Validity of vision screening by school nurses in seven regions of Oman

R. Khandekar,[1] S. Al Harby,[1] T. Abdulmajeed,[1] S.A. Helmi[2] and I.S. Shuaili[3]

مدى الصحة في عملية تحرِّي ممرضات المدارس للقدرة البصرية في سبع مناطق في عُمان

راجيف خانديكار، صالح الحربي، طلعت عبد المجيد، سحر عبد الحليم، عيسى شويلي

الخلاصة: درس الباحثون مدى صلاحية قيام الممرضات العاملات في المدارس بتَحَرِّي القدرة البصرية للتلاميذ في سبع مناطق في عُمان عام 2003. وقد فحص باحثان 1719 تلميذاً ممن تم اختيارهم عشوائياً من المرحلة الدراسية الرابعة وذلك باستخدام اختبار القدرة البصرية بحسب شنين E. وقد سبق لممرضات المدارس المتدرِّبات أن تحرّوا 233 182 تلميذاً. فأُجريت مقارنة للحالة الإبصارية في الدراستَيْن. وقد تبيَّن أن حساسية التحرِّي لدى الممرضات بلغت 68.34٪ (67.30 - 96.38) وبفاصلة ثقة مقدارُها 95٪. في حين بَلَغَت النوعية 99.23٪ (99.19 - 99.27) وبفاصلة ثقة مقدارُها 95٪، وكانت القيمة التنبؤية الإيجابية 85.42٪ (84.63 - 86.21) بفاصلة ثقة مقدارُها 95٪ والقيمة التنبؤية السلبية 97.93٪ (97.87 - 98.00) بفاصلة ثقة مقدارُها 95٪. وقد كانت حساسية اختبار الإبصار أعلى بشكل ملحوظ عند الإناث وكبار التلاميذ، وفي المنطقة الشرقية الشمالية. وبشكل عام فإن تحرِّي الإبصار لتلاميذ المدارس في عُمان يتمتَّع بدرجة من الصحة تبعث على الرضى. ويرى الباحثون أن التدريب الدوري للممرضات والإشراف على إجراءات التحرِّي يمكن أن تحسِّن من الحساسية، أما الأسباب الكامنة وراء الأعداد المرتفعة للحالات السلبية عند الإناث فتحتاج لمزيد من الاستقصاءات.

ABSTRACT We tested the validity of vision screening in schools in 7 regions of Oman in 2003. Two researchers tested 1719 randomly selected students in 4 school grades using the Snellen E acuity test. Trained school nurses had previously screened 182 233 students. The visual status recorded in the 2 screenings was compared. Sensitivity of screening by nurses was 68.34% (95% CI: 67.30–69.38) and specificity 99.23% (95% CI: 99.19–99.27). The positive predictive value was 85.42% (95% CI: 84.63–86.21) and negative predictive value was 97.93% (95% CI: 97.87–98.00). The sensitivity of the vision test was significantly higher in females, older students and in North Sharqiya region. In general, the vision screening of school students in Oman has satisfactory validity. Periodic training of nurses and supervision of the screening procedures could improve its sensitivity. Underlying causes of the high numbers of false negative cases should be further investigated.

Validité du dépistage visuel réalisé par des infirmières scolaires dans sept régions d'Oman

RÉSUMÉ Nous avons testé la validité du dépistage visuel dans des écoles de sept régions d'Oman en 2003. Deux chercheurs ont testé 1719 élèves choisis de manière aléatoire dans quatre classes à l'aide du test de Snellen (test du E). Des infirmières scolaires formées avaient examiné auparavant 182 233 élèves. Le bilan visuel noté lors des deux examens a été comparé. La sensibilité de l'examen visuel réalisé par les infirmières était de 68,34 % (IC 95 % : 67,30-69,38) et la spécificité de 99,23 % (IC 95 % : 99,19-99,27). La valeur prédictive positive était de 85,42 % (IC 95 % : 84,63-86,21) et la valeur prédictive négative était de 97,93 % (IC 95 % : 97,87-98,00). La sensibilité du test de vision était significativement plus élevée chez les filles, chez les élèves plus âgés et dans la région septentrionale de Sharqiya. De manière générale, le dépistage visuel des écoliers et écolières à Oman avait une validité satisfaisante. La formation périodique des infirmières et le contrôle des procédures d'examen pourraient améliorer sa sensibilité. Les causes sous-jacentes du nombre élevé de cas faux négatifs devraient faire l'objet d'études approfondies.

