Efficacy of Vision Screenings in Waterloo Region

by

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Author’s Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

Abstract

Purpose:

In 2018, the province of Ontario (Ontario) mandated a universal vision screening program for all senior kindergarten (SK) children (age 4-6 years). The purpose of the vision screening program is to detect children with risk factors for amblyopia, strabismus, and/or high refractive errors. The overarching aim of this thesis is to evaluate the effectiveness of Ontario's universal vision screening program for SK children and how accurate the program is in identifying vision problems. These objectives are explored through two studies: parental adherence to vision screening recommendations survey, and investigation of the ability of Ontario's vision screening program in identifying a SK child with a vision problem combined with determination of overall referral rates.

Methods:

All parents/guardians (parents) of SK students who participated in Ontario's vision screening program in the Region of Waterloo (ROW) from October 2022 to December 2023 were invited to participate in the initial study to evaluate parental compliance to vision screening recommendations and barriers to seeking vision care. Following the first study, parents who reported taking their child to an optometrist following the vision screening were invited to participate in a follow-up study, evaluating the program sensitivity and specificity and overall screening accuracy. For the second study, the vision screening results were compared to the eye exam results, and all vision screening data (visual acuity, stereoacuity and autorefraction) for children who participated in the 2022-23 vision screening program were analyzed to determine the screening program's overall referral rate and for all three screening tools.

Results:

108 parents from 67 schools in the ROW responded to the survey to evaluate parental compliance in seeking vision services following the screening. The results of the survey found that over half (58/108, 54%) of the children screened were already under the care of an optometrist prior to the screening and less than half (48/108, 44%) of parents were prompted to obtain eye care, including 25% (27/108) who had already had a previous optometric examination. For the follow-up study that examined vision screening accuracy, 65 individuals participated. The vision screening program demonstrated a sensitivity of 0.935 and specificity of 0.406, producing a high rate of false positives (30%). Paired t-tests revealed significant differences in the accuracy of the vision screening tools compared with eye exam findings, particularly for refraction – sphere (OD: $p = 0.005$, OS: $p < 0.001$), cylinder (OD: $p = < 0.001$, OS: $p < 0.001$), and spherical equivalent (OD: $p = 0.016$, OS: $p = 0.004$). The retrospective review of the screening data included a total of 4837 vision screening results from 135 schools in ROW. The screening had an overall referral rate of 54% (2606/4837) and children were most commonly referred for autorefraction (43%; 2099) results followed by stereoacuity (31%; 1510).

Conclusion:

This analysis of Ontario's vision screening program for SK children in the ROW highlighted key findings. The program was effective at encouraging parents that received a refer to go to the optometrist (64%), though 31% of all parents misreported screening results, suggesting a need for clearer communication. The program showed high sensitivity (0.935) but low specificity (0.406), with a 54% referral rate and 30% false positives which may contribute to lack of public trust over time. Adjusting referral criteria based on evidence could reduce false positives.

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I would like to express my deepest gratitude to my supervisors, Dr. Lisa Christian and Dr. Elizabeth Irving, for their unwavering support and mentorship throughout the duration of this project. They have provided me with the opportunity to explore optometry and vision science, for which I am extremely grateful. They provided me with insightful critiques from their extensive knowledge throughout my research journey. Their deep commitment to academic excellence and meticulous attention to detail have significantly shaped this thesis. Their guidance has not only encouraged me, but they have given me endless patience and understanding, making their mentorship irreplaceable.

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Chapter 1
Introduction

1.1 Background

1.1.1 Disease screening

Early disease detection may allow for effective treatment for conditions that would otherwise go undetected.[1–3] Screening tests are commonly used in healthcare in a defined population to identify those at risk of having a particular disease, prompting timely detection.[4] If the screening identifies risk factors for the disease the individual is encouraged to seek further evaluation by a healthcare professional.[2,5,6]

Screenings have two possible outcomes, either positive/refer (high likelihood of the person having the disease) or negative/pass (low likelihood of having the disease) and should have a high sensitivity and specificity (i.e., 1.0 or 100%).[7] The sensitivity of a screening test refers to its ability to correctly identify an individual with a problem and specificity refers the test correctly identifying a person without a problem.[8] In cases where the screening has a low specificity (high number of false positives), a large number of people are identified as having a condition when they do not which may lead to increased anxiety and reduced public confidence in the screening program as noted by Kaur et al.[9] Conversely, low sensitivity (high number of false negatives) indicates that individuals with the disease are missed, causing delayed intervention, diagnosis and treatment, and reduced confidence in the screening program.[10]

Disease screening can be either universal to the general population or targeted to high-risk groups.[11] Universal screening programs screen an entire population, usually selected by age, while targeted screening may be used for screening a selected high-risk group of the population based on risk factors such as family history.[11] Targeted screenings are generally less costly than universal screenings due to the lower population size.[11] However, the challenge with targeted screenings is in correctly identifying high-risk individuals.[4,11] For example, many countries target specific age groups for mammographic screening for early diagnosis of breast cancer. Changing the risk factor from one factor (i.e., age) to a variety of factors (i.e., women with a family history of breast cancer, women with variants in breast cancer genes, and women who underwent mantel or chest radiation) increases the effectiveness of targeted breast cancer screening.[12,13] Due to this shift in evidence, in 2024 the United States (U.S.) Preventive Task Force adjusted their recommendation for breast cancer screening from starting at age 50 to start at age 40, if the woman presents with the risk factors mentioned above.[14,15] Therefore, as demonstrated with breast cancer screenings, targeted screening measures need an established method of identifying those at high risk for developing the disease to be effective.[4] By doing so, targeted screenings may be a more desirable approach compared to universal screenings, if the ability to establish the high-risk population is present and/or if resources are limited.[16]

1.1.1.1 Pediatric Vision Screening

Vision screenings can be universal or targeted dependent upon the purpose of the program and are most commonly offered to pediatric populations.[17,18] Vision screenings are a short series of tests that aim to detect risk factors for eye conditions, such as amblyopia, strabismus, and refractive error requiring correction.[17,18] Following a vision screening, test results are reviewed based on a pass / refer criteria. The criteria for referral are typically set by the program and should be sensitive enough to identify individuals suspected of having a vision impairment, such as amblyopia, without over-referring those who do not. If referred, individuals are encouraged to obtain further testing with an optometrist (OD) or ophthalmologist.

In Canada and the US, preventive health screenings, such as vision screenings, may be mandated under health law, falling under the responsibility of provincial or state governments for enforcement.[19] The law may charge either the governing health or education board with the implementation of a vision screening program.[20] The mandated protocol may be very specific; identifying participant age, tools, procedures and equipment, as well as pass/refer criteria. In the U.S., forty states (including the District of Columbia) have mandates for in-school vision screening, and four states in the US have mandated comprehensive eye exams for children entering kindergarten.[20] In Canada, six provinces have mandates for in-school vision screenings and no provinces have mandated comprehensive eye exams for children.[18,21]

Screenings are typically performed by a variety of personnel, ranging from eyecare professionals (i.e. optometrist, ophthalmologist) to lay screeners, and the age at the time of screening can range from preschool to high school (age 4 – 18 years), with varying frequency (every year to only once).[22] Vision screening methods also vary, dependent upon the purpose of the program (i.e., the vision condition being screened for) and participant age. However, most vision screenings include the following tools:

- Visual acuity – Tested using: Snellen, LEA Symbols, or HOTV visual acuity chart with crowding bars[20,23,24]
- Stereopsis – Tested using: Tumbling E, Titmus Stereo Fly, or Frisby[20,23,24]
- Autorefraction – Tested using: Plusoptix, Retinomax, Visionix, SureSight, iScreen, or Welch Allyn Spot[20,25–27]
- Additional tools – Ocular alignment (i.e., cover test and corneal light reflex), color vision (i.e., pseudoisochromatic plates)[23]

Although vision screenings are carried out throughout Canada and the US, there is a lack of consistency between screening programs for test factors such as age (preschool to school-age), the condition being screened for, screening personnel (optometrists, ophthalmologists, nurses, lay-screeners such as volunteers and teachers), type of screening tools used (visual acuity, stereoacuity, photoscreening, ocular alignment, and color vision), and pass/refer criteria.[5,28–31] For example within Canada, some provinces screen only children in kindergarten (British Columbia and Ontario) while some screen a range of grades such as kindergarten to grade 11 (Manitoba).[18,21,32] Variation between programs also exists within the U.S. for tools used, age range, and personnel conducting screenings. The states that require more screening tools often require more experienced screeners (such as ODs) to perform screenings.[20,22] For example, Ohio screens visual acuity, refractive error, color vision and eye alignment for children in preschool and kindergarten performed by volunteer ODs; Utah only screens for visual acuity in kindergarten, grades 1, 3, 5, 7, and 9, with the screening performed by lay screeners.[20,22] In this comparison, Ohio emphasizes screenings conducted by trained professionals, utilizing a comprehensive battery of tools for preschool-aged children.[20,22] In contrast, Utah has more frequent screenings conducted by lay screeners, focusing primarily on visual acuity for a range of grade levels.[20,22]

1.1.1.2 Child Health Protocol Vision Screening Tools

1.1.1.2.1 Visual Acuity

Visual acuity is a measure of the ability of the visual system to resolve detail, typically by the identification of a standardized optotype, either a letter or symbol.[33–35] Visual acuity tools may detect vision impairments associated with refractive errors or amblyopia.[24,28] Traditional visual acuity tools use charts with optotypes displayed in a horizontal line, or by presenting a single letter or picture.[36–39] Visual acuity tools that use single letters have been shown to overestimate a child's acuity.[38,39] Therefore visual acuity tools utilizing crowding bars reduce the visibility of neighboring letters or words in the periphery, simulating real word conditions in which letters are not often presented in isolation but surrounded by other visual stimuli. Crowding bars in visual acuity tools may help assess how the brain can process and discriminate visual stimuli when in busy environments (i.e., crowding) and are useful when testing for conditions such as amblyopia.[40–42] For example, the Ontario vision screening program utilizes the single letter HOTV visual acuity test with crowding bars, as depicted in Figure 1.[24,36,43]

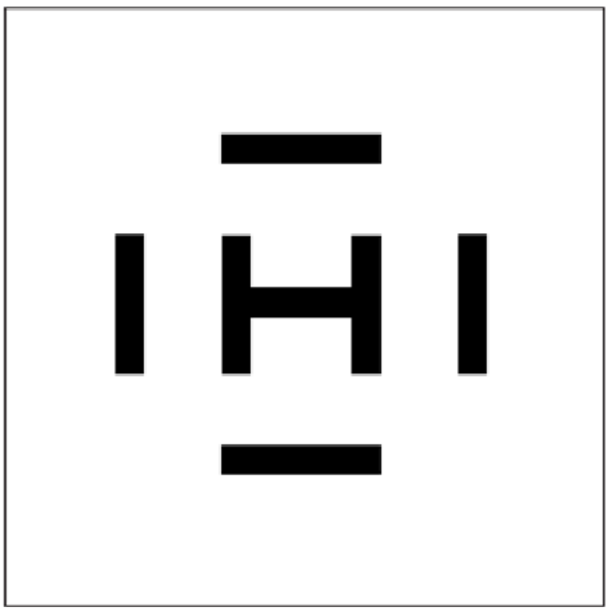


Figure 1: Examples of the HOTV optotype with crowding bars used.[44]

1.1.1.2.2 Stereoacuity

Stereopsis measures depth perception through disparity, by showing different images to both eyes with varying levels of disparities.[45,46] Stereoacuity is the measure of the smallest difference in depth (i.e., disparity) a person can detect.[45,46] A reduction in stereoacuity is common with conditions such as amblyopia or strabismus.[46,47] Global stereopsis tools, such as the Randot® Preschool Stereotest, use horizontal retinal image disparities to create the appearance of depth.[48]

To perform the test, the child is asked to wear polarized lenses over their spectacles (if applicable) and is asked to identify the 3D image seen in the book/plate.[46] Normative data for the Randot® Preschool Stereotest varies based on age, for example, children age 4 achieve a mean disparity level of 100 arcsec, while the lower limit is 200 arcsec. The lower limit is defined as a cutoff value that which 95% of normal eyes within this population are expected to achieve.[49] Alternatively, for children age 6, the mean disparity is lower at 60 arcsec, but the lower limit is 100 arsec.[49]

1.1.1.2.3 Autorefraction

To measure refractive error, vision screenings often use automated refraction or autorefractors.[50,51] Autorefractors are designed to estimate the patient's refractive error by determining the dioptric power of the lens required to focus light on the retina.[52] The machine works by emitting light into the patient's eye then analyzes the reflected light to determine the patient's refractive error.[53] Autorefractors may be used in optometry clinics as a starting point for subjective refraction or when screening children for refractive errors.[54,55] In recent years autorefractors have gained popularity for screenings and eye exams as they are easy to use and obtain multiple measurements at once.[56] The screening results for autorefractors, such as the Plusoptix instrument include refractive error measurements for sphere, cylinder, axis, pupil size, and gaze asymmetry, as shown in Figure 2. These measurements provides an estimate of the refractive error to determine if a person has a significant refractive error or amblyogenic risk factors, including anisometropia, hyperopia, astigmatism, and myopia.[53]

Patient's name or ID		*06/24/2015
OD	Refer	OS
+0.75 dpt	Sphere	+0.25 dpt
-0.75 dpt	Cylinder	-2.25 dpt
176°	Axis	87°
5.8 mm	Ø pupil	4.5 mm
Pupil distance		56 mm
Gaze asymmetry		7.6 °
ROC 1, Ver. 7.0.4.0		01/31/2018
	www.plusoptix.com	

Figure 2: Example of Plusoptix photoscreener printout.[57]

1.1.1.4 Universal Vision Screenings in Ontario

1.1.1.4.1 Development of Ontario's Vision Screening Program

Prior to 2018, the province of Ontario had no universal vision screenings and the responsibility was through primary care providers (i.e., physicians) to screen children and refer those for optometric care.[58] While vision screenings were supposed to occur in every well-child visit, a study by Le et al., found that family physicians reported performing vision screenings at 65% of all well-child visits and pediatricians reported 52%.[58] In 2013, a report by the OAO reported that only 14% of children under the age of 6 had an eye exam that year.[59] At this time, other provinces in Canada and states in the US were mandating universal vision screenings as a tool to promote parents to seek vision care for their children.[5,18,59,60] Thus to increase the uptake of vision services in Ontario, a research group (Nishimura et al.,) investigated the feasibility of implementing a universal program in the province.[59,60] In 2014, Nishimura et al., conducted a study to identify which vision screening tools would best detect risk factors for amblyopia and to establish referral criteria for a universal school-based vision screening program for children aged 4 to 5 years.[60] The five tools included in the study were the Cambridge crowded acuity cards, Randot® preschool, Plusoptix photoscreener, Spot photoscreener, and the Pediatric vision scanner (PVS). The pass/refer criteria for each tool was based on the American Association for Pediatric Ophthalmology and Strabismus (AAPOS) vision screening guidelines (Table 1).[60]

Table 1: Referral criteria for Nishimura et al., 2017 pediatric vision screening study[60]

	Referral Criteria	
Screening tool	Pass	Refer
Visual acuity	≥ 20/32	< 20/32
Stereoacuity	≥ 100 arcsec	< 100 arcsec
Autorefraction	Sphere: -1.50 D to +3.50 D Cylinder: plano to -1.50 D Spherical equivalent: < 1.50 D	Outside pass refractive thresholds.
PVS	≥ 0.6 binocularity	< 0.6 binocularity

Following the vision screening, study investigators provided a comprehensive eye exam for all children as a gold standard comparison against the screening results. For children aged 4, Nishimura found 63% of children (279/442) obtained a refer result, with 40% of those children (179/442) accurately identified as having a vision problem (through the eye exam).[60] For children aged 5, 54% of children were referred (145/267) and 32.5% of children (87/267) had a confirmed vision problem.[60] The diagnostic capability of each screening tool (including sensitivity and specificity for detecting amblyopia) was also assessed for detecting vision problems in children (Table 2).[60] Based on these results, the study recommended the use of three screening tools; one acuity tool, one stereoacuity, and one photoscreener for a school-based screening program for children aged 3 to 6.[60]

Table 2: Vision screening tool sensitivity and specificity in Nishimura et al., 2017 study[60]

Screening tool	Sensitivity	Specificity
All five tools	0.84	0.50
Cambridge visual acuity	0.59	0.73
Randot® Preschool stereotest	0.33	0.90
Plusoptix photoscreener	0.64	0.88
Spot photoscreener	0.60	0.93
Pediatric vision screening (PVS)	0.41	0.77
Combination of acuity, Plusoptix, and Randot®	0.81	0.64

Following the initial study, in 2015, Nishimura et al., investigated their suggested vision screening criteria among kindergarten children in Ontario (referral rates shown in Table 3).[59] The program screened children in junior (JK) and senior kindergarten (SK) over 2 years in 43 schools across Ontario.[59] Results from this study helped to further refine the screening criteria, namely children in both kindergarten years did not need to be screened since few children in SK were identified after being screened the year prior. For this reason, study investigators adjusted their screening age to SK children only.[59] Informed by the results of these studies, in 2018 the Government of Ontario decided to implement a universal vision screening program for children in SK known as the Child Visual Health and Vision Screening Protocol.[59]

Table 3: Overall referral rates from Nishimura et al., 2020 study[59]

	JK	SK
Overall (PVS data included)	64.2%	48.2%
Overall (PVS data excluded)	53.3%	34.4%
Cambridge visual acuity	27.9%	
Randot® Preschool stereotest	14.3%	
Plusoptix photoscreener	8.3%	
Spot photoscreener	9.9%	

1.1.1.4.2 Child Visual Health and Vision Screening Protocol

In August 2018, the Child Visual Health and Vision Screening Protocol was implemented by the Ontario (ON) government.[61] The purpose of the program is to identify children with risk factors for amblyopia, reduced stereopsis and/or strabismus, and refractive vision disorder.[61] The vision screening protocol provides guidelines and direction for implementing and conducting the program and is overseen by the ON Ministry of Health and Long-Term Care who mandates local public health (PH) units to administer the program.[61]

The mandated protocol includes three tools (HOTV visual acuity chart with crowding bars, Randot® Preschool Stereotest, Plusoptix autorefractor), and specifies the "pass" and "refer" criteria for each, as shown in Table 4 below.[61]

Table 4: Child Visual Health and Vision Screening Protocol Referral Criterion[61]

	Referral Criteria	
Screening tools	Pass	Refer
Visual acuity	≥ 20/32	< 20/32
Stereoacuity	≥ 60 arcsec*	< 60 arcsec*
Autorefraction	Sphere: -1.50 D to +1.00 D* Cylinder: plano to -0.75 D* Spherical equivalent: < 1.50 D	Outside pass refractive thresholds.

*Referral criteria chosen by the Ministry of Health, not utilizing the criteria of Nishimura et al., (2020).[59,61]

PH units are required to ensure all vision screeners are trained in accordance with the protocols, using the appropriate tools and methods as outlined in the manual.[61] For the 2022-23 and 2023-24 ROW PH SK vision screening program, all vision screening personnel were trained by a registered optometrist through the University of Waterloo School of Optometry and Vision Science (UWOVS). The program utilized 6 groups of volunteers, comprised of Lions Club group members, the Cowan Foundation personnel, and 3rd and 4th year UWOVS optometry student interns. The training included a review of the mandated screening protocol, including documentation of the pass/refer criteria and hands-on workshop. Finally, a mock vision screening was conducted to confirm all screeners were able to accurately perform and document all three screening tools.

1.1.1.4.2.1 Vision Screening Process

The vision screening process began with the pre-screen notification, coordinating with schools to make arrangements for the vision screening and notifying parents at least 10 business days before the screening was scheduled.[61] Upon receiving notification of the screenings, parents were provided with an opportunity to opt-out of the screening for their child up to 2 business days prior to the screening date.

