A review of the science underlying preschool vision screening with implications for BC

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Executive Summary

Improved detection and treatment of visual deficits in preschool children may lead to better vision and related health, social, academic and athletic benefits during school years and in later adult life.

Objective

This 'review of reviews' has the overall objective of informing policy making through a concise presentation of available evidence and choices at a time when the BC Ministry of Health is seeking to improve the provincial infrastructure for early detection in preschool children.

Practice variation

There is enormous variability in preschool vision screening practices across British Columbia, Canada, Europe and the USA. Practices range from ad hoc voluntary testing by a mix of health care professionals to legislatively-mandated and standardized vision screening requirements as a condition of public school entry. In Canada, Nova Scotia and New Brunswick have public health nurses providing preschool screening. School-age screening that was once commonplace has largely been discontinued. Different configurations of preschool vision screening programs result from different interpretations of the indirect research evidence.

Recommendation convergences and discrepancies

Variability in practice is mirrored by discrepancies in recommendations, even among those based on systematic reviews of research evidence. There is generally a consensus amongst review groups that the available research evidence, though flawed and incomplete, provides a reasonable basis, on balance, for recommending preschool vision screening. However, there are serious discrepancies among recommendations on how to best configure preschool screening programs. Recommendations vary on basic features such as: 1) the optimal age range to target; 2) type of personnel to employ for screening; 3) specific tests to use; and 4) testing protocols.

Research evidence

A direct cause and effect relationship between a preschool screening protocol and better long term health outcomes has not been conclusively established on the basis of randomized clinical trials -- the gold standard for evidence of effectiveness. Nonetheless, many review organizations have conducted systematic reviews, and on that basis found the indirect evidence for preschool vision screening to be compelling enough to recommend preschool vision screening. There are no proven harms to children associated with screening.

The case for preschool screening builds on indirect evidence that visual impairments are important, common, difficult to detect without testing, and treatable. While the evidence that health care systems with programs of vision screening preschool children followed by treatment reduce the prevalence of important conditions during school years, research on outcomes in terms of measurable health, academic and social impacts is a major gap.

Research on the development of the optical system in children provides another type of evidence. Children need to use both eyes in a coordinated way to develop optimally. Correction may be less feasible or effective once a sensitive period is passed; hence the drive

to detect underuse (amblyopia) early. The first few months of life are critical, but the sensitive period extends to at least four years of age during which the children's vision system is particularly susceptible to disruption of the development of binocular fusion (both eyes aiming to fall on the same image) and stereopsis (depth perception).

Visual impairment conditions

Of primary importance to early detection efforts is amblyopia (under used eye) which may also occur together with strabismus (misaligned eye) or refractive error (near or farsightedness). The US Task Force on Preventive Services estimates prevalence of amblyopia to be between 2.9% to 3.9% and the prevalence of all vision deficits, including refractive errors, is 7% to 8.2%. Extrapolating this to the 40,000 children born in BC each year leads to estimates of 2,800 children with visual impairment, of which 1,160 have amblyopia per age cohort.

Following screening programs in Sweden and Israel, the prevalence of amblyopia in school-age children was found to be reduced to 0.03% and 1 % respectively. As these studies were conducted retrospectively, they do not provide the strongest evidence of effect. Nonetheless, this evidence suggests that a preschool screening program at best could ameliorate amblyopia in about 960 children in each BC age cohort, and ensure that about 2,800 have optimal care before school start.

Over the continuum from severe to mild that exists for every condition, minor visual impairments are less urgent. Controversy about vision screening is furthered when differences in clinical significance are insufficiently nuanced. Minor refractory errors do not disrupt the development of the visual system as profoundly or permanently as amblyopia does, and yet their correction may support the development of reading. Still, legitimate concerns have been raised about the over-prescription of spectacles in young children, and about a theoretical risk of interfering with the normal correction that occurs during maturation. In the absence of good outcome data, these debates are difficult to resolve.

Vision tests

The major categories of tests under consideration for screening protocols are for visual acuity (detail in central vision) and stereopsis (binocular vision). Vision screening systems have been adapted for preliterate children but their performance depends on well-trained examiners and follow-up. In recent rigorous analysis sponsored by the US National Health Institute, a set of four screening tests were found to be age-appropriate for 3- to 5-year-old children regardless of whether the tests were administered by eye care professionals, by trained nurses, or by lay screeners. With 90% specificity, 90% of children with conditions most important to detect and treat early were identified. The sensitivity of each test component varies with age and condition from 50 to 88% for the most important conditions (a negative test correctly rules out an important visual condition from 50 to 88% of the time). A comprehensive ophthalmologic/optometric exam is expected to approach a detection rate of 100% for important conditions.

Photoscreening technology photographs the eyes and then analyses the data to detect patterns which predispose to amblyopia, such as strabismus and refractive error. As a passive test, it places fewer demands on children and examiners. However, automating examination through photoscreening technology is not recommended on the basis of systematic reviews or professional endorsement. There is a lack of evidence from rigorous research of a performance advantage compared to functional testing. Interest has been high, however, and this technology is in use in the US.

Screening providers

There are a variety of trained personnel that play a role in providing eye care in the preschool age group. Primary care physicians, public health nurses and pediatricians are the main providers of child health care throughout the province. Optometrists (doctors of optometry) and ophthalmologists (medical doctors) provide comprehensive eye examinations. Ophthalmologists, including paediatric ophthalmologists, are relatively rare medical specialists who provide the most comprehensive range of diagnostic testing and treatment expertise. Orthoptists assist ophthalmologists and are the main screening examiners in the UK. Opticians are vision professionals who primarily dispense corrective eyewear. Other vision technical groups and even lay examiners have been engaged in vision screening programs.

Explaining practice variation/ recommendation discrepancies

The recommendations of groups using an explicit process of systematic review were identified (Appendix 1). While the more recent recommendations generally endorse preschool screening, there are major discrepancies in recommendations. The UK National Screening Committee, for example, has recommended universal screening of 4-to-5 year-old children by orthoptists with 'at minimum' a single visual acuity test. In contrast, an 'interim recommendation' of a US taskforce sponsored by the National Eye Institute and the Maternal and Child Health Bureau describes a screening regime for 3 and 4 year olds. The latter reports that "fewer than half of 3 year olds are screened in pediatric practices with current methods". This highlights the differences in the practice settings, and in the interpretation of the term 'screening'. Preschool vision screening as part of a paediatric practice does not equate with a universal program in which less qualified examiners attempt to reach all children.

Not distinguishing screening and diagnostic eye examinations has contributed to discrepancies. Screening tests are quick, simple, relatively-inexpensive tests to administer. Comprehensive eye exams are needed for diagnosis and treatment, and can only be carried out by optometrists and medical doctors—ideally ophthalmologists or paediatricians. Screening tests, on the other hand, can be applied by nurses, orthoptists or even trained lay examiners. A screening program implies that the test would be universally applied; that is, to all children even though their vision seems to be normal, in order to identify unsuspected conditions. Screening implies 'mass screening' using a systematic, coordinated population-based approach. While screening protocols could miss important visual impairments, they may result in greater overall detection because testing is more widespread. Screening tests are evaluated in comparison to diagnostic tests.

Evidence and interpretation

The divergence of UK and US reports both recommending preschool vision screening but with different target population and testing protocols can also be traced to different approaches to reviewing evidence and formulating recommendations. In the absence of conclusive direct evidence, review groups have used various approaches to appraising indirect evidence and formulating evidence-based recommendations (see Appendix 2). The UK National Screening Committee reviewers adhered more closely to a standardized set of criteria- and evidence-requirements based on the pioneering 10 principles first put forward by Wilson and Jungers for the World Health Organization for evaluating universal screening programs. The criteria applied requires quality screening studies before proceeding with universal screening programs because of the ethical obligation to offer a proven intervention when offering services to an apparently healthy population.

While the screening principles adhered to by the UK review groups are evident in US review processes, US reviewers were prepared to formulate interim recommendations that go beyond the available indirect evidence from existing studies. That is, though all the links between testing at younger ages and vision outcomes were not conclusively demonstrated through research, it was thought that practice variation was confusing and led to unwarranted under-testing in the preschool population. The US environment has been characterized by the range of disparate recommendations on preschool vision screening. US review groups may have been influenced by their environment, where vision testing may be mandated by state legislation on the basis of the more limited evidence requirement that untreated visual deficits in school-age children interfere with academic performance.

