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Title

Spectacle Compliance and its Determinants in a School Vision Screening Pilot in Botswana

Running head

Spectacle Compliance in Botswana School Children

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Abstract

Purpose: The effectiveness of school eye health programmes relies on many factors, including compliance with spectacle wear. The objectives of this study were to determine spectacle compliance in a school vision screening pilot programme in Botswana, and investigate factors predictive of compliance.

Methods: The study was an observational, cross-sectional follow-up of a pilot school screening programme. Unannounced compliance checks were completed after 3-4 months in a convenience sample of 19 schools. Sex, age, school level, visual acuity and refractive error were analysed using logistic regression to investigate factors predictive of compliance.

Findings: Compliance data was recorded for 193/286 (67.5%) children; 62.2% were female and the median age was 15 years (interquartile range 12-17 years). 60.1% of the sample were compliant with spectacle wear. Girls were more likely to be compliant than boys (adjusted odds ratio (aOR)=2.32, 95% confidence interval (CI) 1.03-5.27). Children at primary and junior secondary school were more likely to be complaint than senior secondary school children (aOR=16.96, 95% CI 5.60-51.39; and aOR=3.39, 95% CI 1.39-8.22 respectively). Children with binocular uncorrected visual acuity (UCVA) of 6/7.5 to 6/12 were 2.76 (95% CI1.05-7.23) times more likely to be compliant than children with binocular UCVA of 6/6.

Conclusion: Compliance was higher in Botswana than previous African studies, however, improvement in this area would increase the effectiveness of the programme. Further investigation into barriers to spectacle wear affecting boys and older children is warranted. A prescribing protocol to avoid low prescriptions – especially where binocular UCVA is 6/6 – is desirable.

Introduction

The number of children aged 5-15 years who are blind or visually impaired worldwide due to uncorrected refractive error (uRE) has been estimated at 12.8 million.[1] Data on the prevalence of refractive error (RE) in African children is limited, but reveals it to be lower than in other parts of the world.[2] However, a lack of access to eye care services magnifies the impact of relatively low prevalence as a public health problem.[3] There is evidence that normal or spectacle-corrected vision positively influences perceived quality of life and school performance, which is recognised as a positive predictor for future well-being.[4-6]

School eye health programmes can address the issue of accessibility by bringing refractive services directly to children at low or no cost. The quality of such programmes relies on factors such as the accuracy of screening, availability of human resources, and availability and appearance of spectacles.[7] It also relies on compliance with spectacle wear. If spectacle compliance is low, as has been found in previous studies,[8-20] the impact of such programmes on the prevalence of uRE will be limited.

Along with evidence for screening protocols, evidence for prescribing protocols and appropriate health education interventions is needed to ensure good compliance and, as a consequence, programme effectiveness and sustainability. In low and middle-income settings this is especially important as financial and human resources can be constrained and opportunity cost must be borne in mind.[7] To date only two studies have reported on spectacle compliance in schoolchildren in Africa; a trial in Tanzania found 47% of children given free spectacles were compliant, while 31% of children were compliant in a survey in South Africa.[11, 13]

The objectives of this study were to determine the level of compliance in a school vision screening pilot programme in Botswana and investigate factors predictive of spectacle compliance.

Methods

The study was an observational, cross-sectional follow-up of a pilot school vision screening programme in Botswana. In August 2016, 12,877 students were screened across 49 schools in Goodhope district in the Southern region. Screeners included guidance and counselling teachers, health care assistants and health education assistants. Children who could not see 6/12 in either eye were referred to optometry triage. There were 2,065 referrals and 835 children were prescribed spectacles. There was no prescribing protocol in place for optometrists.

To review spectacle compliance, a convenience sample of 19 schools was selected. A random sample of 300 students, stratified by primary and secondary school level, was drawn from the 485 students who were believed to have received spectacles at these schools in March 2017. The sample size and schools to be included were proposed with consideration for the time and resources available for the study.

