

Tribal Odisha Eye Disease Study (TOES # 2) Rayagada school screening program: efficacy of multistage screening of school teachers in detection of impaired vision and other ocular anomalies

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Purpose: To describe program planning and effectiveness of multistage school eye screening and assess accuracy of teachers in vision screening and detection of other ocular anomalies in Rayagada District School Sight Program, Odisha, India.

Methods: This multistage screening of students included as follows: stage I: screening for vision and other ocular anomalies by school teachers in the school; stage II: photorefractive correction and other ocular anomaly confirmation by optometrists in the school; stage III: comprehensive ophthalmologist examination in secondary eye center; and stage IV: pediatric ophthalmologist examination in tertiary eye center. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of teachers for vision screening and other ocular anomaly detection were calculated vis-à-vis optometrist (gold standard).

Results: In the study, 216 teachers examined 153,107 (95.7% of enrolled) students aged 5–15 years. Teachers referred 8,363 (5.4% of examined) students and 5,990 (71.6% of referred) were examined in stage II. After prescribing spectacles to 443, optometrists referred 883 students to stage III. The sensitivity (80.51%) and PPV (93.05%) of teachers for vision screening were high, but specificity (53.29%) and NPV (26.02%) were low. The specificity and NPV, in general, were higher in ocular anomaly detection but varied from disease to disease.

Conclusion: Multistage school screening is rapid and comprehensive in a resource-limited community. Regular training and periodic reinforcement of teachers for vision assessment and other ocular anomaly identification are required for further success of the strategy.

Keywords: vision screening, school children, sensitivity, specificity, tribal, ocular anomalies

Introduction

The eastern Indian state of Odisha is home for 9.7% of the tribal population of the country. At 8,140,000 people, the tribal population in Odisha was 22.1% of the total population in 2011 census. It exceeded 50% of the total population in 4 of 30 districts of Odisha; they were Malkangiri (57.4%), Rayagada (55.8%), Nabrangpur (55%), and Mayurbhanj (56.6%).¹ The tribal people live in remote areas with poor access to health and education. The Tribal Odisha Eye Disease Study is the evaluation of various eye health aspects of people from the tribal districts of Odisha. The current report is part of this study.

School eye health survey is a time-tested method to screen students for refractive error.^{2–4} It is the second largest program under the National Program for Control of Blindness in India after cataract surgery^{5,6} and is currently a priority of *Rashtriya*

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Bala Swasthya Karyakram (National Child Health Program) of the Government of India. But the task is not easy due to large number of students, and lack of trained ophthalmic personnel, worse in hilly and remote terrain like Rayagada district, Odisha state, India. The Rayagada School Sight Program (SSP) was designed to examine all students attending schools in the district. In order to overcome the human resource constraint, we designed the program in 4 stages. The program also used a rapid objective refraction system, the photorefractor. This study assessed the effectiveness of the program and the accuracy of teachers for vision screening and detection of other ocular anomalies vis-à-vis the optometrists.

Methods

The Rayagada SSP was a multistage cross-sectional descriptive and analytical study done between August 2016 and June 2017. The study included all students of either gender but excluded the ones with contagious diseases (such as scabies diagnosed by physician) and those absent on the days of examination. The older students (≥ 16 years of age) were excluded. The study was approved by the local district administration (Rayagada, Odisha) and ethics committee of L V Prasad Eye Institute, Bhubaneswar, India (2016-15-CB-14). The research protocol adhered to the provision of the Declaration of Helsinki for research involving human beings. The school authorities provided consent for eye examination by optometrists in their premises. Written informed consent was obtained from the parents of the children who were referred for examination by ophthalmologist in the hospital.

The study was done in 4 stages: stage I: screening by the trained school teachers in the school; stage II: photorefractor, optometrist examination, and subjective correction by optometrist in the school; stage III: cycloplegic-refraction and comprehensive ophthalmologist examination in secondary eye center; and stage IV: surgery and visual rehabilitation by pediatric ophthalmologist in tertiary eye center.

Stage I. A. Teacher training and screening strategy

The local administration selected teachers from the pool of teachers available in the district depending on the location for the screening program. Male teachers were preferred because of the travel logistics in this difficult hilly terrain. Optometrist (SN) and public health personnel (BCM and JW) imparted 1-day teachers training at Rayagada-based secondary eye center. The training consisted of recording vision by using Snellen E chart, basic eye anatomy, and common eye disorders

(such as red eye, white shining deposits suggestive of Bitot spot). At conclusion, teachers were provided with a screening kit that contained a measuring tape, flashlight, an illustrative booklet, and a spreadsheet for data entry.

