Factors Associated with Refractive Error Among Primary School Going Children in Molepolole, Botswana

.

ABSTRACT

|  |
| --- |
| **Aims:** To identify factors associated with refractive errors as well as assess the prevalence and pattern of refractive errors among primary school children in Molepolole, Botswana.**Study design:** Cross-sectional study.**Place and Duration of Study:** Lewis memorial Primary school, from June 2023 to end of June 2023.**Methodology:** A total of 173 Lewis Primary school children, in Molepolole aged 9 to 15 years of both genders were selected using stratified randomised sampling. School children were interviewed to collect demographics data using a special data collection tool, After the collection of basic information and relevant history, visual acuity was measured using the Snellen chart in a well light room. Each eye was examined separately with the Snellen’s chart placed 6 m from the study participant. The pupils having a visual acuity of <6/6 in either eye was examined again by putting the pinhole in front of each eye for any improvement on the Snellen chart. The improvement of visual acuity by pinhole represents the presence of refractive errors. The pupils having a visual acuity of <6/6 in either eye will undergo the objective and subjective refraction using an auto refractometer, retinoscopy. **Results:** Of the 173 participants included in this study, 15 (8.7%) participants had uncorrected refractive errors, of which one third had hyperopia (5, 33.3%) and one third had hyperopic astigmatism (5, 33.3%), while one Quarter had myopic astigmatism (3, 20.0%). Watching television for more than two hours (AOR 8.59; 95% CI: [2.33 31.61], p = 0.001) and reading for more than two hours (AOR 5.64; 95% CI: [1.45 21.94], p = 0.013) were associated with an increased risk of uncorrected refractive errors. **Conclusion:** Not all children have their refractive error corrected, highlighting the need for timely intervention and access to vision correction services to improve overall visual health. The promotion of healthy visual habits, such as taking regular breaks from screen time and practicing proper reading posture, should also be emphasised in order to prevent and manage refractive errors. |

*Keywords:*  *refractive error, school children, hyperopia, screen time*

1. INTRODUCTION

Refractive error is the failure of the eye to focus light from an object onto the retina to form a clear image. Therefore, causing a blurry vision, this is very detrimental especially for children because 80% of their learning is visual. Globally, uncorrected refractive errors account for 88.4 million cases of visual impairment. Half of these are children aged between five and fifteen years in low to middle income countries with no access to corrective spectacles (Shakeel and Mittal, 2016)**1**.

In Sub-Saharan Africa the prevalence of visual impairment amongst children differs from country to country. In 2003, Naidoo et al.**2**, in a study conducted in South Africa found the prevalence to be at 2.15%, however a more recent study from the same country highlighted a prevalence of 12.3%, (Hansraj *et al*., 2020)**3**. Many children with refractive errors have no access to refractive error correction services and it is unfortunate that there are communities whose burden of refractive errors remains unknown.

Factors associated with refractive error have been noted to be multifactorial in their characteristics depending on gender, race, geographic location and socioeconomic status. Early identification of these factors can help with prevention, diagnosis and timely interventions, because children in school going age group fall within the preventable age group for correction of refractive error (Usha *et al*., 2018)**4**

Visual impairment and blindness due to uncorrected refractive errors (URE) in children can impede learning, personality development, and future career opportunities, as well as impose a financial burden on society (Yared *et al.*, 2012)**5**. This burden, however, varies depending on the type of refractive error, socioeconomic status, and environment.

Interventions aimed at managing refractive errors early in children may also reduce cases of amblyopia and subsequent disability. It is thus imperative that factors associated with refractive errors in school-aged children are explored (Ahmed, Alrasheed and Alghamdi, 2020)**6**

Therefore, this study assessed the factors associated with refractive error, amongst pupils in a rural school of Molepolole, a village in Botswana, so that an effective approach can be planned to tackle the burden of correctable refraction problem, in school going children. The paucity of information regarding factors as well as patterns of refractive error, is what has motivated this study, to guide the efficient organization of refractive and eye care services in Botswana.

Several studies have demonstrated that uncorrected refractive errors contribute to visual impairment and ocular morbidity, and thus steadily becoming a huge public health issue. Therefore, knowledge about factors associated with URE is pertinent in evaluating, monitoring, and planning eye health services, in a country that has very limited eye health professionals like Botswana. The information generated from this study may help in identifying modifiable risk factors, leading to prevention, early diagnosis and timely interventions as well as advocating for school eye health screening programmes.

2. material and methods

**Study site**

Lewis Primary School, Molepolole, Botswana

**Study population**

All those primary school going children (learners) aged between nine and fifteen years, at Lewis Primary School, who fits the inclusion criteria.

