Appendix 1 (as submitted by the authors): Additional Methods, Results, & Interpretation

Methods

1. Participants

Typically, school boards identified a sample of high-needs schools for recruitment (based on information such as neighbourhood income and/or referral rates from oral health screening); other school boards allowed principals to volunteer for participation. One private school principal was contacted directly. The six Toronto schools in this sample were different from the one school in our concurrent study[1] examining the diagnostic accuracy of screening tools.

List of cities and number of schools where we offered the screening program. Populations from Statistics Canada Census Data 2016.		
City	Population (2016)	Number of Schools
Cambridge	129,920	1
Eramosa	12,854	1
Fergus	28,191	1
Guelph	131,794	1
Hamilton	536,9917	5
Ingersoll	12,757	1
Kirkland Lake	7,981	4
Kitchener	233,222	8
Norwich	11,001	1
Ottawa	934,243	3
Rockwood	4,629	2
Sarnia	71,594	5
Toronto	5,028,040	6
Wellesley	11,260	1
Woodstock	40,902	3

2. Screening tools

Times given for each screening tool include the total time at each screening station – including time to get settled at the screening station, hear instructions, be tested, and receive the screening sheet with the result recorded.

2.1. Cambridge Crowded Acuity Cards[2-3]

A child-friendly crowded acuity test was chosen because crowded acuity charts are more accurate than single optotypes in identifying visual problems, especially amblyopia.[4-5] Letters (H, O, T, V, W) are crowded by encircling

Appendix to: Nishimura M, Wong A, Dimaras H, et al. Feasibility of a school-based vision screening program to detect undiagnosed visual problems in kindergarten children in Ontario. *CMAJ* 2020. doi: 10.1503/cmaj.191085.

letters on each card. The child must name the letter “in the middle” or point to the corresponding letter on a matching board. Testing was done monocularly at a distance of 3 metres while the child wore occluding glasses and typically took 5-10 minutes per child. The results from our concurrent study[1] examining the accuracy of screening tools in identifying amblyopia and its risk factors (such as clinically significant refractive errors) revealed sensitivity to be 59% and specificity to be 73%.

2.2 Plusoptix S12 and Spot photoscreeners

The Plusoptix S12 (software version 6.1.10.0) and Spot (Welch Allyn; software version 2.1.4) photoscreeners were commercially available at the start of our research program in 2014, and both have high accuracy in detecting visual problems in young children.[6-11] In our concurrent study,[1] the Plusoptix had a sensitivity of 64% and specificity of 88%, whereas the Spot had a sensitivity of 60% and specificity of 93%. That study also showed that the results of the two photoscreeners are highly correlated. Therefore, in Year 2, we used just one photoscreener (mostly the Plusoptix; sometimes the Spot based on screener preference). Children already wearing glasses were not screened with the photoscreener but completed the other tests. Screening took 1-2 minutes per child, per device.

2.3 Randot Preschool Stereoacuity Test[12]

Neither the Cambridge Crowded Acuity Cards nor the photoscreeners assess binocular vision. Therefore, we included a child-friendly stereoacuity test. Children wore 3D polarized glasses and either named or matched objects “hiding in the snow”. We began with the easiest stereoacuity of 800 arcseconds and proceeded to test smaller binocular disparities (400, 200) down to the pass criterion of 100 arcseconds. Our concurrent study[1] revealed sensitivity to be 33% and specificity to be 90%. Screening took 2-5 minutes per child.

2.4. Pediatric Vision Scanner[13]

The Pediatric Vision Scanner (PVS) was an early prototype of an experimental device on loan from the manufacturer. The PVS detects eye misalignment by binocular retinal birefringence scanning. In our concurrent study,[1] it had a sensitivity of 41% and specificity of 77%, although these values do not represent the intended performance of the PVS because it was not designed to detect refractive errors. We report referral rates with

and

without PVS data because no future screening program will use this prototype PVS. Screening took 1-2 minutes per child.

3. Screeners

Volunteers were recruited from Lions Clubs (District A-15 clubs in Rockwood, Fergus, Cambridge, and Wellesley), University of Ottawa's iScreen Interest Group (medical students at University of Ottawa), personnel at Lambton Public Health, Southwestern Public Health (at the time Oxford County Public Health), and Timiskaming Health Unit, and 3rd and 4th year students from the School of Optometry and Vision Science, University of Waterloo.[14] Elsewhere, screeners were recruited through advertising and personal contacts. After training, authors MN and/or DM accompanied the screening team to at least one school in each community to observe actual screening (and supervised at additional schools when different volunteers were involved).

