

Development and Validation of a Screening Tool for The Identification of Refractive Errors Among School Going Children In Tamil Nadu, India

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ABSTRACT

Background: The inability to focus light onto the retina, known as refractive error, is a significant cause of correctable visual impairment. Unfortunately, students' ocular complaints often go unnoticed due to a lack of awareness. To address this issue, a questionnaire with high sensitivity and reasonable specificity was developed for teachers to identify students with refractive error.

Methods: A questionnaire with surrogate indicators for refractive error in children was used and the data was analysed using SPSS. Significant markers were scored and a ROC curve determined a suitable cut-off. Sensitivity and specificity were calculated based on this cut-off.

Results: The questionnaire was developed using five variables that had a 65% probability of identifying refractive error, including copying errors, copying from peers, eye squeezing, previous use of glasses, and eye deviation. A cut-off score of 5.5 out of 14 achieved 90% sensitivity and 50% specificity in detecting refractive errors.

Conclusion: This study created a tool with five markers that demonstrated good internal consistency and content validity, it had an average sensitivity and specificity of 84% and 63%, respectively. The tool is twice as likely to identify someone with refractive error than someone without it.

Keywords: Refractive error, screening tool

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INTRODUCTION

A child's ability to see clearly is an extremely important aspect of its development especially for communication and education.¹ Refractive error that is left uncorrected has become a very big challenge to the public health programmers and makers of policy in hospital and health organisations.² Vast amounts of children, counting to 190 lakhs, have been estimated to be visually impaired all around the globe out of which, close to 120 lakhs are due to refractive errors which can be treated.³ Children in whom the problem is left uncorrected, seem to perform poorly on a large number of cognitive and motor tests when compared with children who have either corrected vision or those unaffected by refractive errors, with attendant implications for general development and educational performance.⁴ While there are programs in schools that serve the purpose of screening and treating illness including these refractive errors, they are not too frequent and can be overwhelming at times and therefore are not efficient enough to deliver timely services.⁵ Active screening and timely intervention will help in restoration of proper eyesight which will further impact the child's overall growth and development.^{6,7} In 1960, the Government of India developed a plan and advised schools to medically examine all the children at the time of admission, but this has hardly been practiced in India.⁸ It has been observed that the school children in their teen years are more affected by refractive errors than their younger counterparts,⁹ this is a demographic in which screening tools, in the form of questionnaires, can be very effective as they can vocalise these problem. This study was designed to develop a questionnaire which has high sensitivity and reasonable specificity to identify students with refractive error in order to reduce the burden of the disease in this population and thereby enable school programs and other hospitals to cater to the population that actually requires care. Our objective was to develop a validated 5-item screening tool to screen Tamil speaking school students with refractive errors.

METHODOLOGY

A population based cross sectional study was done among school going children in Model Rural Health Research Unit's (MRHRU) field practice area. MRHRU is a rural research scheme initiated by the Department of Health Research. Located in Tirunelveli this unit is mentored and administrated by the National Institute of Epidemiology and Tirunelveli Medical College and Hospital. The field practice area comprised of 3851 children in the age group of 5-19 years studying in 35 schools, spread across two blocks in Tirunelveli District. Camps were conducted in each school with prior permission from all responsible authorities in the district and school. 3432 students who were present on the day of the camp, with their parents or guardians, were examined after

they gave their consent and ascent to participate.

A study questionnaire was developed by the ophthalmologists involved in the study to collect data on surrogate markers of refractive errors found among school children, along with the socio-demographic characteristics. In order to diagnose refractive errors, various examinations were done including Snellen's chart in both English and Tamil. In children of lower grades who were not able to read Snellen's letter chart, tumbling E chart was used. Retinoscopy and subjective correction were done for all children.

Prevalence of refractive errors were calculated in percentage, after which the surrogate markers for refractive errors were calculated using chi-squared test to develop multiple screening tools with the most relevant and most significant items arranged in various combinations of 5. The tool which had the highest area under the curve as given by the Receiver Operating Characteristic Curve (ROC) was tested for content validity by calculating Individual- content validity scores (I-CVI) and Sum- Content validity score (S-CVI). The reliability of the questionnaire was measured using Cronbach's alpha after translating the tool to Tamil which was later piloted on two sets of thirty students for detecting the sensitivity and specificity of the tool.