On the day of the screening, screening volunteers arrive at the school to begin the screening. While location of the screening varied by school, most screenings took place in the school gym or library. Four stations – one for each screening tool plus documentation – were set up by the volunteers. As shown below in Table 5, each station required proper set up to align with the Child Visual Health and Vision Screening protocol.[61]

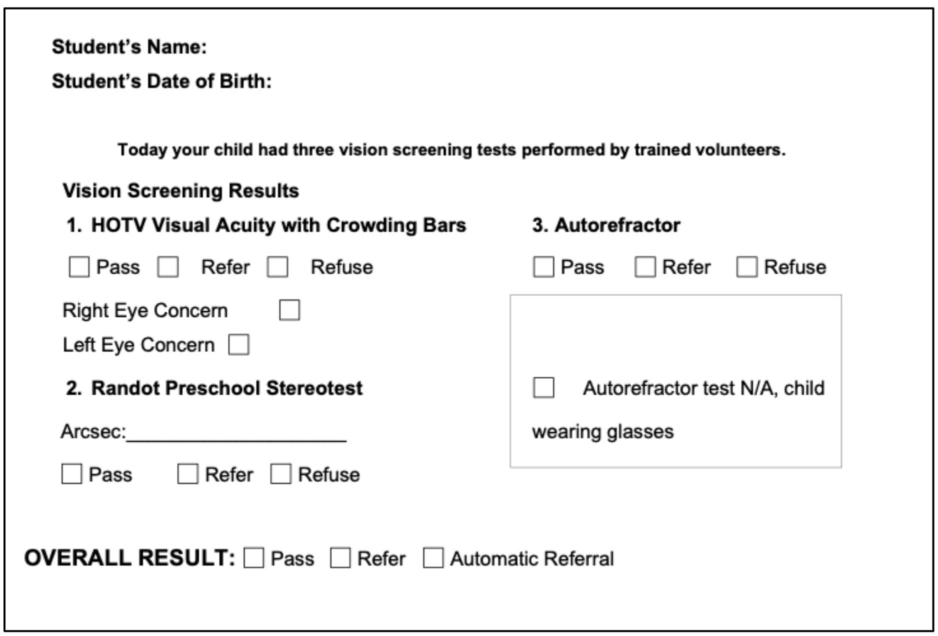
Table 5: Vision Screening Station Requirements for Each Screening Tool[61]

Vision Screening Tool	**Station Requirement**
HOTV visual acuity chart	• HOTV booklet. • One screener to flip the cards • 10-meter distance between the screener and the child. • Occluder glasses to test the visual acuity of each eye.
Randot® Preschool Stereotest	• Stereotest booklet. • Copy of the answers for the screener. • Stereoglasses that appropriately fit the child. • A chair for both the child and the screener, and a table. • The screener was able to choose to hold the booklet or use a stand if it was available to help the child view it at an appropriate distance of 40 cm.
Autorefraction	• Autorefractor instrument • Appropriate lighting (recommended a testing area with no direct sunlight and other light sources). • A 1-meter distance between the screener and the child.

Following set-up, SK students entered the screening location by class and were given their personal screening form (Figure 3). Screeners guided the child through all three stations and were responsible for recording the results of their station. After the child completed all stations, their form was handed to the documentation station and the child returned to class.

Once each class had completed the screening, screening results were reviewed. If all three screening tests were recorded as a "pass", the overall result was a "pass". However, if any one of the three screening tests were recorded as a “refer”, the overall result was recorded as a “refer”.[61] A “refer” was also marked if the child was unable or unwilling to perform the screening test(s).[61] In addition, a child might have received an overall screening result of “automatic referral” if the child appeared to have a visible eye condition such as strabismus, conjunctivitis or anisocoria.[61]

Once all screening forms had been reviewed and the overall result was recorded, parents were given a Parent Notification Form (PNF-A or PNF-B) in a sealed personalized envelope, notifying them if vision concerns were identified. The original personal screening forms were then returned to ROW PH and individual results were input into the ON government’s Oral Health Information Support System (OHIS).[61]


Student’s Name:
Student’s Date of Birth:

Today your child had three vision screening tests performed by trained volunteers.

Vision Screening Results

1. HOTV Visual Acuity with Crowding Bars

☐ Pass ☐ Refer ☐ Refuse

Right Eye Concern ☐
Left Eye Concern ☐

2. Randot Preschool Stereotest

Arcsec:____________________

☐ Pass ☐ Refer ☐ Refuse

3. Autorefractor

☐ Pass ☐ Refer ☐ Refuse

☐ Autorefractor test N/A, child wearing glasses

OVERALL RESULT: ☐ Pass ☐ Refer ☐ Automatic Referral

Figure 3: Vision Screening Form used in the ROW PH SK screening program.

1.1.1.4.2.2 Parent Notification Form (PNF)

Vision screening results were reported to parents via the Parent Notification Form (PNF). PNFs were sent home to parents by the child’s teacher in a sealed envelope.[61] If the child did not pass at least one of the vision screening stations or received an automatic referral, Parent Notification

Form A (PNF-A) (Appendix A) was sent to parents (via child). PNF-A notified the parents that a vision problem was suspected and recommended the child be seen by an optometrist for a comprehensive eye exam.[61] Additional information also included:

- Recommendation to book an appointment with an optometrist for a comprehensive eye exam;
- The importance of routine eye exams for children;
- What a comprehensive eye exam includes;
- Coverage for eye exams through OHIP for children annually under the age of 19;
- Resources to find their local optometrist.

A reminder letter from ROW PH to book an eye exam was also mailed to parents 20 days following the screening.[61]

If the child passed all 3 vision screening stations, parents received Parent Notification Form B (PNF-B) (Appendix B). Similar to PNF-A, PNF-B provided information about the importance of routine eye exams for children, OHIP coverage for pediatric eye exams, and how to find an optometrist to book an eye exam.[61] In addition, parents were reminded that vision screenings are not a replacement for an eye exam and encouraged parents to book an exam with an optometrist for a more comprehensive evaluation.[61]

1.2 Study Rationale

1.2.1 Pediatric Vision Screening Effectiveness in Encouraging Vision Care for Children

Over the past decade, on average 10 – 14% of children under the age of 4 receive a comprehensive eye exam in Ontario.[59,62] While the reason for why so few parents brought their child to see an optometrist is unknown, some reasons reported by Ng et al., may be a reliance on vision screenings to detect vision problems.[63] Similarly, Nishimura et al., found vision screenings to be an effective tool in detecting vision problems.[60] Thus, this study sought to evaluate if vision screenings are effective in encouraging parents to seek comprehensive eye care with an optometrist.

In addition, since the implementation of the Child Visual Health and Vision Screening Protocol in 2018, few studies have investigated the effectiveness of Ontario's vision screening mandate. As previously mentioned in section 1.1.1.4.1, Ontario's mandate was supported through the results of two studies initiated by Nishimura et al in 2014 and 2015 respectively, but these studies have differences in their recommendations from what was mandated by Ontario.[59,60] For example, Nishimura et al., concluded that in-school vision screenings with follow-up eye examinations are an effective strategy in increasing the uptake of vision services for children. The study stated that "*The success of any vision screening program depends on the extent of the follow-up care that is provided*", however, Ontario's vision protocol lacks any mandatory follow-up care with an optometrist for children that receive a refer. Therefore, parental compliance was also explored to evaluate if vision screenings are effective in encouraging parents to seek eye care in the absence of any direct follow-up procedure.

1.2.2 Pediatric Vision Screening Effectiveness in Detecting Vision Problems

Based on current literature regarding pediatric vision screenings, the overall effectiveness of screenings in detecting vision problems is widely debated.[5,52,64,65] It is important to determine if a vision screening program can discriminate between children with a vision problem and those without. Systematic reviews by Hopkins et al., and Mathers et al., investigated the effectiveness of pediatric vision screenings in detecting children with a vision problem.[64,65] Specifically, Hopkins and Mathers found screening programs had no consistency between protocols, thus, contributing to the variation in their effectiveness and concluded further research was required to determine a standardized pediatric vision screening protocol to create agreement amongst mandated vision screening programs.

The 2014 study by Nishimura et al., explored the sensitivity and specificity of pediatric vision screening tools in identifying children with a vision problem.[60] The results of the study found the screenings tools for visual acuity, stereoacuity and autorefraction had an overall sensitivity of 0.81 and specificity of 0.64.[60] These tools were the same as the ones used in the Child Health and Vision Screening Protocol, however, the referral criteria used in Nishimura's study were not identical to the criteria mandated by the Ontario government. For example, while Ontario adopted the same cutoffs for visual acuity, myopia and the spherical equivalent difference between both eyes, the referral criteria for stereoacuity, hyperopia and astigmatism were different (Table 4).[60,61] While it is unknown why the Government of Ontario chose to mandate a different set of criteria, sensitivity and specificity should be further investigated as they are likely to be different than what was reported by Nishimura.[60,61]

1.2.3 Thesis Rationale

Therefore, the overarching aim of this thesis project was to evaluate the effectiveness of the Government of Ontario's universal vision screening program for SK children specifically the sensitivity and specificity of the program in identifying children with vision problems. These objectives are explored through two studies: parental compliance in response to vision screenings in the ROW, and outcomes of the Government of Ontario's vision screening program in identifying vision problems in SK children in the ROW. This project aims to provide the Government of Ontario with data regarding their universal vision screening program.

1.3 Thesis Objectives

1.3.1 Parental Compliance in Response to Vision Screenings in Waterloo Region

The purpose of the first study was to evaluate the effectiveness of the government's SK vision screening program in increasing the number of children receiving appropriate eye care in the ROW. This study sought to determine:

- If parents adhered to the Government of Ontario's recommendation to see an optometrist following a vision screening;
- Whether the child was already under the care of an optometrist prior to the vision screening;
- Reasons why parents chose not to take their child to an optometrist despite public health recommendations.

1.3.2 Accuracy of the Government of Ontario's Vision Screening Program in Identifying Vision Problems in SK Children

The purpose of the second study was to perform an overall evaluation of the Government of Ontario's vision screening protocol in the Waterloo Region. This study was conducted in two parts and sought to determine:

- The accuracy of vision screening results and eye exam findings in three areas: visual acuity, stereoacuity, and refraction (Part 1);
- The sensitivity and specificity of the vision screening program (Part 1).
- The overall referral rate of the Region of Waterloo Public Health (ROW PH) Senior Kindergarten (SK) vision screening program for the 2022 to 2023 school year and compare to rates in other published studies (Part 2).

Chapter 2
Parental Compliance in Response to Vision Screenings in Waterloo Region

2.1 Summary

Purpose:

In 2018, the province of Ontario implemented a universal in-school vision screening program for all kindergarten children (age 4-6 years). Following the screening, all parents are informed of the result and are recommended to bring their child to an optometrist for further evaluation. This study evaluates parental compliance in seeking vision care for their child after receiving a vision screening in the Region of Waterloo (ROW).

Methods:

All parents/guardians of SK students enrolled in the Waterloo Region District School Board and Waterloo Catholic School Board who participated in the vision screening program were invited to participate in the study. Parents who consented to participate were asked to complete a survey to identify 1) if their child had seen an optometrist prior to screening, 2) the result of the vision screening (pass/refer), and 3) whether an appointment was made with an optometrist following the screening. To identify possible barriers to accessing vision care, additional questions were asked if parents reported they did not seek follow-up vision care with an optometrist.

Results:

108 parents from 67 schools responded to the survey from October 2022 to December 2023. 54% (58/108) of parents reported their child had seen an optometrist within 18 months prior to the vision screening. 69% (75/108) of respondents reported their child passed the vision screening (no visual concerns detected). Of those parents that reported a pass, 41% (31/75) incorrectly reported their

child passed the screening when they had actually been referred. 44% (48/108) of parents reported they took their child to an optometrist following the vision screening. Of the 56% (60/108) of parents that did not seek eye care, reasons why included: recently had an eye exam and did not require another one (42%, 25/60), lack of time (28%, 17/60), eye exams perceived not to be important (25%, 15/60), and cost (5%, 3/60).

Discussion and Conclusions:

The program was significantly more effective in encouraging parents to seek vision care if they interpreted their child was referred than if the child passed the screening ($p = 0.008$). It would appear that the information in the communication material was not well understood by parents, as 31% of parents misinterpreted their child's screening result. To improve program effectiveness in promoting vision care, increased public education on the difference between vision screenings and eye exams and the importance of early vision care for children is recommended.

2.2 Introduction

In Canada, it is estimated that one in five children between the ages of three to six years have a vision problem.[60,66] Vision has an important role in a child's development and is vital for social and academic skills.[67–70] Children with untreated vision issues may struggle to read and comprehend text, resulting in lower academic performance.[71–80] If left untreated, correctable childhood vision problems may have lifelong impacts, affecting a child's overall quality of life, educational attainment, and employment.[81–83] Early diagnosis of vision problems is therefore important to prevent these challenges.[29]

To aid in the early detection of vision problems such as amblyopia, various provinces in Canada have implemented pediatric vision screening programs.[5,18,21] Vision screenings are a short series of tests that can detect potential risk factors for certain eye conditions.[18] A vision screening may indicate if a referral to an optometrist or ophthalmologist is necessary, however, screenings cannot diagnose a vision problem nor are they a replacement for a comprehensive eye exam.[61] In 2018, the Government of Ontario implemented a screening program for children in senior kindergarten.[5,61] The Child Visual Health and Vision Screening protocol outlines the required tests and the "pass" and "refer" criteria for each test.[61] As per the protocol, following the vision screening, parents receive the Parent Notification Letter-A (PNF-A), indicating a vision problem was identified or the Parent Notification Letter-B (PNF-B), indicating no problem was identified at the screening.[61] Both Child Vision Screening Parent Notification Letters include information on:

- Recommendation to book an appointment with an optometrist for a comprehensive eye exam;
- The importance of routine eye exams for children;

- What a comprehensive eye exam includes;
- Coverage availability for eye exams through OHIP for children annually under the age of 19;
- Resources to find their local optometrist.

If a child is referred, PH sends an additional letter home to parents within 20 business days to remind parents to book an appointment. Once parents are notified of their child's vision screening results, there are no additional follow-up procedures to ensure a child who received a refer obtained appropriate vision care, and parental compliance to vision screening recommendations is not monitored for this program.

As mentioned in Chapter 1, the studies by Nishimura et al., provided evidence demonstrating the effectiveness of vision screenings in detecting vision problems in children, but did not investigate parental compliance in seeking follow-up eye care with an optometrist if recommended.[59,60] Studies that have investigated the translation of vision screenings to eye exams have reported mixed results.[84–86] For example, the Baltimore Screening Project found that only 30% of parents took their child for an eye exam after a vision problem was identified at the screening program, despite the program facilitating the appointment and covering the cost of any spectacles prescribed.[87] However, studies by Mark & Mark, and Chu et al., found slightly higher compliance rates of 50% and 52% respectively.[88] [87,89]

Reasons why parents did not take their child for an eye exam following a vision screening have also been investigated. Su et al. found that 29% of parents were unaware their child did not pass the screening because the program did not clearly report the vision results.[84] Another study by Mark & Mark found the reason parents did not follow-up with an eye care provider was due to a lack of time or financial resources.[88]

The success of any vision screening program is dependent on whether the individual identified as having a vision problem is compliant with receiving recommended care following the screening.[90] Therefore, the purpose of this study was to determine if Ontario's mandated vision screening program was effective in prompting parents to seek vision care in the Region of Waterloo. Additionally, for parents who reported not taking their child for an eye exam, barriers to seeking vision care were explored. The aim of this study was to evaluate parental compliance to the Government of Ontario's vison screening program.

2.3 Methods

This study was reviewed and approved by the University of Waterloo Research Ethics Board (ORE#: 44548) and the Waterloo Region District School Board (WRDSB) Research Review Committee on September 21, 2022.

2.3.1 Participants

All parents of senior kindergarten students who participated in the ROW PH vision screening program between the dates of October 2022 – December 2023 were invited to participate in the study. Parents who agreed to participate completed the study survey (by phone or online, participant preference) and consented to release their child's vision screening results from the ROW PH to the study investigators.

2.3.1.1 Participant Recruitment

Parents received an information letter about the study including how to participate by two methods (see Appendix C for information and consent form):

- Before the vision screening: a letter sent by the school principal educating parents about the study; QR code and web-link for study information included.
- After the screening: study information letter including the child's vision screening report, QR code and web-link for study information.

2.3.2.2 Survey design

A survey was designed to investigate parental compliance to seek eye care following their child's vision screening. The goals of the survey were to determine how many children did not require the screening (i.e., were they already under the care of an optometrist), if parents understood the communication materials from the government, and if any follow-up care was obtained. The survey was administered online via Qualtrics.com or through a phone call interview, which consisted of three questions (Figure 4, Appendix D).

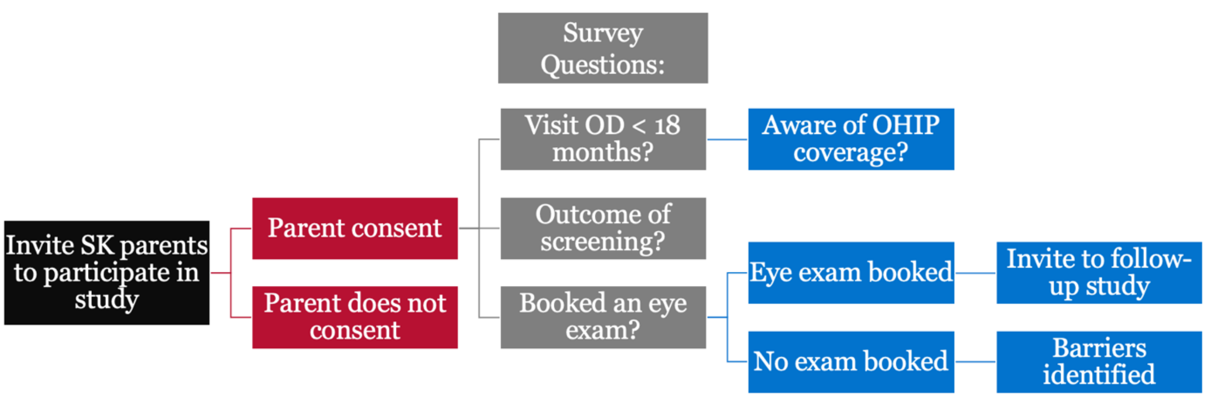


Figure 4: Design of Translating Vision Screenings into Eye Exams Survey.

Q1. Did your child see an optometrist within the last 18 months?

If the participant responded yes, the survey followed up and asked for the month/year of the child's last eye exam to verify if it has been within 18 months.

If the participant responded no, the survey provided additional information about the importance of vision and learning. The survey also provided education on coverage for comprehensive eye exams through OHIP and asks if the parent was aware of this coverage.

Q2. What was the finding of the vision screening – pass or refer?

Parent reported result based on PNF form received.

Q3a – Parent reported child passed the screening.

The survey provided information about the importance of receiving a comprehensive eye exam by an optometrist annually and asked the parent if they had booked an appointment following the vision screening. If the parent responded yes, they were invited to participate in the follow-up study that investigated the accuracy of the vision screening results relative to the eye exam findings (Chapter 3.3).

Q3b – Parent reported child did not pass the screening.

The survey provided information about the difference between vision screenings and eye exams and discussed the importance of children being seen for annual eye exams by an optometrist. Parents were then asked if an eye appointment had been booked following the vision screening. The options for this question were yes or no. If the parent responded yes, they were invited to participate in the follow-up study that investigated how accurate the vision screenings were at detecting vision problems (Chapter 3.3). If the parent responded no, additional questions were asked to investigate barriers preventing parents from seeking vision care. The survey then provided further education on the relationship between vision and learning. Parents were also offered assistance with booking an appointment with an optometrist.

2.3.2.3 Survey protocol

2.3.2.3.1 Study survey

The consent form provided the option for participants to complete the study survey by phone (one-on-one interview) or electronically. If the parent did not respond after initial contact, a reminder email or call was sent two weeks after that date, and a final reminder two weeks after that. If the parent did not complete the survey within six weeks, the survey link became invalid.

All data obtained by the phone interviews was recorded electronically on Qualtrics.com and interview notes were recorded on a password protected Excel spreadsheet.

2.3.2.3.2 Vision Screening Results

A copy of the child's vision screening result was obtained from the ROW PH. Data for visual acuity, stereoacuity, refractive error, and overall screening results were extracted and recorded in a password-protected Excel spreadsheet.

2.3.3 Data Analysis

Survey responses were reviewed individually by question and categorized into binary (yes/no or pass/refer) options. Responses between questions were further examined for association using a chi-squared test. All statistical analyses was performed at a 99% confidence interval using SPSS statistical software.[91]

When completing the survey, each participant reported their child's school. Population data for this study were taken from the location of the child's school (i.e., a child attending a school in Cambridge ON was assumed to live in Cambridge ON) and were used to investigate whether parental responses varied based on location (i.e., rural vs urban areas). Population related data for each participant were obtained through Statistics Canada from the 2021 census and were grouped by population size: low > 25,000, middle 25,000 to 250,000, and high < 250,000.[92] Population sizes for the municipalities in the Region of Waterloo are shown in Table 6 below.

Table 6: Population Sizes for Each Municipality in the ROW.

Location and Population Size		
Low	**Medium**	**High**
Ayr (5,383)	Cambridge (138,479)	Kitchener (256,885)
Baden (21,429)	Waterloo (121,436)	
Breslau (5,053)		
Conestoga (1,272)		
Elmira (10,790)		
Linwood (734)		
New Dundee (1,174)		
New Hamburg (14,379)		
St Clements (11,586)		
St Jacobs (1,959)		
Wellesley (11,318)		

2.4 Results

2.4.1 Participation

A total of 108 parents/guardians from 67 schools in the ROW participated in the study. The survey had a 1% response rate, as approximately 10,000 parents were invited to participate during the study period. School locations and number of participants are shown in Table 7.

Table 7: Participation by School Location in ROW

Location	Schools Included in Study	Total Number of Schools
Ayr	1	3
Baden	1	2
Breslau	1	2
Cambridge	18	36
Conestogo	0	1
Elmira	1	4
Kitchener	30	54
Linwood	0	1
New Dundee	0	1
New Hamburg	0	3
St Clements	0	1
St Jacobs	1	1
Waterloo	13	25
Wellesley	0	1
Total	66	135

2.4.2 Survey Results

Q1: Before your child's vision screening, has your child seen an optometrist within the last 18 months?

54% (58/108) of parents reported their child had seen an optometrist within the last 18 months; 66% (38/58) had done so within less than 6 months, 26% (15/58) between 6 to 12 months, and 8% (5/58) between 12-18 months before the vision screening (Figure 5). Of the participants (46%; 50/108) that responded they had not taken their child to an optometrist, 40% (20/50) were aware OHIP provided annual eye exam coverage for children less than 19 years.

