EYE-MAC Project Report

2017-18

McMaster Paediatric Eye Research Group (McPERG)[a]

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[a] McMaster Paediatric Eye Research Group is a group of researchers involved in paediatric eye research directed and founded by Dr. Kourosh Sabri. For more information visit www.mcperg.com

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Background

Importance of Vision Screening in Children

Good vision is imperative for a child's physical, emotional, and social development.[1] Children use their vision for 80% of their learning. Despite the importance of good vision, approximately 25% of school-age children have an undiagnosed visual impairment.[2] Even more crucially, 60% of children with reading difficulties have undetected or uncorrected vision problems.[2]

A child's vision should first be assessed in infancy and then routinely examined every 12-24 months as it continues to develop.[3,4] Amblyopia is an ocular condition in which reduced vision occurs due to insufficient visual stimulation of the brain in early childhood and can be caused by a variety of conditions including strabismus, refractive errors, and/or cataracts.[5] According to screening recommendations, early examination is critical, as early detection can prevent severe visual impairment or loss arising from certain eye conditions such as strabismus (cross eyed) or refractive error (need for glasses) leading to amblyopia (lazy eye).[2] Approximately 2-5% of children have amblyopia, making it the leading cause of vision loss in children. Treatment is typically inexpensive and includes the use of an eye patch and/or glasses. However, treatment becomes more difficult as a child gets older, as visual maturation reaches its end and treatment compliance lowers.[6]

Ocular disorders, whether in one or both eyes, can go unnoticed as children often adapt to their poor vision, causing no alarm to their parents or other care givers. Children with amblyopia can appear to be asymptomatic.[7] Children with a vision impairment in one eye have almost three times the risk of total blindness due to injury or disease affecting the fellow eye over their lifetime, compared to those who do not have a visual impairment.[8] According to the National

Coalition for Vision Health, those with vision loss experience increased difficulties with daily living, have a doubled mortality rate, and triple the risk of depression.[2] Additional reported consequences of poor vision include decreased educational achievements, decreased socioeconomic status, and increased psychosocial issues.[9,10]

Gaps in Vision Screening in Children

While many Canadian provinces, including Ontario, offer free annual comprehensive eye examinations by optometrists for children, only an estimated 14% of Canadian children under the age of six have had an eye examination.[2,11] Rather than universal screening, most provinces conduct opportunistic screening, in which children with eye complaints or symptoms are flagged by teachers or their parents to have their eyes examined.[12] However, this method fails to identify children who may have adapted to poor vision in one eye or appear to be asymptomatic. Often, children may be unaware they have a visual problem.[13] Well-intentioned screening programs such as the Eye-See, Eye-Learn Program in Ontario, which provides a free eye examination and complementary glasses to junior kindergarten children, are problematic because they still rely upon parents to recognize their children's visual impairment and bring them to the optometrist.[14] Furthermore, although vision screening and referral guidelines are outlined for paediatricians, studies have shown that not all paediatricians screen at the recommended age or conduct all vision tests.[15, 16]

Inadequate vision screening may be attributed to multiple factors including:

1. Lack of adequate resources and eye-care professionals to provide universal vision screening, especially in rural areas[2,17]
2. Lack of public awareness of the importance of vision screening

In January 2018, the Ontario Ministry of Health and Long-Term Care set out guidelines and amended legislation for vision screening services to be implemented in the school setting.[18] Children in senior kindergarten will be screened.

EYE-MAC

The Purpose of EYE-MAC

Prior studies have been conducted by the McMaster Paediatric Eye Research Group to investigate the accuracy and feasibility of a new model for vision screening using vision screeners to address the gap in the healthcare system in Ontario. These studies have been vital in providing evidence-based practice in the development of the Eye Examination Mobile Assessment Clinic (EYE-MAC) Project.

I. Hamilton McMaster Students' Eye Examination Screening (HaMSEES 1) Study

In 2013, over 1,000 elementary school children were screened for vision problems by trained McMaster undergraduate students. The results were published in the Canadian Journal of Ophthalmology.[19] The study determined that non-eye care professionals can be trained to perform vision-screening tests on children with an acceptable degree of accuracy, as the newly trained vision screeners had a specificity of 70.8% and sensitivity of 95.5% in detecting children with vision problems.