Recommendations of professional associations

The recommendations of professional associations and other non-governmental organizations that have an interest in preschool vision screening are generally intended to guide routine clinical practice and not the implementation of a system wide screening program (Appendix 3). Professional associations rely more on expert consensus than systematic reviews of research evidence. Without a transparent consideration of research evidence, appraising recommendations is difficult.

Extending preschool vision screening in British Columbia

The baseline or 'no change' position is the current ad hoc screening/case finding/diagnostic testing by various providers. Current practice is further described within the report. Four additional options for universal preschool vision screening were considered. Each of these options requires the provision of information to make the provincial standards of testing and reimbursement transparent for professionals, parents and the public. Coordinated efforts to streamline testing and referral could also be provided and could include monitoring program success. The costs of supporting a systematic approach to vision screening would be comparable across the following four options.

Option 1: Fortify existing vision care (with or without adopting a systematic screening program)

There is a lack of good information on current practice. A focus on preschool vision screening implies that children with obvious problems or at risk are currently receiving optimal care. If this is not the case, then opportunities to direct scarce resources to where they could make the greatest gains may be lost. There is evidence from BC that there are barriers to vulnerable children having adequate support and access to vision care. This could be remedied by operational and more formal research to better understand referral pathways and barriers to access, if any. A data-driven quality improvement approach could then involve clinical and administrative leaders in the development and implementation of a change process that could include, but would not be limited to, screening. The complex human resource, administrative, information systems, and communication and public relations implications of improved vision care for preschoolers warrant an active change process. A draw back of this approach is that additional resources could fail to have an impact, given the demands on the system in its entirety and the challenges of system change.

The evidence that data-driven quality improvement approaches are effective is not specific to preschool vision screening. While there is evidence of gaps in vision care, as well as evidence of an increased association of vision problems in children from minority and low-economic status communities, there is not evaluative data from Canadian settings. Vision care

algorithms have been developed in Nova Scotia for diabetic vision testing. This type of evidence synthesis could be useful for standardizing preschool vision care. Quality improvement approaches may engender less resistance and uncover simple means of improving quality, the solutions and their resource implications are not clear at the outset. Implied are added costs of convening and supporting a quality collaborative.

Option 2: Primary screening by public health nurses with secondary referral to ophthalmology and optometry

Family physicians and public health nurses deliver much routine child health care throughout the province. Yet the primary health care team has not been systematically organized to provide universal preschool vision screening. There is much variation in practice and examiner skill. Public health nurses could administer standardized tests as part of coordinated preschool vision screening programs. This approach could take advantage of the infrastructure already set up for scheduled immunizations. As physicians also provide immunization in some areas, the program would include adjustments for local practice patterns.

Public health nurses administer preschool screening in many of the jurisdictions that have been the setting of research studies. These include Nova Scotia, New Brunswick and Ontario, as well as Sweden and the USA. Most recently, the Vision in Preschool Study found that trained nurses applying a set of standardized tests can detect 90% of important conditions in children aged 3 to 5. Given that the primary care system achieves an immunization rate approaching 95% in BC, nurses may provide the greatest access to eye exams for the preschool population. Screening by nurses is part of global budgets for child health clinics, and therefore Canadian jurisdictions were not able to provide detailed cost information. This approach builds on existing health care infrastructure and supports primary care reform initiatives deemed critical to system sustainability. Additional costs would include the added costs of increased staffing, training and coordination.

Option 3: Screening by technical or lay examiners

A formal and standardized program of preschool vision screening could conceivably be staffed with non-medical non-vision technical staff. Orthoptists have typically been the providers who undertake vision screening in the UK, since they traditionally worked with children with strabismus. In Canada, there are currently too few orthoptists to handle the volume and coverage that universal screening implies. A combination of orthoptist and other trained technical personnel, such as opticians, ophthalmology or optometry assistants, or even lay persons with experience with children could be trained and hired into the primary health care system or an aligned program.

This model would require the oversight and expense of more highly trained and paid public health nurses, although the costs of technical staff would be less. Integrating this level of staff into the current delivery system implies the greatest change, and therefore greater effort to achieve. Evidence of the effectiveness of this approach arises from research from UK and Germany, which base their programs on orthoptist examiners. The VIP study found that even lay persons could perform as well as nurses and licensed vision professionals, and so the challenges are organizational.

Option 4: Comprehensive exams by optometrists in lieu of screening

Optometrists are doctors of optometry who are found in independent private practices throughout the urban and many of the rural areas of BC. Optometrists provide more comprehensive eye examinations than generally implied by screening. An annual optometric examination up to age 18 is currently reimbursed by BC Health Insurance; however, no more than 15% of eligible preschool children are currently tested by optometrists. The endorsement and/or referral from primary care staff and other government sources would likely be critical to successful increase of optometry exams in lieu of a formal screening program.

There is no precedent for universal optometry testing of preschool children (before school start) or rigorous evaluative research. Detection of visual impairments among those actually tested comprehensively would likely approach 100% -- up from 90% with best practice screening. On the other hand, if uptake is not significantly increased through greater social marketing, then there could actually be less testing and detection of unsuspected amblyopia in preschool children. Achieving better population coverage is likely key to reducing population prevalence.

Programs which use comprehensive optometry testing–like those mandated in the US at school entry and the Alberta pilot project–achieve wide coverage, but only of children at the very upper range of the preschool ages. While a large number of problems can be identified at school entry, the trend in Canada has been to discontinue school vision screening, since the indirect evidence points to the improved effectiveness of detection at younger ages and public health budgets become overburdened.

An optometry-led approach implies that the costs of developing, staffing and maintaining standards of a formal screening program would not be drawn from the global health region budgets. The fee-for-service rate is $44.84; therefore, a rough estimate of the cost impact of providing for 40,000 children is $1.8 million. Since there are about 40,000 preschool children in each of the 3, 4 and 5 year age cohorts, this estimate implies only one test per child during the preschool years. Currently, total billings are $1,084,673 for about 25,206 tests, which includes testing for suspected problems and yearly tests for some.

Optometrists are also implicated in the other three options, as the group that currently provides the most eye exams because of the scarcity of ophthalmologists. Any increase in preschool vision screening would generate more referrals for follow-up with comprehensive optometry examinations.

Conclusion

This report has identified and reviewed the major recent recommendations based on systematic reviews of research. The evidence base contained therein is identified. This evidence indirectly supports preschool vision screening while acknowledging the significant gaps in knowledge. Current practice and professional recommendations are also presented and the range of discrepancies identified. Building on the strengths of the current and evolving infrastructure suggests four options that could further vision care for preschoolers in British Columbia. The advantages, limitations and cost implications of each are considered. They are not mutually exclusive – a blended approach may be best for achieving optimal vision care.

Table of Contents

Executive Summary ..... **i**

Table of Contents ..... **vii**

1.0 Report Overview **1**

1.1 Scientific uncertainty and practice variation 1

1.2 Objectives 1

1.3 Scope 1

1.4 Out of Scope 1

1.5 Rationale 1

2.0 Essential concepts **2**

2.1 Conditions: 'Underused' and 'misaligned' eye 2

2.1.1 Amblyopia (Underused eye) 2

2.1.2 Strabismus (Turned eye) 4

2.1.3 Refractive errors (near/far-sightedness) 5

2.2 Systematic approaches to detection 6

2.2.1 Screening vs. testing vs. case finding 6

2.2.2 Tests used for vision screening 6

2.2.3 Providers and other stakeholders 11

3.0 Major Recommendations and their evidentiary basis **16**

3.1 Recommendations based on systematic review evidence 16

3.2 The Evidentiary base 16

3.3 Recommendations of professional organizations 20

4.0 Practice variation **20**

4.1 Other Canadian Jurisdictions 20

4.2 International preschool vision screening programs 23

4.2.1 Sweden and Israel 23

4.2.2 United Kingdom....24

4.2.3 Germany....24

4.2.4 USA....25

5.0 The Options for Extending Vision Testing in British Columbia....26

5.1 Baseline: The current ad hoc system of preschool vision care....26

5.1.1 Fee for Service Coverage of Annual Comprehensive Eye Exams by a Vision Professional....26

5.1.2 Primary care: Physicians and public health nurses....27

5.1.3 Identification of obvious or suspected vision problems without formal screen....27

5.1.4 Referral of all preschool children for a comprehensive eye exam....27

5.1.5 Health information provision....27

5.1.6 Limited screening based on historical programs....28

5.1.7 Discontinued vision screening programs....28

5.2 Option 1: Fortify the current vision care system (with or without formal screening)....29

5.2.1 Description....29

5.2.2 Potential advantages and drawbacks....31

5.3 Option 2: Public health nurses conduct screening....32

5.3.1 Description....32

5.3.2 Potential advantages and drawbacks....32

5.4 Option 3: A new role for technical staff or lay examiners....33

5.4.1 Description....33

5.4.2 Potential advantages and drawbacks....33

5.5 Option 4: Full optometric diagnostic eye examinations in lieu of screening....34

5.5.1 Description....34

5.5.2 Potential advantages and drawbacks....34

5.6 Summary of approaches....35

5.7 Limitations of the analysis....38

Appendix 1. Preschool vision screening recommendations based on systematic reviews ..39

