The Health Technology Inquiry Service (HTIS) is an information service for those involved in planning and providing health care in Canada. HTIS responses are based on a limited literature search and are not comprehensive, systematic reviews. The intent is to provide the best evidence on the topic that could be identified within the time allowed. HTIS responses should be considered along with other types of information and health care considerations. The information included in this response is not intended to replace professional medical advice, nor should it be construed as a recommendation for or against the use of a particular health technology. Readers are also cautioned that a lack of good quality evidence does not necessarily mean a lack of effectiveness particularly in the case of new and emerging health technologies, for which little information can be found, but which may in future prove to be effective.

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**TITLE:** Preschool Vision Screening

**DATE:** September 15, 2006

**RESEARCH QUESTIONS:**
What is the published evidence on the clinical and cost-effectiveness of pre-school vision screening (i.e., in children under the age of six), in comparison to a complete diagnostic vision examination by an optometrist or ophthalmologist?

**CONTEXT AND POLICY ISSUES:**
The purpose of preschool vision screening is to detect vision disorders such as refractive errors, amblyopia and strabismus at an early age (less than 6 years). Amblyopia is loss of vision that cannot be explained by ocular pathology or refractive error. Uncorrected refractive errors, media opacity and strabismus are the causes of amblyopia. Strabismus, a misalignment of the eyes, is the most common cause of amblyopia. Strabismus includes esotropia (eye turned inward), exotropia (eye turned outward) or hypertropia (eye turned upward). Refractive errors include myopia (near sightedness), hyperopia (far sightedness), astigmatism, and anisometropia (unequal refractive power in the eyes). Amblyopia affects approximately 2% to 4% of the population, whereas strabismus affects approximately 4%.

Amblyopia can be corrected if detected in infancy or early childhood. Visual pathways are developing until about 10 years of age, and therefore treatment of amblyopia should begin prior to this age for treatment to be effective. Visual pathways will not develop properly in children if they do not see clear images. Amblyopia may have an impact on health, academic, employment and social functioning. Left untreated, refractive errors and amblyopia may affect the ability to play sports, as well as affecting development and school performance. In addition, vision loss may occur in the non-amblyopic eye resulting in blindness. Early detection of vision disorders is important to allow proper treatment to be undertaken to improve visual acuity.

Various criteria for referral exist for the diagnosis of amblyopia. A visual acuity (VA) of less than 20/40 is the common referral criteria, however, VA < 20/30 and 20/25 have also been used for referral criteria. In addition, VA < 20/25 or a 0.2 line difference between the eyes and VA < 20/40 OR a 2 line difference between the eyes can be used as referral criteria for amblyopia detection.
Detection of vision problems at an early age can lead to effective treatments that may increase visual acuity. There are numerous methods for detection of vision disorders, with different groups reporting various sensitivities and specificities for the specific tests. Tests for visual acuity include the Snellen test, Tumbling E, HOTV test, Allen cards and Lea Symbols. Ocular alignment is tested using the Corneal light reflex test, Red Reflex test (Bruckner reflex), cross cover test, and random dot stereotests (frisby, randot, Random dot E, Lang). Different screening tests are recommended for different age groups. Red reflex and structural abnormalities are checked during the newborn medical exam. To obtain the most accurate results, the most difficult test a child can perform should be part of the vision screening. The American Academy of Pediatrics, the American Optometric Association, the American Academy of Ophthalmology and the US Preventive Services Task Force differ in the tests that they recommend for each age group. The Canadian Pediatric Society recommends testing of visual acuity, red reflex and corneal light reflex in children aged 3 to 5 years.

The effectiveness of preschool vision screening has been debated. There is no agreement as to the age at which children should be screened, which test(s) should be used and which outcomes should be measured. Some organizations suggest that vision exams should only be conducted by licensed eye care professionals, whereas others indicate that non-ophthalmologists can effectively detect vision defects through preschool vision screening. Screening tests can be conducted by nurses, primary care physicians or other health professionals. Trained lay screeners often administer the tests in public screening programs.

METHODS:

Published literature was obtained by cross-searching EMBASE®, MEDLINE®, CINAHL and ERIC databases on the OVID search system. Regular alerts were established on EMBASE, MEDLINE and CINAHL and information retrieved via alerts is current to July 21, 2006. Parallel searches were performed on PubMed and the Cochrane Library (Issue 2, 2006) databases. Publications were limited to English-language only, with publication dates of 1996 to the present. Filters were applied to limit the retrieval to health technology assessments, systematic reviews, clinical studies and economic studies.

Web sites of regulatory agencies, and health technology assessment and related agencies were also searched, as were specialized databases such as those of the University of York Centre for Reviews and Dissemination. The Google™ search engine was used to search for a variety of information on the Internet. These searches were supplemented by hand searching the bibliographies of selected papers. The British Columbia Association of Optometrists and the British Columbia Ministry of Health also supplied several documents for review. Reports were included that assessed vision screening in children under 6 years of age. Studies that included older children were excluded if results were not separated into age groups that included preschool aged children only. Three external reviewers provided comments on this report.

