

ORIGINAL ARTICLE

EFFECTIVENESS OF VISION SCREENING PROGRAM CONDUCTED BY PRE-SCHOOL TEACHERS

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ABSTRACT

Vision impairment when undetected early can affect the social and mental development of a child. Early detection of visual impairment can provide better prognosis and can be conducted through vision screening at pre-school. Vision screening performed using pre-school teachers would allow cost and time savings while providing greater access to perform this screening. The objective of this study was to determine the effectiveness of vision screening conducted by pre-school teachers. A total of sixty pre-school teachers from KEMAS Tabika's and Taska's in the Klang Valley were randomly selected and divided into two groups i.e. a Study Group and a Control Group. The Study Group was given participative and hands-on vision screening training whereas the Control Group was only given brief verbal instructions on conducting the screening. Each of these pre-school teachers was asked to conduct vision screening on 15 pre-school children aged 4 to 6 years old. Trained optometrists then repeated the vision screening on the same children. The results showed that there was a higher validity in the vision screening findings from the Study Group (sensitivity = 79%, specificity = 95%) compared to the Control Group (sensitivity = 26%, specificity = 95%). The level of agreement concurrence between the pre-school teachers in the Study Group and the optometrist was high for all tests ($AC1 \geq 0.89$). In conclusion, the vision screening program conducted by pre-school teachers was effective but needed proper training for the screeners. This program is seen to be able to empower pre-school teachers using vision screening techniques to allow them to identify pre-school children with vision impairment who would then require further examination and management by an eye-care professional. This program would be able to reduce the prevalence of vision impairment among pre-school children in Malaysia in the long term.

Keywords: preschooler, vision screening, vision impairment, early detection, teachers

INTRODUCTION

The presence of vision impairment can disrupt the development of a child whether physical, mental or social¹⁻⁴. Amblyopia is the common cause of vision impairment found among school children. Amblyopia is defined as the presence of interference involving the processing of non-functional visual information⁵. Pan et al. (2017)⁶ found that amblyopia affected 1.43% of the population, and the major causes of amblyopia were refractive errors and strabismus. In Malaysia, 1.3% of the vision impairment found in pre-school children is caused by amblyopia⁷. The risk factors for amblyopia include uncorrected refractive errors, strabismus and obstruction of ocular media^{6, 8-11}. Early detection of these risk factors is important to prevent the condition from worsening as the children get older. Goh et al. (2005)¹² found that 87% of cases of amblyopia among school children aged between 7 and 15 years in Malaysia were due to

uncorrected refractive errors. Therefore, a vision screening program was recommended to detect the presence of vision impairment in children so that intervention can be recommended and implemented as early as possible.

In developed countries, vision screening is typically done at pre-school, i.e. at the age of 3 to 4 years¹³⁻¹⁴. This is because the development of the visual system is very sensitive at that age group. However, it must also be realized that children at this age usually have a short attention span, which then creates a major challenge to conduct vision screening on them^{12,15}. Therefore, using careful selection of the vision screening model and using suitable equipment such as appropriate vision charts can actually reduce the difficulties in conducting vision screening on children. This was supported by a study by Omar et al. (2012)¹⁶ who

found that the Lea Symbol Chart was more sensitive in detecting vision impairment among pre-school children age especially those aged between 4 to 6 years.

In Malaysia, vision screening is conducted for children aged 7 to 12 years through the School Health Team Program which is conducted by staff from the Ministry of Health Malaysia. Currently the program is being expanded to include pre-school children aged 6 years who attend public schools with pre-school classes. The detection of vision impairment, especially amblyopia, at this age is considered delayed and may lead to poor prognosis for treatment and rehabilitation for this children¹⁷⁻¹⁸. Hence a comprehensive vision screening program for pre-school children aged 4 to 6 years is needed. Duratul Ain et al. (2009)⁸ in their study showed that optometrists could effectively implement a vision screening program for pre-school children. However, using optometrists to conduct vision screening can incur significant costs and require the employment of these optometrists in the school health teams. A more cost-effective alternative is therefore needed. Empowering pre-school teachers to conduct the vision screening program is seen as more cost-effective as more pre-schools can implement the program. Delivery of pre-school vision screening service by trained pre-school teachers is a cost-effective solution as it reduces wastage and improves efficiency, in terms of time and coverage¹⁹.

