Two strategies for correcting refractive errors in school students in Tanzania: randomised comparison, with implications for screening programmes

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ABSTRACT

Purpose: To compare whether free spectacles or only a prescription for spectacles influences wearing rates among Tanzanian students with un/undercorrected refractive error (RE).

Methods:

Design: Cluster randomised trial.

Setting: 37 secondary schools in Dar es Salaam, Tanzania.

Participants: Distance visual acuity was measured in 6,904 year-1 students (90.2% response rate; median age 14 years; range 11–25 years) using a Snellen E-chart. 135 had RE requiring correction.

Interventions: Schools were randomly allocated to free spectacles (arm A) or prescription only (arm B).

Primary outcome: Spectacle use at 3 months.

Results: The prevalence of un/undercorrected RE was 1.8% (95% CI: 1.5 to 2.2%). At 3 months, 27/58 (47%) students in arm A were wearing spectacles or had them at school compared with 13/50 (26%) in arm B (adjusted OR 2.4, 95% CI 1.0 to 6.7). Free spectacles and myopia were independently associated with spectacle use.

Conclusions: The low prevalence of un/undercorrected RE and poor uptake of spectacles, even when provided free, raises doubts about the value of vision-screening programmes in Tanzanian secondary schools. Policy decisions on school vision screening in middle- and low-income countries should take account of the cost-effectiveness as well as competing demands for scarce resources.

VISION 2020, the global initiative of WHO/IAPB (International Agency for the Prevention of Blindness) for the elimination of avoidable blindness, recommends the control of refractive error as a priority for national eye programmes.[1 2] One of the strategies suggested is to include a simple visual acuity test into school health programmes with provision of spectacles to all children with significant refractive error.[3] Such policies, commonplace in well-resourced countries, are now being considered in low- and middle-income countries. India, for example, already has a nationwide school screening programme for refractive error, and many other governments subscribe to the VISION 2020 goals.[4] Nevertheless, evidence-based decisions on resource allocation demand information from a range of cultural settings. Key determinants of cost-effectiveness will be the prevalence of refractive errors in the population concerned and the use of spectacles by those to whom they are given or prescribed. The School Eye Screening Study in Dar es Salaam examined the prevalence of refractive errors (uncorrected or undercorrected) in secondary school students and the uptake of spectacles in two groups randomised to obtain spectacles in different ways—by direct provision free of charge, or by a prescription only. To our knowledge, this is the first randomised clinical trial undertaken which addresses compliance with spectacles for refractive errors within the context of school eye health programmes.

METHODS

Setting and participants

The study was conducted in 37 secondary schools in Dar es Salaam, the economic capital of Tanzania, between January and August 2004. The country has no regular school vision screening programme, though screening is provided in some schools by non-governmental organisations. Spectacles with a broad selection of fashionable frames are widely available in government services and the private sector, at prices from US$10 upwards.

Study procedures

All 51 secondary schools within 30 km from the Centre for Community Based Rehabilitation and Treatment (CCBRT), a non-government tertiary eye care facility, were invited to participate in the screening, and all but three agreed. Distance visual acuity testing was offered to all students in the first school year. After an intensive period of training, a team of research assistants collected socio-economic information on participants and tested uncorrected visual acuity (right and left eye separately and both eyes together) with a Snellen's E-chart at 6 m. They also tested presenting visual acuity in students who had their own spectacles with them. All students who were not able to identify at least four of the five optotypes in the 12-line in either eye unaided or wearing their spectacles, were defined as having ''poor eyesight'' and were referred to CCBRT. At CCBRT, an optometrist retested visual acuity and assessed refractive errors by retinoscopy and subjective refraction. Cycloplegia was only used if hyperopia was suspected. An ophthalmologist performed a detailed eye examination in all students whose visual acuity did not improve to normal (better than 6/12 in both eyes) with best correction. The optometrist also refracted non-attenders in their schools 2–4 weeks after referral.