SUMMARY OF FINDINGS:

1. Effectiveness of preschool vision screening

There are general criteria to consider when determining whether a screening program will be useful. The screening program should do more good than harm, the tests must be able to identify the defect, there must be an appropriate intervention to treat the defect, there must be an advantage in detecting and treating the defect at an earlier age, and the cost must be
justified. In addition, the prevalence of the defect must be high enough and must cause substantial disability to justify screening.

A 1997 UK assessment determined that all these criteria were not met in the case of preschool vision screening. The authors concluded that in order to support a screening program, there should be evidence for the efficacy of treatment for the vision disorders and this evidence was lacking. In addition to the lack of evidence that amblyopia, strabismus and refractive errors caused disability, the UK review found insufficient evidence that treatment of these disorders enhanced visual gains. This assessment recommended that screening programs not be implemented unless they have been evaluated, as there is no evidence for the benefits of preschool vision screening. A 2005 Cochrane Collaboration review on amblyopia screening concluded that insufficient evidence exists to determine the effectiveness of screening programs on amblyopia prevalence. The authors stressed that this does not mean there is no benefit to screening, rather it merely means there is a lack of good quality evidence (e.g., randomized controlled trials) in this area.

The state of Kentucky passed a law in 2000 requiring each child entering public school to have a vision examination by an ophthalmologist or optometrist. A 2003 survey of Kentucky Optometric Association members found that 5316 children were examined between July 2000 and April 2001; 13.92% were prescribed spectacles, 3.4% were diagnosed with amblyopia, and strabismus was diagnosed in 2.31%. The Modified Clinical Technique (MCT; consists of visual acuity tests, cover test, retinoscopy and ophthalmoscopy) administered by an ophthalmologist or optometrist is suggested to be the only test that can effectively assess preschool vision with an acceptable sensitivity and specificity. This result is not entirely unexpected, considering this technique consists of multiple tests administered by ophthalmologists or optometrists, and would therefore be similar to a clinical examination.

A 2005 report by C Green in 2005 on preschool vision screening suggests that there is a basis for recommending preschool vision screening, even though research evidence is lacking. Four options are proposed for vision testing in preschoolers: fortify existing vision care, primary screening by public health nurses with referral to ophthalmology and optometry, screening by technical or lay examiners, or comprehensive exams by optometrists. This report suggested that a combination of these approaches for vision testing may be the best option.

Specific screening tests

A comparison of photoscreening to traditional screening methods (HOTV, Random Dot E) found the positive predictive value (PPV) of photoscreening to be 73%, whereas the PPV for traditional screening was 0%. A computer photoscreener was found to have a sensitivity of 94.6% and specificity of 90.1% compared to 85.7% sensitivity and 81.0% specificity for retinoscopy in a study comparing these methods in 300 children ages 9 to 50 months. This indicates that with the computer photoscreener 5.4% of patients will have a negative test result but will have a vision defect (false negative), and 9.9% will test positive but will have no defect (false positive) meaning 5.4% of patients will be missed in screening and not treated whereas 9.9% of patients will be referred unnecessarily. In this study, retinoscopy had a 14.3% false negative rate and a 19% false positive rate. MTI photoscreener sensitivity was higher (89%) than examination of the Brückner reflex (64%) in a case control study of 10 patients with amblyogenic risk factors and 6 control patients.
Comparisons of the different vision screening tests for preschool children have been published. The VIP study group compared sensitivities of 11 different screening tests in 2588 children aged 3 to 5 years. Visual acuity tests included crowded, linear Lea symbols and crowded, linear HOTV tests. Tests for stereacuity were the Random Dot E (RDE) and Stereo Smile II test. Retinoscopy, Retinomax autorefractor, and SureSight autorefractor were used to test refractive error. Sensitivity of photoscreeners (iScreen, MTI, Power Refractor II video/photorefraction) and the cover-uncover test were also examined. Non-cycloplegic retinoscopy (NCR), SureSight, and Retinomax were the most sensitive tests for the detection of amblyopia, at 88%, 80%, and 78% sensitivity, respectively, and 94% specificity. For detection of strabismus, MTI photoscreener, cover-uncover test, Stereo Smile II test, SureSight and Retinomax were most sensitive (88%, 80%, 78%, and 58% respectively). NCR, Retinomax, SureSight and Lea symbols were most sensitive for detection of significant refractive error (74%, 66%, 63%, and 58% respectively). Lea symbols, Retinomax and NCR were most sensitive for detection of reduced visual acuity, at 48%, 39% and 38% sensitivity. Clearly, sensitivities for the numerous screening tests vary widely for the different vision disorders.

The VIP study also examined the sensitivities of these different tests for detection of any vision disorder. The most sensitive test was the NCR (64%), Retinomax (63%), SureSight Vision screener (63%) and Lea Symbols (61%). For detection of conditions that are important to detect and treat early, NCR was the most sensitive at 90%, followed by Retinomax (88%), SureSight (81%), and Lea Symbols (77%). The specificities were all 90% or higher. The VIP study used licensed eye care professionals to administer these tests.