It is also easier for the teachers to get the children under their care to willingly cooperate and participate in the vision screening as they would have greater trust and familiarity with their teachers. This means that the screening can be less time consuming and can be programmed into the children's class timetable thus causing less disruption to their learning activities. This would help ensure the long-term sustainability of the vision screening program. However it is essential that the pre-school teachers must be trained and be made competent in conducting the vision screening. Thus, a proper training is needed for the pre-school teachers. Therefore, this study aims to determine the effectiveness of vision screening program as conducted by pre-school teachers.

METHODOLOGY

This was a cross-sectional study. The targeted population were pre-school teachers in Malaysia. The population of the study comprised Tabika and Taska KEMAS teachers around the Klang Valley. These are pre-school teachers employed by the Department of Community Development, Ministry of Rural and Regional Development (KEMAS) which provides these pre-school services rural and

disadvantaged communities. The sampling method used was random sampling. The subject selection criteria for participation in this study were that they had to be pre-school teachers employed by KEMAS; and further they are to have the following criteria; a) hold academic qualifications of at least SPM certificate (secondary school level); b) have at least two years working experience with children. The sample size (n) required for this study was calculated based on the formula of Snedecor & Cochran (1989)²⁰, referencing comparisons between two independent means as follows:

$$n1 = n2 = 2K\sigma^2/\Delta^2.$$

The vision screening program in the The Vision in Preschoolers (VIP) Study Group (2005)²¹ involved three examinations, i.e. an external eye observation, the Hirschberg's Test and a visual acuity test (VA). VA is the primary and most important component in the vision screening test. Additionally, it is a quantitative variable as compared to the observation of the external eye and the Hirschberg's Test which are qualitative variables. Therefore, the standard deviation of VA measurement obtained from previous study²¹ (0.135 LogMAR) was used for sample size calculation. This study aimed to detect if there is a difference of 0.1 LogMAR between the Study Group and Control Groups with 80% power, at a significance level of 5%. Using the Snedecor & Cochran formula, the number of subjects required in this study was 28 for each group. By assuming a 10% dropout rate, the sample size for each Study Group and the Control Group was determined to be 30 individuals. The list of names of suitable, eligible TABIKA and TASKA KEMAS teachers in the Klang Valley were obtained from the KEMAS state headquarters of both the Federal Territory of Kuala Lumpur and Selangor (both being located in the Klang Valley). This study therefore involved 60 pre-school teachers randomly selected using a random number table and divided to two groups, i.e. the Study Group (n = 30) and Control Group (n = 30). This study followed the Helsinki Declaration for Human Subjects and obtained ethical approval from the Universiti Kebangsaan Malaysia Research and Medical Ethics Research Committee. This study also was approved by the Federal Territory and Selangor KEMAS state offices. The selected pre-school teachers were then briefed on the study and signed the study consent form. For pre-school children involved in the study, informed consent was collected from their parents and only children whose parents allowed their children to take part in the study were screened.

Vision Screening Program

For the Study Group, the pre-school teachers underwent comprehensive participative training on

how to conduct the pre-school vision screening program, which included both theory and practical sessions using the KieVision Pre-school Vision Screening Kit™ whereas for the Control Group, the pre-school teachers received verbal instructions on how to conduct pre-school vision screening. Both groups of pre-school teachers were then required to conduct vision screening program on 15 pre-school children aged between 4 to 6 years at their respective pre-school premises within two weeks of completion of their training or briefing. Optometrists would then repeat the screening protocol on the same pre-school children two weeks after pre-school teachers had completed their vision screening. Pre-school children who failed the vision screening tests performed by the pre-school teachers or optometrists or both were then referred to the Optometry Clinic, UKM for comprehensive eye examination and management.

Screening Room or Space Preparation

The vision screening program was performed in a room or space with an area of at least 4 square meters within the teacher's pre-school premise. The selected room or space should be free from any disturbances and be a reasonable quiet place. The lighting throughout the room or space is to be bright, having at least two 18 W fluorescent lamps and be free from the sun's glare. A total of two seats were required during the screening, one for child and the other for the pre-school teacher or optometrist (examiner).

External eye observation

External eye observation was divided into two parts. The first part was the observation of the child's behavior and was performed by referring to the checklist provided in the record form of the vision screening program. For the second part, the pre-school teacher would then perform external eye observation and any abnormalities they observe were to be recorded in the record form. Children will be referred for further examination if any abnormalities are found based on the checklist.

Hirschberg's Test

Hirschberg's Test was done using a pen torch provided in the KieVision Pre-school Vision Screening Kit™. Pre-school children were required to sit facing the examiner. The distance between the examiner and pre-school children was 33 cm and the examiner's eye position is to be at the same level as the child being examined. The pen torch and a toy were then held at the child's eye level and the child was asked to look at the toy. The light from the pen torch is then directed towards the

center of nose-bridge between the right eye and the left eye of the child. The position of the light reflection from the pen torch was observed and marked in the record form. This test was done without the children using any spectacles. Should the child wear glasses, they were asked to remove their glasses before starting the procedure. Children will be referred for further examination if the position of the light reflection was not observed at the center of the children's pupil on either eye.

