	10.4	3.1	11.8	Black/African
Damal et al.	Egypt/South Sinai	2015	6–15	2070	29.4	NK	NK	NK	Arabic
Arife et al.	Egypt/Seni-Suef	2015	12–14	469	22.5	16.2	6.6	NK	Arabic

Source: Please see the full reference list of this article Ekeonyang EN, Naidoo K, Ahanke K, et al. Visual status and prevalence of eye disorders among school-age children in southern Nigeria. African Eye Health [serial online]. 2017 Jan 30 [cited 2018 Jun 19];78(1):1–6. Available from: <http://www.aehjournal.org/doi.php/lehv/article/view/577>, for more information
RE, refractive error; NK, not reported.

10 randomly selected schools were invited to participate in this study. Of this number, 24 learners were absent on the day scheduled for examination, 42 learners did not assent to the instilling of topical anaesthetic (Novestin Wander, 1 drop) and cycloplegic eye drops (1% cyclopentolate, 2-3 drops), and 8 children did not return signed consent forms. Therefore, a total of 326 learners were eventually included in this study. Five grades were randomly selected from each school from Grades 1 to 12. In each grade, the class register was used as a sampling frame to randomly select eight participants, which included an equal number of male and female participants. All selected learners were given information documents and child assent forms detailing the purpose and nature of the study, as well as parental consent forms for their parents to read and sign, confirming consent.

Learners aged 6-18 years who returned signed parental consent forms, signed assent forms and were present at the school on the day of examination were included in this study. Those with any systemic or ocular diseases, as well as those on any systemic or ocular medication, were excluded from this study.

Permission was granted by the principals of the selected schools. This study adhered to the tenets of the Declaration of Helsinki. A training and standardisation workshop was held for all study personnel prior to the commencement of the study. A pilot study was conducted in Elias Motsoaledi Municipality (Croblersdal Academy) to validate the data collection procedures and recording forms. The subjects recruited for the pilot study were excluded from the main study.

Clinical assessment

A modified Refractive Error Study in Children (RESC) protocol was employed to determine the prevalence values for RE and VI. Visual acuity (VA) was scored with reference to the logarithm of the minimum angle of resolution (LogMAR); each letter was scored independently, and there was no crowding effect as compared to the Snellen chart, which is scored per line.⁶ Distance VA was measured with a retro-illuminated LogMAR chart using the tumbling E optotype from a distance of 4 m.

Habitual binocular alignment was assessed using the Hirschberg and cover tests in conjunction with a prism bar. Pupillary dilation and cycloplegia (in both eyes) were attained using two drops of 1% cyclopentolate, after ocular surface anaesthesia, administered 5 min apart to each eye. If a pupillary light reflex was still present after 15 min, a third drop was administered as required. Cycloplegia was considered complete if the pupillary light reflex was absent and the pupil diameter was 6 mm or more. The achievement of cycloplegia was necessary irrespective of the extent of dilation.

Refractive findings were achieved with an autorefractor (Topcon RM-8000B). A minimum of five readings with valid confidence rankings as per the manufacturer's instructions

were obtained for each eye. The RESC protocol defines myopia in one or both eyes of at least -0.50 dioptre (D), hypermetropia at least 2.00 D in one or both eyes and astigmatism at 0.75 cylindrical refraction or more. The cycloplegic autorefractor findings were inserted in a trial frame for any significant RE as defined above and the aided VA measured as per the procedure described above for VA for all children who attained an initial unaided or aided VA measure of worse than LogMAR = 0 (20/20). In those cases where the aided VA was worse than LogMAR = 0.30 (20/40), the child was categorised as having VI.

Examination of the anterior segment, lens, vitreous and fundus was performed using a Welch Allyn direct ophthalmoscope. The recording of abnormal findings was important as documentary evidence to support the assignment of a principal cause of impairment. Any abnormal fundus findings were recorded by either fundus drawings or photography. Learners who were found to have URE and/or pathology were referred to eye centres of their choice for further management.

Data management and analysis

Collected data were captured and analysed using the Statistical Package for Social Sciences (SPSS version 25) in consultation with a statistician. Descriptive statistics including frequency, mean and standard deviation were computed. Data backup was done daily, and the backup copies were stored in a password-protected file. The distribution of the uncorrected, presenting and best-corrected VA was reported by VA categories. Values of at least -0.50 D, 2.00 D and -0.75 D cylindrical power and above for myopia, hyperopia and astigmatism, respectively, were considered significant. The distribution of spherical equivalent RE amongst those with VI was tabulated by age and gender. The association of myopia or hyperopia with the age and gender of the child was explored with multiple logistic regression. Principle causes of VI (VA, 0.30 LogMAR or worse) were summarised.

Ethical considerations

Ethical approval was obtained from the Biomedical Research and Ethics Committee (BREC) at the University of KwaZulu-Natal. The Biomedical Research and Ethics Committee is registered with the South African National Health Research Ethics Council (REC-290408-009), ethical clearance number BE080/19, 13 March 2019.

Results

Demographics

A total of 326 learners participated in this study, with an almost equal distribution of gender, as there were 165 (50.6%) female participants and 161 (49.4%) male participants. The ages of the learners ranged from 6 to 18 years with a mean of 13.02 ± 3.9 years with a comparable

median age of 13.00 years. The age group mostly represented was 14–18 years (47.5%), and the age group least represented was 6–8 years (23.9%) as indicated in Table 2.

There was a significant difference in the mean age of learners within grades ($p = 0.00$). In general, the highest proportion of participants was in the category with Grades 9–12 (40.5%), with Grades 5–8 being least represented (27.3%) (Table 3).

Visual acuity

A total of 326 learners underwent the eye examination; 271 (83.1%; 95% confidence interval [CI], 79.1–87.2) learners had unaided LogMAR VA of < 0.20 in the right eye, and 268 (82.2%; 95% CI, 78.1–86.4) learners had normal LogMAR VA in the left eye. Fifty-five learners (16.9%; 95% CI, 12.8–20.9) had uncorrected LogMAR VA of ≥ 0.20 in the right eye, and 57 learners (17.5%; 95% CI, 13.4–21.6) had uncorrected LogMAR VA of ≥ 0.20 in the left eye, as shown in Table 4. One learner (0.3%; 95% CI, 0.00–0.90) had uncorrected LogMAR VA of worse than 1.00 in the left eye. In total, 67 learners (20.6%; 95% CI, 16.2–24.9) had uncorrected LogMAR VAs of < 0.20 in one or both eyes.

None of the learners presented wearing any corrective devices like spectacles or contact lenses. The prevalence of uncorrected LogMAR VA of 0.20 or worse in the better eye was found to be 20.6% (95% CI, 16.2–24.9), presenting was 20.6% (95% CI, 16.2–24.9) and best corrected was 2.1% (95% CI, 0.60–3.70).

Prevalence of visual impairment

Forty learners (12.3%; 95% CI, 8.70–15.80) had VI as per the WHO definition, with a presenting VA worse than 0.30 in one or both eyes (46). Thirty learners (9.2%; 95% CI, 6.1–12.3) had mild VI, eight (2.5%; 95% CI, 0.80–4.10) moderate and two (0.6%; 95% CI, 0.00–1.50) severe VI (Table 5). There was no statistically significant difference in the prevalence of VI between males and females ($p = 1.000$) or between age groups ($p = 0.744$). Seven learners (2.1%; 95% CI, 0.60–3.70) could not achieve VA of ≥ 0.30 in one or both eyes after correction.

TABLE 2: Distribution of participants according to age.

Age group (years)	Males		Females		Total	
	n	%	n	%	n	%
6–9	41	12.6	37	11.5	78	23.9
10–13	47	14.4	46	14.1	93	28.5
14 and older	75	22.4	82	25.1	155	47.5
Total	163	49.4	165	50.6	326	100.0

n, number.

TABLE 3: Distribution of participants according to grade.

Grades	Males		Females		Total	
	n	%	n	%	n	%
1–4	37	17.5	48	14.7	105	32.3
5–8	44	13.5	45	13.8	89	27.3
9–12	80	24.4	72	22.1	152	46.5

n, number.

The leading cause of VI was uncorrected RE at 80% (95% CI, 67.6–92.4), followed by amblyopia, corneal opacity or scar and cataract with findings of 10% (95% CI, 0.70–19.3), 7.5% (95% CI, 0.00–15.7) and 2.5% (95% CI, 0.00–7.30).

Refractive error

The prevalence of RE is based on the cycloplegic autorefractometer results of the 324 learners (99.4% of the sample) who satisfied both criteria for full cycloplegia. Furthermore, the prevalence of RE was based on uncorrected LogMAR VA of 0.20 in one or both eyes, as was the case with 67 learners (20.6%; 95% CI, 16.2–24.9).

The overall prevalence of RE for this study was 20.6%, with a greater prevalence observed in the age group 14–18 years. There was no significant difference in the prevalence of RE between females and males ($p = 0.325$). Learners in Grades 9–12 ($n = 31$) had a higher prevalence (46.3%; 95% CI, 34.3–58.2) than all other grades. Refractive error was evenly distributed amongst different schools, except in one school, where there was a prevalence of 68% (i.e. Nokomeitse Primary School).

The most prevalent type of RE was found to be myopia at 10.4% (95% CI, 7.10–13.7), with a higher prevalence of myopia in males (55.9%; 95% CI, 39.2–72.6) than females (44.1%; 95% CI, 27.4–60.8). It was also associated with an increase in age as indicated by Table 6. The amount of myopia ranged from -0.50 D to -18.50 D. The prevalence of hypermetropia was (2.8%, 95% CI, 1.00–4.50) of the overall sample. Hypermetropia ranged from 2.00 D to 5.50 D; it was more prevalent at ages 6–9 and 14–18 years and was associated with females at 77.8% (95% CI, 50.0–100) as compared to 22.2% (95% CI 0.00–49.4) of males. Astigmatism ranged from -0.75 D to -5.50 D cylinder, and the prevalence in the sample was 7.4% (95% CI, 4.5–10.2). A higher prevalence of astigmatism was observed in the 10–13-year age group, as highlighted in Table 6, but there was no significant difference in the prevalence of astigmatism between genders.

Binocular motor function

Heterotropia was found in four children (1.2%). All four had exotropia when viewing a near target (50 cm), and three had exotropia when viewing a target at 4 m. The magnitude of exotropia ranged from 1° to 30° .

TABLE 4: Distribution of uncorrected visual acuity in logarithm of the minimum angle of resolution for right and left eyes.

Range of UVA in LogMAR (Snellen equivalent)	Right eye			Left eye		
	n	%	95% CI	n	%	95% CI
0.00–0.15 (6/6 – \rightarrow 6/9)	271	83.1	79.1–87.2	268	82.1	78.1–86.4
0.20–0.30 (6/9–8/12)	25	7.7	4.8–10.8	30	9.2	6.1–12.3
0.32–0.50 (x 6/12–8/18)	19	5.8	3.3–8.4	19	5.8	3.3–8.4
0.52–1.0 (x 6/18–6/60)	11	3.4	1.4–5.3	8	2.5	0.8–4.1
≥ 1.00 (x 6/60)	0	0.0	0.00	1	0.3	0.00–0.9

UVA, uncorrected refractive error; LogMAR, logarithm of the minimum angle of resolution; n, number; CI, confidence interval.

TABLE 5: Prevalence of visual impairment according to gender, age and grade.

Variable	Types of visual impairments							
	Mild VI†		Moderate VI‡		Severe VI§		Total	
	n	%	n	%	n	%	n	%
Gender								
Male	14	4.3	4	1.2	2	0.6	20	6.13
Female	16	4.9	4	1.2	0	0.0	20	6.13
Age group (years)								
6-9	7	2.1	1	0.3	0	0.0	8	2.5
10-13	5	1.5	2	0.6	1	0.3	8	2.5
14+	16	5.5	5	1.5	1	0.3	24	7.3
Grades								
1-4	9	2.8	2	0.6	0	0.0	11	3.4
5-8	7	2.1	1	0.3	1	0.3	9	2.8
9-12	14	4.3	5	1.5	1	0.3	20	6.13

n, number; VI, visual impairment; VA, visual acuity.

†, VA of worse than 0.32, but better than 0.50.

‡, VA of worse than 0.50, but better than 1.00.

§, VA or worse than 1.00.

Anterior segment examination

No learner was found to have any eye lid abnormalities, and in all learners, the pupils were equally round and reactive to light and accommodation. Eleven learners (3.4%) presented with vernal conjunctivitis, and corneal scars or opacities were observed in three learners (1%).

Posterior segment examination

Out of the total of 326 learners, one learner (0.3%) presented with a cataract in the left eye, and therefore, the vitreous and fundus could not be examined. The remainder (99.7%) had clear and normal media and fundi.

Referral system

A total of 67 learners (20.86%) were referred to eye care practitioners of their choice for a full refraction and prescription of spectacles, if necessary. Eleven learners who had vernal keratoconjunctivitis (VCK) were referred to eye hospitals for further management.

Discussion

The VI prevalence of 12.3% found in the greater Sekhukhune District of Limpopo Province was similar to the VI prevalence of 12.2% found in Vietnam,²³ but it is higher than the reported 7.9% prevalence of a study performed amongst 10-18 year-old school learners in Calabar, Nigeria.⁴⁸ This prevalence value is lower than the prevalence of 29.4% reported from a study in Egypt (South Sinai), which had defined VI as a presenting VA of $\leq 6/9$.⁴⁹ The reason for this difference in prevalence values might be the fact that these studies were performed in different locations and within different population groups.

The leading cause of VI in this study was RE that could be corrected with spectacles. These findings are comparable to those of another study done in South Africa with 63.6% of cases of VI being a result of RE.²⁴ This means that most of these learners could be affected academically, socially and

TABLE 6: Prevalence of refractive error according to gender, age and grade.

Variable	Prevalence of myopia		Prevalence of hypermetropia		Prevalence of astigmatism	
	n	%	n	%	n	%
	Gender					
Male	19	5.8	2	0.6	15	4.0
Female	15	4.6	7	2.1	11	3.4
Total	34	10.4	9	2.7	24	7.4
Age group (years)						
6-9	0	0.0	4	1.2	6	1.8
10-13	6	1.8	1	0.3	12	3.7
14-18	28	8.6	4	1.2	6	1.8
Total	34	10.4	9	2.7	24	7.4
Grades						
1-4	1	0.3	5	1.5	11	3.4
5-8	9	2.6	1	0.3	9	2.8
9-12	24	7.4	3	0.9	4	1.2
Total	34	10.4	9	2.7	24	7.4

n, number.

psychologically by a condition that could be managed by a simple pair of spectacles. Moreover, if this condition is not managed, it could lead to more complicated conditions like amblyopia, which cannot be managed but leads to low vision and ultimately blindness. This indicates a serious need for school vision screening, as it will help with detection of RE and a further management plan. Moreover, there is a need for provision of spectacles at reasonable or low cost in order to cater for children. In most of the schools included in this research study, no vision screening had been performed. A possible reason for the lack of vision screening could be the inaccessibility of the location, as most of these schools are located in the hills and mountains, which poses a challenge and makes them difficult to reach.

In 7 (2.1%) learners, vision could not be corrected with spectacles to LogMAR 0.30 or better. The prevalence of 2.1% was higher than that of the 0.32% prevalence reported by Naidoo et al.²⁴ for a study performed in South Africa. A recent study conducted in Nigeria also found a lower prevalence of 1.3%,²⁰ possibly a result of the fact that they focused on urban children, whilst this study was conducted on rural school-going children. Urban learners have access to eye care services,

unlike rural learners who generally do not have these services. Urban children therefore have earlier detection and management of RE, before it leads to VI. That is why in the Nigerian study, more than 20 learners presented wearing spectacles, contrary to this study.

