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Severe Visual Impairment in Schools (A PEEK Study)

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Abstract

Childhood visual impairment is a major public health concern. The global financial burden of childhood-onset blindness is greater than that of adult-onset blindness due to the longer span of living. The importance of good vision for education and socialisation from an early age has prompted the adoption of vision screening in schools by many national eye care programmes in Zimbabwe. Therefore, the aim and purpose of this study were to determine the prevalence of visual impairment and the pattern of eye conditions affecting school children screened during the course of the "Portable Eye Examination Kit (PEEK) project." The study was a retrospective review that utilized data that was collated and analysed from the PEEK project dashboard from June 2019 to December 2020 by well-trained eye health care providers. The sample size was 4591 school-going children aged between 5 to 20 years of age recruited from the Harare and Bulawayo schools. Results showed that 58% did not have any eye problems while 24% had a red watery and itchy eye, 10% had a red eye, 2% had lid and globe issues and 2% had strabismus. The visual acuity results showed that the majority of participants, 2/3, had a good vision as they recorded a Snellen acuity test score of 6/9 or better. In addition, 1/5 had mild visual impairment, and about 2% of the participants were legally blind. 15% of the participants recruited in this study had moderate to severe visual impairment.

Keywords

Visual Acuity, Visual Impairment, PEEK, Childhood Blindness

1. Introduction

The early detection and management of childhood eye problems are important if

we are to reduce the burden of childhood blindness. Children rarely complain that they cannot see well because they think that their vision is normal. Only a few children would have had a complete ophthalmic evaluation by the time they start school. As a consequence, if some eye conditions are not identified and managed during the critical period of a child's visual development, they can permanently affect the child's vision.

It is estimated that approximately 19 million children the world over are visually impaired, with up to 75% of these children living in low-income countries [1]. Childhood visual impairment is a major public health concern and the global financial cost of blindness with an onset during childhood is much greater than the cost of adult-onset blindness because of the long span of living. The World Health Organization (WHO) through "The Right to Sight" global initiative prioritised childhood blindness as one of the five conditions for control by 2020 [2]. Recognition of the importance of good vision for education and socialisation from an early age has prompted the adoption of vision screening in schools by many national eye care programmes. This intervention has been shown to be an efficient and cost-effective method of early identification of undetected refractive errors and other eye conditions.

This study was conducted to determine the prevalence of visual impairment and the pattern of eye conditions affecting school children screened during the course of the PEEK project.

2. Study Justification

The study was deemed significant in the broader context of the National Eye Health Strategy, in which the country seeks to reduce avoidable blindness by 80% through the implementation of evidence-based eye health interventions. This study will add to the body of knowledge on the burden of childhood blindness in the country. The findings from this study will contribute to the development and design of appropriate and tailor-made eye health interventions and inform future paediatric eye health programming.

3. Objectives

The following were the specific objectives of the study:

- To determine prevalence of visual impairment among school-going children.
- To identify the patterns of the eye conditions of children who were screened under PEEK.

4. Research Methodology

Study Design and Setting

This was a retrospective study which analysed all data on the PEEK project dashboard (which is a school eye screening programme for children in Zimbabwe) from the period June 2019 to December 2020. Currently, the PEEK school-based screening programme is only being conducted in Harare and Bulawayo Prov-

inces and these were purposively sampled for this reason. Electronic data from the PEEK project was collated and analysed by well-trained eye health care providers from the University of Zimbabwe and ophthalmic specialists provided technical backstopping.

Background on the PEEK Project in Zimbabwe

In Zimbabwe, the PEEK-powered programme was launched in 2019. The programme is coordinated by CBM Zimbabwe, and implemented by the ZCfB while technical support comes from relevant line ministries which include the Ministry of Health and Child Care (MoHCC) and the Ministry of Primary and Secondary Education (MoPSE). This innovative programme uses the PEEK Capture application which incorporates a clinically-validated vision examination application within a wider data capture system. The application assists non-specialist users to undertake screening for eye conditions at community level after which referrals can be made for further examination or management. For those clients who would have been screened and referred for follow-up appointments, follow-up automated and personalised SMS reminders are sent out so as to enhance attendances for appointment visits. Data generated on the systems is reported in real-time on the PEEK Administration platform which allows programme managers and implementers to track how services are being utilized, which clients are being reached with regards to treatment and management.