A comparison of Lea Symbols, MTI photoscreening, Keratometry, and Retinomax was done in 379 preschool children for detection of astigmatism. The sensitivity and specificity of the different tests were: Lea symbols, 92% and 56%; MTI photoscreening, 60% and 86%; Keratometry, 95% and 77%; and Retinomax, 93% and 95%. Visual acuity screening by Lea Symbols was compared to noncycloplegic refraction for detection of astigmatism in 245 children aged 3 to 5 years. Lea symbols had a sensitivity of 90% and specificity of 44%, whereas refraction resulted in 91% sensitivity and 86% specificity. The sensitivity and specificity of a digital Random Dot test were compared to the Randot stereacuity test, the Titmus test, and the Lang test and similar results were found for testing in preschool children. Randot stereocards were found to produce reliable valid results in children up to 24 months old.

Two handheld autorefractors (Retinomax and SureSight) were compared to cycloplegic (paralysis to minimize accommodation) retinoscopy in 35 children aged 3 to 5 years. Moderate agreement was found between the two autorefractors, as well as between the autorefractors and cycloplegic retinoscopy. The authors therefore concluded that these devices may be useful as screening tools. A limitation of this study is that these children were cyclopled prior to testing. A screening program would likely not use cycloplegia, and hence these results may not be generalizable to a screening program. Another study of 43 children tested before and after induction of cycloplegia with autorefractors. Autorefractor results were not consistent without cycloplegia, and the best device will be one that can relax the accommodative effort of the child to obtain an accurate reading. Another study found the Retinomax to be a useful screening device for children 46 to 81 weeks old, however, the accuracy of the results was affected by patient cooperation. Furthermore, these children were cyclopled. Results obtained by an ophthalmic nurse using a handheld autorefractor (Retinomax) were compared to traditional retinoscopy performed by an ophthalmologist in children under the age of 6 years. Results were similar using the different methods with cycloplegia, indicating that the Retinomax is useful to measure refractive error. Results obtained without cycloplegia were not accurate.
Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) have been assessed for various vision screening techniques in preschool children. Table 1 summarizes these studies. Screening tests were compared to a complete ophthalmologist, optometrist or orthoptic exam to determine sensitivity and specificity. The studies presented in Table 1 are arranged by type of screening test.

Table 1: Sensitivity, specificity, positive and negative predictive values for various preschool vision screening tests