There was equal distribution of VI between males and females. This was expected because during the time of recruiting subjects for this study, gender was taken into consideration. This is comparable to the study conducted in Aba, Nigeria.²⁶ Visual impairment was associated with an increase in age, with highest prevalence seen in the age group 14–18 years (60%; 95% CI, 44.8–60.0). This is because there is an association between the progression of myopia and puberty. Puberty starts around the age of 10–16 years.²⁸

Four learners had amblyopia in one or both eyes, which is 1.2% of the total population. Their ages were 6, 11, 15 and 18 years, and perhaps it could have been prevented if these learners had had visual assessment earlier. However, even at this stage with an appropriate form of correction and visual therapy, vision might improve in these learners. The results of this study are comparable to those of a recent study done in South Africa by Wajuthian and Hansraj,¹⁸ which also found a value of 1%. Three learners presented with corneal opacity or scar and one with cataract. Cataract is also one of the leading causes of avoidable blindness worldwide. This condition can be managed by surgery. In many circumstances, cataract remains unmanaged because of lack of vision screening, the high cost of surgery and the cataract surgery backlog in public hospitals.

The prevalence of RE amongst school-going children in the greater Sekhukhune District (Limpopo, South Africa) was 20.6%, which was high as compared to two previous studies conducted in South Africa in 2003 and 2017 that found prevalence values of 14%²⁷ and 15%,¹⁷ respectively, as indicated in Table 1. These two studies were done in KwaZulu-Natal, a different location from this study. The 2003 study was done more than 16 years ago before the introduction of smartphones to children, while the 2017 study only considered older learners, aged 13–18-years. This study is comparable to the study conducted by Pi et al.⁶ in a Chinese population.

This again highlights the need for eye care services to school-going children, particularly considering that in this study none of those learners presented with any form of corrective devices. The challenge that arises, though, is ensuring that the learners are able to access any required visual assistive device. Similar to this study, several studies reported a higher prevalence of RE than the expected range of 2%–10% reported by the WHO concerning the African continent. Some of those studies had prevalence values of 25.6%, 22.8% and 18.9% for Ghana,⁴⁰ Egypt³¹ and Rwanda,³² respectively. This suggests that some children with RE might be overlooked, especially those in the deep rural areas of developing countries.

Myopia was found to be the leading type of RE in the current study (10.4%). Globally, the prevalence of myopia is 11.7%, which is a little higher than the results in this study.⁵ Holden

et al.⁵³ estimate that by 2050 the prevalence of myopia will be at 34% globally. This is because of the factors associated with myopia, like increased near-work activities, low levels of outdoor activity and reduced light levels. However, the mechanisms surrounding the development and progression of this condition are not yet fully understood, as myopia seems to be multifactorial in nature.³⁴ Similar to our study, a myopia prevalence of 10.4% was observed in Malabo, Equatorial Guinea, in 2015.⁶ Furthermore, the highest prevalence of 16.2% was observed in Beni-Suef (Egypt).³⁶ In other studies done in Ghana and Malawi, whilst myopia was also found to be the leading type of RE, lower prevalences of 3.7%¹³ and 1.4%,⁴⁴ respectively, were found in these areas.

In the study herein, a higher prevalence of myopia was observed in the older age group (14–18 years). A higher prevalence in older school-going children was also reported by Ezinne and Mashige³⁴ in Anambra State, Nigeria.

As children are expected to have higher near-task demands at higher grades, this finding may be attributed to the axial elongation, and subsequently myopia development, associated with intensive near work.²⁵ Myopia was also more prevalent in males than females, which corresponds to the results in studies done by Parmar,³⁰ Awan³¹ and Ezinne.³⁴ Observation of the practices and culture in this area indicates that boys are more engaged with TV and cell phone games as compared to girls, who do lot of outdoor activities like fetching wood and water for cooking after school. This could be linked to more boys becoming myopic as compared to girls. To the contrary, Ekpenyong et al.³⁴ found a higher prevalence of myopia in girls. This might be a result of the fact that in their study they had more female (53%) than male (47%) participants. However, Atowa et al.³⁶ and Wajuthian and Hansraj¹⁷ found no significant difference in the prevalence of myopia based on gender.

The prevalence of hypermetropia (2.8%) was low in the greater Sekhukhune District. These results corroborate those of Soler et al.,⁶ who also found a low prevalence of 3.1% in Malabo, Equatorial Guinea. In contrast, in another province in South Africa, Wajuthian and Hansraj¹⁷ found a 5% prevalence of hypermetropia, higher than that reported in other studies. This difference could be related to the different definition of hypermetropia; Wajuthian and Hansraj¹⁷ defined hypermetropia as a value of at least +0.50 D, whilst in the current study, a higher value of at least +2.00 D applied. Hypermetropia was slightly more prevalent in the younger age groups than the older age group, which is in keeping with the theory that children are born with hypermetropia that decreases with an increase in age.³⁶ Li Zhijian et al.²⁷ reported a similar trend in Northern China. Moreover, hypermetropia was seen more amongst females than males, as also found by Hashemi et al.³² amongst Iranian school-going children. On the contrary, Kawuma and Mayeku²⁸ found male hypermetropia to be more prevalent in Kampala District.

The prevalence of astigmatism was relatively high (7.4%) in greater Sekhukhune. Naidoo et al.³⁴ and Kumah et al.¹³ also

found a higher prevalence of astigmatism, as was noted in Table 6. In contrast, comparatively lower prevalences of 0.1%, 0.3% and 0.1% were found in Tanzania,⁴² Kenya⁴³ and Malawi,⁴⁴ respectively. This difference in the findings might be a result of the ethnic and racial differences.

The heterotropia prevalence for this study was 1.2%, comparable to the study conducted in South Africa by Naidoo et al.,²⁴ which found a value of 1.3%. However, this finding is lower than the prevalence of 17.5% that was found amongst Nigerian children²² but higher than 0.03%, which was found in South Darfur.²⁰ Vernal conjunctivitis was seen in 3.4% of the study population, which is relatively similar to the 3.6% found by Naidoo et al.²⁴ The presence of vernal conjunctivitis is most probably a result of the rural environmental in which the participants live. Sekhukhune District is very hot and dry. Cataract was observed in 0.3% of the population, which is lower than the prevalences of 2.3% and 4.2% found in South Africa²⁴ and Ethiopia,¹⁵ respectively.

Limitations

This study only included learners from Makhuduthamaga Municipality to represent the entire area of greater Sekhukhune, which might have created a bias. The final sample had a higher participation rate from 14–18-year-old children, which may have skewed the results to be more representative of this age group.

Conclusion

This study contributes to the epidemiological database on VI and RE in children. The results of this study are useful for stakeholders in all sectors involved in child eye health. School health programmes and other programmes involved in vision screening can use this information to devise strategies to address the current challenge of RE and VI as the leading causes of blindness in Africa.

Acknowledgements

Mrs Xulu-Kasaba is acknowledged for paying all publishing costs.

Competing interests

The authors declare that they have no financial motives that could have influenced the writing of this article.

Authors' contributions

T.S.S.M., Z.N.Q.X.-K. and R.H. conceptualised the project and designed the methodology. T.S.S.M. drafted the initial manuscript. R.H. and Z.N.Q.X.-K. supervised the project, guided and reviewed drafts up to the final article.

Funding information

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

Data availability statement

The data are available on request.

Disclaimer

The views expressed in this article are those of the authors and do not necessarily reflect the official policy of the University of KwaZulu-Natal.

References

- World Health Organization (WHO). Priority eye diseases. Geneva: World Health Organization; 2015.
- Sieving PA. Facts about refractive errors [homepage on the Internet]. National Eye Institute, n.d. [cited 2015 Nov 12]; p. 1–2. Available from: <https://nei.nih.gov/health/errors/errors>
- DeCarlo DK, Woo S, Woo GC. Patients with low vision. In: Benjamin WJ, editor. *Bonah's Clinical Refraction*. Philadelphia; 2006.
- Melli JS, Sebobe AL, Cumberland PM. Uncorrected refractive error and education. *BMJ*. 2014;349:g9921. <https://doi.org/10.1136/bmj.g9921>
- Hashemi H, Fotouhi A, Yekta A, et al. Global and regional estimates of prevalence of refractive errors: Systematic review and meta-analysis. *J Curr Ophthalmol*. 2018;30(1):5–22. <https://doi.org/10.1016/j.jcoo.2017.08.009>
- Pi LH, Chen L, Liu Q, et al. Prevalence of eye diseases and causes of visual impairment in school-aged children in Western China. *J Epidemiol*. 2012;22(1):57–64. <https://doi.org/10.21858/jca.2011.00262>
- Chakraborty S, Sankar D, Kumar J. ISSN [c]. 2221–7221. Prevalence of refractive errors in school children in the urban population of Kolkata, India: A prospective study. *Int J Res Health Sci*. 2014;(4):1155–1157.
- Aldehbi YH. Prevalence of correctable visual impairment in primary school children in Qassim Province, Saudi Arabia. *J Optom*. 2014;7(5):165–176. <https://doi.org/10.1016/j.joptom.2014.02.001>
- Kim BC, Morgan JB, Kaloupek H, et al. Prevalence and risk factors for refractive errors: Korean National Health and Nutrition Examination Survey 2008–2011. *PLoS One*. 2015;8(11):e015561. <https://doi.org/10.1371/journal.pone.0155611>
- Sarraf F, Corio F, Munoz S, et al. Prevalence of refractive error and associated coverage in schoolchildren in two urban areas of Chile. *Pan Am J Public Health*. 2015;42(1):1–6. <https://doi.org/10.2196/ajph.2015.01.011>
- Wayne EL, Mark LA, Shiuzy B, et al. Prevalence of uncorrected refractive errors among school-age children in the School District of Philadelphia. *J Am Assoc Podiatr Ophthalmol Strabismus*. 2015;22(5):214–217.e2. <https://doi.org/10.1016/j.jaapos.2015.01.011>
- Geo Z, Mong N, Muzock J, et al. Refractive error in school children in an urban and rural setting in Cambodia. *Ophthalmic Epidemiol*. 2012;19(1):16–22. <https://doi.org/10.5109/09168656.2011.632703>
- Kumah SO, Ebi A, Abdulkadir M, et al. Refractive error and visual impairment in private school children in Ghana. *Optom Vis Sci*. 2015;90(11):1458–1461. <https://doi.org/10.1097/OPX.0000000000000099>
- Okoyong SN, Naidoo K, Aheiwu K, et al. Visual status and prevalence of eye disorders among school-age children in southern Nigeria. *African Vis Eye Health*. 2017;76(1):1–6. <https://doi.org/10.4102/aveh.v76i1.377>
- Mehari ZA, Yimer AW. Prevalence of refractive errors among schoolchildren in rural central Ethiopia. *Clin Exp Optom*. 2015;96(1):65–69. <https://doi.org/10.1111/cxo.12299>
- Arufe ABB-D, Ewa AAB, Mahran WM, et al. Prevalence and risk factors of refractive errors among preparatory school students in Beni-Suef, Egypt. *J Public Health (Bangkok)*. 2018;27(1):1–5. <https://doi.org/10.1007/s10389-018-0950-8>
- Wajuhian SO, Harora K. Refractive error in a sample of black high school children in South Africa. *Optom Vis Sci*. 2017;94(12):1145–1152. <https://doi.org/10.1097/OPX.0000000000001145>
- You QS, Wu LJ, Duan JL, et al. Prevalence of myopia in school children in greater Beijing: The Beijing childhood eye study. *Acta Ophthalmol*. 2014;92(5):e398–e406. <https://doi.org/10.1111/aos.12299>
- Wu JF, Shi H, Wang SM, et al. Refractive error, visual acuity and causes of vision loss in children in Shandong, China: The Shandong children eye study. *BMC Ophthalmol*. 2015;8(12):e82765. <https://doi.org/10.1186/s12876-015-0262-5>
- Al Wadaani FA, Amin T, Ali A, et al. Prevalence and pattern of refractive errors among primary school children in Al Hassa, Saudi Arabia. *Glob J Health Sci*. 2012;5(1):125–154. <https://doi.org/10.5529/gjhs.v5n1p125>
- Phuol P, Kamson P, Nadvilath T, et al. Prevalence of vision impairment and refractive error in school children in Sa Kae – Vung Tau province, Vietnam. *Clin Experiment Ophthalmol*. 2014;42(5):217–226. <https://doi.org/10.1111/cxo.12275>
- Seiwund SA, Arede KK, Godofow M. Uncorrected refractive error and associated factors among primary school children in Debre Markos District, Northwest Ethiopia. *BMC Ophthalmol*. 2014;14(1):95. <https://doi.org/10.1186/1471-2415-14-95>
- French AN, Morgan JB, Burlutsky G, et al. Prevalence and 5- to 8-year incidence and progression of Myopia and Hyperopia in Australian school children. *Ophthalmology*. 2015;120(7):1482–1491. <https://doi.org/10.1016/j.ophtha.2012.12.016>
- Naidoo KS, Mghununden A, Mashige KP, et al. Refractive error and visual impairment in African children in South Africa. *Investig Ophthalmol Vis Sci*. 2005;44(9):3764. <https://doi.org/10.1167/iov.05-0265>

