2015-2018 Report

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Kindergarten Vision-Testing Programme

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Summary

Every year in Ontario 3% to 5% of children lose the use of one eye—4000 to 6000 children every year—and countless more do poorly in school, because they have an eye problem that is not treated in time. Family doctors are expected to test for eye problems but many do not, and parents seldom take young children to optometrists even when targeted by publicity campaigns stating that the exam and any eyeglasses will be free.

To deal with this problem we developed and tested a programme to (1) screen kindergarteners in school for potential eye problems and then (2) schedule appointments for optometric examinations to be done either in school or in a nearby optometrist's office.

In one test of our programme we screened 712 children then gave them all a full optometric examination with drops. A single screening detected 84% of those who proved to have eye problems.

Many parents are reluctant to take children to optometrists. Some believe glasses for kindergarteners to be needless, some believe glasses to be a stigma, and many mind the expense of taking time off work. It seems clear that many parents need a gentle push, so when a child failed screening we booked a tentative appointment in a letter we sent home, either at school or a nearby optometrists's office, and then followed up by telephone. Of those children referred, 58% ended up seeing an optometrist.

A few children begin school with glasses and glasses can be beneficial only if the child wears them. To see if our programme led to more kindergarteners actually wearing glasses over the course of a school year, in six similar schools we counted children wearing glasses at the beginning of the year and children wearing glasses at the end. In three of those schools we had offered the screening program, in three we had not. At the beginning of the year, the percentages were the same in both schools: 2%. At the end of the year, the numbers were 3% where we had not worked and 10% where we had. Thus, our screening was responsible for the use of glasses by 7% of the kindergarteners we had screened.

The main eye problems

Amblyopia. 3% to 5% of children grow up with one eye that is misfocused and/or misaligned ("lazy eye").[1] Without treatment the brain stops using that eye. The eye effectively goes blind. Treatment before age seven usually maintains the eye's vision.[2] Treatment may involve eyeglasses and/or surgery to realign the eyes, and it may require the child to wear an eye patch for part of the day.

Refractive error. Approximately 10% of young children are too far-sighted to read a book comfortably. Another 1% are too near-sighted to read the blackboard.[3] In kindergarten these children already score lower on tests of reading-readiness[4] and IQ.[5] Eyeglasses remedy this.

Eye testing today

Ontario family doctors are supposed to screen children for eye problems but most do not, because even when they appreciate the importance, they usually lack the knowledge and the tools.[6] Nor do many parents take young children to an eye doctor, not even when their family doctor recommends it. Parents say that they don't understand the need, where to go, what would happen, or what it costs.

The Ontario Association of Optometrists recommends that all children have an annual examination by an optometrist. Since 2011 the Association has promulgated a programme called "Eye See…Eye Learn" that encourages parents to take four-year-olds to an optometrist for a free exam and arranges for free eyeglasses if needed.[7] Few parents heed this advice.[8]

Our goal

We want to design a vision programme for kindergarten children that is cost-effective and can be offered in all schools across Ontario. To this end we have tested the available methods and we have run demonstration projects implementing the most useful methods in enough schools to identify practical problems.

Our approach

1. Screen children quickly *in school*.

2. If a child fails a screening test, book a full optometry exam either in school or at a local optometrist.

3. If a child needs eyeglasses, provide them for free.

Our criteria

A screening programme errs in two directions. It sees some normal eyes as problematic and it sees some problematic eyes as normal. The first leads to needless optometric examinations; the second leads to more children losing the use of an eye or having problems learning to read.

Children who read poorly do poorly in school, end up in less satisfying and remunerative jobs, and are more likely to develop behaviour problems and feed the criminal courts and jails. These cost society a lot of money. In the long run it would be cheaper to pay for some extra optometric exams but catch every child who has eye problems.

Indeed, even in the short run it would be cheaper. OHIP pays $42.50 for each eye exam. In our study OHIP has paid roughly $100 to find each child with bad eyes. Buying eyeglasses for a child costs $50 to $100. In contrast, for each child held back one grade because he or she cannot read, the cost of the extra year's schooling averages $6000.[9]

For these reasons we prefer screening criteria to catch as many problems as seems reasonable, despite the cost of extra exams.[10]