The primary outcome – spectacle compliance – was determined by unannounced direct observation of children in classrooms at school visits carried out between 22 June and 13 July 2017. Compliance was divided into four categories:

1. Wearing spectacles in class
2. Not wearing spectacles, but had them at school
3. Spectacles not at school, but at home
4. Spectacles not at school, lost or broken

Children in Categories 1 or 2 were considered compliant and those in Categories 3 or 4 were considered non-compliant.

Data on potential predictors of compliance and non-compliance were collected at interviews in school guidance and counselling offices. Age, sex, level of school, monocular and binocular uncorrected visual acuities (UCVA), and monocular and binocular best-corrected visual acuities (BCVA) were collected using the Open Data Kit (ODK) platform and the Peek Acuity app on a Google Nexus tablet. Spherical equivalent (SE) refractive errors (the sphere plus half the cylinder value) were determined from a record of spectacle prescriptions issued.

The number of lines improvement in VA (recently proposed as a spectacle prescribing protocol[21]) was calculated as the difference between uncorrected and corrected VA for each eye and binocularly and categorised as 0, 1 or 2+ lines improvement. This was only possible for children who had their spectacles at the time of a school visit. Students who had been given spectacles but had left the sample schools by the time of data collection were considered lost to follow up.

Statistical analysis was carried out with STATA 14. Associations between rates of non-participation in the compliance study and categorical baseline variables such as sex and school level were assessed using Fisher's exact test. A Wilcoxon ranksum test was used to assess whether non-participation was associated with the age of the child. Associations between study factors and compliance were investigated using logistic regression. Multivariable logistic regression was used to investigate the independence of putative risk factors.

This study followed the tenets of the Declaration of Helsinki. Ethical approval was granted by the LSHTM MSc Research Ethics Committee and the Health Research and Development Division at the Ministry of Health and Wellness, Botswana. Parental consent was sought via a combined information and opt-out consent form and assent was given by children on the day of school visits prior to any data collection.

Results

Compliance data was recorded for 193 of 286 (67.5%) students. (14 duplicates or 'unknowns' in the sample of 300 were excluded from analysis). Females were among the majority of the sample (62.2%) and the median age was 15 years (interquartile range (IQR) 12-17 years). There were 67 participants from primary school, 64 from junior secondary and 62 from senior secondary school.

The characteristics of children included in the compliance study and lost to follow-up are described in Table 1. The proportion of students lost to follow-up increased with increasing school level (P < 0.001). There was, therefore, a significant difference in the ages of those included and those lost to follow-up (P < 0.0001). There was no significant difference in the proportions of male and female students or the types of refractive error in the two groups.

Table 1 Characteristics of children included in the study and lost to follow-up.

	Full sample		**Included in compliance study**		**Lost to follow-up**		**Test**	**P value**
Characteristic	n	(%)	n	(%)	n	(%)		
Total	286	(100)	193	(67.5)	93	(32.5)		
Sex								
Male	103	(36.0)	73	(37.8)	30	(32.3)	Fisher's exact	0.43
Female	183	(64.0)	120	(62.2)	63	(67.7)		
Age (years)	284[a]	(100)	193	(68.0)	91	(32.0)		
Range	7-23		7-22		7-23			
Median (IQR)	16 (13-17)		15 (12-17)		17 (16-18)		Wilcoxon rank-sum	<0.001
School level								
Senior secondary	114	(39.9)	62	(32.1)	52	(55.9)	Test for trend	<0.001
Junior secondary	88	(30.8)	64	(33.2)	24	(25.8)		
Primary	84	(29.4)	67	(34.7)	17	(18.3)		
Refractive error type (SE) in worse eye	286	(100)	193	(68.2)	93	(31.8)		
Myopia	217	(75.9)	149	(77.2)	68	(73.1)	Fisher's exact	0.74
Emmetropia	25	(8.7)	16	(8.3)	9	(9.7)		
Hyperopia	44	(15.4)	28	(14.5)	16	(17.2)		
Astigmatism								
<0.75D	205	(71.7)	143	(74.1)	62	(66.7)	Fisher's exact	0.21
≥0.75D	81	(28.3)	50	(25.9)	31	(33.3)		

[a] Data missing for 2 children

Visual status of children included in compliance study

The distribution of worse eye refractive error by age in the compliance study is shown in the box plots in Figure 1. The data does not show any trend in changing level of refractive error by age.