25. Caka I, Cingu AK, Sahin A, et al. Amblyopia and refractive errors among school-aged children with low socioeconomic status in Southeastern Turkey. *J Pediatr Ophthalmol Strabismus*. 2015;50(1):37-43. <https://doi.org/10.5923/j.1091.5915.20150504-02>
26. Akawa UC, Mursamy AJ, Wajuhian SD. Prevalence and risk factors for myopia among school children in Abuja, Nigeria. *African Vis Eye Health*. 2017;76(1):1-5. Available from: <https://doi.org/10.4102/aveh.v76i1.569>
27. Li Z, Xu K, Wu S, et al. Population-based survey of refractive error among school-aged children in rural northern China: The Heilongjiang eye study. *Clin Experiment Ophthalmol*. 2014;42(4):379-384. <https://doi.org/10.1111/ceo.12195>
28. Wu PC, Tsai CL, Wu HL, et al. Outdoor activity during class recess reduces Myopia onset and progression in school children. *Ophthalmology*. 2015;120(5):1060-1065. <https://doi.org/10.1016/j.ophtha.2012.11.009>
29. Lim HT, Yoon JS, Hwang S-S, et al. Prevalence and associated sociodemographic factors of myopia in Korean children: The 2005 Third Korea National Health and Nutrition Examination Survey (KNHANES III). *Am J Ophthalmol*. 2012;56(1):76-81. <https://doi.org/10.1007/s10584-011-0090-7>
30. Panmar A, Kartha G, Sarin M. A study on the prevalence of refractive errors among school children of 10-16 years in Surendranagar district, Gujarat. *Int J Community Med Public Health*. 2017;9(9):3376. <https://doi.org/10.18205/2394-8040.ijcmh.201715645>
31. Awan AM, Jameh J, Khan MM, et al. Prevalence and causes of visual impairment and blindness among school children in Muzaffarabad, Pakistan. *Int J Sci Res*. 2015;4(4):93. <https://doi.org/10.18205/issn.2454-2156.150501061955>
32. Zinne NB, Mashig KP. Refractive error and visual impairment in primary school children in Onitsha, Anambra State, Nigeria. *African Vis Eye Health*. 2016;77(1):1-6. <https://doi.org/10.4102/aveh.v77i1.455>
33. Kodir J, Girma A. Prevalence of refractive error and visual impairment among rural school-age children of Gore district, Guraiga zone, Ethiopia. *Ethiop J Health Sci*. 2014;24(4):553. <https://doi.org/10.4314/ejhs.v24i4.11>
34. Resnikoff S. Assessment of the prevalence of visual impairment attributable to refractive error or other causes in school children. Protocol and manual. Geneva: World Health Organization; 2007.
35. Pascolini D, Mariotti SP. Global estimates of visual impairment: 2010. *Br J Ophthalmol*. 2012;96(5):614-618. <https://doi.org/10.1136/bjophthalmol-2011-000559>
36. Sarmá F, Cortés R, Muñoz S, et al. Prevalence of refractive error and spectacle coverage in school children in two urban areas of Chile. *Rev Panam Salud Pública*. 2016;42:1-6. <https://doi.org/10.26653/RPSP.2016.61>
37. Gason M, Nalawala S, Kong A, et al. Exceptionally low prevalence of refractive error and visual impairment in school children from Lao People's Democratic Republic. *Ophthalmology*. 2012;119(10):2021-2027. <https://doi.org/10.1016/j.ophtha.2012.05.049>
38. Kumar P, Paro P, Dixit AK, et al. Prevalence and demographic distribution of refractive error in school children of Pune, India. *Int J Res Health Sci*. 2014;(1):55-67.
39. Naipal S, Ramprasad N. A review of visual impairment. *African Vis Eye Health*. 2015;77(1):1-4. <https://doi.org/10.4102/aveh.v77i1.595>
40. Yamamah GAN, Taleat Abdel Alim AA, Mostafa YSD, et al. Prevalence of visual impairment and refractive errors in children of South Sinai, Egypt. *Ophthalmic Epidemiol*. 2015;22(4):246-252. <https://doi.org/10.5109/09235556.2015.1056511>
41. Ovonneri-Ogboro OO, Omuomu VO. Prevalence of refractive error among school children in the Ope Coast Municipality, Oshana. *Clin Optom*. 2010;2:59-66. <https://doi.org/10.2147/OPTO.S10583>
42. Wodner SH, Ross DA, Balise R, et al. Prevalence of eye diseases in primary school children in a rural area of Tanzania. *Br J Ophthalmol* [serial online]. 2000 [cited 2018 Oct 12];84(11):1291-1297. Available from: <http://bjophth.com/>
43. Numa MK, Kimani K, Wanyoko MK, et al. Prevalence of refractive errors among primary school pupils in Kilungu division of Nakuru district, Kenya. *Med J Zambia* [serial online]. 2009 [cited 2018 Oct 12];36(4):165-170. Available from: <http://www.ajol.info/doi.php/mj/article/view/7657354>
44. Tinkham Maska V. Of Nairobi. Magnitude and pattern of significant refractive errors among primary school children in Ndiheu and ulungu districts in Malawi [Homepage on the Internet]. [cited 2018 Oct 12]. Available from: https://repository.uonbi.ac.ke/bitstream/handle/11295/25194/Maska_Magnitude_and_pattern_of_significant_refractive_errors_among_primary_school_children.pdf?sequence=3
45. Solor M, Anora MB, Castro JJ, et al. Prevalence of refractive errors in children in Equatorial Guinea. *Optom Vis Sci*. 2015 [cited 2018 Jun 19];92(1):53-58. <https://doi.org/10.1097/OPX.0000000000000445>
46. Final IDP/Budget Review 2017-2018. By the executive mayor: Councillor Kamekosing Stanley Kamalla. Polokwane [Homepage on the Internet]. [cited 2018 Oct 22]. Available from: [http://www.sakhukhuni.district.gov.za/sdm-admin/documents/IDP/Final2017-2018\(2\)\(2\).pdf](http://www.sakhukhuni.district.gov.za/sdm-admin/documents/IDP/Final2017-2018(2)(2).pdf)
47. Lebelo AP. Statistics South Africa. The state of basic service delivery in South Africa: in-depth analysis of the Community Survey 2016. Statistics South Africa. Pretoria: Statistics South Africa; 2016.
48. Murdoch H, Allstair Laidlaw DH, Rozser DA, et al. Reduced logMAR visual acuity test chart. London: United States Patent; 2000.
49. Ebri AB, Gwendor P, Naidoo KS. Prevalence of vision impairment and refractive error in school learners in Calabar, Nigeria. *African Vis Eye Health*. 2016;75(1):1-6. <https://doi.org/10.4102/aveh.v75i1.487>
50. Puberty definition, stages, duration, signs for boys & girls [Homepage on the Internet]. [cited 2019 Dec 11]. Available from: <https://www.mediacent.com/puberty/article.htm>
51. Opehin I, Pedro-Egbe C. Screening for refractive error among primary school children in Bayelsa state, Nigeria. *Pan Afr Med J*. 2015;14(1):74. <https://doi.org/10.1186/1475/pamj.2015.14.74.1545>
52. Semanyoni S, Karimuro J, Nkayimbano M. Prevalence and pattern of refractive errors in high schools of Nyanungu district, East African J Ophthalmol [serial online]. 2015 [cited 2020 Jun 25];13. Available from: <https://www.google.com/search?rlz=1C1CH80>
53. Holden BA, Frisby TA, Wilson DA, et al. Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. *Ophthalmology*. 2016;123(5):1036-1042. <https://doi.org/10.1016/j.ophtha.2016.01.006>
54. Wolffsohn JS, Calossi A, Cho P, et al. Global trends in myopia management attitudes and strategies in clinical practice. *Cont Lens Anterior Eye*. 2016 Apr 1; 59(2):106-116. <https://doi.org/10.1016/j.clae.2016.02.005>
55. Lee YJ, Lo CT, Sheu SJ, et al. What factors are associated with myopia in young adults? A survey study in Taiwan military conscripts. *Invest Ophthalmol Vis Sci*. 2015 Feb;54(2):1026-1033. <https://doi.org/10.1167/inv.12-10480>
56. Gupta N. Refractive error & childhood visual impairment. *Adv Ophthalmol Vis Syst*. 2016 Oct 14;5(1):1-7. <https://doi.org/10.15406/avovs.2016.05.00146>
57. Haslomi H, Yekta A, Jafarzadehpour S, et al. High prevalence of refractive errors in 7 year old children in Iran. *Iran J Public Health* [serial online]. 2016 Feb [cited 2018 Jun 19];45(2):194-202. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/27114954>
58. Kawuma M, Mayeku K. A survey of the prevalence of refractive errors among children in lower primary schools in Kampala district. *Afr Health Sci* [serial online]. 2002 Aug [cited 2019 Feb 6];2(2):69-72. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/127789105>
59. Alkhashod SH, Naidoo KS, Clarke-Farr PC. Prevalence of visual impairment and refractive error in school-aged children in South Darfur State of Sudan. *African Vis Eye Health*. 2016;75(1). <https://doi.org/10.4102/aveh.v75i1.555>

CHAPTER 3 – Second Manuscript

Chapter 3 is a manuscript assessing the quality of life amongst 155 learners. The tool used was the National Eye Institute Visual Function Questionnaire. All the scores were collected and analyzed using SPSS where low scores indicated a poor quality of life (QoL) whilst a high score indicated a good QoL. This manuscript answers a question on the impact of RE/VI on the QoL of school-children and is titled “The impact of refractive error and/ visual impairment on quality of life among school-going children in Sekhukhune district (Limpopo), South Africa”. It is an original research manuscript written following the guideline of the British Medical Journal(BMJ) and will be submitted for publishing.

The impact of refractive error and visual impairment on quality of life among school-going children in Sekhukhune district (Limpopo), South Africa.

Abstract

Objective To assess the impact of refractive error (RE) and visual impairment (VI) on quality of life (QoL) among school-going children in Sekhukhune district (Limpopo), South Africa.

Design Quantitative, cross sectional, school-based study

Setting Ten rural schools around Sekhukhune district, Limpopo province, South Africa, 2019.

Participants One hundred and fifty-four learners aged 14-18 years from grade R to 12. There were 100% participants.

Interventions Children were provided the free eye examination and they were referred to the closest eye center if they had any form of visual disorder. Many of these children never had their eyes tested.

Main outcome measures The tool used to assess the quality of life was the National Eye Institute Quality of Life Questionnaire (NEI-VFQ-25). The questionnaire was presented in English, Data captured from the questionnaires was entered into Microsoft Excel and analysed using the Social Package for Social Sciences (SPSS), version 25. Correlations were used to look at the strengths of the relationship between QoL scores

Results One hundred and fifty-four learners aged 14-18 years completed the questionnaire which was offered in an interview format. A total of 56 learners (36.4%

[95% CI, 28.8-44.0]) had RE, with three also presenting with VI while 98 (63.6% [95% CI, 36.0-71.2]) had no RE and/ VI. Children with refractive RE and/ VI scored low on the NEI-VFQ-25 as compared to children without.

Conclusion Refractive error and/or visual impairment have an impact on the quality of life of learners in greater Sekhukhune district. This call for attention from government and all stakeholders responsible for eye care to come up with strategies to address these conditions.

Introduction

Refractive error (RE) can be defined as a defect in the focusing of light on the retina leading to blurred vision.¹ Linked to it is visual impairment (VI), which is defined as RE that cannot be corrected by means of spectacles/contact lenses, medication or surgery, leaving a person with poor distance vision categorized as worse than 20/40.^{2,3} Uncorrected refractive error (URE) has been established as the leading cause of VI and a contributory factor to childhood blindness globally.³

Globally, the prevalence of refractive errors among school-going children is estimated to be around 11.7%⁴ with the Asian population having the highest prevalence (36.9%)⁵ and the African population, the lowest (9.7%).⁶ In contrast, other studies have reported a relatively lower prevalence of 4.5% in an Asian population⁷⁻⁹ as opposed to the lower 24% in some parts of the African continent.^{10,11} The prevalence in South Africa has been reported as 7%.¹² Myopia was found to be the leading type of RE in most studies, followed by astigmatism and then hypermetropia.^{5,11,13} Furthermore, nineteen million children have visual impairment worldwide, of which 1.4 million are blind and 17.5 million have low vision, with 90% of these children living within the African continent.¹⁴

Relative to cataract and glaucoma which are regarded as the other major contributors to global blindness, RE and subsequent VI has its onset much earlier in life thus affecting individuals for many years and on many levels including socially, psychologically and financially.^{15,16} In the United States of America (USA), the medical expenditure of a person with RE and/ VI was estimated at around \$4000 per annum, excluding the cost of loss of productivity, anxiety and distress.^{17,18} Not surprisingly therefore, the World Health Organization (WHO) has prioritized URE and VI in their campaigns like "VISION 2020: Right to Sight".¹⁹

It is known that VI is associated with depression, anxiety and frustration.^{18,20} Moreover, people with VI worry that the condition might worsen, and they could become blind,¹⁸ which may impact their quality of life (QoL). According to the WHO, QoL can be defined as a personal perception of one's position in life in a context of culture and value systems in which he lives and in relation with his goal, expectations, standards and concerns.²¹ Therefore, vision-related QoL can be defined in the context of VI²² and is an important aspect to review particularly amongst children¹⁵ as RE and VI can affect

the learning ability of children²³ with a ripple effect on their lives. Most children with RE and/ VI complain of having difficulties copying what is written on the blackboard at school.²² Furthermore, they cannot participate in most sporting codes that require good vision. Myopia was found to be a factor resulting in poorer vision-related QoL for both distance and near vision, while hyperopia had no association with neither near nor distance difficulties.²³ Pan *et al*²⁴ reported that children with poor vision often score very low on health related QoL (HRQoL). In addition, children with worse VI are reported to experience more difficulty in life as compared to those with average VI,²⁵ and children with VI in one eye could still score better on the QoL assessment, than those with bilateral VI.²³

There is little information about the burden these two conditions have on children's QoL.¹⁵ To the researchers' knowledge the assessment on the impact of RE and/ VI on QoL of school-going children has not been done in Sekhukhune district. The outcome of this study has the potential to guide policy makers in channelling resources to alleviate the burden children experience due these conditions.²⁶

Methods

A quantitative, cross-sectional, school-based study was conducted to determine the prevalence and distribution of RE, VI and their impact on QoL among school-going children aged 6-18 years residing within the borders of greater Sekhukhune district, Limpopo province, South Africa.

- Part one of the study focussed on the prevalence and distribution of RE and VI among school-going children aged 6-18 years in Sekhukhune district, (Limpopo), South Africa and it is reported in another paper.
- The second part of the study focussed on the impact of RE and VI on the QoL among school-going children in Sekhukhune, (Limpopo), South Africa and it is the part that this paper is reporting on.

Sekhukhune district is the smallest district of the province of Limpopo, making up 11% of the geographic area (that is. 13 528km²) with a recorded population of 1 169 762 as per STATS SA, (2016).²⁷ This area is made up of four municipalities which are Elias Motsoaledi, Ephraim Mogale, Makhuduthamaga and Tubatse (Fetakgomo). The

whole of Sekhukhune is a low socio-economic district with 64% of unemployment and many people living on an income of less than R1500 per month per household.^{27,28}

The study population comprised of school going children aged 6-18 years residing within Sekhukhune district. Makhuduthamaga municipality was sampled by convenience due to access to this municipality by the principal investigator and it was a representative of the entire district of Sekhukhune. After consulting with statistician, the sample size of 337 was agreed upon and it was rounded off to 400 to allow an equal distribution of genders and grades. A total of 400 school-children from 10 randomly selected schools were invited to participate in this study. Forty randomly selected learners represented each school from five randomly selected grades. In each grade the class register was used to randomly select eight learners, both males and females equally represented.

Out of 400 learners who were invited to participate, Forty-two children did not assent to be instilled with local anaesthetic (Novesin wander 1 drop) and cycloplegic eye drop (1% cyclopentolate 2-3 drops), twenty-four children did not attend school at the day scheduled for eye examination and eight children did not bring back the signed concern forms. Therefore, the total of 326 learners participated in this study and it was 96.7% of the required sample size.

Children aged 6-18 years who returned signed consent forms, assent forms and were present at school at the day scheduled for the eye examination were included. All children with any systemic or ocular diseases and/or on any systemic or ocular medication were excluded from the study.

A modified RESC (Refractive Error Study in Children) protocol was employed to determine the prevalence value of refractive error (RE) and visual impairment (VI). Data was collected from 326 learners who were selected using multi-stage systematic random sampling and had undergone a battery of vision assessment tests. The tests included unaided visual acuity with a LogMAR chart. Any child who scored between 0.00M to < 0.2M in both eyes was considered to have good vision, a score of 0.2M or worse in one or both eyes was considered as RE while a score of 0.3 or worse in one or both eyes was considered as VI. Binocular motor function assessment using

Hirschberg and the cover test was performed without any correction. Cycloplegic autorefractometry was performed and a value of $-0.50D$ and higher in one or both eyes was considered as myopia, $+2.00D$ and higher in one or both eyes was hypermetropia and -0.75 cylindrical refraction in one or both eyes as astigmatism. Aided visual acuity with the autorefractor findings was used to determine the correctable RE. The outcome of the vision assessment on the study sample is detailed in another paper.

A total of 155 [47.5% (95% CI, 42.1-53.0)] out of the original sample of 326 learners, aged 14-18 years, were invited to participate in an interview using the National Eye Institute Visual Functioning Questionnaire-25 (NEI-VFQ-25) version 2000,²⁹ before they proceeded to the eye examination. The older age group of learners were selected on the basis they would understand the questionnaire better as compared to the young ones. The validated NEI-VFQ-25 was modified by removing subscale driving as it was irrelevant for this study population of school-going children and used as the instrument to measure the QoL.

The NEI-VFQ-25 was administered in a structured interview format consisting of 23 questions which were compulsory. A trained research assistant read out the question/statement about vision problems or difficulty that each child might experience due to his/her vision condition. After each question/statement, the research assistant then read the list of possible answers, and the child was requested to choose the response that best described his/her situation. The questions were categorized into various sub-scales including global vision rating (1), difficulty with near vision activities (3), difficulty with distance vision activities (3), limitation in social functioning due to vision (2), dependency on others due to vision (4), limitation with peripheral (1) and ocular pain (2). The average score was 100 with a low score reflecting a poor QoL. The questionnaire was presented in English with the research assistant being proficient in both English and each child's indigenous language (Sepedi), further enabling him to translate to the respondent in case of confusion.