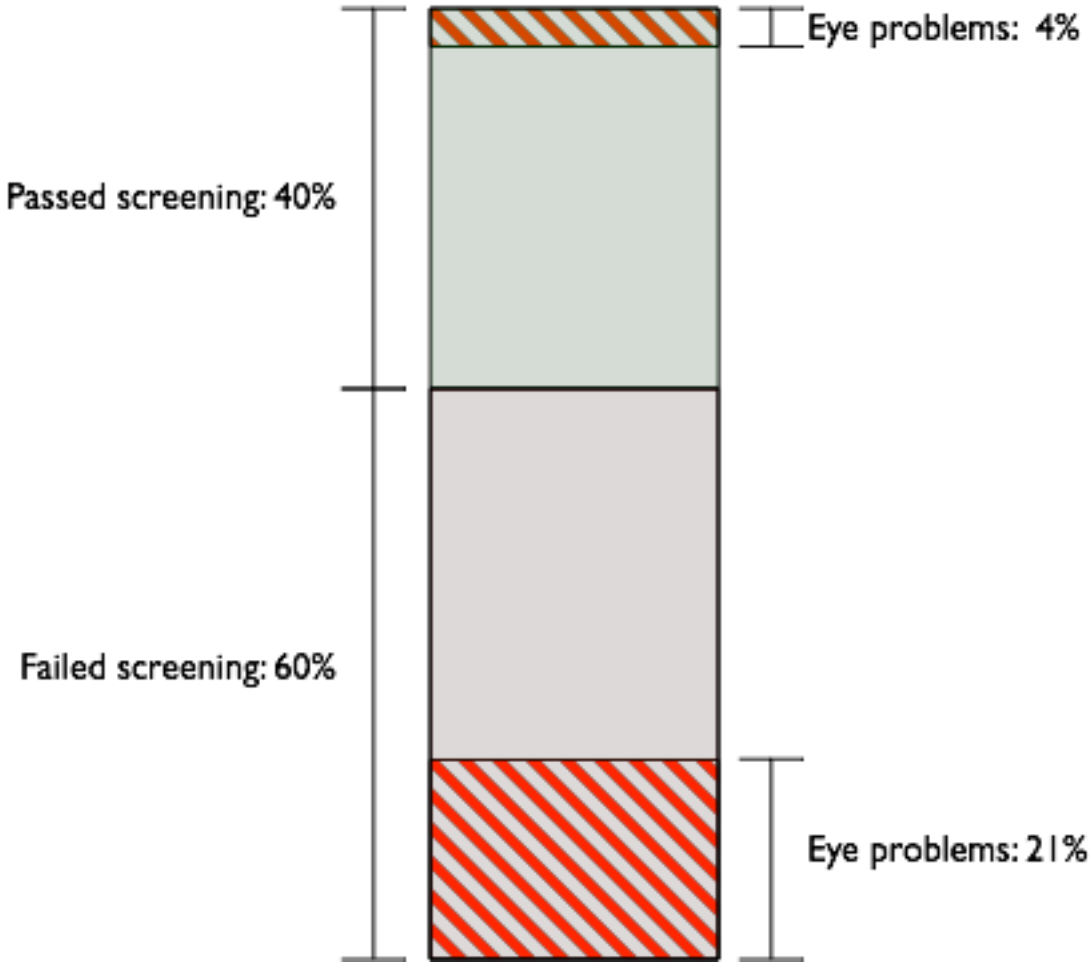
We selected five screening tools (Appendix 1: Screening tests) and applied the most appropriate criteria we could find in the medical and optometric literature. (See Appendix 2: Criteria.) Afterwards, we decided that three minor changes would be appropriate:

- One of our tools was a machine for detecting eye misalignment. It was an experimental device that broke and could not be replaced, so there is no reason to consider it.
- The results from two brands of autorefractor proved to be so similar that there is no reason to employ both.
- Our data showed it appropriate to alter the screening criterion for children with hyperopia (far-sightedness) and for stereoscopic vision, to pick up more children with problems.[11]

Most of the studies in this report use the original criteria but we present data with the modifications at the end.