The district administration divided schools into clusters and each teacher was given a fixed area for screening.

Stage I. B. Screening by school teachers

Each screening day in the school started after a brief description of the methodology of vision testing. All location and demographic details of students were entered in the spreadsheet. Students already wearing spectacles were identified. The school teachers screened for vision using Snellen's E chart of 3 lines, for testing vision of 20/60, 20/40, and 20/30. Vision in each eye was tested separately (with spectacles, if any), at 6 m. If the child was able to read the last line (20/30), it was marked "pass" denoted by "1"; if not able to, it was marked "fail" denoted by "0"; and if uncooperative for vision testing, it was marked "uncooperative" denoted by "99". An external eye flashlight examination and a Hirschberg test⁷ followed the vision testing and a specific number, 0–9, was assigned for various identified causes (Table 1).

Students with presenting visual acuity (PVA) $< 20/30$, uncooperative students, and those detected to having any ocular anomaly were referred.

Stage 2. Photorefractor and optometrist examination

Stage 2 was done in the school premises. The following sequence was maintained: measurement of the PVA, ocular motility, Hirschberg test, cover–uncover test, flashlight examination of the anterior segment, refraction by photoscreener (Spot™, Welch Allyn, Skaneateles Falls, NY, USA) and subjective refraction. Presenting vision was tested for each eye (with spectacles if any) by placing the vision chart

Table 1 Assignments in school screening

Denotation	Signs and symptoms
0	Squint
1	Eye lid problem
2	Bitot spot
3	Night blindness
4	Redness (with watering and discharge)
5	Injury
6	Eye swelling
7	Corneal problem
8	Cataract
9	Other

at 6 m distance. The subjective correction was done by placing the appropriate lenses in the trial frame and testing the vision with the chart placed at 6 m.

Trained community workers did the photorefractometry. The instrument was held at a 1 m distance at the eye level of the subject. The subject was asked to look at the target inside the screener; the device was moved in a manner that the examiner captured both the eyes on the screen. As per the manufacturer, the Spot screener is capable of detecting refractive error between $-7.5D$ and $+7.5D$, and the system notifies when it is beyond this range. Following photorefractometry, the students were referred in 3 situations – when the photorefractometry value was beyond $+2D$, beyond $-7.5D$ (high myopes), and not recordable. Photoscreener $> +2D$ were referred for cyclo-refraction as studies have shown the possibilities of underestimation by photoscreener in hyperopia beyond this range.^{8–10}

Subjective correction

It was done by the optometrist using the E-chart for those having vision $<20/20$ in 1 or both eyes and photoscreener value between $-7.5D$ and $+2D$. The photoscreener suggested values for subjective correction were used and the spectacles were prescribed only when vision improved to $20/20$ in both eyes. Those who had vision $<20/20$ after photoscreener suggested subjective correction were referred. Those having any ocular anomalies were referred irrespective of the vision and photoscreener finding.

Phase III. Comprehensive ophthalmologist examination

The referred children received a detailed eye examination in the hospital by a comprehensive ophthalmologist (LP). This included visual acuity measurement using COMProg system (London, UK), repeated photorefractometry, dry refraction using a retinoscope (Heine, Germany), cover–uncover test, slit-lamp examination (Carl Zeiss, Göttingen, Germany), followed by post dilation cyclo-refraction, and indirect ophthalmoscopic examination (Heine, Germany). Spectacles and medical treatment were given as per the need. Children who needed surgery were referred to the pediatric ophthalmologist (VW) (stage IV).

Data entry and analysis

The data were entered into Microsoft excel 2016 database. Data were double checked on the day of entry. The school screening effectiveness was compared with the parameters laid down by Limburg et al.² The accuracy of teachers

in vision screening and ocular anomaly detection were compared with findings of the optometrist where the latter was considered the gold standard. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated. Children referred by teachers only for ocular anomaly (presumably with normal vision) received a repeat vision testing by the optometrist to determine the specificity and NPV for vision screening; the children referred only for vision problem (presumably no ocular anomaly) received a comprehensive eye examination by the optometrists to determine the specificity and NPV for ocular anomaly detection by the teachers. The children referred for both vision problem and ocular anomaly were examined by optometrists to determine the sensitivity and PPV. The p -value for inter-age and inter-gender difference were calculated by chi square test and p -value <0.05 was considered significant.