Data captured from the questionnaires was entered into Microsoft Excel and analysed using the Social Package for Social Sciences (SPSS), version 25. Correlations were used to look at the strengths of the relationship between QoL scores. The independent sample t-test/ ANOVA was used to compare the mean QoL scores between the

categories of RE. All the tests were two tailed and statistical significance was set at $\alpha = 5\%$. This study adhered to the tenets of the Declaration of Helsinki and was approved by the Biomedical Research and Ethics committee at the University of KwaZulu (BE080/19). Further approval was obtained from the Limpopo Department of Education and the principals of the schools concerned. Signed consent and assent forms from parents and children was a requirement before the child could be allowed to form part of this study.

Results

One hundred and fifty-five learners participated in the interview; however, one record went missing thus the responses of only 154 learners were analysed for this part of the study.

Demographics

Gender and age demographics of the sample are shown in Table 1. Respondents were aged 14 and 18 years with the majority (61% [95% CI; 53.3-68.7]) being 17+ years of age. The mean age of the sample was 16 years \pm 1.42, with a median age of 14 years. There were slightly more female than male respondents. One hundred and nine (70.8% [95% CI, 63.6-78.0]) of the respondents were from Grades 10-12.

Refractive error and visual impairment

In the eyes with successful cycloplegia, refraction was performed with an autorefractor. A minimum of five readings with valid confidence rankings as per the manufacturer's instructions was obtained for each eye. Following the RESC protocol, we defined myopia in one or both eyes of at least -0.50 diopter (D), hyperopia at least +2.00 D in one or both eyes and astigmatism at 0.75 cylindrical refraction or more. Of the 154 respondents, 56 learners (36.4% [95% CI, 28.8-44.0]) presented with RE and/or VI as determined with cycloplegic autorefraction (Table 2). The prevalence of myopia was (21.4% [95% CI, 14.9-27.9]) and associated with males and older children as Table 3 shows. In three learners', vision could not be improved to better than 0.30 (20/40). The prevalence of VI in this study was therefore 1.9% [95% CI, 0.00-4.10].

Table 4 shows the mean and standard deviation sub scores of the 11 subscales (including the composite score) on the VFQ-25 for learners with and without RE and/or

VI. The sub scores had been determined by averaging the score for the items under each subscale. The p-value from the independent t-test run for each sub score reflected in Table 4 is also provided for the comparison between learners with RE and/or VI and those without RE and/or VI. A lower score represents poorer functioning. For all items, the mean sub scores of those learners with RE and /or VI were consistently lower than for those without RE and/or VI. These sub scores, for all items were also statistically significantly different (p -values < 0.05) with the exception of General Health. However, as the difference in the number of respondents in the two groups was 56, a minimum of 20-point difference in the sub scores would indicate a difference between the groups, and as noted only for the subscales Distance Activities, Mental Health, Role Difficulties and Dependency.

There was no significant difference noted in the composite scores when extrapolated according to age groups as per Table 5, however significant differences were found for the sub-scores of near and distance activities, role difficulties and colour vision. Neither the mean and standard deviation composite score or any of the sub scores of the items on the VFQ-25 was influenced by gender as shown by Table 6. When further analysed according to refractive status, learners with myopia scored low in all the items of VFQ-25 as compared to those with hyperopia and/or astigmatism (as per Table 7).

Further analysis was conducted to determine if there were any correlations between the scorings for each of the subscales using Pearson's correlations. The p-values obtained for each pair of subscales is depicted in Table 8. It was noted that all subscales were significantly correlated at a 95% confidence level ($p < 0.05$) with all other subscales with the exception of general health, which was correlated only with general vision, ocular pain, near activities, distance activities and dependence.

Discussion:

The current study was done to understand the impact of RE and/or VI on the QoL among children in greater Sekhukhune. A total of 154 school-children aged 14 to 18 years completed the NEI-VFQ-25 and underwent vision assessment. The sample of the current study had an almost equal distribution of males and females, which is

important considering the findings of some studies where the prevalence of RE differs according to gender.^{30,31} A total of 56 learners (36.4% [95% CI, 28.8-44.0]) had RE, with three also presenting with VI while 98 (63.6% [95% CI, 36.0-71.2]) had no RE and/ VI. This prevalence of 36.4% was closer to 36.9% found among Chinese children,⁵ but much higher than the 15% prevalence reported among South African children.¹² The difference might be related to the latter study being done in a different location which is Kwa-Zulu Natal province while the current one was done in Limpopo province. Myopia was the leading type of RE and was associated with older age and female gender. Similar findings were found among Nigerian children.⁶ In South Africa¹² did not find any association between demographics (age and gender) and RE. The prevalence of 1.9% of VI was similar to the value of 1.8% found among Ethiopian children,³² but lower than 2.74% find in South Africa.³³ On average 36% (95% CI, 28.8-44.0) of learners presented with RE and/ VI and 63.6% (95% CI, 56.0-71.2).

The NEI-VFQ-25 is a validated tool that has been used to assess health domains including mental and social well-being and in particular self-ratings of functioning in specific vision related tasks in many studies involving ocular pathology.^{34,35} This study has largely focussed on the functioning of school-children with RE and/or VI. The first statement in the questionnaire required a rating of general health, and the current study found almost identical ratings of general health by the schoolchildren irrespective of whether they had RE and/or VI or not. In addition, ratings of general health were found to only be correlated to 5 of the other 10 vision-targeted subscales. This could imply that schoolchildren do not perceive a direct influence of their general health on vision functioning. This corresponds to results found by Parrish *et al.*³⁵ after administering the NEI-VFQ on glaucoma patients, general health scores were found to be the same for patients with glaucoma and those without.

For all vision targeted subscales, statistically significant differences were noted in the rating scores of school-children with RE and/VI and those without, with the trend being a lower score obtained for the group with RE and/VI. This implies that this grouping of schoolchildren perceived their visual functioning to be of lower quality compared to that of their counterparts. The tasks that school-children are involved in is largely dependent on vision, this score means learners with RE and/ VI have difficulty with doing their schoolwork. Kumaran *et al.*²² further reported that most learners with

uncorrected refractive error admit that their academic performance is always average due to their vision problems.

While statistically significantly lower ratings for all vision targeted subscales were obtained from the school-children with RE and/or VI, this difference must be interpreted with caution considering the relatively small number of subjects in this grouping. As per the NEI-VFQ-25 manual, for the sample size ($n = 38$) in this group, a difference of at least 20 points is required to indicate a difference in rating compared to the schoolchildren without RE and/or VI. This difference of 20 points or more was noted for the subscales of difficulty with distance vision activities, mental health symptoms due to vision, role limitations due to vision and dependency on others due to vision.

Difficulty with distance vision may be experienced more than tasks involving near vision in this group as the majority of schoolchildren presented with myopia rather than hyperopia. Furthermore, due to good accommodative ability in this age group a reduction in near vision can be overcome with accommodation. Hsieh et al. (2016)²³ also found the same results after administering the same questionnaire on Taiwanese junior high school students.

The subscales of mental health symptoms due to vision, role limitations due to vision and dependency on others due to vision all relate to mental and social well-being and appear to be significantly affected as rated by the children with RE and/VI in the current study. Similar findings have been established by other studies.^{15,16} This may be related to this group of learners not at liberty to participate in most sports or games at school or home due to the poor vision. Moreover, it has been found that people with vision problems find it difficult to make friends.³⁴ Therefore, their social skills are negatively affected considering they spend most of their time alone, with subsequent psychological affects also reported.^{36,37} The results also show that learners with RE and/ VI scored relatively lower on mental health. This implies that this group of learners possibly experience tremendous frustration due to poor vision. Furthermore, studies also have indicated that people with VI are often depressed, frustrated and anxious, because they are worried that their condition might get worse.^{34,38}

Learners with RE and/ VI are limited in performing duties they were supposed to perform reflected in the significantly lower rating score for dependency on others due to vision in the current study. They often have to rely on others for help and unfortunately if they cannot get help on time, they are unable to complete the task. This can result in them often being mistaken as learners with difficulties or some form of dyslexia, if this vision problem is not solved early.²²

With respect to ocular pain: even though the rating scores of the learners with RE and VI was found to be statistically significantly different to the other group, the difference was not found to be more than 20 points, indicating a minimal difference in rating for this aspect. One may have expected those with RE and VI to report more discomfort, however, Kumaran *et al.*²² actually found that people with better functional vision experience more pain and discomfort than those with poor functional vision. This may be due to frequent rubbing of eyes in an attempt to focus clearly, and this eyestrain and discomfort were seen mostly in children with Astigmatism.²²

Overall, the current study supports the assertions that VI, either from RE or ocular pathology, has an impact on QoL as reflected in the global vision rating score. Pan *et al.*²⁴ used a health-related quality of life (HRQoL) questionnaire on Chinese adolescents and found that those with reduced visual acuity reported lower HRQoL scores in comparison to those with normal visual acuity. Similar findings were reported by Elsmann *et al.*³⁹, who employed the Low vision quality of life questionnaire on young adults aged 18-25 years at a Dutch low vision rehabilitation centre, as well as by Parrish *et al.*³⁵ after administering NEI-VFQ among glaucoma patients attending a glaucoma clinic at the University of Miami. This is of particular concern as Frick *et al.*¹⁷ indicated that children with VI find it difficult to make it in life.

The findings of this study must be interpreted with caution as the number of school-children that completed the NEI-VFQ-25 was relatively small. Only 47% of the total sample of a larger study took the questionnaire, however, this was to ensure that the child was old enough to complete the questionnaire satisfactorily. Furthermore, only 38 (approximately 25%) of the 154 respondents had RE and/or VI and a study with a larger sample of children with RE and/or VI would be useful to corroborate the findings of the current study. The NEI-VFQ-25 was not translated into the learners' indigenous

language, which is Sepedi, which may have brought into question the validity of their responses, however, the research assistant that administered the questionnaire was proficient in both English and Sepedi. It is recommended though, that the NEI-VFQ-25 be translated into the 11 official languages for future use at South African schools. The strength of this study is that it is one of a few studies globally, and only one in Africa that have attempted to investigate the quality of life among school-children, a population who will carry any current RE and/or VI for many years in their lives.

Conclusion

Refractive error and/ visual impairment were found to have a significant impact on the QoL of learners in greater Sekhukhune district. This calls for attention from the government and all stakeholders responsible for eye care to devise strategies to address these conditions particularly in this vulnerable group.

Author's contributions

Mr Magakwe: drafted the proposal, applied for authorization, recruited the participants, collected data and draft the manuscript.

Prof Hansraj: edited the proposal, supervised the data collection and helped with writing and editing the manuscript.

Mrs Xulu-Kasaba: edited the proposal, helped with data analysis and helped with writing and editing the manuscript.

Disclosure Statement

"None of the authors" have any proprietary interests or conflicts of interest related to this submission.

Declaration

This paper has not been submitted anywhere for publication previously and it is not simultaneously being considered for any other publication.

Sources of support:

College of Health Science financial support of R40 000.00 as a stipend and a laptop.

References:

1. WHO. International statistical classification of diseases and related health problems - 10th revision. World Heal Organ. 2011;
2. DeCarlo DK, Woo S, Woo GC. Patients with low vision. In: Borish's Clinical Refraction. 2006.
3. Resnikoff S. Assessment of the prevalence of visual impairment attributable to refractive error or other causes in school-children. Protocol and Manual. World Heal Organ. 2007;
4. Hashemi H, Fotouhi A, Yekta A, Pakzad R, Ostadimoghaddam H, Khabazkhoob M. Global and regional estimates of prevalence of refractive errors: Systematic review and meta-analysis. *J Curr Ophthalmol*. 2018 Mar 1 [cited 2018 Jun 19];30(1):3–22. Available from: <https://www.sciencedirect.com/science/article/pii/S2452232517300227>
5. Wu JF, Bi HS, Wang SM, Hu YY, Wu H, Sun W, et al. Refractive Error, Visual Acuity and Causes of Vision Loss in Children in Shandong, China. The Shandong Children Eye Study. Barnes S, editor. *PLoS One*. 2013 Dec 23 [cited 2018 Jun 19];8(12):e82763. Available from: <http://dx.plos.org/10.1371/journal.pone.0082763>
6. Ezinne NE, Mashige KP, Ezinne N. African Vision and Eye Health. 2018 [cited 2018 Oct 3]; Available from: <https://doi.org/10.4102/>
7. Pradhan N, Sachdeva A, Goel T, Bholra B, Jha D. Prevalence of refractive errors among school-children of 6-12-years of age group and reason for not using spectacles even after correction. *Int J Res Med Sci*. 2018 Feb 22 [cited 2018 Jun 19];6(3):798. Available from: <http://www.msjonline.org/index.php/ijrms/article/view/4549>
8. Hashemi H, Yekta A, Jafarzadehpur E, Ostadimoghaddam H, Etemad K, Asharlous A, et al. High Prevalence of Refractive Errors in 7 Year Old Children in Iran. *Iran J Public Health*. 2016 Feb [cited 2018 Jun 19];45(2):194–202. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/27114984>
9. Caca I, Cingu AK, Sahin A, Ari S, Dursun ME, Dag U, et al. Amblyopia and Refractive Errors Among School-Aged Children With Low Socioeconomic Status in Southeastern Turkey. *J Pediatr Ophthalmol Strabismus*. 2013 Jan 1

- [cited 2018 Jun 19];50(1):37–43. Available from:
<http://www.healio.com/doiresolver?doi=10.3928/01913913-20120804-02>
10. Oveneri-Ogbomo GO, Omuemu VO. Prevalence of refractive error among school-children in the Cape Coast Municipality, Ghana. *Clin Optom.* 2010;2:59–66.
 11. Arafa AEE-D, Ewis AAE, Mahran WM, Mohamed AAE, El-Shabrawy EM. Prevalence and risk factors of refractive errors among preparatory school students in Beni-Suef, Egypt. *J Public Health (Bangkok)*. 2018 May 26 [cited 2018 Jun 19];1–5. Available from: <http://link.springer.com/10.1007/s10389-018-0930-8>
 12. Wajuihian SO, Hansraj R. Refractive Error in a Sample of Black High School-children in South Africa. *Optom Vis Sci.* 2017 Dec [cited 2018 Jun 19];94(12):1145–52. Available from:
<http://insights.ovid.com/crossref?an=00006324-201712000-00010>
 13. Yang M, Luensmann D, Fonn D, Woods J, Jones D, Gordon K, et al. Myopia prevalence in Canadian school-children: a pilot study. *Eye.* 2018 Jun 2 [cited 2018 Jun 19];32(6):1042–7. Available from:
<http://www.nature.com/articles/s41433-018-0015-5>
 14. Naipal S, Rampersad N. A review of visual impairment. *African Vis Eye Heal.* 2018 Jan 26 [cited 2018 Jun 20];77(1):1–4. Available from:
<https://avehjournal.org/index.php/aveh/article/view/393>
 15. Kandel H, Khadka J, Goggin M, Pesudovs K. Impact of refractive error on quality of life: a qualitative study. *Clin Exp Ophthalmol.* 2017 Sep 1;45(7):677–88.
 16. Kocur I, Resnikoff S. Visual impairment and blindness in Europe and their prevention. Vol. 86, *British Journal of Ophthalmology*. BMJ Publishing Group Ltd; 2002. p. 716–22.
 17. Frick KD, Gower EW, Kempen JH, Wolff JL. Economic impact of visual impairment and blindness in the United States. *Arch Ophthalmol.* 2007 Apr;125(4):544–50.
 18. Lin JC, Yu JH. Assessment of quality of life among Taiwanese patients with visual impairment. *J Formos Med Assoc.* 2012 Oct 1;111(10):572–9.
 19. WHO | Priority eye diseases. WHO. 2018;
 20. Toit R du, Palagyi A, Ramke J, Brian G, Ophthalmology EL-, 2010 U. The

