Assessing accuracy of non–eye care professionals as trainee vision screeners for children

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ABSTRACT • RÉSUMÉ

Objective: To determine the level of agreement between non–eye care trainees and a trainer (ophthalmologist) in a vision screening program.

Design: Prospective, observational study carried out in 3 phases (Phase I–III).

Participants: Study population included 1228 children, aged 6–14 years, at 5 elementary schools in the city of Hamilton.

Methods: In Phase I, 1228 children were screened by the trainee screeners, of which 273 children failed the vision testing. Of these 273 children, 170 consented to enrolment into Phase II and were examined by an ophthalmologist, who confirmed that 105 of these children were true positives. On retesting (Phase III), the ophthalmologist passed 158 of the 163 randomly selected children who passed in Phase I.

Results: Overall, trainee screeners had a sample sensitivity of 95.5% and sample specificity of 70.8% in detecting children who should fail vision screening. When we used the positive and negative prediction values obtained, 198 of the 1228 children had vision impairment—providing an estimated prevalence of 16.1%, or 161 children per 1000 population.

Conclusions: Non–eye care professionals can be trained to an acceptable degree of accuracy to perform certain vision screening tests on children. Such screening methods may be a useful approach to address existing gaps in provision of eye care for many Canadian children, thereby ensuring that all children receive timely vision screening.

Objectif : Déterminer le niveau d'accord entre des non-professionnels de la vue en formation et un formateur (ophtalmologiste) dans un programme de dépistage des troubles de la vue.

Nature : Étude observationnelle prospective en trois phases (phase I-III).

Participants : 1228 enfants de 6 à 14 ans de cinq écoles élémentaires de Hamilton.

Méthodes : À la phase I, 1 228 enfants ont été évalués par des dépisteurs en formation. De ce nombre, 273 enfants n'ont pas réussi le test de vision. 170 de ces 273 enfants ont accepté de participer à la phase II et ont été examinés par un ophtalmologiste, qui a confirmé le diagnostic de 105 enfants. À la suite d'un nouvel examen réalisé par l'ophtalmologiste (phase III), 158 élèves ont réussi le test sur 163 choisis au hasard parmi ceux qui l'avaient réussi à la phase I.

Résultats : Les dépisteurs en formation ont affiché une sensibilité de 95,5 % et une spécificité de 70,8 % pour la détection d'enfants qui auraient dû échouer au test de vision. En utilisant les valeurs de prédiction positives et négatives obtenues, on a déterminé que 198 des 1228 enfants avaient un trouble de la vision, soit une prévalence estimée de 16,1 % ou de 161 enfants par tranche de 1000 personnes.

Conclusions : Il est possible de former des non-professionnels de la vue pour qu'ils atteignent un niveau de précision acceptable en réalisant divers tests de dépistage de troubles de la vue chez des enfants. De telles méthodes de dépistage peuvent être utiles pour pallier des lacunes dans les régions mal desservies du Canada, et ainsi offrir à tous les enfants canadiens un dépistage rapide des troubles de la vue.

Over 80% of a child's learning is based on vision, and good eyesight is a key requirement for the development of a child, both physically and emotionally.[1] Among children, the prevalence of myopia can range from 3.4% to 43.6%, astigmatism from 1% to 11%, and hyperopia from 1.2% to 10.6%, depending on ethnicity and associated risk factors,[2–6] whereas strabismus affects 3%–4% of the population.[7,8] Childhood vision screening recommendations begin as early as infancy and continue every 12–24 months throughout childhood.[9,10] Despite the importance of identifying children with vision disorders, 6 Canadian provinces, including Ontario, have no preschool vision screening programs in place.[11] To mitigate this, the Ontario Association of Optometrists has established the Eye See … Eye Learn program, which offers vision testing to junior kindergarten pupils via participating optometrists in certain school regions.[12] Although this is an important step in bridging this gap, Eye See … Eye Learn relies on parents to bring their children to the optometrist. Despite these efforts, less than 14% of children in Canada under the age of 6 years have had an eye examination.[13]

Aim of the Study

The aim of this study was to assess the feasibility and accuracy of a new vision screening program for elementary school children in a Canadian urban setting.

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METHODOLOGY

Study design and participants

This was a prospective, observational study carried out in 3 phases in children aged 6–14 years who were currently enrolled in full-time education at 5 elementary schools in Hamilton, Ontario. These schools serve an urban population that, based on census data, has one of the lowest living standards in Canada.[14,15] All 3 phases required informed consent and assent forms. The study team obtained research ethics board approval from Hamilton Integrated Research Ethics Board (REB No. 12-426) and from the Evidence-Based Education and Services Team at Hamilton Wentworth District School Board.

Phase I: in-school vision screening. Two bachelor of health science students were trained in vision screening at McMaster Children's Hospital. These Two trainee screeners then conducted on-site vision screening of children aged 6–14 years at 5 local schools. Two M&S smart systems were used as the vision screening tools in this study, with presenting acuity recorded by line and the fellow eye occluded with an adhesive Ortopad orthoptic eye patch (Master-Aid Pietrasanta Pharma S.p. A Viareggio, Lucca, Italy). Each child's acuity was measured at a distance of 20 feet with Snellen crowded letters. Regarding stopping criteria, an eye's best visual acuity (VA) was recorded as the lowest line of which the child was able to correctly identify half or more of presented optotypes.

