Visual Acuity Screening By by School Teachers in Far West Nepal: A randomized trial of alternate screening models

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ABSTRACT

Background

Studies have not examined alternate school visual acuity screening methods in Nepal in terms of accuracy and cost.

Objective

To validate recent evidence from India of the effectiveness and cost of alternate school visual acuity screening models involving all class teachers (ACTs) versus a few selected teachers (STs).

Method

This was a prospective cluster randomized controlled study. The sample size was 5000 students. Five schools were randomly selected for the all-class teachers or intervention arm and four schools for selected teachers or standard arm. Teachers from both arms were trained to identify children aged 6 years and above with Snellen visual acuity 6/9 or worse in either eye as well as obvious ocular abnormalities and refer them to an ophthalmic team. The screen positive and negative children as well as cost for screening were calculated in STATA software (version 11.0; StataCorp, Texas, USA).

Result

All class teachers (80 teachers) screened 3713 children and STs (9 teachers) screened 2064 children aged 6 to 15 years. All class teachers had better sensitivity, 95.1% (95% CI: 91.9-98.2) and specificity, 92.8% (95% CI: 92.0-93.6) compared to selected teachers: sensitivity, 73.2% (95% CI: 64.4-82.0) and specificity, 85.3% (95% CI: 83.8-86.7). The cost of screening per child with refractive error and or other ocular abnormalities was $3.05 for all class teachers and $ 5.29 for selected teachers.

Conclusion

A school vision screening involving all class teachers in Nepal was more accurate than selected teachers in identifying refractive error and or other ocular abnormalities at approximately 60% of the cost.

KEY WORDS

Accuracy and cost, School, Screening, Teachers, Visual acuity

INTRODUCTION

An estimated 19 million school-aged children worldwide are visually impaired, mostly due to uncorrected refractive error, making it the leading cause of visual impairment among children.[1-3]

The International Agency for the Prevention of Blindness recommends visual acuity screening once in the primary school years (aged 5-10) and every 2 years in secondary school (aged 11-18), followed by annual screening for new students and those previously prescribed spectacles.[4] School screening program are substantially more effective and less costly for identifying school children with poor vision than are other primary eye care models.[5,6] A study in rural China showed that teachers were more cost effective (cost per case detected $37.53) in identifying children with vision problems than were optometrists (cost per case detected $59.14) and local volunteers (cost per case detected $52.19).[7]

To increase screening capacity, Geta Eye Hospital ophthalmic staff began training school teachers to test visual acuity. Typically, each school trains a few teachers, defined as 'selected teachers', hereinafter, and they screen all the children attending that school. The selected teachers reduced the workload of the ophthalmic team but correctly identified eye problems in only 47% of the children (true positives).[8]

In this study, we tested the accuracy and cost of an alternate school visual acuity screening model involving 'all class teachers' (or home room teachers) versus selected teachers in Far West Nepal. We hypothesized that 'all class teachers', where teachers screen only one classroom, would lead to a significantly greater proportion of true positives and fewer false negatives to the ophthalmic team.

METHODS

This was a prospective cluster randomized controlled study of alternative teacher-based visual acuity screening methods. In this study, we tested the accuracy and cost of an alternate school visual acuity screening model involving 'all class teachers' (or home room teachers) versus selected teachers. Ethical approval was obtained from the Institutional Research Review Committee of Nepal Netra Jyoti Sangh with reference number 140-071-072. The study period of the study was 2016 to 2018. All study procedures adhered to the recommendations of the Declaration of Helsinki.

Data on school demographics (both public and private) around Geta Eye Hospital were obtained from the district education office. Schools were included if screening had not been conducted during the previous academic year or if they included grades 1 to 10 (children aged 6 to 15 years) or a minimum of 200 students and were located within 50 kilometers of Geta Eye Hospital. There were 262 schools satisfying the inclusion criteria, 30 of which were randomly selected with a probability proportional to their size. More schools than needed for the sample size were selected because approval for research is typically low in this region. All 30 schools were contacted, but 21 schools were unwilling to participate in the research for reasons unrelated to the research, for example, because of conflicts with their internal academic exam schedule. The 9 remaining schools were randomly allocated to one of the two screening models: 'all class teachers' (5 schools) or 'selected teachers' (4 schools) (Fig. 1). The nine schools were large enough to satisfy our sample size requirement.