- impact of reduced distance and near vision on the quality of life of adults in Timor-Leste. Elsevier. 2010 [cited 2019 Oct 4];1. Available from: <https://www.sciencedirect.com/science/article/pii/S0161642010003209>
21. Skevington SM. Measuring quality of life in Britain: Introducing the WHOQOL-100. *J Psychosom Res.* 1999;47(5):449–59.
 22. Kumaran SE, Balasubramaniam SM, Kumar DS, Ramani KK. Refractive error and vision-related quality of life in South Indian Children. *Optom Vis Sci.* 2015 Mar 6;92(3):272–8.
 23. Hsieh M-H, Lin J-C. Association of refractive error with vision-related quality of life in junior high school students. *Taiwan J Ophthalmol.* 2016 [cited 2018 Jul 30];6(1):32–5. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/29018707>
 24. Pan C, Wu R, Li J, ophthalmology HZ-B, 2018 undefined. Low prevalence of myopia among school-children in rural China. Springer. [cited 2020 May 6]; Available from: <https://link.springer.com/article/10.1186/s12886-018-0808-0>
 25. Kinengyere P, Kizito S, Kiggundu JB, Ampaire A, Wabulembo G. Burden, etiology and predictors of visual impairment among children attending Mulago National Referral Hospital eye clinic, Uganda. *Afr Health Sci.* 2017;17(3):877–85.
 26. Ku PW, Steptoe A, Lai Y-J, Hu H-Y, Chu D, Yen Y-F, et al. The Associations between Near Visual Activity and Incident Myopia in Children. *Ophthalmology.* 2019 Feb [cited 2019 Mar 6];126(2):214–20. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0161642017334644>
 27. South African, Lehohla AP, Statistics South Africa. The state of basic service delivery in South Africa: In-depth analysis of the Community Survey 2016 data. Statistics South Africa. Pretoria: Statistics South Africa. 2016.
 28. Adrian Frith S. Census 2011 — Local Municipality “Makhuduthamaga”. [cited 2018 Sep 3]. Available from: <https://census2011.adrianfrith.com/place/985>
 29. Mangione, C. M., Lee, P. P., Gutierrez, P. R., Spritzer, K., Berry, S., & Hays RD. Visual Function Questionnaire (VFQ-25) from RAND Health | RAND. *Archives of Ophthalmology*, 119, 1050-1058. 2001 [cited 2018 Aug 20]. Available from: https://www.rand.org/health/surveys_tools/vfq.html
 30. Mehari ZA, Yimer AW. Prevalence of refractive errors among schoolchildren in rural central Ethiopia. *Clin Exp Optom.* 2013 Jan [cited 2018 Jun 19];96(1):65–9. Available from: <http://doi.wiley.com/10.1111/j.1444-0938.2012.00762.x>

31. Ekpenyong BN, Naidoo K, Ahaiwe K, Ezenwankwo O, Ndukwe O, Ogar E, et al. Visual status and prevalence of eye disorders among school-age children in southern Nigeria. *African Vis Eye Heal.* 2017 Jan 30 [cited 2018 Jun 19];76(1):1–6. Available from: <http://www.avehjournal.org/index.php/aveh/article/view/377>
32. Kedir J, Girma A. Prevalence of Refractive Error and Visual Impairment among Rural School-Age Children of Goro District, Gurage Zone, Ethiopia. *Ethiop J Health Sci.* 2014 Nov 4 [cited 2018 Jun 19];24(4):353. Available from: <http://www.ajol.info/index.php/ejhs/article/view/109429>
33. Naidoo KS, Raghunandan A, Mashige KP, Govender P, Holden BA, Pokharel GP, et al. Refractive Error and Visual Impairment in African Children in South Africa. *Investig Ophthalmology Vis Sci.* 2003 Sep 1 [cited 2018 Jun 19];44(9):3764. Available from: <http://iovs.arvojournals.org/article.aspx?doi=10.1167/iovs.03-0283>
34. Hassell JB, Lamoureux EL, Keeffe JE. Impact of age related macular degeneration on quality of life. *Br J Ophthalmol.* 2006 May 1;90(5):593–6.
35. Parrish RK, Gedde SJ, Scott IU, Feuer WJ, Schiffman JC, Mangione CM, et al. Visual function and quality of life among patients with glaucoma. *Arch Ophthalmol.* 1997;115(11):1447–55.
36. Pascolini D, Mariotti SP. Global estimates of visual impairment: 2010. *Br J Ophthalmol.* 2012 May 1 [cited 2018 Jun 19];96(5):614–8. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/22133988>
37. Garcia GA, Khoshnevis M, Gale J, Frousiakis SE, Hwang TJ, Poincenot L, et al. Profound vision loss impairs psychological well-being in young and middle-aged individuals. *Clin Ophthalmol.* 2017 Feb 23;11:417–27.
38. Rovner BW, Casten RJ, Tasman WS. Effect of depression on vision function in age-related macular degeneration. *Arch Ophthalmol.* 2002 Aug 1;120(8):1041–4.
39. Elsmann EBM, van Rens GHMB, van Nispen RMA. Quality of life and participation of young adults with a visual impairment aged 18–25 years: comparison with population norms. *Acta Ophthalmol.* 2019 Mar 1;97(2):165–72.

TABLE 1: Demographics of the respondents

	Males n (%)	Females n (%)	Total n (%)
Age(years)			
14-16	27(17.5)	33(21.4)	60(39)
17+	46(29.9)	48(31.2)	94(61)
Total (%)	73(47.4)	81(52.6)	154(100)
Grade			
6-7	7(4.5)	4(2.6)	11(7.1)
8-9	18(11.7)	16(10.4)	34(22.1)
10-12	48(31.2)	61(39.6)	109(70.8)
Total (%)	73(47.4)	81(52.6)	154(100)

n= number of samples

TABLE 2: Participants with and without RE and/ VI based on age and gender

	Learners without RE and/ VI n (%)	Learners with RE and/ VI n (%)	Chi- square
Age(years)			
14-16	36(60)	24(40)	0.454*
17+	62(66)	32(34)	
Total	98(63.6)	56(36.4)	
Gender			
Males	46(63)	27(37)	0.879
Females	52(64.2)	29(35.8)	
Total	98(63.6)	56(35.8)	

n: number of samples

TABLE 3: Prevalence of refractive error according to types, gender and age

	Myopia n (%)	Hyperopia n (%)	Astigmatism n (%)
Gender:			
Males	18(11.7)	1(0.6)	8(5.2)
Females	15(9.7)	2(1.3)	12(7.8)
Total	33(21.4)	3(1.9)	20(13)
Age (years)			
14-16	13(8.4)	2(1.3)	9(5.8)
17+	20(13)	1(0.6)	11(7.1)
Total	33(21.4)	3(1.9)	20(13)

n= number of samples

TABLE 4: Comparison of the mean and standard deviation of the sub scores of the items on the VFQ-25 between learners without RE and/VI or those with

Scale Name	Sub scores (Mean (SD))		Independent t-test p-value
	Learners without	Learners with	P
	RE and/ VI	RE and/ VI	
Composite scores	80.56(10.36)	65.21(17.65)	0.000*
General health	59.43(26.50)	60.71 (24.24)	0.768
General vision	76.12 (17.85)	67.41(23.08)	0.010*
Ocular pain	76.19(18.74)	61.38(22.64)	0.000*
Near Activities	83.41(12.58)	70.16(21.21)	0.000*
Distance Activities	86.30(12.21)	69.79(20.26)	0.000*
Social Functioning	88.05(13.30)	72.76(21.46)	0.000*
Mental Health	79.75(15.79)	52.56(26.82)	0.000*
Role Difficulties	79.33(19.08)	58.24(27.34)	0.000*
Dependency	83.58(16.68)	56.84(30.00)	0.000*
Colour Vision	88.52(16.51)	77.41(23.90)	0.001*
Peripheral Vision	85.45(14.76)	70.00(23.55)	0.000*

Keys: (*) indicates that the mean difference is significant at $\alpha=5\%$

SD: standard deviation

RE: refractive error

VI: visual impairment

TABLE 5: The mean and standard deviation of sub scores of the items on the VFQ-25 for participants with RE and/ VI based on age groups.

Scale name	Sub score (mean(SD))		Independent t-test
	14-16 years	17+ years	
Composite scores	68.27(21.12)	62.92(14.47)	0.753
General health	64.58(23.21)	57.81(24.95)	0.753
General vision	69.37(23.04)	65.93(23.36)	0.990
Ocular pain	64.06(27.16)	59.37(18.78)	0.112
Near activities	71.52(26.00)	69.13(17.16)	0.003*
Distance activities	71.87(23.54)	68.22(17.64)	0.021*
Social functions	71.35(22.56)	73.82(20.90)	0.392
Mental health	60.41(30.10)	46.67(22.83)	0.039
Role difficulties	67.70(31.25)	51.14(21.91)	0.031*
Dependency	65.96(29.89)	49.99(28.63)	0.703
Color vision	73.33(29.32)	80.46(18.77)	0.034*
Peripheral vision	70.83(25.18)	69.53(22.66)	0.586

SD: standard deviation

Keys: (*) indicates that the mean difference is significant at $\alpha=5\%$

TABLE 6: The mean and standard deviation of sub scores of the items on the VFQ-25 for participants with RE and/ VI based on gender.

Scale name	Sub score (mean(SD))		Independent t-
	Males	Females	test p-value
Composite scores	63.31(18.01)	66.98(17.45)	0.476
General health	55.55(26.25)	65.51(21.56)	0.311
General vision	66.48(24.01)	68.27(22.57)	0.651
Ocular pain	59.25(22.35)	63.36(23.13)	0.857
Near activities	68.67(22.63)	71.55(20.10)	0.381
Distance activities	70.05(20.58)	69.54(20.32)	0.931
Social functions	68.06(22.56)	77.16(19.78)	0.195
Mental health	50.92(26.27)	54.09(27.71)	0.815
Role difficulties	55.01(28.27)	61.25(26.59)	0.715
Dependency	53.39(30.42)	60.05(29.74)	0.545
Color vision	79.63(20.84)	75.34(26.62)	0.621
Peripheral vision	69.44(26.25)	70.69(21.20)	0.148

SD: standard deviation,

TABLE 7: The mean and standard deviation of sub scores of the items on the VFQ-25 according to refractive status

Scale name	Emmetropia	Myopia	Hyperopia	Astigmatism	p
	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)	
Composite	80.56(10.36)	62.09(19.02)	60.98(00.68)	71.00(15.03)	0.000*
General health	59.43(26.50)	57.57(23.78)	75.00(0.00)	63.75(26.25)	0.620
General vision	76.12(17.85)	64.24(24.53)	80.00(00.00)	70.75(21.78)	0.027*
Ocular pain	76.19(18.74)	62.87(25.09)	54.16(7.21)	60.00(20.11)	0.000*
Near activities	83.41(12.57)	65.02(23.15)	74.99(22.04)	77.91(15.36)	0.000*
Distance activities	86.30(12.21)	66.41(20.88)	66.66(8.33)	75.83(19.66)	0.000*
Social function	88.05(13.30)	68.18(21.89)	75.00(12.50)	80.00(20.43)	0.000*
Mental health	79.75(15.79)	50.56(28.00)	50.00(6.25)	56.25(27.12)	0.000*
Role difficulties	79.33(19.08)	57.98(30.27)	41.66(14.43)	61.15(23.37)	0.000*
Dependency	83.58(16.68)	49.99(30.76)	49.99(36.32)	69.16(24.94)	0.000*
Colour vision	88.52(16.51)	75.75(22.95)	45.00(32.78)	85.00(20.51)	0.000*
Peripheral vision	85.45(14.76)	64.39(24.23)	58.33(14.43)	81.25(19.65)	0.000*

SD: standard deviation

Keys: (*) Indicates that the mean difference is significant at $\alpha=5\%$

TABLE 8: Correlations between the items of VFQ

		<i>General Health</i>	<i>General Vision</i>	<i>Ocular Pain</i>	<i>Near Activity</i>	<i>Distance Activity</i>	<i>Social Functioning</i>	<i>Mental Health</i>	<i>Role Difficulty</i>	<i>Dependency</i>	<i>Colour Vision</i>	<i>Peripheral Vision</i>
<i>Gen Health</i>	Personal Correlation	1	0.229	0.199	0.257	0.241	0.116	0.151	0.162	0.153	0.018	0.170
	p-value		0.004**	0.013*	0.001**	0.003**	0.154	0.062	0.044**	0.058	0.825	0.035*
<i>Gen Vision</i>	Personal Correlation		1	0.441	0.445	0.445	0.345	0.495	0.372	0.504	0.202	0.364
	p-value			0.000*	0.000**	0.000**	0.000**	0.000*	0.000*	0.000**	0.012*	0.000**
<i>Ocular Pain</i>	Personal Correlation			1	0.495	0.547	0.506	0.618	0.625	0.566	0.296	0.478
	p-value				0.000**	0.000**	0.000**	0.000*	0.000**	0.000**	0.000**	0.000**
<i>Near Activity</i>	Personal Correlation				1	0.726	0.621	0.634	0.539	0.605	0.376	0.586
	p-value					0.000**	0.000**	0.000*	0.000**	0.000**	0.000**	0.000**
<i>Distance Activity</i>	Personal Correlation					1	0.683	0.712	0.644	0.621	0.490	0.758
	p-value						0.000**	0.000*	0.000**	0.000**	0.000**	0.000**
<i>Social Functioning</i>	Personal Correlation						1	0.651	0.560	0.603	0.548	0.658
	p-value							0.000*	0.000**	0.000**	0.000**	0.000**
<i>Mental Health</i>	Personal Correlation							1	0.700	0.854	0.449	0.614
	p-value								0.000**	0.000**	0.000**	0.000**
<i>Role Difficulty</i>	Personal Correlation								1	0.611	0.371	0.612
	p-value									0.000**	0.000**	0.000**
<i>Dependency</i>	Personal Correlation									1	0.430	0.533
	p-value										0.000**	0.000**
<i>Colour Vision</i>	Personal Correlation										1	0.483
	p-value											0.000**
<i>Peripheral Vision</i>	Personal Correlation											1
	p-value											

p-value <0.01= * and p-value <0.05=**

CHAPTER 4 - Synthesis Chapter

4.1 General discussion

Uncorrected refractive error (URE) is a major problem in school going children in Sekhukhune district. It was also found to be the leading cause of visual impairment among school-going children in this area. In addition to the negative implications on learners' academic performance, URE and or visual impairment also affects school-going children socially and psychologically. Learners with VI often feel frustrated and helpless due to their poor vision. They also fail to participate in certain games that require good vision outside classroom.