Results

The Rayagada district has a population of 1,099,827 living in 11 blocks.¹¹ It has 2,124 schools and 164,374 students (16.9% of the total population) are admitted to these schools. We trained 216 teachers (213 male). The schools were divided into 125 clusters depending on the location and the class size. Two teachers each were deployed in 91 school clusters and 1 teacher each was deployed in remaining 34 school clusters; after excluding 4,389 students (specified earlier), 159,985 were enrolled for the study. Finally, 153,107 (95.7% of enrolled – 77,837 male, 50.83%; 75,270 female, 49.16%) students were screened in the program. The mean age of students was 9.3 ± 2.7 (range 5–15) years and 2,044 (1.3% of screened) were wearing spectacles. Stage I was completed in 36 days.

Teachers referred 8,363 (5.4% of screened) students for the following 3 reasons – 3,844 for poor PVA ($<20/30$), 3,433 for other ocular anomalies, and 1,086 for both. A total of 5,990 (71.6% of referred) were examined in the Phase II – 3,049 for poor PVA (presumably no ocular anomaly), 1,970 for ocular anomaly (presumably with normal vision), and the remaining 971 for both. The optometrist reexamined all children detected to have no ocular anomaly (with poor PVA) ($n=3,049$) and the children detected to have normal vision (with ocular anomaly) ($n=1,970$) by the teachers for calculations of specificity and NPV of ocular anomaly and visual acuity detection, respectively. The stage II was completed in 47 working days. A total of 883 students were referred to stage III. (Figure 1) Table 2 shows the effectiveness of school screening as per Limburg et al.²

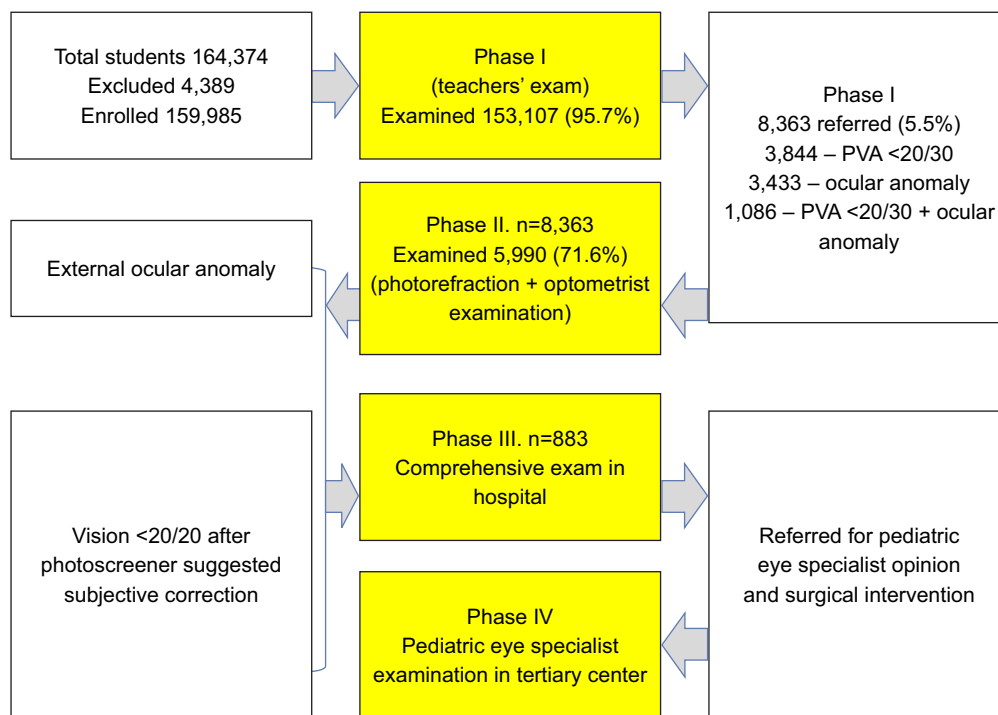


Figure 1 Patient flow in multistage school screening.
Abbreviation: PVA, presenting visual acuity.