Ethical committee approval for the study was obtained from Tirunelveli Medical College and Hospital's ethical committee (IEC REF NO- 1299/CM/2018). The data collected from the students were stored in a secure server, after the removal of the identifiers (E.g., Name, Phone Number, Aadhaar, etc).

RESULTS

A total of 3432 children were screened between the ages of 5 and 19 years. Out of them, 1659 (48.30%) were boys. 1893 (55.15%), 1463 (42.64%) and 76 (2.21%) children were in the age groups of 5 to 9 years, 10 to 14 years, 15 to 19 years respectively. 53.61%, 28.05%, 17.01% and 1.31% of the students were studying in primary, middle, secondary and higher secondary schools respectively.

Refractive errors: Refractive error was found in 351 (10.2%) students, of which, Simple myopia was most predominant n = 299 (85.18%), while 24 (6.8%) had simple myopic astigmatism, 8 (2.27%) had simple hypermetropia.

Several surrogate markers such as, spelling mistakes while copying from board, habit of copying notes from neighbouring student, squeezing eyes to see things clearly, having head ache for more than thrice a week and sitting in the first bench to see the board clearly showed strong association to refractory errors (Table 1), the surrogate markers that showed a strong significance (P<0.001) were grouped in to several combinations of five, the five markers with the highest AUC ROC score (in this case it was 65%) (Figure 1) was considered.

Table 1: Inferential table showing association between Refractive Errors and Surrogate Markers

Surrogate Markers	Refractive Error (%)	No Refractive Error (%)	P-value
Do you prefer to sit in 1st row as you could not see blackboard clearly?			
Always	36 (31.6)	78 (68.4)	<0.001
Sometimes	65 (28)	167 (72)	
Never	250 (8.1)	2836 (91.9)	
Do you get spelling mistake while coping from board?			
Always	10 (47.6)	11 (52.4)	<0.001
Sometimes	80 (25.5)	234 (74.5)	
Never	261 (8.4)	2836 (91.6)	
Do you have the habit of copying notes from neighboring child rather than nothing down from black board?			
Always	17 (47.2)	19 (52.8)	<0.001
Sometimes	64 (26.9)	174 (73.1)	
Never	270 (8.5)	2888 (91.5)	
Do you have headache on returning from school for more than thrice in a week?			
Yes	46 (29.9)	108 (70.1)	<0.001
No	305 (9.3)	2973 (90.7)	
Do you play games outdoor daily for more than an hour?			
Always	116 (10.4)	1001 (89.6)	<0.001
Sometimes	87 (7)	1148 (93)	
Never	148 (13.7)	932 (86.3)	
Do you spend daily more than one hour per day at home watching cell phone/ television?			
Always	90 (11.3)	706 (88.7)	0.383
Sometimes	131 (9)	1330 (91)	
Never	130 (11.1)	1045 (88.9)	
Do you have the habit of watching Television sitting close by within a feet distance?			
Always	55 (19.9)	222 (80.1)	<0.001
Sometimes	66 (7.1)	861 (92.9)	
Never	230 (10.3)	1998 (89.7)	
Do you squeeze your eyes for seeing things clearly?			
Always	16 (40)	24 (60)	<0.001
Sometimes	35 (18.6)	153 (81.4)	
Never	300 (9.4)	2904 (90.6)	
Have you ever used spectacles previously?			
Always	32 (66.7)	16 (33.3)	<0.001
Sometimes	27 (43.5)	35 (56.5)	
Never	292 (8.8)	3030 (91.2)	
Was spectacles worn throughout the day?			
Always	28 (71.8)	11 (28.2)	<0.001
Sometimes	27 (61.4)	17 (38.6)	
Never	4 (14.8)	23 (85.2)	
Did you discontinue / not use spectacles which was advised to you?			
Always	9 (45)	11 (55)	0.549
Sometimes	16 (64)	9 (36)	
Never	34 (52.3)	31 (47.7)	
Has someone mentioned you that you have deviation of eyes?			
Always	1 (12.5)	7 (87.5)	<0.001
Sometimes	7 (19.4)	29 (80.6)	
Never	343 (10.1)	3045 (89.9)	
Do you tilt your head to see things clearly?			
Always	1 (20)	4 (80)	0.307
Sometimes	7 (14.3)	42 (85.7)	
Never	343 (10.2)	3035 (89.8)	
Have you ever noticed drooping of eyes in your picture?			
Always	0 (0)	4 (100)	0.444
Sometimes	1 (3.1)	31 (96.9)	
Never	350 (10.3)	3046 (89.7)	
If yes, does this drooping increase during night?			
Always	0 (0)	1 (100)	0.533
Sometimes	0 (0)	9 (100)	
Never	1 (3.8)	25 (96.2)	
Do you often develop painful swelling over eyes once every 2 months?			
Always	4 (14.8)	23 (85.2)	0.833
Sometimes	347 (10.2)	3057 (89.8)	
Never	0 (0)	1 (100)	
Do you have watering of eyes?			
Always	4 (15.4)	22 (84.6)	0.007