**Study design**

This study was a cross-sectional study, designed to establish the factors associated with refractive errors as well as prevalence and patterns of such among primary school going children at Lewis Primary School.

**Sample size and sampling method**

A total of **173** pupils participated in the study.

Stratified randomised sampling was employed to get an equal number of representations from each age group. The strata were done according to age, and randomisation was done by selecting every fifth pupil

**Eligibility Criteria**

***inclusion Criteria***

1. Children aged between nine and fifteen years.
2. All those present on the day of conducting the study.
3. All those with signed consent

***exclusion Criteria***

1. Visual impairment secondary to trauma
2. Unclear ocular media
3. No improvement with pinhole exam

**Data Collection**

Data was collected using a pre-tested, interviewer-administered structured questionnaire. Themes reflecting the variables outlined in the table of variable were explored. These were derived from the general and specific objectives. Information collected included age, gender, grade, history of refractive error diagnosis, parental history of refractive error and awareness of refractive error if diagnosis was made on examination. The interviews were conducted in English and Setswana since all participants were pupils. The participants were led through a series of questions.

Participants were then examined for visual acuity using the Snellen’s ‘E’ chart at 6 meters in well-lit room. Depending on the V/A if 6/6 or better they were discontinued from further examination. However, if the V/A is less than 6/12, they were subjected to pin hole examination. If they did not improve on pinhole examination, they were referred to Scottish Livingstone Hospital for further ocular examination by an ophthalmologist. However, if there is improvement on pinhole examination, they were then subjected to objective refraction using both a retinoscope and an auto refractor. The refraction was further fine-tuned by subjective refraction. This was performed by both the principal researcher and a qualified as well as experienced optometrist. The average of three readings for each eye were recorded. The readings were taken by the researcher and an experienced optometrist. Supervisors provided quality checks on the process.

Spherical equivalent was calculated by the addition of half of cylinder powers to the spheres. Ametropia was diagnosed if spherical equivalent is ±0.50D or greater or a sphere/cylinder of ± 0.50 DS or greater. The ametropia was then classified according to type and severity.

Participants found to have refractive error were recommended to get corrective spectacles.

**Data Analysis**

All statistical analyses were performed using the software STATA version 17 and both descriptive and inferential statistics were used to analyse the data. The median and interquartile range were computed for continuous variables because the data did not follow a normal distribution, while frequencies and percentages were calculated for all categorical variables. The univariate (unadjusted) and multivariable (adjusted) logistic regression analysis was performed to determine factors associated with refractive errors reporting for odds ratios (ORs) and 95 % confidence interval (95 % CI). A p-value <0.05 was considered statistically significant. To create the final model, backward elimination logistic regression was used retaining all explanatory variables with a p-value <0.20. The significance level for variable selection was set high so that important variables that can influence the outcome are not missed, and so that less important variables with practical and clinical implications are not deleted (Chowdhury and Turin, 2020)**7**. In model selection, the Bayesian information criterion (BIC) and Akaike's information criterion (AIC) were used, with the model with the lowest value being preferred. The Hosmer–Lemeshow test was used to evaluate the goodness of fit of the final models.

3. results and discussion

**Demographic Characteristics**

The study involved 173 school children (learners) in total, with a median age of 11 (IQR 10-12) years. The majority of participants were male 91, (52.6%).

 Most participants 159, (91.9%) participated in outdoor activities, and most participated in outdoor or indoor activities for over an hour 168, (97.1%). Of the participants, 140 (80.9%) watched television, of which the majority watched less than two hours 105, (75%). Electricity was the most common type of lighting used by study participants 158, (91.3%). Additionally, most participants spent less than two hours reading 150, (86.7%) and ate two meals a day 99, (57.2%). Most participants spent time on computers or mobile phones (88, 50.9%) and most of them spent less than two hours on computers or mobile phones 72, (81.8%)

**Prevalence of Uncorrected Refractive Errors**

Figure 1 below shows the presence of uncorrected refractive errors and of the 173 participants included in this study, 15 (8.7%) participants had uncorrected refractive errors.

**Figure 1: Prevalence of Refractive Errors among primary school children in Molepolole village, Botswana.**

**Patterns of refractive error**

Of the 15 participants who had uncorrected refractive error, a third had hyperopia 5, (33.3%) and a third had hyperopic astigmatism 5, (33.3%), while a quarter had myopic astigmatism 3, (20.0%) (Table 1).