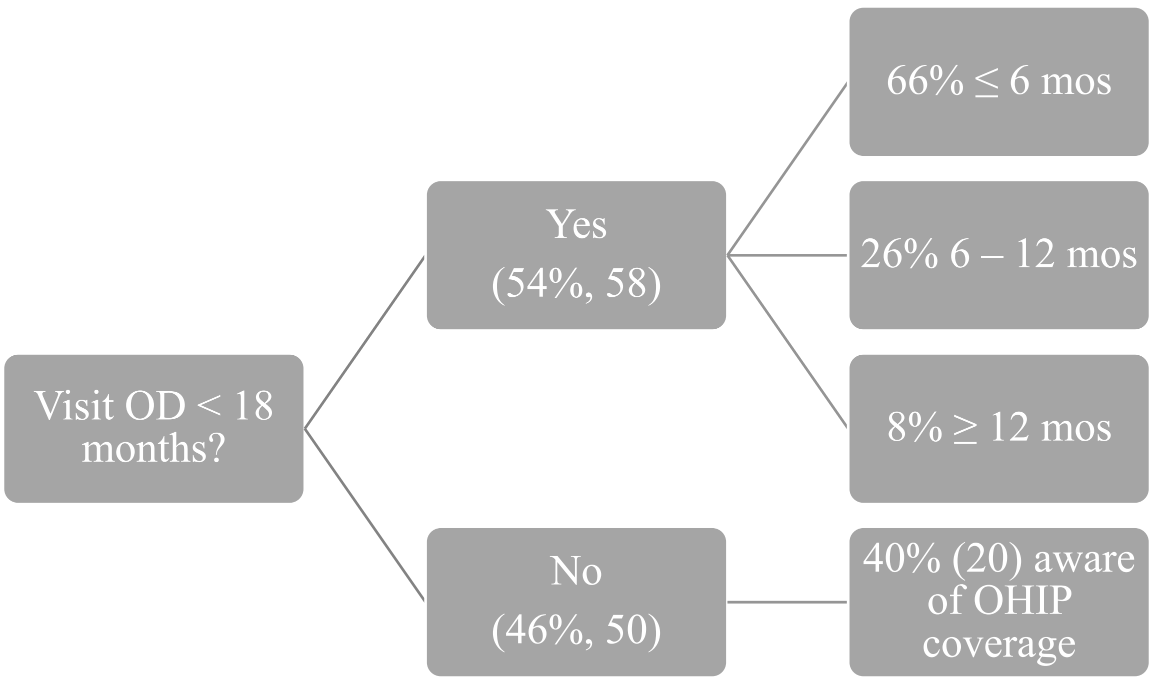


Figure 5: Children under care of an OD prior to screening (Question 1)

Q2: What were the findings of your child's SK vision screening?

69% (75/108) of parents reported their child had passed the screening (no visual problems were detected) and 31% (33/108) said their child had been referred (Figure 6). When comparing these responses to the actual vision screening results obtained by public health, 31% (33/108) of parents reported incorrectly; 41% (31/75) of parents incorrectly reported their child had passed the screening and 6% (2/33) incorrectly reported their child had been referred.

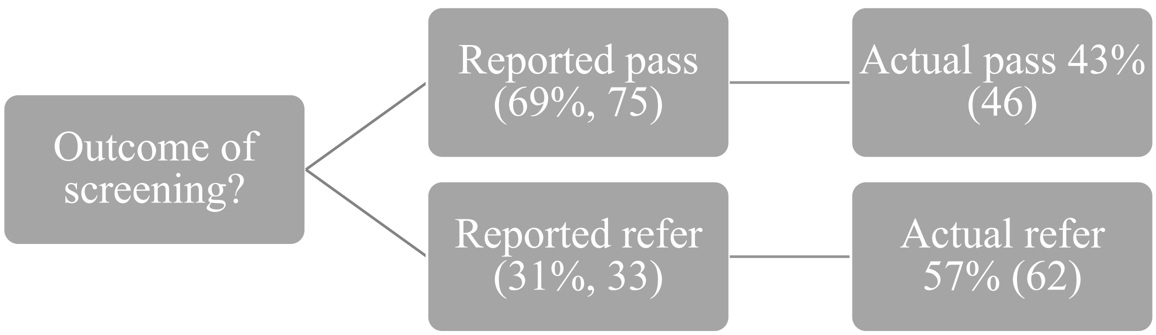


Figure 6: Reported screening outcome (Question 2)

Q3: Have you booked an appointment with an optometrist after receiving the parent vision screening letter?

Less than half of parents (44%, 48/108) reported they had booked an appointment for their child with an optometrist following the vision screening and 56% (60/108) responded no that they had not booked an appointment (Figure 7). For those that responded no, the survey followed up and asked if the parent required assistance in booking an eye exam with an optometrist. 5% (3/60) of parents agreed they would like help with scheduling an eye exam appointment for their child.

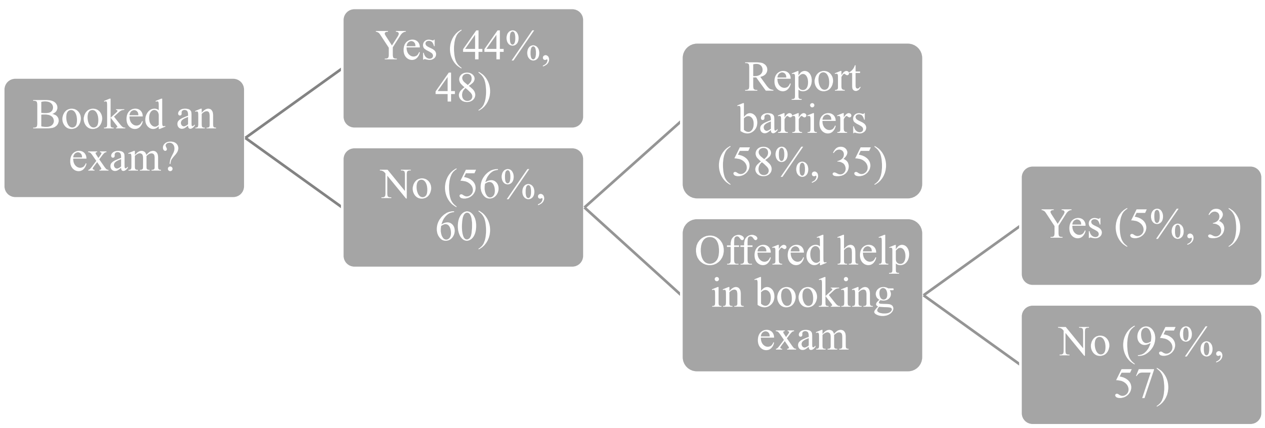


Figure 7: Parental compliance with the recommendation to book an eye exam (Question 3)

Q3a (follow-up question if parent did not book an eye exam): Are there any barriers preventing you from accessing vision care?

Of the 56% (60/108) participants who responded no to having taken their child for an eye exam (Figure 8), barriers reported include: lack of time (28%, 17/60), eye exams were perceived to not be important (25%, 15/60), cost (5%, 3/60) and “other” (13%, 8/60). Of all 8 responses from the “other” option, parents reported their child recently had an eye exam and did not require another. 42% (25/60) of parents (including the 8 that selected the “other” option) indicated their child recently had an eye exam and did not require another but all reported their child had an eye exam within 18 months prior to the screening (Q1).

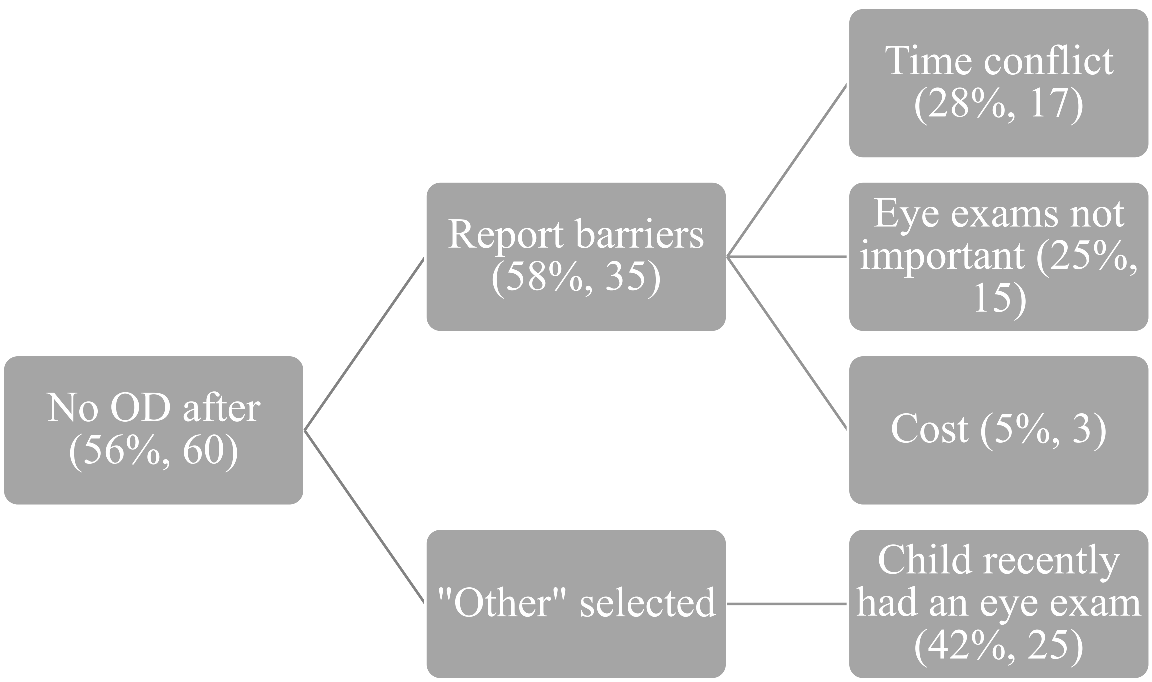


Figure 8: Reported barriers for parents that did not seek vision care.

2.4.3 Association Between Questions

Statistical analyses were performed to further investigate the efficacy of the vision screening program.

2.4.3.1 Efficacy of Program Prompting Parents to Seek Care

Results showed a significant association between the vision screening result reported and whether this prompted parents to book an appointment with an optometrist ($X^2 = 6.014$, d.f. = 1, p = 0.008) (Table 8). If parents obtained a pass result, they were less likely to obtain an eye exam for their child. Conversely, if the child was referred, they were more likely to obtain an eye exam.

Table 8: Association of Reported Screening Result (Q2) and Obtaining an Eye Exam (Q3)

		Q3		
		No	**Yes**	**Total**
Q2	**Pass**	48	27	75
	Refer	12	21	33
Total		60	48	108

2.4.3.2 Association of School Location and Parents Obtaining Optometry Services

Results showed no significant association between population size and whether the child was already under the care of an optometrist ($X^2 = 2.87$, d.f. = 2, p = 0.238) (Table 9). However, for the low population size, 6/50 (12%) parents responded no to obtaining optometry services prior to the screening, which in comparison to the medium ($X^2 = 2.75$, d.f. = 2, p = 0.097) and high ($X^2 = 2.54$, d.f. = 2, p = 0.111) population size (48%, 24/50, and 40%, 20/50, respectively), was much lower.

Table 9: Association of School Location Population Size and Children Already Under Care of an Optometrist (Q1)

		Q1		Total
		No	Yes	
Population Size	Low	6	2	8
	Medium	24	31	55
	High	20	25	45
Total		50	58	108

In addition, no significant association was found between population size and whether this influenced parents to book an appointment with an optometrist ($X^2 = 1.391$, d.f. = 2, $p = 0.499$) (Table 10).

Table 10: Association of School Location Population Size and Obtaining an Eye Exam (Q3)

		Q3		Total
		No	Yes	
Population Size	Low	4	4	8
	Medium	28	27	55
	High	28	17	45
Total		60	48	108

2.5 Discussion

Published evidence has shown parental compliance is improved when follow-up procedures are in place (i.e., providing an eye exam following the vision screening), however, Ontario's protocol currently lacks follow-up procedures to ensure a child who receives a refer result obtains appropriate vision care following the screening.[59,93] Thus the purpose of this study was to examine parental compliance in seeking eye care following their child's vision screening in the Region of Waterloo.

Despite the lack of follow-up procedures in Government of Ontario Child Health Vision Screening Protocol, study results found a positive association between parents booking an appointment based on vision screening results ($p = 0.008$), 36% (27/75) for children who passed and 64% (21/33) for children who received a refer. This result is similar to the study by Wang et al., who investigated parental compliance to the same protocol in Kingston, Ontario, from 2018 to 2020 and reported 70% ($p < 0.05$) of the referred children obtained eyecare following the screening.[94] The results of this study, and that of Wang et al., both demonstrate vision screenings are effective at encouraging parents to seek vision care when a vision problem is identified. However, it is interesting to note that although a significant association was found between screening results and parental compliance, of the 44% (48/108) of parents who took their child to the optometrist, 56% (27/48) had seen an optometrist within the last 18 months.

To investigate why some parents choose not to take their child for an eye exam, parents who reported they were not intending to take their child to an optometrist (56% 60/108) were surveyed on barriers preventing them from seeking vision services. The most reported barrier was lack of time (28%). While a follow-up question was not asked to clarify what parents meant by this response, a study by Kimel et al., which also investigated barriers inhibiting parents from seeking eye care for their child, categorized the "lack of time" response into logistical (problems with scheduling an appointment), social/family (not a priority), and perceptual barriers (all adults in the house worked — no time to schedule an appointment).[95] Therefore, it is unknown if lack of time translated to the inability to book an appointment due to busy schedules (logistical) or if parents felt taking their child for an eye exam was not a priority among day-to-day activities (social/family). Examining the logistical rationale, optometric services were investigated within the Region of Waterloo. According to the College of Optometrists of Ontario, within the municipality of Waterloo, 114 registered optometrists practice in the area or 1 optometrist for every 1065 people.[96] Similarly, the city of Cambridge had 1 optometrist for every 3,077 people, while in the city of Kitchener, there was 1 optometrist for every 3,252 people. When reviewing the hours of operation for most practices in this area, many clinics (over 75%) were open on weekends or after work hours (before 9 a.m. or after 5 p.m.), which provides flexibility for parents to schedule an appointment. Similarly, the social/family rationale would assume parents did not place a priority on their child's vision. This is unlikely to be the case as seen in a study by Ng et al., who surveyed parents in the same region as this study.[63] Ng's study found parents understood the role vision plays in academic learning but also found this did not translate to parents taking the child for routine eye care.[63] Further research is therefore needed to better understand why parents felt "lack of time" was a barrier.

Because lack of time was assumed to be a barrier, parents were educated on the importance of pediatric vision care, the association between vision and learning, and the coverage for pediatric eye care and glasses in Ontario. Following this, researchers offered to facilitate booking an eye exam for parents. Of all parents who participated in the survey, 5% of parents (3/60) agreed for researchers to help coordinate the appointment. The remainder declined the offer despite the education provided. This was an interesting finding, since other screening studies have not reported such a high percentage of parents declining eye exam follow-up. Possible reasons may include parents' perception of the importance of vision care or parental health literacy.[95] Additionally, parents may have declined help if they prefer to have the choice and control in making their health appointments for their children. Further investigation to explore why parents choose not to accept help in booking an eye exam is recommended.

Another reported barrier was that eye exams were not important (25%, 15/60). Although additional questions were not asked to investigate the reasons why parents did not feel their child needed an eye exam, reasons suggested by Kimel et al., included a child denying having a vision problem and the parent not seeing any signs of a vision problem.[95] Both these reasons are interesting since they show parents believe that they would know if their child has trouble seeing.[95]

However, as reported by Spafford et al., many eye problems, such as amblyopia, exist without symptoms, and the general public is unaware of the asymptomatic nature of many eye diseases.[97] Therefore, parental beliefs about the importance of eye exams and whether their child can see well could erroneously influence seeking out vision services for their child.[98]

The least commonly reported barrier to parents seeking eye care was cost (5%). While this was not a significant barrier observed, this finding was surprising since comprehensive eye exams are covered for children living in Ontario through the Ontario Health Insurance Program (OHIP) annually up to 19 years of age, as detailed in the PNF letter.[99] In addition, the Region of Waterloo Public Health website informs parents, children in junior and senior kindergarten are eligible for spectacle coverage if needed through the Ontario Association of Optometrists Eye See… Eye Learn® (ESEL).[100] Cost or sufficient eye insurance was the most commonly reported barrier found in the Wang et al., study, evaluating Ontario's SK screening program in Kingston, ON.[94] Despite the education, when participants were asked if they were aware of provincial insurance coverage for pediatric eye exams, 60% reported they were not. This finding showed that parents may have been confused by, or may not have carefully read the information provided within the provincial letter that went home following the vision screening.

Parental confusion was further demonstrated in this study when 31% (33/108) of parents incorrectly reported their child's screening result. Forty-one percent (31/75) thought their child had received a pass when in fact they received a refer. The most likely reason for this confusion was the interpretation of the Parental Notification Form. There were two Parental Notification Forms sent by the Ministry of Long-Term Care following the screening (Appendix A and B). One form was for when a child passed the screening (PNF-B), and one form was when the child was suspected to have a vision problem (PNF-A); however, the difference in wording between these two forms is not easy to understand. For example, PNF-A states “there may be an issue with your child’s vision”. This wording may have led parents to believe their child had passed when it was meant to indicate the child received a refer. Conversely, PNF-B, states “no vision issues were identified”. While fewer parents misunderstood this result, results from this study did show that 6% (2/33) also misinterpreted this finding. In addition, both forms also inform parents that eye examinations are covered through OHIP annually for children up until 19 years of age and discuss the areas investigated within a comprehensive eye exam. However, like the screening result interpretation, 60% (30/50) of parents were found to be unaware of OHIP coverage for their child, demonstrating the form was not effectively disseminating the information to parents.

The miscommunication on the form may have arisen from using complex words such as *comprehensive eye examination*s, instead of eye exams, or *optometrists* instead of eye doctors. Another possibility is that parents did not fully read the form that was sent home. While the exact reason for the miscommunication is unknown, survey results highlight several areas for improvement within the Parent Notification Form which is further discussed in Chapter 4 (section 4.1.1).

2.6 Conclusion

Survey results found a significant association between children who received a refer and children who sought follow-up eye care, demonstrating that the screening encouraged parents to seek vision care when a problem was identified. Barriers for parents not taking their child for an eye exam include time constraints, not understanding the importance of vision care, not prioritizing vision care, and potentially relying on the screening result. Additional research is need to better understand the specifics of the reported barriers. Finally, the lack of parental compliance observed may have further been contributed by the communication materials as 47% thought their child had passed when they received a refer. Improvements in communication material are recommended to improve compliance.

Chapter 3
Outcomes of the Government of Ontario's Vision Screening Program in Identifying Vision Problems in SK Children in Waterloo Region

3.1 Summary

Purpose:

In 2018, the Ontario Ministry of Health and Long-Term Care instituted a province-wide school-based senior kindergarten vision screening program implemented by local public health units.[61] The program's purpose is to identify children with undiagnosed vision problems. It is currently unknown how successful Ontario's mandated protocol is in detecting a problem as there have been no published studies examining the program's accuracy. This study investigates the ability of Ontario's vision screening tools in identifying visual problems for Senior Kindergarten (SK) children within Waterloo Region.

Methods:

The study was conducted in two parts. First, parents/guardians (parents) of SK students who participated in the vision screening study (Chapter 2) and who brought their child to an optometrist following the vision screening were invited to participate in the study comparing vision screening data against eye exam results. Program sensitivity and specificity were determined, and cut-off criteria for each vision screening tool was examined using the eye exam results as the gold standard. Second, vision screening data (visual acuity, stereoacuity and autorefraction) for all children who participated in Ontario's vision screening program from 2022-2023 were obtained from the ROW PH. The program's overall referral rate and the referral rate for each screening test was determined and compared to published values.

Results:

A total of 65 participants were included in the study comparing vision screening to eye exam results. Overall, the vision screening program had a sensitivity of 0.935 and specificity of 0.406, with the majority of children being correctly identified (67%, 42/63) as having or not having a vision problem. However, the low specificity produced a high rate of false positives (30%, 19/63), leading to over-referrals. The average refractive error found for both eyes for the eye exam was 0.34 for the right eye and 0.41 for the left eye (average 0.38), and for vision screening was 0.68 and 0.84 (average 0.76) for the right and left eyes, respectively. The paired t-test analysis found significant differences between eye exams and the vision screening tools for refraction: sphere (OD: $M = -0.46$, $d.f. = 56$, $t = -2.68$, $p = 0.005$, OS: $M = -0.57$, $d.f. = 56$, $t = -3.32$, $p < 0.001$), cylinder (OD: $M = 0.25$, $d.f. = 56$, $t = 3.11$, $p = < 0.001$, OS: $M = 0.28$, $d.f. = 56$, $t = 4.74$, $p < 0.001$), and spherical equivalent (OD: $M = -0.34$, $d.f. = 56$, $t = -2.21$, $p = 0.016$, OS: $M = -0.43$, $d.f. = 56$, $t = -2.71$, $p = 0.004$). The vision screening measurements were significantly more positive than the eye exam. A Bland-Altman analysis revealed that for stereoacuity ($p < 0.001$), refraction – sphere (OD: $p < 0.001$, OS: $p = 0.001$) and cylinder (OD: $p < 0.001$, OS: $p < 0.001$), the screening results were closer in value to the eye exam results at lower values (i.e., closer to plano) than when the values were higher.