Surrogate Markers	Refractive Error (%)	No Refractive Error (%)	P-value
Sometimes	21 (15)	119 (85)	
Never	326 (10)	2940 (90)	
Did you have injury to eye with sharp objects like pencil, needle or thorn?			
Always	1 (25)	3 (75)	0.716
Sometimes	8 (9.3)	78 (90.7)	
Never	342 (10.2)	3000 (89.8)	
Did you have injury to eye with blunt objects like ball?			
Always	0 (0)	2 (100)	0.001
Sometimes	12 (25.5)	35 (74.5)	
Never	339 (10)	3044 (90)	
Do you have difficulty in seeing normal ambient light?			
Always	3 (12.5)	21 (87.5)	0.058
Sometimes	14 (17.5)	66 (82.5)	
Never	334 (10)	2994 (90)	
Do you take any medications continuously for more than 3 months?			
Yes	0 (0)	3 (100)	0.526
No	351 (10.2)	3078 (89.8)	
Have you undergone any previous eye surgery?			
Yes	1 (7.1)	13 (92.9)	0.586
No	350 (10.2)	3068 (89.8)	
Do you have the habit of bumping into objects?			
Always	1 (100)	0 (0)	0.008
Sometimes	0 (0)	17 (100)	
Never	350 (10.3)	3064 (89.7)	
Do you have difficulty in seeing things during night?			
Always	0 (0)	6 (100)	0.228
Sometimes	9 (16.4)	46 (83.6)	
Never	342 (10.1)	3029 (89.9)	
Does any of your parents use thick spectacles?			
Yes	14 (15.4)	77 (84.6)	0.04
No	337 (10.1)	3004 (89.9)	

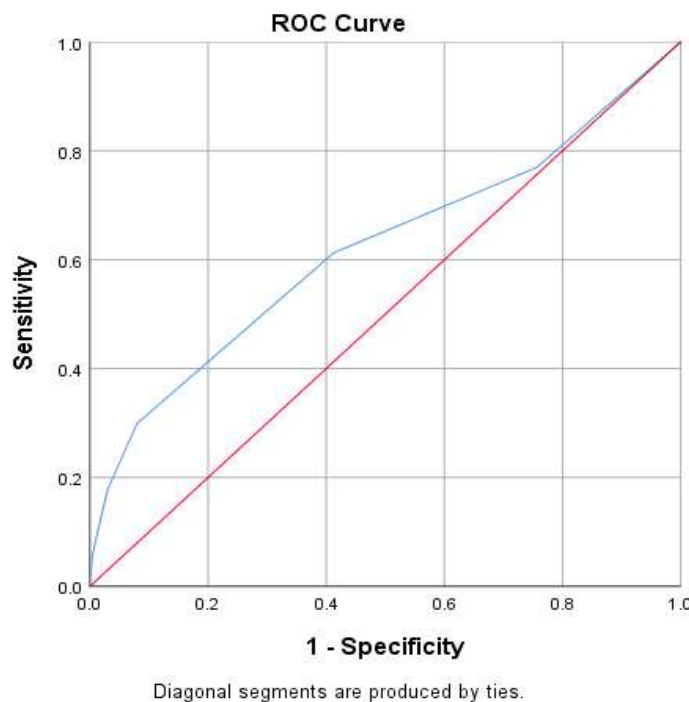


Figure 1: ROC curve for questionnaire

The tool that was found to have high predictive probability to the outcome was taken, a cut-off of 2 was determined based on the scores given by the curve, which had a sensitivity of 78, and specificity of 80. Further the tool was translated into Tamil and

then back to English translated to check for the consistency of the translation. (Annexure 1)

Content validity of the tool was determined by sharing the tool with 4 experts in ophthalmology and ask-

ing them to rate each item on their relevancy to the topic which is identification of refractive error. I- CVI for 3 items was 1 and for two items it was 0.75, S-CVI/ average was 0.9. Cronbach's alpha for internal consistency was acceptable levels of 0.72.