Interventions

Secondary schools were randomly allocated to one of two intervention arms (A or B) before the screening took place. The screening team and the optometrist were not aware of the allocation at the time of visual acuity measurement and refraction. Students who had refractive errors causing visual impairment of 6/12 or worse whose visual acuity improved with spectacles by at least one line, and students with significant hyperopia (⩾2D), were provided with free spectacles (arm A) or with a prescription only (arm B).

A choice of fashionable metal frames was available to students in arm A, whereas students in arm B could purchase their spectacles at CCBRT or any optical workshop of their choice. All of them received an information leaflet explaining the importance of spectacles and regular eye examinations. Three months after the intervention, members of the research team revisited each school unannounced, to establish whether students were using their spectacles.

Compliance was measured in four categories: Students (1) were wearing spectacles, (2) were not wearing spectacles but had them at school, (3) were not wearing spectacles and did not have them at school but said that they had them at home or (4) claimed that they did not have any spectacles.

Outcomes

The primary trial outcome was spectacle use at 3 months in arms A and B. Secondary outcomes were the prevalence of uncorrected significant refractive error and predictors of spectacle use.

Sample size

The sample size for the trial assumed a 5% prevalence of uncorrected significant refractive error, on the basis of a previous study elsewhere in Tanzania.[5] With this prevalence, screening of 2500 students in each intervention arm would give 80% power to show a difference in spectacle use of 70% versus 50% between the two trial arms as being statistically significant at a 95% confidence level. This sample size included a design effect of 1.5 to allow for clustering.

Data entry and analysis

Data were double-entered using EpiData software and verified by means of FoxPro (version 2.6, Microsoft Corporation, Seattle, WA). After range and consistency checks, the data were analysed using STATA 8.0 (Stata Corporation, College Station, TX). Continuous variables were described as means and ranges. Proportions for categorical variables were compared using Pearson's chi square test (or Fisher's exact test for variables where more than 80% of expected values were under 5).[6] The certainty of estimated parameters was expressed by 95% confidence intervals. The significance of differences was tested by multivariate analysis, with adjustment for clustering by school. Predictors of spectacle use (two definitions) were identified by logistic regression models, their predictive power being estimated through crude and adjusted odds ratios. The two alternative definitions were: (1) students either wearing them or having them at school; and (2) students wearing them, or having them at school, or claiming to have them at home. A preliminary study showed that many students did not wear their spectacles continuously, that many of them only wore them in a class room setting and not outside school and that teachers' attitudes towards spectacles influenced wearing patterns during lessons. The a priori definition of spectacle use therefore includes students who had their spectacles at school but did not wear them at the time of examination. In fact, 30% of students who had their spectacles at school but were not wearing them at 3 months in the current study were wearing their spectacles at a 6-month follow-up visit. The follow-up at 6 months also showed that 40% of students who had said that they had spectacles at home at 3 months had their spectacles at school at 6 months, and we therefore included this group as spectacle users in definition 2

The costs of screening and treatment were based on average cost estimates collected at the end of the trial in 2004. It assumed that an ophthalmic nurse screened approximately 100 students at school and that referred students were refracted in a referral hospital. Estimates were calculated based on definition 1 of spectacle use for students who were provided either free spectacles or only a prescription. They include costs to the provider and to the recipient. For simplicity, it assumed that no students were wrongly referred and that all examined students were examined at the hospital.

Ethics

Ethical approval was granted by the Government of Tanzania through its Medical Research Coordinating Committee and by the Ethics Committee of the London School of Hygiene and Tropical Medicine, UK. Before beginning, the study was explained in writing to all parents and students, and it was explained again verbally to students on the day of examination. Students agreed to participate by signing a consent form. Parents were asked to inform the head teacher or the study team verbally or in writing if they did not want their children to participate. Children could opt out at any stage without this affecting their normal management.