4. Referral criteria and classification of visual problems

In Year 2, we lowered the referral criterion for hyperopia from SPH > 3.5 to SPH > 2.0 based on the results from a concurrent study[1] which revealed that photoscreeners underestimate cyclopleged hyperopia, consistent with reports in the literature.[6,8] We also modified our screening strategy in several communities whereby children could skip the remaining tests as soon as they failed a test, because subsequent testing would take more time but not change the screening decision of "refer". We report the frequency of when this occurred, excluding PVS results and the results of children already wearing glasses as they automatically skip the autorefractor.

5. Gold standard eye examinations

Gold standard eye examinations were performed by licensed optometrists (and supervised trainees). In six Toronto schools, optometrists, opticians, and glasses were provided through the Gift of Sight & Sound program of the Toronto Foundation for Student Success (all in-school exams). In eight schools in the Kitchener-Waterloo region, in-school optometry exams were conducted by 3rd or 4th year students from the School of Optometry and Vision Science at the University of Waterloo, under direct supervision of a licensed optometrist (one of the eight schools dropped out in Year 2 because of lack of space for screening). For the remaining communities (29 schools), optometrists participating in the Eye See…Eye Learn (ESEL) program of the Ontario Association of Optometrists (OAO) whose offices were located closest to the school were recruited by phone, email, and/or fax

(23 schools both years; two in Year 1 only because a community group had already conducted screening in Year 2; four newly recruited in Year 2). ESEL is a non-profit program that offers free glasses to any 4-year-old who needs them, and that offer was extended to older children for this research collaboration. In Year 1, these optometrists conducted in-school optometry exams and in Year 2, they did so at their offices. One ESEL optometrist conducted exams at her office both years because her office was located next to the school.

6. Comparison of in-school and at-office exams.

Data from 19 schools for which we had individual results from in-school exams in Year 1 and in-office exams in Year 2 were analyzed. Six additional schools had received screening and follow-up exams both years but were not included in this analysis. For three schools, the school board REB did not allow us to collect individual data when exams were conducted at the optometrist's office. Thus, in Year 2, optometrists forwarded aggregate results, which allowed us to determine the number of children with visual problems but we could not link individual screening results to optometry exam results. Three additional schools that participated both years were excluded from this analysis because of a pre-arrangement for in-office exams both years (one school) or in-school exams both years (two schools serviced by the School of Optometry and Vision Science, University of Waterloo).

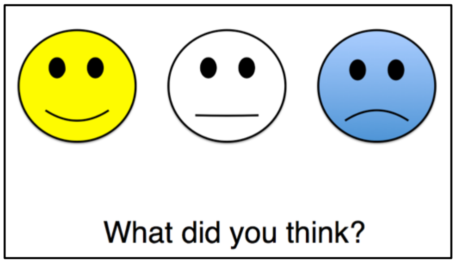
7. Statistical analyses

Data for post-hoc analyses were obtained from the Internet. Average household income for the neighbourhood in which each school was located was determined using CensusMapper (https://censusmapper.ca) and Canada Census 2016 data. From the Education Quality and Accountability Office (EQAO) (https://eqaoweb.eqao.com), we obtained the % of students for whom English is not the first language and % of students born in Canada, for each school.

8. Feedback from children

Below is the card used to collect feedback from children. Each child was asked to circle the face that corresponded to his/her thoughts about playing the "vision games".

Supplemental Figure 1:



Additional Results

Of the 2534 children screened in Year 1, 38 children had spherical values between 2.0 (the referral cutoff in Year 2) and 3.5 (the cutoff in Year 1). However, 31 of these children were referred based on cylinder values or another test. This meant that only 7 children (0.3% of screened children) who passed screening in Year 1 would have been referred based on the new criteria used in Year 2 of hyperopia > 2.0 D, a result suggesting little impact of the change in screening criterion in our sample.

To minimize screening time we skipped subsequent tests once a child failed a test in 21 schools in Year 2 (N = 1106). We found that 81% of students completed all three tests (67% passed and 14% was referred on the third test) but 10% skipped the last test and 9% were referred on the first test and thus skipped two tests.