The validated tool was then piloted on two sets of thirty children in a school in Tirunelveli, who be-

longed to classes 4-5 and 6-8 respectively. The sensitivity of the tool in the first and second group were 88.23 (63.56 – 98.54) and 80 (28.36-99.49). While the specificity of the tool was 61.53 (31.58 – 86.14) and 60 (38.67 -78.87). The positive likelihood ratios in the first and second groups were 2.29 and 2 respectively.

Table 3: Content Validity

	Rater 1	Rater 2	Rater 3	Rater 4	Number Agreement	I-CVI
Item 1	2	3	3	3	3	0.75
Item 2	2	3	3	3	3	0.75
Item 3	3	3	3	3	4	1
Item 4	3	3	3	3	4	1
Item 5	3	3	3	3	4	1
					S-CVI/Avg.	0.9
					Total Agreement	3
					S-CVI/UA	0.6

*Item 1- Do you get spelling mistake while coping from board?

*Item 2- Do you have the habit of copying notes from neighbouring child rather than nothing down from black board?

*Item 3- Do you squeeze your eyes for seeing things clearly?

*Item 4- Do you have headache on returning from school for more than thrice in a week?

*Item 5- Do you prefer to sit in 1st row as you could not see blackboard clearly?

Table 4: Sensitivity and Specificity

Group	Sensitivity (95% CI)	Specificity (95% CI)	Accuracy (95% CI)	Positive Predictive Value	Negative Predictive Value	Likely Hood Ratio (LR+, LR-)
Group I (n=30)	88.23 (63.56 – 98.54)	61.53 (31.58 – 86.14)	76.6 (57.72 – 90.07)	75 (59.61 – 85.91)	80 (50.38 – 94.03)	2.29, 0.19
Group II (n=30)	80 (28.36-99.49)	60 (38.67 -78.87)	63.3 (43.86 – 80.07)	28.57 (17.27 – 43.38)	93.75 (71.63 – 98.89)	2, 0.33

DISCUSSION

This study wanted to address the issue of uncorrected refractive error, which can have negative impacts on a child's development, including cognitive and motor performance, as well as educational achievement. While schools may have programs for screening and treating illness, including refractive errors, they may not be efficient enough to deliver timely services. Therefore, the study aimed to develop a validated 5-item screening tool to screen Tamil speaking school students with refractive errors. No study was found on the internet, through literature search, which had tried to develop a screening tool for detecting refractive errors, which essentially makes this study novel.

The study found that 10.2% of the screened children had refractive errors, with simple myopia being the most predominant type. Several surrogate markers showed a strong association with refractive errors, including spelling mistakes while copying from the board, copying notes from neighbouring students, squeezing eyes to see things clearly, having a headache more than three times a week, and sitting in the first bench to see the board clearly. The tool with the highest AUC as given by the Receiver Operating Characteristic Curve (ROC) was used for further validity testing, in our case the AUC was 65%. The reli-

ability as measured using Cronbach's alpha, after translating the tool to Tamil, was at acceptable levels of 0.72 according to six factor model.¹⁰ Items 3-5, of the five-item questionnaire, was considered relevant as per the calculations. For checking the validity of the tool, content validity was performed by experts. The I-CVI of the tool was found to be 0.75 for items 1 and 2, 1 for items 3-5. Items with I-CVI values between 0.70 and 0.79 are considered to require revision, while items with an I-CVI greater than 0.79 are deemed relevant.¹¹, although an article by Jingcheng Shi et al claims an I-CVI of 0.78 and above is satisfactory.¹² The Universal Agreement method though only considers items that have an I-CVI of 1.00 and this may be considered more comprehensive than the average approach. This method may be underestimating content validity of the overall questionnaire since the likelihood of achieving 100% agreement in all items decreases when the number of experts increases. The alternative and less constricted method are the S-CVI/Ave approach. Both the S-CVI/UA and the S-CVI/Ave were calculated and The Universal Agreement approach suggested the overall content validity of the tool was moderate (S-CVI/UA = 0.6), while the average method suggested high content validity (S-CVI/Ave = 0.9).^{13,14,15}