[1]Eye and Ear Health Care Department; [2]School Health Department, Directorate General of Health Affairs; [3]Department of Noncommunicable Diseases, Ministry of Health, Muscat, Oman.
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Introduction

Despite the widespread acceptance of vision screening programmes as a means of detecting ocular disorders in children, there has been little formal assessment of their validity and reliability [*1*]. This is more challenging as different methods are used for vision screening, e.g. the Snellen letter acuity and Modified Clinical Technique vision screening kits, the Random Dot E stereogram and the hand-held autorefractor [*2*].

A study to assess the predictive ability of school screening programmes suggested the need for a detailed prospective study to review predictability of both test-positive and test-negative findings [*3*]. In our study, the validity of the school vision screening programme was evaluated using specificity and sensitivity parameters. First level screening was performed by trained nurses and was compared with screening by practising optometrists. Validating vision screening by estimating the number of false negatives was also done [*4*].

In Oman, the eye health care programme is aimed at the early detection of common and blinding eye diseases. Hence, trained nurses conduct vision screening annually, targeting students in 4 grades in all schools in Oman. Refractionists in each region recheck the students shortlisted with defective vision, refract them in schools and prescribe visual aids [*5*]. In 2002, the number of students with defective vision referred by nurses and subsequently found to be normal was high for 1st primary students but lower for 1st secondary students [*6*]. Rapid turnover of the health staff involved in this activity has raised serious doubts concerning the quality of the screening procedures. The programme therefore evaluated the validity of vision screening using sensitivity and specificity parameters, reviewed the predictability of vision screening for detection of refractive error and recommended steps to further strengthen the vision screening activities.

Methods

We carried out a cross-sectional agreement study on 182 233 students in 7 regions of Oman during school year 2002–2003. The study population was from 4 school grades: 1st primary (6–7 years), 4th primary (9–10 years), 1st preparatory (12–13 years) and 1st secondary (16–17 years).

The list of schools in each region and the number of students in each grade were provided by the Ministry of Education. The visual status of a randomly selected sample was examined by the study investigators. The visual status of the same students that had been noted by the school nurses during school year 2002–2003 was recovered from school health records.

Hypothesis: the vision screening done by school health staff matched the supervisor's screening in 90% or more of students. Null hypothesis: the vision screening done by school health staff does not match the supervisor's screening in 90% or more of the students.

The study aimed to achieve a goal of 90% power of the study and 95% significance level among a study population which ranged from 15 000 to 45 000 per region. With an acceptable error of 7%, the sample required was 137. To compensate for the clustering effect of students in selected schools and to cover loss of data, the sample was multiplied by a factor of 1.8. Thus, the minimum sample in each region was 250.

The list of schools was used to randomly select 4–6 schools in each region. Since the proportion of male and female students is almost equal, equal numbers of boys' and girls' schools were selected. In each

school, 1 class from each grade was randomly selected. If the class had less than 50 students, an additional sample was enrolled from another randomly selected class of the same grade. The aim was to enrol and examine 50 students in all 4 grades in 1 region and give an equal opportunity to all students of that grade in the school to participate in the study.

The field staff comprised 2 national eye health care supervisors who had at least 5 years of experience of vision screening.

The vision testing procedure and method of response were explained to all students. Each student then was called according to his or her serial number. The Snellen distant vision E chart was placed 6 metres away from the student. The vision of the right eye was tested first followed by the left and the results immediately noted on a standard form. Personal details of the students such as age, sex, area of residence and visual status of each eye with and without visual aids were collected. History of check-ups by an optician or ophthalmologist was obtained from students who had defective vision.