II. Hamilton McMaster Students' Eye Examination Screening (HaMSEES 2) Study[20]

Further research was conducted on the feasibility and accuracy of a program using trained vision screeners in elementary schools.

In this follow up study eight trainee vision screeners each received 40 hours of theoretical and practical training in conducting basic vision tests by the trainer optometrist. Next, each trainee screened between 70 to 80 children within elementary schools in the Hamilton-

Wentworth Catholic District School Board. All children were also examined by the trainer optometrist. In total, 690 children across nine schools were examined.

Trainee vision screeners had a screening sensitivity of 0.78 and a screening specificity of 0.91. Screening specificity was also found to be higher than other published studies using nurses and community volunteers.[21] The average trainee accuracy in correctly identifying eyes with and without vision impairment was 91%.

III. Development of the EYE-MAC Project

Building on the results of the HaMSEES 1 & 2, the EYE-MAC project was conceived with the aim of being a cost-effective, accurate and sustainable paediatric vision screening program run by trained non-eye care professionals. Additional schools within the Hamilton Wentworth community were included in the project, and new vision screeners from McMaster University were recruited and trained to perform the tests.

Turning Vision Screener Training into a Science

The EYE-MAC vision screeners undergo rigorous theoretical and practical, hands-on training. Vision screeners are trained to conduct distance visual acuity tests using the M&S Smart System, which includes Snellen, Allen and LEA charts to accommodate children's varying developmental and literacy levels. Additionally, volunteers are trained to conduct stereoacuity (depth perception) tests using the Randot Stereotest Booklet (2009 Stereo Optical Co., Inc.). A detailed and comprehensive training manual provides the theoretical training. Trainees learn the background knowledge required to understand the purpose of visual acuity and stereoacuity tests. This includes step-by-step instructions on how to perform both tests on children and an outline of the standardized procedures that must be followed during a typical screening day. Supplemental videos are available to help screeners further understand how to set up equipment and conduct

vision screening tests in children. Furthermore, child life specialists train screeners on increasing child compliance when conducting vision screening, as the accuracy of the said tests is dependent upon the child's level of cooperation.

During the first phase of practical training, an experienced vision screener simulates a full vision screening for the trainee and gives them a chance to practice. In the next phase of practical training, trainees perform both visual acuity and stereoacuity tests on 30 children aged 4 to 14 years and compare results with a local optometrist or ophthalmologist while being blind to each other's results. Throughout this process, trainees can further observe screening techniques, ask questions and receive feedback to improve upon their skill-set. Screeners are deemed eligible to independently perform the tests on children if there is a minimum of 80% level of agreement between the trainee and eye care professional.

Fail Criteria

Children undergoing vision screening fail based on the following criteria:

For distance visual acuity:

- Worse than or equal to 20/32 for children 4-5 years old*
- Worse than or equal to 20/40 for children ≥5 years old*
- Greater than one line difference between right and left eye visual acuity (all ages)

For stereo acuity:

- Worse than 70 seconds of arc[2]*

* Worse than indicates a number larger than that indicated. Pass/fail criteria is consistent with widely accepted vision screening recommendations.[22,23] Fail criteria differs between ages to account for differences in development in visual acuity. Screeners measured distance visual

acuity with a LogMAR score, however for ease of use, all visual acuity scores in this report have been converted to Snellen acuity scores. (Appendix 1).

EYE-MAC Vision Screening 2017-18

Overview of Screening

Twelve McMaster undergraduate students and community volunteers conducted screening in elementary schools within the Hamilton-Wentworth Catholic District School Board. Screening occurred between October 2017 and June 2018 at a total of twelve schools. (Appendix 2)

Set-Up on Screening Day

Prior to screening, consent and assent forms were handed out at schools to all children aged 4 to 14 years. Two schools were provided passive consent forms, in which parents could opt out of screening and all other children in the schools were screened. This method allowed for a greater percentage of children to be screened at each school.