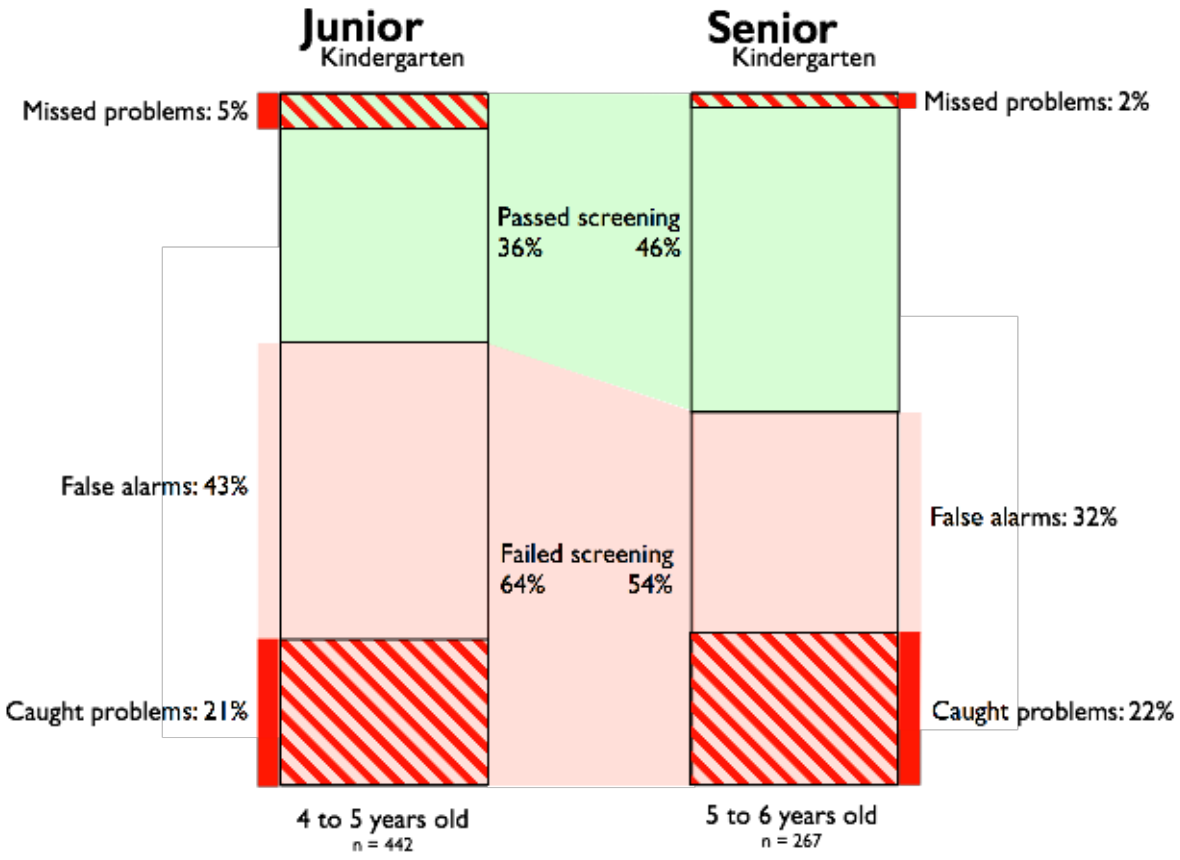
How well our screening works

To begin we evaluated our five screening tools and the criteria of the American Association for Pediatric Ophthalmology and Strabismus. One large kindergarten[12] allowed us to offer every child both our battery of screening tests and a full optometric examination with cycloplegia drops, all within the school. Enough parents accepted this offer to let us compare our screening tests to full eye exams for 712 children. Eye exams found 25% of these children to have eye problems. At least one of the screening tests discovered this in all but 4%:



What year to screen

The chart above intermixes children from junior and senior kindergarten. If we separate the two, we find a difference. Screening is more accurate with the older children. It misses fewer eye problems and it raises fewer false alarms.[13]



Despite this, if a child has been screened in junior kindergarten, then we have found little reason to screen him or her again in senior kindergarten. In another study spread across 25 schools we screened 754 kindergarteners twice, once in each grade. The second year's screening saw:

- Among children who had passed the first year's screening, no eye problems detected.
- Among children who had failed the first year's screening but had passed an eye exam, three new eye problems detected.

A second failed screening did push more parents into an optometrist's office for the first time, so nine additional eye problems were found, but these represented hardly more than one percent of the children—and again, all of those nine had failed screening before.

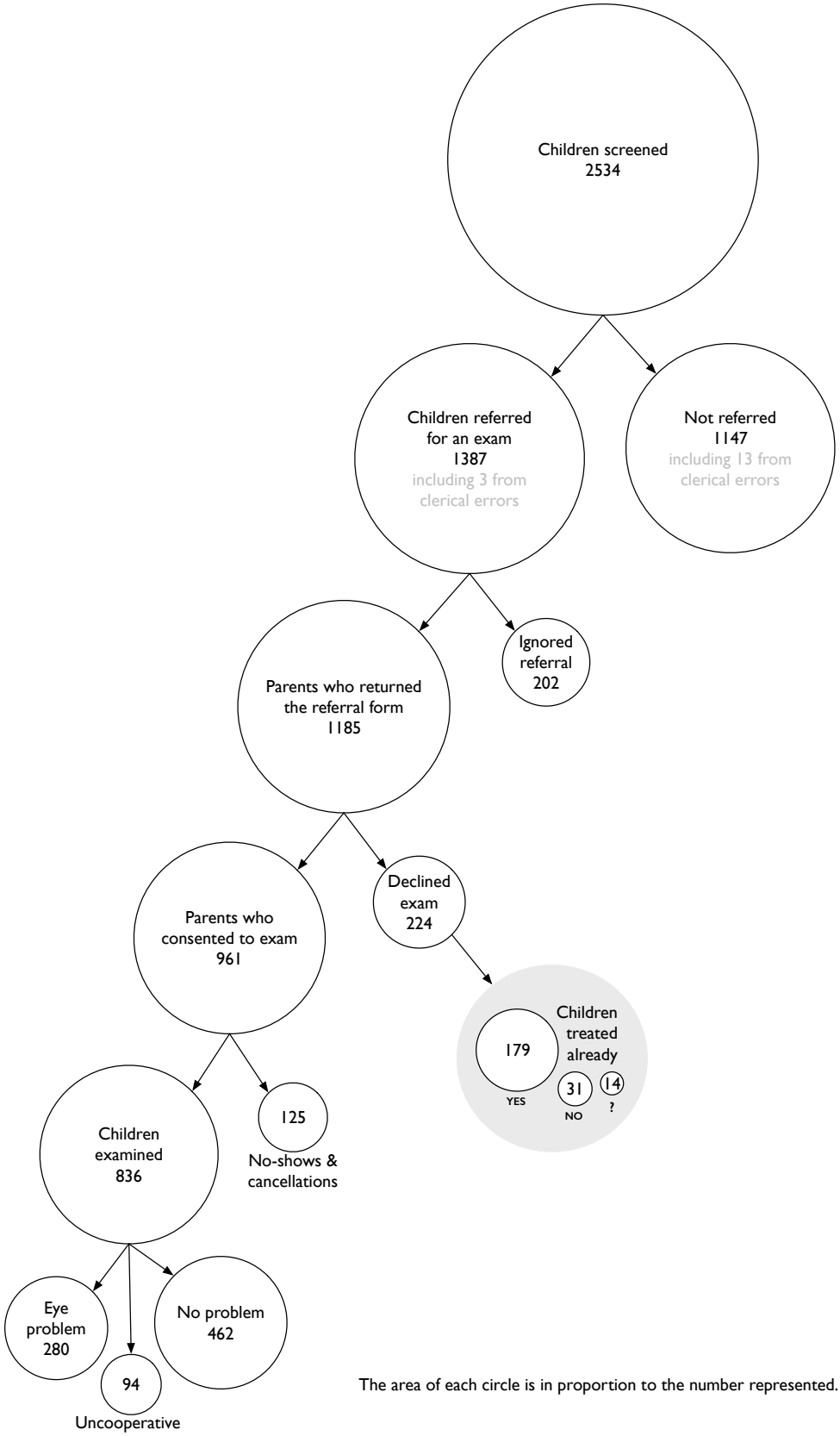
We think it sensible to screen only one of the two years, preferably the second, and to spend extra manpower not on extra screening but on helping parents get children to an optometrist.

