Original Article

Validity of external observation examination by teachers during vision screening for preschool children

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ABSTRACT

Background: A vision-screening program is effective in prevention of vision impairment. The validity of vision screening conducted by nurses, medical assistants, and teachers has been previously reported. However, the validity of preschool teachers in conducting external eye observations in preschool children has not been widely investigated. This study aimed to determine validity of preschool teachers in conducting external eye observation tests, including the observation of behavior and external eye health, in preschool children.

Methods: In this cross-sectional study, preschool teachers from Kemajuan Masyarakat kindergarten in Klang Valley, Malaysia, were randomly allocated to the study (n = 30) or control (n = 30) groups. The study group underwent theory training with an optometrist and practical sessions with preschool children on vision screening, while the control group received only brief verbal instructions on steps to conduct the screening. After the briefing, teachers from both groups conducted vision screening tests at their kindergartens on preschool children aged 4–6 years. The same vision screening procedure was repeated in the same children by optometrists to verify results of the teachers.

Results: A total of 700 preschool children were screened by 60 preschool teachers and optometrists. Teachers from the study and control groups displayed high validity in screening for external ocular health, including sensitivity (66.67% versus 66.67%), specificity (95.21% versus 95.54%), and negative predictive value (99.41% versus 99.69%). The positive predictive value was slightly higher in the study group (19.05%) than in the control group (11.76%).

Conclusions: Preschool teachers competently observed external eye health in preschool children. A training module for vision screening is important, and a revision of the current training module is needed. Empowering preschool teachers could help in the early detection and intervention necessary in needy children. This could reduce the nationwide prevalence of visual impairments.

KEY WORDS

child, preschool, vision screening, external eye, early diagnosis, teachers, sensitivity and specificity, negative predictive value, positive predictive value

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INTRODUCTION

Vision impairment is defined as a specified vision that is poorer than an optimal requirement. It can affect a child's physical, mental, and psychosocial development [1-4]. Its prevalence is 6.7% among preschool children in Malaysia [5]. Routine vision screening is effective in preventing vision impairment in preschool settings [6]. However, the number of optometrists in Malaysia is very limited, with an optometrist-to-population ratio of 1: 22,460 [7]. Thus, there is an urgent need to empower lay individuals to serve as frontline screeners in detecting vision impairment.

Programs are available to train lay screeners, such as teachers [8-12] and parents [13], to perform vision screening in children. Furthermore, nurses from school health services are responsible for school vision screening for children aged 6–15 years [14]. However, the governmental vision screening program has limited coverage. Moreover, screening starts at the age of 6 years, which is considered late [15]. This may delay the detection and treatment of vision impairments and amblyopia, leading to permanent vision impairment. Thus, it is advisable to have a vision-screening program that is accessible to children as early as possible. Conducting vision screening on preschool children poses many challenges, and children may not cooperate with unfamiliar screeners [16]. Thus, empowering preschool teachers could be cost effective, as it can ensure children a comfortable vision screening process with a familiar screener, helping in the early detection of visual anomalies.

Trained teachers were found to be competent in conducting vision screening for children, achieving a sensitivity similar to that of nurses [8], with high positive predictive value (PPV) and negative predictive value (NPV) [11]. Empowering preschool teachers to conduct the vision screening program is not the only cost-effective solution [17]; for instance, a wider area of coverage can be included, such as rural areas. However, as children have longer contact with teachers, they are more willing to cooperate during vision screening, as they would have greater trust and familiarity with their teachers. In addition, incorporating the screening test into the children's class timetable can reduce the disruption of their learning activities. This would help ensure a sustainable vision-screening program in the long term.

Proper training is required for preschool teachers to conduct vision screenings. Several studies have reported the validity of vision screening tests conducted by teachers, particularly the visual acuity test [8, 12]. However, there are limited reports on the validity of other screening tests performed by lay screeners or teachers, such as observation of the child's behavior and external eye health. Therefore, this study aimed to determine the validity of preschool teachers in observing preschool children's behavior and external eye health.

METHODS

In this cross-sectional study, the targeted population comprised preschool teachers from Kemajuan Masyarakat (KEMAS) kindergartens in the Department of Community Development, Ministry of Rural and Regional Development, Malaysia. The random sampling method was used to include preschool teachers employed by KEMAS kindergartens, possessing academic qualifications of the Sijil Pelajaran Malaysia (SPM) certificate (secondary school level) or higher, and having two or more years of experience working with preschool children. The names of suitable and eligible KEMAS kindergarten teachers in Klang Valley were obtained from the KEMAS state headquarters of both the Federal Territory of Kuala Lumpur and Selangor (both located in the Klang Valley).