The retrospective review of the screening data included a total of 4837 vision screening results from 135 schools in Waterloo Region. The screening had an overall referral rate of 54% (2606/4837) and children were most commonly referred because of a failure in autorefraction screening (43%%; 2099/4837) followed by stereoacuity screening (31%; 1510). Visual acuity had the lowest screening referral rate (15%; 714) and a low agreement with the two other screening tests. For refraction, 37% (1602/4351) of children were referred for being outside the sphere, 24% (1033/4351) cylinder, and 1% (52/4351) spherical equivalent thresholds.

Discussion and Conclusion:

The study findings indicate that children with a vision problem are likely to be identified by the SK vision screening program, but that the program had low specificity and a high rate of false positives (30%). Over half of the referrals were from failure on autorefraction screening. To improve program sensitivity and specificity, adjustment to the cut-off criteria for refraction and stereoacuity to align with age-expected normative values is recommended.

3.2 Introduction

Health screenings can be an important strategy in disease prevention.[101] Screenings are a quick relatively inexpensive method to detect if a person may be at risk for a particular health concern without referring those who are not.[4,11,102] Disease screenings may be universal in design or targeted to high-risk populations.[11] Common health screenings include screenings for systemic disease, genetic conditions in newborns, and ocular conditions, such as amblyopia and uncorrected refractive errors. [11,103–105] To determine if a person is at risk for the disease, screening guidelines should be developed through empirical and clinical evidence, including the screening tool, age of person to be screened, frequency of screening, and referral criteria.[106–108] While most health screening protocols are standardized across North America, pediatric vision screenings are not.

The World Health Organization (WHO) recommends childhood vision screening as part of vision impairment prevention.[109] In Canada and the US, vision screenings are typically performed by a variety of personnel, ranging from eyecare professionals (i.e. optometrist, ophthalmologist) to lay screeners, and the age at time of screening can range from preschool (3 years) to high school (18 years), with varying frequency for how often a person is screened (one-time screen vs screening every year).[22] Vision screening methods also vary dependent upon the purpose of the program (i.e., the vision condition being screened) and participant age. Informed by the studies published by Nishimura et al., conducted in 2014 to 2017, the Government of Ontario mandated a vision screening program for Senior Kindergarten (SK) children in 2018.[61] The purpose of the mandated protocol was to identify children with risk factors for amblyopia, reduced stereopsis and/or strabismus, and refractive vision disorder using the following diagnostic tools: visual acuity (HOTV), stereoacuity (Randot® Preschool) and autorefraction (PlusOptix) and comparing each result to a “pass” and “refer” criteria.[61]

To receive a pass, a child must meet the pass criteria for each of the 3 vision screening tests. If any one of the three screening tests is recorded as a “refer”, the overall result is “refer”.[61] Following the vision screening, parents receive a Parent Notification Form (PNF) from the Ministry of Health and Long-Term Care advising them if their child passed (no vision problem) or is referred (vision problem suspected). A recommendation to book a comprehensive eye exam with an optometrist for their child is also included in the PNF regardless of the screening outcome.[61]

Since the mandate in 2018, no published studies have examined the program’s accuracy in identifying vision problems.[110] It is important to determine if a vision screening program can discriminate between children with a vision problem and those without. The ideal vision screening program should have a high sensitivity and specificity to avoid false-negatives (low sensitivity) or false-positives (low specificity).[4,11] False negatives indicates that children with a vision problem were missed, which may cause delayed intervention, diagnosis and treatment, and lead to reduced public confidence in the screening program over time.[10] Conversely, false-positives incorrectly identify children with a vision problem, which may also lead to public distrust in the screening results over time.[111] A systemic review by the US Preventive Services Task Force (USPSTF) evaluated vision screening tools accuracy in detecting amblyopia, its risk factors, and refractive errors for children aged 6 months to 5 years.[52] The review found screening tool accuracy had a high rate of false positives if the disease prevalence in the population was low.[52] For example, amblyopia has an overall prevalence of 0.8-5% in children.[52] The USPSTF review found a high rate of false positives (~75%) when screening for amblyopia if the disease prevalence was lower than 10%.[52] Therefore, the expectation is vision screening programs with an objective of detecting amblyopia would be expected to have a low specificity/ high false positives due to the low disease prevalence.[66,112,113]

The purpose of this chapter was to investigate the vision screening outcomes in two ways. First, the accuracy of the Ontario vision screening program in ROW was determined by comparing the screening results against the gold standard comprehensive eye exam, in the three areas tested in the screenings: visual acuity, stereoacuity, and refraction. To further assess screening outcomes, the 2022-2023 vision screening data obtained by the Region of Waterloo Public Health (ROW PH) Senior Kindergarten (SK) vision screening program, was retrospectively analyzed to determine the overall referral rate and the referral rate for each individual screening tool.

3.3 Methods

Vision screening outcomes were measured in two ways: comparison of vision screening to eye exam results, and a retrospective review of all vision screening results from SK children from 2022 to 2023 school year in Waterloo Region.

3.3.1 Comparing the accuracy of vision screening results

The study was reviewed and approved by the University of Waterloo Research Ethics Board (ORE#: 44548) and the Waterloo Region District School Board (WRDSB) Research Review Committee on January 30, 2023.

3.3.1.1 Recruitment

Participants were recruited for this study by two methods:

1. Parents who participated in the initial survey (Chapter 2) and who had taken their child to an optometrist for a full eye exam.

2. Parents were recruited from local ROW optometry clinics who took their child in because of the ROW PH vision screening program recommendation.

3.3.1.2 Data Collection

Parents who expressed interest in participating in the follow-up study were given an information and consent letter (Appendix C). By consenting to participate, parents agreed for the ROW PH to share their child's vision screening findings and for their optometrist to share their child's eye exam findings for visual acuity, stereoacuity and refraction only. All data for this study were stored in a password-protected Excel spreadsheet for analysis.

3.3.1.3 Data Analysis

Statistical analyses (paired t-test, Bland-Altman plots, and sensitivity and specificity calculations) were performed in IBM SPSS Statistics for Windows, Version 29.0.2.0 Armonk, NY: IBM Corp.[84]

The paired t-test compared vision screening outcomes to eye exams for stereoacuity and refraction. For stereoacuity, vision screenings stopped at 60 arcsec; therefore, when the comparison was made for stereoacuity, values recorded better than 60 arcsec by the optometrist were converted to 60 arcsec. For refraction, values were calculated separately for each eye, comparing the results for sphere, cylinder, axis, and spherical equivalent between screening outcomes and eye exam results.

To assess the agreement between the vision screening and eye exam results, a Bland-Altman analysis was performed. Similar to the t-test, the analysis was performed for stereoacuity and refraction tools only. Bland-Altman plots are typically constructed using the difference between the results of the two methods (i.e., for stereoacuity the difference in arcsec obtained from the vision screening - eye exam) and compared to the average of the two methods (vision screening and eye exam). The calculations for the difference and average are shown below. If variation between the mean difference was observed on the Bland-Altman plot, a linear regression was performed using the difference and average to determine if there was any proportional bias present.

$$Difference = vision\ screening - eye\ exam$$

$$Average = \frac{vision\ screening + eye\ exam}{2}$$

Program sensitivity and specificity were also determined. To calculate the program's sensitivity and specificity, the child's vision screening results (pass = negative; refer = positive) were compared against their eye exam results. All three screening tools were included in the calculation. Results were also reviewed individually for each screening tool. For analysis, eye exam results were defined as either positive or negative using Ontario's mandated vision screening referral criteria:

- Visual acuity : pass = 20/32; refer = > 20/32[61]
- Stereoacuity : pass = 60 sec of arc; refer = > 60 sec of arc[61]
- Refraction : pass = refraction error must be within the following threshold:[61]
  - Sphere = -1.50Ds to +1.00Ds;
  - Cylinder = plano to -0.75Ds;
  - Spherical Equivalent = < 1.50Ds;

  refer = all findings that fall outside the refractive thresholds.

Vision data from the eye exam were compared using the Child Health Vision Screening Protocol pass/refer criteria. A child was considered to have a problem if they were outside the criteria based on the findings of the eye exam. A child's result was recorded as a true positive (TP) if they failed both the screening and eye exam, true negative (TN) if they pass both screening and exam, false positive (FP) if they were referred to an optometrist at the screening but passed the eye exam, and false negative (FN) if they passed the screening but were referred at the optometrist. The calculations for sensitivity and specificity were as follows:[114]

$$Sensitivity = \frac{TP}{TP + FN}$$

$$Specificity = \frac{TN}{TN + FP}$$

3.3.2 Retrospective vision screening review

This study has been reviewed and approved by the University of Waterloo Research Ethics Board (ORE#: 45040).

3.3.2.1 Data collection

De-identified vision screening data (overall result and individual result for visual acuity, stereopsis and autorefraction) were obtained from the Region of Waterloo Public Health for all SK children who participated in the vision screening program for the 2022-23 academic year. All results were input into a password protected Excel file and were stored electronically on a secure University of Waterloo One-Drive.

3.3.2.2 Data Analysis

Vision screening data were reviewed to determine referral rates. Not all children who should have received a refer based on criteria (optimum) obtained a refer result (actual). The actual overall referral rate of the program and referral rate for each individual screening test were calculated. All analyses were performed in Microsoft® Excel for Mac, Version 16.78.2, 2019.[115] All figures were prepared in IBM SPSS Statistics for Mac, Version 29.0.2.0 Armonk, NY: IBM Corp.[91]

For analysis purposes, individual pass/refer rates were reviewed, and the optimum overall referral rate (those who should be referred based on test results) was determined based on whether the child received a pass for all 3 tests (pass overall) or was referred for at least one of the three tests (refer). For the exploration of criteria changes on the effect of referral rates, visual acuity was again excluded because visual acuity was not recorded (only whether the child achieved a pass (VA = 6/12) or did not pass (VA < 6/12)). For stereopsis, if an arcsec result was not recorded and the child received a pass, it was assumed they achieved 60 arcsec. Results for the stereoacuity test were excluded from analysis if the child received a refer, and no arcsec was recorded. To examine the stereoacuity referral criteria, the cutoff for a pass (60 arcsec) was adjusted to 800, 400, 200, and 100.[61] For the autorefractor test, results were recorded as sphere, cylinder and spherical equivalent. Results were excluded if they were incomplete, missing, or received a "N/A" (for sphere or cylinder only). To explore the referral criteria, the effect of changing the criteria for hyperopia, myopia, and astigmatism detection on referral criteria was investigated.

3.4 Results

3.4.1 Vision screening results compared to eye exams

3.4.1.1 Participation

A total of 65 parents participated in this study. 30/108 (28%) participants were recruited from the initial survey study (Chapter 2), and 35 were recruited from optometry offices.

3.4.1.2 Stereoacuity

For the analysis comparing vision screening stereopsis results to eye exam results, 53 results were included, 12 results were excluded from analysis - 3 children were unable to perform stereoacuity testing at both screening and eye exam, 2 at screening only, and 7 did not have stereoacuity testing performed at the eye exam. The results of the paired t-test for stereoacuity showed no significant difference (M = -67.7, d.f. = 52, t = -1.92, p = 0.060) between the vision screening and the eye exam results.

3.4.1.3 Refraction

Refraction measurements were compared for sphere, cylinder, axis, and spherical equivalent. Of the 65 participants, 8 were excluded from analysis due to an absence of refractive data from the vision screening. The average refraction measurements and standard deviation for the vision screening (VS) and eye exam (EE) are shown in Table 11.

Table 11: Average Refraction Measurement

	Sph		**Cyl**		**Axis**		**SE**	
	VS	**EE**	**VS**	**EE**	**VS**	**EE**	**VS**	**EE**
OD	+1.00 (1.18)	+0.50 (0.69)	-0.75 (0.90)	-0.50 (0.67)	080 (65.9)	080 (85.0)	0.68 (0.88)	0.34 (0.74)
OS	+1.00 (1.26)	+0.50 (0.70)	-0.75 (0.72)	-0.50 (0.56)	070 (64.1)	080 (84.6)	0.84 (1.07)	0.41 (0.79)

A significant difference was found for sphere (OD: M = -0.46, d.f. = 56, t = -2.68, p = 0.005, OS: M = -0.57, d.f. = 56, t = -3.32, p < 0.001), cylinder (OD: M = 0.25, d.f. = 56, t = 3.11, p = < 0.001, OS: M = 0.28, d.f. = 56, t = 4.74, p < 0.001), and spherical equivalent (OD: M = -0.34, d.f. = 56, t = -2.21, p = 0.016, OS: M = -0.43, d.f. = 56, t = -2.71, p = 0.004) between the vision screening and eye exam findings. No significant difference was found in axis measurements between the vision screening and eye exam findings (OD: M = -6.54, d.f. = 56, t = -0.48, p = 0.318, OS: M = 4.40, d.f. = 56, t = 0.29, p = 0.386). For sphere and spherical equivalent, the vision screening results were significantly more positive than the refraction measurements obtained from the eye exam. Similarly, for cylinder the results were significantly more negative from the vision screening to the eye exam. The sphere measurement was on average +0.50D more hyperopic for the vision screening than eye exam, and for cylinder the vision screening was -0.25D more myopic than the eye exam average. Lastly, for spherical equivalent, the difference for both eyes was 0.39D more hyperopic for vision screening compared to the eye exam.

3.4.1.4 Bland-Altman Analysis

3.4.1.4.1 Stereoacuity

The mean difference between the vision screening and eye exam stereoacuity measurements was 74.63 arcsec with a 95% confidence interval of -422.36 to 571.62 (Figure 9). The results of the linear regression indicate a proportional bias is present ($t = 7.97$, $p < 0.001$). When the stereoacuity average values between vision screening and eye exam values were closer to zero, the two methods have a stronger agreement than when the stereoacuity is higher (i.e., worse stereopsis).

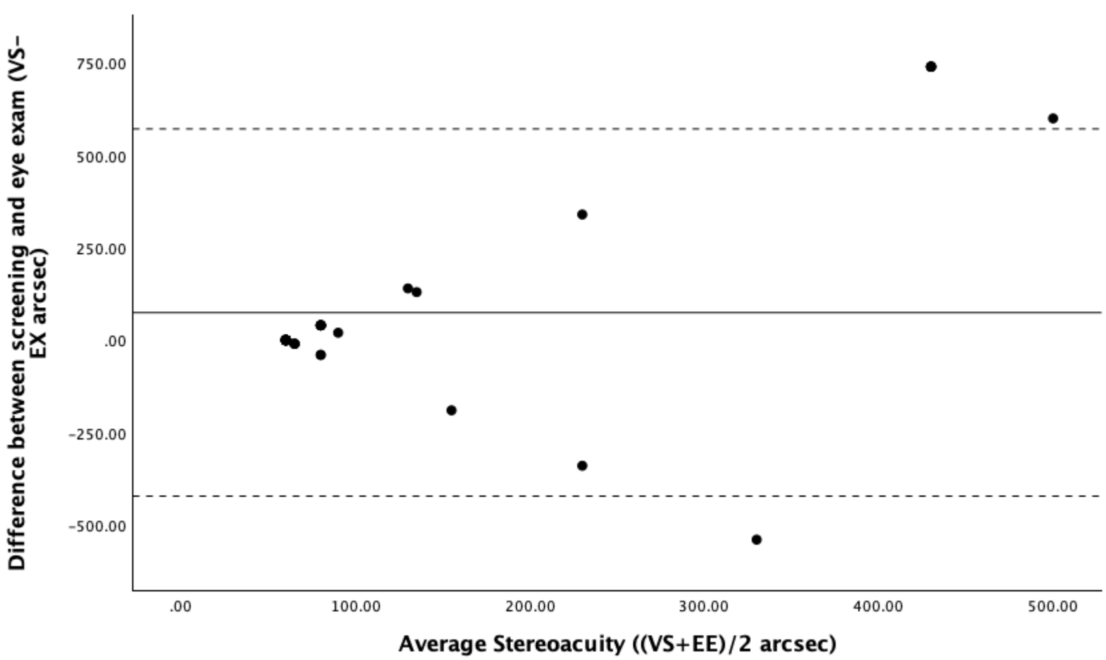


Figure 9: Bland-Altman Plot for the difference between vision screening and eye exam for stereoacuity values.

3.4.1.4.2 Refraction

For the right eye (Figure 10), the mean difference between the vision screening and eye exam sphere measurements was 0.46 diopter sphere (DS) with a 95% confidence interval of -2.10 to 3.03. The linear regression indicated a proportional bias was present ($t = 4.29$, $p < 0.001$). When the sphere values were closer to zero (plano), the two measurements had a stronger agreement than when the sphere becomes more negative or positive.

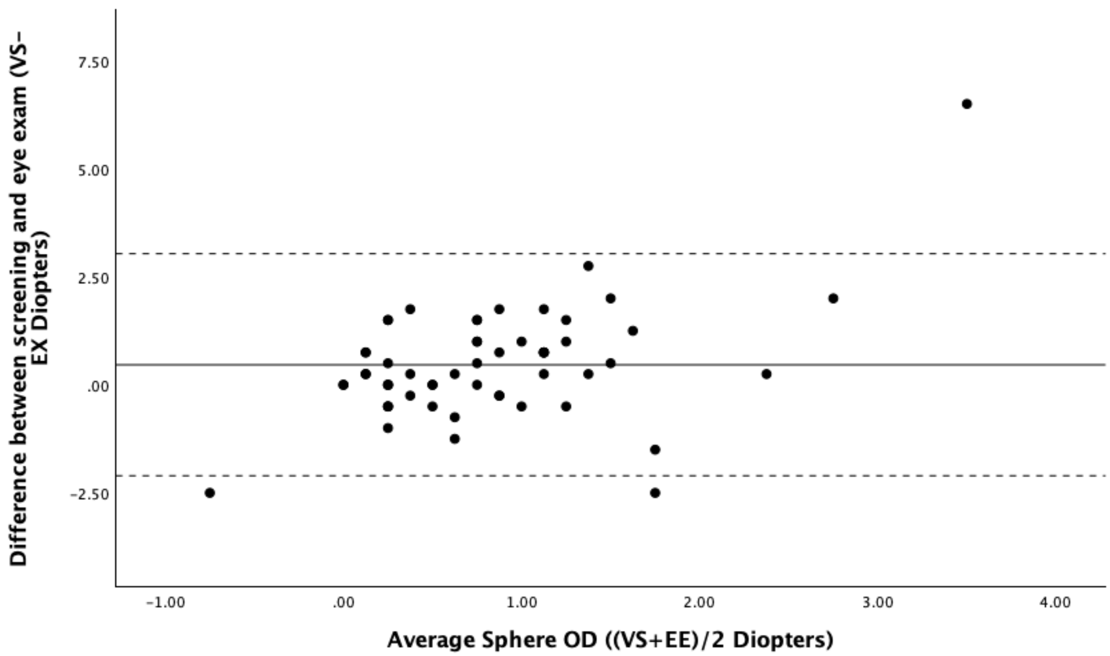


Figure 10: Bland-Altman Plot for the difference between vision screening and eye exam for right eye sphere values.

For the left eye, the mean difference between the vision screening and eye exam sphere measurements was 0.57 DS with a 95% confidence interval of -2.02 to 3.16 (Figure 11). The results of the linear regression indicate proportional bias was present ($t = 4.67$, $p < 0.001$), similar to the right eye. When the sphere values were closer to zero, the screening and eye exam had a stronger agreement than when the refractive error was more negative or positive.

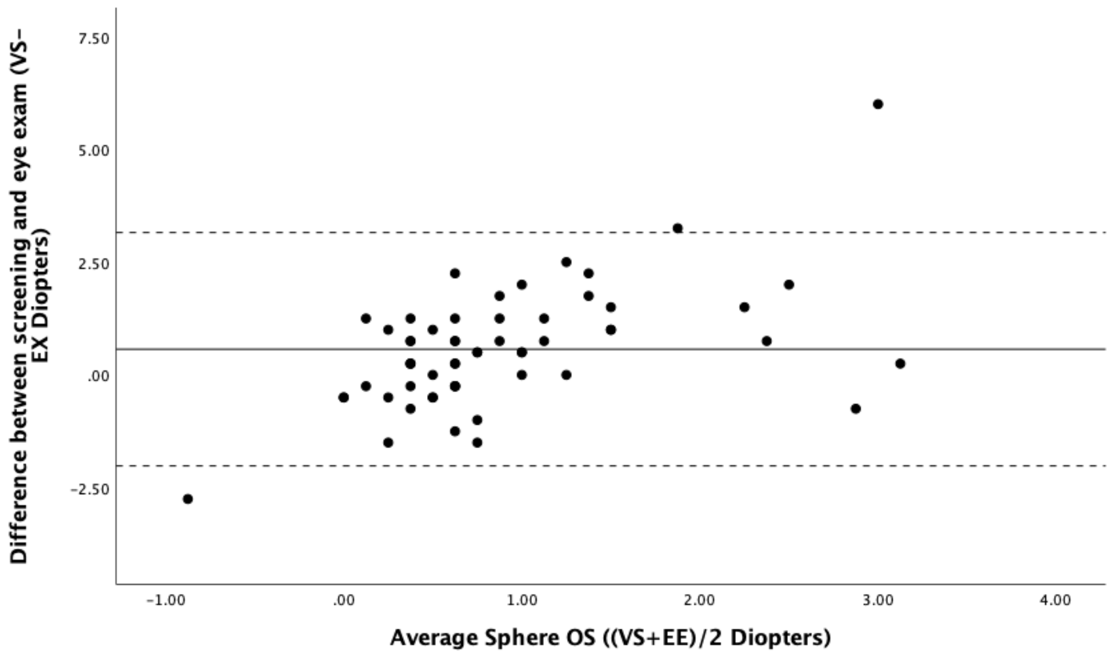


Figure 11: Bland-Altman Plot for the difference between vision screening and eye exam for left eye sphere values.