That said, with large schools it may also be sensible to send screeners back a second time in the year to pick up children who were absent the first time. In Toronto, the average pupil in senior kindergarten is absent eight days out of 100.[14]

Demonstration project 1: Optometry exams in school[15]

Identifying eye problems requires more than screening, it also requires parents who are willing and able to have a child examined by an optometrist. To see how often screening leads to exams in the real world, in 2015-16 we screened kindergarteners in 25 schools ranging far and wide across Ontario (outside Aboriginal reserves), and we offered the parents of any child who failed screening a free optometric exam in school. If a child failed any of our screening tests, we sent a note home asking the parents to consent to an exam[16] and scheduling a tentative appointment.[17] The letter was commonly in multiple languages and it explained how to change the appointment if necessary. The letter also promised that any eyeglasses needed would be free.[18]

Of the parents whose children failed screening, 13% told us they were already taking their child to an optometrist or ophthalmologist. Of the others, 69% brought in their child for an examination. Some of the children were uncooperative, but of those who allowed themselves to be examined, 33% evinced eye problems warranting either immediate treatment or close scrutiny. (See Appendix 4: Definitions of eye problems.) Those children represented 11% of all the children we screened. Here are the numbers:



The area of each circle is in proportion to the number represented.

Demonstration project 2: Eye exams in the optometrist's office

As we mentioned on page 4, intensive advertising by the Ontario Association of Optometrists sees few parents take 4-year-olds to an optometrist's office, even when promised that there will be no charges for the examination or for any glasses. We wanted to see if this would hold if (1) children failed screening and (2) we made appointments for parents at an optometrist's office nearby. To this end, in 2016-17 we used the same system we used before except that we booked eye exams at an office rather than at school. Each year saw a similar proportion of children examined: 60% of 790 in school, 55% of 894 in an office.

We do not know how many parents would book an appointment without receiving a specific appointment at a specific office and then a telephone call, but judging from many parents' hesitations when we speak with them, we suspect that both of these are important, especially in neighbourhoods with poorer families and a lot of recent immigrants from the second and third world.

Demonstration project 3: Is all this warranted?

If vision screening in kindergarten is warranted, it must catch more problems during the school year than parents, teachers, and family doctors normally catch, and parents must be convinced to make sure the children wear their glasses (or, indeed, to *allow* them to wear glasses: some parents deem poor vision to be a stigma and/or not worth the trouble to treat in young children). To see whether the programme is warranted, we compared three schools where we worked in 2015-16 to three schools where we did not, all serving low-income neighbourhoods in Toronto. After one school year, three times as many children wore eyeglasses in the schools where we worked.[19]