**Table 1: Patterns of refractive errors among primary school children in Molepolole village, Botswana.**

|  |  |  |
| --- | --- | --- |
| Pattern of Refractive Errors | Frequency | Percent |
| Astigmatism  | 1 | 6.7% |
| Hyperopia | 5 | 33.3% |
| Hyperopic Astigmatism | 5 | 33.3% |
| Myopia | 1 | 6.7% |
| Myopic Astigmatism | 3 | 20.0% |
| Grand Total | 15 | 100.0% |

**Factors associated** **with refractive errors**

Additionally, univariate and multivariable logistic regression analysis was performed to identify significant factors associated with refractive errors. The results of the univariate analysis in Table 2. below shows that spending time on outdoor activities, spending more than two hours watching television, and spending more than two hours reading were associated with refractive errors (*P* < 0.05). After adjusting for the influence of other variables, watching television for more than two hours was associated with an increased risk of developing refractive errors (AOR 8.59; 95% CI: [2.33 31.61], *P* = 0.001). In addition, reading for more than two hours was associated with an increased risk of developing refractive errors (AOR 5.64; 95% CI: [1.45 21.94], *P* = 0.013).

**Table 2: Multivariable logistic regression of factors associated with refractive errors**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Associated factors** | **Crude OR (95% Cl)** | ***P* value** | **Adjusted OR (95% Cl)** | ***P* value** |
| **Age** | 1.15 (0.82 – 1.62) | 0.412 |   |   |
| **Sex** |  |  |   |   |
| Female | Ref |  |   |   |
| Male | 0.57 (0.20 - 1.68) | 0.311 |   |   |
| **Parenteral use of spectacles** |  |  |   |   |
| No  | Ref |  |   |   |
| Yes | 1.05 (0.34 - 3.23) | 0.934 |   |   |
| **Parent using spectacles** |  |  |  |  |
| Fathers | Ref |  |  |  |
| Mother | 1.9 (0.18 – 19.63) | 0.590 |  |  |
| Both parents | 6.33 (0.31 – 130.75) | 0.232 |  |  |
| **Outdoor/indoor activity** |  |  |   |   |
| Indoor | Ref |  |   |   |
| Outdoor | 0.19 (0.50 - 0.69) | **0.012** | 0.23 (0.48 - 1.06) | 0.059 |
| **Watching TV** |  |  |   |   |
| No | Ref |  |   |   |
| Yes | 3.56 (0.45 - 28.05) | 0.229 |  |  |
| **Hours spent on watching TV** |  |  |   |   |
| <2hours | Ref |  |   |   |
| >2hours | 10.1 (2.95 - 34.88) | **<0.001** | 8.59 (2.33 - 31.61) | **0.001** |
| **Type of lighting** |  |  |   |   |
| Candles | Ref |  |   |   |
| Electricity | 0.19 (0.02 - 2.28) | 0.192 |   |   |
| **Spend time on computer/ mobile phone** |  |  |   |   |
| No | Ref |  |   |   |
| Yes | 2.89 (0.88 - 9.47) | 0.079 |   |   |
| **Hours spent on computer/mobile phone** |  |  |   |   |
| <2hours | Ref |  |   |   |
| >2hours | 1.85 (0.43 - 7.91) | 0.409 |   |   |
| **Reading Time** |   |  |   |   |
| <2hours | Ref |  |   |   |
| >2hours | 5.53 (1.75 - 17.45) | **0.004** | 5.64 (1.45 - 21.94) | **0.013** |

The study found that 8.7% of school children had uncorrected refractive errors, which was a significant problem that could adversely affect their academic performance. Evidence suggest that school-based vision screening and the provision of spectacles can be effective in reducing uncorrected refractive errors in children, leading to improved school performance in the long term (Opare *et al.*, 2020)**8**.

The study findings are supported by another study from Nigeria, where uncorrected refractive error rates were 9.7% (Olatunji *et al.*, 2019)**9**. Contrary to these results, a Ghanaian study reported a much lower prevalence of uncorrected refractive error of 1.8% (Asare and Morjaria, 2021)**10**, and so did Muma et al**11**, in Zambia, Kafue District demonstrated a prevalence of 3.3% in 2020 than that reported in this study.

The possible explanation for this difference is unknown, but it can be speculated that it may be due to methodological and locational differences.