RESULTS

A total of 6904 (90.2% of all eligible) students attending 48 schools were screened (fig 1), and 2.9% (n = 199) were shown to have uncorrected poor visual acuity confirmed by the optometrist. An additional 1.4% (n = 96) had poor visual acuity at screening but were not examined fully, because they did not attend CCBRT and were absent at the time of the optometrist's follow-up visit to their school. The cause of visual impairment in 168 of the 199 students with confirmed poor visual acuity was refractive error, responsible for 96% of bilateral and 60% of unilateral visual impairment; 145 (86.3%) of these were myopic. Most of the other causes of poor visual acuity were not treatable, e.g. corneal scars, and retinal and optic nerve disorders. In addition to the 168 with confirmed refractive error, 40 students were not refracted but were assumed to have a refractive error because on screening their poor eyesight improved to good with their own spectacles. Four (10%) of the students with assumed corrected RE had an uncorrected VA of 6/12 in at least one eye, 12 (30%) of 6/18 or 6/24 in the better eye, 21 (53%) of 6/36 or 6/60 in the better eye and 3 (7%) of worse than 6/60 in the better eye. 61% (126/208) of students with significant refractive error had uncorrected or undercorrected defects (prevalence 1.8% (126/6904); 95% CI: 1.5 to 2.2%).

All students provided with spectacles or a prescription were eligible for follow-up. Of the 126 students with un- and undercorrected significant refractive errors, six had erroneously not been prescribed spectacles, and four students with keratoconus had received contact lenses instead of spectacles. An additional nine students with borderline refractive errors

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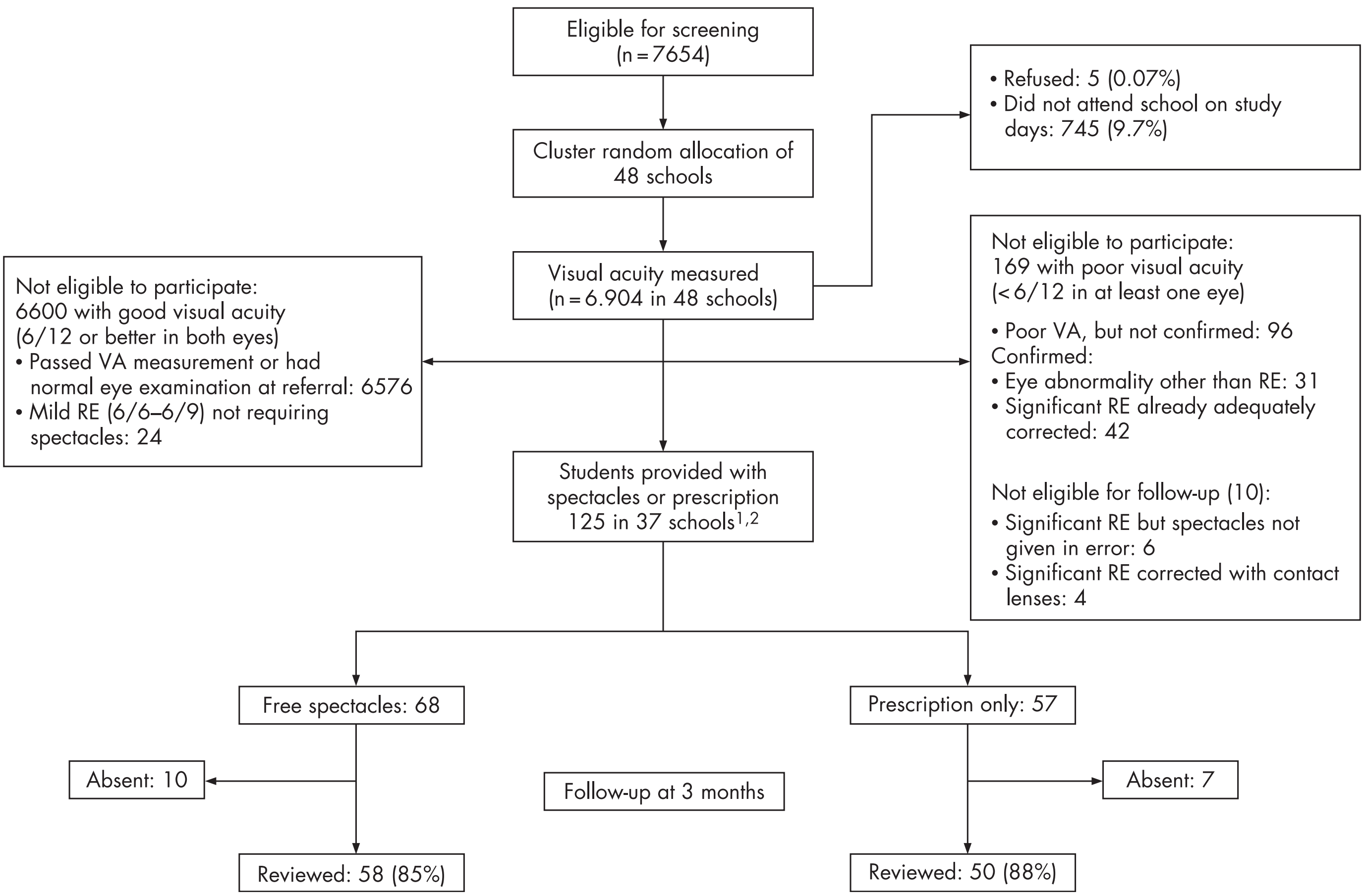