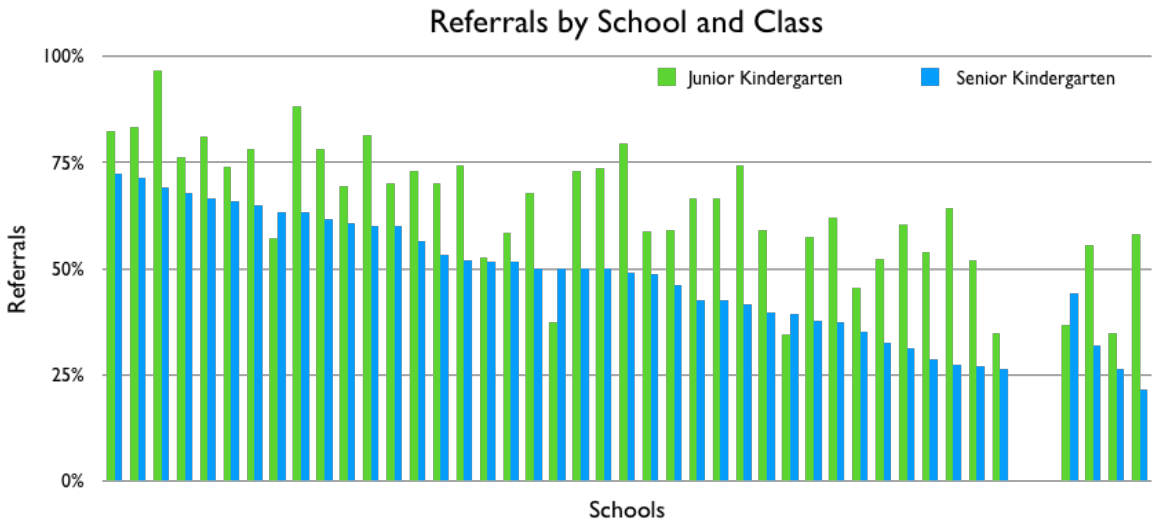
	Children	Wearing eyeglasses September	Wearing eyeglasses June
No programme	661	15 = 2%	20 = **3%**
Our programme	581	14 = 2%	56 = **10%**

Demonstration project 4: Variability from school to school

Like other medical concerns, eye problems are not distributed evenly throughout the population. For example, one cause, insufficient sunlight,[20] will be affected by climate and microclimate, by cultural expectations of children's play, and by the community's wealth—i.e., whether children have parks or backyards available. Genetic differences among ethnic groups can also affect the distribution.[21] It is even possible that some populations have so many problems as to warrant universal eye exams instead of screening.

Indeed, the latter is what we found on a northern Aboriginal reserve. There we screened all of the kindergarten and grade 1 classes (65 children), and had a referral rate of 89%. Such a high rate has been found on other reserves as well.[22] With this rate of referrals, it would be cheaper and more practical on reserves to forgo screening and have an optometrist examine every child.

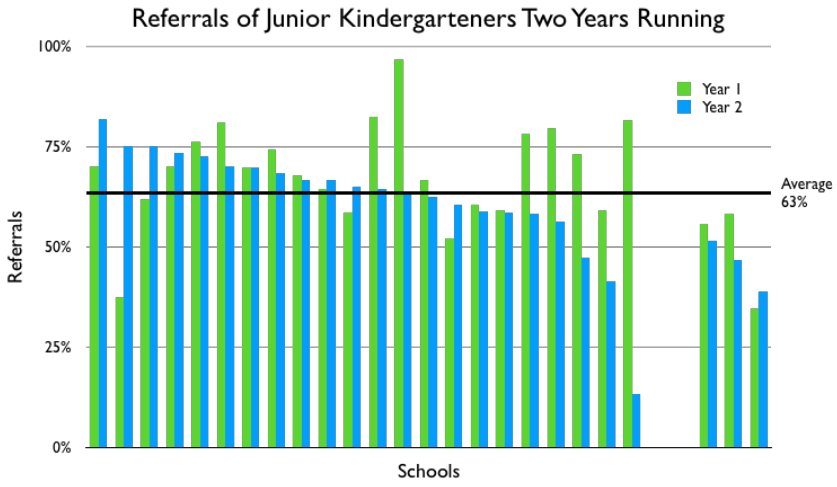
But a different story plays elsewhere. To assess the variation outside reserves, we screened 2534 children in 31 Ontario schools from south to north, east to west, rich to poor, rural to city. (See Appendix 3: List of communities by population.) The results of our screening varied greatly from one school to another[23]—see the graph below—but overall we referred 55% of these children for in-school optometry exams. This is comparable to our referral rate in our initial study. As expected, at all but three schools the referral rates were higher for junior than for senior kindergarten.



The three bars on the right represent schools where we were unable to use one of our machines. Using it would have led to more referrals.

Demonstration project 5: Variability from year to year

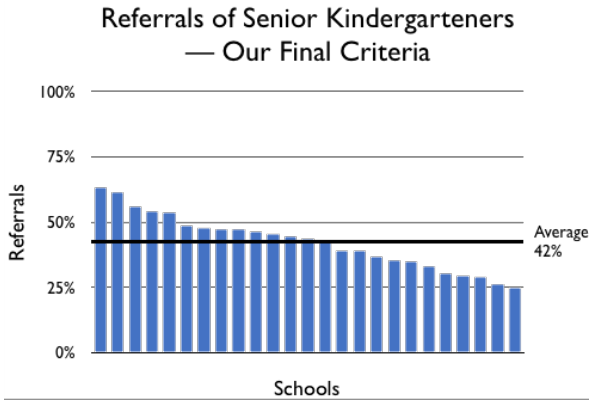
To see whether this distribution is constant from one year to the next, we returned to 25 of those schools in a second year, testing junior kindergarteners each time. The range and variation is similar to the junior kindergarteners' in the graph just above but individual schools fluctuated markedly from year to year.