This tool was later piloted on two sets of thirty students for detecting the sensitivity and specificity of

the tool. The questionnaire was found to be reliable and valid after its translation to Tamil after piloting. The sensitivity of the tool in the first and second group were 88 and 80. While the specificity of the tool was 62 and 60. The likelihood ratio was 2 on both the occasions. When a test has a sensitivity of 0.8 or 80% it can correctly identify 80% of people who have the disease, but it misses 20%. A test that has an 60% specificity can correctly identify 60% of people in a group that do not have a disease, but it will misidentify 40% of people.¹⁶ A positive likelihood ratio, or LR+ of the test was 2.29 and 2 on two occasions, an LR+ is the true positivity rate divided by the false positivity rate, someone who is screened positive to have refractive error through this tool is 2 times as likely to be actually diagnosed to have refractive error than someone with a negative test. The negative likelihood ratio LR- (0.19,0.33) can be interpreted as a person who is actually diagnosed to have refractive error through traditional means will be either 0.33 or 0.19 times likely to be screened negative for refractive error through this tool, and similar to sensitivity and specificity, likelihood ratios are not impacted by disease prevalence.^{16,17,18,19}

LIMITATIONS

The study was conducted only in a specific rural area of Tirunelveli district in India, which may limit the generalizability of the findings to other populations with different demographics and geographical locations.

The study relied on surrogate markers of refractive errors, which may not always accurately reflect the presence or severity of refractive errors.

The sample size of the study was limited to 3432 children, which may not be representative of the entire population of school-going children in the area.

The study was cross-sectional in design, which means that causal relationships between the surrogate markers and refractive errors cannot be established.

The study only assessed the validity and reliability of a 5-item screening tool in Tamil-speaking school students, which may not be applicable to students who speak other languages or attend schools outside of the study area.

CONCLUSION

The tool developed by this study has 5 markers, viz. spelling mistakes while copying from board, habit of copying notes from neighbouring student, squeezing eyes to see things clearly, having head ache for more than thrice a week and sitting on the first bench to see the board clearly were taken to form a tool that has a cut off of 2, and has acceptable levels of internal consistency and content validity. The average sensi-

tivity and specificity of the tool tested on two different occasions has been calculated to be 84%, 63% respectively. This tool is twice as likely to find the diseased as compared to the non-diseased.

BENEFITS

All the students who were diagnosed to have refractive error through the study were given glasses through the Tamil Nadu government's scheme "Palli Sirar Kannoli Kappom Thittam".

RECOMMENDATIONS

Regular screening for refractive errors in school will be the best solution to prevent complications due to uncorrected refractive errors. This tool can be used for screening students before they are screened by traditional methods, as this does not require a trained optometrist to screen children for refractive errors, within a few minutes.

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Annexure 1

1. கரும்பலகையில் இருந்து பார்த்து எழுதும்போது எழுத்துப் பிழை ஏற்படுமா?
 - a. எப்பொழுதும் (0)
 - b. எப்பொழுதாவது (2)
 - c. என்றமில்லை (1)
2. நீங்கள் கரும்பலகையை பார்த்து எழுதுவதை தவிர்த்து அருகில் இருப்பவரின் நோட்டு புத்தகத்தை பார்த்து எழுதும் பழக்கம் உள்ளவரா?
 - a. எப்பொழுதும் (0)
 - b. எப்பொழுதாவது (2)
 - c. என்றமில்லை (1)
3. பொருட்களோ/எழுத்துக்களோ தெளிவாகப் பார்ப்பதற்காக உங்கள் கண்களை குறுக்கி பார்க்கும் பழக்கம் உள்ளவரா?
 - a. எப்பொழுதும் (0)
 - b. எப்பொழுதாவது (2)
 - c. என்றமில்லை (1)
4. நீங்கள் பள்ளியை விட்டு வீட்டிற்கு வரும்போது வாரத்தில் மூன்றிற்கும் மேற்பட்ட முறை தலைவலி ஏற்படுகிறதா?
 - a. ஆம் (3)
 - b. இல்லை (0)
5. நீங்கள் கரும்பலகை தெளிவாக தெரியாத காரணத்தினால் வகுப்பில் முதல் வரிசையில் அமரும் பழக்கம் உள்ளதா?
 - a. எப்பொழுதும் (0)
 - b. எப்பொழுதாவது (2)
 - c. என்றமில்லை (1)