Screening was conducted in a room provided by the school. To ensure the screening environment was standardized for all children, screeners were instructed to leave the lights on and close the door to provide a well-lit, quiet, and distraction-free environment.

Two vision screeners were present at each school during the screening day. One vision screener acted as a "runner" and escorted children to and from class while the other screened children individually in the screening room. No screening took place during breaks or within 10 minutes on either side of a break period..

Distance visual acuity was measured using the M&S system at a distance of 20 ft using Snellen crowded letters, or Allen or Lea symbols for illiterate children. One eye was tested at a time, with the other covered with an occluder. Visual acuity was recorded as the best line on

which the child could correctly identify more than half of the letters or symbols, plus the number of letters or symbols correctly read on the next line. The Randot Stereotest Booklet (2009 Optical Co., Inc.) was used for assessing near stereoacuity and was held at 40 cm from the child's eyes. When possible and applicable, all tests were performed using the child's existing visual correction, such as glasses or contact lenses.

Informing Parents Post Screening

Once screening was complete, pass and fail letters were sent home to parents with respective students in concealed envelopes. Parents of children who failed vision screening received a letter advising them to take their child to an optometrist within a specified amount of time based upon the level of visual impairment measured at screening. Children who failed the stereo acuity test and/or had a visual acuity score better than 20/50 were advised to see the optometrist within three months and children who had a visual acuity worse than or equal to 20/50 were advised to see the optometrist within one month. Parents of children who passed the vision screening received a letter informing them of the results and reminding them that all children are recommended to see an optometrist annually.

Quality Checks

All children enrolled in this project, received an information sheet for their optometrist to fill out and return to the McPERG office, at their next eye examination session. Comparing the visual acuity and stereopsis measurements obtained by the optometrist to those obtained by the volunteer screeners, allows for an ongoing quality control on the accuracy of the volunteers in conducting these tests. Follow-up for children who failed screening is set to take place.

An outline of the Eye Mac project set-up can be seen in Figure 1.