Visual Acuity Test

The Lea Symbol Chart™ (250150) was used for the visual acuity test. The chart was suspended or pasted at a child's eye level on an empty wall with good contrast. A distance of 3 meters from the chart was measured and marked using the measuring tape and adhesive tape provided in the KieVision Pre-school Vision Screening Kit™. A chair was placed at that position and the child was asked to sit on the chair. A small table was placed in front of a child to place the student response card together with an occluder. Symbols found on the student response card would then be shown to child. They were then asked to match the symbols on the chart by pointing to the same symbol found on the response card and the results were recorded. The test starts with the right eye, during which the left eye is occluded using an occluder. For children who wore glasses, the vision test was conducted with them using their glasses. The symbols on the top row of the chart would then be pointed out one at a time. Children who were unable to read the top line on the Lea Symbol Chart were considered to have failed the test and would then be referred directly to an optometrist. The test is continued should the child be able to match the symbols correctly. If the child's response is delayed or the symbols wrongly matched, the screener would then return to the previous line. If the child skipped any symbols, they would be asked to try again with the screener pointing to the skipped symbol. The test is continued until the smallest readable line by the child is obtained. The value of the line is recorded when the child reads at least 3 symbols correctly on the particular line. If the child can read up to row 6/6, a plus 1.00DS test is performed on that child. The child is asked to re-read line 6/6 while he or she is wearing +1.00DS glasses with the left eye being occluded. The procedures were then repeated for left eye. Children who can still read line 6/6 after wearing +1.00DS glasses are considered to have failed the visual acuity test and were referred for further examination at the Optometry Clinic, UKM. The pass/fail criteria of visual acuity test for each age group are shown in Table 1.

Table 1: The pass/fail criteria of visual acuity test for each age group passing criteria for visual acuity test for each age group

Age	Pass	Fail
4 years	0.3 logMAR (6/12)	Less than 0.3 logMAR (6/12)
5 years	0.2 logMAR (6/9)	Less than 0.2 logMAR (6/9)
6 years	0.1 logMAR (6/7.5)	Less than 0.1 logMAR (6/7.5)

Standardised Vision Screening

Children who were referred for further examination at the Optometry Clinic UKM would undergo a detailed optometric examination by an optometrist. The detailed optometric examination includes a Visual Acuity Test and refraction, Hirschberg's Test, external eye examination using a slit lamp and an ophthalmoscopy examination.

Data Analysis

The results of the study were analyzed using SPSS 19.0. The Shapiro-Wilk test was used to test for normality as the sample size was less than 100. Data is considered to be distributed normally if $p > 0.05$ and therefore parametric analysis would be performed. If the p value was < 0.05 , it is considered not normally distributed and therefore non-parametric analysis would be conducted. The value $\alpha = 0.05$ was used as a reference. A p value of less than 0.05 was considered as statistically significant. The mean, standard deviation (SD), range and percentage of the screening test results

as performed by pre-school teachers in both study groups and optometrists were determined using descriptive analysis. The results of the screening test performed by the Study Group and Control Group were compared with the results of screening tests performed by optometrists. A 2x2 Table was then constructed (Figure 1) to determine the validity value of each test which includes the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) according to the method of Armitage et al. (2002)²². The inter-rater reliability between examiners can be determined using either the Kappa value or the First Order Agreement Coefficient (AC1). Kappa value is suitable to use for high prevalence of disease, but AC1 is more suitable to use when prevalence of disease is low²¹. Thus, the inter-rater reliability between screening tests conducted by pre-school teachers and optometrists in this study was determined using First Order Agreement Coefficient (AC1) where the value in the 2X2 table of screening test results as shown in Figure 2 is included in the formula proposed by Wongpakaran et al. (2013)²³:

Figure 1: 2X2 Table

		Standardised Test	
		Positive	Negative
Test Result	Positive	True Positive (TP)	False Positive (FP)
	Negative	False Negative (FN)	True Negative (TN)

Sensitivity	=	$\frac{TP}{(TP + FN)}$
Specificity	=	$\frac{TN}{(FP + TN)}$
Positive Predictive Value (PPV)	=	$\frac{TP}{(TP + FP)}$
Negative Predictive Value (NPV)	=	$\frac{TN}{(FN + TN)}$