The school nurse had tested vision 3 months prior to the study and the visual status of each student had been recorded in the student's health booklet. These records were referred to after the vision testing was completed by the supervisors.

Definitions: if vision screening in 1 eye was found to have no more than 1 line difference in the 2 screenings, it was defined as being in agreement. If vision screening in 1 eye differed by more than 1 line in the 2 screenings, the vision screening of that student was defined as being in disagreement. The disagreement was further graded according to the difference in visual status. Sensitivity was defined as ability of vision screening by the nurse to correctly identify the students with defective vision. Specificity was defined as ability of vision screening by the nurse to correctly identify the students without defective vision. Positive predictive value was defined as ability of vision screening to correctly predict cases of defective vision among students with suspected defective vision. Negative predictive value was defined as ability of the test to correctly predict students without defective vision among those declared to have normal vision.

The data was computed using *EpiData*. Univariate analysis was conducted using *SPSS*, version 11. Agreement and disagreement rates per student were calculated. The sensitivity, specificity, false positives, false negatives, positive predictive and negative predictive values of the vision screening were estimated. The rates of validity parameters were projected for the study population. They were also adjusted by sex, school grade and region using indirect standardization. The determinants of these parameters by sex, school grade and region of residence were also evaluated. The frequencies, percentage proportions, odds ratios and 95% confidence intervals were estimated to validate the results.

To ensure a high and uniform quality of the study, a standardization workshop was conducted for the field staff. A pilot study was carried out in schools not selected for the study; on the basis of the pilot study, the methodology, data collection form and data entry format were revised. Field staff having at least 5 years experience in vision screening and supervision work were selected for the study. The study was supervised by the study investigators at various stages. During the pilot study, inter-observer variation was evaluated and was found to be minimal. The supervisors' skills in vision screening were also compared to those of optometrists and were found to match.

The authorities in the Department of School Health, Ministry of Health and Ministry of Education were approached and their consent was obtained for the study. Verbal consent of school principals was also taken. The results of the study were used to improve the vision screening of students. The results were also distributed to regional health authorities and health managers of related health programmes.

Due to logistic problems, the study could not be conducted in Dhofar, Musundam and Al Wousta regions of Oman. Hence, the result of the study should be extrapolated to the whole of Oman with caution. There was a gap of around 3 months between the vision screening done by the nurse and that done by the supervisors. It is assumed that vision status between the 2 screenings had not changed in most of the students. However, a marginal increase in refractive error or progress in pathology causing further deterioration of visual status in a limited number of cases cannot be ruled out.

Results

The profile of the study population and the sample we examined is given in Table 1. The total study population comprised 182 233 students in 4 school grades in 7 regions of Oman during the school year 2002–2003. We enrolled a sample of 1720 students as participants in our study. One student did not complete the vision testing as he had to leave the school. Of the 1719 students examined, 861 (50.1%) were male and 858 (49.9%) were female. The sample was evenly distributed between the 4 grades and the 7 health regions. The proportion of the study population and the sample differed by region so adjusted rates should be used for comparison.

Table 1 **Profile of the study population and the sample**

Variable	Study population (*N* = 182 233)		Sample (*n* = 1719)	
	No.	%	No.	%
Sex				
Male	94 276	51.7	861	50.1
Female	87 957	48.3	858	49.9
School grade				
1st primary	40 437	22.2	415	24.1
4th primary	48 396	26.6	416	24.2
1st preparatory	51 043	28.0	479	27.9
1st secondary	42 357	23.2	409	23.8
Region				
Muscat	34 056	18.7	250	14.5
Dhakhiliya	29 101	16.0	237	13.8
North Sharqiya	14 542	8.0	255	14.8
South Sharqiya	15 750	8.6	228	13.3
North Batinah	45 280	24.8	235	13.7
South Batinah	26 621	14.6	259	15.1
Dhahirah	16 883	9.3	255	14.8

The vision of 1599 students (93.0%) was 6/6 in both eyes in both screenings. In 74 (4.30%) students, vision was impaired in at least 1 eye. In 13 (0.76%) students, the screening by the nurse suggested impaired vision but screening by the supervisor showed 6/6 vision. In 33 (1.92%) students the screening by the nurse suggested either 6/6 or 6/9 vision, but on re-screening by a supervisor, these students were found to have a higher grade of defective vision. Based on these findings, we calculated validity parameters for the sample and for the study population as a whole. For the statistical validation, 95% confidence intervals were also estimated (Table 2).