Phase II: ophthalmic examination for children who failed screening in the first phase. Previously published criteria[16] were used to define which children failed the vision screening tests carried out in the first phase:

1. presenting distance VA of 20/40 or worse in one or both eyes, and/or
2. difference of 2 or more lines in presenting distance VA measurement between 2 eyes

Children who failed vision screening in Phase I were enrolled in the second phase of the study, in which their visual acuities were re-measured under the same conditions as in Phase I, this time by the pediatric ophthalmologist. The ophthalmologist in Phase II was masked to the children's VA measurements from Phase I. All children in Phase II had a follow-up with a pediatric ophthalmologist within 2 weeks of Phase I.

Phase III: assessing false-negative rate. In Phase III, a randomly selected sample of children who passed vision screening in Phase I was re-tested on site in schools by the pediatric ophthalmologist. All children who failed vision testing by the trainee screeners or the pediatric ophthalmologist in any phase were invited for a full ophthalmological examination at McMaster Children's Hospital by the pediatric ophthalmologist, which included a cycloplegic refraction. Importantly, the same devices and protocol were used for VA measurements in Phases I, II, and III and in any follow-up visits for consistency. Those results are not discussed as they were not the focus of this study.

Statistical analysis

Screening test accuracy was measured by calculating and reporting sample sensitivity, sample specificity, positive and negative predictive values, and likelihood ratios with their corresponding 95% CIs. StatsDirect (www.statsdirect.com) statistical software was used for the analyses.

RESULTS

Phase I

Overall, 1228 children (age range 6.8–14.8 years, mean 10.6 years, median 10.6 years) from 5 schools were enrolled into the first phase. Of these children, 273 (22%) failed the vision screening based on the previously mentioned criteria.

Phase II

All 273 children who failed Phase I were invited to enrol in Phase II, of which 170 (69.9%) attended and were examined by the pediatric ophthalmologist. On retesting, the ophthalmologist passed 65 and failed 105 of the children in Phase II.

Phase III

In Phase III, 163 randomly selected children who passed screening in Phase I were reassessed by the pediatric ophthalmologist, who passed 158 of these children a second time.

Accuracy of trainees as vision screeners. Table 1 shows the screening test properties of the trainee screeners compared with the pediatric ophthalmologist. The trainee screeners

Table 1—Accuracy of trainee screeners compared with eye care professionals

Phase	Children Failed by Pediatric Ophthalmologist	Children Passed by Pediatric Ophthalmologist	Total
II			
Children failed by trainee screeners in Phase I	105	65	170
III			
Children passed by trainee screeners in Phase I	5	158	163
Total	110	223	333

Sample sensitivity (105/110) = 95.5% (95% CI: 89.7%–98.5%).
Sample specificity (158/223) = 70.8% (95% CI: 64.4%–76.7%).
Sample accuracy [(105 + 158)/333] = 79.0% (95% CI: 74.3%–83.0%).
Likelihood ratio of a positive test (sensitivity/[1 − specificity]) = 3.27 (95% CI: 2.68–4.10).
Likelihood ratio of a negative test ([1 − sensitivity]/specificity) = 0.06 (95% CI: 0.02–0.14).

had very high sample sensitivity (95.5%) and high sample specificity (70.8%). This translated into a likelihood ratio of 3.27 (95% CI 2.68–4.10) for a positive test. This indicates that a child with vision impairment is 3 times more likely to fail the vision test performed by the trainee screeners compared with a child without vision impairment. The likelihood ratio of a negative test was 0.06 (95% CI 0.02–0.14). In other words, a child with vision impairment is 16 times less likely to pass the vision test performed by the trainee screeners than a child without vision impairment. The trainee screeners' accuracy in correctly identifying an eye with perfect vision (true negative) and correctly detecting an eye with imperfect vision (true positive) was 79.0%.

Estimated prevalence of impaired vision in Hamilton elementary schools. If we project a 61.8% (105/170) positive predictive value for the trainee screeners' vision screening test to the 273 children who failed screening in Phase I, 169 children would have failed vision testing in both Phase I and Phase II. If we project a 96.9% (158/163) negative predictive value for the trainee screeners' screening test to the 955 children who passed vision testing in Phase I, a total of 926 children would have passed vision testing in both Phase I and Phase III. The remaining 29 of 955 children would have passed vision testing in Phase I and failed vision testing in Phase II. Therefore, 198 (169 + 29) of the 1228 children aged 6–14 years in the study population have vision impairment (based on the study's failure criteria)—giving an estimated prevalence of 16.1% or 161 children per 1000 population.

Burden of eye disease in this study population. On the basis of WHO definitions,[17] 16 study children had bilateral moderate visual impairment and 2 had bilateral severe visual impairment. The significant visual deprivation of these 18 children was not known to their teachers or schools at the time of study enrolment.