4.1.1 Prevalence and distribution of Refractive error among school-going children in Sekhukhune district, Limpopo (South Africa)- First Manuscript

a. The prevalence of RE among learners in Sekhukhune district was 20.6% (95% CI, 16.2-24.9), and was outside the range of between 2-12% previously recorded on the African continent (1-4). Similarly, a high prevalence was also observed amongst school-children in Malamulele district (Limpopo), where the prevalence value of 20.1% (5) was found. In this study, the highest prevalence of RE was 11.6% in age-group 14-18 years. The lowest prevalence of 3% however, was seen on the younger age group of children aged 6-9-years, similar to the findings by Atowa and Ijof (2020) among Nigerian Children (6). Learners of Grades 9-12 had the highest prevalence of RE (46.3% [95% CI, 34.3-58.2]) with no significant difference in prevalence of RE between males and females. This was also reported in a study done among KwaZulu-Natal school going children, where there was no association between RE and gender (7). All the children who were sent for an eye examination had never had their eyes tested before.

b. Myopia was the leading type of RE in Sekhukhune with a prevalence value of 10.4% (95% CI, 7.10-13.7). Myopia was found to be more common on older children, with a greater association with males as compared to females. This is similar to the results found in South Africa by Baloyi *et al* (5) and Wajuihian and Hansraj (7). The prevalence of hypermetropia was 2.8% [95% CI, 1.00-4.50]) of the overall sample and was observed mostly on the younger age group 6-9-years and females, similar as it was in Nigerian children (8). Astigmatism ranged from -0.75 D to -5.50 D cylinder and the prevalence in Sekhukhune district was 7.4% (95% CI, 4.5-10.2). A higher prevalence of astigmatism was observed among children aged 10-13-years 3.7% (95% CI, 1.64-5.72) and there was no significant different in prevalence of astigmatism between genders.

4.1.2 Prevalence and distribution of Visual impairment among school-going children in Sekhukhune district, Limpopo (South Africa)- First Manuscript

a. The prevalence of VI in Sekhukhune district was 12.3% as per definition of the WHO as presenting visual acuity of 0.30 M or worse (9). Thirty learners (9.2% [95% CI, 6.1-12.3]) had mild VI, eight (2.5% [95% CI, 0.80-4.10]) moderate and two (0.6% [95% CI, 0.00-1.50]) severe VI. The highest prevalence of VI was observed in age group 14-18-years and Grades 9-12 similar to that was found among Ethiopian children (10). There were no difference in the prevalence of VI between males and females. The leading cause of VI was uncorrected RE (80% [95% CI, 67.6-92.4]) as it was also found by the study done in KwaZulu Natal (11), followed by amblyopia, corneal opacity/scar and cataract with findings of 10% [95% CI, 0.70-19.3], 7.5% [95% CI, 0.00-15.7] and 2.5% [95% CI, 0.00-7.30]

respectively. After correction, only Seven learners (2.1% [95% CI, 0.60-3.70]) could not achieve VA of ≥ 0.30 in one or both eyes. Two learners with significant refractive error were offered a pair of spectacle correction by a principal investigator.

4.1.3 The impact of refractive error and visual impairment on quality of life of learners in Sekhukhune district, Limpopo (South Africa) – Second manuscript

a. The total of 154 (47% [95% CI, 41.8-52.7]) learners completed a NEI-VFQ questionnaire before they underwent the eye examination. After the eye examination it was found that 38 (24.7% [95% CI, 17.9-31.5]) learners had RE and/ VI, while 116 (75.3% [95% CI, 68.5-82.1]) had normal vision. The results were all about comparing mean scores between the two groups (i.e. the group of learners with RE and/ VI and the group of learners without RE and/ VI). On average learners with RE and/ VI scored lower on the NEI-VFQ (65.21) as compared to learners without RE and/VI (80.56). Only with general health did these two groups of learners achieved nearly equal scores, but with all other categories of NEI-VFQ-25 learners with RE and/ VI scored significantly lower. The tasks that school-children are involved in is largely dependent on vision, this score means learners with RE and/ VI have difficulty with doing their schoolwork. Kumaran *et al.* (12) further reported that most learners with uncorrected RE admit that their academic performance is always average due to their vision problems

b. Concerning the group of learners with RE and/ VI, the younger age group seemed to experience more difficulties as compared to older age group, this might be due to the fact that older children have a way of developing their own coping strategy (13). Females attained better scores than males and children with hyperopia seems to struggle a lot with their academics that those with myopia.

4.2 Conclusion

The prevalence of RE and VI was high among learners in greater Sekhukhune and this highlights the need for all stakeholders and policy makers to devise a strategy to address these conditions as they also decrease the quality of life on learners. We recommend that there should be regular school visual screening. Provision of spectacles to learners with poor vision should also be prioritized.

4.3 Recommendations into future research

The strength of this study is that it is one of a few studies globally, and only one in Africa that have attempted to investigate the quality of life among school-children in the chosen study site, a population who will carry any current RE and/or VI for many years in their lives. It is recommended though, that the NEI-VFQ-25 be translated and modified for local context for future use at South African schools.

4.4 Limitations of this study

The number of school-children that completed the NEI-VFQ-25 was relatively small, therefore the results of this study should be taken with caution. Only 25% of these children who completed NEI-VFQ-25 had RE and/VI which is relatively small size as compared to 75% of those children without RE and/ VI. The validity of NEI-VFQ-25 in the pediatric population remains unclear because there appears to be no previous evaluation of this on RE and/VI in the pediatric population. Whilst it is quite understandable that a field worker might be needed to read the questions, this might have resulted in biasness.

References

1. Kumah BD, Ebri A, Abdul-Kabir M, Ahmed A-S, Koomson NY, Aikins S, et al. Refractive Error and Visual Impairment in Private School-children in Ghana. *Optom Vis Sci*. 2013 Dec [cited 2019 Mar 31];90(12):1456–61. Available from: <http://content.wkhealth.com/linkback/openurl?sid=WKPTLP:landingpage&an=00006324-201312000-00016>
2. Mehari ZA, Yimer AW. Prevalence of refractive errors among schoolchildren in rural central Ethiopia. *Clin Exp Optom*. 2013 Jan [cited 2018 Jun 19];96(1):65–9. Available from: <http://doi.wiley.com/10.1111/j.1444-0938.2012.00762.x>
3. Ekpenyong BN, Naidoo K, Ahaiwe K, Ezenwankwo O, Ndukwe O, Ogar E, et al. Visual status and prevalence of eye disorders among school-age children in southern Nigeria. *African Vis Eye Heal*. 2017 Jan 30 [cited 2018 Jun 19];76(1):1–6. Available from: <http://www.avehjournal.org/index.php/aveh/article/view/377>
4. Arafa AEE-D, Ewis AAE, Mahran WM, Mohamed AAE, El-Shabrawy EM. Prevalence and risk factors of refractive errors among preparatory school students in Beni-Suef, Egypt. *J Public Health (Bangkok)*. 2018 May 26 [cited 2018 Jun 19];1–5. Available from: <http://link.springer.com/10.1007/s10389-018-0930-8>
5. Baloyi V, Akinsola H, Physical JM-AJ for, 2018 undefined. Pattern of distribution of refractive error among primary school-children in Malamulele community of Limpopo province, South Africa. *journals.co.za*. [cited 2020 Apr 16]; Available from: <https://journals.co.za/content/journal/10520/EJC-132839854a?crawler=true&mimetype=application/pdf>
6. Atowa UC, Ijof SW, 2020 undefined. Associations between near work, outdoor activity, parental myopia and myopia among school-children in Aba, Nigeria. *ncbi.nlm.nih.gov*. [cited 2020 May 6]; Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7013793/>
7. Wajuihian SO, Hansraj R. Refractive Error in a Sample of Black High School-children in South Africa. *Optom Vis Sci*. 2017 Dec [cited 2018 Jun 19];94(12):1145–52. Available from: <http://insights.ovid.com/crossref?an=00006324-201712000-00010>
8. Atowa UC, Munsamy AJ, Wajuihian SO. Prevalence and risk factors for myopia among school-children in Aba, Nigeria. *African Vis Eye Heal*. 2017 Jan 30 [cited 2018 Jun 19];76(1):1–5. Available from: <http://www.avehjournal.org/index.php/aveh/article/view/369>

9. Resnikoff S. Assessment of the prevalence of visual impairment attributable to refractive error or other causes in school-children. PROTOCOL AND MANUAL. World Heal Organ. 2007;
10. Garede Woldeamanuel G, Derese Biru M, Gensa Geta T, Abera Areru B. Visual impairment and associated factors among primary school-children in Gurage Zone, Southern Ethiopia. *Afri Heal Sci.* 2020 [cited 2020 May 6];20(1):533. Available from: <https://www.ajol.info/index.php/ahs/article/view/195170>
11. Chan VF, Singer S, Naidoo KS. Disability-related-distress in primary school learners with vision impairment due to uncorrected refractive error in KwaZulu-Natal Province, South Africa - A qualitative study. *PLoS One.* 2020;15(3).
12. Evangeline Kumaran S, Manni Balasubramaniam S, Senthil Kumar D, Kumar Ramani K. Refractive Error and Vision-Related Quality of Life in South Indian Children. Vol. 92, *Optometry and Vision Science.* 2015 [cited 2020 Feb 23]. Available from: https://journals.lww.com/optvissci/fulltext/2015/03000/Refractive_Error_and_Vision_Related_Quality_of.7.aspx
13. Hopkins S, Narayanasamy S, Vincent SJ, Sampson GP, Wood JM. Do reduced visual acuity and refractive error affect classroom performance? *Clin Exp Optom.* 2020 May 22 [cited 2020 May 5];103(3):278–89. Available from: <https://onlinelibrary.wiley.com/doi/abs/10.1111/cxo.12953>

APPENDICES

Appendix 1- Information document (detailing the overall study)

Appendix 1

Information document (detailing the overall study)

Child Name: _____ School #: ____ Grade #: ____ Class #: ____

Principal Investigator Name: MAGAKWE SELLO

Organization Name: University of Kwa-Zulu Natal

I am Magakwe Sello, a master's student at the University of Kwa-Zulu Natal. My email address is: sellomagakwe80@gmail.com and cell phone number is: 081 098 1603. We are studying the vision status of school-children.

Purpose: In children it is quite common that a number of them may have impaired or low vision and may not be able to see the blackboard clearly in a classroom. Such a child may not be able to perform well in studies because of this impaired vision. Impairment because of myopia, or short sightedness, can easily be corrected by wearing appropriate devices such as glasses. Many children or parents may not know about the presence of such problems. In **Limpopo province** we do not have an idea of how many children may have problems with their vision. After examining a large number of school-children, we will know the extent of the problem. This will help in planning adequate eye service for school-children by government or school authorities. To obtain such important information we invite your child to have his eye examined by an optometrist and his team.

Your child will receive a test that will be able to indicate whether he/she needs a full eye test. If your child participates in the examination, he/she may require the instillation of eye drops (Cyclopentolate 1 %), which may cause temporary light sensitivity and difficulty in reading printed materials for up to one day. The examination may last ten minutes to one hour. This is a routine procedure performed during an eye examination by optometrists in their daily clinical practice.

Benefits: The examination will detect if your child has any vision problems. If your child has poor vision which can be corrected by glasses, he/she will be given a referral letter to optometrist or hospital to get spectacles. If medical/surgical treatment for your child's eyes is necessary, you will be given an explanation and your child will be referred to an appropriate hospital/clinic.

Confidentiality: The examination information will be kept confidential and will not be given to anyone outside the study. Your name and your child's name will never be used in any reports.

Right to refuse or withdraw: Your child's participation is voluntary, and he/she can withdraw from the study after having agreed to participate. Your child is free to refuse any aspect of the examination. If

you have any questions you may ask now or later. If you wish to ask question later, you may contact the following:

BIOMEDICAL RESEARCH ETHICS ADMINISTRATION

Research Office, Westville Campus
Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604769 - Fax: 27 31 2604609
Email: BREC@ukzn.ac.za

Researcher:

Mr Sello Magakwe

Cell no: 0810981603

Email address: sellomagakwe80@gmail.com

Research Supervisors:

Mrs Zamadonda Xulu-Kasaba

Tel: 031-260 7091

Email: XuluKasabaZ@ukzn.ac.za

Prof Rekha Hansraj

Tel: 031-2607089

Email: hansraj@ukzn.ac.za

This study has been approved by UKZN Biomedical research Ethics Committee (BE080/19)

Appendix 2- Certificate of consent

Certificate of consent

My child has been invited to take part in the research on vision impairment of children. I have read the foregoing information, or it has been read to me. I have had opportunity to ask questions about it and any questions that I have asked has been answered to my satisfaction. I consent voluntarily for my child's participation as a subject in this study and understand that my child has right to withdraw from the study at any time without any way affecting his medical care.

Name: _____ Signature: _____

Date: _____

If illiterate:

Name of independent literate witness:

_____ Signature: _____

Date: _____

(If possible, the witness should be selected by the illiterate participant and have no

Connection to the research team)

Name of Researcher: _____ Signature: _____

Date: _____

If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact:

BIOMEDICAL RESEARCH ETHICS ADMINISTRATION

Research Office, Westville Campus

Govan Mbeki Building

Private Bag X 54001

Durban

4000

KwaZulu-Natal, SOUTH AFRICA

Tel: 27 31 2604769 - Fax: 27 31 2604609

Email: BREAC@ukzn.ac.za

Researcher:

Mr Sello Magakwe

Cell no: 0810981603

Email address: sellomagakwe80@gmail.com

Research Supervisors:

Mrs Zamadonda Xulu-Kasaba

Tel: 031-260 7091

Email: XuluKasabaZ@ukzn.ac.za

Prof Rekha Hansraj

Tel: 031-2607089

Email: hansrajr@ukzn.ac.za

This study has been approved by UKZN Biomedical research Ethics Committee (**BE080/19**)

Appendix 3- Assent form

PARTICIPANT INFORMATION LEAFLET AND ASSENT FORM

TITLE OF THE RESEARCH PROJECT: Prevalence and Distribution of Refractive error, Visual impairment and their impact on quality of life in school going children aged 6-18 years in Sekhukhune district (Limpopo), South Africa.

RESEARCHERS NAME(S): Magakwe Sello

ADDRESS: no 138 Mohlarekoma village, Nebo 1059

CONTACT NUMBER: 081 098 1603

What is RESEARCH?

Research is something we do to find new information about the way things (and people) work. We use research projects or studies to help us find out more about disease or illness. Research also helps us to find better ways of helping or treating children who are sick.

What is this research project all about?

In children it is quite common that a number of them may have poor eyesight and may not be able to see the blackboard clearly in a classroom. In this case, the child may not be able to perform well in school because of their vision is not good. Often, poor vision either due to short sightedness or long-sightedness can easily be corrected by wearing glasses. Many children or parents may not know about such problems. In Limpopo province we do not know how many children poor vision do have, especially if they can be helped with glasses. By doing testing on a large number of school-children, we will get to know the extent of the problem. This will help in planning eye service for school-children. To get this important information we invite you to have your eyes examined by an optometrist and team from the University of KwaZulu-Natal).

Why have I been invited to take part in this research project?

Your one of the children that are randomly chosen from a list, so that your eyes can be examined, and your test results be used as the information or as we call it data. There are other children that have been also chosen to take part in this study. This collected data from all children examined will be used to know understand this problem better and help those children affected.

Who is doing the research?

Sello Magakwe, I am a qualified optometrist working for Spec-Savers in Groblersdal and my interest is working with children that have eyesight problems.

What will happen to me in this study?

Your will receive two or three drops of medication in both your eyes which won't hurt but may just sting a little. Because of these drops you may not be able to read clearly for a few hours and may find the light a little bright. Your teacher will be aware of this, and you will not be punished in any way. There will be ham to your eyes or your body. Then I will be performing some tests to check if you can see well or not.

Can anything bad happen to me?

Besides the unclear near vision and bright lights, nothing bad will happen to you.

Can anything good happen to me?

Yes, you will get to have your eyes tested to check if you can see well. If I find that you are not able to see clearly, your parents will be informed and they will be told how to take you for a full eye test so that you can get some glasses, or anything else that will help you see better.

Will anyone know I am in the study?

Other than your parents, teacher and principal, no one else will know that you took part in this study. Your name will not be used in any report

Who can I talk to about the study?

You can talk to Me, School principal or your parents. Your parents can also contact the University if they want to know anything more about this study.

What if I do not want to do this?

Your participation is voluntary which means you can refuse to take part in the study, even if your parents say that you should. Also, if you do take part in the study, but feel you want to stop being in the study, you are free to do so at any time without getting in trouble.