The validity parameters of vision screening by sex are given in Table 3. The specificity of screening was high for both sexes. However, the sensitivity of vision

Table 2 **Parameters of validity**

Parameter	No.	Crude OR	Adjusted OR	95% CI
True positives	74	4.30	4.24	3.79–4.69
False positives	13	93.02	93.07	92.95–93.19
False negatives	33	0.76	0.72	0.26–1.18
True negatives	1599	1.92	1.96	1.51–2.41
		%	%	
Sensitivity		69.16	68.34	67.30–69.38
Specificity		99.19	99.23	99.19–99.27
Positive predictive value		85.06	85.42	84.63–86.21
Negative predictive value		97.98	97.93	97.87–98.00

Rates are adjusted for sex, school grade and region.
The false positive rate was 13/1719 × 100 = 0.76%.
The false negative rate was 33/1719 × 100 = 1.92%.
OR = odds ratio; CI = confidence interval.

screening was significantly higher in female than in male students.

The agreement and disagreement rates for 1st primary and 4th primary were determined and compared to those for 1st preparatory and 1st secondary students (Table 4). The screening of students in higher grades by school nurses had significantly higher specificity than that for primary students.

Table 3 **Validity of vision screening by sex**

Variable	Males (*n* = 861) No.	%	Females (*n* = 858) No.	%
True positives	32	4.0	42	4.5
False positives	2	0.3	11	1.2
False negatives	18	2.2	15	1.7
True negatives	809	93.5	790	92.6
	% (95% CI)		% (95% CI)	
Sensitivity	64.87 (63.35–66.39)		72.09 (70.68–73.49)	
Specificity	99.73 (99.69–99.76)		98.69 (98.62–98.77)	
Positive predictive value	94.02 (93.29–94.75)		78.46 (77.32–79.60)	
Negative predictive value	97.72 (97.62–97.81)		98.17 (98.08–98.26)	

Rates are adjusted for school grade and region.
CI = confidence interval.

The validity parameters (adjusted for sex and school grade) for each region were compared (Table 5). Sensitivity ranged from 57.29% in Dhahirah to 80.08% in North Sharqiya.

Discussion

After 10 years of annual vision screening in schools, a review was needed. Our study tested the validity of vision screening. On the basis of our results, the programme would be able to strengthen the strategy for reducing eye strain in schoolchildren. Thus, the study was crucial for the eye care programme.

Since the sample was evenly distributed in all regions and the number of school students varied in different regions and grades, the study results were adjusted before outcomes of variants were compared. This also helped to minimize the confounding effects of school grade, sex, region and other related confounders on the validity.

The cooperation of students could be the effect modifiers in such a study [*7*]. Proper explanation of the procedures along with help from teachers ensured the full cooperation of all participants.

The vision screening done by the nurses had a specificity of 99.23%. Thus, vision screening by nurses could accurately identify students who did not have vision defects. The test had 68.34% sensitivity. Thus, the vision screening procedures missed a substantial proportion of students with defective vision.