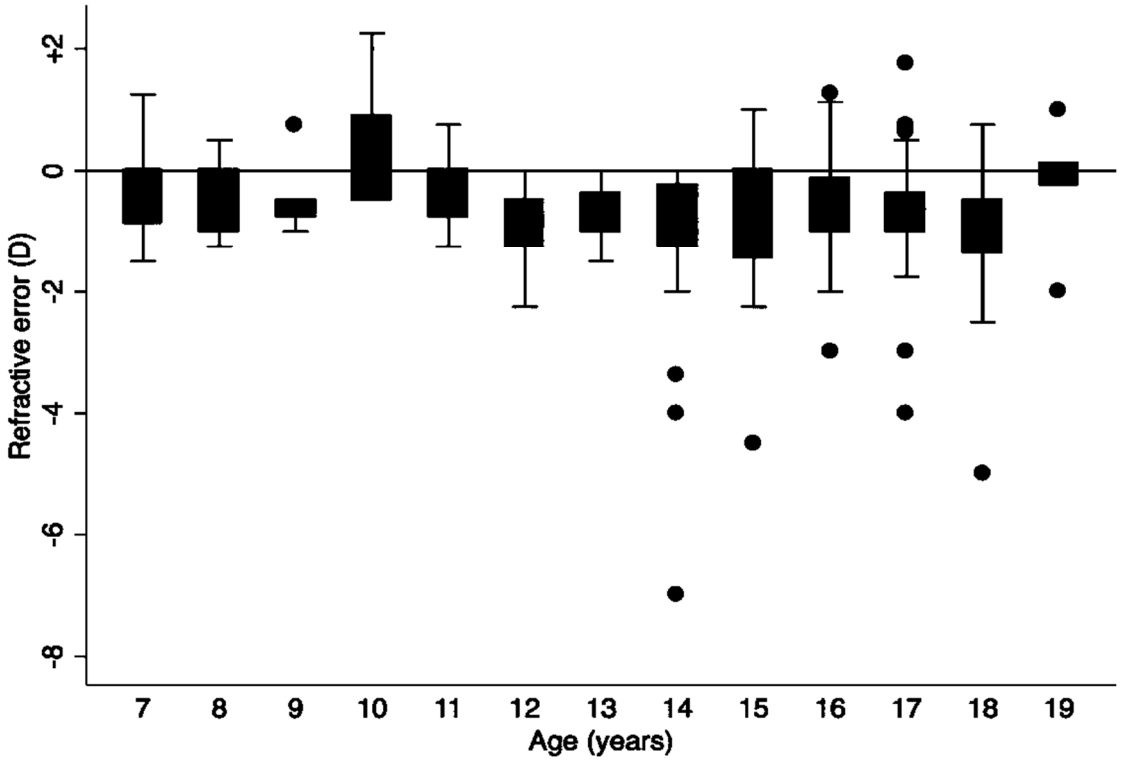

Figure 1 Distribution of worse eye SE refractive error by age in 193 children in the compliance study. Boxes describe the interquartile range for each age with the bar representing the median. One age category with less than 5 observations not shown (22 years).

Uncorrected visual acuities (UCVAs) were recorded for all 193 students in the compliance study. Over half the students (51.3%; 99/193) had a binocular UCVA of 6/6 and 37 (19.2%) had worse than 6/12 binocular UCVA. When measuring UCVA in the worse eye, 18.7% of students (36/193) had a UCVA of 6/6 while 53.4% of students (103/193) had a UCVA of better than or equal to 6/12 (the screening cut-off) in their worse eye (Table 2).