The transmission of real time data also allows implementers and managers of the programme to timeously respond to any gaps in order to continuously enhance services offered. There has been scientific evidence to indicate that PEEK tools improve both eye screening coverage and adherence to referral services [3] [4].

Study Population

The study population consisted of 4591 school-going children aged between 5 to 20 years of age recruited from the schools where screening was undertaken during the PEEK project. The school-going children were drawn from a total of 17 schools from Harare and 32 schools from Bulawayo.

5. Results

Demographic data in **Table 1** showed that there were 1846 (40.2%) male participants and 2745 (59.8%) female participants. The majority of participants, 2 677 (58.3%) were from Bulawayo whilst the minority, 1914 (41.7%) were from Harare. The participants' median age was 13 years. Most of the participants in this study, 42.4%, were in the 6 - 12 age group, followed by 41.3% in the 13 - 16 age group, and the remaining 13% belonged to the 17 - 20 age group. The findings differed from those of Kalikivayi *et al.* who had a slightly younger sample (median age 9.3 years) and a female preponderance in their study [5].

5.1. Eye Conditions for the PEEK Data

The study sought to determine the pattern of eye conditions affecting school-going children. This pattern is depicted in **Figure 1** shown below.

Table 1. Demographic data of respondents from PEEK data.

Characteristic	Number of participants, n (%)
Gender	
Male	1846 (40.2)
Female	2745 (59.8)
Age (years), median (IQR)	13 (9 - 15)
Site	
Harare	1914 (41.7)
Bulawayo	2677 (58.3)
Age group	
5	151 (3.3)
6 - 12	1948 (42.4)
13 - 16	1896 (41.3)
17 - 20	596 (13)

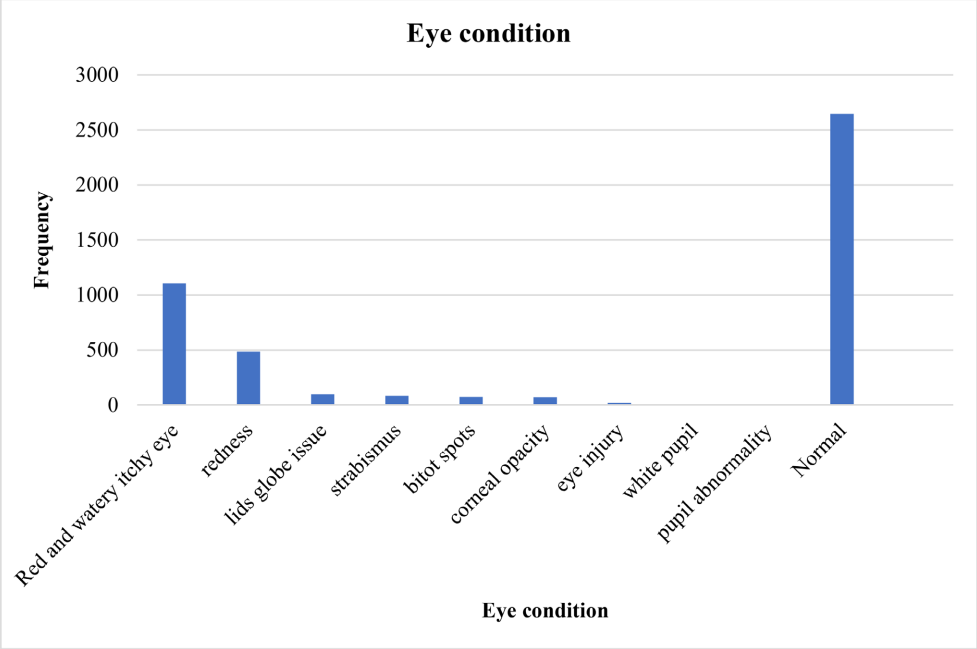

Figure 1. Distribution of eye conditions observed during the PEEK study.

From the data above, it can be shown that most of the participants in this study, 2646 (57.63%), did not have any eye problems while 1105 (24.07%) had a red watery and itchy eye, 484 (10.54%) had a red eye, 98 (2.13%) had lid and globe issues and 84 (1.83%) had strabismus. Other eye conditions prevalent in this study included bitot spots 73 (1.59%), corneal opacity 72 (1.57%), eye injury 19 (0.41%), white pupil 6 (0.13%) and pupil abnormality 4 (0.09%). These results are in sync with research findings by Galloway *et al.* (2016) [6] who noted that

most children had conditions such as redness of the eyes, red and watery itchy eyes, strabismus, bitot spots amongst other conditions.