Figure 1 Participants. RE, refractive error. (1) Includes 116 students with significant RE and nine students with borderline RE who failed the screening test, but could see 6/12 in both eyes without correction at the hospital. (2) There were no students with un- or undercorrected significant RE in 11 schools.

(failed screening test, but uncorrected visual acuity of 6/12 in both eyes in the hospital) had been given spectacles or a prescription. Thus, a total of 125 students (126–6–4+9) attending 37 of the 48 screened schools were eligible for follow-up.

The socio-economic characteristics of students in the two arms were broadly similar, though those in arm A were more likely to be female ($p = 0.032$) or staying with their parents ($p<0.001$; table 1).

Nearly all students in both trial arms had good bilateral best corrected visual acuity with spectacles. Follow-up at 3 months was achieved in 58 of 68 (85%) students in arm A schools and 50 of 57 students (88%) in arm B schools (fig 1). In arm A, 27/58 (47%) were wearing spectacles or had them at school, compared with 13/50 (26%) in arm B (adjusted odds ratio 2.4: 95% CI: 1.0 to 6.7; fig 2). Of the 10 students in arm A who said that they did not have their spectacles, six said they had lost or broken them, and four said they had not picked them up. Thirty-three of the 35 in arm B who were not using spectacles at follow-up had not purchased them.

For both definitions of spectacle use (see Methods), the significant independent predictors were free provision and myopia. For definition 1, bilateral poor presenting visual acuity was an additional predictor, but even among those students, spectacle use was low at 44.3% (tables 2 and 3). Of the students with bilateral poor presenting vision, spectacle use was similarly low for students with presenting VA of 6/18 or 6/24 in the better eye (20/45; 44%) and for students with 6/36 or 6/60 in the better eye (11/25; 44%). None of the 108 students included in the trial had a presenting VA of less than 6/60 in the better eye.

Age, sex, ethnicity, residence, parental occupation, wealth, best corrected eyesight, and possession of spectacles at the time of the screening test or a history of spectacle use did not contribute significantly to the model. Including the 10 students with uncorrected significant RE who had not been provided with spectacles or a prescription (intention to treat analysis) resulted in nearly identical odds ratios and p values for all of the above predictors.

Details of the cost calculation are provided in table 4.

The overall cost of screening and spectacle provision for each screened student is US\$0.87. The overall cost of screening and spectacle provision for each student who uses spectacles (definition 1) is US\$46.3 (87.4×0.53; £23.4) for free spectacles or US\$64.7 (87.4×0.74; £32.7) for prescribed spectacles. This is based on spectacle use of 47% if spectacles are provided free and 26% if spectacles are only prescribed.