Table 2 Distribution of uncorrected visual acuity (UCVA) in 193 children in the compliance study.

	UCVA worse eye		**UCVA both eyes**	
	n = 193	100.0%	n = 193	100.0%
Visual acuity				
6/6	36	18.7	99	51.3
6/7.5 to 6/12	67	34.7	57	29.5
≤6/15*	90	46.6	37	19.2

* Shaded row indicates UCVA that would fail initial school screening.

Compliance

Overall, 60.1% (116/193) of children were compliant with spectacle wear (Category 1 or 2) at 3-4 months follow-up from spectacle distribution.

Predictors of compliance

Predictors of compliance were investigated with univariable logistic regression (Table 3). Increasing age (as a continuous variable) and increasing school level were both significantly associated with decreased compliance. The odds of compliance were 0.73 (95% CI 0.65 to 0.82) times less per year increase in age. The odds of compliance in junior secondary schools were 2.19 (95% CI 1.07 to 4.49) times greater than senior secondary, while the odds of compliance in primary schools were 13.41 (95% CI 5.43 to 33.09) greater than senior secondary. The odds of compliance were 2.82 (95% CI 1.01 to 7.87) times greater in children with myopia of at least -0.50D SE but less than -1.25D, compared to myopic SE prescriptions less than -0.50D. There was no evidence of any association between odds of compliance and severity of either hyperopia or astigmatism.

Table 3 Univariable logistic regression analysis of potential factors influencing spectacle compliance.

	Number of children	**% Compliance**	**Crude OR (95% CI)**	**P value**
Total	193	60.1		
Sex				
Male	73	52.1	1	
Female	120	65.0	1.71 (0.95 to 3.09)	0.08
Age				
Per year increase			0.73 (0.65 to 0.82)	<0.001
School level				
Senior	62	35.5	1	
Junior	64	54.7	2.19 (1.07 to 4.49)	0.03
Primary	67	88.1	13.41 (5.43 to 33.09)	<0.001
UCVA				
Binocular				
6/6	99	53.5	1	
6/7.5 to 6/12	57	68.4	1.88 (0.95 to 3.73)	0.07
≤6/15	37	64.9	1.60 (0.73 to 3.50)	0.24
Worse eye				
6/6	36	55.6	1	
6/7.5 to 6/12	67	59.7	1.19 (0.52 to 2.69)	0.68
≤6/15	90	62.2	1.32 (0.60 to 2.88)	0.49
Refractive error				
Myopia worse eye	149			
<0 and >-0.50	19	36.8	1	
≤-0.50 and >-1.25	90	62.2	2.82 (1.01 to 7.87)	0.05
≤-1.25 and >-2.00	23	65.2	3.21 (0.91 to 11.41)	0.07
≤-2.00	17	64.7	3.14 (0.80 to 12.28)	0.10

Hyperopia worse eye	28			
<+1.00	20	55.0	1	
≥+1.00	8	50.0	0.82 (0.16 to 4.23)	0.81
Astigmatism worse eye	193			
<0.75	143	62.2	1	
≥0.75	50	54.0	0.71 (0.37 to 1.37)	0.31

Variables that reached statistical significance in univariable analysis, as well as sex and binocular UCVA, were included in a multivariable model (Table 4). Age was not included as it was strongly correlated with school level (r=0.85). In the multivariable model, the odds of compliance in female children were 2.32 (95% CI 1.03 to 5.27) greater than in male children. The odds ratios for junior secondary and primary school compliance levels relative to senior school increased compared to the univariable analysis; adjusted OR=3.39 (95% CI 1.39 to 8.22) and OR=16.96 (95% CI 5.60 to 51.39) respectively. The level of SE myopia in the worse eye was not statistically significant, but children with binocular UCVA of 6/7.5 to 6/12 were 2.76 (95% CI1.05 to 7.23) more likely to be compliant than children with binocular UCVA of 6/6. The study was insufficiently powered to explore further differences between sub-samples by school level.