The formula of Allen [18] regarding comparisons between two independent means was used for the sample size calculation, and the number of participants required in this study was 28 for each group. Assuming a 10% dropout rate, the sample size for each group was determined to be 30. A total of 60 preschool teachers were randomly allocated to the control group (n = 30) or the study group (n = 30) using a random number table. This study adhered to the tenets of the Helsinki Declaration for Human Research, obtained ethical approval from the Universiti Kebangsaan Malaysia (UKM) Research and Medical Ethics Research Committee, and was approved by the Federal Territory and Selangor KEMAS state offices. The selected preschool teachers were briefed on the study and signed the study consent form. For the preschool children, informed consent was obtained from their parents, and only those children whose parents consented to participation in the study were screened.

As this study focused on external observation, we excluded the procedures, results, and discussion of other vision screening tests, such as Hirschberg's test and the distance visual acuity test. There were two subsections of the external observation test: 1) observation of the child's behavior and 2) observation of the child's external eye health. Preschool teachers were allocated to a study group or a control group. The study group received theory training by an optometrist and practical sessions with preschool children on vision screening, whereas the control group received only brief verbal instructions on steps to conduct the screening.

For observation of the child's behavior, the teacher was given a checklist closely pertaining to vision impairment, containing the following elements: face turning frequently when looking at distant objects; excessive blinking; often rubbing the eye(s); head tilting when looking at distant objects; often falling, tripping, or bumping into things; squinting the eyes when looking at distant objects; closing one eye when looking at distant objects or in bright conditions; often frowning; and aversion to playing games that require distance viewing [19]. If the teacher observed any of these behaviors, the designated column for that item was checked. If there were one or more checks on the checklist, the child was considered to have an abnormal test result and required a comprehensive eye examination.

For observation of the child's external eye health, the teacher was given a checklist of abnormal external eye features that are closely related to eye diseases, containing the following items: swelling around the eye, excessive tearing, eye discharge, drooping eyelid, red eye, growth on the sclera, different iris colors in the right and left eye, distorted pupil, and white pupil [19]. If the teacher observed any of the signs on the list, the designated column was checked by the teacher. If one or more checks were present on the checklist, the child was considered to have an abnormal test result and required a comprehensive eye examination. Children with abnormal screening test results were referred for a comprehensive eye examination at the Optometry Clinic, UKM. This included a visual acuity test and refraction, Hirschberg's test, detailed slit lamp examination, and fundus assessment.

The results were analyzed using IBM SPSS Statistics for Windows (version 22.0; IBM Corp., Armonk, NY, USA). As the sample size of our study was less than 100, the Shapiro–Wilk test was used for normality testing. Parametric analysis was performed if data were normally distributed, whereas a non-parametric test was performed for non-normally distributed data. This study used an alpha (α) value of 0.05, in which a *P*-value of less than 0.05 was considered statistically significant. Descriptive analysis was used to present the results. The external eye observations of the study and control groups were compared with those of the optometrists. The validity of the screening test was determined according to its sensitivity, specificity, PPV, and NPV [20] using a 2 × 2 table. The first-order agreement coefficient (AC1) was used to determine the inter-rater reliability between examiners when the disease prevalence was low [19, 21]. Thus, the inter-rater reliability between screening tests conducted by optometrists and the preschool teachers in both groups was determined using AC1, with values in the 2 × 2 table of screening test results, as proposed by Wongpakaran et al. [21].

RESULTS

Vision screening tests were conducted at 51 KEMAS kindergartens in Klang Valley. A total of 700 preschool children participated and were screened by the preschool teachers and optometrists: 185 (26.5%) were aged 4 years, 253 (36%) were aged 5 years, and 262 (37.5%) were aged 6 years. Preschool teachers in the study group screened 361 children, whereas those in the control group screened 339 children. Optometrists visited three times to complete the vision screenings of all children screened earlier by the preschool teachers. They screened 511 (73%) children on the first visit, 168 (24%) on the second visit, and 21 (3%) on the third visit.