The three bars on the right represent schools where we were unable to use one of our machines. Using it would have led to more referrals.

Demonstration project 6: Screening as we suggest

In 2017-18 we applied our screening recommendations—senior kindergarteners only, modified criteria[11]—to 25 schools across Toronto, all serving high-needs communities. The mean percentage referred was 42%. Here are the results:



The child's perspective

From the child's perspective our screening usually seems like a game—"These magic glasses let you see things in the snow: do you see anything in the snow?"—and then someone snaps the child's picture. Talking with a stranger upsets some

kindergarteners but most of the frightened children lose their fear after watching their classmates being screened.

We confirmed this with a survey of 322 kindergarteners at six schools. We gave them a paper showing a smiling face, a frowning face, and a neutral face, and asked them to choose the face that showed how well they liked what they just did. 90% chose the smiley face, 7% chose the neutral face, and 3% chose the sad face. Of the eight children who represented those 3%, some told us they were sad because they had not been permitted to play all of the games (because they had failed the first screening test).

The most common negative reaction came not from children who were screened but from children who were left behind in the classroom because their parents had not permitted the screening.

After eyeglasses are dispensed we encourage the teacher to have a party in class celebrating glasses—maybe cookies and a song about eyes and colouring a cartoon character wearing glasses. After these parties a few children do not want to wear their glasses but just as many are sad that they do not need them.

The parent's perspective

Most parents are pleased to have the child's vision screened. If the child is then examined and found to have a problem, most parents are surprised but pleased that the problem was found. However, a few react negatively. "I don't want my child to wear glasses. I don't care what anybody says, nothing is wrong with him."

If the child is examined and found not to have a problem, most parents are relieved but an occasional parent is annoyed. "You people made me take time off work for no reason at all. I brought Mary to an eye doctor, and the doctor gave her drops and she screamed, and I spent an hour there, and the doctor found nothing wrong."

Active vs. passive consent

Most of the schools informed parents about our screening ahead of time and permitted them to opt out. Of 4300 parents, 4% opted out. In most of these cases the child was already seeing an optometrist. Some of the schools insisted that parents return a form permitting the screening. In these schools 32% of the 1576

parents did not return the form (or occasionally opted out). Since the screening is totally innocuous—indeed, most children enjoy it—we see no reason to require active consent and we see strong reason not to.

Conclusion

In an ideal world with infinite resources, every child would have an annual eye exam, but given limits to resources and to parents' time, it makes sense to screen all children quickly and then send to an optometrist only those most likely to need treatment. Universal screening can only be done efficiently in schools.

In an ideal world with rich and perfect parents, every child who fails screening would be taken to an optometrist for an eye exam. In the real world, many parents cannot afford to take time off work and/or do not think children have eye problems or that children's eye problems matter. For these reasons we think it important (1) not to over-refer needlessly and (2) to facilitate eye exams by making tentative appointments and contacting parents for confirmation.

We also deem it important to permit passive consent for the screening rather than active consent. No child should lose the vision in an eye because his parents do not bother to send in a form permitting a harmless set of screening tests that most children enjoy.

Appendix 1: Screening tests

1. Cambridge Crowding Cards (5-10 minutes). This is an eye chart designed for pre-schoolers (5-10 minutes). It detects:

- amblyopia caused by a difference in acuity between the eyes
- myopia
- significant astigmatism

The HOTV with crowding bars gives comparable results.

2. Randot Preschool Stereoacuity Test (2 minutes). This detects amblyopia caused by a reduction in binocular 3-D vision.

3. The PlusoptiX S12 and, initially, the Spot Autorefractor (1 minute each). These detect refractive errors. After using both for two years we stopped using the Spot.[24]

4. Pediatric Vision Scanner (1 minute). This is an experimental machine—our use of it is formally a Health Canada clinical trial—that detects eye misalignment.[25]

Appendix 2: Criteria

Original criteria
- Pediatric Vision Scanner
  - Failure to fixate binocularly in 60% of 10 attempted measurements
- Randot stereoacuity
  - Worse than 100 arc secs
- Crowded acuity
  - 31-48 months
    - Worse than 20/40 in either eye
  - >48 months
    - Worse than 20/30 in either eye
- Refractive error
  - 31-48 months
    - Astigmatism worse than 2.0D
    - Hyperopia worse than +4.0D
    - Myopia worse than -3.0D
    - Anisometropia worse than 2.0D
  - >48 months
    - Astigmatism worse than 1.5D
    - Hyperopia worse than +3.5D
    - Myopia worse than -1.5D
    - Anisometropia worse than 1.5D