DISCUSSION

This study showed the prevalence of uncorrected or under-corrected refractive error to be lower than expected. Nevertheless, the results did indicate a clear advantage, in terms of uptake, for direct provision of spectacles over prescription only. How should these new data affect decisions on school screening programmes, of the kind advocated by VISION 2020?

Table 1 Baseline characteristics of students prescribed or given spectacles (N = 125)

Characteristics	Intervention A: free spectacles		Intervention B: prescription only			Total	
	n	Mean (range)	n	Mean (range)	p*	n	Mean (range)
Age (years)	68	14.1 (12 to 18)	56†	14.8 (12 to 19)	0.054	124	14.4 (12 to 19)
No. of siblings	66‡	3.0 (0 to 9)	57	3.6 (0 to 8)	0.213	123	3.3 (0 to 9)
	n	%	n	%	p*	n	%
Sex							
Male	20	29.4	34	59.7	–	54	43.2
Female	48	70.6	23	40.4	0.032	71	56.8
Ethnicity							
African	65	95.6	55	96.5	–	120	96.0
Non-African	3	4.4	2	3.5	0.781	5	4.0
Residence:							
Family	67	98.5	53	93.0	–	120	96.0
Other	1	1.5	4	7.0	<0.001	5	4.0
Father's occupation							
Professional	26	38.2	20	35.1	–	46	36.8
Others	23	33.8	26	45.6	–	49	39.2
No father	14	20.6	10	17.5	–	24	19.2
Unknown	5	7.4	1	1.8	0.377	6	4.8
Mother's occupation							
Professional	13	19.1	8	14.0	–	21	16.8
Others	44	64.7	41	71.9	–	85	68.0
No mother	7	10.3	6	10.5	–	13	10.4
Unknown	4	5.8	2	3.5	0.505	6	4.8
Possessions							
Car, TV and computer	10	14.7	5	8.8	0.319	15	12.0
School status							
Government	22	32.4	21	36.8	–	43	34.4
Private	46	67.7	36	63.2	0.599§	82	65.6
Spectacles							
Wearing (incorrect) spectacles	5	7.4	3	5.3	0.636	8	6.4
Owned spectacles in the past¶	11	18.3	8	15.7	0.701	19	17.1
Siblings with spectacles**	12	18.8	9	16.1	0.758	21	17.2
Visual acuity (VA)††							
Presenting							
Bilateral poor	43	63.2	38	66.7	–	81	64.8
Unilateral poor	18	26.5	11	19.3	–	29	23.2
Bilateral good	7	10.3	8	14.0	0.648	15	12.0
Presenting better eye							
≥6/12	25	36.8	19	33.3	–	44	35.2
6/18 or 6/24	29	42.7	25	43.9	–	54	43.2
6/36 or 6/60	14	20.6	13	22.8	0.648	27	21.6
Best corrected							
Bilateral poor	1	1.5	2	3.5	–	3	2.4
Unilateral poor	0	0.0	1	1.8	–	1	0.8
Bilateral good	67	98.5	54	94.7	0.404‡‡	121	96.8

*Random effects model adjusting for clustering; †age unknown for one student; ‡number of siblings unknown for two students; §Pearson's chi square test; ¶N = 111 students who do not wear or claim to have spectacles; **N = 122, no information for three students; ††poor visual acuity defined as VA worse than 6/12; ‡‡Fisher's exact test.