The observation test involved two parts: behavioral observation and external eye health observation. In the study group, 21 children were found to have abnormalities. Optometrists found abnormalities in only six children, four of whom required referral by preschool teachers for further examination. In the control group, preschool teachers reported abnormalities in 17 children, with only two requiring referral by optometrists for further examination. Optometrists found abnormalities in only three children. Table 1 shows the validity of the external observation test conducted by preschool teachers in the study and control groups, compared to that of the optometrists.

The McNemar test and level of agreement were determined using AC1 based on a 2 × 2 table. There was a significant difference between the external observation test results of both the study group ($P < 0.05$) and the control group ($P < 0.05$) and those of the optometrists. The level of agreement with optometrists for both groups of preschool teachers was equally high (both AC1 = 0.95). Table 2 lists the behavioral and external eye health abnormalities as reported by preschool teachers and optometrists.

DISCUSSION

A total of 700 preschool children were successfully screened by 60 preschool teachers in either the study or control group. Vision screening programs in preschool children could be challenging because of the children's younger age and unwillingness to cooperate. Most abnormal behaviors, such as squinting the eyes when looking at distant objects, can only be observed during a teaching session. These behaviors might be difficult to detect by optometrists, as children may not portray these abnormal signs during their vision screening visit.

Table 1. Validity of external observation tests conducted by preschool teachers in the study and control groups, compared to that of the optometrists

Group		Optometrists		
		Referred	Not referred	Total
Preschool teachers (Study, n = 30)	**Referred**	4	17	21
	Not referred	2	338	340
	Total	6	355	361
Sensitivity = 66.67 (95% CI =22.28 – 95.67), Specificity = 95.21 (95% CI =92.44 – 97.19), PPV = 19.05 (95% CI = 10.17 – 32.84), NPV = 99.41 (95% CI = 98.20 – 99.81)				
Preschool teachers (Control, n = 30)	**Referred**	2	15	17
	Not referred	1	321	322
	Total	3	336	339
Sensitivity = 66.67 (95% CI = 9.43 – 99.16), Specificity = 95.54 (95% CI = 92.74 – 97.48), PPV = 11.76 (95% CI = 4.95 – 25.46), NPV = 99.69 (95% CI = 98.48 – 99.94)				

Abbreviations: n, number; CI, confidence interval; PPV, positive predictive value; NPV, negative predictive value. Note: The study group received theory training by an optometrist and practical sessions with preschool children on vision screening, whereas the control group received only brief verbal instructions on steps to conduct the screening. There were two subsections of the external observation test: 1) observation of the child's behavior and 2) observation of the child's external eye health.

Table 2. Behavioral and external eye health abnormalities observed by optometrists and preschool teachers in the study and control groups

	Type of Abnormalities	Study Group (n = 30)	Optometrist	AC1	Control Group (n = 30)	Optometrist	ACI
The Child's Behavior	**Face turning frequently when looking at distant objects**	3	1	0.99	7	0	0.98
	Excessive blinking	4	2	0.99	6	0	0.98
	Often rubbing of the eye(s)	3	0	0.99	6	0	0.98
	Head tilting when looking at distant objects	8	1	0.98	11	1	0.96
	Often falling, tripping, or bumping into things	1	0	0.99	1	0	0.99
	Squinting the eyes when looking at distant objects	6	3	0.99	4	2	0.98
	Closing one eye when looking at distant objects or in bright conditions	1	0	0.99	0	0	1.00
	Often frowning	3	0	0.99	4	0	0.98
	Aversion to playing games that require distance viewing	1	0	0.99	2	0	0.99
External Eye Health	**Swelling around the eye**	1	0	0.99	2	0	0.99
	Excessive tearing	3	0	0.99	3	1	0.99
	Eye discharge	5	0	0.98	2	0	0.99
	Drooping eyelid	3	0	0.99	1	0	0.99
	Red eye	2	0	0.99	3	0	0.99
	Growth on the sclera	0	0	1.00	1	0	0.99
	Different iris colors in the right and left eye	0	0	1.00	0	0	1.00
	Distorted pupil	0	0	1.00	0	0	1.00
	White pupil	0	0	1.00	0	0	1.00

Abbreviations: n, number; AC1, first Order agreement coefficient. Note: The study group received theory training by an optometrist and practical sessions with preschool children on vision screening, whereas the control group received only brief verbal instructions on steps to conduct the screening. There were two subsections in the external observation test: observation of the child's behavior and observation of the child's external eye health. Because a child may have more than one observed abnormality, the sum of the observed abnormalities in Table 2 does not match the total number of referred children in Table 1.