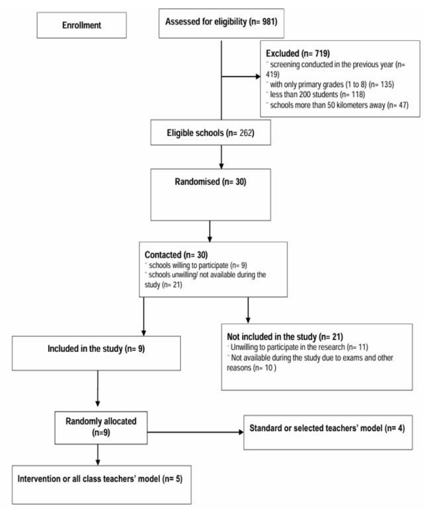

Figure 1. **School enrollment process**

Written approval was obtained from all included schools.

Based on a pilot study, the 'all class teachers' model was estimated to correctly identify 95% of the participants, and the 'selected teachers' model correctly identified 90% of the children with reduced vision and/or obvious ocular abnormalities. Given the desire to detect a difference of 5%, 3315 subjects were needed to have 80% power with 95% confidence. With a 1.5% variance assumption, the final total sample size was increased to 5000 students aged 6 to 15 years.

In the 'selected teachers' model, one teacher per 200 children was selected by the principals to complete the visual acuity screening. The principals and the selected teachers from the four schools were invited to Geta Eye Hospital for vision screening training and to create awareness about childhood visual problems. Longer training sessions were provided to the selected teachers because they took a full day off work and traveled to the Geta Eye Hospital for training. The longer training sessions for the selected teachers were a motivating factor for them to screen several hundred students each. The 'all class teachers' were trained in the schools on a working day. Training consisted of 2 sessions: Session 1 (1 hour for 'all-class teachers' and 2.5 hours for 'selected teachers') on basic eye health and eye problems; Session 2 (1 hour for 'all-class teachers' and 2.5 hours for 'selected teachers') to screen for visual acuity using a Snellen chart and identify obvious ocular abnormalities such as strabismus, dropping of the upper eyelid, corneal opacity and red or watery eyes. All participating teachers were given incentives for the training day and were reimbursed for travel costs in the case of selected teachers. Each teacher also received vision screening kits, which included two externally illuminated Snellen's vision charts (letter and number), a 6-meter rope and recording forms. As an additional incentive, a free eye examination and a guided hospital tour were provided to the selected teachers. All the class teachers were given incentives for the training day but did not receive the travel cost.

Teachers screened on a working day from May to June 2016. School teachers, in consultation with the principal, arranged for suitable time for screenings in one of the classrooms. The children were invited one by one to the classroom to complete the screening. Teachers conducted visual acuity screenings of all children aged 6 years to 15 years using a Snellen chart placed at 6 meters; a letter chart for the right and a number chart for the left eye. Two different charts were used to prevent children from memorizing the vision chart presented to one eye, which could influence the visual acuity of the other eye. A visual acuity of 6/9 (20/30) or worse was defined as reduced vision and was recorded on a standardized form. Children identified as having visual acuity of 6/9 (20/30) or worse in either eye were referred for ophthalmic examination. Teachers also referred to children with obvious ocular abnormalities, such as abnormal alignment of one or both eyes (strabismus), dropping of the upper eyelid (ptosis), corneal opacity and red or watery eyes. Teachers directly referred to children wearing spectacles or those whose visual acuity could not be assessed by the ophthalmic team. Upon completion of the screening, the head teacher or principal set a date for a diagnostic visit by the ophthalmic team. Teachers provided parental consent forms to all the children and asked them to provide parental signatures prior to the ophthalmic team visit to the schools.

The ophthalmic team consisted of a pediatric optometrist with 5 years of clinical experience and two ophthalmic assistants with 3 years of vocational training and 3 years of clinical experience.Members of the ophthalmic team were not blinded to which teacher screening model was used in the school. The ophthalmic team examined all the children who underwent screening, regardless of the results of the teachers' screening. Visual acuity was assessed by externally illuminated Snellen's charts (both letters and number charts). Preliminary ocular examination was performed with a torch light, and fundus examination was performed by direct ophthalmoscopy. All abnormalities were recorded. Ocular motility was assessed in all 6 cardinal positions along with the primary gaze. The cover test was performed at distances of 0.5 meters and 6 meters to observe ocular alignment. The right and left eyes were covered in turn (cover-uncover test) with an occluder, and the fellow eye was observed for any correcting movement (tropia). The magnitude of tropia was not measured. The ophthalmic team diagnosed allergic conjunctivitis on the basis of allergic signs such as conjunctival hyperemia, papillary reaction, chemosis or lid edema, and the patients were referred as needed.