Appendix 2: Interpretations of the evidentiary basis of preschool vision screening in major reviews 42

Appendix 3: Preschool vision screening recommendations of professional or voluntary associations 51

1.0 Report Overview

1.1 Scientific uncertainty and practice variation

Scientific uncertainty contributes to the considerable variation in preschool screening programs across British Columbia, Canada and globally. Practice variation ranges from ad hoc testing by a mix of health care professionals to legislatively mandated and standardized vision screening requirements as a condition of public school entry (Kentucky). Despite advances in scientific understanding, questions remain about how vision develops normally, how deficits develop in years before the ocular system has fully matured and how to effectively intervene.

1.2 Objectives

To review recent research on vision screening effectiveness in preschool children

To outline alternative scenarios for extending access to vision screening in BC with linkage to research and BC specific utilization data

1.3 Scope

This report summarizes collected research synthesis and BC data. Policy alternatives for expanded access to vision screening in preschool children under age 6 years are outlined with a focus on those conditions that have the greatest potential to impact learning and social development in order to give children the best possible start as they commence school years.

1.4 Out of Scope

At risk children: premature with developmental disorders. It is assumed that these children will already be receiving the care that they need.

Routine clinical examinations of newborns and toddlers by general practitioners and nurses that generally include observation of eye structures and corneal light reflexes.

1.5 Rationale

The BC Government has committed $19 Million over 3 years to improve the visual function for children under age six as part of an early childhood screening program announced in March of 2005. The goal is to develop a systematic approach that will ensure that children receive early and appropriate intervention and treatment for problems that affect a child's ability to participate as they enter the school system. Supplemental to this endeavor is this summary of the available research and utilization data to facilitate program implementation.

2.0 Essential concepts

This section contains a primer on the essential concepts required to discern the underlying issues, approaches and evidence pertaining to preschool vision screening for early detection.

First the conditions that screening seeks to detect are presented along with remaining areas of scientific uncertainty about their natural history (the understood course of each as a medical condition) and pathophysiology. Screening is distinguished from diagnostic and case finding strategies. Next the tests that are employed in screening programs are introduced along with statements about the limitations of current comparative research. Finally the various occupational groups that have played a role in vision screening and who may play an expanded role in the future are outlined.

The case for vision screening in preschool children is based primarily on the anticipated benefit of early detection of amblyopia (under used eye) and a related condition, strabismus (misaligned eye). Both conditions are common in children under age 6. By the time children start school; a window of therapeutic opportunity to prevent or ameliorate these serious types of visual impairment may have passed, lending urgency to the need for earlier detection.

2.1 Conditions: 'Underused' and 'misaligned' eye

Both the lay and scientific definitions of the conditions that preschool vision screening seeks to detect are provided in this section. There is a hazard of oversimplifying these complex disorders for the public, thereby obscuring the biological complexity and scientific uncertainty underlying debates about vision screening. Understanding has evolved as evidence from biological and clinical sciences accumulates; therefore, older understandings are being superseded. Informing the public about vision care is critical to enrolling them in improved provincial preschool vision screening strategies, information needs to be up-to-date. Given the recent scientific focus advances can be expected.

The short, medium and long-term consequences of failing to identify the array of visual deficits in preschool children is not well understood. Severity for each is on a continuum. Some minor conditions do not require treatment. Severe and obvious deficits will be identified and treated without screening. Rigorous research using broad measures of health, learning, employment and social development is required to better estimate the impact of screening in terms of consequences averted. To date this is a major gap in the research knowledge base.

2.1.1 Amblyopia (Underused eye)

The public is increasingly being exposed to definitions of amblyopia in which the importance of the development of the visual system is central:

> Normal vision develops with regular, equal use of the eyes. Amblyopia, commonly called "lazy eye," occurs when one eye is not used enough for the visual system in the brain to develop properly. The brain ignores the images from the weak eye and uses only those from the stronger eye, leading to poor vision.(1)

If not treated, the brain eventually loses the ability to perceive in that eye, even though the eye itself is undamaged. The importance to the developing visual system of both eyes being used in a balanced, coordinated way is central to the case being made for preschool screening. Amblyopia is the most important condition for preschool vision screening because

of the opportunity for early correction that may be lost as children age and visual impairment becomes 'hard wired'. Treatment involves stimulating the weak eye by obstructing the vision of the stronger eye by covering it with a patch or using a special eye drop. This is termed 'occlusion'. In describing the research on the natural history of amblyopia, Bassett and Forbes describe the 'sensitive period' for amblyopia reversal as follows:

> With impaired binocular vision, the brain ignores images from the rival fields of the misaligned eye and depends solely on the image of the corrected eye. If sensory deprivation lasts long enough during sensitive developmental stages, cortical development will be delayed or may not adequately occur. The most important observation taken from studying treatment consequences is recognizing the presence of a "sensitive period" for amblyopia reversal.
>
> The literature has long contained a notion of a "sensitive period" in which the visual system is considered particularly in need of parallel image input to develop cortical visual structures and awareness. Amblyopia requires treatment prior to the development of ocular reflexes. Thus the time of greatest need to treat amblyopia is believed to be within the first 2 to 3 years of age, especially from 3 months to 3 years. However the risk of amblyopia developing remains until full visual potential and stability have been achieved, generally by 5 to 6 years of age. It is generally believed that amblyopia is rarely acquired after 7 years of age.(2, p. 6)

A recent review paper on the normal maturational sequence for fusion (both eyes converging on the same image) and stereopsis (depth perception) concluded that: "The functional organization of the maturing visual system appears to be maximally sensitive to disruption by abnormal visual experience during the first months of life, but susceptibility continues until at least 4 years of age."(3, p. 369)

Whereas amblyopia can be simply defined as "a clinical condition characterized by decreased vision in one or both eyes without detectable anatomical damage either in the eye or the visual pathway,"(2, p.1) Simons cautions that emerging research is revealing that amblyopia is actually more complicated:

> Amblyopia can no longer be adequately characterized taxonomically as simply a visual acuity defect. There are a variety of dysfunctions or deficits involved that appear to be independent of each other, including not simply the traditional anisometropic[1], deprivation vs. strabismic distinction, but visual vs. motor-based deficits, different forms of contrast loss-based (or a more general "visual sensitivity") deficit, "second order[2]" deficits, and temporal/motion-based deficits Whether these various deficits are all equally efficaciously treated by the same therapy is not well studied. One report found occlusion to improve function in the amblyopic eye on some measures and reduce it on others.(4, p. 149)

There are clearly still many gaps in scientific understanding of amblyopia. Interpretation of existing studies of amblyopia remains difficult because vague definitions of the condition have not led to the standardization needed for rigorous evaluation of population

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[1] Anisometropic refers to a difference in the refractive power between the two eyes

[2] First-order deficits are those related to the attribute of luminance or light intensity and second-order to texture attributes.

prevalence/incidence and treatment effectiveness. These remain as challenges to designing evidence-based early detection strategies. As better research using more sophisticated research tools becomes available more traditional ways of understanding amblyopia will require revision in this rapidly moving field.

How many children have amblyopia? The estimates range from 1 to 5% depending on the definition and study protocol which produced the estimate. Based on a rigorous review of research the USPSTF estimates that in children under age 5 the prevalence of amblyopia is 2.9% to 3.9% and the prevalence of all vision deficits including refractive errors is 7% to 8.2%. (5) Some cases that can be defined as amblyopia with low threshold definitions may be minor and not generally treated. Important for estimating the impact of screening are those cases that if undetected are likely to suffer significant adverse health and related outcomes.