Table 4 Multivariable logistic regression analysis of potential factors influencing spectacle compliance.

	Number of children	**% Compliance**	**Crude OR (95% CI)**	**P value**	**Adjusted OR (95% CI)**	**P value**
Total	193	60.1				
Sex						
Male	73	52.1	1		1	
Female	120	65.0	1.71 (0.95 to 3.09)	0.08	2.32 (1.03 to 5.27)	0.04
School level						
Senior	62	35.5	1		1	
Junior	64	54.7	2.19 (1.07 to 4.49)	0.03	3.39 (1.39 to 8.22)	0.01
Primary	67	88.1	13.41 (5.43 to 33.09)	<0.001	16.96 (5.60 to 51.39)	<0.001
Refractive error (SE)						
Myopia worse eye	149					
<0 and >-0.50	19	36.8	1		1	
≤-0.50 and >-1.25	90	62.2	2.82 (1.01 to 7.87)	0.05	2.94 (0.90 to 9.59)	0.07
≤-1.25 and >-2.00	23	65.2	3.21 (0.91 to 11.41)	0.07	3.09 (0.72 to 13.23)	0.13
≤-2.00	17	64.7	3.14 (0.80 to 12.28)	0.10	3.29 (0.66 to 16.43)	0.15
Binocular UCVA						
6/6	99	53.5	1		1	

6/7.5 to 6/12	57	68.4	1.88 (0.95 to 3.73)	0.07	2.76 (1.05 to 7.23)	0.04
≤6/15	37	64.9	1.60 (0.73 to 3.50)	0.237	2.29 (0.77 to 6.82)	0.14

Lines improvement in VA as a predictor of spectacle wear amongst compliant children (Categories 1 and 2)

It was not possible to investigate lines improvement in VA as a predictor of compliance versus non-compliance, as the corrected VA could not be determined in children who did not have their spectacles in school. It was, however, investigated as a predictor of spectacle wear (Category 1) versus carrying (Category 2) amongst the 116 compliant children. This was assessed with univariable logistic regression. (Table 5) The sample size was insufficient for stable outputs in a multivariable model.

Table 5 Univariable logistic regression analysis of potential factors influencing spectacle wear amongst compliant children (Categories 1 and 2 only).

	Number of children	**% Wearing spectacles**	**Crude OR (95%CI)**	**P value**
Total	116	63.8		
Sex				
Male	38	52.6	1	
Female	78	69.2	2.03 (0.91 to 4.50)	0.08
Age (n=116)				
Per year increase			0.87 (0.77 to 0.996)	0.04
School level (n=116)				
Senior	22	45.5	1	
Junior	35	40.0	0.8 (0.27 to 2.35)	0.69
Primary	59	84.7	6.67 (2.22 to 20.01)	0.001
Lines improvement in binocular VA (n=111)*				
0	51	49.0	1	
1	21	71.4	2.6 (0.87 to 7.77)	0.09
≥2	39	79.5	4.03 (1.56 to 10.44)	0.004
Greater monocular lines improvement VA (RE or LE) (n=115)Δ				
0	29	55.2	1	
1	19	57.9	1.11 (0.35 to 3.59)	0.85
≥2	67	68.7	1.78 (0.73 to 4.36)	0.21
Binocular UCVA				
6/6	53	52.8	1	
6/7.5 to 6/12	39	66.7	1.79 (0.76 to 4.21)	0.19
≤6/15	24	83.3	4.46 (1.34 to 14.8)	0.02

*5/116 students whose BCVA was recorded as 1 line worse than their UVCA were excluded from the analysis.
Δ1/116 student whose BCVA was recorded as 1 line worse than their UVCA in the eye with greater improvement was excluded from the analysis