<table>
<thead>
<tr>
<th>Study</th>
<th># children tested</th>
<th>Age</th>
<th>Screening Test</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Administered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Donahue et al, 2006</td>
<td>&gt; 400,000</td>
<td>Preschool age</td>
<td>MTI photoscreener</td>
<td>NR</td>
<td>NR</td>
<td>80%</td>
<td>NR</td>
<td>Technicians, orthoptists, optometrists, medical students, program coordinators</td>
</tr>
<tr>
<td>Donahue et al, 2002</td>
<td>949</td>
<td>6 months – 59 months</td>
<td>MTI photoscreener</td>
<td>50%</td>
<td>98.5%</td>
<td>57.5</td>
<td>94.4</td>
<td>NS</td>
</tr>
<tr>
<td>Berry et al, 2001</td>
<td>51</td>
<td>3 – 5 years</td>
<td>MTI photoscreener</td>
<td>83%</td>
<td>68%</td>
<td>68%</td>
<td>83%</td>
<td>NS</td>
</tr>
<tr>
<td>Tong et al, 2000</td>
<td>392</td>
<td>&lt; 4 years</td>
<td>MTI photoscreener</td>
<td>65%</td>
<td>87%</td>
<td>NR</td>
<td>NR</td>
<td>Ophthalmologist, ophthalmic medical technologist</td>
</tr>
<tr>
<td>Weinand et al, 1998</td>
<td>112</td>
<td>6 – 48 months</td>
<td>MTI photoscreener</td>
<td>82.8%</td>
<td>61.8%</td>
<td>68.2</td>
<td>48.1</td>
<td>Pediatrician, orthoptist, ophthalmologist</td>
</tr>
<tr>
<td>Tong et al, 1998</td>
<td>100</td>
<td>≤ 3 years</td>
<td>MTI photoscreener</td>
<td>37% - 88%</td>
<td>40% - 88%</td>
<td>NR</td>
<td>NR</td>
<td>Ophthalmologist, pediatrician, ophthalmic technician, health dept. employee, prevent blindness employee, Lions Club volunteer</td>
</tr>
<tr>
<td>Cooper et al, 1999</td>
<td>105</td>
<td>12 – 44 months</td>
<td>Fortune Photoscreener, MTI photoscreener</td>
<td>60%-68% (Fortune) 56%-61% (MTI)</td>
<td>75%-86% (Fortune) 79%-86% (MTI)</td>
<td>NR</td>
<td>NR</td>
<td>NS</td>
</tr>
<tr>
<td>Cooper et al, 1996</td>
<td>113</td>
<td>11 – 44 months</td>
<td>Otago and Dortmans photoscreeners</td>
<td>70%, 70%</td>
<td>82%, 90%</td>
<td>NR</td>
<td>NR</td>
<td>ophthalmologist</td>
</tr>
<tr>
<td>Fern et al, 1998</td>
<td>220</td>
<td>&lt; 6 years</td>
<td>Photoscreener</td>
<td>27.8% - 47%</td>
<td>NR</td>
<td>66.7% - 94.4%</td>
<td>NR</td>
<td>Optometry students</td>
</tr>
<tr>
<td>Pott et al, 1998</td>
<td>196</td>
<td>5 years</td>
<td>Polaroid suppression test</td>
<td>60%</td>
<td>91%</td>
<td>NR</td>
<td>NR</td>
<td>NS</td>
</tr>
<tr>
<td>Birch et al, 1997</td>
<td>1260</td>
<td>2 – 5 years</td>
<td>Random Dot stereaoctuity</td>
<td>91%</td>
<td>91%</td>
<td>NR</td>
<td>NR</td>
<td>NS</td>
</tr>
<tr>
<td>Rasmussen et al, 2000</td>
<td>400</td>
<td>3 years</td>
<td>Lang II Random Dot stereotest</td>
<td>33%</td>
<td>85%</td>
<td>9.5%</td>
<td>96%</td>
<td>nurses</td>
</tr>
<tr>
<td>Study</td>
<td># children tested</td>
<td>Age</td>
<td>Screening Test</td>
<td>Sensitivity</td>
<td>Specificity</td>
<td>PPV</td>
<td>NPV</td>
<td>Administered by</td>
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<tr>
<td>-------------------------------</td>
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</tr>
<tr>
<td>Simons et al, 1996</td>
<td>112</td>
<td>3 – 5 years</td>
<td>Small target Random Dot Stereogram (STRDS) and Binocular suppression test (STBS)</td>
<td>NR</td>
<td>80% (STRDS) 96% (STBS)</td>
<td>NR</td>
<td>NR</td>
<td>NS</td>
</tr>
<tr>
<td>Lim et al, 2004</td>
<td>894</td>
<td>3 – 5 years</td>
<td>Home vision screening (visual acuity testing with picture cards)</td>
<td>NR</td>
<td>NR</td>
<td>77%</td>
<td>NR</td>
<td>NS</td>
</tr>
<tr>
<td>Barry et al, 2003</td>
<td>1180</td>
<td>3 years</td>
<td>Cover test, Lea single optotype</td>
<td>90.9%</td>
<td>93.8%</td>
<td>NR</td>
<td>NR</td>
<td>Orthoptist</td>
</tr>
<tr>
<td>Cordonnier et al, 2001</td>
<td>1218</td>
<td>9 – 36 months</td>
<td>Retinomax</td>
<td>37% - 87%</td>
<td>93% - 99%</td>
<td>NR</td>
<td>NR</td>
<td>Orthoptist</td>
</tr>
<tr>
<td>Barry et al, 2004</td>
<td>404</td>
<td>3 years</td>
<td>Retinomax – non-cycloplegic retinoscopy</td>
<td>80%</td>
<td>58%</td>
<td>NR</td>
<td>NR</td>
<td>Orthoptist</td>
</tr>
<tr>
<td>Cordonnier et al, 1999</td>
<td>1205</td>
<td>9 – 36 months</td>
<td>Retinomax</td>
<td>51% - 84%</td>
<td>90% - 98%</td>
<td>58% - 84%</td>
<td>90% - 96%</td>
<td>Orthoptist</td>
</tr>
<tr>
<td>Newman et al, 1998</td>
<td>897</td>
<td>9 – 36 months</td>
<td>Retinomax</td>
<td>70.2% – 78.7%</td>
<td>79.2% – 94.6%</td>
<td>51.4% - 78.6%</td>
<td>91.7% – 93.0%</td>
<td>Orthoptist</td>
</tr>
<tr>
<td>Chui et al, 2004</td>
<td>178</td>
<td>3 – 4 years</td>
<td>Lea symbols, Frisby plates</td>
<td>50% - 75%</td>
<td>68% - 95%</td>
<td>NR</td>
<td>90% - 96%</td>
<td>Public health nurses</td>
</tr>
<tr>
<td>Briscoe et al, 1998</td>
<td>292</td>
<td>4 – 6 years</td>
<td>Vision screening computer program</td>
<td>50%</td>
<td>98.9%</td>
<td>63%</td>
<td>NR</td>
<td>Non-trained personnel</td>
</tr>
<tr>
<td>Simon et al, 2004</td>
<td>122</td>
<td>6 months – 5 years</td>
<td>Visual evoked potential system</td>
<td>97.3%</td>
<td>80.8%</td>
<td>70.6%</td>
<td>98.4%</td>
<td>NS</td>
</tr>
<tr>
<td>Atilla et al, 2004</td>
<td>89</td>
<td>&lt; 4 years</td>
<td>Fix-Follow-Maintain</td>
<td>53.1%</td>
<td>38.5%</td>
<td>32.6%</td>
<td>NR</td>
<td>NS</td>
</tr>
<tr>
<td>Kemper et al, 2005</td>
<td>170</td>
<td>&lt; 5 years</td>
<td>SureSight autorefractor</td>
<td>80% - 88%</td>
<td>41% - 58%</td>
<td>NR</td>
<td>NR</td>
<td>Study investigator or ophthalmologist</td>
</tr>
<tr>
<td>Büchner et al, 2004</td>
<td>336</td>
<td>3.5 – 4.5 years</td>
<td>SureSight autorefractor</td>
<td>41% - 95%</td>
<td>73% - 92%</td>
<td>NR</td>
<td>NR</td>
<td>NS</td>
</tr>
</tbody>
</table>