As shown in Figure 12, the mean difference between the vision screening and eye exam cylinder measurements for the right eye was -0.25DS with a 95% confidence interval of -1.46 to 0.95. The results of the linear regression indicate a proportional bias was present (t = 3.16, p = 0.003), as the cylinder values became more negative, the agreement between the measurements was less strong than when the cylinder values were closer to zero.

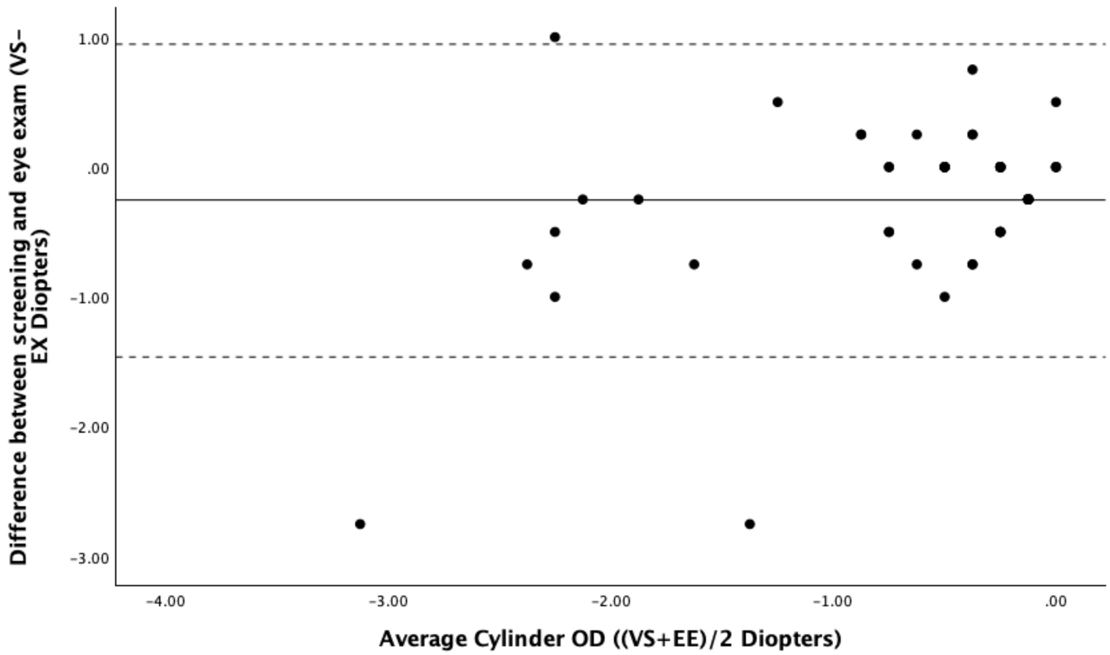


Figure 12: Bland-Altman Plot for the difference between vision screening and eye exam for right eye cylinder values.

The mean difference between the vision screening and eye exam cylinder measurements for the left eye was -0.29 DS, with a 95% confidence interval of -1.18 to 0.61 (Figure 13). As for the right eye, the results of the linear regression indicate a proportional bias was present ($t = 3.01$, $p = 0.004$) When the cylinder values became more negative, the screening became less accurate compared to the eye exam.

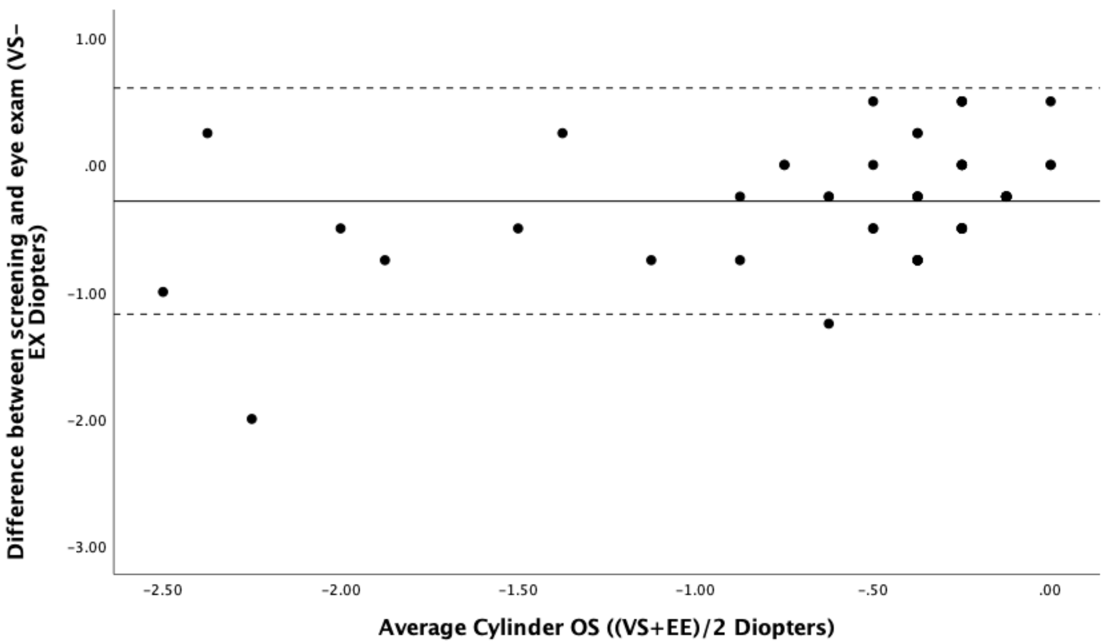


Figure 13: Bland-Altman Plot for the difference between vision screening and eye exam for left eye cylinder values.

For spherical equivalent, the mean difference between the vision screening and eye exam measurements for the right eye was 0.34 DS with a 95% confidence interval of -1.93 to 2.60 (Figure 14). The results of the linear regression indicate no proportional bias was present ($t = 1.33$, $p = 0.190$). There was no trend between the vision screening and eye exam measurements and the confidence interval was large and agreement poor.

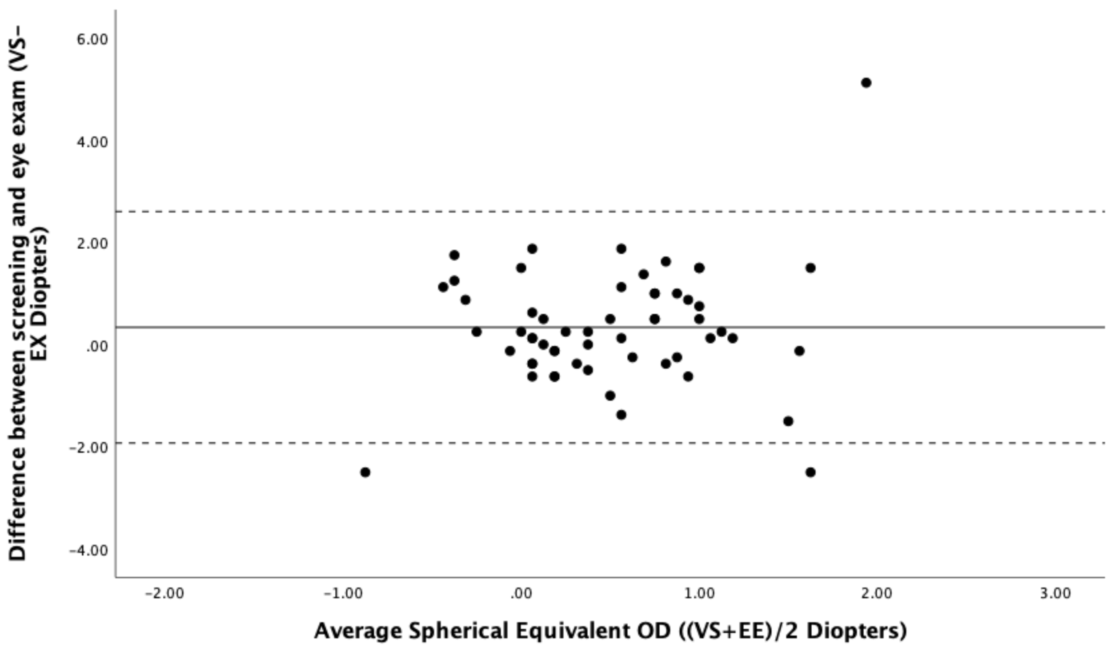


Figure 14: Bland-Altman Plot for the difference between vision screening and eye exam for right eye spherical equivalent values.

The mean difference between the vision screening and eye exam spherical equivalent measurements for the left eye was 0.43 DS, with a 95% confidence interval of -1.90 to 2.76 (Figure 15). The results of the linear regression indicate no proportional bias ($t = 2.34$, $p = 0.023$). Similar to the right eye, the results lack agreement without a trend.

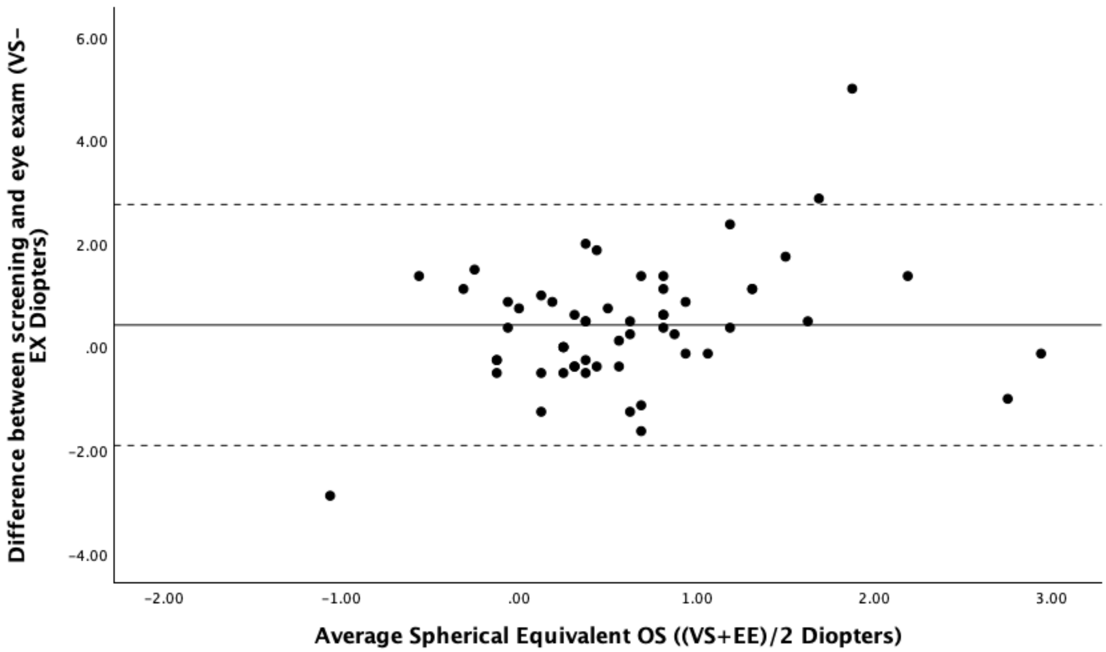


Figure 15: Bland-Altman Plot for the difference between vision screening and eye exam for left eye spherical equivalent values.

3.4.1.5 Program sensitivity and specificity

Of the 65 participants, 2 participants were excluded from the overall program analysis because two or more screening tools had missing data (i.e., autorefraction recorded result was N/A). Similar to the sections above, 53 results were included in stereopsis analysis and 57 for refraction. For visual acuity, 1 result was excluded because the participant refused testing at both the vision screening and eye exam. 24% (15/63) of children received a pass following the vision screening and 76% (48/63) children received a refer (Table 12). 17% (11/63) of children did not pass visual acuity, 29% (18/63) for stereopsis, and 52% (33/63) for autorefraction.

Table 12: Results obtained from the vision screening compared to the results of the comprehensive eye examination

Vision screening results	Eye exam results		
	Refer	**Pass**	**Total**
Refer	29 (46%)	19 (30%)	48
Pass	2 (3%)	13 (21%)	15
Total	31	32	63

Overall, the vision screening program sensitivity was 0.935 and specificity was 0.406. The sensitivity and specificity were reviewed further by each screening tool (Table 13). The screening tool with the highest sensitivity was autorefraction (0.800), and the tool with the highest specificity was visual acuity (0.860). The sensitivity and specificity were also calculated for various combinations of screening tools. The combination with the highest sensitivity was stereoacuity and autorefraction (0.931) and the one with the highest specificity was visual acuity and stereoacuity (0.660).

Table 13: Diagnostic accuracy of the screening tools

Screening Tool(s)	Sensitivity	Specificity
All three screening tools	0.935	0.406
Visual acuity	0.375	0.860
Stereoacuity	0.273	0.674
Autorefraction	0.800	0.541
Visual acuity and stereoacuity	0.579	0.660
Visual acuity and autorefraction	0.783	0.525
Stereoacuity and autorefraction	0.931	0.441

3.4.2 Retrospective vision screening review

3.4.2.1 Referral rate

A total of 4837 vision screening result forms were collected. Based on the cut-off criteria, the refer and pass rates were: 56% (2714/4837) referred (one or more screening result that did not meet the criteria), and 44% (2123) passed (all three screening tests met the criteria). However, when reviewing the overall result, 11% (507/4837) children incorrectly received a pass result when they should have received a refer. Subsequent analysis for this study was based on the criterion pass and refer result, not the result communicated to parents.

Referral rates were found to be different between screening tests. The screening test with the lowest referral rate was visual acuity (15%; 714/4837), followed by stereopsis (31%; 1510), and autorefraction (43%; 2099). The overlap between screening tests is shown in Figure 16.

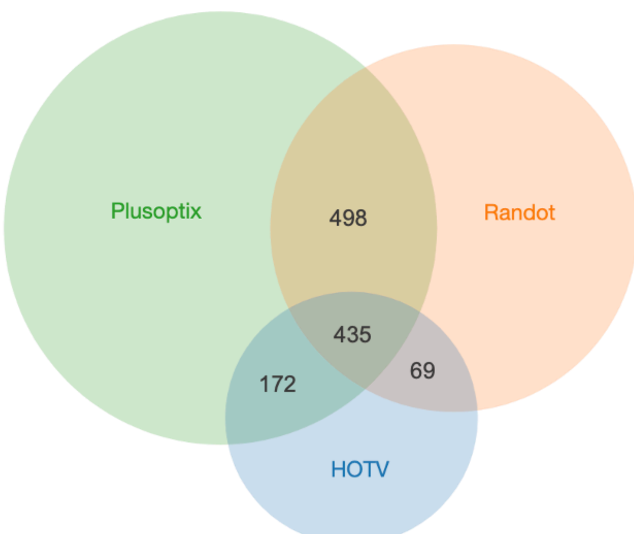


Figure 16: Venn diagram of referral overlaps between HOTV, Randot®, and AR (autorefractor) screening. Numbers represent total number of referrals.

3.4.2.2 Effect of Criterion

3.4.2.2.1 Stereoacuity

A total of 4837 vision screening results were collected, however, 1606 stereopsis results were excluded as no arcsec was recorded. Of the 3231 results remaining for analysis, 75% (2408/3231) passed (60 arcsec) and 25% (823) were referred (> 60 arcsec). The number of referrals changed as a function of criteria as shown in Figure 17. Referral rates can be found in Table 14. For example, changing the referral criteria from 60 (as shown in red in the in Figure 17) to 100 (as shown in blue in the figure below) arcsec would result in a 13% decrease in referrals.

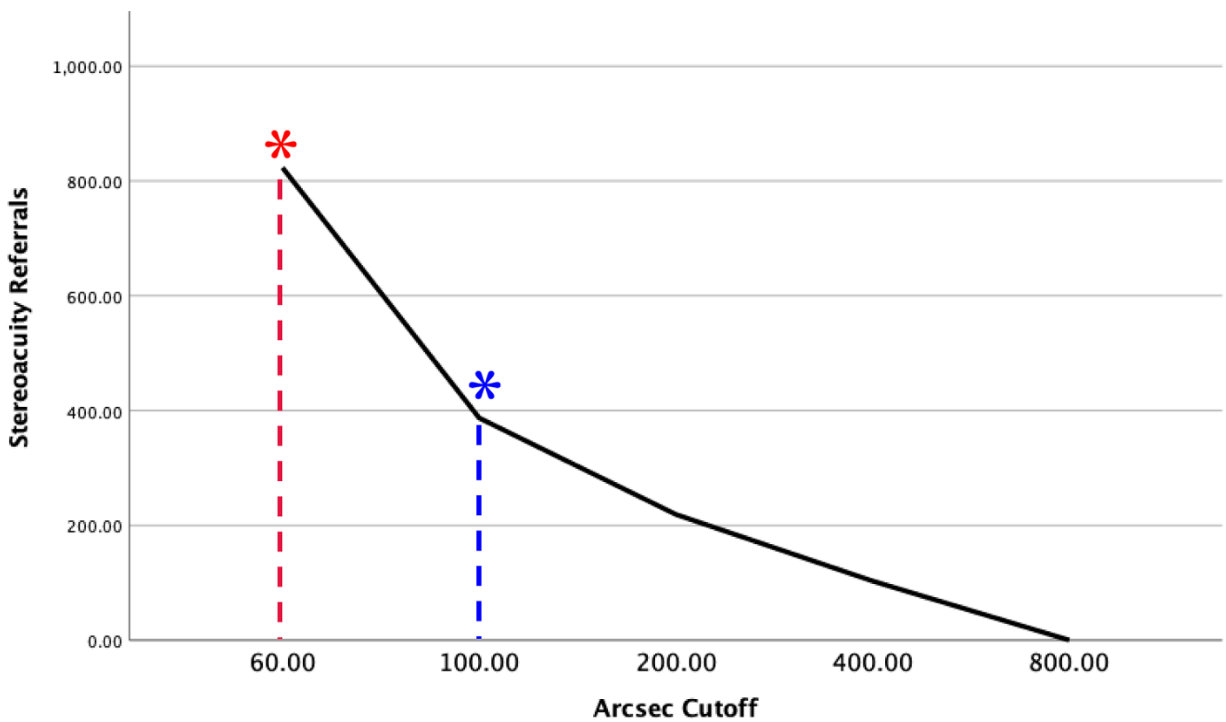


Figure 17: Difference in referrals for stereoacuity screening test with change to referral cutoff criteria. Represented in red (asterisk and line) is the referral rate at 60 arcsec and in blue (asterisk and line) 100 arcsec for the stereoacuity screening tool.

Table 14: Difference in referral rates with change to referral criteria for the stereoacuity screening test.

Cutoff criteria (refer if worse than) (arcsec)	**Total no. of children (n = 3231)**
	Referral rate
60	25% (823)
100	12% (387)
200	7% (219)
400	3% (103)
800	0% (0)

3.4.2.2.2 Refraction

Of the 4837 vision screening results collected, 10% (486/4837) were excluded for missing refractive data. Of the 4351 results included, a total of 65% (2547/4531) received a pass and 45% (1804) were referred. Referral may be on multiple parameters (sphere, cylinder and/or spherical equivalent) or just one. Thirty-seven percent (1602) had a sphere result >+1.00D or <-1.50D, 24% (1033) had a cylinder result <-0.75D , and 1% (52) had spherical equivalent difference of > 1.50Ds between the right and left eyes. The cutoff criteria were examined for sphere and cylinder only. Due to the low number of referrals for spherical equivalent was not explored.

3.4.2.2.2.1 Sphere – Hyperopia

For hyperopia, the vision screening protocol requires a child to have a refractive error between plano and +1.00 to receive a pass. Thirty-five percent (1532/4351) of children received a refer based on this criterion. As seen in Table 15, changing the criteria to +2.50D decreased the refer rate by 20%, from 35% (1532/4351), shown in red in Figure 18, to 15% (634), as shown in blue in Figure 18.