In addition, the study found that the most common type of uncorrected refractive errors were hyperopia (33.3%) and hyperopia astigmatism (33.3%), A study in Iraq found that astigmatism and hyperopia were the most common types of refractive error, supporting the findings of this study (Fayyadh and Abady, 2020)**12**. Similarly, a study in Saudi Arabia found that hyperopia was the most common refractive error, followed by myopic astigmatism and then myopia (Al Bahhawi *et al.*, 2018)**13**. In contrast to the findings of this study, the Kafue study found that myopia was the most common type of refractive error at 66.9%, followed by hyperopia and myopic astigmatism at 12.7% and 20.4% respectively (Muma *et al.*, 2020)**11**. This is an important finding, because Botswana, can anticipate a burden of early onset presbyopia in the future, from the same population if the commonest type of refractive error, being hyperopia remains uncorrected.

Watching more than two hours of TV was associated with an eight times higher risk of developing refractive errors than watching less than two hours of TV. This finding highlights the potential negative impact of excessive TV viewing on eye health, leading to refractive errors. To prevent and manage these conditions, it’s crucial to promote a balanced lifestyle, including limited TV time, outdoor activities, and regular eye check-ups. Raising awareness about the harm of excessive TV viewing and emphasizing the importance of maintaining a healthy lifestyle is essential for optimal eye health. In support of this study's findings, a study from Egypt found that spending more hours a day watching television is associated with refractive errors (Arafa *et al.*, 2019)**14**. A meta- analysis by Zong *et al*., (2024)**15** also confirms that children's and adolescents' exposure to screens was substantially linked to myopia. Interestingly, computer screen time exposure might have the biggest effect on myopia.

Furthermore, reading for more than two hours was associated with an increased risk of developing refractive errors. This findings supports findings from previous studies that suggest that spending time reading is associated with RE (Paudel *et al.*, 2014; Enthoven *et al.*, 2020)**16,17**. This could be attributed to the continuous strain on the eyes caused by prolonged reading.

The 20-20-20 rule, which suggests looking away from the screen every 20 minutes and focusing on an object 20 feet away for 20 seconds, can help reduce refractive errors (Talens-Estarelles *et al*., 2023)**18**. Proper lighting and sitting at an appropriate distance from the reading material also contribute to eye health. By prioritizing eye health and implementing these practices, individuals can significantly reduce the chances of experiencing issues related to prolonged reading.

4. Conclusion

Significant uncorrected refractive error is a common problem in the school going children as evidenced by the prevalence established by this study.

The commonest type of uncorrected refractive error was found to be hyperopia and hyperopic astigmatism.

This study determined that factors associated with uncorrected refractive error, included watching television for more than two hours as well as reading for more than two hours, however factors like gender, age, family history of refractive error and level of education of either parent were not statistically significant.

**Recommendations**

1. There is a need for health professionals to implement vision screening programmes at the community level and integrate them into school health programs to early detect and correct uncorrected refractive errors in children.
2. Dissemination of the results of this study to policymakers and managers at various levels so to address issues of lack of human resource related to refractive errors as well as provision of training opportunities. There is need for collaboration between the Ministry of health and eye care development partners to provide subsidized spectacles
3. Awareness of healthy viewing habits needs to be promoted, such as taking regular breaks from screens and practicing correct reading postures, to prevent and manage refractive errors.
4. Further studies with larger sample sizes and stronger study designs are needed to determine factors are associated with URE.

**LIMITATION OF THE STUDY**

Most covariates were either not included in the model or were not significant due to the small proportion of the result, which reduced the power of the study. Therefore, further studies with larger sample sizes and stronger study designs are needed to determine whether specific factors are associated with URE. Additionally, due to its cross-sectional design, this study could not establish causal relationships. Future researchers should consider employing more objective measures or conducting longitudinal studies to mitigate these limitations.

**Ethical Approval and consent:**

Ethical Research Approval from University of Zambia Biomedical Research Ethics Committee (UNZABREC) and Ministry of Health and Wellness (MoHW) Ethics Committee in Botswana as well as from Ministry of Education and Skills Development (MoESD) were obtained to conduct the study. The study also adhered to the tenets of the Helsinki declaration. The identity of participants was confidential and the study tool were only made available to the principal investigator and statistician for analysis. Consent was obtained from the school headteacher. Informed consent was first obtained from the parents/guardians, then an assent from the children, before enrolling participants.