Do you understand this research study and are you willing to take part in it?

YES NO

Has the researcher answered all your questions?

YES NO

Do you understand that you can pull out of the study at any time?

YES NO

Signature of Child

Date

Thank you for your time, and all the best with school.

Appendix 4- Ethical clearance



**UNIVERSITY OF
KWAZULU-NATAL**
INYUVESI
YAKWAZULU-NATALI

13 March 2019

Mr TSS Magakwe
School of Health Sciences
College of Health Sciences
Sellomagakwe80@gmail.com

Protocol: Prevalence and distribution of refractive error, Visual impairment and their impact on quality of life in school children aged 6-18 years in Sekhukhune district (Limpopo), South Africa
Degree: MOptom
BREC Ref No: BE080/19

EXPEDITED APPLICATION: APPROVAL LETTER

A sub-committee of the Biomedical Research Ethics Committee has considered and noted your application received on 06 February 2019.

The study was provisionally approved pending appropriate responses to queries raised. Your response received on 05 March 2019 to BREC letter dated 27 February 2019 have been noted by a sub-committee of the Biomedical Research Ethics Committee. The conditions have now been met and the study is given full ethics approval and may begin as from 13 March 2019. Please ensure that site permissions are obtained and forwarded to BREC for approval before commencing research at a site.

This approval is valid for one year from 13 March 2019. To ensure uninterrupted approval of this study beyond the approval expiry date, an application for recertification must be submitted to BREC on the appropriate BREC form 2-3 months before the expiry date.

Any amendments to this study, unless urgently required to ensure safety of participants, must be approved by BREC prior to implementation.

Your acceptance of this approval denotes your compliance with South African National Research Ethics Guidelines (2015), South African National Good Clinical Practice Guidelines (2006) (if applicable) and with UKZN BREC ethics requirements as contained in the UKZN BREC Terms of Reference and Standard Operating Procedures, all available at <http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx>.

BREC is registered with the South African National Health Research Ethics Council (REC-290408-009). BREC has US Office for Human Research Protections (OHRP) Federal-wide Assurance (FWA 678).

The sub-committee's decision will be noted by a full Committee at its next meeting taking place on 09 April 2019.

We wish you well with this study. We would appreciate receiving copies of all publications arising out of this study.

Yours sincerely



Prof V Rambiritch
Chair: Biomedical Research Ethics Committee

cc: Postgrad administrator: khumalor@ukzn.ac.za
Supervisor: XuluKasabaZ@ukzn.ac.za hansraj@ukzn.ac.za

Biomedical Research Ethics Committee
Professor V Rambiritch (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 2486 Facsimile: +27 (0) 31 260 4609 Email: brec@ukzn.ac.za
Website: <http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx>


1918 - 2018
100 YEARS OF ACADEMIC EXCELLENCE

Founding Campuses: ■ Edgewood ■ Howard College ■ Medical School ■ Pietermaritzburg ■ Westville

Appendix 5- Approval letter from Limpopo Department of Education



LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF EDUCATION

Ref: 2/2/2

Enq: MC Makola PhD Tel No: 015 290 9448

E-mail: MakolaMC@edu.limpopo.gov.za

Magakwe S
P O Box 283
Nebo
1059

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

1. The above bears reference.
2. The Department wishes to inform you that your request to conduct research has been approved. Topic of the research proposal: **"PREVALENCE OF REFRACTIVE ERRORS, VISUAL IMPAIRMENT AND THEIR EFFECTS ON THE QUALITY OF LIFE AMONG SCHOOL GOING CHILDREN IN SEKHUKHUNE DISTRICT, LIMPOPO PROVINCE"**.
3. The following conditions should be considered:
 - 3.1 The research should not have any financial implications for Limpopo Department of Education.
 - 3.2 Arrangements should be made with the Circuit Office and the schools concerned.
 - 3.3 The conduct of research should not anyhow disrupt the academic programs at the schools.
 - 3.4 The research should not be conducted during the time of Examinations especially the fourth term.
 - 3.5 During the study, applicable research ethics should be adhered to; in particular the principle of voluntary participation (the people involved should be respected).

REQUEST FOR PERMISSION TO CONDUCT RESEARCH: MAGAKWE S

CONFIDENTIAL


Cnr. 113 Biccard & 24 Excelsior Street, POLOKWANE, 0700, Private Bag X9489, POLOKWANE, 0700
Tel: 015 290 7600, Fax: 015 297 6920/4220/4494

The heartland of southern Africa - development is about people!

Appendix 6- Approval letters from the principals of the selected schools

MAMAKGATLAPE PRIMARY SCHOOL

EMIS NO: 924643216
ENQ. : Masemola MR
CELL NO: 0721931050



PO BOX 614
MARBLE-HALL
0450

Mr Sello Magakwe
Groblersdal

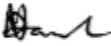
Dear Sir.

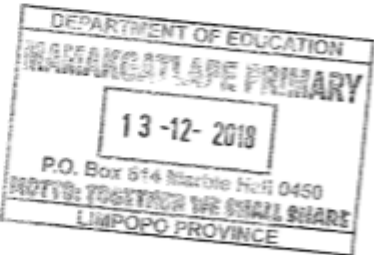
REQUEST (RESEARCH ON PREVALENCE OF REFRACTIVE ERROR & VISUAL IMPAIRMENT)

The above matter refers:

Your request is almost approved by the above mentioned school management for the year 2019 pertaining to visual impairment to our learners.

Thanking you in anticipation

Yours in education
Masemola M.R (Principal).




DEPARTMENT OF EDUCATION
MAMAKGATLAPE PRIMARY
13-12-2018
P.O. Box 614 Marble Hall 0450
MOTTO: TOGETHER WE SHALL SHINE
LIMPOPO PROVINCE

MAGALE SEC SCHOOL
P.O Box 485
NEBO
1059
13/12/2018

TO WHOM IT MAY CONCERN

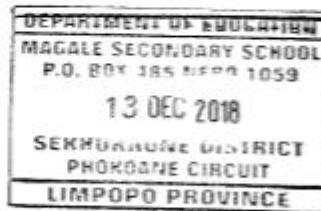
REF: PERMISSION TO CONDUCT A RESEARCH

1. The above matter refers.
2. Please be informed that permission to conduct a research at the above named school is hereby granted to Magakwe Sello. It is based on the subjects mentioned in his letter of request.
3. We hope you will find the above information in order.

Yours Faithfully


Principal

13-12-2018
Date





MORITI SECONDARY SCHOOL

STAND NO: 320, PHOKOANE, NEBO, 1059
P O BOX 829, PHOKOANE, NEBO, 1059
079 - 9710163
@ moritisecschool@gmail.com

MORITI SECONDARY SCHOOL
P O BOX 829
NEBO
1059
2018 DECEMBER 13

TO WHOM IT May CONCERN:

THIS IS TO CONFIRM THAT THE ABOVE SCHOOL RECEIVED A LETTER FROM **SELLO MAGAKWE** A MASTERS STUDENT FROM THE UNIVERSITY OF KWAZULU NATAL WHO WANTS TO CONDUCT A RESEARCH AT OUR INSTITUTION AMONG OUR LEARNERS ABOUT **"THE PREVALENCE OF REFRACTIVE ERRORS, VISUAL IMPAIRMENT AND THEIR IMPACT ON THE QUALITY OF LIFE AMONG SCHOOL GOING CHILDREN."**

HOPING YOU WILL FIND THIS IN ORDER.

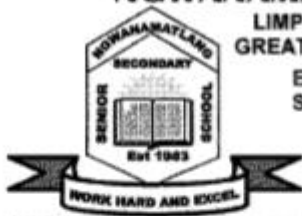
Yours Faithfully


MASHIFANE FRP[Principal]

13-12-2018
FRP - 0670006764

NGWANAMATLANG SECONDARY SCHOOL

LIMPOPO PROVINCE – DEPARTMENT OF EDUCATION
GREATER SEKHUKHUNE DISTRICT – MMASHADI CIRCUIT



Enquiries: Moraila S.T
School Contact: 0716911071
Cell: 0825657879
Fax2Email: 0865665100
E-mail Address: ngwanamatlang@webmail.co.za
Box 354
JANE FURSE
1085
EMIS NUMBER: 924661528

Mr Magakwe Sello
Cell: 081 098 1603
Sellomagakwe80@gmail.com
P.O Box 283
NEBO
1059

Dear Sir

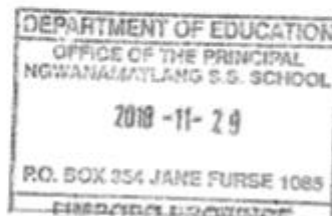
PERMISSION TO CONDUCT WORKSHOP

1. This letter serves as a response to your letter requesting permission to conduct research at our school on "Prevalence of Refractive error, Visual impairment and their impact on the quality of life of school children aged 6-18 years in greater Sekhukhune district, Limpopo, South Africa."
2. It is my pleasure to inform you that we have decided to give you permission to conduct your research at our school.
3. Thank you.

Yours truly,

S.T Moraila

PRINCIPAL



MAPOGO PRIMARY SCHOOL

Eq: Kujane FM
Cell no: 076 100 5091



Mapogo Primary School
Box 37
Glen Cowie 1061
19 November 2018

Magakwe S
P O Box 283
Nebo
1059

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

1. The above matter bears reference.
2. The school, Mapogo Primary wishes to inform you that your request to conduct research has been granted. Topic of the research proposal *"Prevalence of refractive errors, visual impairment and their effects on the quality of life among school going children in Sekhukhune District Limpopo Province"*.
3. The school appreciates the contribution that you wish to make and wishes you success in your investigation.

MAPOGO PRIMARY SCHOOL
P.O. BOX 37 GLEN COWIE 1061

Best wishes 2018 -11- 19

EMIG: 02 404 1272

PRINCIPAL: 

Kujane F.M (Principal)



EMIS NUMBER: 925661030 Enq: Principal Maepa LJ. Tel: 078 096 2888 Cell: 071 299 8565 Email: staloejohn@gmail.com	PO BOX 938 SEKHUKHUNE 1124 PHASE 4 SCHOONOORD VILLAGE SCHOONOORD CIRCUIT SEKHUKHUNE EAST, LIMPOPO PROVINCE
---	---

MR MAGAKWE SELLO

19/11/2019

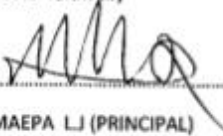
PERMISSION TO CONDUCT RESEARCH ON THE PREVALENCE OF REFRACTIVE ERROR

Sir

Kindly be informed that permission to conduct research on the prevalence of refractive error is granted. Your research will commence in January 2019.

I hope you will find the above to be in order.

Yours faithfully


.....
MAEPA LJ (PRINCIPAL)

DEPARTMENT OF EDUCATION NOKOMEETSE PRIMARY SCHOOL THE PRINCIPAL 19 NOV 2018 SIGNED:  PO BOX 938 SEKHUKHUNE 1124 LIMPOPO PROVINCE
--

Dlamini Primary School

Dlamini village
Emkhondweni
Sekhukhune
1124

P.O box 1128
Sekhukhune 1124
Limpopo province
Republic of south Africa




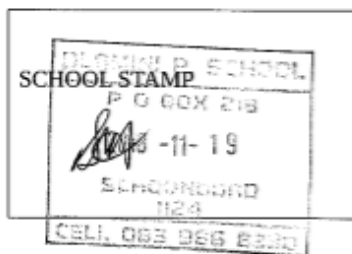
December 2018

DEAR: Sir/Madam

PERMISSION TO CONDUCT RESEARCH

We the above mentioned school confirms that we gave permission to **MAGAKWE SELLO** a masters student at the university of KwaZulu-Natal to conduct a research at our school

Principal signature (Nkosi NL) 



Maila 1 Primary School

Enq : Mampuru P.M
Emis : 925610445
Cell : 079-207 4225 0768995781
:083 207 3987
Email: maila1primary@webmail.co.za



P O Box 5100
JANE FURSE
1085

Limpoop Province, Sekhukhune District, Lepellela Circuit, g.Mails

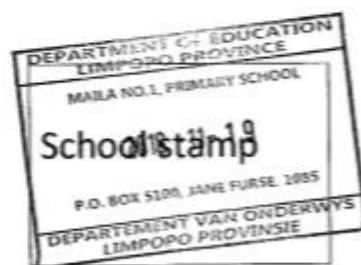
Dear Sir/Madam

To whom it may concern

This is to certify and confirm that our school Maila 1 Primary School allows or gives permission to Magakwe Sello from University of Kwa-Zulu Natal to conduct a research on the prevalence of refractive error, visual impairment and their impact on the quality of life of school children age 6-18 year. The research will commence in January 2019.

Yours

Mampuru P.M (principal)



Appendix 7- National Eye Institute Visual Functioning Questionnaire – 25

National Eye Institute
Visual Functioning Questionnaire - 25
(VFQ-25)
version 2000

(INTERVIEWER ADMINISTERED FORMAT)

January 2000

RAND hereby grants permission to use the "National Eye Institute Visual Functioning Questionnaire 25 (VFQ-25) July 1996, in accordance with the following conditions which shall be assumed by all to have been agreed to as a consequence of accepting and using this document:

1. Changes to the NEI VFQ-25 - July 1996 may be made without the written permission of RAND. However, all such changes shall be clearly identified as having been made by the recipient.
2. The user of this NEI VFQ-25 - July 1996 accepts full responsibility, and agrees to hold RAND harmless, for the accuracy of any translations of the NEI VFQ-25 Test Version - July 1996 into another language and for any errors, omissions, misinterpretations, or consequences thereof.
3. The user of this NEI VFQ-25 - July 1996 accepts full responsibility, and agrees to hold RAND harmless, for any consequences resulting from the use of the NEI VFQ-25.
4. The user of the NEI VFQ-25 - July 1996 will provide a credit line when printing and distributing this document or in publications of results or analyses based on this instrument acknowledging that it was developed at RAND under the sponsorship of the National Eye Institute.
5. No further written permission is needed for use of this NEI VFQ-25 - July 1996.

7/29/96

© R 1996

Instructions:

I'm going to read you some statements about problems which involve your vision or feelings that you have about your vision condition. After each question I will

read you a list of possible answers. Please choose the response that best describes your situation.

Please answer all the questions as if you were wearing your glasses or contact lenses (if any).

Please take as much time as you need to answer each question. All your answers are confidential. In order for this survey to improve our knowledge about vision problems and how they affect your quality of life, your answers must be as accurate as possible. Remember, if you wear glasses or contact lenses for a particular activity, please answer all of the following questions as though you were wearing them.

Visual Functioning Questionnaire - 25

PART 1 - GENERAL HEALTH AND VISION

1. In general, would you say your overall health is*:
(Circle One)

READ CATEGORIES:

Excellent 1
Very Good..... 2
Good..... 3
Fair..... 4
Poor..... 5

2. At the present time, would you say your eyesight using both eyes
(with glasses or contact lenses, if you wear them) is excellent, good,
fair, poor, or very poor or are you completely blind?
(Circle One)

READ CATEGORIES:

Excellent 1
Good..... 2
Fair..... 3
Poor..... 4
Very Poor 5
Completely Blind..... 6

3. How much of the time do you worry about your eyesight?
(Circle One)

READ CATEGORIES:

None of the time..... 1
A little of the time..... 2
Some of the time..... 3
Most of the time 4
All of the time? 5

4. How much pain or discomfort have you had in and around your eyes
(for example, burning, itching, or aching)? Would you say it is?
(Circle One)

READ CATEGORIES:

- None 1
- Mild..... 2
- Moderate 3
- Severe, or..... 4
- Very severe?..... 5

PART 2 - DIFFICULTY WITH ACTIVITIES

The next questions are about how much difficulty, if any, you have doing certain activities wearing your glasses or contact lenses if you use them for that activity.