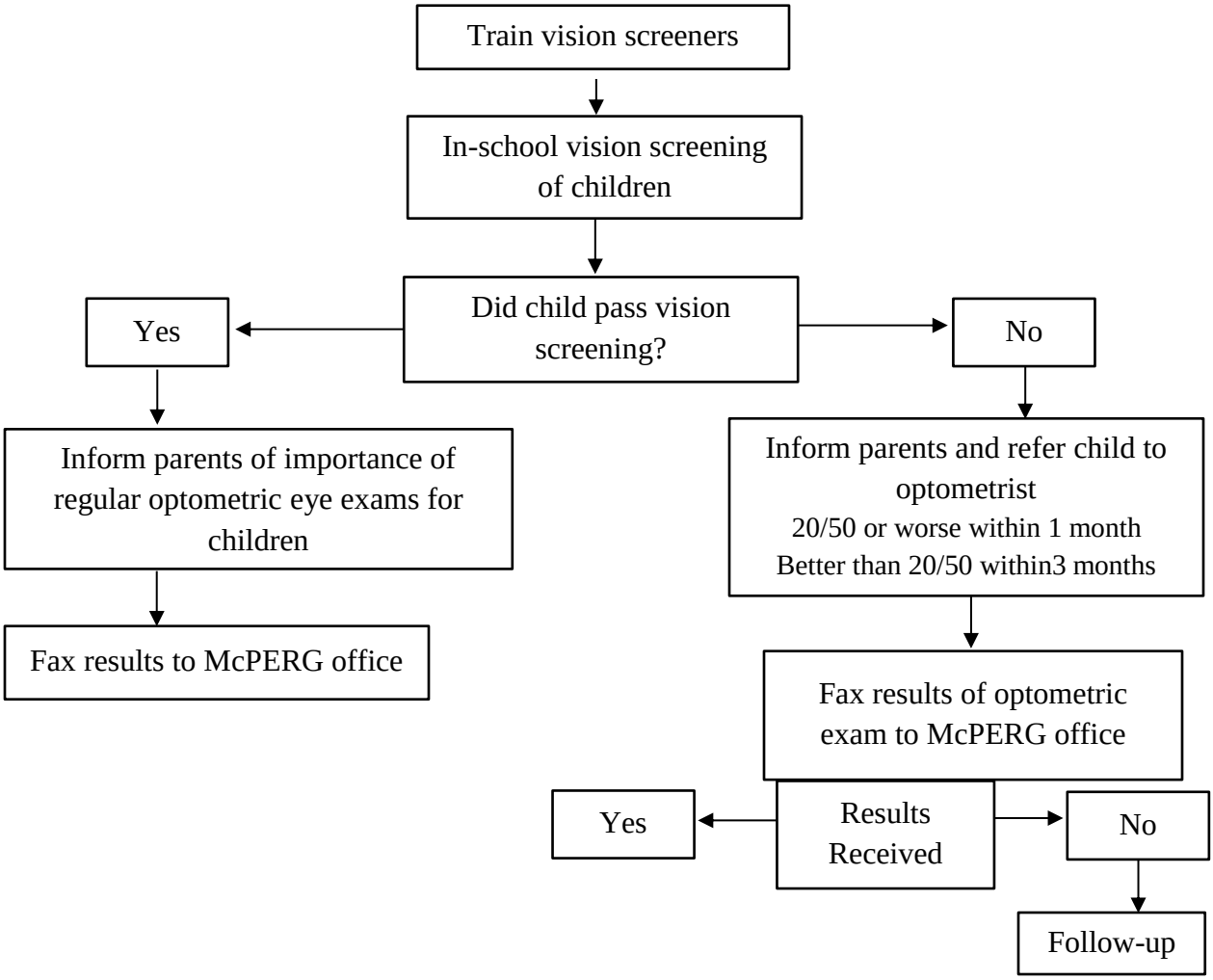

Figure 1: Study Outline

Results

Altogether, 2,125 children between the ages of 4 and 14 years were examined between September 2017 and June 2018, of which 333 (16% of total) failed the vision screening. Table 1 shows the breakdown of children who failed according to the different screening criteria. Children may have failed based on more than one criteria. The category ‘further attention

required' refers to children who failed due to an incomplete test. Reasons for an incomplete test included developmental delays, lack of cooperation or inattention.

Table 1: Number of Children Who Failed Vision Screening Based on Fail Criteria

Fail Criteria for Vision Tests	Number of Children Who Failed Test (n=333)	% of Children Who Failed in Total (n=2125)
Visual acuity worse than 20/40 (age 4) or 20/32 (ages 5 and older) of either eye using Snellen, Allen, or Lea chart	207	9.7
Visual acuity difference of more than 1 line between eyes	196	9.2
Stereo acuity of worse than 70 seconds of arc^2 at 40 cm	121	5.7
Further Attention Required	19	0.9

Most children failed, at least in part, based on visual acuity score criteria (n=207). Figure 2 displays the spread of visual acuity in the worst eyes of those who failed based on distance visual acuity. The highest number of children that failed were in the 20/32 – 20/40 range. Visual acuity scores worse than 20/50, marked as requiring immediate attention, were found in at least one eye of 69 children. Two children had visual acuities of 20/400 in their worse eyes.