**DISCLAIMER (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

References

1. Shakeel, T. and Mittal, S.K. (2016) ‘Pattern of refractive errors in primary school children in Dehradun city of Uttrakhand State’, *The Official Scientific Journal of Delhi Ophthalmological Society,* 27(2), pp. 106–110.
2. Naidoo, K.S., Raghunandan, A., Mashige, K.P., Govender, P., Holden, B.A., Pokharel, et al., 2003. Refractive error and visual impairment in African children in South Africa. *Investigative ophthalmology & visual science*, 44(9), pp.3764-3770.
3. Hansraj, R., Xulu-Kasaba, Z.N. and Magakwe, T.S. (2020) ‘Visual impairment and refractive error amongst school-going children aged 6–18 years in Sekhukhune District (Limpopo, South Africa)’, *African Vision and Eye Health,* 79(1), pp. 1–8.
4. Usha, S., Karavadi, V.S. and Damayanthi, M. (2018) ‘Factors Associated with Refractive Errors among School Children in Rural Field Practice Area of a Tertiary Care Hospital, Bangalore’, *National Journal of Community Medicine*, 9(11), pp. 824–829.
5. Yared, A.W., Belaynew, W.T., Destaye, S., Ayanaw, T. and Zelalem, E., 2012. Prevalence of refractive errors among school children in Gondar town, northwest Ethiopia. *Middle East African Journal of Ophthalmology*, 19(4), p.372.
6. Ahmed, Z.A., Alrasheed, S.H. and Alghamdi, W. (2020) ‘Prevalence of refractive error and visual impairment among school-age children of Hargesia, Somaliland, Somalia’, *Eastern Mediterranean Health Journal*, 26(11), pp. 1362–1370.
7. Opare, A., Abdullahi, L.H., Minnies, D., Cook, C., Shung-King, M. and Mwangi, G. (2020) “School vision screening programmes in reducing uncorrected refractive error among children in Low and Middle-Income countries-LMIC (systematic review),” *Advances in ophthalmology & visual system*, 10(4), pp. 91–105.
8. Olatunji, L.K., Abdulsalam, L.B., Lukman, A., Abduljaleel, A. and Yusuf, I. (2019) “Academic Implications of Uncorrected Refractive Error: A Study of Sokoto Metropolitan Schoolchildren,” *Nigerian medical journal: journal of the Nigeria Medical Association,* 60(6), pp. 295–299.
9. Asare, F.A. and Morjaria, P., 2021. Prevalence and distribution of uncorrected refractive error among school children in the Bongo District of Ghana. *Cogent Medicine,* 8(1), p.1911414.
10. Muma, K. I. M., Nyaywa, M., Mwelwa, G., Buglass, A., & Mboni, C. (2020). Prevalence of Eye Diseases among Learners in Kafue District, Zambia. Medical Journal of Zambia, 47(1), 1–7.
11. Fayyadh, R.A. and Abady, N.H. (2020) “Prevalence of Uncorrected Refractive Errors Among the Internally Displaced Schoolchildren in Iraq,” *Medico-Legal Update*
12. Al Bahhawi, T., Makeen, A.M., Daghreeri, H.H., Tobaigy, M.F., Adawi, A.M., Guhal, F.M., et al. (2018) “Refractive Error among Male Primary School Students in Jazan, Saudi Arabia: Prevalence and Associated Factors,” *The open ophthalmology journal,* 12, pp. 264–272.
13. Arafa, A.E.E.-D., Ewis, A.A.E., Mahran, W.M., Mohamed, A.A.E. and El-Shabrawy, E.M. (2019) “Prevalence and risk factors of refractive errors among preparatory school students in Beni-Suef, Egypt,” *Journal of public health*, 27(1), pp. 43–47.
14. Zong Z, Zhang Y, Qiao J, Tian Y, Xu S. The association between screen time exposure and myopia in children and adolescents: a meta-analysis*. BMC Public Health. 2024 Jun 18;24(1):1625*. doi: 10.1186/s12889-024-19113-5. PMID: 38890613; PMCID: PMC11186094.
15. Paudel, P., Ramson, P., Naduvilath, T., Wilson, D., Phuong, H.T., Ho, S.M., et al. (2014) “Prevalence of vision impairment and refractive error in school children in Ba Ria - Vung Tau province, Vietnam,” *Clinical & experimental ophthalmology,* 42(3), pp. 217–226.
16. Enthoven, C.A., Tideman, J.W.L., Polling, J.R., Yang-Huang, J., Raat, H. and Klaver, C.C.W. (2020) “The impact of computer use on myopia development in childhood: The Generation R study,” *Preventive medicine*, 132, p. 105988.
17. Talens-Estarelles C, Cerviño A, García-Lázaro S, Fogelton A, Sheppard A, Wolffsohn JS. (2023) The effects of breaks on digital eye strain, dry eye and binocular vision: Testing the 20-20-20 rule. *Cont Lens Anterior Eye*. 2023 Apr;46(2):101744.