PPV = positive predictive value  
NPV = negative predictive value  
NR = not reported  
NS = not specified  

To calculate likelihood ratios:  
Likelihood ratio of a positive test = sensitivity / (1-specificity)  
Likelihood ratio of a negative test = (1-sensitivity) / specificity
Screening effectiveness

A randomized controlled trial examining the effects of preschool vision screening was conducted in 2001 in the UK. The method of randomization and allocation concealment of this trial was inadequate, as date of birth was used to determine children assigned to the intervention group. The control group was assessed by visual surveillance (8 and 18 month exams by health visitors and family doctors using the cover test and observing visual behavior), while the intervention group received exams from an orthoptist (health professionals that assist ophthalmologists) to test visual acuity, ocular alignment, stereopsis and non-cycloplegic refraction. The specificity was 92% for the control group and 95% for the intervention group (p < 0.01). More children were found to have amblyopia in the intervention group (1.6%) compared to the control group (0.5%) (p < 0.01). A comparison of the tests administered as part of the intervention group found that photorefraction was the most sensitive component.

An observational study designed to test the validity of a preschool vision screening program was conducted in 1999 in Canada. Public health nurses administered tests for visual acuity, stereoacuity and ocular alignment to more than 1100 children per year, over a 3 year period. These results were compared to results from practitioner reports, and the sensitivity ranged from 60.4% to 70.9% and the specificity ranged from 69.6% to 79.9%. The positive predictive value (PPV) was 21.6% to 32.3% and the negative predictive value (NPV) was 92.6% to 95.3%. This study concluded that based on the numbers of children detected with vision defects the screening program is valid and should be continued.

A comparison of 8 year old children who had either received screening for vision defects in infancy (808 children) or who did not receive screening (782 children) found that the prevalence of amblyopia was much higher in the children who were not screened (2.6%) compared to those who received screening (1%) (p = 0.0098). Ophthalmologists conducted the screening, which included a corneal reflex test, fixation-and-following test, ductions and versions examination, cover-uncover test, alternate cover test and retinoscopy. The screening program had a sensitivity of 85.7%, a specificity of 98.6%, a PPV of 62.1% and a NPV of 99.6% indicating an effective screening program.

A 2003 retrospective cohort study of 6081 children, assessed visual outcomes of children aged 7.5 years who received preschool vision screening or who did not receive screening in the UK. More children were offered preschool vision screening (24.9%) than actually attended the screening (16.7%). Children who received vision screening had a 45% lower prevalence of amblyopia compared to those who did not receive screening. Once all children who were offered the screening were included in the analysis, the effects of early detection on amblyopia outcome diminished. The authors concluded that the effectiveness of preschool vision screening has to be improved. This study indicated that although a vision screening program can be efficacious, the effectiveness is limited by the number of children who actually receive screening. The effectiveness of the screening program will be increased if a greater proportion of children who are offered vision screening actually receive screening.

Screening of 3.5 year old children by an orthoptist and the results of referrals to the hospital eye service were examined in a retrospective study 6794 children conducted in 1996 in the UK. The screening test resulted in 5.1% of children referred to the hospital eye service, and detection of children with straight-eyed amblyopia and strabismic amblyopia. Upon treatment of amblyopia, 87.2% of straight-eyed amblyopia and 64.3% of strabismic amblyopia children achieved an improvement in visual acuity.
Another retrospective study that followed 3126 children from birth to age 10 found that vision screening is effective in detecting vision defects. Visual acuity was assessed at age 4, 5.5, 7 and 10 years by nurses at Child Health Care Centres or in the school. Ametropia (any refractive error) was mainly detected at age 4. Most cases of strabismus were detected before age 4 years while microtropia (small angle heterotropia) was detected at 4 years. Prevalence of amblyopia was reduced to 0.2% from 2% by screening and treatment, and the majority of patients with amblyopia increased their visual acuity with treatment, indicating that screening and treatment can reduce the prevalence of amblyopia.

An assessment of the vision screening program in Sweden found that screening tests (HOTV chart) for children 4 years and 5.5 years of age had a sensitivity of 92% and specificity of 97%. This study found that screening and subsequent treatment of amblyopia decreased the prevalence of this condition.

Re-screening effectiveness

A 2002 retrospective study of 1545 children in the UK examined the effects of a secondary screening program led by optometrists and orthoptists. Children were referred to the program from physicians, community medical officers, health visitors, school nurses and primary orthoptic screeners who had conducted their own screening protocol. This study found that this type of screening was effective to detect most children with vision problems, while avoiding referrals to the hospital eye service unnecessarily. This method of secondary screening by combining the skills of an optometrist and an orthoptist was found to be effective in reducing the number of referrals to the hospital eye service. Upon secondary testing, 43% of patients were found to be normal and did not require examination by the hospital eye service.