Amongst compliant children, the odds of wearing spectacles compared to carrying them (Category 1 vs Category 2) were 4.03 (1.56 to 10.44) times greater in those with 2 or more

lines improvement in binocular VA compared to those with 0 lines improvement. Comparing 2 or more lines improvement with a reference category of 1 line improvement, the odds of wearing spectacles were 1.25 (0.67 to 2.30) greater in children with 2 or more lines improvement in VA but the finding was not statistically significant. In this instance, the sample size was reduced to 60 (Table 6). The greater monocular VA improvement in each child was not found to be predictive of spectacle wear. Of the other variables investigated amongst compliant children, the odds of spectacle wear decreased with increasing age, OR=0.87 (95% CI 0.77 to 0.996). For school levels, the odds of spectacle wear were significantly greater in primary schools compared with senior secondary school (OR=6.67 (95% CI 2.22 to 20.01)) while there was no statistically significant difference between junior and senior secondary schools. The odds of wearing spectacles were 4.46 (1.34 to 14.8) times greater in children with binocular UCVA equal to or worse than 6/15 compared to those with binocular UCVA of 6/6. (Table 5).

Table 6 Output of univariable logistic regression analysis using three different reference categories for the lines improvement in binocular VA variable.

	Number of children	**% Wearing spectacles**	**Crude OR (95%CI)**	**P value**
Lines improvement in binocular VA				
0	51	49.0	1	
1	21	71.4	2.6 (0.87 to 7.77)	0.09
≥2	39	79.5	4.03 (1.56 to 10.44)	0.004
<2	77	55.8	1	
≥2	39	79.5	3.06 (1.24 to 7.52)	0.02
1	21	71.4	1	
≥2	39	79.5	1.25 (0.67 to 2.30)	0.48

Discussion

This study was designed to investigate spectacle wear compliance and its determinants in a pilot school vision screening programme in Botswana. Only two previous studies describing spectacle compliance in an African setting have been published. The overall compliance of 60% in this study was higher than the two previously published studies of compliance in Sub Saharan Africa.[11, 13]

In our study there was a marked difference in compliance between primary school level and the two levels of secondary school. Compliance decreased from 88% in primary schools, to 55% in junior secondary schools, to 36% in senior secondary school. School levels were included in multivariable analysis as they were considered to reflect child development and compliance behavior more accurately than age as a linear change. The adjusted odds of compliance were 3.4 times greater in junior secondary and 17.0 times greater in primary schools than in senior secondary school. While the majority of studies have not found age to be a predictor of compliance,[8, 11, 13, 15, 20, 22-26] the finding that compliance decreased with increasing school level was in keeping with studies in Mexico, Chile and the USA.[12, 27, 28] There appeared to be more teacher engagement and influence in the primary schools visited during data collection, however, it is not possible to comment on whether the age of the children or their school environment was responsible for the differences in compliance.

Girls were significantly more likely to be compliant than boys, with an adjusted odds ratio of 2.3. This outcome has been reported in previous spectacle compliance studies[8-10, 13, 20, 24, 26] and, while others have found sex not to be a significant predictor of compliance,[11, 12, 15, 18, 22, 23, 25, 27, 29] none have found boys to be more compliant than girls.

There is little evidence for health education interventions and spectacle compliance. Health education materials to improve compliance were used in two cluster randomised controlled trials in China,[16, 24] however, these trials did not provide evidence for an effective intervention. In Botswana, research into local barriers to spectacle wear – especially amongst boys and senior secondary school children – ought to be undertaken in an effort to develop effective, targeted eye health education and improve overall compliance in this setting.

Factors associated with the refractive status of children were also investigated. In multivariable analysis, the odds of compliance were 2.8 times greater in children with binocular UCVA of 6/7.5 to 6/12 than those with binocular UCVA of 6/6. Compliance was