What is the impact of undetected amblyopia? Another important question for evaluating preschool vision screening is how many children will be spared health, academic, employment and social impacts if and only if their amblyopia is detected early. There are not high quality estimates of this. Adults in whom amblyopia was not detected or treated often adapt to their lack of stereovision and therefore measurable impact may be negligible on standard indices. Where adaptation is not possible is in high functioning activities like competitive sports and more difficult when vision is lost in the non amblyopic eye later in life.

2.1.2 Strabismus (Turned eye)

The condition of strabismus or misalignment of the eyes is related to amblyopia and therefore there may also be a 'sensitive period' after which permanent visual loss may occur without early intervention. The BC Health Guide provides this lay explanation for strabismus:

> Strabismus is a vision problem in which the eyes are misaligned, meaning they do not both look at the same point at the same time. For example, while one eye looks straight ahead, the other may turn the wrong way (deviate), looking up, down, in, or out. … When the eye muscles do not work correctly, the eyes may become misaligned and the brain may not be able to merge what the misaligned eyes see into a single image. The immature visual system of a young child (typically under the age of 6) handles these conflicting images in varying ways. For example, the brain can ignore (suppress) the image from one eye [resulting in amblyopia], thus avoiding the confusion of receiving two images. …Once the visual system in the brain is fully developed, however, such adaptations are not possible.(1)

Correcting strabismus when it is distinct from amblyopia may involve strategies directed to restoring muscular alignment including glasses, exercises, injections to relax eye muscles or surgery. The major categories of strabismus are esotropia (eyes turn inward), exotropia (eyes turn outward) and hypertropia (one eye is pointed more upward). In addition to improved vision the cosmetic benefits of correction provide valued social benefits for children.

While strabismus is a 'cause' of amblyopia, the cause-effect relationship may be more complex. There is evidence that strabismic amblyopia is a different and more severe condition and treatment less effective as compared to amblyopia related to refractive differences between eyes (anisometropic amblyopia).(4) There is conflicting evidence as to whether to first correct amblyopia before surgical correction of the strabismic misalignment of esotropia (cross eyes).(4, p. 132) As research advances, the better understanding of these

interrelated conditions and their effective treatment will produce an evidence base that can better inform early detection strategies.

Emerging research on the development of normal fixation of both eyes (necessary to achieving binocular vision) will likely be important to better understand strabismic amblyopia.(4, p. 124) Investigation into the development of binocular vision 'suggests that the eyes begin life fixating independently… However, an interocular neural competition for synaptic space in the primary visual cortex in early visual development means that there remains a vulnerability to establishment of a monocular-dominated state.'(4, p. 124) The 'characteristic distortion' of the visual field that is found to occur in strabismic amblyopia may result from images that are under sampled like the course grain of peripheral vision, scrambled or diplopia-like or double.'(4, p. 124) This type of emerging understanding of the pathophysiology of strabismic amblyopia may lead to more effective therapeutic responses.

2.1.3 Refractive errors (near/far-sightedness)

Refractive errors like nearsightedness and farsightedness, while common and important to school aged children, are of lesser importance than amblyopia and strabismus to preschool vision screening. This description of refractive errors illustrates this by explaining them as natural variations:

> When light rays entering the eye meet in front of or behind the retina rather than directly on it, this is called a refractive error. A refractive error results in blurred vision. Normally, light rays are bent (refracted) by the cornea and lens and focus directly on the retina, the nerve layer at the back of the eye, which results in clear vision. In most cases, refractive errors represent a natural variation from normal vision and are not considered a disease.(1)

The imperative for school aged children to have corrected refractive errors like farsightedness that interfere with learning to read and write is universally accepted. A UK report on preschool vision screening however disputed their importance in preschool vision screening:

> Pre-school screening for refractive errors and non-obvious squint, without associated amblyopia, does not seem to be justified since these conditions do not appear to be problematic by themselves and their treatment at an asymptomatic stage has not been shown to confer benefit.(6, p. 9)

US researchers have also questioned whether children with 'normal' vision are being prescribed eye glasses unnecessarily:

> Of 102,508 preschool children screened, 890 children did not have amblyogenic factors (false-positive screenings). Nevertheless, spectacles were prescribed for 174 (19.5%) of these children. Only 5/272 children (1.8%) were prescribed glasses following examination by a pediatric ophthalmologist, while glasses were prescribed for 24/205 children (11.7%) examined by comprehensive ophthalmologists and 145/413 (35.1%) of children seen by optometrists ($P < 0.001$).(7, p. 224)

To contribute a layer of complexity and perhaps confusion to the preschool screening debate, one of the major types of amblyopia is anisometropic amblyopia (amblyopia with refractive differences between the two eyes). Correction of refractive errors in anisometropic amblyopia can sometimes lead to reversal although this has not been conclusively demonstrated through controlled trials.(4) Here is another area where emerging research will likely advance clinical understanding and response. Amblyopia classification issues should not obscure preschool

vision screening debates however as screening tests used to detect amblyopia would arguably identify cases of anisometropic amblyopia for referral.

2.2 Systematic approaches to detection

2.2.1 Screening vs. testing vs. case finding

In reviewing the evidence pertaining to preschool vision screening, it is useful to keep in mind the distinction between screening, testing and case finding.

2.2.1.1 Screening

Screening approaches use simple tests intended to detect a possible problem and refer for full testing. Screening is typically intended to be universal, that is, applied to the entire population of preschool children al though universally targeted screening can also be done. The target subpopulation is then identified on the basis of easily applied criteria. Screening does not need to be done by vision professionals and does not result in a definitive diagnosis. Screening can be defined as "the examination of asymptomatic people in order to classify them as likely or unlikely to have a disease".(8, p. 499)

2.2.1.2 Vision testing

Comprehensive diagnostic eye examinations involve a more complex series of vision tests than those used for screening. Comprehensive testing protocols are performed by optometrists and ophthamologists to diagnose a suspected problem. In general diagnostic eye examinations are not universally applied but done as a follow-up to a screening test or because of a concern raised by a parent or provider. An accurate diagnosis is required for treatment. Diagnostic tests are also used in research as the standard against which screening tests are evaluated (see below).

2.2.1.3.Case finding

Case finding or ‘opportunistic screening’: Case finding implies that a provider initiates screening at a time when they are seeing a child for other reasons. The provider may be aware of risk factors for amblyopia such as family history or maternal history of difficulties during pregnancy and delivery that they take into account in deciding to screen. The provider could also initiate an automatic referral for testing and skip the screening test altogether. Case finding strategies are not standardized and are therefore difficult to evaluate.

2.2.2 Tests used for vision screening

The ability of preschool children to cooperate with screening manoeuvres varies with age and literacy. Vision screening in preschool children therefore requires special tests, testing strategies and training for providers. A wide variety of tests have been used, however the lack of good data on test parameters hinders the development of standardized screening protocols that are the foundation of a population-based screening approach. Screening children under 3 years of age when the visual system is undergoing critical development and therefore at a time of therapeutic opportunity challenges providers of care and researchers.

In addition to checking the appearance of the eyes through observation, common screening tests for preschool screening are variations of the visual acuity test for amblyopia and the cover test for strabismus and a depth perception or stereopsis test that may reveal either.(2)

2.2.2.1 Visual acuity tests

Vision acuity tests examine the sharpness of central vision for detail as is required for reading. The Snellen is the classic single optotype [letter] wall chart in which lines of letters in diminishing sizes are read with one eye and then the other to measure the smallest recognizable figure. This test is suitable from ages 5 to 6 years onward and so currently there is a search for better tests for preschool children at widely variable developmental stages. There are many commercial tests that have been adapted for preschool children. These tests do not require mastery of the alphabet and are more likely to engage. For example, the Snellen Illiterate E chart requires only that children indicate which direction the letter E is facing. The Stycar HOTV system uses a response card with the letters HOTV that a child uses as an examiner points to a wall chart. Breaking away from letters are charts like the Sheridan Gardiner that ask children to match shapes. Lea Symbols charts use a circle, a square, a house, or an apple and have been found to be easier for 3 year olds.(9)

Bassett and Forbes report that tests for amblyopia alone (HOTV or E charts) generally have high specificity (> 95%) and low sensitivity (30%) (2, p. 13) This means that 95% of the time the test will be correct when the result indicates no amblyopia (5% false negative rate) and 30% of the positive tests will correctly identify a case of amblyopia (70% false positive rate). Therefore using a visual acuity test to screen for amblyopia means that you will miss a lot of cases. The question has yet to be settled on the basis of a body of evidence as to which of the plethora of commercial tests produces the highest sensitivity and with which examiners (See Section 2.2.2.5).