In a study in New York State in the United States of America (USA), using a vision screening battery, the Snellen test was 100% specific but it missed 75.5% of the children found to have vision problems when given a complete visual examination [*8*]. Although the methodology is different in the 2 studies, our study had a higher rate of specificity and a relatively low sensitivity. The World Health Organization has recommended that vision screening should

Table 4 **Validity of vision screening by school grade**

Variable	1st & 4th primary (*n* = 831)		Preparatory and secondary (*n* = 888)	
	No.	%	No.	%
True positives	14	1.67	60	6.68
False positives	4	0.53	9	0.91
False negatives	11	1.36	22	2.54
True negatives	802	96.43	797	89.87
	% (95% CI)		**% (95% CI)**	
Sensitivity	55.08 (52.55–57.61)		72.49 (71.39–73.60)	
Specificity	99.45 (99.40–99.50)		99.00 (98.93–99.07)	
Positive predictive value	75.87 (73.97–77.76)		88.06 (87.30–88.81)	
Negative predictive value	98.61 (98.53–98.68)		97.26 (97.15–97.36)	

Rates are adjusted for sex and region.
CI = confidence interval.

Table 5 **Validity of vision screening by region**

Region	Specificity (%)	Sensitivity (%)	Positive predictive value (%)	Negative predictive value (%)
Muscat	67.64	98.92	84.21	97.30
Dhakhiliya	75.84	99.19	84.23	98.55
North Sharqiya	80.08	97.83	73.22	98.51
South Sharqiya	67.38	98.52	74.00	97.97
North Batinah	62.71	98.72	75.25	97.71
South Batinah	74.78	99.98	99.61	98.29
Dhahirah	57.29	99.97	99.09	97.53

Rates are adjusted for sex and school grade.

have at least 80% specificity and sensitivity for it to be cost-effective (A. Choudhury, unpublished data, 2003).

Vision screening of 652 elementary students by lay volunteers was compared to that of optometrists in the USA. The Modified Clinical Technique was used in this study. It showed 5.5% false positives and 4.3% false negatives [*9*]. Our study had a very low number of false positives (0.76%) and false negatives (1.92%). Considering a difference of 1 line as normal in our study could be a lenient criterion resulting in these low rates.

There is no evidence to suggest that a more complex protocol would improve the detection of ocular disorders in screening. Rather, a more effective implementation of the current screening procedure gives better results [*1*]. In our study, simple vision testing methods were used and still had valid outcomes. This is in agreement with the observations of earlier studies [*1,9*].

In view of the shortage of qualified opticians, it would be impossible to screen the large number of children in the present school population. Wong found that following an educational programme and collaboration with optometrists, nurses were able to correctly refer a high percentage of children [*10*]. Therefore, first level screening should be conducted by nurses or other school staff trained in such procedures. Oman has adopted a similar model of using simple vision screening tools, annual training of nurses and active supervision by opticians. This has resulted in a reasonable quality of screening. Countries with limited resources should focus on strengthening vision screening procedures using similar models and strategies instead of investing in costly equipment and using complicated screening methods.

Bailey compared vision screening procedures done by optometric students with those done by licensed opticians using the Modified Clinical Technique. They were found to have less satisfactory validity. It was proposed that the limited experience of the first level vision screeners was mainly responsible for the low predictive ability of this test [*3*]. The staff involved in our study had been trained in vision screening frequently. This could have accounted for the high validity in our study.

Vision screening of schoolchildren in many states of the USA has suggested that even if different procedures and criteria are used, school screening may show a false positive rate of 30% or more [*11,12*]. In

our study, the rate for false positives and false negatives was less than 2%. The low rate of refractive error and the high quality of vision screening in our study could account for these observations.

The vision screening carried out by nurses could accurately predict the presence of refractive error in almost 70% of the students with this problem. The number of students declared as having normal vision by a nurse after vision screening was almost 98% accurate. This high rate could be due to the large number of students in our study sample who did not have defective vision.

Refractive errors, which often become manifest during school age, rarely carry any serious prognostic implications. Experts disagree on whether an uncorrected refractive error that would be detected by screening has any adverse effects on academic performance in school-age children [*13,14*]. Hence, the 1.92% asymptomatic refractive error cases that were missed in schools might be of minimal importance.

The sensitivity of vision screening in our study was significantly higher for female than for male students. Differences in the attitudes of male and female students to cooperating with female nurses and male supervisors could be responsible for this observation.