Preschool attendance rates can vary [22, 23], as reflected in our study. The optometrists were able to screen only 73% of children on the first visit and had to visit the preschools three times, to screen all the children. Children who are absent when vision screening is conducted may have undetected vision problems. Therefore, if optometrists require multiple visits to ensure that all children are screened, their work schedules will be impacted. This should be considered in light of the overwhelming shortage of optometrists in Malaysia [7]. This could affect optometrists' scope of patient care services in their daily practices. In contrast, preschool teachers are always in their preschools and, hence, are able to conduct the screening of a child at their convenience. Thus, one may surmise that fewer children will miss the screening program if screening is conducted by preschool teachers.

The engagement of lay screeners is required to overcome the shortage of professional eye-care practitioners. Pattison and Plymat [24] noted that school health nurses were highly accurate in visual acuity screening if adequately trained by orthoptists. They proposed future research to examine the efficacy of teachers' screening and referral methods as a substitute for professional screening [24]. However, the higher referral rate among preschool teachers in our study may indicate that they have not fully understood the warning signs of vision impairments. Thus, common visual impairments in children may require inclusion in the training module.

The McNemar test compares overall proportions. When the overall proportion of passes or failures by the two examiners is similar, it is assumed that there is no difference [25]. In our study, the McNemar test revealed a significant difference between the results of the external observation test results obtained by optometrists and those of preschool teachers in both groups. There are two possible explanations for this discrepancy. Teachers may have over-referred children due to unfamiliarity with the abnormal signs or behaviors. In addition, although the abnormal behaviors or signs might have been present when teachers performed the observation test, signs such as red or watery eyes might have resolved when optometrists performed the screening after a delay of two or more weeks. Certain signs may only be present on a task-related basis. Other signs, such as a drooping eyelid, do not usually spontaneously resolve. However, the level of agreement on the external observation test between optometrists and teachers from both groups was high, implying that preschool teachers were able to produce results nearly identical to those of optometrists.

Most studies on vision screening in children only include external eye health observations [26, 27]. However, abnormal behavior may be a sign of vision impairment. Our results showed that a large number of children observed by preschool teachers in both the study and control groups had behavioral abnormalities. The most commonly observed behavioral abnormality was a head tilting when looking at distant objects. This behavior has often been considered a benign habit; however, it may be a sign of vision problems such as strabismus, anisometropia, uncorrected refractive error, and nystagmus [28, 29]. In addition, it may present with neural problems such as congenital fourth nerve palsy, Duane syndrome, or Brown syndrome [30, 31]. Children assume a head tilt position to overcome the double vision or eye strain caused by these disorders.

The second most commonly observed abnormal behavior was squinting the eyes when looking at distant objects. This behavior can be detected by preschool teachers and is the most abnormal behavior observed by optometrists. It is a classical sign in children with uncorrected refractive errors, such as myopia and astigmatism [32]. Other abnormal behaviors were observed by both the study and control groups that are not often detected by optometrists. Among them is face turning frequently when looking at distant objects, excessive blinking, and often rubbing the eye (s) (Table 2). Children may exhibit these behaviors unconsciously while conducting activities with teachers. However, in the presence of optometrists, the unusual behaviors of children may be restrained because of fear or shyness. Hence, the abnormal behavior may be undetected by optometrists.

Signs such as often falling, tripping, or bumping into things, or signs only observable when involved in children's daily activities such as aversion to playing games that require distance viewing are nearly undetectable for optometrists who have time constraints [33]. This could explain why teachers from both groups were more likely to observe these behaviors than qualified optometrists. Optometrists only obtain this information when interviewing teachers or parents. Children tend to react differently to health personnel such as dentists and optometrists [34]. This may be due to the trauma experienced during a clinic visit or by parents' or teachers' reaction when the child makes a mistake. Therefore, when an optometrist visits a preschool, the children will often change behavior from cheerful and noisy to rigid and quiet. When this occurs, the abnormal behaviors are not apparent, and this may affect the accuracy of vision screening results. Therefore, teachers, as frontline workers [35], should be purposefully trained to detect abnormal signs. Preschool teachers spend much time with children, allowing them to observe abnormal behavior during a child's routine activities. Although the abnormal behaviors may be simple habits, they may be an indication of vision impairment. This can be further verified by teachers by performing tests such as the Hirschberg test [36] to detect strabismus and visual acuity tests, before a referral for further examination and treatment.