2.2.2.2 Stereopsis tests

Stereopsis tests help to detect amblyopia. They evaluate the depth perception provided by two eyes working in tandem to distinguish the relative distance and physical displacement between objects. Children look at pictures through polarized glasses in tests like the Random Dot E test. Embedded images – such as a floating “E” – are only revealed if the child has binocular vision. Younger children are asked to tickle the wings of the fly for the Titmus stereofly test. There are many other commercially available tests of stereoacuity such as the Random Dot Cube which does not require polarized glasses because all visual clues provided cannot be interpreted with just one eye i.e, monocular vision. The Fisby, Lang I and II, Randot and Worth dot are other available tests. Again a consensus has not emerged on the relative worth of the various tests.

2.2.2.3 The Cover/uncover test

Cover /uncover tests are a very simple way to check for strabismus. The child is asked to focus on an object while first one eye then the other is covered. A misaligned eye will move to focus on an object when the non-strabismic eye is covered. Research on test performance has not confirmed the usefulness of this test

2.2.2.4. Photoscreening technology

There are many commercial varieties of photoscreening tests with more technologies appearing on the market every year. Photocreeening produce images of the eye structures and require little active cooperation on the part of young children. Images are analysed to detect patterns suggesting abnormalities which are considered to be risk factors for amblyopia such the misalignment of strabismus. Interpretation is automated with some of the available technologies while others require examiner interpretation. Professional associations have not endorsed photoscreening. For example, the American Academy of Pediatrics committee on practice and ambulatory medicine made this recommendation following their review:

> Photoscreening needs to be studied more extensively. The AAP favors additional research of photoscreening devices and other vision screening methods in large, controlled studies to elucidate validity of results, efficacy, and cost-effectiveness for identifying amblyogenic factors in different age groups as well as subgroups of children. The goal remains to eliminate preventable childhood blindness and treatable visual disability.(10, p. 525)

2.2.2.5 Best practice in preschool screening

Recent efforts to address the issue of which tests to use in preschool screening programs are illustrative. In 1999 Kemper undertook a systematic review of vision screening tests for the detection of amblyopia to help primary care practitioners select a strategy. The author concluded that '[t]he available data help the primary care provider only minimally. We recommend the evaluation of vision screening tests in primary care settings using a standardized ophthalmologic examination.'(11, p. 1222) The review revealed that:

> Despite the great number of screening tests available, this systematic review found only 1 high quality study of traditional vision screening and 3 of photoscreening. None of the 4 studies took place in primary care settings using usual screening procedures, and thus generalization of these articles to the primary care setting is difficult. Furthermore, each article used a different ophthalmologic examination standard to evaluate the screening test, making comparisons across studies challenging….(12, p. 1221)

The dearth of good evaluative research hampers efforts to make evidence-based decisions about preschool screening. A multidisciplinary[3] Taskforce supported by the National Eye Institute of the US National Institutes of Health made interim recommendations on a screening protocol in 2000. The report emphasized that "recommendations are conditional and not based on adequate validation data, since such data are not yet available."(13, p. 1108)

Since 2003, the Vision in Preschoolers (VIP) Study also sponsored by the National Eye Institute has started to publish the results of "multi-phased, multi-center, interdisciplinary, clinical study… [undertaken] to determine whether there are tests or combinations of tests that can be used effectively to determine which preschoolers would benefit from a comprehensive eye examination to detect amblyopia, strabismus, significant refractive errors, and associated risk factors."(14, p. 1) The 1000 plus preschoolers age 3 to 5 enrolled in the

[3] The task force included researchers studying early visual development, clinicians (pediatricians, pediatric ophthalmologists, and optometrists),various professionals with direct experience in vision screening in the United States and other countries, biostatisticians, epidemiologists, and health care economists'

VIP Study annually are also enrolled in the 'Head Start' program for low income families which provides a variety of services including health screening programs.

The first phase of the study determined the test parameters of 9 commercial and 2 traditional screening tests (cover/uncover test and retinoscopy) when they were performed by ophthalmologists and optometrists. With the specificity set at 90%[4] (90% of the time the test will identify amblyopia if present) the tests were 'approximately equivalent' however the following four tests had the highest sensitivity: noncycloplegic retinoscopy[5] (64%), Retinomax autorefractor[6] (63%), SureSight Vision Screener[7] (63%), and Lea symbols visual acuity testing[8] (61%).(15) (14) Nurses and lay examiners were able to achieve comparable test performance sensitivity using this set of tests minus retinoscopy but including the Stereo Smile II test.[9]

The advantage of this study is its rigor and independence from the commercial proponents of the testing technologies provided by NIH funding. This provided the relative performance comparisons that are relatively rare.

Are these results generalizable to the BC population? The generalizability is limited by the requirement of both low income status and enrolment in a government sponsored program for children from low income families. The study population is not therefore representative of all children in the relevant age groups and the program not representative of the practice conditions in BC. Furthermore, given that vision deficits may be higher in children of low socioeconomic status(16) and that populations with higher prevalence of impairments are more likely to provide the better test parameters, the findings are likely to be better than could be achieved in routine practice. Finally, there are many more studies examining preschool vision testing parameters that would have to be synthesized to provide a definitive statement on best practice.

Two studies of screening test parameters illustrate the efforts to identify their performance characteristics and feasibility for application in younger age groups. The results are promising. Nova Scotia program developers found it 'impossible' to administer their a preschool screening testing protocol for 4 to 5 year olds in the younger 3 to 4 year age group.(17) Public health nurses therefore applied a modified screening strategy using Lea symbols for visual acuity testing and Frisby plates.[10] They found they could lower the reliable

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[4] The number of 'positive' cases that a test identifies depends in part on how rigorous the standard is for case definition. As this cut-off can be selected, a specificity of 90% can be chosen.

[5] Noncycloplegic retinoscopy is the examination of the retina at the back of the eye performed without dilating the pupil.

[6] An autorefractor is a computerized screening test that identifies errors of refraction such as nearsightedness, farsightedness and astigmatism.

[7] Also automates testing of refractory error.

[8] These test visual acuity with symbols rather than letters.

[9] A measure of stereoscopic vision / depth perception.

[10] Frisby plates are series of glass plates which contain an indepth target that can only be seen with stereovision. They have been in use for over two decades.

screening age by 13 months from 4 ½ years (54 months) to approximately 3 ½ (41 months): "In children <41 months old, the screening test NPV[11] was 90%, specificity, 68%, and sensitivity, 75%. In comparison, children >/=41 months old had screening test NPV of 96%, specificity, 95%, and sensitivity, 50%. The authors advise that the "test's simplicity allows easy use by non-eye-care professionals."(17, p. 225)

In Sweden where vision testing targets 4 year old children, researchers investigated whether vision screening is possible for 3 year olds.(18) In a study which compared the HVOT with the Lea Symbols chart they found the tests produced comparable results in either age group. The positive predictive value was lower at 3 years (58%) vs 75% at 4 years reported in the literature. The testability rate was about 10% lower at 3 than 4 years though most children were able to 'cooperate well'.(18)

Legislatively mandated screening programs in the US ensure that the market for testing equipment will continue and so the technology sector will continue to attempt to develop better and more automated alternatives to add to the current array of choices. New technologies for preverbal children include wave-front analysis[12] and a visual evoked potentials-based screening tool.(19) Although visual evoked potentials (VEP) technologies have been around for decades, recent research claims comparable test parameters in children as young as 6 months.(20) How well these newer technologies will perform in relative efficacy and cost effectiveness trials is unknown. The opportunity to deliver a test with acceptable test performance in the under 3 years of age groups (during the sensitive period during which treatment is arguably easier and more effective) will continue. The limitations of adequately tested screening strategies will ensure that debates about the optimal screening strategy will undoubtedly persist and best practices in preschool vision screening testing continue to evolve.