Accuracy calculation was based on PVA of 20/30 or worse in the right eye. Compared with optometrists, the sensitivity of teachers in identifying students with impaired vision was 80.51% and the specificity was 53.29% (teachers erroneously identified problem in 46.71% students). The PPV (agreement of abnormality by teachers and optometrists) was 93.05%. NPV (agreement of “normal” by teachers and optometrists) was 26.02%. (Table 3).

Sensitivity of vision testing was more in male children (trend) and was more specific in older age group children with a statistically significant difference ($p < 0.05$). In the detection of ocular anomalies, specificity and NPV were comparatively high with cataract, 98.74% and 99.71%, respectively.

The sensitivity and PPV were low (Table 4). Strabismus had highest sensitivity (31.45%) and PPV (25.64%). Cataract had lowest sensitivity (5.56%) and Bitot’s spot had lowest PPV (0.67%).

Discussion

The primary advantages of multistage screening were the speed and effective utilization of skilled manpower. Because teachers were involved after a brief training, stage I was completed in 36 working days. Because rapid refraction (photorefractometry) was used by a trained community worker, optometrist’s time was more effectively used for subjective correction and detection of other ocular anomalies.

Table 2 Effectiveness of our school screening as per Limburg et al²

Parameter	This study	Indicator	Formula	Controlled program	This study
a No of schools in area	2,124	Coverage, organization	b/a	One teacher per school	One teacher for 10 schools
b No of teachers trained	216				
c No of children enrolled	159,985	Coverage, organization	d/c	80%–100%	95.7%
d No of children screened	153,107				
e No of children referred	8,363	Quality training/quality screening	e/d	5%–10%	5.4%
f No of children examined by optometrist	5,990	Organization refraction services faith	f/e	60%–90%	71.6%
g No of children referred to ophthalmologist	883	Confidence of optometrist/faith	g/f	10%–20%	14.7%

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Table 3 Sensitivity, specificity, and predictive values of the school teachers for visual acuity

	Sensitivity; % (95% CI)	Specificity; % (95% CI)	PPV; % (95% CI)	NPV; % (95% CI)
Total	80.51 (79.35 to 81.61)	53.29 (49.32 to 57.22)	93.05 (92.23 to 93.79)	26.02 (23.66 to 28.53)
Male	81.59 (79.99 to 83.09)	52.68 (47.02 to 58.28)	93.29 (92.13 to 94.28)	26.21 (22.85 to 29.88)
Female	79.39 (77.70 to 80.98)	53.87 (48.31 to 59.34)	92.81 (91.59 to 93.86)	25.85 (22.62 to 29.36)
p-value for inter-gender difference	0.0565	0.7689	0.5466	0.8851
Aged 5–10 years	80.93 (79.30 to 82.47)	48.28 (42.28 to 54.32)	93.39 (92.22 to 94.28)	21.91 (18.72 to 25.47)
Aged 11–15 years	80.08 (78.43 to 81.64)	57.06 (51.80 to 62.16)	92.72 (91.51 to 93.77)	29.55 (26.22 to 33.12)
p-value for inter-age difference	0.4609	0.0319 ^a	0.3996	0.0022 ^a

Note: ^aSignificant.

Two optometrists could complete stage II in 47 working days. We anticipate further advancement and refinement of the technology in the coming years.

The sensitivity for vision screening at 80.51% was higher than some studies^{4,12,13,16,18,19} and lower than few others.^{14,15,17,20} PPV at 93.05% was higher than other studies.^{13,14,16,17} Specificity and NPV were 53.29% and 26.02%, respectively; this was lower compared with 70.8%–99.2% specificity^{4,11–19} and 95.7%–99% NPV in other studies.^{13,14,16,17,20} High sensitivity and PPV signifies that most of the students with impaired vision were detected by the teachers. This is a good sign. But low specificity and NPV signifies that the teachers were unprepared to take any risk of missing impaired vision. This resulted in referral of many normal children that impacted the program cost and the burden.