Figure 2: 2X2 Table of screening test results

		Examiner A		Total
		1	2	
Examiner B	1	A	B	B1
	2	C	D	B2
Total		A1	A2	N

$$AC1 = p - \phi / 1 - \phi$$

where

$$p = (A+D)/N,$$

$$\phi = 2q(1-q),$$

$$q = (A1+B1)/2N$$

RESULTS

Vision screening tests were conducted at 31 KEMAS Tabikas and 20 KEMAS Taskas in the Klang Valley. The number of children to be screened was targeted at 900. However, as there were parents who did not give permission for their children to be screened,

only 700 pre-school children were able to participate and be screened by the pre-school teachers and optometrists. The pre-school teachers in the Study Group screened 361 children while pre-school teachers from the Control Group screened the balance of the children. The number of pre-school children aged 4 years who were screened was

185 (26.42%), while 253 children (36.14%) aged 5 years and 262 children (37.42%) aged 6 years were also screened.

Of the children screened by pre-school teachers in the Study Group, 42 needed referral for follow-up examination while only 35 needed referral when screened by optometrists. Twenty four children were found to have been similarly referred by both

the pre-school teachers and optometrists. In the Control Group, the pre-school teachers referred 24 children and the optometrists referred 22 children, only 4 children were referred by both the pre-school teachers and optometrists. Figure 3 and Figure 4 summarizes the number of children referred by pre-school teachers and optometrists in both the Study Group and Control Group.

Figure 3: Number of pre-school children screened by optometrists and pre-school teachers from Study Group

		Optometrists		Total
		Refer	Not refer	
Study Group n = 30	Refer	24	18	42
	Not refer	11	308	310
Total		35	326	361

Figure 4: Number of pre-school children screened by optometrists and pre-school teachers from Control Group

		Optometrists		Total
		Refer	Not refer	
Control Group n = 30	Refer	4	20	24
	Not refer	18	297	315
Total		22	317	229

The reliability of the screening test results performed by pre-school teachers is determined by the validity of the tests, which includes the sensitivity, specificity, positive expectation value (PPV) and negative expectation value (PFV). A total of 39 children who were screened by pre-school teachers from the Study Group and 30 children screened by pre-school teachers from the Control Group presented for the standard eye examination at the Optometry Clinic, UKM. Children who passed the screening test by pre-school teachers and were verified by an optometrist through re-screening were counted as true negatives. The value of validity was obtained and summarized in Table 1.

The number of pre-school children referred by the pre-school teachers from the Study Group and optometrists was 53 but only 39 children attended the comprehensive eye examination at the Optometry Clinic, UKM. These 14 children did not get permission from their parents to attend the comprehensive eye examination. Figure 5 illustrates the 2X2 table of the results of comprehensive eye test performed on children referred from the Study Group. Based on this table, 31 (73.8%) of the preschoolers were found to have vision impairment of which 21 (67.7%) of them were referred by both pre-school teachers and optometrists. 10 (32.3%) were those referred by optometrists only. Meanwhile, 8 (19.0%) of the children who were

referred by the teachers were found to have normal results and therefore did not need any treatment. Hence the sensitivity of the screening by pre-school

teachers was 67.7% and their specificity was 97.4%. The PPV value was 72.4% while the NPV value was 96.9% (Table 1).

Figure 5: Results of the comprehensive eye test performed on children referred from the Study Group

		Optometrists		Total
		Refer	Not refer	
Study Group n = 30	Refer	21	8	29
	Not refer	10	308	318
Total		31	316	347

There were 42 children referred by both pre-school teachers and optometrists from the Control Group to undergo comprehensive eye examination at the Optometry Clinic, UKM. Of these, only 30 pre-school children presented. The results obtained after the comprehensive eye examination is shown in Figure 6. Only 15 (35%) of these children were found to have visual impairment. Only of 4 (26%) pre-school

children referred by pre-school teachers were found to have visual impairment while the rest were referred by optometrists. The sensitivity of screening by the Control Group pre-school teachers was very low at 26.7% while specificity was 95.2%. The PPV value was 21.1% while NPV value was 96.4%. Table 4.8 shows the validity values obtained for both groups of pre-school teachers.