2.2.2.6 Diagnostic eye examinations

Simple screening tests do not diagnose vision deficits but serve to direct referral to more comprehensive testing conducted by optometrists or ophthamologists to rule out or diagnose diseases and disorders of the eye. Preschool vision screening is primarily directed towards a narrower range of visual impairments – amblyopia, strabismus and refractive errors. Screening test are evaluated by research that tests all the children in a sample with both screening and diagnostic eye examinations. Cases incorrectly classified by the simpler screening test are identified and these statistics are used to determine the false negative and positive rates. In addition to simple tests of acuity, alignment and refraction, diagnostic testing could include more invasive and potentially harmful testing procedures like testing intraocular pressure or using pharmaceutical eye drops to dilate the pupils. Other technological assists to diagnosis include fundoscopy to examine the fundus at the back of the eyeball or a slit lamp to examine structures toward the front. Pediatricians and ophthalmologists also test the 'Red Reflex' and 'Corneal Light Reflex'. These are not neurological reflexes but are examinations of how light reflects from the retina of the eye when observed with an ophthalmoscope and the symmetry of reflection on the translucent cornea at the front of the eye. These types of examinations are unsuitable as simple screening

[11] NPV = negative predictive value, which means the change in likelihood that a child has normal vision ('true' negative) given a negative test

[12] Provides more accurate information on refractive error.

tests but provide comparison for evaluating screening test parameters as well as allow optometrists and opthamologists to diagnose the full array of visual impairments.

2.2.3 Providers and other stakeholders

There are a number of occupational groups who could conduct vision screening testing or follow-up testing. In British Columbia the Health Professions act regulate health care providers.

2.2.3.1. Medical specialists (M.D.s)

Ophthalmologists and pediatric ophthalmologists are fully qualified medical doctors with a post medical specialization in the diagnosis and treatment (may include surgery) of diseases and injuries of the eye. Pediatricians who specialize in the medical care of children also have an interest in preschool screening. In British Columbia, all physicians are regulated under the Medical Practitioners Act [RSBC 1996] CHAPTER 285 which has designated the College of Physicians and Surgeons of British Columbia (CPSBC) as the governing body. To practice as an ophthalmologist or paediatrician in BC requires qualifications that are accepted by the provincial registrar of the CPSBC.

Ophthalmologists see themselves as leaders of the vision care team. This policy statement about the role of ophthalmologists was produced by the Canadian Ophthalmological Society:

> All evaluations that purport to diagnose eye disease should be carried out by a physician. An ophthalmologist is a doctor of medicine who specializes in the diagnosis and treatment of disorders of the eye, in addition to diagnosing systemic disease when manifest in eye signs or symptoms…
>
> For the ultimate benefit of the public, a clear distinction should be made between a diagnostic eye examination and an examination for the purpose of refraction. A diagnostic eye examination involves the practice of medicine and requires the highly specialized training of a physician. A refractive examination involves the taking of measurements from the visual system, which is simply a data-gathering procedure and involves no medical expertise.(21)

This statement suggests that children testing positive on a preschool vision screening test be referred to an ophthalmologist for follow-up and treatment. Currently in BC there may be too few ophthalmologists to conduct timely follow up exams for all cases that a universal screening program could generate and to provide access to preschool children wherever they are located. Pediatricians routinely test vision and produce clinical practice guidelines for testing vision in children.

2.2.3.2 Primary care physicians and nurses

Primary care physicians are relatively more numerous in British Columbia than ophthalmologists particularly in rural BC and provide routine health care to preschool children. As the primary care system undergoes renewal, there would appear to be a larger role for these medical doctors to play a role in earlier detection of visual defects. Nonetheless this group of providers does not appear to be as engaged with preschool vision screening, nor is it equipped, trained or organized to lead preschool vision screening at the present time. If Canadian practice patterns follow those in the US then many preschool children get no vision examination though they are in routine contact with the health care system. Castanes reports

that 80% of American preschool age children never get an eye examination and that low income, minority, uninsured children are at high risk of not being screened.(16)

Public health nurses could likely undertake an expanded role in preschool vision screening in BC as they have done in the past with school screening programs. Registered nurses in British Columbia are baccalaureate trained and currently provide a variety of services like hearing screening and immunizations to the relevant age groups in services organized regionally. The results of the VIP study(22) and the Nova Scotia study(17)(14) support the use of nurses in screening programs.(22)

2.2.3.3 Doctors of optometry (O.D.s)

Optometrists are doctors of optometry who "examine eyes to diagnose vision problems and ocular disease (disease pertaining to the eye). They prescribe and fit eyeglasses and contact lenses and recommend treatments, such as exercises to correct vision problems or ocular disorders.(23) Being much more numerous than ophthalmologists in British Columbia optometrists are actively seeking to expand their professional scope of practice. There were 402 optometrists in active practice in British Columbia in January of 2005 (http://www.optometrybc.com)

Optometrists are regulated in BC under the Health Professions Act. To practice in British Columbia, optometrists must have completed a Doctor of Optometry degree, passed a provincial board examination and be registered with the BC Association of Optometrists. Canadian optometry programs are located at the University of Waterloo and University of Montreal. Training involves two years of university level science followed by a four year professional program. The Canadian Association of Optometrists defined the optometry as follows:

> Doctors of Optometry are independent primary health care providers who examine diagnose, treat and manage diseases and disorders of the visual system, the eye and associated structures, as well as diagnose related systemic conditions. (http://www.optometrybc.com/)

There is considerable overlap in the type of examinations and corrective treatments offered by ophthalmologists and optometrists. Both groups prescribe corrective lenses used in eye glasses. Optometrists also have a legislative mandate to claim the right to undertake vision testing. The act currently sanctions the following practice scope:

> Practice of optometry
> 33 Any one or any combination of the following practices constitutes the practice of optometry:
> (a) investigation of the functions of the human eye by diagnostic drugs in accordance with the rules made under this Act and by test lenses, test cards, trial frames and other instruments or devices designed for that investigation;
> (b) prescription or adaptation of lenses, prisms or the use of orthoptic instruments of any kind to improve or correct the visual function, or to adapt the visual function to the requirements of a special occupation.(24)

2.2.3.4 Dispensing opticians

Opticians are licensed through the College of Opticians of BC to fit eyeglasses and contact lenses in accordance with the Health Professions Act. In British Columbia regulatory changes

in the Act permitted opticians to use automated measurement of refractory error to obtain the correction necessary to dispense eyewear thereby bypassing the vision testing that was standard care when opticians required a prescription from an ophthalmologist or optometrist. The BC Association of Optometrists and College of Physicians and Surgeons both opposed the changes to the regulation of opticians arguing that eyesight could be compromised in the long run if important pathologies were missed. Likewise, the availability of photoscreening technology similarly raises concern that automated sight testing of preschool children could miss important visual and systemic conditions that could compromise child health.

The Opticians Association of Canada have expressed an interest in expanding their practice into preschool vision screening as part of community outreach programs conducted in easy-to-access venues such as shopping centres and libraries.(25) The success of a pilot program conducted by the Opticians of Manitoba for school-aged children is provided as precedent. The job description and qualifications of opticians seem to be at odds with this role however. Opticians are described on the College of Opticians of BC to consumers as follows:

> Opticians are highly trained, non-medical eye care professionals who design and dispense eyeglasses, contact lenses, low vision aids and prosthetic ocular devices for B.C. customers. Registered opticians also educate and advise consumers about product choices that will provide maximum visual acuity. All practicing Registered opticians in B.C. must be registered with the College of Opticians of British Columbia and have met educational and examination standards (http://www.cobc.ca/index.html)

Work futures BC distinguishes between vision examination and measurements for the purposes of fitting eyewear:

> Unlike optometrists or ophthalmologists, opticians do not examine the eyes or vision. Instead, they read the prescription to check for completeness and to obtain lens specifications. They measure the customer's eye curvature, distance between pupils and width of the bridge of nose using a keratometer and other optical measuring devices.(23)

The training of opticians is at the community college level. In British Columbia, Douglas College offers a 1-year certificate in Dispensing Opticianry - Eyeglasses and a two-year diploma in Dispensing Opticianry - Contact Lenses. Northern Alberta Institute of Technology offers a two-year Dispensing Optician distance education course for students employed with a licensed optician. Graduates are then eligible to apply for the licensure required to practice in BC.(23)

The Opticians Association of Canada support their case for involvement in preschool vision screening using the US VIP study on screening tests administered by trained nurses and lay people which concluded that nurses and lay screeners can provide comparable sensitivity. (22) The 15 lay screeners in the study had years of experience working with young children and at least high school level education.(22) Whereas opticians are comparable to the VIP Study screeners educationally their licensure does not imply a comparable level of experience with young children.