Interpretation

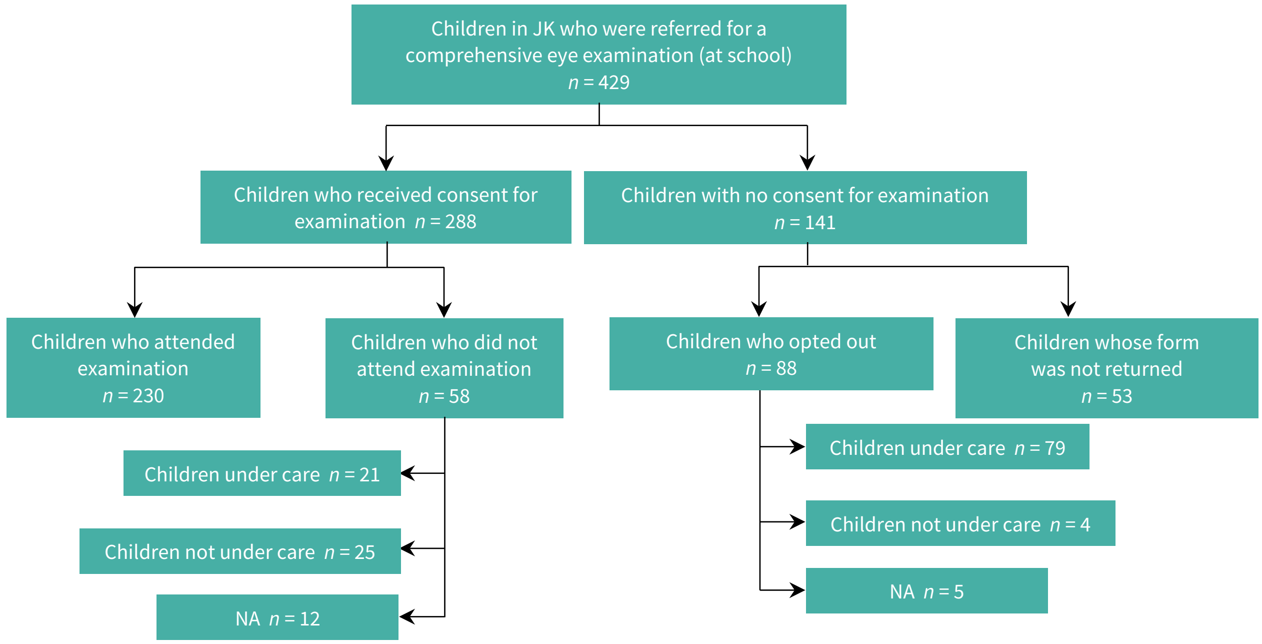
Our success in having 2/3 of children attend the follow-up eye exam is likely attributable to our efforts to minimize difficulties that parents might encounter, such as having to search for an eye doctor, worry about paying for glasses, or having to call to book an appointment. Similar difficulties were identified in an evaluation of the screening program in British Columbia.[15] Parents who consented to the exam but could not attend the assigned appointment were encouraged to book their own appointment at the eye doctor's office; thus, our numbers likely underestimate the number of children who received treatment because of the screening program.