In Phase II, 28 children had VA worse than 20/50 OU; 11 of these children had never before had an eye examination. After examination in Phase II, 25 of the 28 children received new glasses, and at 1-month follow-up, 14 of these children could already see better than 20/50 OU. Of those who were still unable to see better than 20/50 at 1-month follow-up, 5 had amblyopia (4 had strabismus and 1 had posterior capsular fibrosis), and in 6 children the presenting VA was reduced because they did not bring their glasses to follow-up, though it should be noted that their pinhole VA was better than 20/50.

Given the school age of the study children, if we define significant refractive error as myopia (nearsightedness), > -1.50D, hyperopia (farsightedness), $> +3.50$D, and astigmatism, $> \pm 1.50$D, only 15 out of 83 (18.1%) eyes actually requiring refractive correction (glasses) were corrected with glasses at the time of enrolment in the study.[18]

Discussion

Need for vision screening in children

Early intervention allows detection and treatment of vision disorders that, if missed, can lead to amblyopia in later life, whereas screening in older children (elementary school and beyond) is primarily aimed at detecting vision disorders such as uncorrected myopia. These disorders impair vision and visual function, causing visual disability while undetected, although this can be rectified if treated. A recent U.S. study performed vision screening on 9743 children of differing ethnicities (6–11 years of age) and found failure rates ranging from 11.0% to 14.2%, with the highest rates of failure and poorest vision found in the 9–11-year age range.[19] A large study conducted over a 16-year period in Germany found the overall prevalence of low vision and blindness to have increased by 11.6% in the population as a whole and by 7.3% among children aged 6–17 years.[20] Furthermore, children growing into adult amblyopes have an increased risk of bilateral visual impairment. Those with amblyopia have more than twice the risk of nonamblyopic individuals of losing vision in the other (good) eye and becoming visually impaired in both eyes for life.[21] The loss of vision in the better eye is usually caused by accident or trauma. According to the National Coalition for Vision Health,[13] individuals with vision loss have double the risk of mortality and difficulties with day-to-day living and triple the risk of depression.

There also appears to be a correlation between certain vision disorders and a child's education and socioeconomic status.[22] Researchers from England found that children from less-advantaged backgrounds were at a higher risk of developing hypermetropia, amblyopia, and convergent strabismus.[23] Another study from Australia found that a significantly lower number of children with amblyopia complete higher education degrees than those without amblyopia.[24] This growing body of evidence supports an acute need for vision screening in children.

Existent vision screening by non–eye care professionals

Although there have been several publications regarding the use of non–eye care professionals such as teachers, nurses, and volunteers to screen for vision disorders in children,[19,25–28] many unanswered questions remain regarding the details of the ideal vision screening program for children. It may be that more than one such optimum screening program needs to be devised based on age, geographical and socioeconomic conditions. For a vision screening program to be successful, a wide range of questions should be answered during the development phase, including who will carry out the screening. When we apply these standards, the various existent ad-hoc and community-based[29–31] vision screening programs run by non–eye care professionals, although commendable, fall short of an ideal screening program. These attempts at

screening have arisen as a direct result of the important gap that currently exists in vision screening for children in North American communities. This study demonstrates how, even today, an important group of children in elementary schools who have moderately or severely reduced vision still remain undetected. This visual impairment has an important negative effect on their education, behaviour, and future in general.

Burden of visual impairment based on study results

On the basis of the sample size, criteria for failure of vision screening tests, and measured accuracy of the trainee screeners, the prevalence of poor vision in the elementary school population in an urban Canadian setting is estimated to be 16.1%. Other studies have defined failure of vision screening as distance VA $<20/30$ in at least one eye or one line or more difference in the distance VA between the 2 eyes.[32] When we use these more strict cut-offs for failure, the prevalence of children with amblyopia or poor vision would be greater than reported in this study. The need for vision screening is demonstrated even further when one considers the reversible nature of reduced vision in cases of uncorrected myopia, hyperopia, and astigmatism.

In our study, only 18.1% of children requiring glasses actually wore glasses at the time of study enrolment, further highlighting the importance of and need for screening in the pediatric and school-aged population.

Economic impact and next steps

The screening method used in this study becomes less expensive over time, as the equipment required ($5000 per M&S system) needs to be purchased only once for any given school or screening team, and any trainee screener needs to be trained only once. The cost of training the trainees was negligible because it was incorporated into the daily practices of the eye clinic by the pediatric ophthalmologist.

The study team has developed new ties with the Hamilton Wentworth District School Board and is devising a large, prospective study to assess the accuracy of different types of non–eye care professionals in performing various visual examination tasks on children aged 4–14 years. The investigators believe that such a large, well-designed, prospective study can provide important, evidence-based answers to questions regarding whether non–eye care professionals can be accurately trained to perform various types of vision screening tests on children ranging in age from kindergarten to high school. It is the investigators' hope that such studies will help close the real and existent gap in the provision of eye care for thousands of Canadian children, as investing in children's vision is investing in their future.

In conclusion, this study provides strong evidence to suggest that non–eye care professionals can be trained, to an acceptable degree of accuracy, to perform specific vision screening tests on children in a community setting, which may prove to be an important method of addressing existing vision screening gaps in Canada.

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Footnotes and Disclosure:

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