2.2.3.4 Orthoptists

Orthoptics is branch of vision care that was traditionally involved with therapeutic vision training programs, for example, for children with strabismus who have problems with binocular vision. In British Columbia, orthoptists:

> …assist ophthalmologists in the diagnosis and treatment of eye disorders. They perform specialized eye tests to measure and assess defective binocular vision or abnormal eye movement in patients. They educate patients about proper visual habits and prescribe treatment, such as eye exercises or other visual training.
>
> An intensive, 24 consecutive month orthoptic training program is offered by the Orthoptic Clinic at the B.C. Children's Hospital in Vancouver. Two students are accepted into the program every second year. **…**Graduates must write the exam administered by the Canadian Orthoptic Council to become certified. …Currently there is no regulatory body for orthoptists, and licences are not required in order to practise… In Canada only about 10% of orthoptists are men… (23)

The role of orthoptists in an expanded preschool vision program in BC will be constrained by their numbers. There are no more than 15 orthoptists employed in BC with about 10 in the lower mainland, two on Vancouver Island, one in Kelowna and one in Terrace. With so few people graduating in BC these numbers are unlikely to rise quickly. Whereas UK recommendations favour the use of orthoptists in preschool screening programs, orthoptists are more numerous in the UK therefore the favourable research findings and recommendations may not be reproducible in BC.

2.2.3.4 Ophthalmic assistants and technologists

Ophthalmic assistants and technologists also assist ophthalmologists. With approximately one year of training under the supervision of an ophthalmologists and a home study course, Ophthalmic assistants may operate ophthalmic testing and measuring instruments to assess vision and vision fields and to test for diseases. Ophthalmic technologists do much the same work as orthoptists.(23) They are not regulated.

2.2.3.5 A Child-centred approach

Children and their parents have the greatest stake in optimal preschool vision care. The public requires information to discern the best care available for their child and determine how to access services. A systematic provincial approach with web-based information for parents and accessible electronic records would support a coordinated approach to information dissemination.

There is evidence from British Columbia that not all families will be able to access the information and services children require. A study conducted by Clyde Hertzman, Director of the Human Early Learning Partnership of BC, University of British Columbia demonstrated this:

> [O]ur mapping of kindergarten vision screening, at age five, showed a ten-fold gradient across neighbourhoods in the proportion of children who need referral to a specialist for vision problems. The high-risk neighbourhoods were also those at high developmental risk. In other words, children with vision problems in more privileged neighbourhoods were being identified earlier. Thus, the evidence of effectiveness of public health screening simultaneously underscored the prospect that a much higher proportion of children in high-risk neighbourhoods were not getting timely access to services that could remove important barriers to their early development.(26, p. 6)

In the BC context, many of the areas with the highest proportion of children under age 5 are in non urban areas.(27) This is also away from areas of concentration of vision specialists.

Everyone has a stake in a healthy society. Increasingly early childhood development and its support are being looked at broadly by researchers. Children and their families are embedded in families, schools, communities and society at large.

> Decisions made in one sector can have a profound influence on the effectiveness of other sectors in assisting in child development. For instance, when regional health authorities decide to eliminate kindergarten screening for hearing, vision, and dental problems, they may do so on the understanding that such services are not central to their mandate of patient care. However, the repercussions for the school system, and for the long-term health, well-being, and competence of the children affected, may be significant. (28)

Researchers like Hertzman put forward an argument for support of early childhood development that goes beyond screening and surveillance:

> The challenge we face is mobilizing and sustaining the basket of programs, services, and societal changes that will support healthy child development. Thus, for example, although proposals such as universal newborn hearing screening are well understood as health system issues, access to play spaces that allow children to use their large and small muscles are equally issues in healthy child development that health authorities must confront in partnership with those who are responsible for parks and recreation. In this sense, healthy child development requires the same kind of strategic approach that anti-smoking initiatives have taken, with much success, in recent years. In BC, the decline in adult smoking rates from 60% to 18% was achieved by a 'basket' of strategies; from individual programs to help smokers quit, to taxation/cost strategies, to regulation of public spaces, to attempts to downgrade the cultural image of smoking. The success of this approach sets a positive precedent for healthy child development. (29, p. 2)

Likewise there is a case that optimal vision care for preschool children needs is supported by public policies that foster healthy child development. On the other hand, the majority of children with visual impairments will not be from high risk neighborhoods because these make up a smaller proportion of all neighborhoods in BC. The challenge for developing preschool vision screening policy which addresses the needs of all BC children is to take both circumstances into account.

3.0 Major Recommendations and their evidentiary basis

In this section contemporary recommendations are examined. Points of both agreement and disagreement are noted. Next the review processes and evidence drawn on are examined to identify where the evidence is adequate and gaps that indicate areas of uncertainty for policy making.

3.1 Recommendations based on systematic review evidence

Recommendations on preschool vision screening have been produced by numerous scientific, professional and governmental organizations. Appendix 1 presents prominent and recent recommendations based on systematic reviews. They are of particular interest in the British Columbia context being from countries with similarly organized health care systems.

What is remarkable about recent recommendation on preschool vision screening all claiming to be based on research evidence is their variability. In 2004/20055, a UK multidisciplinary committee recommended universal screening between ages 4 and 5 to be lead by orthoptists.(30) The US Preventive Services Task Force which makes recommendations for primary care physicians came out with a B recommendation for screening in the under age 5 group to detect amblyopia, strabismus and visual acuity defects acknowledging a lack of direct evidence.(5) An extensive 2005 literature review revealed that multivariate screening for amblyopia "using continuous-scale measurements may be more effective than traditional single-test dichotomous pass/fail measures."(4, p. 123)

In 2002, an Australia review group found there was insufficient evidence to recommend for or against preschool visual acuity testing.(31) Instead a recommendation was made that visual acuity screening be replaced by comprehensive assessments when children are identified with learning or behavioural problems. In 2001, the American Public Health Association also encouraged a regular comprehensive eye examination schedule at age 6 mo, 2 and 4 years as opposed to screening(32). A 2001 Canadian statement based on a UK report advised that preschool vision screening could not be recommended based on research evidence and that parent be given full and accurate information for their decision making.(33) The 1997 UK report produced by the Health Services Research Unit at University of Oxford advised that the ethical basis for preschool screening was very insecure.(34)

The range of recommendations calls for a closer examination of the evidence basis in support of these recommendations.

3.2 The Evidentiary base

The 1995 health technology assessment report conducted in British Columbia at the request of the Public Health Department of the former Victoria Capital Regional District concluded that: "controlled trials have not established that children detected through any vision screening program are ultimately better off because of the screening effort. Instead, evidence of testing validity and treatment efficacy for vision screening can only be supported by indirect evidence."(2, p. 1)

In the 10 years since this topic was reviewed in a health technology assessment report conclusive and direct evidence on preschool vision screening has not appeared. The definitive randomized control trial (RCT) will probably not be conducted given the ethical implications of leaving vision deficits undetected and untreated in a control arm. Review groups have

therefore been left to 'mine' the wide and less rigorous research for evidence that indirectly supports a causal link between preschool vision screening and improved vision for school start and over the lifespan. Appendix 2 presents the interpretation of the evidence that has lead to the recommendations of major review groups.