5. How much difficulty do you have reading ordinary print in School books? Would you say you have?
(READ CATEGORIES AS NEEDED)

(Circle One)

- No difficulty at all..... 1
- A little difficulty..... 2
- Moderate difficulty..... 3
- Extreme difficulty..... 4
- Stopped doing this because of your eyesight 5
- Stopped doing this for other reasons or not interested in doing this 6

6. How much difficulty do you have doing school work or hobbies that require you to see well up close, such as reading, computer games, reading messages from your cell phone, or playing cell phone games? Would you say:
(READ CATEGORIES AS NEEDED)

(Circle One)

- No difficulty at all..... 1
- A little difficulty..... 2
- Moderate difficulty..... 3
- Extreme difficulty..... 4
- Stopped doing this because of your eyesight 5
- Stopped doing this for other reasons or not interested in doing this 6

7. Because of your eyesight, how much difficulty do you have finding something on a crowded shelf?
(READ CATEGORIES AS NEEDED)

(Circle One)

- No difficulty at all..... 1
- A little difficulty..... 2
- Moderate difficulty..... 3
- Extreme difficulty..... 4
- Stopped doing this because of your eyesight 5
- Stopped doing this for other reasons or not interested in doing this 6

8. How much difficulty do you have reading street signs or the names of stores?

(READ CATEGORIES AS NEEDED)

(Circle One)

- No difficulty at all..... 1
- A little difficulty..... 2
- Moderate difficulty..... 3
- Extreme difficulty..... 4
- Stopped doing this because of your eyesight 5
- Stopped doing this for other reasons or not interested in doing this 6

9. Because of your eyesight, how much difficulty do you have going down steps, stairs, or curbs in dim light or at night?

(READ CATEGORIES AS NEEDED)

(Circle One)

- No difficulty at all..... 1
- A little difficulty..... 2
- Moderate difficulty..... 3
- Extreme difficulty..... 4
- Stopped doing this because of your eyesight 5
- Stopped doing this for other reasons or not interested in doing this 6

10. Because of your eyesight, how much difficulty do you have noticing objects off to the side while you are walking along?

(READ CATEGORIES AS NEEDED)

(Circle One)

- No difficulty at all..... 1
- A little difficulty..... 2
- Moderate difficulty..... 3
- Extreme difficulty..... 4
- Stopped doing this because of your eyesight 5
- Stopped doing this for other reasons or not interested in doing this 6

11. Because of your eyesight, how much difficulty do you have seeing how people react to things you say?
(READ CATEGORIES AS NEEDED)

(Circle One)

- No difficulty at all..... 1
- A little difficulty..... 2
- Moderate difficulty..... 3
- Extreme difficulty..... 4
- Stopped doing this because of your eyesight 5
- Stopped doing this for other reasons or not interested in doing this 6

12. Because of your eyesight, how much difficulty do you have picking out and matching your own clothes?
(READ CATEGORIES AS NEEDED)

(Circle One)

- No difficulty at all..... 1
- A little difficulty..... 2
- Moderate difficulty..... 3
- Extreme difficulty..... 4
- Stopped doing this because of your eyesight 5
- Stopped doing this for other reasons or not interested in doing this 6

13. Because of your eyesight, how much difficulty do you have visiting with people in their homes, at parties, or in restaurants?
(READ CATEGORIES AS NEEDED)

(Circle One)

- No difficulty at all..... 1
- A little difficulty..... 2
- Moderate difficulty..... 3
- Extreme difficulty..... 4
- Stopped doing this because of your eyesight 5
- Stopped doing this for other reasons or not interested in doing this 6

14. Because of your eyesight, how much difficulty do you have going out to see movies, plays, or sports events?
(READ CATEGORIES AS NEEDED)

(Circle One)

- No difficulty at all..... 1
- A little difficulty..... 2
- Moderate difficulty..... 3
- Extreme difficulty..... 4
- Stopped doing this because of your eyesight 5
- Stopped doing this for other reasons or not interested in doing this 6

PART 3: RESPONSES TO VISION PROBLEMS

The next questions are about how things you do may be affected by your vision. For each one, I'd like you to tell me if this is true for you all, most, some, a little, or none of the time.

(Circle One On Each Line)

READ CATEGORIES:	All of the time	most of the time	some of the time	a little of the time	none of the time
	1	2	3	4	5

15. Do you accomplish less than you would like because of your vision? 1 2 3 4 5

16. Are you limited in how long you can work or do other activities because of your vision? 1 2 3 4 5

17. How much does pain or discomfort in or around your eyes, for example, burning, itching, or 1 2 3 4 5

aching, keep you from doing what you'd like to be doing? Would you say:

For each of the following statements, please tell me if it is definitely true, mostly true, mostly false, or definitely false for you or you are not sure.

(Circle One On Each Line)

	Definitely True	Mostly True	Not Sure	Mostly False	Definitely False
18. I stay home most of the time because of my eyesight.....	1	2	3	4	5
19. I feel frustrated a lot of the time because of my eyesight.....	1	2	3	4	5
20. I have much less control over what I do, because of my eyesight.	1	2	3	4	5
21. Because of my eyesight, I have to rely too much on what other people tell me..	1	2	3	4	5
22. I need a lot of help from others because of my eyesight.....	1	2	3	4	5
23. I worry about doing things that will embarrass myself or others, because of my eyesight.....	1	2	3	4	5

That's the end of the interview. Thank you very much for your time and your help.

Appendix 8- Examination Record Card

EXAMINATION RECORD CARD

Examination Station:

School Name: _____

Exam Date: ____/____/____

Section A: Child Identification

Child Name: _____

Child ID: School: ____/____/____ Grade: ____ Class: ____ Child: ____

Age: _____ Sex (1: Male; 2: Female): ____

Section B: Vision Assessment

VA Examiner ID: _____

B1. Child is wearing corrective lenses. _____

0: NO; Go to B3 1: YES

B2. Visual Acuity with corrective lenses:

V/A: OD: /

OS: /

Visual Acuity cannot be determined (reason):

B3. Uncorrected Visual Acuity (UCVA):

UCVA: OD: /

OS: /

Visual Acuity cannot be determined (reason):

Section C: Binocular Motor Function

Examiner ID: _____

C1. Tropia at 0.5-meter fixation: _____

0: None 1: Esotropia 2: Exotropia

3: Vertical 9: Undetermined

If tropia, degrees? _____

1: 1 to 15; 2: 16 to 30; 3: 30+

C2. Tropia at 4-meter fixation: _____

0: None 1: Esotropia 2: Exotropia

3: Vertical 9: Undetermined

If tropia, degrees? _____

1: 1 to 15; 2: 16 to 30; 3: 30+

Section D: External/Anterior Segment Examination

Examiner ID: _____

0: Normal 1: Abnormal 9: Undetermined

D1. Eyelids?

OD: _____ If abnormal: _____

OS: _____ If abnormal: _____

D2. Conjunctiva?

OD: _____ If abnormal: _____

OS: _____ If abnormal: _____

D3. Cornea?

OD: _____ If abnormal: _____

OS: ____ If abnormal: _____

D4. Pupil?

OD: ____ If abnormal: _____

OS: ____ If abnormal: _____

D5. Anterior segment?

OD: ____ If abnormal: _____

OS: ____ If abnormal: _____

Section E: Refraction with cycloplegia

E0. Is Uncorrected VA \geq 20/32 in both eyes? ____

0: NO; continue 1: YES; Go to G

9: Undetermined; continue

E1. Pupil dilated \geq 6mm and light reflex absent?

0: NO; Go to E5 1: YES; continue

2: Light reflex absent, but $<$ 6 mm; continue

8: \geq 6mm, but light reflex present; Go to E5

9: Undetermined; Go to E5

OD: ____ If 0 or 9, comment: _____

OS: ____ If 0 or 9, comment: _____

E3. Autorefraction (staple printout & record results)

Examiner ID: ____

	Sphere	Cyl	Axis
--	--------	-----	------

OD:			
OS:			

Cannot be examined (reason) _____

E5. V/A with Auto Refraction results on a trial frame:

Examiner ID: ____

OD: /

OS: /

Cannot be examined (reason) _____

E6. Is BCVA $\geq 20/32$ in both eyes?

0: NO; continue 1: YES; Go to F

9: Undetermined; continue

E7 Pinhole BCVA (optional)

Pinhole BCVA: OD: /

OS: /

Cannot be examined (reason) _____

Section F: Lens, Vitreous and Fundus

Examiner ID: ____

0: Normal 1: Abnormal 9: Undetermined

F1: Lens?

OD: ____ If abnormal: _____

OS: ____ If abnormal: _____

F2: Vitreous?

OD: ____ If abnormal: _____

OS: ____ If abnormal: _____

F3: Fundus?

OD: ____ If abnormal: _____

OS: ____ If abnormal: _____

Section G: Impairment cause

Examiner ID: ____

0: No impairment (UCVA \geq 20/32)

1: Refractive Error (UCVA \leq 20/40 and
BCVA/Pinhole BCVA \geq 20/32)

2: Amblyopia (only if BCVA & Pinhole \leq 20/40)

3: Corneal opacity/scar

5: Cataract

6: Retinal disorder

7: Other cause

9: Undetermined cause

10: Missing UCVA, or UCVA \leq 20/40

& missing BCVA

OD: _____ If other, specify: _____

OS: _____ If other, specify: _____

Section H: Action taken

0: None indicated

1: Glasses prescribed only

2: On-site medical treatment given

3: Prescribed medical treatment

4: Referred to Eye Centre

5 Other/Multiple actions

_____ If other/multiple actions, specify: _____

Appendix 9- Class (Cluster) Enumeration Form

CLASS (CLUSTER) ENUMERATION

Name of school: ----- School #: -----

Address: ----- Grade #: -----

Principal's Name: ----- Class #: -----

Number of Children: ----- Enumerator ID: ----- Date: ----/----/----

<u>Child #</u>	<u>Child Name</u>	<u>Age</u>	<u>Sex</u>	<u>Parent/Guardian Name</u>
<u>Home Address</u>		<u>Cell No #</u>		

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

Scheduled Examination Date: -----/-----/-----

Appendix 10- Ethical certificates



TRREE

Zertifikat Certificat

Certificado Certificate

Promouvoir les plus hauts standards éthiques dans la protection des participants à la recherche biomédicale
Promoting the highest ethical standards in the protection of biomedical research participants



Clinical Trials Centre
The University of Hong Kong

Certificat de formation - Training Certificate

Ce document atteste que - this document certifies that

sello magakwe

a complété avec succès - has successfully completed

South Africa

du programme de formation TRREE en évaluation éthique de la recherche
of the TRREE training programme in research ethics evaluation

Release Date: 2018/12/03
CD : VZ0cRLTy0f



Professeur Dominique Sprumont
Coordonateur TRREE Coordinator



Continuing Education Program (3 Crédits)
Programme de Formation continue (3 Crédits)



Foederatio Pharmaceutica Helvetica
Programmes de formation continue

Ce programme est soutenu par - This program is supported by :
European and Developing Countries Clinical Trials Partnership (EDCTP) (www.edctp.org) - Swiss National Science Foundation (www.snf.ch) - Canadian Institutes of Health Research (<http://www.cihr-irsc.gc.ca/2691.html>) -
Swiss Academy of Medical Science (SAMS/ASMS/SAMW) (www.saww.ch) - Commission for Research Partnerships with Developing Countries (www.fdrp.ch)

[REV : 20170310]



Zertifikat Certificat

Certificado Certificate

Promouvoir les plus hauts standards éthiques dans la protection des participants à la recherche biomédicale
Promoting the highest ethical standards in the protection of biomedical research participants



Certificat de formation - Training Certificate

Ce document atteste que - this document certifies that

sello magakwe

a complété avec succès - has successfully completed

Introduction to Research Ethics

du programme de formation TRREE en évaluation éthique de la recherche
of the TRREE training programme in research ethics evaluation

January 29, 2018
CID: FjMYN6F8z

Professeur Dominique Sprumont
Coordinateur TRREE Coordinator



Ce programme est soutenu par - This program is supported by :

European and Developing Countries Clinical Trials Partnership (EDCTP) (www.edctp.org) - Swiss National Science Foundation (www.snf.ch) - Canadian Institutes of Health Research (<http://www.cihr-irac.gc.ca/2891.html>) - Swiss Academy of Medical Sciences (SAMS/SSM/SA MW) (www.ssmw.ch) - Commission for Research Partnerships with Developing Countries (www.kfpc.ch)

[REV : 20170310]



Zertifikat Certificat

Certificado Certificate

Promouvoir les plus hauts standards éthiques dans la protection des participants à la recherche biomédicale
Promoting the highest ethical standards in the protection of biomedical research participants



Certificat de formation - Training Certificate

Ce document atteste que - this document certifies that

sello magakwe

a complété avec succès - has successfully completed

Public Health Research Ethics

du programme de formation TRREE en évaluation éthique de la recherche
of the TRREE training programme in research ethics evaluation

May 31, 2018
CID: YFwUg8N

Professeur Dominique Sprumont
Coordinateur TRREE Coordinator



Ce programme est soutenu par - This program is supported by :

European and Developing Countries Clinical Trials Partnership (EDCTP) (www.edctp.org) - Swiss National Science Foundation (www.snf.ch) - Canadian Institutes of Health Research (<http://www.cihr-irac.gc.ca/2891.html>) - Swiss Academy of Medical Science (SAMS/ASSM/SAMW) (www.sams.ch) - Commission for Research Partnerships with Developing Countries (www.kfpc.ch)



Zertifikat **Certificado**
Certificat **Certificate**

Promouvoir les plus hauts standards éthiques dans la protection des participants à la recherche biomédicale
 Promoting the highest ethical standards in the protection of biomedical research participants



Certificat de formation - Training Certificate

Ce document atteste que - this document certifies that

sello magakwe

a complété avec succès - has successfully completed

Informed Consent

du programme de formation TRREE en évaluation éthique de la recherche
 of the TRREE training programme in research ethics evaluation

February 21, 2018
 CID-F0PB3VAL3

Professeur Dominique Sprumont
 Coordinateur TRREE Coordinator



Ce programme est soutenu par - This program is supported by :

European and Developing Countries Clinical Trials Partnership (EDCTP) (www.edctp.org) - Swiss National Science Foundation (www.snf.ch) - Canadian Institutes of Health Research (<http://www.cihr-ircc.gc.ca/2891.html>) - Swiss Academy of Medical Science (SAMS/ASMS/SAMW) (www.samw.ch) - Commission for Research Partnerships with Developing Countries (www.kjpc.ch)

[REV : 2010010]



Zertifikat Certificat

Certificado Certificate

Promouvoir les plus hauts standards éthiques dans la protection des participants à la recherche biomédicale
Promoting the highest ethical standards in the protection of biomedical research participants



Certificat de formation - Training Certificate

Ce document atteste que - this document certifies that

sello magakwe

a complété avec succès - has successfully completed

Research Ethics Evaluation

du programme de formation TRREE en évaluation éthique de la recherche
of the TRREE training programme in research ethics evaluation

February 20, 2018
CID - JUKep2mf

Professeur Dominique Sprumont
Coordinateur TRREE Coordinator



Continuing Education Program
Programmes de formation continue

Ce programme est soutenu par - This program is supported by :

European and Developing Countries Clinical Trials Partnership (EDCTP) (www.edctp.org) - Swiss National Science Foundation (www.snf.ch) - Canadian Institutes of Health Research (<http://www.cihr-irsc.gc.ca/2891.html>) - Swiss Academy of Medical Science (SAMS/ANSM/SAMW) (www.sams.ch) - Commission for Research Partnerships with Developing Countries (www.kfpc.ch)

[REV - 20170310]