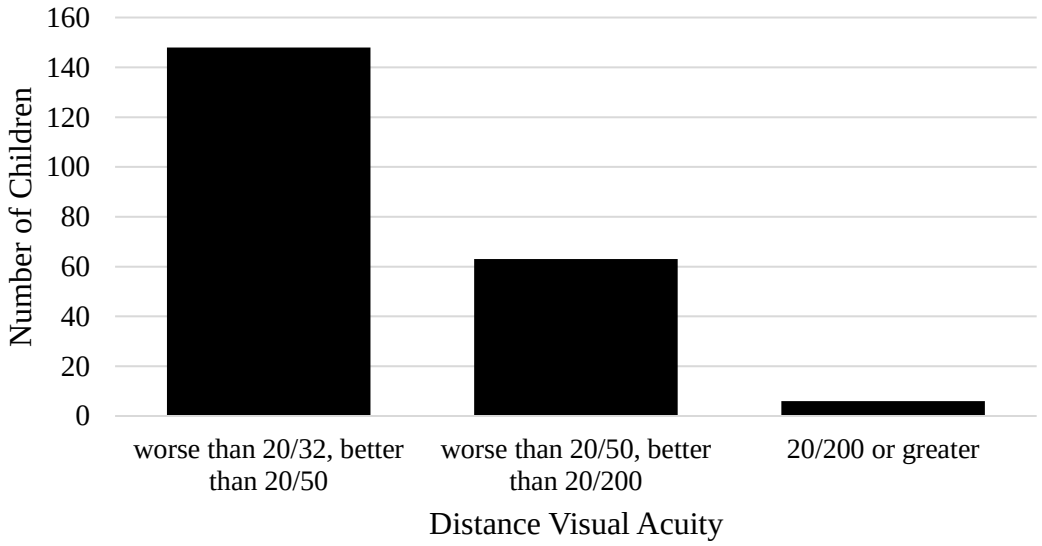

Figure 2: Distance VA Scores in Worst Eye of Children with a Failed VA Score (n= 207)

Prevalence of Visual Impairment in Children Screened

Visual acuity can be categorized into normal vision (20/32 or better), mild/manageable vision loss (worse than 20/32 to 20/50), moderate vision loss (worse than 20/50 to better than 20/200) and severe vision loss/near-blind (20/200 or worse).[24,25] The number of individual eyes that had a degree of visual impairment was 306 (Table 2) of which 81 eyes had moderate vision loss and 9 had severe visual impairment. The impact of visual impairment can be further assessed when comparing the distance visual acuity scores in both eyes of children (Table 3). Eight children had severe visual impairment in at least one eye, including one child with severe visual impairment in both eyes. Seventeen children were also found to have low vision in both their eyes.

Table 2: Number of Eyes with Visual Impairment (n = 306 eyes)

Visual Impairment	Number of Eyes (n=306)
Mild (worse than 20/32 to 20/50)	216 (70.6%)
Moderate (worse than 20/50, better than 20/200)	81 (26.5%)
Severe (20/200 or worse)	9 (2.9%)

Additionally, age proves to be a considerable factor in determining the impact of visual loss in a child. As previously outlined, vision is integral to a child's learning and early detection of visual abnormalities may prevent permanent visual loss. Alarmingly, three children aged 10 to 14 years were found to have severe vision loss: 20/200 or worse in their worse eye (Figure 3). This data underscores the need for ongoing vision assessment throughout childhood and adolescence, not just a one-time screening in Kindergarten.

Table 3: Number of children with a visual impairment, by eye (n=2125 children)

Degree of vision loss in Better Eye	Degree of vision loss in Worse Eye		
	Mild (worse than 20/32 to 20/50)	Moderate (worse than 20/50 to better than 20/200)	Severe (20/200 or worse)
None (20/32 or better)	84 (4.0%)	21 (1%)	3 (0.1%)
Mild (worse than 20/32 to 20/50)	53 (2.5%)	24 (1.1%)	2 (<0.1%)
Moderate (worse than 20/50, better than 20/200)		17 (0.8%)	2 (<0.1%)
Severe (20/200 or worse)			1 (<0.1%)

Individuals with a visual impairment can be partially sighted or legally blind. In Canada, legal blindness is defined as having a best corrected visual acuity of worse than or equal to 20/200 in the better eye.[25] Partially sighted is defined as having a best corrected visual acuity less than 20/60 and better than 20/200. Using these criteria to analyze the results of the vision screening, *one individual was legally blind, and six individuals were partially sighted*. On a practical level, in Canada a best corrected overall visual acuity of 20/50 is required for people to obtain a driver's license[26]. Within our screened population, twenty-five children would not be allowed to drive based on their current visual acuity.