A preschool vision screening program developed by nursing students and faculty in the US assessed vision using Lea Symbols and Random Dot E stereopsis test. This 2005 study screened 181 children aged 3 to 5 years, and found 5.5% had abnormal results (28/181). Upon re-screening of 20 of these children, only 9 had an abnormal result and were referred. This re-screening approach decreased the number of referrals to primary care providers.

Personnel administering vision screening

A study of various personnel using the MTI photoscreener for children under 3 years of age found that the sensitivity and specificity of the screening method was not affected by ophthalmic knowledge of the screeners. Screening was conducted by ophthalmologists, pediatricians, ophthalmic technicians, health department employees, Prevent Blindness employees and Lions Club volunteers. The American Academy of Pediatrics (AAP) suggests that photoscreening may result in higher screening rates. Photoscreening will be useful for difficult to screen children, however, the evaluator should be properly trained. The American Academy of Ophthalmology (AAO) recognizes that photoscreening and autorefractive devices may be useful for screening, but state that they should not replace current screening protocols.

An evaluation of screening programs in Sweden and Canada found that properly trained non-opthalmologists can reliably screen 4 year old children, and children who fail screening tests should be referred to an ophthalmologist. The HOTV test is the most common test used in Canada. The Vision in Preschoolers (VIP) study compared administration of vision screening tests in 3 to 5 year olds by nurses and lay screeners. The tests administered were Retinomax,
SureSight, crowded linear Lea Symbols, single Lea Symbols (administered by lay screeners only) and stereo smile II test. A gold standard examination by an ophthalmologist or an optometrist was used for comparison. The single Lea symbols test administered by lay screeners resulted in higher sensitivity compared to the crowded linear Lea symbols administered by either lay screeners or nurses. All other screening tests resulted in higher sensitivity when administered by the nurses compared to the lay screeners, although with the exception of the linear Lea symbols, these differences were small and not statistically significant. These results indicate that similar results can be achieved with nurses and lay screeners.

A 1996 UK study comparing vision screening conducted by orthoptists (1582 children), health visitors (2081 children) and clinical medical officers (1701 children) found insufficient evidence to support an orthoptic conducted preschool vision screening program. The prevalence of amblyopia was similar in children screened by the different examiners.

A 1998 Canadian review of literature from 1983 to 1995 was conducted to assess screening for strabismus. This review found that low-risk children should be screened by a primary care physician, whereas high-risk children (children with low birth weight, family history of strabismus, congenital ocular abnormality or systemic conditions with vision-threatening ocular manifestations) should be examined by an ophthalmologist. Another UK study conducted in 2000 of 2041 children examined effectiveness of preschool vision screening conducted by health visitors. This study found that screening by health visitors was as effective as screening by orthoptists. Lay screeners were used in a study using the MTI photoscreener for preschool vision screening. The positive predictive value was 41.4% for astigmatism, 60.5% for anisometropia and 84.2% for strabismus. In a 2006 study based in Taiwan, trained and certified kindergarten teachers have also been shown to effectively test preschool children for amblyopia and strabismus.

Testability

A more direct comparison of HOTV letters and Lea Symbols in the VIP study found that HOTV scores were lower than Lea Symbols scores, likely due to the difficulty in testing younger children (3 years) with HOTV numbers. Another study found similar results, with testability rates higher for Lea Symbols than HOTV for vision screening of 3 year olds. In contrast, testability rates were found to be similar for Lea symbols and the HOTV chart for testing of 3 year old children. Lea symbols have been shown to be effective for detection of amblyopia in children as young as 23 months. The VIP study also examined testability of three different random dot stereotests and found a significant difference. Testability of the Stereo Smile test, the Random Dot E test and the Randot Preschool test was assessed in children aged 3 to 3.5 years. The testability was 91% for the Stereo Smile test, 81% for Random Dot E, and 71% for Randot. The authors suggest that a combination of two tests would increase the testability. Another study found that successful screening in 4 year olds was much higher (88% - 98%) compared to 3 year olds (70% - 90%), and suggest that there is insufficient evidence that detection of amblyopia at 3 years of age results in better treatment outcomes than if detected at 4 years of age. Overall, testability is higher in older children, as screening in younger children is more difficult.
Limitation of Studies

There is a lack of rigorous controlled studies examining the effectiveness of preschool vision screening. Only one randomized controlled study was identified and it was not of high quality.66 The other types of studies reviewed are observational studies or non-randomized controlled studies. Another limitation relates to the population screened. Some studies are screening children from a head start program, which is a program that serves children from low-income families,24,32-34 and would not reflect the general population. Furthermore, one study used children from a clinical practice, who may have had underlying conditions.45 Another limitation is the size of the sample undergoing screening. Small sample size was used in some studies.29,31 The age of screening can also be considered a limitation of some studies. Screening of children under 4 years can be difficult, and results will be difficult to apply to an older population.45,77 Agreement in the literature regarding the type of test to use for preschool vision screening is lacking. Furthermore, the majority of these studies measure the reduction in amblyopia as the outcome. Measures such as school performance may be a relevant outcome to consider in these studies. In addition, no long term studies exist making it difficult to determine how these screening programs may affect future outcomes for these children.