The reported prevalence of significant refractive error in children ranges from 1.8% in South Africa to 20% in Malaysia and 30% in Southern China—uncorrected in 81%, 55% and 33%, respectively.[7–9] In Mwanza, Tanzania, 4.7% (95% CI: 3.9 to 5.6%; $p<0.001$ binomial probability test) of urban secondary school students had uncorrected or undercorrected significant refractive error—much more than the 1.8% in Dar es Salaam.[5] However, the high prevalence in the Mwanza study may not be representative because schools had been selected purposively to include a high proportion of Asian students, and all but one of the schools was fee-paying. Asian origin and high socio-economic status are both associated with myopia.[5 10–12] The prevalence of significant RE is expected to be even lower in primary school students and in children who do not attend school, as myopia is associated with education.[10 13] In rural Mwanza, only 1% of primary school students had significant refractive error, but none of them had spectacles.[14]

A document from the World Health Organization recommends that interventions to decrease the prevalence of uncorrected refractive error should have a low priority where the prevalence is <2%.[15] However, the basis for this recommendation is not explicit, and a counterargument is that spectacles can be cheap, and good visual acuity may be important for academic achievement at secondary school.[16]

However, spectacles can only be effective if worn. In Dar es Salaam, the uptake was low, even when spectacles were supplied free, and the children were able to choose frames. In other countries, young people have shown reluctance to wear

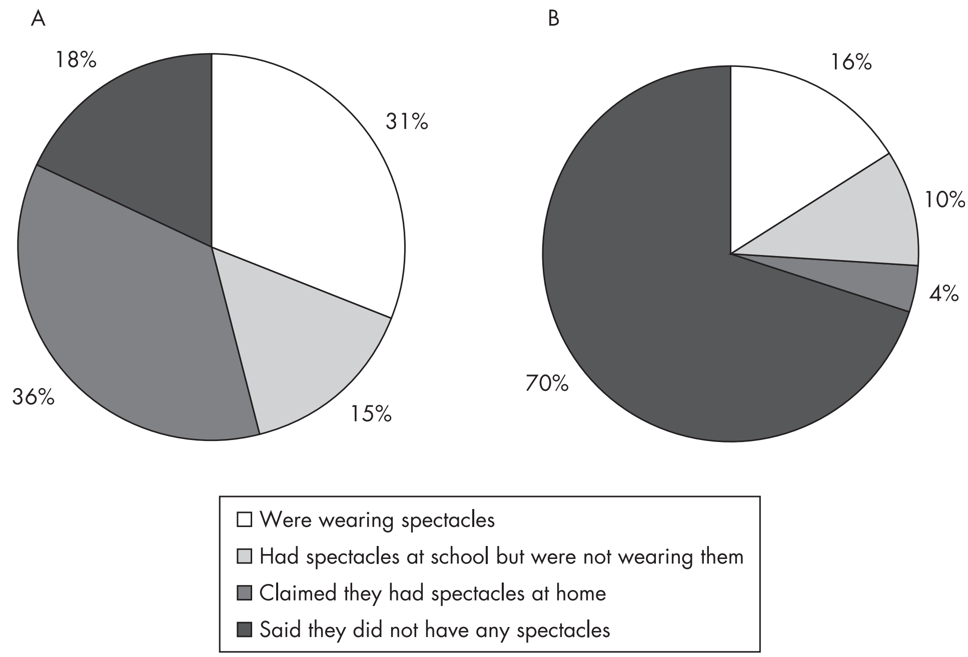

Figure 2 Use of spectacles. Intervention arm A: free spectacles (n = 58). Intervention arm B: prescription only (n = 50).

prescribed spectacles—sometimes, perhaps, because they were not really needed.[17–20] However, the Tanzanian students initially seemed far from reluctant, often pretending not to see well at the vision screening in order to obtain spectacles. A research group in Mexico reported that only 13% of primary and secondary school students who had been given free spectacles (VA<6/12 in either eye) were wearing them 18 months later, and an additional 34% had them at school.[21] In Mexico and in Tanzania, myopic students were more likely to use spectacles than students with hyperopia and/or astigmatism.