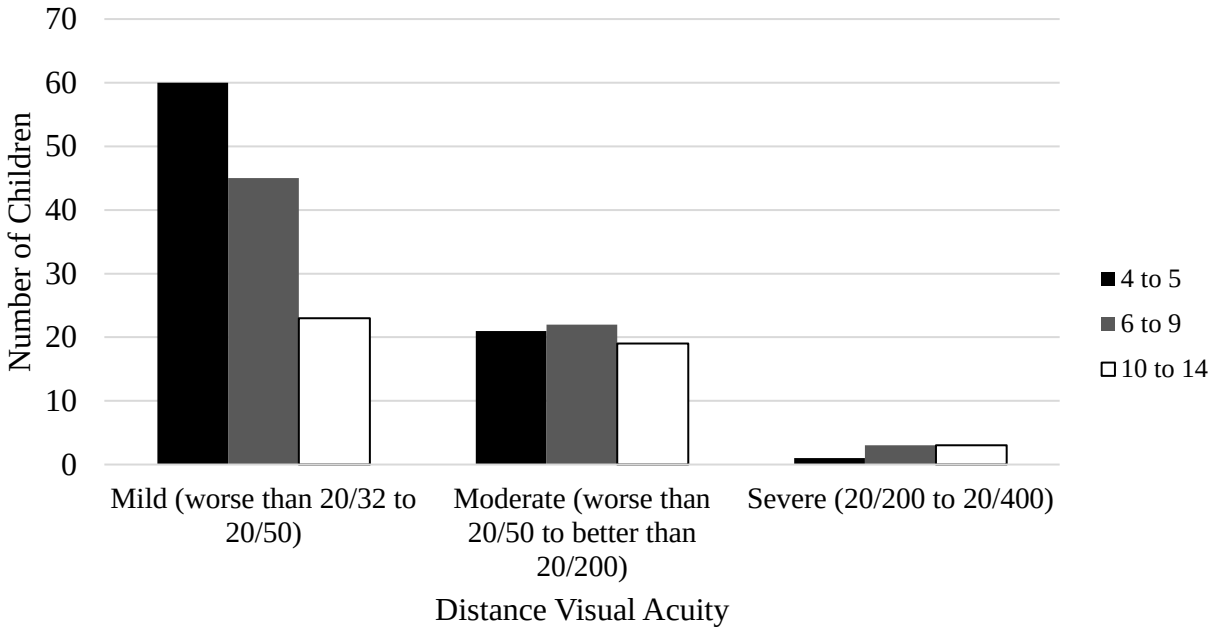

Figure 3: Ages of Children with Visual Impairment, by score in worse eye (n=209 children)

Quality Control

To date, optometrist examination results have been sent to the McPERG office regarding 33 children. Table 4 shows the number of true positives (both screener and optometrist failed child); true negatives (both screener and optometrist passed the child); false positives (screener failed the child while optometrist passed the child); and false negatives (screener passed the child while optometrist failed the child). Passing or failing in this instance refers to screening criteria. Some children passed based on screening criteria but may have required eye care or a prescription based on other variables tested during the optometrist's more comprehensive examination. For these results, sensitivity was calculated as 62.5% and specificity as 76%. However, this only accounts for 1.5% of all optometrist letters that were sent out.

Most alarmingly, a child that failed vision screening was found by an optometrist to have 20/400 in both eyes.

Table 4: Optometrist vs. Vision Screener Results

	Optometrist Fail	Optometrist Pass
Screener Fail	5	6
Screener Pass	3	19

It should be noted that only distance visual acuity and stereo acuity tests were performed by vision screeners while optometrists provided comprehensive eye examinations.

Cost-analysis

In total, the cost for school vision screening was $10,340 CAD. The cost can be broken down as follows: $10,000 (2 x $5,000 per M&S System) + $40 for occluders ($20 each) + $300 for Randot stereo acuity booklets ($150 each) + $0 for vision screeners. This accounts for a cost of less than $5 per child screened. However, all supplies were reused from the previous year of screening and can be used for further screenings.