Modified criteria
- Randot stereoacuity
  - 31-48 months
    - Worse than 100 arc secs
  - >48 months
    - Worse than 60 arc secs
- Crowded acuity
  - 31-48 months
    - Worse than 20/40 in either eye
  - >48 months
    - Worse than 20/30 in either eye

Refractive error
- 31-48 months
  - Astigmatism worse than 2.0D
  - Hyperopia worse than +2.0D
  - Myopia worse than -3.0D
  - Anisometropia worse than 2.0D
- >48 months
  - Astigmatism worse than 1.5D
  - Hyperopia worse than +2.0D
  - Myopia worse than -1.5D
  - Anisometropia worse than 1.5D

Appendix 3: List of communities by population

Rockwood	4000
Kirkland Lake	8000
Eramosa	9000
Wellesley	11,000
Norwich	11,000
Fergus	19,000
Woodstock	38,000
Sarnia	90,000
Guelph	120,000
Cambridge	130,000
Kitchener	220,000
Hamilton	520,000
Ottawa	890,000
Toronto	6,000,000

Appendix 4: Definitions of eye problems

To define eye problems we used the recommendations of the American Association for Pediatric Ophthalmology and Strabismus.[26]

For children aged 31-48 months of age:

- astigmatism worse than 2.0 D
- hyperopia worse than +4.0D
- myopia worse than -3.0D
- anisometropia worse than 2.0D

For children >48 months of age:

- astigmatism worse than1.5 D
- hyperopia worse than +3.5D
- myopia worse than -1.5D
- anisometropia worse than 1.5D

For all children:

- Visually significant media opacities or strabismus..
- Amblyopia

  ≥ 2-line difference in best corrected acuity and worse than 20/40 in at least one eye

- Amblyopia risk factors

  Stereoacuity (>100 arc secs)
  Anisometropia (as defined above)
  High hyperopia (worse than +4.0D bilaterally or worse than +3.0D with acuity worse than 20/40 in at least one eye)

- Visually significant media opacities and manifest (not intermittent) strabismus should be detected at all ages.

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- Public Health Units in Sarnia, Oxford County, and Tamiskaming
- Many Lions Clubs
- Medical students at the University of Ottawa (iScreen)

We would also like to thank our Central Coordinator Sally Stafford for her outstanding work, and Charles Maurer, who serves as a volunteer programmer, webmaster, and writer.

Notes

[1] Drover, J.R., Kean P.G., Courage M.L., Adams R.J. "Prevalence of amblyopia and other vision disorders in young Newfoundland and Labrador children." *Canadian Journal of Ophthalmology*. 2008;43:89-94. For other countries see Chia, A., Dirani, M., Chan, Y-H., Gazzard, G., Au Eong, K-G., Selvaraj, P., Ling, Y., Quah, B-L., Young, T. L., Mitchell, P., Varma, R., Wong, T-Y., & Saw, S-M. "Prevalence of amblyopia and strabismus in young Singaporean Chinese children." *Clinical & Epidemiologic Research*, 2010; 51:3411-3417.

[2] Bradfield, Y.S. "Identification and treatment of amblyopia." *American Family Physician*. 2013;87:248-52.

[3] Drover, J.R., Kean P.G., Courage M.L., Adams R.J. "Prevalence of amblyopia and other vision disorders in young Newfoundland and Labrador children." *Canadian Journal of Ophthalmology*. 2008;43:89-94. Multi-ethnic Pediatric Eye Disease Study Group. Prevalence of myopia, hyperopia and astigmatism in non-Hispanic White and Asian children: Multi-Ethnic Pediatric Eye Disease Study. Ophthalmology. 2013;120(10): 2109-2116. doi:10.1016/j.ophtha.2013.06.039. Giordano L, Friedman DS, Repka MX, Katz J, Ibironke J, Hawes P, Tielsch JM. Prevalence of refractive error among preschool children in an urban population: The Baltimore Pediatric Eye Disease Study. Ophthalmol. 2009;166:739-746. Dirani M, Chan YH, Gazzard G, Hornbeak DM, Lwo SW, Selvaraj P, Zhou B, Young TL, Mitchell P, Varma R, Wong TY, Saw SM. Prevalence of refractive error in Singaporean Chinese Children. Clin Epidemiologic Research. 2010;51:1348-1355.

[4] Shankar, S., Evans, M.A., Bobier, W.R. "Hyperopia and emergent literacy of young children: Pilot study." *Vision Science*. 2007;84:1031-1038

[5] Roch-Levecq, A.C., Brody, B.L., Thomas, R.G., Brown, S.I. "Ametropia, preschoolers' cognitive abilities, and effects of spectacle correction." *Archives of Ophthalmology*. 2008;126:252-258.

[6] Le, T.D.., Raashid, R.A., Colpa, L., Noble, J., Ali, A., Wong, A."Pediatric vision screening in the primary care setting in Ontario." *Paediatrics & Child Health*. 2018; 23:233-e39..

[7] OHIP pays for children's optometric exams. In addition, "Eye See…Eye Learn" receives funds from the Ontario Ministry of Health and Long-Term Care, Nikon and OGI have provided complimentary eyeglasses, and optometrists in the programme charge no dispensing fee.