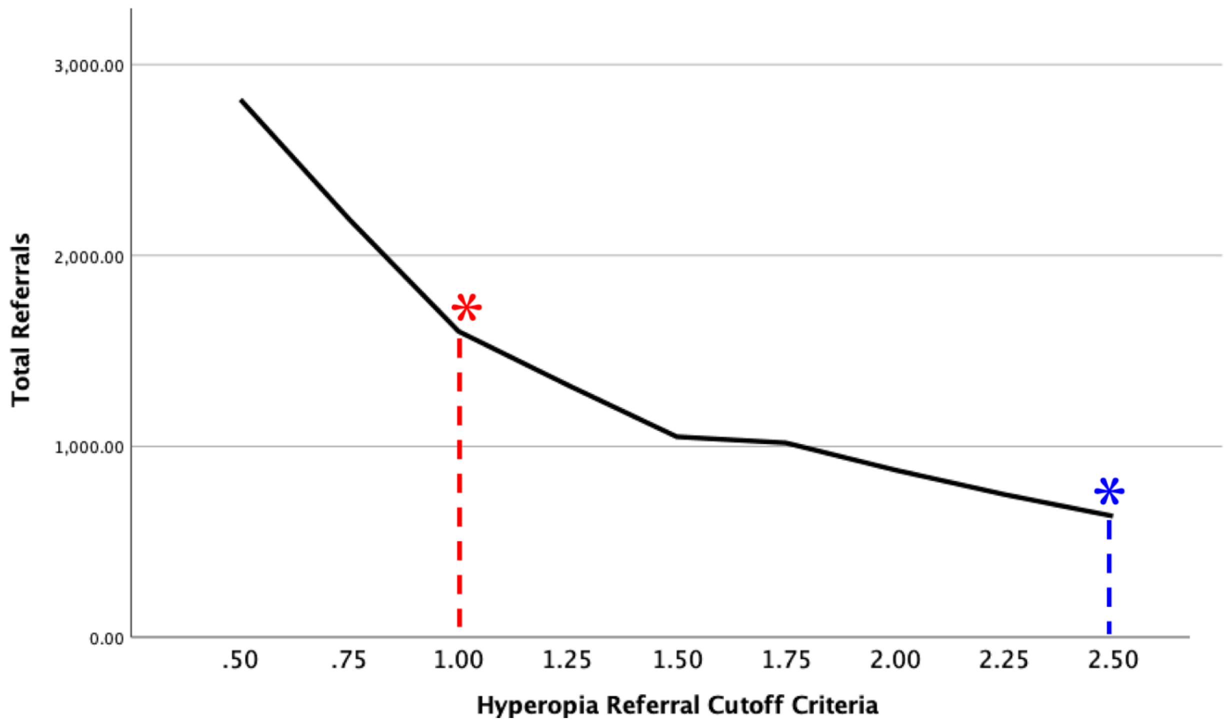


Figure 18: Difference in referrals for autorefractor screening test with change to hyperopia referral cutoff criteria. Represented in red (asterisk and line) is the referral rate at +1.00D and in blue (asterisk and line) +2.50D.

Table 15: Referral rates at different cutoffs for hyperopia detection

Cutoff criteria (refer if worse than) (diopters)	**Total no. of children (n = 4351)** **Referral rate**
0.50	65% (2817)
0.75	50% (2188)
1.00*	35% (1532)
1.25	30% (1321)
1.50	24% (1050)
1.75	23% (1018)
2.00	20% (876)
2.25	17% (748)
2.50	15% (634)

** = Ontario's mandated referral criteria*

3.4.2.2.2.2 Sphere – Myopia

The current program referred 2% (71/4351) of children for being outside the myopic threshold of plano to 1.50D. Changing the referral thresholds from -1.50D (shown in red in Figure 19) to -0.25D (shown in blue on Figure 19) increased the referral rate by 5%. The referral rates for myopia detection are shown in Table 16. Contrary to the hyperopia criteria, the myopia criterion was under-referring children, since children are not expected to have a refractive error below plano.[116]

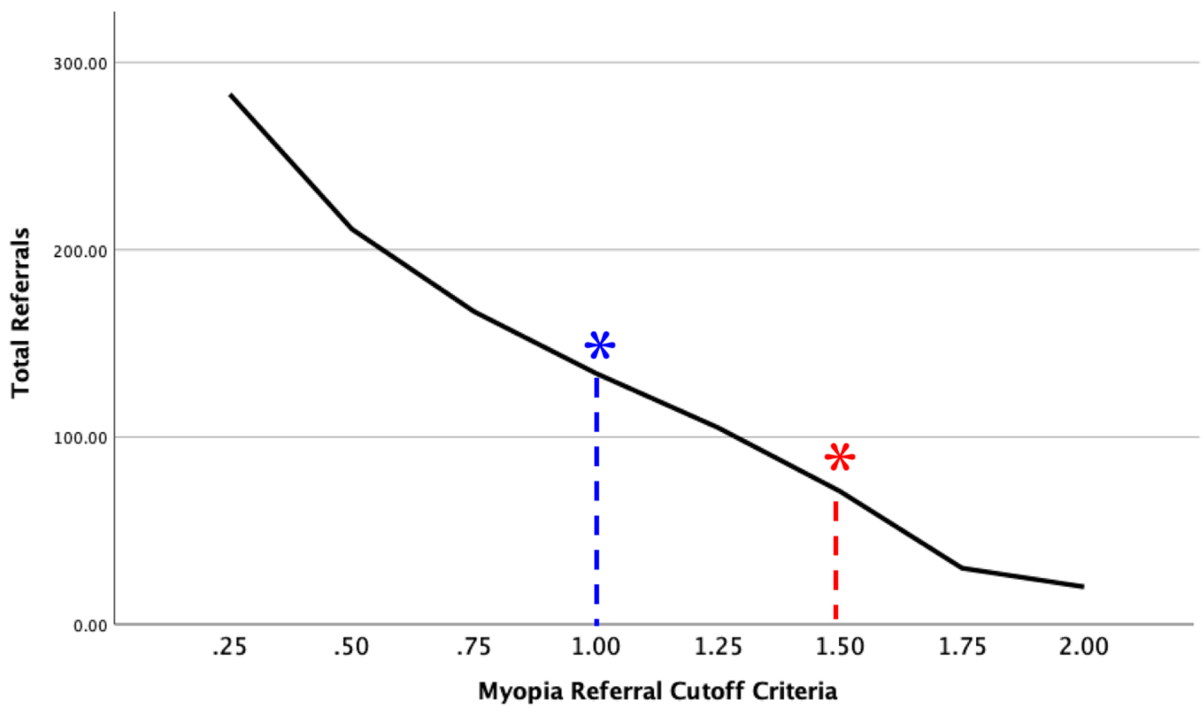


Figure 19: Difference in referrals for autorefractor screening test with change to myopia referral cutoff criteria. Represented in red (asterisk and line) is the referral rate at -1.50D for myopia and in blue (asterisk and line) -1.00D.

Table 16: Referral rates at different cutoffs for myopia detection

Cutoff criteria (refer if worse than) (diopters)	**Total no. of children (n = 4351)**
	Referral rate
-0.25	7% (283)
-0.50	5% (211)
-0.75	4% (167)
-1.00	3% (134)
-1.25	2% (105)
-1.50*	2% (71)
-1.75	1% (30)
-2.00	0.5% (20)

** = Ontario's mandated referral criteria*

3.4.2.2.2.3 Astigmatism

24% (1044/4351) of children were referred for having a cylinder result outside the refractive threshold for detecting astigmatism (> 0.75Ds). Changing the criteria decreased the number of referrals as shown in Figure 20 and Table 17. For example, changing the referral criteria from > 0.75D (as observed in red in Figure 20) to 1.50D (shown in blue in the figure below) would result in a 14% decrease in referrals.

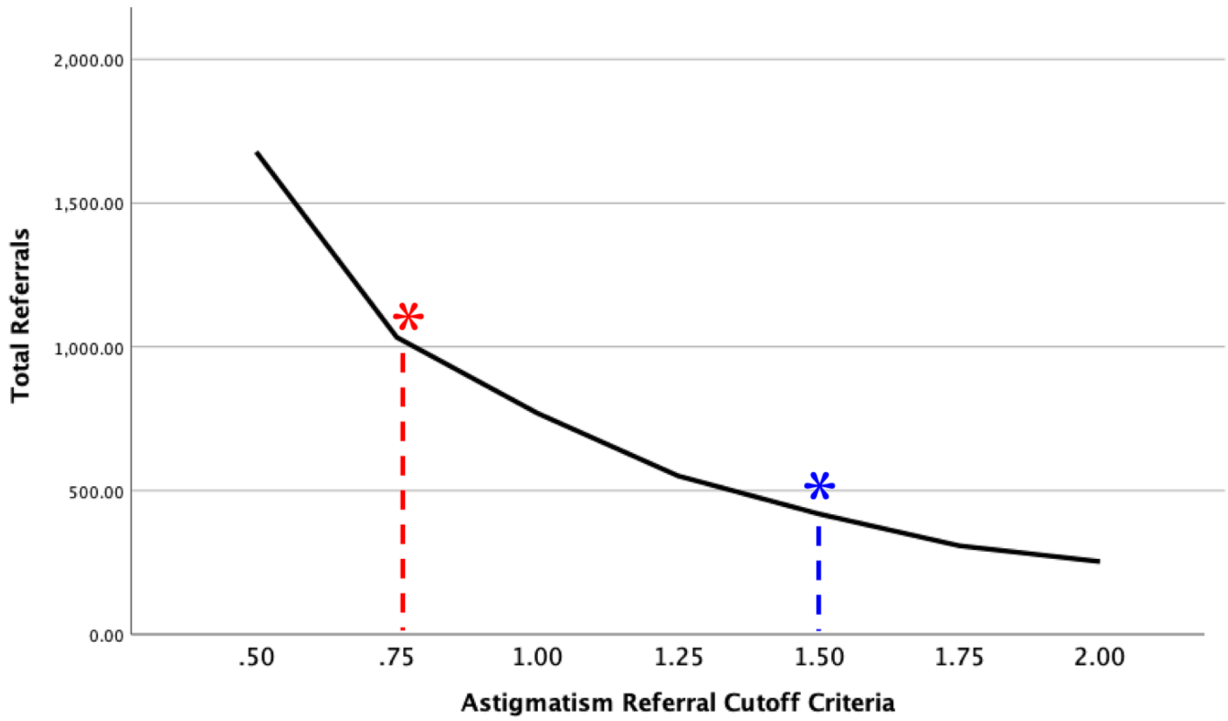


Figure 20: Difference in referrals for autorefractor screening test with change to astigmatism referral cutoff criteria. Represented in red (asterisk and line) is the referral rate at -0.75D and in blue (asterisk and line) is at -1.50D.

Table 17: Referral rates at different cutoffs for astigmatism detection

Cutoff criteria (refer if worse than) (diopters)	**Total no. of children (n = 4351)** **Referral rate**
0.50	39% (1678)
0.75*	24% (1033)
1.00	18% (769)
1.25	13% (551)
1.50	10% (419)
1.75	7% (308)
2.00	6% (253)

** = Ontario's mandated referral criteria*

3.5 Discussion

The purpose of this study was to evaluate the outcomes of the Government of Ontario's Child Health Vision Screening Protocol. Results found, the vision screening program's sensitivity was 0.935 and specificity was 0.406 with an actual referral rate of 54%. These results indicate that children with a vision problem are unlikely to be missed, however, the program had a false positive rate of 30% which means children without a vision problem were incorrectly identified. The referral rate for stereopsis and autorefraction were 31% (specificity = 0.674) and 56% (specificity = 0.541) respectively.

One reason for the high number of false positives may be due to the cut-off criteria for the stereopsis and autorefraction screening tools. The current vision screening protocol has a stereoacuity cut-off of 60 arcsec, which is the highest of all programs in Canada and the US. Birch et al., provide normative data for the Randot® Preschool stereopsis test for children. The study found children aged 4 to 6 years typically reach 60 to 100 arcsec on the stereopsis test and defined a cutoff value of 100 to 200 arc sec for this age group, based on a 95% confidence interval.[49] Thus, based on Birch's study, setting a referral criteria at 60 arcsec is too strict for children in our study group, which may be a reason for the large number of refers seen for stereoacuity.[49] To improve program specificity, adjusting the referral criterion for stereopsis from 60 to 100 arcsec would be in line with other vision screening programs such as British Columbia and results in 13% less children being referred for this tool. Thus, decreasing the sensitivity from 0.273 to 0.250 and increasing specificity from 0.674 to 0.840.

The contribution of referral criteria on the autorefraction screening tool's referral rate was also investigated. It was observed that 37% (1602/4351) of children were referred for sphere and 24% (1033) for cylinder. The pass criteria for refraction (sphere -1.50D to +1.00D; cylinder plano to -0.75D; spherical equivalent difference between OD and OS 1.5D) does not align with expected refractive errors for children between the ages of 4-6. Specifically, a literature review by Leat (2011) reported children in this group should have refractive errors of: -1.00 to +2.50D for sphere and plano to -1.25D for cylinder.[116] Using Leat's hyperopia criteria (>+2.50D), 8% (9/114) of children would have been referred by the program, compared to 42% (48/114) in this study.[116] Similarly, 14% (16/114) of children would be referred for astigmatism (>-1.25D), compared with 22% (25/114) found in this study.[116]

The referral criteria for refractive error were further investigated by comparing the average refraction measurements between screening versus eye exam. The average spherical equivalent (SE) found in this study was 0.34 for right and 0.41 for left eye (for both eyes 0.375) from the eye exam, and 0.68 for right and 0.84 for left eye (both eyes 0.76) for the vision screening. In comparison, Irving et al., found the mode SE for children aged 4 to 6 years to be 0.50 and Saunders et al., found the mean SE for children aged 5 to be of 0.63.[117,118] The results show that the vision screening average SE found varied from the corresponding eye exam and published norms. Not only for the SE, but for the average sphere, cylinder and axis measurements, the vision screening was more hyperopic for sphere and SE, and more myopic for cylinder refractive values. Several studies have reported the mean refractive error for children aged 5 to 6. A study by French et al., in Northern Ireland reported +1.41D, Ojaimi et al., in Australia reported +1.26D and Watanabe et al., in Japan in reported +0.96D.[119–121] These studies found a mean refractive error for children age 6 years to be around or above +1.00D. These refractive error values indicate that referral criteria set at +1.00D is too strict and is contributing to the high number of false positives. For example, the cutoff criteria for hyperopia is > +1.00D while the average measurement found for sphere was, +1.00D for OD and OS. This indicates that children with the average SE would be referred, signifying the referral criteria is not set appropriately. Using the vision screening results, the average sphere found was +1.00, with a standard deviation of 1.22D, indicating an appropriate cut off may be around +2.25D. Similarly, for cylinder, with an average of -0.75D and standard deviation of 0.81D, an appropriate cut off may be -1.50D. Changing the criteria to using a more conservative threshold in line with age-appropriate values from Leat's review would improve the programs specificity from 0.406 to 0.733 and decrease the number of false positives from 30% to 19%.[116] However, this change would result in a trade-off by decreasing the sensitivity from 0.935 to 0.778. If the goal is to capture as many people as possible at the expense of over-referral, then the lower criteria may be deemed appropriate. However, if this results in very high referral rates, the value of mandated screening becomes questionable.

The referral criteria were not the only problem. Results of the Bland-Altman analysis found that the vision screening measurements themselves did not agree well with those obtained in the eye exam. The screening results were more like the eye exams results when the measurements for stereoacuity ($p < 0.001$) and refraction (sphere (OD: $p < 0.001$, OS: $p = 0.001$) and cylinder (OD: $p < 0.001$, OS: $p < 0.001$) were closer to zero, but were more inconsistent as the average became more negative or positive. The difference in refractive values observed between vision screening to eye exam may be due to the method of refractive error measurement used by the optometrist (i.e., static retinoscopy, subjective refraction or cycloplegic refraction).[122] Unfortunately the method of refraction was not recorded by the optometrist so it is unclear whether this is the reason for the discrepancy between the vision screening and eye exam findings. If the refractive error was measured using cycloplegia, the eye exam results would differ from the vision screening, since cyclopentolate prevents the eye from focusing/accommodating.[123] However, this is unlikely to be the reason for the discrepancy as noncycloplegic refractive measurements (i.e., at the vision screening) are typically more myopic than those with cycloplegia.[123] To improve this analysis, further research should include a question asking optometrists the method they used to measure the child's refractive error. In addition to the discrepancies between the refraction values from vision screening to eye exam, this can be seen in the stereoacuity results. This is an interesting finding since many of the optometrists recorded measuring child's stereoacuity using the Randot® Stereotest, similar to the tool used at the screening. The reason there was a linear relationship ($p < 0.001$) between the vision screening and eye exams results observed may be the difference in tools used (i.e., global vs. local stereotests). A study by Read et al., found the Preschool Randot® screening tool to have a high reliability within clinical settings as opposed to other settings.[124] However, in non-clinical settings, there was a low test/retest reliability for children aged 2 to 5, indicating this tool is effective in clinic but in the screening setting it was not as reliable since testing conditions are variable.[124] Further research should assess the discrepancies between stereoacuity results obtained in various settings (i.e., screening vs. clinical).

To date, one study has reviewed Ontario's mandated SK vision screening program referral rate. Wang et al., reviewed vision screening data for 1127 children collected from 2018 to 2020 in the Kingston, Frontenac, Lennox, and Addington (KFL&A) Public Health screening program.[94] Wang found an overall referral rate of 32%, with the majority of children being referred on the autorefractor screening test, followed by stereoacuity then visual acuity.[94] Similar to the results of this study, Wang also found children were referred most on either stereoacuity or autorefractor with the most common agreement of any tests being between these two tests.[94] Comparatively, this current study found a higher overall referral rate of 54% compared to Wang's 22%. This difference may be due to screener training. The ROW PH SK vision screening program mandated all vision screening personnel to participate in a training session provided by a registered optometrist

(UWOVS) while the training used in the KFL&A program was not disclosed in the study and the extent of the training is unknown. Additionally, the vision screening protocol does not stipulate type of autorefractor. Different autorefractors may have different accuracy thresholds and results produced may not be the same. For example Nishimura et al., found the Plusoptix photoscreener to have a sensitivity of 0.64 and specificity of 0.88, while the Spot screener to have a sensitivity of 0.60 and specificity of 0.93.[60] Another difference may due to population size. The KFL&A program screened 1127 SK students from 41 schools while the Waterloo program screened 4837 children from 150 schools. In addition, population demographics may be different, producing varying referral rates within the vision screening programs. Further research should be undertaken to explore this variation in referral rates between screening programs to determine the reason for the discrepancy.

As discussed in Chapter 1, Ontario's mandated vision screening program was developed based on the findings by Nishimura et al.[59] This study reported the most commonly referred screening test was visual acuity (28%), which conversely was the lowest (15%) based on the findings from this study.[59] Similarly, Nishimura et al., found autorefraction was the least referred screening test (8%), while this study found it to be the highest referred test (43%).[59] Some of the discrepancy in referral rates may be explained by the referral criteria used, as it varies significantly from the cut-off criteria of the Child Health Vision Screening Protocol (Table 18).

Table 18: Difference in referral criteria between Ontario's mandated program[61] and Nishimura et al.[59]

Screening Test	**Current Program**[61]	**Nishimura et al**[59]
Visual acuity	< 20/32	< 20/32
Randot®	< 60 arcsec	< 100 arcsec
	Autorefraction	
Sphere	< -1.50D or > +1.00D	< -1.50D or > +3.50D
Cylinder	< -0.75D	< -1.50D
Spherical equivalent	< 1.50D	< 1.50D

The referral criteria used by Nishimura et al., was less strict for stereoacuity, hyperopia and astigmatism detection.[59] For example, the hyperopia criteria has a 2.50D difference between programs. Changing the criteria has a significant impact on referrals, for example changing the hyperopia criteria from +1.00D to +2.50D results in a 15% referral decrease.

3.6 Conclusion

This analysis of Ontario's mandated vision screening program for SK children in the ROW revealed significant insights into its accuracy and possible areas for improvement. With an overall specificity of 0.406 and a 30% rate of false positives, the program is not accurately identifying children with vision impairments. Improvements to increase program specificity by increasing the stereoacuity threshold to 100 seconds of arc and revising hyperopia detection criteria from < +1.00D to +2.50D, would significantly reduce referral rates.

Chapter 4
Discussion and Conclusion

4.1 Discussion

In 2018, the Ontario Ministry of Health and Long-Term Care mandated local public health units to execute a universal vision screening program for senior kindergarten children. Since its implementation, there has been little research into the program's overall efficacy. Several key metrics, such as parental compliance to program recommendations, screening sensitivity and specificity, and screening accuracy are unknown. Based on current literature regarding pediatric vision screenings, the overall efficacy of screenings in detecting vision problems and improving health outcomes for children is widely debated.[5,52,64,65] This thesis investigates Ontario's vision screening protocol by evaluating the above metrics for children that participated in the vision screening program from October 2022 to December 2023 in the Region of Waterloo (ROW). The results of this study aim to provide the Government of Ontario with data regarding the province's universal vision screening program.

4.1.1 Parental Compliance in Response to Vision Screenings in Waterloo Region

The purpose of the first study was to survey parental compliance following a vision screening, specifically investigating if parents adhered to screening result recommendations. Results from the parental compliance survey found 44% (48/108) of parents were prompted to seek eye care after receiving the parent notification form (PNF) and reminder letter (sent to families by the ROW PH if child received a "refer") following the vision screening. The rate of parents following-up when their child was referred from screening was significantly higher than in children who passed (p =

0.008). Thus, vision screenings were found to be effective in encouraging parents to seek care when a vision problem was identified.

If a parent reported they did not intend to take their child for an eye exam, the survey provided parents with additional information on the importance of pediatric eye care and the association between vision and learning. After educating parents, the survey extended an offer to help parents book an appointment with an optometrist to further encourage compliance with the government's recommendation to seek eye care. A total of 60 parents received the additional information on the importance of vision care for children, and 3/60 (5%) agreed for researchers to coordinate the appointment while 57 (95%) declined. For the purposes of this study, if a parent declined the appointment offer, it was assumed the child would not receive an eye exam following the screening. Thus, while education and offering to help arrange the appointment did prompt a few parents to obtain eye care, the majority still refused.