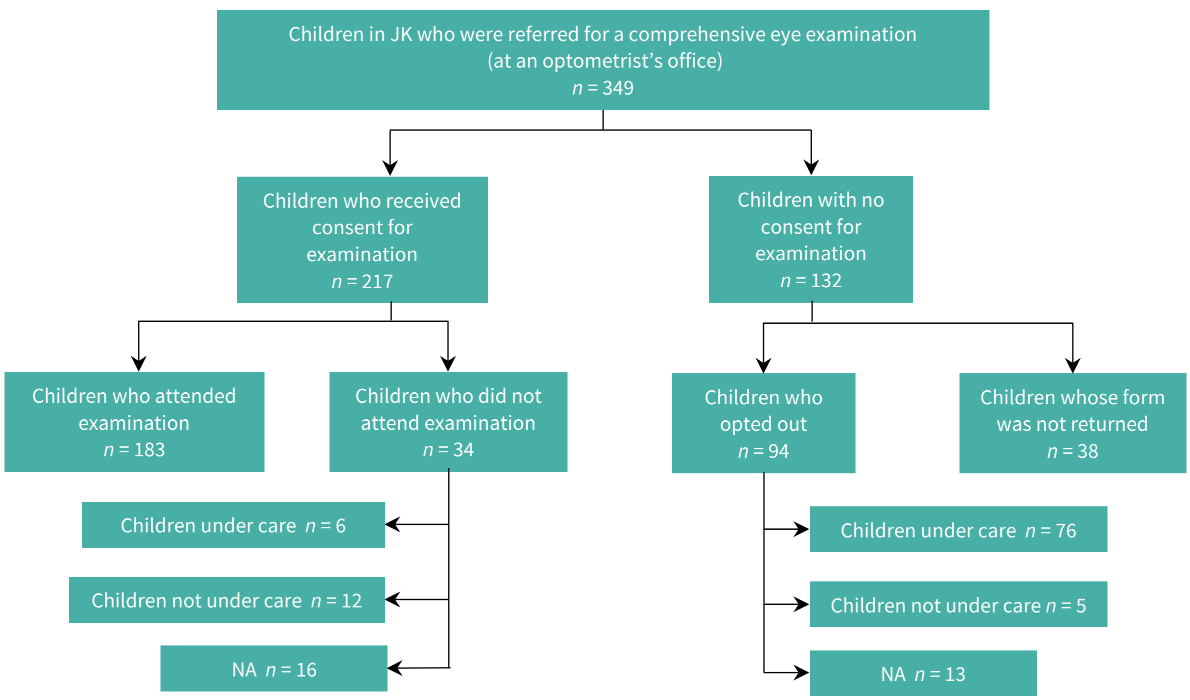
Although <4% of children were "unable" to complete a screening test, they were more likely to have a visual problem, consistent with previous research.[16] Therefore, the best strategy is for children who are unable to complete a test to be referred for follow-up eye exams. We implemented some changes in Year 2 in an effort to maximize the efficiency of the screening program. Based on the results of a concurrent study,[1] we chose to use only one photoscreener and in 21 schools, stopped screening when a child failed a test because subsequent tests would not impact the overall decision of “pass” or “refer”. The results showed that 19% of children would be able to skip 1-2 tests using this strategy, shortening screening time slightly.

The referral criterion of failing “any” test was chosen because in Ontario, the provincial health care plan covers annual eye exams for children aged 0-19 years (an overview of the Eye See…Eye Learn program in 2018 by the Canadian Association of Optometrists[17] shows that provincial health care plans cover the cost of comprehensive eye exams for children in AB, BC, ON, MB, NB). The Canadian Association of Optometrists recommends at least one eye exam before starting school, and annually thereafter.[18] Thus, referring children without a visual problem in this context does not “create” any more eye exams than what is already recommended. However, in many areas of Canada (including northern Ontario), over-referrals will cause a significant burden on eye care professionals. An in-depth examination of how to maximize sensitivity vs. specificity can be found elsewhere.[1]

No school board that we contacted declined participation. Of the 31 schools that participated in Year 1, only three schools declined participation in Year 2—two because children had already been screened by a community program, and one because of lack of space. Two school boards added more schools to be screened in Year 2 and all optometrists who collaborated with us in Year 1 agreed to work with us again in Year 2. Thus, stakeholders were generally supportive of the program.

Supplemental Figure 2: Rate of consent and attendance at the follow-up optometry examinations when the examinations were conducted at the child's school versus at the local optometrist's office. Note: JK = junior kindergarten, NA = no answer.





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Appendix 1, Supplementary Table 1: Cost of vision screening, estimated for 5 years of screening in Hamilton (~6000 children in senior kindergarten annually, based on 2016 Census data). Equipment costs are manufacturer's price in Canadian dollars with tax. Repair and supply estimates are based on actual experience for the current study. Labour costs are based on actual costs of hiring personnel for screening 414 students in 5 Hamilton schools. Screeners and local coordinators were not paid for travel time.	
Items	Cost (2016)
Equipment Cost (5 years)	$10,266
Plusoptix S12C Photoscreener ($8,615)	
Preschool Randot Stereo Acuity ($678)	
Cambridge Crowding Cards x 2 ($505)	
Pelican travel case ($468)	
Equipment repair & maintenance costs ($1000/year)	$5,000
Supplies (hand wipes, letters, envelopes) $0.75/child x 6000 x 5 years	$22,500
Labour	
5 schools in Hamilton = 414 students Local Coordinator: $25/hour x 45 hours = $1125 Screeners: $20/hour x 4 screeners x 30 hours = $2400 ($1125 + $2400)/414 = $8.50 per child Estimate: $8.50/child x 6000 x 5 years	$255,000
Total =	$292,766
Cost per child (6000 x 5 years)	$9.76/child