Table 2 below shows results from an explorative analysis of each triage eye condition per site. The "normal" triage eye condition variable falls between the lower limit (1.68) and upper limit (1.72) of the 95% confidence interval, giving a sample mean difference of (1.70).

The "red and itchy eye triage" condition is between (1.38) lower bound and (1.44) upper bound of the 95% CI, with a mean difference of (1.41) while "redness" triage condition falls between (1.39) lower bound and (1.49) upper bound of the 95% CI, giving a mean difference of (1.44).

As statistically computed on Table 2 below, prevalence of each triage eye condition varies across the sample as analysed.

Table 2. Statistical analysis on prevalence of eye conditions.

	Triage Eye Condition			Statistic	Std. Error
site	Normal	Mean		1.70	0.009
		95% Confidence Interval for Mean	Lower Bound	1.68	
			Upper Bound	1.72	
		5% Trimmed Mean		1.72	
		Median		2.00	
		Variance		0.209	
		Std. Deviation		0.457	
	Red and watery itchy eye	Mean		1.41	0.015
		95% Confidence Interval for Mean	Lower Bound	1.38	
			Upper Bound	1.44	
		5% Trimmed Mean		1.40	
		Median		1.00	
		Variance		0.241	
		Std. Deviation		0.491	
	Redness	Mean		1.44	0.026
		95% Confidence Interval for Mean	Lower Bound	1.39	
			Upper Bound	1.49	
		5% Trimmed Mean		1.44	
		Median		1.00	
		Variance		0.247	
		Std. Deviation		0.497	
	Lids globe issue	Mean		1.59	0.054
		95% Confidence Interval for Mean	Lower Bound	1.48	
			Upper Bound	1.70	

Continued

	5% Trimmed Mean		1.60	
	Median		2.00	
	Variance		0.245	
	Std. Deviation		0.495	
Eye injury	Mean		1.67	0.211
	95% Confidence Interval for Mean	Lower Bound	1.12	
		Upper Bound	2.21	
	5% Trimmed Mean		1.69	
	Median		2.00	
	Variance		0.267	
	Std. Deviation		0.516	
Strabismus	Mean		1.77	0.045
	95% Confidence Interval for Mean	Lower Bound	1.68	
		Upper Bound	1.86	
	5% Trimmed Mean		1.80	
	Median		2.00	
	Variance		0.179	
	Std. Deviation		0.423	
White pupil	Mean		1.57	0.137
	95% Confidence Interval for Mean	Lower Bound	1.27	
		Upper Bound	1.87	
	5% Trimmed Mean		1.58	
	Median		2.00	
	Variance		0.264	
	Std. Deviation		0.514	
Bitot spots	Mean		1.32	0.069
	95% Confidence Interval for Mean	Lower Bound	1.18	
		Upper Bound	1.46	
	5% Trimmed Mean		1.30	
	Median		1.00	
	Variance		0.222	
	Std. Deviation		0.471	
Corneal opacity	Mean		1.26	0.052
	95% Confidence Interval for Mean	Lower Bound	1.16	
		Upper Bound	1.36	

Continued

	5% Trimmed Mean		1.23	
	Median		1.00	
	Variance		0.195	
	Std. Deviation		0.442	
Pupil abnormality	Mean		1.44	0.176
	95% Confidence Interval for Mean	Lower Bound	1.04	
		Upper Bound	1.85	
	5% Trimmed Mean		1.44	
	Median		1.00	
	Variance		0.278	
	Std. Deviation		0.527	
Other diagnosis	Mean		1.02	0.011
	95% Confidence Interval for Mean	Lower Bound	0.99	
		Upper Bound	1.04	
	5% Trimmed Mean		1.00	
	Median		1.00	
	Variance		0.015	
	Std. Deviation		0.122	

5.2. Triaging and Referral

During the study, screening was done in two stages. The first stage involved school children being triaged by a team which had ophthalmic and non-ophthalmic professionals. The second stage was exclusively made up of ophthalmic professionals, who included refractionists and ophthalmic nurses. The purpose of the second screening was to positively identify, for certainty, school children who came out positive and needed referral to the next level of care. A total of 2781 participants were deemed not to have any eye problems by the triaging team (described as "None" on the descriptive statistics table below). After screening, the number of children that needed referral was 135 while the number of children that was dispensed was 1374 and only 34 were prescribed. From this data we deduce that the sensitivity of the triaging team in making a correct referral was 72%. The triaging data is shown on Table 3 below.