The major limitation of this review is the fact that it is not based on robust evidence from studies. In addition, the literature search for this review was limited to English language only, and excluded studies published prior to 1996. In addition, some of the studies above used orthoptists to administer the vision screening tests to preschool children. Orthoptists are common in other areas, such as the United Kingdom, however; there is a lack of orthoptists in Canada. The generalizability of these findings to a Canadian setting is therefore questionable.

2. Current practice

Throughout Canada, there are various practices for vision screening in children. Table 2 describes the current preschool vision screening programs in some provinces.

<table>
<thead>
<tr>
<th>Province</th>
<th>Current practice</th>
<th>Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Brunswick (Claudette Landry, NB Department of Health, Fredericton: personal communication, 2006 July 11)</td>
<td>Public health nurses conduct vision screening for children at age 3.5 years.</td>
<td>Visual inspection of the eyes, Randot, HOTV</td>
</tr>
<tr>
<td>Prince Edward Island (Aaron Campbell, Medical Programs Coordinator Dept. of Health Charlottetown: personal communication, 2006 September 12)</td>
<td>Public health nurses conduct vision screening for children at birth, 2, 4, 6, 12, 15 and 18 months and 4 to 4.5 years.</td>
<td>Frisby stereo test and Lea symbols</td>
</tr>
<tr>
<td>Newfoundland</td>
<td>Public health nurses. Children aged 3 years.</td>
<td>Sheridan-Gardner tests, cover/uncover, corneal light reflexes.</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>Public health nurses. Children ages 4.5 to 5.5.</td>
<td></td>
</tr>
<tr>
<td>Quebec</td>
<td>No information submitted</td>
<td></td>
</tr>
<tr>
<td>Ontario</td>
<td>Screening done by primary care providers as part of the 18 month “Well Baby” visit. Testing repeated at ages 2-3 years and 4-5 years.</td>
<td>Red reflex, corneal light reflex, cover/uncover test.</td>
</tr>
<tr>
<td>Manitoba</td>
<td>No information submitted</td>
<td></td>
</tr>
</tbody>
</table>
Saskatchewan

No province-wide preschool vision screening program.

Alberta

"Eye see...Eye learn" program provides exams conducted by an optometrist for children before they start school.

British Columbia

No province-wide preschool vision screening program.

Nunavut (Terry Creagh, Health & Social Services, Government of Nunavut, Iqaluit: personal communication, 2006 Aug 21)

Screening done primarily by public health nurses, community health nurses and community health representatives. Screening is done for children aged 4 to 6 years.

Yukon

No information submitted

North West Territories

Conducted by public health nurses.

Illiterate E test or symbol chart, stereoscopic fly, corneal light reflex, cover/uncover.

*Preschool vision screening programs may not be universally conducted across the province. Additional vision screening programs may be available in some regions through the work of charitable organizations.

3. Recommendations of Professional Organizations

The Canadian Paediatric Society (CPS) recommends a complete examination of external eye structures for newborn children to age 3 months. In addition, inspection of red reflex, signs of posterior eye disease, and corneal light reflex should be tested in this age group. For children aged 6 to 12 months, ocular alignment and fixation and following should be tested in addition to the tests for newborn to 3 months. Visual acuity testing should be completed in addition to these tests for children aged 3 to 5 years. These recommendations are based on the AAO recommendations. A 1994 Canadian Task Force on Preventive Health Care also recommends visual acuity testing of preschoolers.

The American Public Health Association recommends a comprehensive eye exam for preschool children at age 6 months, 2 years and 4 years. The US Preventive Services Task Force (USPSTF) assessed vision screening for children under the age of 5 years, and found fair evidence to suggest that screening tests could detect amblyopia, strabismus and refractive error with "reasonable accuracy." The cover test and Hirschberg light reflex test can be used to screen for strabismus from birth to one year. Amblyogenic risk factors can be detected by photoscreening in children up to the age of three years. Stereopsis (with Random Dot E, Titmus Fly Stereotest), visual acuity (HOTV chart, Lea Symbols, tumbling E) can be used in children over three years old. No direct evidence was found to suggest that screening improves visual acuity in preschool children. Furthermore, the USPSTF did not find sufficient evidence to suggest an optimal screening test. They found that visual acuity can be improved by early detection of amblyogenic risk factors. These recommendations are "B level," which indicates that fair evidence was found that the outcomes of preschool vision screening can outweigh the harms, and this service should be provided.