Refractive error may be marginal in children of primary-school age compared to students in preparatory and secondary grades. Difference in prevalence in these 2 groups of students and differential understanding of vision screening procedures may have resulted in high specificity in students of higher grades.

Differences in the training of the nurses as well as in the quality of vision screening by different nurses could account for the regional variation in the validity.

Vision screening by nurses and second level screening performed by school refractionists in Oman is similar to the model proposed in the USA [*15*]. This would certainly reduce unnecessary referrals to the ophthalmologist.

Vision screening in schools by trained nurses in a large part of Oman has very high validity. However, false negative cases observed in this study could be further reduced through vigilant screening. Further operational research is needed to determine yield and efficiency for the low rate of refractive error cases in 1st primary grade.

Recommendations

Vision screening in schools is an important strategy in many countries to detect and manage defective vision in the early stages. The use of primary staff for first level screening needs to be validity tested. In Oman, screening sensitivity was 68.3% and specificity 99.2.% The large number of false negative cases compromised the quality of vision screening. The underlying causes of low sensitivity should be identified and addressed. Further training and periodic supervision of vision screening by nurses could improve the validity of the vision test. The sensitivity of vision screening in primary school and validity was lower than in preparatory and secondary students. It could be improved through training and more thorough screening

Vision screening of school students in Oman has satisfactory validity. Its low sensitivity needs to be improved. Periodic training of nurses and supervision of the screening procedures could improve the quality of vision screening. Because of the low yield, vision screening of primary-school students should perhaps be discon-

tinued and replaced by preschool vision screening. Determinants of low sensitivity such as being male and of young age, as well as regional variation, should be further investigated to strengthen the quality of screening.

References

1. Macfarlane DJ, Fitzgerald WJ, Stark DJ. Assessment of the Queensland School Health Service vision screening programme. ***Australian and New Zealand journal of ophthalmology***, 1987, 15(3): 175–80.
2. Hammond RS, Schmidt PP. A Random Dot E stereogram for the vision screening of children. ***Archives of ophthalmology***, 1986, 104(1):54–60.
3. Bailey RN. Assessing the predictive ability of the test-positive findings of an elementary school vision screening. ***Optometry and vision science***, 1998, 75(9): 682–91.
4. Robinson B et al. Measurement of the validity of a preschool vision screening program. ***American journal of public health***, 1999, 89(2):193–8.
5. ***Eye health care manual***, 1st ed. Muscat, Oman, Ministry of Health and United Nations Children's Fund, 1995:55–7.
6. ***Annual health report year 2002***. Muscat, Oman, Ministry of Health, 2003:1–41.
7. ***Elimination of avoidable visual disability due to refractive errors***. Geneva, World Health Organization, 2000 (WHO/PBL/00.79).
8. Lieberman S et al. Validation study of the New York State Optometric Association (NYSOA) vision screening battery. ***American journal of optometry and physiological optics***, 1985, 62(3):165–8.
9. Wick B, O'Neal M, Ricker P. Comparison of vision screening by lay and professional personnel. ***American journal of optometry and physiological optics***, 1976, 53(9 Pt 1):474–8.
10. Wong SG. Comparison of vision screening performed by optometrists and nurses. ***American journal of optometry and physiological optics***, 1978, 55(6): 384–9.
11. Appelboom TM. A history of vision screening. ***Journal of school health***, 1985, 55(4):138–41.
12. Romano PE. Summary and conclusions. Symposium on preschool/school vision and eye screening: current techniques and future trends. ***American orthoptic journal***, 1988, 38:73–80.
13. Halveston EM et al. Visual function and academic performance. ***American journal of ophthalmology***, 1985, 99(3):346–55.
14. Rosner J, Rosner J. Comparison of visual characteristics in children with and without learning difficulties. ***American journal of optometry and physiological optics***, 1987, 64(7):531–3.
15. Donaldson LA et al. Pediatric community vision screening with combined optometric and orthoptic care: a 64-month review. ***Ophthalmic and physiological optics***, 2002, 22(1):26–31.