From Tables 1-3, it is important to note that a total of 4324 children were either described as referred, prescribed, dispensed or deemed to have no eye problems (None). The sample had n = 4591 children and thus 267 children had their data computed as missing because there was no data on their screening condition, probably they did not come for screening and no data available to compute.

Table 3. Statistical analysis for triage medication outcome per age group.

Triage Medication Outcome * site * Age Group Crosstabulation					
Count					
Age Group			Site		Total
			Harare	Bulawayo	
0 - 5	Triage Medication Outcome	None	17	62	79
		Dispensed	22	34	56
		Referred	1	2	3
		Prescribed	0	1	1
	Total		40	99	139
6 - 12	Triage Medication Outcome	None	423	721	1144
		Dispensed	354	229	583
		Referred	24	46	70
		Prescribed	17	13	30
	Total		818	1009	1827
13 - 16	Triage Medication Outcome	None	389	775	1164
		Dispensed	363	217	580
		Referred	26	25	51
		Prescribed	2	0	2
	Total		780	1017	1797
17 - 20	Triage Medication Outcome	None	109	285	394
		Dispensed	87	68	155
		Referred	8	3	11
		Prescribed	0	1	1
	Total		204	357	561
Total	Triage Medication Outcome	None	938	1843	2781
		Dispensed	826	548	1374
		Referred	59	76	135
		Prescribed	19	15	34
	Total		1842	2482	4324

5.3. Referrals

In terms of referrals, as depicted in Table 4 below, the majority of the participants, 2781 (60.58%), did not require any referral.

A total of 734 (15.99%) participants were referred to a refractionist. In addition, 592 (12.89%) of the participants were referred for an ophthalmologist assessment whilst 217 (4.73%) had to have an accelerated ophthalmologist review.

Table 5 below shows the distribution of the diagnosis made by the Ophthalmologist at the referral centre, as shown by the PEEK data.

The results reveal that the majority of participants (50.63%) were diagnosed with refractive errors, followed by allergic conjunctivitis (17.72%). Some of the other ophthalmic diagnoses shown in Table 5 below include cataracts, infective conjunctivitis, eye injury, keratoconus, posterior segment disease and strabismus. The findings in this study vary from those of Salman who showed that allergic conjunctivitis was the commonest eye problem amongst school children followed by refractive errors.

5.4. Visual Acuity Results

Visual acuity (VA) is a measure of the ability of the eye to distinguish between two points in space at a given distance. It is important to assess VA in a consistent way in order to detect any changes in vision. One eye is tested at a time.

According to the World Health Organisation (WHO), ranges of visual acuity

Table 4. Referral.

Referral	Freq.	Percentage
Accelerated ophthalmologist review	217	4.73
None	2781	60.58
Not stated	267	5.81
Ophthalmologist review	592	12.89
Refractionist review	734	15.99
Total	4 591	100

Table 5. Diagnosis by ophthalmologist.

Diagnosis by Ophthalmologist	Frequency	Percent
refractive errors	40	50.63
allergic conjunctivitis	14	17.72
other diagnosis	12	15.19
Cataract	2	2.53
infective conjunctivitis	2	2.53
eye injury	1	1.27
Keratoconus	1	1.27
posterior segment disease	1	1.27
Strabismus	1	1.27
Normal	4	5.06
not seen	1	1.27
Total	79	100

loss are categorized into three main groups depending on the Snellen acuity score or the LogMAR value. These are Normal vision, Low vision and Blindness category. For the first group, "Normal Vision" is further split into good vision and mild visual impairment. Similarly, the second category, Low Vision, is also divided into 3 groups which are the moderate visual impairment, severe visual impairment, and profound visual impairment. Table 6 and Table 7 illustrate the distribution of visual acuity amongst the study participants.

From the visual acuity results shown above, it can be noted that the majority of participants, two thirds, had good vision as they recorded a Snellen acuity test score of 6/9 or better. One fifth had mild visual impairment, and about two percent of the participants were legally blind. Fifteen percent of the participants recruited in this study had moderate to severe visual impairment. From these findings, one in three pupils screened during the PEEK screening is visually impaired stressing the point for the need for the expansion of the schools vision screening programmes. Most studies with similar settings found a prevalence of visual impairment ranging between 5% - 12%. The marked discrepancy could be

Table 6. Visual acuity right eye results.