The time requirement for screeners amounted to at least one 8-hour school day per week. On average 40 children were screened per day.

With no costs associated with trainee vision screeners and a relatively low time commitment for screening with enough available screeners, the EYE-MAC program has demonstrated the potential cost benefits of using non-eye care professionals to conduct vision screening.

Challenges

Challenges with Children

Although screeners used strategies learned in training to increase compliance in children during vision screening, it was nevertheless challenging to screen children with developmental delays. A lack of verbal ability in some children can be compensated for by using cards which

allow for pointing to symbols rather than verbally identifying letters. However, the amount of attention required to complete the test proved difficult for these children. Some children were accompanied by an education assistant who repeated instructions and helped capture the child's attention. Children who were unable to be screened were noted as requiring further attention and provided with a fail letter.

Another challenge for vision screeners was malingering. Children that malingered during the vision test were often noted to be eager to obtain glasses and intentionally played down their ability to see in an attempt to achieve a lower score. Some children admitted that they wished to get glasses, or that expect to get glasses because their siblings or friends have them as well. Additionally, a number of children of younger ages were also reluctant to take the test or were restless.

Challenges in the schools

Limitations with screening rooms occurred in some schools. Schools were often limited in the number of rooms that both met the aforementioned requirements and were available for a full day of screening. At times, vision screening took place in supply rooms and rooms within hearing distance of a gym as no other rooms were available. Lighting and distractions in these rooms may have affected the quality of testing and attention of the child for screening.

In 2018, a van was acquired that will be transformed into a mobile eye-screening unit. This will ensure that vision testing can be conducted in a proper environment regardless of any school's room availability.

Conclusion

The Eye Mac project has demonstrated the potential benefits of using non-eye care professionals to conduct community paediatric vision screening. Namely, that this method of screening could detect children with visual abnormalities and bring awareness to parents on the importance of vision screening. Vision screeners have demonstrated accuracy with vision screening and can serve as a more cost-effective option for in-school vision screening, compared to using paid professionals such as ophthalmologists, optometrists, nurses and/or public health staff.

Furthermore, the findings of the vision screenings demonstrate the need for universal vision screening. 79 eyes screened had moderate vision loss and 9 eyes had severe vision loss. 45 had moderate vision loss in one eye only, seventeen children had moderate vision loss in both eyes, seven had severe vision loss in one eye only, and one child had severe vision loss in both eyes. Vision screening could ensure timely care is given to children and that children are given equal learning opportunities.

Next Steps

The eye-van has been purchased and will be reconstructed into a fully equipped mobile unit for vision screening. The eye-van will provide a distraction-free and standardized environment for screening that may not otherwise be available in the schools. Transportation of expensive ocular equipment would be limited with the eye van, putting it at a much lower risk for damage. Finally, a mobile eye unit would allow for vision screening in more remote and rural areas.

Additionally, improvements to the training of vision screeners are underway. Theoretical training material has been transferred into module format that adheres to evidence-based

multimedia principles that foster learning. A prospective goal with the training program is to administer it as an undergraduate course which can provide a sustainable option in recruiting students to conduct vision screening.

Appendix 1: Visual Acuity Snellen to Lomar conversion table

Snellen	LogMAR
20/20	0.0
20/25	0.1
20/32	0.2
20/40	0.3
20/50	0.4
20/63	0.5
20/80	0.6
20/100	0.7
20/125	0.8
20/160	0.9
20/200	1.0
20/400	1.3

Appendix 2: Participating Schools

- Annunciation of our Lord C.E.S.
- Corpus Christi C.E.S.
- Holy Name of Mary C.E.S.
- Immaculate Conception C.E.S.
- Regina Mundi C.E.S.
- St. Ann (Ancaster) C.E.S.
- St. Augustine C.E.S.
- St Joachim C.E.S.
- St. Theresa of Avila C.E.S.
- St. Therese of Lisieux C.E.S.
- St. Thomas the Apostle C.E.S.
- St. Vincent de Paul C.E.S.

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