The most common abnormalities of the external eye observed by preschool teachers in the study group were eye discharge, followed by excessive tearing, drooping eyelid, red eye, and swelling around the eye, whereas excessive tearing and red eye were the most common abnormalities observed by those in the control group. Teachers from both groups easily detected these abnormalities as listed in the second part of the screening checklist. Therefore, external observation by shining the pen-torch on the eyes is a simple test for teachers to assess for abnormalities [37, 38] included in the checklist. However, knowledge of the normal anatomical structures of the eye, and education about the causes and impact of visual abnormalities on children, helps preschool teachers understand the importance of referring a child for further examination. Teachers in both groups observed more abnormal behaviors and/or external eye abnormalities than optometrists. This indicates a need to train preschool teachers [24].

There is also a possibility that symptoms observed by preschool teachers may be confused with the benign habits of children, since teachers reported more abnormalities in our study. This indicates the need for preschool teachers to undergo proper training in vision screening [24], and the training module should include photographs of abnormal eyes and case studies. We found that the specificity of preschool vision screening by teachers was similar between the study (95.21%) and control (95.54%) groups. This value is higher than those of Mezbah et al. [10], Tung et al. [39], and Sharma et al. [40], who reported only 91–92% specificity. This indicates that preschool teachers can use the screening test to accurately identify normal children with no abnormal behaviors or signs of the external eye.

The NPVs of the screening test for the study (99.41%) and control (96.69%) groups were high. The sensitivities of vision screening conducted by teachers in the study groups were equivalent (66.67%). This suggests that preschool teachers who are given comprehensive training or a short briefing on preschool vision screening were capable of conducting vision screening by utilizing the screening checklist. However, it should be noted that there is a need for revision of the training module, as the sensitivity obtained by the preschool teachers in this study is still lower than those found in programs conducted overseas, which achieved a sensitivity greater than 91% [29, 39, 40].

The PPVs of vision screening by preschool teachers were relatively low (study versus control group: 19.05% versus 11.76%). It is possible that teachers were overly cautious and feared missing children with vision problems if they were not referred. The PPVs were lower than that obtained by Tung et al. [39], which was 27.3%; thus, there is still room for improvement. This illustrates that more comprehensive training is needed as an important aspect of the preschool vision-screening module. Theoretical and practical training could improve teachers' ability to conduct screening tests accurately and consistently.

This study showed that preschool teachers were competent in observing the external eye health of a substantial number of preschool children. Empowering preschool teachers to implement the screening program would allow the teacher to schedule the screening program at a suitable time within the preschool curriculum, which could improve early detection and intervention in children at risk. This could reduce the prevalence of visual impairment in the country. Thus, involvement of preschool teachers in the vision screening program can not only produce quality referrals, but establish good relationships between teachers and the children under their care. This could also simplify the screening process, effectively saving time and costs. The preschool teachers, who are familiar with the children, would be the most suitable candidates for conducting a vision-screening program at the preschool level. There are several limitations to the study design that should be considered when interpreting our data. All data were collected at a single time point only, and changes during long-term follow-up were possible, but could not be assessed. The participants also required more accurate and objective tests for low-vision examinations. Furthermore, we believe that multicenter national population studies can lead to stronger conclusions. Future studies should address these limitations to improve the quality of life and economic benefits associated with childhood vision screening.

CONCLUSIONS

The sensitivity was moderate, and PPV was low in the preschool vision screening program conducted by preschool teachers. However, the high specificity indicates that preschool teachers can use the screening test to accurately identify normal children with no abnormal behaviors or signs of the external eye. A training module for vision screening is important, and a revision of the current training module is needed. Empowering preschool teachers could help in the early detection and intervention necessary in needy children. This could reduce the nationwide prevalence of visual impairments.

ETHICAL DECLARATIONS

Ethical approval: This study adhered to the tenets of the Helsinki Declaration for Human Research, obtained ethical approval from the UKM Research and Medical Ethics Research Committee, and was approved by the Federal Territory and Selangor KEMAS state offices. The selected preschool teachers were briefed on the study and signed the study consent form. For the preschool children, informed consent was obtained from their parents, and only those children whose parents consented to participation in the study were screened.
Conflict of interests: None

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