Dry streak retinoscopy, followed by subjective refraction, was used to assess refractive status except in patients requiring cycloplegia. Cycloplegia was induced by optometrists on the day of eye examination in children with strabismus, amblyopia, or hypermetropia and in uncooperative patients for whom refractive status could not be determined by retinoscopy. Findings from subjective refraction were used to diagnose refractive error, which was defined as refraction of at least 0.5 diopter spherical equivalents or cylinders. Children found to have minor eye problems were treated at the school. Glasses were provided free of cost.

Children requiring medical intervention, including strabismus, amblyopia, cataracts and postmydriatic tests, were referred to Geta Eye Hospital. Strabismus was diagnosed in eyes with any correcting movement on the cover-uncover test. Amblyopia was defined as a unilateral or bilateral visual acuity of 20/30 or worse even after refractive correction, without any structural or pathological anomalies. Cataracts were diagnosed for any eye with clouding of the crystalline lens.

The children were referred to Geta Eye Hospital. The records of these slips were filed and maintained in the pediatric department. The referred children who reached Geta Eye Hospital for further evaluation within 3 months after the eye examination by the ophthalmic team were considered 'compliant' with the referral recommendation.

The following data were collected: the total number of children screened, their visual acuity, ocular abnormalities observed by teachers, the total number of children examined, and their diagnosis and treatment by an ophthalmic team. Children diagnosed with visual acuity of 6/9 (20/30) or worse in either eye or with obvious ocular abnormalities by school teachers and confirmed by an ophthalmic team were classified as true positives. Patients diagnosed with normal visual acuity (6/6; 20/20) in both eyes without any obvious ocular abnormalities by schoolteachers and confirmed by an ophthalmic team were classified as true negatives. The ophthalmic team confirmed the diagnosis by teachers of reduced visual acuity, strabismus, ptosis, corneal opacity and allergic conjunctivitis. The proportions of children who were screen positive and negative according to the screening model were calculated. Mean values were compared using Student's t test and the Wilcoxon rank sum test, and proportions were compared between study groups using chi-square statistics in STATA software (version 11.0; StataCorp, Texas, USA).

Detailed costs were recorded for both models and included the salaries of ophthalmic staff, travel, teacher training, incentives, accommodations, supplies (including vision screening kits), training materials and anticipated costs of examination for false positives.

RESULTS

A total of 3793 children in 5 class teachers' (ACT) schools and 2144 children in 4 selected teacher (ST) schools were included, with no significant differences in age or sex between the two samples. ACTs (80) screened 3713 children (97.9% of the sample), and STs (9) screened 2064 children (96.3% of the sample) aged 6 to 15 years. ACTs screened an average of 46 students, while STs screened an average of 229 students. Almost all the dropouts were due to absenteeism. ACTs required less than 2 weeks, while STs required up to 1 month to finish screening (Table 1).

Table 1. Visual acuity screening parameters, referral and compliance, by screening model

Sample	ACT n (%)	ST n (%)	p-value
Children sampled	3793(100)	2144(100)	
Children screened by Teachers	3713 (97.9)	2064 (96.3)	
Number of Teachers Trained	80	9	
Average students screened per teachers	46	229	
Children referred by the teachers	448 (12.1)	411 (19.9)	<0.05
Examination			
Children examined by ophthalmic team	3702 (99.7)	2051 (99.4)	
True positive	173 (4.7)	71 (3.4)	0.010
False positive	275 (7.4)	340 (16.5)	-<0.05
False negative	9 (0.24)	26 (1.3)	<0.05
True negative	3531 (95.4)	1967 (96)	0.237
Total children with eye conditions (True positive plus false negative)	182 (4.9)	97 (4.7)	
Sensitivity	95.1%	73.2%	
Specificity	92.8%	85.3%	
Referrals			
Referred to hospital for further examination	30 (0.8)	18 (0.9)	0.79
Student compliance with hospital referrals (within 3 months)	10 (33.3)	5 (27.7)	0.69

Note: n= number, ACT= all class teacher, ST= selected teacher

ACTs represented a significantly lower proportion of students than STs did: 448 [12.1%; 95% CI: 11.0-13.1] versus 411 [19.9%; 95% CI: 18.2-21.6] for ACTs and STs, respectively ($p < .001$). A significantly greater percentage of the children from the ACTs than from the STs had vision loss (visual acuity of >30 or worse) and/or other ocular abnormalities (173/3713 [4.7%; 95% CI: 4.0-5.3] versus 71/2064 [3.4%; 95% CI: 2.6-4.2] for ACTs and STs, respectively; p=.01). A significantly greater proportion of children with vision loss (20/30 or worse) and/or other ocular abnormalities were referred for by ACTs than STs (38.6% [N=173/448]) versus ACTs (17.3% [N=71/411]), respectively; p=0.01 (Table 1).