The sensitivity of vision screening was more in male children. Specificity was higher with older age, similar to an earlier report.²¹ Contrary to couple of reports, we did not notice a statistically significant decreased sensitivity with age.^{16,21}

The specificity and NPV for ocular anomaly detection were comparatively high with cataract, 98.74%, and 99.71%, respectively. Thus, normal students were not referred unnecessarily. But the sensitivity and PPV were low. Detection of strabismus had highest sensitivity (31.45%), followed by eyelid anomalies (10.71%) and corneal problems (10.23%). Similarly, strabismus had highest PPV (25.64%) followed

by corneal problems (6.98%). This probably owes to the gross deviations, eyelid anomalies, and large visible corneal scars. Since Bitot's spot was a trivial sign, the school teachers missed the same; it had very low sensitivity (6.06%) and the least PPV (0.67%). Cataract also had least sensitivity (5.56%) and it might be due to difficulty in detection in a well-lit screening site. Despite this major disadvantage, teachers detected few ocular anomalies without additional expenditure of additional time and resources. This could have been missed if measurement of vision would have been the only focus. Hence, we suggest that screening by teachers should include detection of ocular anomalies also. We are unable to comment on the reasons for inter-age and inter-gender difference in few ocular anomalies.

Reasons for low specificity and NPV for vision screening and low sensitivity and PPV for ocular anomaly detection could include: 1) 1-day training of the teachers in both vision screening and ocular abnormality detection was probably insufficient; 2) screening by the selected teachers versus all teachers (screening by all teachers is shown to be more efficacious²²); 3) insufficient number of assigned teachers versus 1 teacher per school (Limburg et al suggested at least 1 teacher per school²); 4) assignment of male teachers contrary to suggested female class teachers wearing spectacles;² 5) using 20/30 as the cutoff vision by teachers contrary to few others who used 20/40 as cutoff^{14,15,17,19} (in our opinion, students would have difficulty reading if

Table 4 Accuracy of school teachers in the detection of other ocular anomalies

Diagnosis	Sensitivity; % (95% CI)	Specificity; % (95% CI)	PPV; % (95% CI)	NPV; % (95% CI)
Strabismus	31.45 (24.74 to 39.03)	97.51 (97.08 to 97.88)	25.64 (20.02 to 32.20)	98.12 (97.74 to 98.44)
Eye lid problem	10.71 (5.74 to 19.12)	97.53 (97.10 to 97.89)	5.81 (3.08 to 10.67)	98.71 (98.39 to 98.97)
Bitot's spot	6.06 (1.68 to 19.61)	95.00 (94.41 to 95.52)	0.67 (0.18 to 2.40)	99.46 (99.23 to 99.62)
Cornea problem	10.23 (5.47 to 18.31)	97.97 (97.57 to 98.30)	6.98 (3.71 to 12.73)	98.65 (98.32 to 98.92)
Cataract	5.56 (0.99 to 25.76)	98.74 (98.43 to 99.00)	1.32 (0.23 to 7.08)	99.71 (99.54 to 99.82)
Other ^a	31.44 (27.70 to 35.70)	55.88 (54.56 to 57.19)	6.28 (5.41 to 7.28)	89.74 (88.68 to 90.71)

Note: ^aOther includes redness, injury, and eye swelling, etc.

their PVA is <20/30); and 6) unfamiliarity of the teachers to the program, this being the first school eye screening of this magnitude in the district.

Screening by optometrist and community workers is a definite option^{2,3,23} though screening by teachers is easier in terms of compliance of the students, continuity of the program over years, and overall low opportunity cost. Additionally, teachers could better motivate children for subsequent visit to ophthalmic personnel and monitor the impact of treatment on their performance in studies.

In view of the severe shortage of trained manpower in eye care,^{24,25} use of teachers appears a better choice for this program. The teachers should be given an annual training with periodic assessment to increase the efficacy. It is prudent to train all teachers rather than selected teachers. This will also avoid the travel logistics. Taking into account the difference in geography and socioeconomic condition, the data cannot be extrapolated to the entire country, but due to the systematic methodology and effectiveness, it is replicable in the other tribal districts of the state.

Conclusion

Multistage screening is time- and cost-effective in resource-constraint setting. Assessment of efficacy of teachers in detection of other ocular anomalies besides impaired vision was done for the first time by us (PubMed search); we suggest that detection of ocular anomaly beyond refractive error should be an integral part of all program. Teachers need more training and regular evaluation for better efficacy. Our study could act as a guide for program planning to address correctable visual impairment and other ocular anomalies in children.

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Disclosure

The authors report no conflicts of interest in this work.

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