Furthermore, even though it seems likely that better eyesight improves quality of life and school performance, so far we lack evidence on the impact of school vision screening on academic performance and quality of life in children in developed and developing countries.[22]

Identifying and addressing potential barriers to wearing spectacles may increase their use. We conducted a series of focus-group discussions with students who were either using or not using spectacles which will be the subject of a separate report. Preliminary findings indicate that key issues related to non-compliance included parental fear that spectacles might destroy eyesight, teasing by peers, user preference for traditional medicines and cost. The importance of these factors may or may not vary substantially between settings in lower- and middle-income countries.

The average cost per pair of spectacles used depends on the mode of screening and referral, the number of students screened per day, the validity of the screening test and the actual uptake of spectacles, and may therefore be higher or lower than in our setting. It is worth considering that the estimated total cost (provider and consumer) of screening for refractive errors and treatment of US$0.87 per student is nearly one-fourteenth of the Tanzanian total expenditure on health of US$12 per capita in 2004.[23]

CONCLUSION

In this Tanzanian secondary school population, the prevalence of uncorrected significant refractive error was so low and the uptake of spectacles so poor, even when they were provided free of charge, that the value of any screening programme must be questionable. However, the effectiveness of school vision screening is likely to vary in different cultural settings. In addition, for those whose poor vision is corrected as a result of screening, the gains may be great, even though empirical

Table 2 Independent predictors of spectacle use using definition 1*

Predictors	Compliance (%)	Crude OR	Adjusted OR	95% CI	p†
Intervention					
Prescription only	26.0	–	–	–	–
Free spectacles	46.6	2.5	2.4	1.0 to 6.7	0.064
Presenting VA					
Bilateral good	7.1	2.4	2.1	1.0 to 4.4	0.038
Unilateral poor	33.3				
Bilateral poor	44.3				
Type of RE					
Hyperopia or astigmatism only	0.0	–	–	–	–
Myopia (any severity)	42.6	∞	∞	–	<0.001

N = 108; schools: 37, p = 0.005 (Wald test).
*Students using spectacles who either were wearing them or had them at school versus students who claimed that they had them at home or said that they had none; †multivariate analysis adjusted for clustering by school.

Table 3 Independent predictors of spectacle use using definition 2*,†

Predictors	Compliance (%)	Crude OR	Adjusted OR	95% CI	p‡
Intervention					
Prescription only	30.0	–	–	–	–
Free spectacles	82.8	12.5	14.3	4.6 to 50.0	<0.001
Type of RE					
Hyperopia or astigmatism only	30.6	–	–	–	–
Myopia (any severity)	69.4	68.4	43.4	3.8 to 496.9	0.002

N = 108; schools: 37, p<0.001 (Wald test).
*Students using spectacles were wearing them, had them at school or claimed that they had them at home versus students who said that they had none; †presenting vision: adjusted OR = 1.7 (0.8 to 3.7); p = 0.181; ‡multivariate analysis adjusted for clustering by school.

Table 4 Cost estimates

Cost	US$
Screening per day	
Done by ophthalmic nurse	
Return transport	3
Salary for ophthalmic nurse	9
Out of station allowance and equipment	5
Total (screening)	17
Eye examination per student	
In referral hospital	
Cost to student	
Return transport (assumes one visit)	3
Loss of income parent (one day)	9
Cost to provider of one refraction (equipment, utilities, salaries)	4
Total (examination)	16
Spectacles (metal frame)	
Common prescription (96% of prescriptions)	10 (6*)
Sphere 6D, cylinder 4D or higher (4% of prescriptions)	40 (24*)
Total (spectacles)	(10×0.96)+(40×0.04) = 11.2
Total/100 students†	17+(3×16)+(2×11.2) = 87.4

*Actual provider cost; †assumptions: out of 100 students who had their visual acuity screened per day three students with uncorrected poor vision need further examination at the referral clinic. Two of those three require spectacles.

evidence on this is lacking. Before policy decisions on school vision screening are made, the strategies need to be assessed in terms of local cost-effectiveness, and their impact on school performance and quality of life. This is particularly important in low-income countries with scarce financial and human resources.

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