To investigate why parents were not taking their child for a comprehensive eye exam, parents were asked about barriers that might have been preventing them from seeking eye care for their child. The most reported barrier was lack of time (28%, 17/60), followed by eye exams perceived to not be important (25%, 15/60), and cost (5%, 3/60). The remaining 25 parents (42%) indicated their child had seen an optometrist greater than 18 months ago and did not require another exam.

While the reason for why parents felt time was a barrier was not directly asked in the survey, possible reasons include lack of available eye appointments at convenient times and competing priorities. Specifically, to explore lack of available appointments, a correlation analysis was undertaken between population size (municipality of school location) and number of parents who took their child for an eye exam after the screening. Results found no significant association (p = 0.499; Chapter 2, Table 10) between size of community and parents seeking pediatric eye care. Therefore, while parents may feel lack of time is due to a limited availability of eye appointments (i.e., from living in smaller municipalities with less optometrists available), it is important to educate parents on how to find an optometrist within their community and to let them know that most practices have appointments readily available (within 1-2 weeks). Another reason parents felt time was a barrier may be due to competing daily priorities. A study by Kimel et al., found that 38% of parents reported priorities such as food and housing prevented them from taking their child for an eye exam following a vision screening.[95] A potential way of mitigating this barrier is by offering eye exams at more convenient locations (i.e. child's school) or during times that do not interfere with work or other activities (i.e. early morning or weekends). For example, Nishimura et al., investigated whether parents were more compliant to taking their child for an eye exam if the exam was offered at the child's school or at an optometry practice.[59] Study authors found no difference between groups (69.1% for in-school and 69.4% for in-office). However, in both cases, researchers booked the eye exam for the parents versus passively offering to book an eye exam, as was done in this study.[59] Therefore, the barrier of competing priority may be due to a lack of time that parents have to book an eye exam, and not because parents do not feel eye exams are important, or because eye exams are offered at inconvenient locations or times. Thus, one way to increase parental compliance would be to book an eye exam on behalf of the parents if their child had received a refer following a vision screening.

Currently, the Child Health and Vision Screening Protocol does not mandate public health to follow up with families whose child did not pass the vision screening beyond providing a reminder letter 20 business days following the screening. This is in contrast to the Government of Ontario's Oral Health Protocol (OHP) which stipulates children who are identified to need dental services following a dental screening must obtain proper care.[125] Specifically, the OHP requires PH and (if needed) the Children's Aid Society (CAS) to follow up with parents to confirm a child has seen a dentist. If the parent refuses to comply, child neglect and/or abuse is considered, and the child may be placed under CAS protection.[125] While currently, the vision screening protocol does not have the same rigor as the OHP, it can be assumed that if the Government chooses to adopt a similar follow-up procedure, children with suspected vision problems would receive appropriate care with an optometrist. While no provinces in Canada that conduct universal vision screenings have a follow-up procedure as rigorous as the OHP, other provinces do have further follow-up protocols. For example, in British Columbia (BC) parents are contacted by public health directly (up to three times) when a child is referred and is offered support to arrange an eye exam with an optometrist if needed.[126] The additional direct follow-up by public health (contact by phone vs letter) saw a 12.5% increase in parents obtaining eye exams for their children in 2009 - 2010.[93]

However, initiating additional follow-up procedures for Ontario's vision screening program may not be a feasible solution for public health units to implement without financial support. An alternative approach to encouraging parents to seek eye care would be to include the child's school. Because the provincial Government oversees both the Ministry of Health and Long-Term Care and the Ministry of Education, and because screenings occur between local public health units and elementary schools, including schools within the mandate is a feasible solution to ensuring children receive appropriate eye care.[20] Currently, the Child Health and Vision Screening Protocol treats screening results as confidential health information, preventing the school from becoming involved.[126] However, if school boards were involved in the protocol, screening results could be shared, and teachers/principals would be empowered to encourage parents to seek further care (if needed); as seen in the province of Manitoba.[127] In Manitoba, teachers are privy to vision screening results and communicate results with parents (via a referral letter), and assist in booking an appointment with an optometrist for parents that may need additional help.[127] While Manitoba does not have a collaborative approach, some states in the US utilize a collaborative approach between public health and education. In states such as Maryland and New Mexico, both the health and education sectors of government share the responsibility of implementing the in-school vision screening program.[128,129] This collaborative process between public health and schools provides improved oversight and may increase parental compliance to seeking eye care following a vision screening.

Another barrier to seeking eye care following a vision screening was parents believing their child did not have a vision problem (25%, 15/60). As reported by Masarwa et al., parental understanding of comprehensive eye exams and how well they (parents) feel their child can see influences whether a child receives eye care.[98] This finding is further supported by Spafford et al., who reported the public is generally unaware of asymptomatic eye conditions, such as amblyopia.[97,130,131] In addition, Irving et al., found that the public often equates good vision with not having any eye problems, further supporting the notion that people are not aware that eye conditions can exist in the absence of any vision problems.[130] To explore why some parents were not compliant to seeking eye care for their child following a vision screening, Kimel et al., found parents who wear glasses, parents having at minimum a high school education, a non-working adult at home, the family having access to both a phone and car, and parents having trust in the vision screening results were influencing factors.[95] Therefore, to better understand survey results regarding barriers to seeking eye care, follow-up questions on whether parents are aware of asymptomatic eye disease, and demographic information (i.e. education and family history of glasses wear) may have helped to further investigate reasons why parents did not feel their child needed an eye exam.

One way to improve public education on eye and vision disorders may be the utilization of social media. A systemic review by Pinto et al., found that social medial platforms, such as Instagram™, are an effective communication tool. The study concluded a social media presence was vital to Government public health services when communicating or educating the public.[132] This approach is further supported by Spafford et al., who found the majority of sampled Canadians (99%) use the internet to search for information, specifically 81% search for health and 69% for eye health information.[133] This study found that while primary health providers were the most trusted source of information for respondents, over half reported using the internet as their primary source of eye health information.[133] Creating educational materials online may improve eye care service utilization, since the public is already searching for eye health information online.[133] Therefore, different communication strategies (i.e., social media) should be considered by the Government of Ontario to bring awareness regarding asymptomatic eye and vision disorders in children and vision resources available to parents.

The final barrier to eye care identified was cost (5%). This finding was surprising since the Ontario Health Insurance Program (OHIP) has always covered yearly eye exams for children up to 19 years of age and the Eye See…Eye Learn (ESEL) program has provided complimentary prescription glasses for children in kindergarten regardless of income since 2013.[21,99,134,135] When asked whether parents were aware of OHIP coverage for pediatric eye exams, 60% reported they were not aware, despite the information being included in the PNF form (Chapter 2, section 2.4.2). Similarly, another area that was misunderstood by parents was their child's vision screening result. PNF-A (referral letter) states "*The screening results indicated that there may be issues with your* *child's vision*" which was interpreted by 29% (31/108) to mean their child passed the vision screening. However, when survey results were compared to the child's actual screening results, 31% (33/108) of parents were found to incorrectly report their child's result. This finding demonstrates the PNF form is not accurately communicating to parents when a child has not passed the vision screening, which further supports why parents in this study reported they did not take their child for an eye exam because there were no vision concerns. One reason the PNF forms may be misinterpreted is the use of confusing and unclear language when reporting screening results. Specifically, because PNF A states "*there* ***may be issues*** *with your child's vision*" parents mistakenly interpret the wording to believe their child passed the screening. Instead, if wording were to change to "*there are suspected issues with your child's vision*" or "*your child did not pass one or more of the screening tests"* parents may better understand a vision concern exists which requires further investigation by an optometrist. Another reason the PNF letter may be confusing to parents, is the language used. When communicating health information to the public, it has been shown that creating materials aligned with the public's literacy ability is best.[136–139] For example in Canada, the average reading ability of adults is estimated to be between grade 8 (age 13) and grade 9 (age 14).[140,141] When analyzed, the PNF-A letter is written at a grade 10 (age 15) level, while the recommended referral form is at a grade 7 (age 12) reading level and therefore can be more easily understood by parents, especially if English is not their first language.[142,143] However, by simplifying the language of the referral letter to a grade 7 (age 12) level, parents should better understand the screening results, recommendation to seek further eye care, and exam coverage by OHIP (Figure 21).

Dear Parent/Guardian of ________________________________

Your child had a vision screening at school today. The screening results indicated that **there may be issues with your child's vision**. We urge you to please book an appointment now for your child to see an optometrist for a comprehensive eye examination.

Comprehensive eye examinations are important to detect vision problems that may interfere with a child's eye health, learning and social development. In rare cases, some untreated problems can lead to permanent vision loss/vision disorders.

Ontario Health Insurance Plan (OHIP) covers the cost of a comprehensive eye examination once every 12 months for all children (0-19 years) who have a valid OHIP card.

A comprehensive eye examination includes:

- Reviewing your child's health history and the family history of eye problems;
- Checking visual acuity and 3D vision;
- Checking eye alignment;
- Checking eye focusing ability (i.e., how well the eye muscles can focus at various distances);
- Checking eye health (e.g. allergies, infections);
- Identifying if your child is meeting visual developmental milestones; and
- Determining if your child needs eye glasses or other treatment (e.g., eye drops, vision therapy, a referral to a healthcare provider, etc.)

If you require more information, including if you need assistance finding an optometrist, or if your child does not have a valid OHIP card, please contact the public health unit at the top of this page.

To find a local optometrist, please go to: www.findaneyedoctor.ca.

NOTE: If your child has had a comprehensive eye examination within the past 12 months, please check first with your optometrist to determine if an appointment is necessary.

Date:

Dear Parent/Guardian of:

Your child's vision was screened at school today as part of the [insert health public health unit] and failed the school vision screening.

Your child needs a professional eye exam.

Please take your child to an eye doctor in the near future. If your child has been seen by an eye doctor in the last six months, please contact your child's eye doctor.

Call [insert health public health unit and include contact #] if you have:

- Any questions concerning the vision screening result;
- Require assistance finding an eye doctor;
- Help in making an appointment;
- Resources available for covering eye exams and glasses.

Figure 21: Ontario Referral Letter (PNF-A) (above) and Recommended Referral Letter (below)

Similarly, PNF-B which is given if a child passes the screening should also be changed for language and clarity as shown in Figure 22.

Dear Parent/Guardian of ________________________________

Your child had a vision screening at school today. While no vision issues were identified during the vision screening, it should be noted that a screening is not designed to detect all vision problems. For this reason, we encourage you to contact an optometrist regarding the need to book a routine comprehensive eye exam for your child.

Ontario Health Insurance Plan (OHIP) covers the cost of a comprehensive eye examination once every 12 months for all children (0-19 years) who have a valid OHIP card.

Comprehensive eye examinations are important to detect vision problems that may interfere with a child's eye health, learning and social development. In rare cases, some untreated problems can lead to permanent vision loss/vision disorders.

A comprehensive eye examination includes:

- Reviewing your child's health history and the family history of eye problems;
- Checking visual acuity and 3D vision;
- Checking eye alignment;
- Checking eye focusing ability (i.e., how well the eye muscles can focus at various distances);
- Checking eye health (e.g. allergies, infections);
- Identifying if your child is meeting visual developmental milestones; and
- Determining if your child needs eye glasses or other treatment (e.g., eye drops, vision therapy, a referral to a healthcare provider, etc.)

If you require more information, including if you need assistance finding an optometrist, or if your child does not have a valid OHIP card, please contact the public health unit at the top of this page.

To find a local optometrist, please go to: www.findaneyedoctor.ca.

Date:

Dear Parent/Guardian of:

Your child's vision was screened at school today as part of the [insert health public health unit] and passed the school vision screening. A vision screening may detect a vision problem and is not a replacement for an eye exam, the only method of diagnosing and treating a vision problem is through an eye exam.

It is recommended that your child has a professional eye exam. If your child is currently under care of an eye doctor, we encourage you to contact your child's eye doctor to continue routine eye exams for your child.

Call [insert health public health unit and include contact #] if you have:

- Any questions concerning the vision screening result;
- Require assistance finding an eye doctor;
- Help in making an appointment;
- Resources available for covering eye exams and glasses.

Figure 22: Ontario Pass Letter (PNF-B) (above) and Recommended Pass Letter (below)

4.1.2 Outcomes of the Government of Ontario's Vision Screening Program in Identifying Vision Problems in SK Children in Waterloo Region

4.1.2.1 Comparing vision screening results to eye exams

The purpose of this study was to evaluate the accuracy of the Government of Ontario's Vision Screening Program in identifying vision problems in SK children. Notable differences were observed between the vision screening and eye exam results, indicating the screening tools are not accurately identifying children at risk for a vision problem.

Study results showed the spherical equivalent (SE) was significantly different (OD: $p = 0.016$, OS: $p = 0.004$) between vision screening and eye exam results. The average SE for children age 5 is approximately 0.50D – 0.63D, however, vision screening results in this study found SE to be 0.68 OD and 0.84 OS, which were 0.34D and 0.43D higher than the child's exam findings as reported by their optometrist for OD and OS respectively. This significant finding should be considered when establishing cut-off criteria, as these inaccuracies may be contributing to the programs high rate of false positives. Based on the results of this study and taking into account evidence-based studies regarding expected refractive errors for children age 5-6 years, it is recommended the referral criteria change to < -1.00D or > +2.50D for sphere and < -1.50D for cylinder as discussed in Chapter 3 (section 3.5).

In addition to decreasing the number of false positives for autorefraction, another reason the referral criteria should be adjusted would be to potentially improve public trust in the screening program.[111] Public trust is a key aspect in parental compliance with the screening recommendations.[144] For example, a study by Kimel et al., found that 38% of parents did not believe their child's screening result which contributed to their noncompliance with seeking eyecare. Reasons cited for having poor trust in the screening program include: child was not correctly referred (i.e., child did not respond correctly to screening tool), screening tools used were not accurate, and distrust in screening personnel.[95] The screening outcome may also have an impact on public trust in the screening program. For example, Dietz et al., reviewed parental compliance following their child's screening for problems with social development. The study found that children with false positive results were more likely to be noncompliant with the referral recommendations.[145] Generally, all positive screenings, including false positives, may promote more parents to seek care (as their child was referred by the screening program), but the detriment is parents' trust after obtaining the follow-up care.[144,146] For example, in this study, the unnecessary referrals may promote parents already under the care of an optometrist to go back to the optometrist following screening, leading to possible distrust between the parents and the optometrist towards the vision screening program over time. While this study did not investigate parental trust in the screening program, further studies should do so and assess the impact on trust and parental compliance with seeking eyecare following a vision screening.

A possible explanation for the differences observed between the vision screening and eye exams results in the Bland Altman analysis (stereoacuity ($p < 0.001$), refraction – sphere (OD: $p < 0.001$, OS: $p = 0.001$) and cylinder (OD: $p < 0.001$, OS: $p < 0.001$)) may be the setting of the testing. As mentioned in Chapter 1 (Table 5), each screening station requires certain parameters to conduct the testing, as according to the manual. For example, the Randot® tool requires a working distance of 40cm. Variation seen in the screening results may be because the working distance was not correctly maintained. To improve screening accuracy, a suggestion would be to ask screeners to use a ruler or mark the 40cm working distance to ensure the child was not too close or too far way. Another reason for screening inaccuracy may be due to variable lighting conditions. While the stereoacuity test requires full light, the autorefractor works best in low or no light environments. While accurate lighting conditions can be maintained in a clinical setting lighting in vision screening environments are variable. A suggestion to improve accuracy would be for screeners to bring additional lighting when needed for stereopsis or materials to reduce light for autorefraction.

4.1.2.2 Retrospective vision screening review

To further review the vision screening results, a retrospective review of each screening test (HOTV, Randot® and autorefractor) was collected from the ROW PH. The 2022-23 ROW PH vision screening program resulted in a 56% overall referral rate. As discussed in Chapter 1 section 1.1.1, the ideal vision screening test should be able to detect most children at risk for amblyopia or high refractive error (high sensitivity), but also exclude children who are not at risk for these conditions (high specificity). When analyzing the results for all vision screenings performed between October 2022 – December 2023 (Chapter 3, section 3.4.1.5), the pass/refer criteria for stereoacuity and autorefraction did not align with age-expected normative findings as reported in literature. For example, the refer rate for hyperopia was > +1.00D, however, literature shows that most children age 5 – 6 years likely have low hyperopia around this same amount. Therefore, having a cut-off criterion that is similar to age expected norms may be too strict. Adjusting criteria based on literature (Table 19) is found to improve screening specificity.[60,116]

Table 19: Recommended changes to the referral criteria

Screening tool		**Child Health Vision Screening Refer Criteria**	**Recommended Refer Criteria***
Visual acuity		< 20/32	< 20/32
Stereoacuity		< 60 arcsec	< 100 arcsec
Autorefraction	**Sphere**	< -1.50D or > +1.00D	< -1.00D or > +2.50D
	Cylinder	< -0.75D	< -1.50D
	Spherical equivalent	< 1.50D	< 1.50D

**recommendations based on evidence supported by Nishimura et al., (VA, stereoacuity)*[59] *and Leat (refractive error)*[116]

Utilizing the recommended refer criteria in Table 19, changes can be observed to the sensitivity and specificity for each of the 3 vision screening tools as shown in Table 20 below.[59,116] Improvements in sensitivity can be observed for the autorefraction screening tool (from 0.800 to 1.00) and in specificity (from 0.541 to 0.939 using Nishimura et al. criterion or 0.938 using Leat).[59,116] For the stereoacuity screening tool, improvements can be also observed in the specificity (from 0.674 to 0.840).[59,116]

Table 20: Accuracy of screening tools with changes to referral criteria.

Screening tool	**Sensitivity**			**Specificity**		
	Current Protocol	**Nishimura et al.,**	**Leat**	**Current Protocol**	**Nishimura et al.,**	**Leat**
Visual acuity	0.375	0.375	0.375	0.855	0.855	0.855
Stereoacuity	0.273	0.250	0.250	0.674	0.840	0.840
Autorefraction	0.800	1.00	1.00	0.541	0.939	0.938

Therefore, to reduce the number of false positives in the vision screening program, the suggested cut off value for stereopsis should be adjusted from 60 to 100 arcsec and the refraction cut off should change from < -1.50D to < -1.00D and >+1.00D to >+2.50D for sphere, and from <-0.75D to <-1.50D for cylinder. [59,116]

4.2 Limitations

While this study offers insights into the efficacy of Ontario's vision screening mandate, there are several study limitations. One limitation was the low survey response rate of 1% which may have led to response rate bias. In other words, because only our survey population consisted of only 19% of parents who utilized vision services for the first time following the vision screening, study results lacked the perspective of all parents who choose not to take their child for eye exams. Thus, potential barriers preventing parents from obtaining vision services may have been missed. Reasons for the low response rate may be due to the lack of incentive (i.e., remuneration) for completing the survey. A systemic review by Stunkel and Grady found that the financial reward was the primary motivator to volunteering to participate in studies.[147] Similarly, a study by Coryn et al., found the response rate improved from 36% to 44% when an incentive was offered for the completion of an online survey, and Yu et al., reported offering a remuneration of $10 improved survey participation by 18%.[148,149]

Another contributor to the low response rate may be due to the survey's method of asking parents to consent online via a QR code or web address. Studies have shown, since the onset of online surveys over the last decade, response rates have declined because of survey fatigue or burnout.[150,151] Additionally, the sample population for this survey was parents with young children. As noted in the results for barriers, parents reported a lack of time as their main reason for not booking an eye exam for this child, which may also be the reasons they did not complete the study survey. Therefore, to improve survey participation as recommended above, offering participant remuneration may create an incentive for parents to make the time to fill out the survey.

The low response rate also affected the study evaluating the accuracy of the screening results. If survey participation was improved using the suggested methods (i.e., remuneration), more parents may have consented to participate in the follow-up study comparing screening results to eye exam findings, therefore also improving generalizability of results. To further improve participation in this study, offering to provide the eye exam at the child's school (as seen by Nishimura et al.,) may have encouraged parents who declined an eye exam to allow their child to be seen by an optometrist since the lack of time barrier would be eliminated.[60,85,152–155] Despite the low response rate, the survey responses received were insightful identifying perceived barriers to seeking pediatric eye care following a vision screening, and uncovering confusion by parents regarding whether their child received a pass or refer based on the wording of the PNF letters.

4.3 Summary of Recommendations

This thesis sought to investigate the efficacy of the Province of Ontario's SK vision screening program in the Region of Waterloo. Based on the results found in Chapters 2 and 3, three key changes are recommended to improve parental compliance and the accuracy of the Child Health and Vision Screening Program as outlined in Table 21.