also higher in children with binocular UCVA of ≤6/15 compared to those with 6/6, however the odds ratio was not statistically significant for this category. A trend for improved compliance with worsening uncorrected VA has been reported in the literature,[8-10, 18, 24, 25, 30] with only two studies finding no predictive value to poorer vision.[23, 28] Children with worse eye SE myopia of less than -0.50D (i.e. not meeting a common definition of myopia in children[31]) were less compliant than those with higher degrees of myopia, however, the odds ratios for compliance was not statistically significant in multivariable analysis. A South African study evaluating the effect of prescribing protocols on compliance did not find any dioptric cut-offs predictive of wearing or carrying spectacles.[13] Binocular UCVA – as a measure of visual function – may be a more useful predictor of compliance than SE refractive error. On a practical level, VA is the basis of any screening protocol and the same values are used in analysis as in clinical settings. The use of spherical equivalent prescriptions in protocol research may not fully explain the effect of sphero-cylindrical prescriptions and may not easily translate to practical prescribing recommendations. In light of this, further research to develop a UCVA-based prescribing protocol should be undertaken as the school screening programme becomes established in Botswana.

Two or more lines improvement in VA in one or both eyes has recently been proposed as a prescribing protocol,[21] however, there is currently no evidence available to support its adoption. It could not be investigated as a predictor of compliance in this study, but amongst children who had spectacles with them at school (Categories 1 and 2), those with 2 or more lines binocular improvement were significantly more likely to be wearing their spectacles in class than children with less than 2 lines improvement. The majority of children with less than 2 lines improvement were found to have 0 lines improvement in binocular VA so those with 2 or more lines were also compared to the group with 1 line improvement; compliance was still higher but the odds ratio was not statistically significant. This study was not powered to detect such a difference, however, the data does suggest that further research into lines improvement in VA – along with UCVA – is warranted.

While investigating outcomes related to the screening process was not an objective of this study, screening accuracy and prescribing at triage determined the refractive characteristics of the children followed up and, therefore, affected compliance. In the pilot programme, screening protocol dictated that children who could not see 6/12 in either eye were referred to optometry triage. However, only 47% of children in the study had a worse eye UCVA of ≤6/15 (i.e. correctly failed screening) while 19% had a worse eye UCVA of 6/6 (i.e. both eyes saw 6/6). In settings with low RE prevalence, the lower positive predictive value of screening will result in more false positives – ongoing monitoring and training for screeners should be

in place to mitigate against this, but optometrists also need to manage such referrals appropriately. That 51% of children prescribed spectacles had a binocular UCVA of 6/6 was likely the result of the screening cut-off being applied to either eye (not both) as well as prescribing to false positives in the absence of any protocol.

The relatively small 19-school convenience sample was used due to limited time and resources; it may not be representative of other schools in Botswana or even the remaining schools in the pilot programme, so care should be taken when generalising the findings. The follow-up rate of 67.5% (193/286) was lower than expected. Delays in the procurement and distribution of spectacles meant that the pilot programme ran across two school years and older children in particular had left the sample schools before follow-up was undertaken. The proportion of children found to be compliant may be subject to bias from this loss to follow-up and the convenience sampling method used. Students lost to follow-up were significantly older and more likely to attend senior secondary where compliance was significantly lower, therefore, the study may overestimate true overall compliance. Class visits were not carried out at the senior secondary school. While the distinction between compliant and non-compliant students was unaffected, the distinction between compliance categories 1 and 2 was made at the guidance and counselling office and may not represent classroom behaviour – compliant senior secondary school students may wear their spectacles more than was recorded.

Conclusion

While overall spectacle compliance was higher in Botswana than previous African studies, improvement in this area would increase the effectiveness of the programme. Male sex and secondary school-age were demographic factors significantly associated with lower compliance. Further studies to confirm this finding and investigate the barriers to spectacle wear affecting these groups is warranted. Any such barriers may need to be taken into consideration when planning future health education interventions.
A protocol for optometrists to manage false positive referrals, as well as avoid low prescriptions – especially where binocular UCVA is 6/6 – should be in place in order to improve compliance and programme effectiveness. Such a prescribing protocol may not be generalisable to all settings. A higher resource setting may choose to prescribe to children with lower refractive error and better UCVA, even if there is evidence that compliance is lower in these groups; however, the development and implementation of a prescribing protocol is likely to be of interest to programmes in other low and middle income countries.

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