Visual Acuity RE	Snellen acuity right eye	Freq.	Percent	Category of vision loss
0	6/6	1 737	39.0	Good vision 2786 (62.59%)
0.1	6/7.5	655	14.7	
0.17	6/9	394	8.9	
0.3	6/12	455	10.2	Mild visual impairment 943 (21.19%)
0.4	6/15	282	6.3	
0.47	6/18	206	4.6	
0.6	6/24	177	4.0	Moderate visual impairment 516 (11.59%)
0.7	6/30	136	3.1	
0.8	6/38	105	2.4	
0.9	6/48	98	2.2	
1	6/60	53	1.2	Severe visual impairment 101 (2.27%)
1.1	6/75	20	0.5	
1.2	6/95	11	0.3	
1.3	6/120	17	0.4	
1.5	6/190	3	0.1	Blind 105 (2.36%)
1.8	Finger counting	59	1.3	
2.5	Hand movement	24	0.5	
3	Light perception	10	0.2	
4	No light perception	9	0.2	
Total		**4451**	**100**	

Table 7. Visual acuity left eye results.

Visual Acuity LE	Snellen acuity left eye	Frequency	Percent	Category of vision loss
0	6/6	1,681	37.8	Good vision 2768 (62.19%)
0.1	6/7.5	690	15.5	
0.17	6/9	397	8.9	
0.3	6/12	450	10.1	Mild visual impairment 940 (21.12%)
0.4	6/15	280	6.3	
0.47	6/18	210	4.7	
0.6	6/24	193	4.3	Moderate visual impairment 588 (13.2%)
0.7	6/30	157	3.5	
0.8	6/38	96	2.2	
0.9	6/48	95	2.1	
1	6/60	47	1.1	
1.1	6/75	8	0.2	Severe visual impairment 36 (0.81%)
1.2	6/95	11	0.3	
1.3	6/120	17	0.4	
1.5	6/190	1	0.0	Blind 119 (2.67%)
1.8	Counting fingers	63	1.4	
2.5	Hand movement	28	0.6	
3	Light perception	18	0.4	
4	No light perception	9	0.2	
Total		**4451**	**100**	

because participants from schools for the blind and those with low vision were also included in this study.

5.5. Severe Visual Impairment and Blindness

Table 7 above shows that even though both severe visual impairment (0.81%) and blindness (2.67%) constitute a smaller combined percentage of (3.48%) when compared with other variables such as moderate visual impairment, mild visual impairment or good vision, it does show that more resources are needed to screen for these two severe conditions since these results were derived from a smaller sample and in only two study institutions and thus results are difficult to generalise outside the stated study sample characteristics. In addition, (3.48%) is actually a big number when one looks at the severity and effects of the conditions that children experience under this category.

Resources are therefore needed for early screening and diagnosis so that conditions that can be treated are done so whilst it is still early among children and,

before conditions generate to stages where they become severe visual impairment or total blindness.

6. Discussion

Although the global age-adjusted prevalence of blindness and visual impairment has decreased in the last three decades, mostly due to population growth, concerns have been raised on progress of interventions to address the needs which have been slow to address these challenges [5]. School-based eye screening programmes appear to have promising results in public health programming. Apart from alerting school authorities, parents, caregivers and healthcare workers on the visual problems children may be having, such programmes present opportunities for scaling up public health interventions in areas which have low and limited resources using cost effective technology based innovations such as PEEK. With the CBM-PEEK school eye health programmes in place in Zimbabwe, there have been estimations that the number of children screened across Harare and Bulawayo provinces increased four-fold from around 10,000 annually to more than 40,000 in the first year of programmes before the COVID-19 pandemic (*Using Technology for Eye Health Impact in Africa*, 2018). This retrospective review of the PEEK programme data set in Zimbabwe is very important because it unravelled the prevalence of visual problems among school-going children in Harare and Bulawayo provinces.

Results from the review indicated that 42% of the children screened had visual problems, which is a cause for concern to both educationists and public health personnel. Although this proportion was lower in comparison to the 56.8% prevalence of visual impairment within a community sample in Mashonaland Central province [7], it is important to note that the latter study included age ranges from 5 years to 100 years and it is well established that older populations tend to have more visual impairments compared to younger populations. More focus should be put on screening the population at an earlier stage in life for effective interventions to be put in place. Additionally, many studies with similar settings to this study found a prevalence of visual impairment ranging between 5% - 12%, which is markedly lower than that reported in Zimbabwe. The marked discrepancy could be because participants from schools for the blind and those with low vision were also included in this study [5] [8] [9].