Figure 6: Results of the comprehensive eye test performed on children referred from the Control Group

		Optometrists		Total
		Refer	Not refer	
Control Group n = 30	Refer	4	15	19
	Not refer	11	297	308
Total		15	312	327

Table 2: Validity of vision screening tests by the teachers in the Study Group and Control Group

Validity	Pre-school Teachers	
	Study Group	Control Group
Sensitivity	67.7%	26.7%
Specificity	97.4 %	95.2%
PPV	72.4%	21.1%
NPV	96.9%	96.4%

DISCUSSION

The results showed that 700 children from 31 KEMAS Tabikas and Taskas were successfully screened by pre-school teachers from both the Study Group and Control Group. Of these, 66 (9.4%) were referred for comprehensive eye examination at the Optometry Clinic, UKM. Hartmann et al. (2001)²⁴ stated that an average reference rate of 5.0% represents a good screening program. This suggests that pre-school teachers in Malaysia would be able to implement a vision screening program on pre-school children under their care. Conducting a vision screening program is a huge challenge, especially performing the VA test. This is because children have a short attention span and frequently are unlikely to cooperate with strangers. Therefore, pre-school teachers, being familiar to the children, would be the most suitable candidate to conduct a vision screening program. This is further facilitated by the fact that they spend a lot of time with these children on a daily basis. Good relationships between teachers and the children under their care make a screening process easier to conduct and manage. Empowering the pre-school teachers to implement the screening program would also allow the teacher to schedule the screening program at a suitable time in the curriculum of the pre-school.

The results of this study show that optometrists were only able to screen 73% of pre-school children on the first visit and had to return to the pre-schools three times on average to complete the screening of all the 700 children who were screened by the pre-school teachers. This is because it was found that not all children attend pre-school every day. Children who are absent when the vision screening was conducted may have their vision problems undetected. Therefore, the optometrists had to attend the pre-school several times in order to ensure that all children were screened. This circumstance would impact the work schedule of the optometrists responsible for the screening program and this would impact on their ability to conduct patient care services in their daily practices. Whereas pre-school teachers are 'always' in their pre-schools and hence would be able to conduct the screening a child at their convenience. Thus, it may be surmised that less children would miss the screening program.

Specificity is the ability of a test to identify negative results while a negative predictive value (NPV) is a negative result negative value verified by a standard test. Based on the analysis of the results of the study, it was found that the specificity of pre-school vision screening by teachers was found to be higher (97.4%) in Study Group compared to the Control Group (95.2%). Our study results are higher

than the specificity obtained by Tung et al. (2006)²⁵ and Sharma et al. (2008)²⁶ which only achieved 91% specificity.

The NPV of the screening test results for both groups were found to be almost the same, 96.9% in the Study Group and 96.4% in the Control Group. This indicates that pre-school teachers are able to identify children who have no vision impairments with an accuracy of over 96%. The sensitivity of vision screening conducted by teachers in Study Group was markedly higher (67.7%) compared to the Control Group (26.7%). This means that pre-school teachers who are given comprehensive training on pre-school vision screening are more capable in conducting the vision screening on pre-school children and they were found to be able to detect 67.7% of children who are suspected to having vision impairment. However, teachers who were not trained were only able to detect 26.7% of children with vision impairments. This difference illustrates that a comprehensive training session is an important aspect of the pre-school vision screening module. Theoretical and practical training improved the understanding of teachers on the method of conducting screening tests both accurately and consistently. This screening program provides for quality referrals for comprehensive optometric assessments by eye care professionals and so reduce 'unnecessary' referrals that would congest the available eye care referral centers and reduce the time available for comprehensive examinations at these same centers. It should be noted that there is a need for revision of the training module as the sensitivity obtained by the pre-school teachers in this study is still lower than those found in programs conducted overseas, which can achieve a sensitivity of greater than 91%²⁵⁻²⁶.

The results also showed that the value of PPV of the vision screening by pre-school teachers in the Study Group was 72.4%. The PPV is a positive result rate by vision screening and is confirmed positively by standard tests. The value of PPV obtained shows that 72.4% of the children referred by the pre-school teachers actually do suffer from vision impairments while the remaining 27.6% are false positives. This may be due to the teachers being overly cautious and being worried that the children who may have vision problems would be missed out if not been referred. Over-referral would be a burden for eye care professionals hence emphasizing that the teachers would need refresher training to maintain their confidence and ensure that their competency is maintained in the long term. Although the value of PPV seen is higher than the PPV obtained by Tung et al. (2006)²⁵ which was 27.3%, there is still room for improvement.

CONCLUSIONS

The sensitivity of a pre-school vision screening program conducted by pre-school teachers was only moderate. However, the high specificity, PPV and NPV showed that pre-school teachers are capable of screening vision impairments in pre-school children more accurately when appropriate training is given to them. Thus, the pre-school vision screening program used and the training provided to pre-school teachers is effective in improving the accuracy of vision impairment detection in pre-school children.

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