A greater proportion of children referred by ACTs than STs reached Geta Eye Hospital for further investigations within 3 months, but the difference was not statistically significant (33.3% versus 27.7%, for ACTs and STs, respectively) (p=.688) (Table 1). ACTs and selected STs primarily identified children with refractive error (83.5% and 81.4%, for ACTs and STs, respectively). ACTs were more common in children with other nonrefractory conditions than STs were, although the difference was not statistically significant (Table 2).

Table 2. Confirmed ophthalmic diagnosis, by screening model

Diagnosis	ACT n (%)	ST n (%)	p-value
Refractive Error	152 (83.5)	79 (81.4)	0.922
Strabismus	10 (5.5)	4 (4.1)	0.522
Amblyopia	9 (4.9)	7 (7.2)	0.610
Ptosis	2 (1.1)	2 (2)	0.619
Cataract	2 (1.1)	1 (1)	0.999
Vitamin A deficiency	2 (1.1)	0	0.499
Others	5 (2.7)	4 (4.1)	0.488
Total	**182 (100)**	**97 (100)**	

Note: n= number, ACT= all class teacher, ST= selected teacher

ACTs identified significantly fewer false-negative children than STs did (9 [0.24%] versus 26 [1.3%] for ACT and ST, respectively; $p < .05$). ACTs had better sensitivity (95.1% CI: 91.9-98.2) and specificity (92.8% CI: 92.0-93.6) than STs (sensitivity 73.2% CI: 64.4-82.0) and specificity 85.3% (95% CI: 83.8-86.7) (Table 1).

ACTs spent approximately 3 to 6 hours screening their assigned students, compared to approximately 19 to 24 hours for STs. The costs of screening for a child were US$ 0.15 and US$ 0.25 for ACTs and STs, respectively. The cost of screening per child with ocular abnormalities was $ 3.05 and $ 5.29 for ACTs and STs, respectively. The estimated costs of examination for each or total false positives were $ 41.25 (275*0.15) for all classteachers and $ 85 (340*0.25) for selected teachers (Table 3).

Table 3. Cost comparisons

	ACT n	ST n
Total number of Children Screened	3702	2052
Cost of Screening a Child	$ 0.15	$ 0.25
Total cost of screening	$ 555.30	$ 513
Total children with eye conditions (True positive plus false negative)	182	97
Cost per child with ocular pathologies	$ 3.05	$ 5.29
False positives	275	340
Anticipated costs of examination for false positives	$ 41.25	$ 85

Note: n= number, ACT= all class teacher, ST= selected teacher

DISCUSSIONS

Among the children aged 6 to 15 years enrolled in the study, 97.89% and 96.3% were screened by ACTs and STs, respectively, indicating strong cooperation from schools, teachers and students. The nine schools willing to participate were selected from among the 30 schools randomly selected from the region around Geta Hospital. Although the nine schools may not accurately represent schools in the area, they were a mixture of large and small, urban and rural schools, and they were further randomized to ACT or ST to test this screening model, regardless of their representativeness.

The proportion of screen-positive children with true ocular pathology in this study (ACTs 4.7% and STs 3.4%) was similar to that reported in a study of school screening (ACTs 5.7% and STs 4%) in Southern India.[9]

Uncorrected refractive error accounted for the highest proportion of children with ocular pathology (ACTs 4.1% and STs 3.8%), similar to the findings of studies in Nepal and India.[9,10] The prevalence of refractive error (myopia-0.5 diopters and more; hyperopia 2 diopters and more) among school-age children in Nepal varies from 3% among Indo-Aryan children to 21.7% among children of Mongolian descent.[10-16] The refractive error of approximately 4% in this study is consistent with that of the primarily Indo-Aryan ethnicity in the area.

Myopia is also associated with urbanization and higher socioeconomic status, mostly among Chinese and other Asian populations.[15-17] The moderate proportion of uncorrected refractive errors in our study is consistent with our sample, which included a mix of public and private, urban and rural schools.