Our findings on the common eye problems that were found among the school children in this sample resonated those previously reported in other settings by Galloway and colleagues who found that most children had conditions such as redness of the eyes, red and watery itchy eyes, strabismus, bitot spots amongst other conditions [6]. It is important to note that redness of the eyes is sometimes preventable as it may be caused by allergies, eye fatigue, or common eye infections such conjunctivitis. The findings in this study vary from those of Salman who showed that allergic conjunctivitis was the commonest eye problem amongst school children followed by refractive errors [10]. The discrepancies could however be

due, in part, to the fact that redness of the eye in our review was put as a category on its own without having been linked to a cause such as conjunctivitis.

Although results from this study indicated that both severe visual impairment (0.81%) and blindness (2.67%) constituted a smaller combined percentage of (3.48%) when compared with other variables such as moderate visual impairment, mild visual impairment or good vision, more resources are needed to screen for these two severe conditions as they have major negative effects on the quality of life for the affected children. However, in light of the small sample sizes and the geographical non-representativeness of this study, there is need to conduct more robust studies which would include rural provinces of Zimbabwe and out-of-school children so as to ascertain the true magnitude and extent of visual impairment and blindness.

In terms of referrals, study results revealed that the majority were not referred to any specialist. However, a considerable proportion of these children had a refractionist review, ophthalmologist review and accelerated ophthalmologist review. Out of those reviewed by the ophthalmologist, the majority were diagnosed with refractive errors and thus similar to already existing literature from outside Zimbabwe [10].

7. Conclusions

Results from this study review have shown that screening for eye conditions and visual impairment in schools is important for a number of reasons. Firstly, it gives provision to pathways for referral and further management of cases needing more specialised care. Secondly, this study revealed that 3.48% of the students in Harare and Bulawayo had severe visual impairment, a finding that is worrying to both educationists and healthcare practitioners, therefore, more preventive and screening programmes should be channelled into schools so that children can access eye health services at an early stage when there are still interventions that can be done.

Study results also revealed that the most prevalent eye conditions were red, watery and itchy eyes, followed by redness, lids globe issues, strabismus, and bitot spots with the least prevalent being pupil abnormality. The triage results indicated that the majority of respondents were normal, followed by those with red and watery itchy eyes, redness, other diagnosis, lids globe issues, strabismus, corneal opacity, bitot sports with the least condition being eye injury.

Encouragingly, the visual acuity results for both eyes, as measured by the Snellen Scale as well as the Log Mar score, indicated that the majority of school children in the study had normal vision, followed by those with near normal vision. A considerable proportion was considered to be in the low vision category with the moderate visual impairment sub-category constituting the majority in this low vision category. The minority of study participants however fell in the near-blindness and blindness category.

In terms of referrals, study results reveal that the majority were not referred to

any specialist. However, a considerable number of these children had a refractionist review, ophthalmologist review and accelerated ophthalmologist review. Out of those reviewed by the ophthalmologist, the majority were diagnosed with refractive error. These were followed by those diagnosed with simple atopic allergic conjunctivitis, cataract, infective conjunctivitis, eye injury, keratoconus, posterior segment disease and strabismus.

The study also sought to determine the prevalence of bitot spots in different schools and regions. Despite Harare schools having the least participants, they however registered the highest prevalence rate of bitot spots as compared to schools in Bulawayo that had the majority of school-going children involved in the study.

8. Study Limitations

This study had a number of limitations. Firstly, the review was only confined to schools within Harare and Bulawayo which makes it difficult to generalize the results to the rest of the country. Secondly, the study was descriptive in nature and did not use robust statistical analyses to compute associations between variables as the objective was mainly to describe the patterns. Lastly, record reviews preclude views from the school children and their caregivers on the nature of difficulties they may be facing.

9. Recommendations

1) More research should be done on the appearance of bitot spots in school-going children (since it is a sign of Vitamin A deficiency).

2) Plan for Vitamin A supplementation in schools with a high prevalence of bitot spots.

3) School screening is an effective way of capturing eye conditions at an early age and should be cascaded to other provinces of Zimbabwe.

4) Prevention, health education and early presentation of children to eye screening are essential.

5) The PEEK programme should have linkage to eye health care such as Low Vision services which are available at SKH and Richard Morris.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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