Table 21: Suggested recommendations to improve the Child Health and Vision Screening Protocol (in order of significance to the program's efficacy)

Recommendation	**Implication**
1. Adjusting refer criteria to better align with expected age norms	Reducing the number of false positives and improvement in program specificity
2. Clarify PNF letter and vision screening result communication materials to parents	Editing communication to a level that is better understood by the general public to improve parent understanding and compliance
3. Including schools boards improve eye care for children who received a refer	Including school boards and teachers may encourage more parents whose child received a refer to receive the appropriate care

4.4 Future Directions

This thesis evaluated the Government of Ontario's Child Health and Vision Screening Protocol in the Region of Waterloo. Study results found the screening is sensitive, but not specific, resulting in a high number of false positives. Adjusting the cut-off for all 3 vision screening tools, should improve screening specificity and reduce the risk of public distrust; however, further research should also review if Ontario's vison screening program should be universal or change to targeted to high-risk children and whether one method is more effective than the other. While not investigated in this thesis, adjusting the vision screening protocol to targeted would decrease the number of children screened, which may allow public health to devote additional resources to follow-up with families whose child received a refer. This, in turn, would improve parental compliance to adhering to vision screening recommendations following a vision screening.

4.5 Conclusion

This analysis of Ontario's mandated vision screening program for SK children in the ROW revealed significant insights into its implementation. Parental compliance was significantly higher when their child was referred, as two-thirds (64%) of referred children obtained an eye exam after the screening. Additionally, 31% of parents incorrectly reported their child's screening results, indicating a need to clarify communication materials to improve compliance. The program also exhibited a high referral rate, with an overall actual referral rate of 54%, resulting in 30% false positives. While the program had high sensitivity (0.935), concerns remain regarding its specificity (0.406) in identifying children with vision problems. To improve specificity and reduce false positives, the referral criteria should be adjusted based on empirical evidence.

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Appendix A Parent Notification Form-A (PNF-A)

Ministry of Health and Long-Term Care

Child Vision Screening Parent Notification Form-A (PNF-A) Instructions

Public Health Unit: ___________
Address: __________________
____
Phone: ______ Fax: ______
Client's school: _______________
Date of issue: _________________

PHU Use Only
Client's Name: ___________________
Screening date: ___________________
Screening location: _______________
By: _____________________________
Date received: __________________

Dear Parent/Guardian of _________________________________

Your child had a vision screening at school today. The screening results indicated that **there may be issues with your child's vision**. We urge you to please book an appointment now for your child to see an optometrist for a comprehensive eye examination.

Comprehensive eye examinations are important to detect vision problems that may interfere with a child's eye health, learning and social development. In rare cases, some untreated problems can lead to permanent vision loss/vision disorders.

Ontario Health Insurance Plan (OHIP) covers the cost of a comprehensive eye examination once every 12 months for all children (0-19 years) who have a valid OHIP card.

A comprehensive eye examination includes:

- Reviewing your child's health history and the family history of eye problems;
- Checking visual acuity and 3D vision;
- Checking eye alignment;
- Checking eye focusing ability (i.e., how well the eye muscles can focus at various distances);
- Checking eye health (e.g. allergies, infections);
- Identifying if your child is meeting visual developmental milestones; and
- Determining if your child needs eye glasses or other treatment (e.g., eye drops, vision therapy, a referral to a healthcare provider, etc.)

If you require more information, including if you need assistance finding an optometrist, or if your child does not have a valid OHIP card, please contact the public health unit at the top of this page.

To find a local optometrist, please go to: www.findaneyedoctor.ca.

NOTE: If your child has had a comprehensive eye examination within the past 12 months, please check first with your optometrist to determine if an appointment is necessary.

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Appendix B Parent Notification Form-B (PNF-B)

Ministry of Health and Long-Term Care

Child Vision Screening Parent Notification Form-B (PNF-B) Instructions

Public Health Unit: ______	PHU Use Only
Address: ______	Client's Name: ______
______	Screening date: ______
Phone: ______ Fax: ______	Screening location: ______
Client's school: ______	By: ______
Date of issue: ______	Date received: ______

Dear Parent/Guardian of ______

Your child had a vision screening at school today. While no vision issues were identified during the vision screening, it should be noted that a screening is not designed to detect all vision problems. For this reason, we encourage you to contact an optometrist regarding the need to book a routine comprehensive eye exam for your child.

Ontario Health Insurance Plan (OHIP) covers the cost of a comprehensive eye examination once every 12 months for all children (0-19 years) who have a valid OHIP card.

Comprehensive eye examinations are important to detect vision problems that may interfere with a child's eye health, learning and social development. In rare cases, some untreated problems can lead to permanent vision loss/vision disorders.

A comprehensive eye examination includes:

- Reviewing your child's health history and the family history of eye problems;
- Checking visual acuity and 3D vision;
- Checking eye alignment;
- Checking eye focusing ability (i.e., how well the eye muscles can focus at various distances);
- Checking eye health (e.g. allergies, infections);
- Identifying if your child is meeting visual developmental milestones; and
- Determining if your child needs eye glasses or other treatment (e.g., eye drops, vision therapy, a referral to a healthcare provider, etc.)

If you require more information, including if you need assistance finding an optometrist, or if your child does not have a valid OHIP card, please contact the public health unit at the top of this page.

To find a local optometrist, please go to: www.findaneyedoctor.ca.

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Appendix C Information and Consent Form

UNIVERSITY OF WATERLOO

SCHOOL OF OPTOMETRY & VISION SCIENCE
519-888-4567, ext. 33178
optometry.uwaterloo.ca

Translating Vision Screenings to Eye Exams in Waterloo Region Study:
Examining Vision Screening to Eye Exam Data

Principal Investigator: Dr. Lisa Christian, University of Waterloo School of Optometry and Vision Science

You are being invited to participate in a research study conducted by the School of Optometry & Vision Science, University of Waterloo.

Why is this research being done?
Undetected and untreated vision problems such as poor vision or one eye that sees better than another (known as amblyopia) may interfere with a child's learning potential. Research has shown a correlation between early detection of vision problems and improved educational performance. The Region of Waterloo Public Health is currently offering vision screening to all Senior Kindergarten (SK) students enrolled in the Waterloo Region District School Board (WRDSB) and the Waterloo Catholic District School Board (WCDSB). Following the vision screening, parents/guardians are provided with results and recommendations are made for follow-up care. However, there is currently no data to show how many vision screenings resulted in confirmed eye health problems.

What is the purpose of the study?
The purpose of this study is to investigate how many vision screenings resulted in confirmed eye health problems.

What does this study involve if you decide to take part?
Consent to participation in this study allows the University of Waterloo Researcher Investigators to contact the Region of Waterloo Public Health to obtain your child's vision screening results and to obtain the following results of your child's most recent eye exam (these are the same tests that were also performed during your child's vision screening):

Visual Acuity
Stereopsis/ Depth Perception
Refractive Error

Who can participate in the study?
Parents/guardians of all SK children who participated in the Region of Waterloo Public Health Vision Screening Program who have or will be taking their child to an optometrist for a full eye exam are eligible to participate.

What are the possible benefits of the study for me and my child and/or society?
While there are no direct benefits to you or your child, the benefit to society includes a better understanding on the effectiveness of vision screenings and the number of children with a confirmed eye health problem that were detected by a vision screening.

What are the possible risks?
There are no known risks associated with this study.

UNIVERSITY OF WATERLOO
CONCORDIA CUM VERITATE

What information will be kept private and confidential?
As required by the province of Ontario, study related records with identifying information will be kept confidential. Safeguards for authorized access, security, and privacy of your child's information have been put in place. For instance, you and your child's name will be kept in a separate master list from your study data. This personal information will be removed from the electronic study data and will be replaced with a number code. Your child's electronic study data will be stored at the University of Waterloo School of Optometry and Vision Science. Electronic records will be retained for a minimum of 10 years after the study is completed and data will be kept on drivers which are password-protected. Only members of the research team will have access to the study data. It is anticipated that the results of this research project will be published or presented in a variety of forums. The results will be presented in such a way that you or your child cannot be identified. If you are interested in the findings of this study, you are encouraged to contact the Investigators.

Can I end my participation early?
Participation in this research is voluntary. If you do not wish to take part, you do not have to. If you choose to volunteer to be in this study, you may withdraw up to 90 days after consent. After this time, non-identifying data may be used for analysis or publications. If you decide not to take part, or to withdraw from this study, it will in no way influence you or your child's current or future care with your child's school, the Region of Waterloo Public Health or the University of Waterloo, School of Optometry and Vision Science.

Will I be paid to participate in the study?
There is no cost for participating in this study. Nor will any payment be made to you to be involved in this study.

What should I do if I am interested in participating in this study?
If you are interested in participating in this study, please electronically sign and submit the consent form on the next page. If you are unable to electronically sign the form, a paper copy of this information and consent form can be mailed to you. Please email lisa.christian@uwaterloo.ca to request a copy of the paper form.

Questions or concerns about the study?
This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board (REB 44548). If you have any questions for the Committee, contact the Office of Research Ethics, at 1-519-888-4567, ext. 36005 or reb@uwaterloo.ca.

If you have questions about this research at any time, you should contact the Principal Investigator of the study Dr. Lisa Christian at lisa.christian@uwaterloo.ca

UNIVERSITY OF WATERLOO
CONCORDIA CUM VERITATE

CONSENT FORM

Translating Vision Screenings to Eye Exams in Waterloo Region Study:
Examining Vision Screening to Eye Exam Data

By providing your consent, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

I have read the information presented in the information letter about a study conducted by Dr. Lisa Christian, School of Optometry and Vision Science at the University of Waterloo. I have had the opportunity to ask questions related to the study and have received satisfactory answers to my questions and any additional details.

I was informed that participation in the study is voluntary and that I can withdraw this consent by informing the researcher (circle one)

Yes No

I agree to allow the University of Waterloo Researcher Investigators to contact the Region of Waterloo Public Health to obtain my child's vision screening results and to obtain the results of my child's most recent eye exam (circle one)

Yes No

Please provide us with the following information:

Name of Child: ______________________________

Name of Child' School: ______________________________

Name of Child's Optometrist: ______________________________

I agree of my own free will to participate in the study.

Yes No

Parent Name: ______________________________

Parent Consent Signature: ______________________________

Appendix D Parental Compliance Survey

STUDY 1A: SURVEY (VIA QUALTRICS.COM)

Title of the study: Translating Vision Screenings to Eye Exams in Waterloo Region study

Principal Investigator: Dr. Lisa Christian, University of Waterloo School of Optometry and Vision Science

Thank you for agreeing to participate in this study. As a reminder, the purpose of this study is to investigate the following:

- Number of children who are currently under the care of an optometrist and who recently saw an optometrist 18 months prior to the screening
- Adherence to Region of Waterloo Public Health recommendations following the vision screening
- Whether additional education about vision and eye health improves adherence to Region of Waterloo Public Health recommendations following the vision screening

Please answer all questions to the best of your ability. Should you have any questions or run into any technical issues while taking the survey, please email lisa.christian@uwaterloo.ca.

The survey should take no more than 5-10 mins of your time to complete.

Participant ID (sent in email): ___________

Question 1: Has your child seen an optometrist within the last 18 months?

1A: Yes, my child has seen an optometrist within the last 18 months

1Ai: (follow-up response): When did your child have their last eye exam (month/year)? – move onto question 2

1B: No, my child has not seen an optometrist within the last 18 months

1Bi: (follow-up response): In January 2018, the Ministry of Health and Long-Term Care released the Ontario Public Health Standards. As part of the standards the Region of Waterloo Public Health was mandated to perform vision screenings to all SK children. Studies have shown undetected and untreated vision problems can interfere with the ability of children to perform to their full learning potential. With a diagnosis and appropriate intervention, the prognosis has been shown to improve academic performance. The province of Ontario currently covers yearly eye exams to children who have valid OHIP coverage, at no cost to you. Were you aware of the relationship between vision and learning and current OHIP coverage by the province?

1Bia: Yes – move onto question 2

1Bib: No – move onto question 2

Question 2: What were the findings of your child's SK vision screening?

2A: No problem detected

email you in 2 weeks to follow-up to see if an eye exam has been made by an optometrist?
            - No, I do not wish to be contacted again
                - Thank you for your time in participating in this study. Have a great day.
            - Yes, I can be contacted again
                - Thank you. We will send you an email in a few weeks to follow-up. Thank you for your time in participating in this study. Have a great day.

- Yes I would like to receive a list of optometrists
    - There is a great online resource to locate optometrists anywhere in Canada. The website is: https://opto.ca/find-doc. We can also help you book an appointment. Would you like me to help facilitate this?
        - No I do not need help in booking an appointment
            - (follow-up question): As a follow-up to this this study, we are also investigating how effective vision screenings are at detecting vision problems. Would we be able to email you in 2 weeks to follow-up to see if an eye exam has been made by an optometrist?
                - No, I do not wish to be contacted again
                    - I understand. Thank you for your time in participating in this study. Have a great day.
                - Yes, I can be contacted again
                    - Thank you. We will send you an email in a few weeks to follow-up. Thank you also for your time in participating in this study. Have a great day.
        - Yes I would like help to book an appointment
            - We would be happy to help you book an appointment. Please provide the preferred method of contact to schedule the appointment: __________
                - Thank you for your time in participating in this study. Have a great day.

2Aid: Yes I have booked an appointment with an optometrist.

- (follow-up question): Thank you for letting us know. We are also investigating how effective vision screenings are at detecting vision problems. Would you be willing to allow us to contact your child's optometrist and get their most recent exam results?
    - No, I do not wish to participate in the follow-up study.
        - Thank you for your time and have a great day.
    - Yes, I would like to participate in this follow-up study
        - Thank you for agreeing to participate. You will receive another email that will provide you with information about the follow-up study. Please click

2Ai: (follow-up response): Based on your child's vision screening finding, the Region of Waterloo Public Health the recommendation is that all children receive a full eye exam by an optometrist annually. Have you booked an appointment with an optometrist after receiving the parent vision screening letter?

2Aia: No, I did not book an appointment

- (follow-up response): Are there any barriers preventing you from accessing vision care?
  - Money / cost of prescription eye glasses
  - Time / work
  - I do not feel eye exams are important
  - Other reason (please specify below):___________________
- (follow-up response): What is the reason you have not booked an appointment?
  - I do not feel my child needs an eye exam
    - Thank you for your time in participating in this study. Have a great day.
  - My child recently had an eye exam and does not require another one
    - Thank you for your time in participating in this study. Have a great day.

2Aib: I plan on booking an appointment but have not made one yet

- (follow-up response): Are there any barriers preventing you from accessing vision care?
  - Money / cost of prescription eye glasses
  - Time / work
  - I do not feel eye exams are important
  - Other reason (please specify below):___________________
- (follow-up question): As a follow-up to this this study, we are also investigating how effective vision screenings are at detecting vision problems. Would we be able to email you in 2 weeks to follow-up to see if an eye exam has been made by an optometrist?
  - No, I do not wish to be contacted again
    - I understand. Thank you for your time in participating in this study. Have a great day.
  - Yes, I can be contacted again
    - Thank you. We will send you an email in a few weeks to follow-up. Thank you also for your time in participating in this study. Have a great day.

2Aic: I would like to book with an optometrist, but I don't know who to contact

- (follow-up response): Are there any barriers preventing you from accessing vision care?
  - Money / cost of prescription eye glasses
  - Time / work
  - I do not feel eye exams are important
  - Other reason (please specify below):___________________
- (follow-up question): Would you like to receive a list of names of optometrists in your area?
  - No I do not need a list of optometrists
    - As a follow-up to this this study, we are also investigating how effective vision screenings are at detecting vision problems. Would we be able to

on the consent and survey link in the email. We appreciate your time participating in this study. Have a great day.

2B: Yes at least one vision problem was detected
2Bi: (follow-up response): Based on your child's vision screening finding, the Region of Waterloo Public Health recommends your child be seen by an optometrist for a comprehensive eye exam. Have you booked an appointment with an optometrist after receiving the parent vision screening letter?

2Bia: No, I did not book an appointment

- (follow-up response): Are there any barriers preventing you from accessing vision care?
    - Money / cost of prescription eye glasses
    - Time / work
    - I do not feel eye exams are important
    - Other reason (please specify below):___________________
- (follow-up response): What is the reason you have not booked an appointment?
    - I do not feel my child needs an eye exam
        - Studies have shown undetected and untreated vision problems can interfere with the ability of children to perform to their full learning potential. With a diagnosis and appropriate intervention, the prognosis has been shown to improve academic performance. A full eye exam will be able to identify any vision problems that may exist, and we recommend you consider booking an eye exam with an optometrist. Based on this information are you now likely to book an exam with an optometrist.
            - No, I still do not feel my child needs an eye exam.
                - Thank you for your time in participating in this study. Have a great day.
            - Yes, I will book an appointment with an optometrist.
                - (follow-up question):Would you like to receive a list of names of optometrists in your area?
                    - No I do not need a list of optometrists.
                        - As a follow-up to this this study, we are also investigating how effective vision screenings are at detecting vision problems. Would we be able to email you in 2 weeks to follow-up to see if an eye exam has been made by an optometrist?
                            - No, I do not wish to be contacted again
                                - Thank you for your time in participating in this study. Have a great day.
                            - Yes, I can be contacted again
                                - Thank you. We will send you an email in a few weeks to follow-up. Thank you for

your time in participating in this study. Have a great day.

- Yes I would like to receive a list of optometrists
  - There is a great online resource to locate optometrists anywhere in Canada. The website is: https://opto.ca/find-doc. We can also help you book an appointment. Would you like me to help facilitate this?
    - No I do not need help in booking an appointment
      - (follow-up question): As a follow-up to this study, we are also investigating how effective vision screenings are at detecting vision problems. Would we be able to email you in 2 weeks to follow-up to see if an eye exam has been made by an optometrist
      - No, I do not wish to be contacted again
        - Thank you for your time in participating in this study. Have a great day.
      - Yes, I can be contacted again
        - Thank you. We will send you an email in a few weeks to follow-up. Thank you for your time in participating in this study. Have a great day.
    - Yes I would like help to book an appointment
      - We would be happy to help you book an appointment. Please provide the preferred method of contact to schedule the appointment: __________
        - Thank you for your time in participating in this study. Have a great day.

2Bib: My child recently had an eye exam and does not require another one

- (follow-up response): Are there any barriers preventing you from accessing vision care?
  - Money / cost of prescription eye glasses
  - Time / work
  - I do not feel eye exams are important
  - Other reason (please specify below):___________________
- (follow-up question) As a follow-up to this study, we are also investigating how effective vision screenings are at detecting vision problems. Would you be interested in participating in our follow- up study.
  - No, I am not interested.
    - Thank you for your time in participating in this study. Have a great day.
  - Yes, I am interested

        - Thank you for agreeing to participate. An email will be sent to you about our follow-up study. Thank you also for your time in participating in this study. Have a great day.

2Bic: I plan on booking an appointment with my optometrist but have not made one yet

- (follow-up response): Are there any barriers preventing you from accessing vision care?
    - Money / cost of prescription eye glasses
    - Time / work
    - I do not feel eye exams are important
    - Other reason (please specify below):___________________
- (follow-up question): As a follow-up to this study, we are also investigating how effective vision screenings are at detecting vision problems. Would we be able to email you in 2 weeks to follow-up to see if an eye exam has been made by an optometrist?
    - No, I do not wish to be contacted again
        - Thank you for your time in participating in this study. Have a great day.
    - Yes, I can be contacted again
        - We will send you an email in a few weeks to follow-up. Thank you for your time in participating in this study. Have a great day.

2Bid: I would like to book with an optometrist, but I don't know who to contact

- (follow-up response): Are there any barriers preventing you from accessing vision care?
    - Money / cost of prescription eye glasses
    - Time / work
    - I do not feel eye exams are important
    - Other reason (please specify below):___________________
- (follow-up question): Would you like to receive a list of names of optometrists in your area?
    - No I do not need a list of optometrists
        - (follow-up question): As a follow-up to this this study, we are also investigating how effective vision screenings are at detecting vision problems. Would we be able to email you in 2 weeks to follow-up to see if an eye exam has been made by an optometrist?
            - No, I do not wish to be contacted again
                - Thank you for your time in participating in this study. Have a great day.
            - Yes, I can be contacted again
                - Thank you. We will send you an email in a few weeks to follow-up. Thank you for your time in participating in this study. Have a great day.
    - Yes I would like to receive a list of optometrists
        - There is a great online resource to locate optometrists anywhere in Canada. The website is: https://opto.ca/find-doc. We can also help you book an appointment. Would you like me to help facilitate this?

- No I do not need help in booking an appointment
    - (follow-up question): As a follow-up to this this study, we are also investigating how effective vision screenings are at detecting vision problems. Would we be able to email you in 2 weeks to follow-up to see if an eye exam has been made by an optometrist?
        - No, I do not wish to be contacted again
            - Thank you for your time in participating in this study. Have a great day.
        - Yes, I can be contacted again
            - Thank you. We will send you an email in a few weeks to follow-up. Thank you also for your time in participating in this study. Have a great day.
- Yes I would like help to book an appointment
    - We would be happy to help you book an appointment. Please provide the preferred method of contact to schedule the appointment: ___________
        - Thank you for your time in participating in this study. Have a great day.

2Bie: Yes I have booked an appointment with an optometrist.

- (follow-up question) Thank you for letting us know. We are also investigating how effective vision screenings are at detecting vision problems. Would you be willing to allow us to contact your child's optometrist and get their most recent exam results?
    - No, I do not wish to participate in the follow-up study.
        - Thank you for your time and have a great day.
    - Yes, I would like to participate in this follow-up study
        - Thank you for agreeing to participate. You will receive another email that will provide you with information about the follow-up study. Please click on the consent and survey link in the email. We appreciate your time participating in this study. Have a great day.