The American Optometric Association (AOA) recommendations for screening of infants and toddlers include: visual acuity (Fixation preference tests, preferential looking visual acuity test), refraction (cycloplegic retinoscopy, near retinoscopy), and binocular vision and ocular motility (cover test, Hirschberg test, Krimsky test, Brückner test, versions, near point of convergence). Tests for preschool children should include: visual acuity (Lea symbols chart, broken wheel acuity cards, HOTV test), refraction (static retinoscopy, cycloplegic retinoscopy), binocular vision, accommodation and ocular motility (cover test, positive and negative fusional vergences, near point of convergence, stereopsis, monocular estimation method retinoscopy, versions).
Recommendations from the American Academy of Ophthalmology (AAO) for newborn to age 3 months include red reflex and inspection. Infants aged 3 to 6 months should be tested by their ability to fix and follow, red reflex and inspection. Children aged 6 to 12 months should be tested with the above mentioned tests, as well as alternate occlusion and corneal light reflex. Visual acuity, corneal light reflex/cover-uncover, red reflex and inspection should be performed on children age 3 years. These tests should be repeated at 5 years of age. If abnormalities are detected by screening, a comprehensive medical eye examination should be performed. These recommendations are based on interpretations of an expert panel on the best available scientific data.

The American Academy of Pediatrics (AAP) recommends ocular history, vision assessment, external inspection of the eyes and lids, ocular motility assessment (corneal reflex test, cross cover test, random dot E test), pupil examination and red reflex examination for children up to the age of 3 years old. In addition to these tests, age-appropriate visual acuity (Lea symbols, Allen cards, Snellen letter and numbers, tumbling E test and HOTV test) and ophthalmoscopy is recommended for children 3 to 5 years old.

4. Cost-effectiveness of preschool vision screening

A study was developed to design and test a cost-efficient preschool vision screening program. Autorefraction was found to be the most expensive test, however, it had the greatest specificity. An economic evaluation found that vision screening in kindergartens by orthoptists had a cost-effectiveness ratio of 924 Euro for each case of amblyopia detected. Another study found the cost-effectiveness ratio for orthoptic screening in kindergarten to be 727 Euro for each case of amblyopia detected. The cost-effectiveness ratio was found to be heavily influenced by prevalence rate of the target condition as well as test specificity. One orthoptic exam was 7.87 Euro, compared to 36.40 Euro for an examination by an ophthalmologist. In Canada, there is a lack of orthoptists, and therefore, orthoptic screening is not likely to be an option. The costs of screening described in these studies are not generalizable to the Canadian situation.

The cost per detected case of amblyopia was assessed for various methods of vision screening for 3 year olds. In this 2002 German study, the least expensive option was visual acuity testing with re-screening for children who had inconclusive results. The most expensive option was visual acuity, cover test, examination of eye motility, and either direct referral to an ophthalmologist or re-screening for inconclusive results. Another study comparing costs of different screening strategies found that the most cost-effective screening strategy for detection of amblyopia or its risk factors is for an ophthalmologist to screen all children before the age of 1 year.

The benefit-to-cost ratio for screening programs exceeded 1.0, indicating the benefits of screening outweighed the costs. Another study found that comprehensive eye exams conducted by an ophthalmologist or optometrist compared to usual care would cost 2005 US$12,985 per quality-adjusted life year (QALY); the authors concluded it was highly cost effective. This may be an overly optimistic view since the authors used the cost of monocular blindness to define costs and not all children with amblyopia will develop monocular blindness. This same study also found universal eye exams were highly cost-effective, compared to vision screenings, at 2005 US$18,390 per QALY. The cost-effectiveness of treatment of amblyopia is 2005 US$1800 per QALY. The incremental cost-effectiveness ratio (ICER) was found to be 7397 Euro per QALY for orthoptic screening of 3 year old children. The authors suggest
CONCLUSIONS AND IMPLICATIONS FOR DECISION OR POLICY MAKING:

Preschool vision screening aims to detect vision disorders at an early age, with the assumption that early detection leads to earlier treatment and an improvement in outcomes. The specific test used, the age and underlying health of the children and the personnel administering the test all influence the effectiveness of preschool vision screening. Some studies suggest that screening should only be conducted by a trained eye care professional, whereas others state that physicians, nurses and even lay screeners can effectively conduct preschool vision screening. There does not appear to be consensus as to who should be administering the preschool vision screening test.

The effectiveness of the different tests for preschool vision screening is variable. For example, results obtained with photoscreening were highly variable, with sensitivities ranging from 27.8% to 88% and specificities ranging from 40% to 98.5% in different studies (Table 1). Similarly, other preschool vision screening tests have variable sensitivities and specificities. In addition, various professional organizations recommend different tests to assess vision in the different age groups of preschool children. Although numerous studies have been published examining different tests to detect vision defects in preschool children, no single test or group of tests has been shown to be superior for preschool vision screening. Moreover, while no Canadian studies have assessed the cost-effectiveness of preschool vision screening, the studies described suggest that universal eye exams for preschool children have a relatively low cost per QALY.

A preschool vision screening program meets most of the general criteria to consider when assessing a screening program. Although the prevalence of vision defects is relatively low, they do cause disability and an earlier age of detection is an undeniable benefit for treatment of amblyopia. No studies showed harms associated with screening, the tests can detect the defects they are meant to detect, and there are effective treatments for these vision defects.

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Preschool vision screening


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