ACTs were found to constitute a significantly greater proportion of screen-positive children than STs were. A number of factors likely improved their performance, including greater time to commit to testing and retesting, better pretest awareness of visual impairment, better knowledge of the child's behavior or personality and greater commitment to and contact with individual students and their families.

This study used a visual acuity threshold of 6/9 (20/30) as per recent guidelines, whereas most other studies used 6/12 (20/40) as the threshold for identifying children.[4] Our study chose the lower threshold to avoid missing any children with eye problems due to lack of electricity in the rural hilly areas. In these settings, they used externally illuminated Snellen's charts, but bu and natural light in schools is often poor. A letter chart for the right eye and a number chart for the left eye were used to measure visual acuity in the children. As the optotypes of these two charts differ, some letters are more difficult to recognize than others are, which could affect visual acuity.[18] However, the influence is expected to be small enough to impact the overall results of the study. A study reported that the difference between the Snellen score and the ETDRS score was less than 1 for patients with good visual acuity (> 20/50).[19]

ACTs achieved better sensitivity and specificity despite more intensive hospital-based training for STs. The sensitivity and specificity of the ACTs (95% and 93%, respectively) approached those achieved by trained eye personnel. A study among preschool children revealed that licensed eye care professionals performed visual acuity tests with high sensitivity (70%) and specificity (90%).[20] In another study, trained certified medical assistants had lower sensitivity (58%) and higher specificity (98%).[21,22] Paudel et al. reported that trained teachers were effective at promoting eye health and identifying older children (aged 12 to 15 years) with uncorrected visual acuity ≥ 20/40 or worse in Vietnam (86.7% sensitivity and 95.7% specificity).[23] A possible explanation for the high accuracy of our study is that ACTs had the maximum interaction with students in their own class and had an ongoing opportunity to identify students with visual impairment.

Acts had significantly fewer false-negative results (N=9) than STs did (N=26). Children with reduced vision diagnosed as normal during screening are at risk of prolonged problems with no other eye services available in the area. Younger children are more comfortable with their own teachers than with those whom they may not know, causing differences in their responses. Their own teachers will know when the children are paying attention and trying their best to respond, which could be useful in monitoring peeking and other aberrant behaviors during screening.

The number of children referred for ophthalmic examination was small in comparison to the number of children examined by ophthalmic team ACTs (3702 and STs = 2051) because most children with minor problems or who were in need of glasses were treated at the school itself.

ACTs resulted in a numerically greater proportion of students who complied with the recommendation to attend the Geta Eye Hospital within 3 months (ACTs 33% and STss 27.7%). The percentage of patients who complied with follow-up referrals was expected to be much greater among ACTs because the teacher would be better known about the patient. The referral compliance in our study was lower than that reported in a school screening study from India involving all class teachers (59.2%).[9] This lower compliance could be due to the lower educational level of parents in our setting, a factor strongly associated with spectacle compliance in the region.[24]

ACTs (7.4%) identified approximately half as many false-positive students as STs (16.5%). In Vietnam, 29.5% of children were falsely identified as having visual impairment by teachers.[23] Unnecessary examination of students is the most significant source of additional costs associated with using STs. Falsely labeling children with vision loss (with a visual acuity of > 20/30) may induce anxiety in children and their caretakers and decrease trust in the screening programs.

Frick and colleagues estimated that the cost of the ophthalmic team examining each student during school-based screening in Delhi was approximately US$ 0.64 while in our study, we found ACTs US$ 0.15 and STs US$ 0.25.[6] In the same study, Frick reported that school-based screening is highly cost effective for 5-15 year-old children in urban India and 7-15 year-old children in rural India.

One of the study limitations is that the ophthalmic personnel were not blinded to ACT versus ST screening. This awareness may have created bias, but none of the ophthalmic personnel expressed any preference for one screening model over the other in this study setting where they were seeing all children, regardless of the initial screening model.

This study is limited to comparing two overall screening models without the power or capacity to determine the major factors resulting in greater ACT accuracy (pretest awareness of visual acuity, school performance, time to test and retest individual students). Given that all the children did not undergo cycloplegia, the number of hyperopic and anisometropic children could have been underestimated, resulting in an overestimation of the sensitivity. This approach resulted in dry refraction data for some children and cycloplegic refraction data for others. In terms of referral compliance, we did not study parents' education or families' socioeconomic background.

CONCLUSION

ACTs achieved significantly more accurate visual acuity screening in school than did the 'selected teachers' model at approximately 60% of the cost.

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