[8] Of the 109,485 Ontario children eligible in 2016-17, only 20% enrolled in E.S.E.L. ['Eye See…Eye Learn']." Ontario Association of Optometrists, Eye See...Eye Learn. 2016-17 Fourth Quarter report.

[9] Craig, W., Schumann, L., Petrunka, K., Khan, S., and Peters, R. "Government Costs Associated with Delinquent Trajectories." *International Journal of Child, Youth and Family Studies* 2, no. 2.1 (2011): 263-293.

[10] This is opposite to the practice in the United States, which makes it impossible to compare screening studies there and here.

[11] Based on normative data published after our study commenced, we recommend that the cutoff for stereoacuity for senior kindergarten be reduced to 60 arcsecs, a value passed by more than 80% of children between 60 and 72 months (the age of children in senior kinderarten). [Afsari, S., Rose, K.A., Pai,A. S.-I., Gole, G.A., Leone, J. F., Burlutsky, G. et al. (2013). Diagnostic reliability and normative values of stereoacuity tests in preschool-aged children. *Br J Ophthalmol*, 97(3), 308-313.] Based on our own findings on the 712 children, all of whom had eye exams, we recommend that the cutoff for hyperopia be +2.0 because that cutoff in screening is more likely to detect the child with a large hyperopia once drops are administered by the eye doctor.

[12] The Fraser Mustard Early Learning Academy in Toronto is a normally sized school with only kindergarten classes.

[13] The results suggest that screening was more accurate for SK than JK children ($P <$ 0.001). The estimated odds of having a correct screening result in SK were 1.75 times those in JK (95% CI: 1.28, 2.40).

[14] Page 21 of the PDF on <http://www.tdsb.on.ca/Portals/0/AboutUs/docs/2010-11VisionOfHopeEScanOfTheTDSB.pdf>

[15] We thank the Ontario Association of Optometry and the School of Optometry and Vision Science of the University of Waterloo for their collaboration on our demonstration projects.

[16] O.H.I.P pays for children's optometry exams.

[17] If a child passed all of our screening tests, we sent a note home saying that quick tests had found no problem but that to be certain the parents should arrange a full eye exam at their local optometrist, which OHIP would pay for.

[18] Clearly, Nikon, and OGI donated eyeglasses.

[19] The next year we offered our programme to the three schools where we did not work the first year.

[20] Xiong, S., Sankaridurg, P., Naduvilath, T., Zang, J., Zou, H., Zhu, J., Lv, M., He, X., & Xu, X. "Time spent in outdoor activities in relation to myopia prevention and control: a meta-analysis and systematic review." *Acta Ophthalmol*gica. 2017; 95(6):551-566. doi: 10.1111/aos.13403.

[21] Multi-ethnic Pediatric Eye Disease Study Group. Prevalence of myopia, hyperopia and astigmatism in non-Hispanic White and Asian children: Multi-Ethnic Pediatric Eye Disease Study. Ophthalmology. 2013;120(10):2109-2116. doi:10.1016/j.ophtha.2013.06.039.

[22] Chiarelli, C.A., & Chris, A.P. "Visual status of First Nations children: The Sagamok First Nation Vision Care Project." *Canadian Journal of Optometry*, 2013;75:39-46.omni

[23] We do not know why but we do know that refractive error is related to fat and to inadequate time spent outdoors, and both of these are affected by a community's culture—Do parents push hockey or homework?—and by climate and the availability of places to play outside. Fen, Y., Chongming Y., Yuzhong, L., Shuzhen, P., Bei, L., Xudong, G., & Xiaodong, T. "Associations between Body Mass Index and Visual Impairment of School Students in Central China." *International Journal of Environmental Research & Public Health*. 2016;13(10),1024;doi:10.3390/ijerph13101024. Multi-ethnic Pediatric Eye Disease Study Group. "Prevalence of amblyopia and strabismus in African American and Hispanic Children ages 6 to 72 months." *Ophthalmology*. 2008;115:1229-1236. Multi-ethnic Pediatric Eye Disease Study Group. "Prevalence of amblyopia or strabismus in Asian and non-Hispanic White preschool children: Multi-Ethnic Pediatric Eye Disease Study." *Ophthalmology*. 2013;120:2117-2124.

[24] The two autorefractors agreed 89% of the time. When they disagreed, the PlusoptiX combined with the three other tests caught all but one child with eye problems, but the Spot with the three other tests missed six.

[25] Loudon, S.E., Rook, C.A., Nassif, D.S., Piskun, N.V., & Hunter, D.G. "Rapid, high-accuracy detection of strabismus and amblyopia using the Pediatric Vision Scanner." *Investigative Ophthalmology & Vision Science*, 2011;52:5043-5048.

[26] "Guidelines for automated preschool vision screening: a 10-year, evidence-based update."*Journal of AAPOS: the official publication of the American Association for Pediatric Ophthalmology and Strabismus*. 2013;17:4-8.