Groups reported many deficiencies in the scientific base in support of preschool screening on the basis of systematic reviews of research evidence. Lack of knowledge makes program design difficult and is undoubtedly responsible for the wide variation in programming. The Australian report provides this overview of the difficulty of evaluating research on screening:

> The early detection of health and other problems in children is a worthy goal. At first glance the benefits appear to be self evident. It is not until one begins to systematically review the evidence for screening and surveillance, topic by topic, that the complexity of this endeavor becomes apparent.
>
> There is surprisingly little evidence for the effectiveness of screening programs in many domains (that is not to say that the corollary is true – for some, there is inadequate evidence for lack of effectiveness either). There are scant data about cost effectiveness. There are major issues of program quality, monitoring of compliance with referrals for assessment, and whether facilities exist in many communities for assessment and follow up. There are concerns that much attention is paid to the test or procedure itself and little to the main elements of a community-wide program. In some cases, there is little evidence that therapy alters outcomes… Finally there are problems with terminology, and the way in which terms such as "screening" and " surveillance" are used.(31, p. 4)

Even without direct RCT evidence of long term benefit, the case for early detection following preschool vision screening was compelling enough that, like the 1995 BCOHTA report, review groups made recommendations that in general are supportive of preschool vision testing. They were able to do this by examining indirect evidence against criteria for evaluating screening programs. Criteria have been adapted from the following 10 principles originally proposed by Wilson and Junger for the World Health Organization in 1968:

1. The condition sought should pose an important health problem.
2. The natural history of the disease should be well-understood.
3. There should be a recognizable early stage.
4. Treatment of the disease at an early stage should be of more benefit than treatment started at a later stage.
5. There should be a suitable test.
6. The test should be acceptable to the population.
7. There should be adequate facilities for the diagnosis and treatment of abnormalities detected.
8. For diseases of insidious onset, screening should be repeated at intervals determined by the natural history of the disease.
9. The chance of physical or psychological harm to those screened should be less than the chance of benefit.

10. The cost of a screening program should be balanced against the benefit it provides.(35)

A 1997 UK report that evaluated the case for screening against these principles reported that the ethical basis for screening was insecure given the dearth of evidence of benefit.(34) By 2005 the UK Child Health Sub-Group of the National Screening Committee (NSC) using an expanded version of these criteria recommended vision screening for 4 to 5 year olds by orthoptists.(30) The authors report was adamant stating that: "No other preschool vision screening can be justified".(30, p. 6)The report also recommended discontinuing the school screening programs that had been widespread in the UK once the new recommendations were implemented.

The 'highlights' of the report available online[13] indicates that the committee agrees that there is evidence that: 1) the condition is an important health problem; 2) the epidemiology and natural history of the condition are adequately understood; 3) that there is some evidence that the screening programme is effective in reducing morbidity; and 4) there is an economic case for screening 4-5 year olds vs. alternatively screening at 3-3.5 years and then again at school age. It is also reported that the NSC endorsed[14] a recommendation arising from the book Health for all Children that school vision testing programs be replaced with testing in the 4 to 5 year age group.(36) The NSC has a mandate to evaluate population based screening manoeuvres across the life span against a standard set of 16 criteria which are based on and extend the 10 Wilson & Junger principles (See Appendix 2).

Whereas the 20004 update of the US Preventative Services Task Force (USPSTF) does not make the same age specific and provider specific recommendations they did examined much the same evidence and used many of the same evaluation criteria.(5) The 2004 review is an update of a 1999 recommendation. A systematic review was conducted which produced evidence tables of recent evidence on the following key questions:

1. What is the prevalence of visual impairment in children through 5 years of age?
2. Do reliable, accurate, and feasible screening tests exist that can be used to detect visual disorders in children less than 3 years of age or in children between the ages of 3 and 5 years? These visual disorders include amblyopia, strabismus, refractive errors associated with amblyopia, other more rare conditions associated with amblyopia such as cataracts or ptosis, and refractive error not associated with amblyopia?
3. Do detection and treatment of conditions associated with amblyopia before amblyopia has developed lead to better treatment outcomes (primary prevention)?
4. Under what conditions is the treatment of amblyopia successful?
5. Under what conditions is the treatment of refractive errors not associated with amblyopia successful?

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[13] The full report was not available online and so it has not been possible review a detailed presentation of the research used for the May 2005 recommendation

[14] As reported by the National Electronic Library for Health Specialist Library on Screening.

6. Does improving vision result in improved health outcomes?
7. What are the adverse effects of screening?
8. What are the adverse effects of treatment?

How can the differences in recommendations be explained given that these sets of criteria appear to be compatible? The USPSTF was intended to inform as well as to be informed by the primary care professional societies as well as the US federal government. The health care systems are differently configured so for example, a population based perspective has greater currency in UK and Canadian policy making contexts. The USPSTF recommendations were not intended to lead to a systematic national program. It is noteworthy though that the USPSTF adopted the approach of the Canadian Task Force on Preventative Health Care (CTFPHC). The CTFPHC has not updated their 1994 recommendation.(37)

A prominent US ophthalmological researcher, Kurt Simons, Director of the Pediatric Vision Laboratory at Johns Hopkins University School of Medicine disagrees with the UK NSC interpretation of the available research. Simons 2005, who reports no proprietary or commercial interests in vision screening, has published a 43 page comprehensive expert narrative review paper supported by 580 research citations in the peer reviewed journal Survey of Opthamology.(4) In contrast to the focused, prospective and rigorous systematic review methodology developed by the Cochrane collaboration and emulated by other review groups, Simon's approach is less transparent.[15] Nonetheless, the arguments Simons makes are logical and supported by research. This is how Simons characterized the UK rationale:

> Thus, for instance, an advisory group in the United Kingdom has recommended discontinuing screening for strabismus and amblyopia in infants and children less than 4 years of age, while mandating it for all 4-5 year olds, based on the rationale of the greater accuracy of visual acuity-based screening possible in the older age group.(Rahi 2002; Rahi 2001) The success of a program in Sweden based on multiple early screenings in reducing amblyopia prevalence, and related findings (see section III.E.[16]), and the success of an early screening and prophylactic intervention program (section VII.A[17]), however suggest just the opposite, that maximally efficacious treatment is achieved through detection and treatment as soon as possible after amblyopia onset.(4, p. 129)

A more extensive excerpt from the Simons 2005 review is contained in Appendix 2.(4) Simons was a consultant to the US Preventative Services Taskforce for the 2004 recommendation and sat on the US National Eye Institute Task Force on Vision Screening in the Preschool Child that produced 2000 interim preschool vision screening recommendations. Both task forces acknowledge knowledge gaps and need for further research while at the

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[15] The author reports: "Literature was derived from the author's files, from broad searches of Medline (up to November 11, 2004) under headings related to esopropia, amblopia, anisometropia, child vision screening, perinatal, binocular fusion, emmetropization/ emmetropization, and, for older material, from library searches" <ref Simons 2005 p 154>

[16] This section of Simon's review is Subheading E "Age or amblyopiagenic duration?"under III "Variables affecting outcome"

[17] This ection of Simon's review is Subheading A "Accomodative esotropia"under VI "A better solution: prophylaxis"

same time endorsing preschool vision screening on the basis of indirect evidence and the likelihood that benefits outweigh harms.

Older reviews from the Australian Health and Medical Research Council, the American Public Health Association, the Public Health Research, Education and Development Program of the City of Hamilton in Ontario, Canada and the critical 1997 UK Health Services Research Unit at the University of Oxford all endorse various limitations of the knowledge base and provide a nuanced perspective on the difficulties of preschool vision screening. Appendix B provides excerpts of key discussions on evidence from the full reports.

3.3 Recommendations of professional organizations

Numerous professional organizations that have produced public recommendations on preschool vision testing. The variety and discrepancies contribute to the confusion in program configuration. Select recommendations are presented in Appendix 3. Whereas a logically argued rationale is generally provided, the evidence base of this type of recommendation is not transparent as with systematic reviews. Each professional association has a role in lobbying for the interest of their professional group's scope of practice to enhance though there is a fine line between providing public education and marketing. This is why professional associations prohibit direct advertising to consumers.

4.0 Practice variation

4.1 Other Canadian Jurisdictions

A number of jurisdictions responded to a request for information about their preschool vision screening policies.

Discontinuation: Saskatoon Health Region discontinued vision screening on the basis of their evaluation.

Public health: Public health nurses conduct preschool screening programs in Calgary and Regina health regions as well as Prince Edward Island, Newfoundland/Labrador, New Brunswick and Northwest Territories in community public health clinics that provide immunizations and other types of routine health care for preschoolers.

Various tests are used. Calgary uses an illiterate E test at 18 months and provides parents with a checklist of signs of vision problems along with the recommendation to have an optometry eye exam. Regina uses an HOTV or Random dot E test as well as a cover/uncover test at age 4. New Brunswick provide a battery of tests including HOTV and a Random Dot E test at 3.5 years as well as encouraging a full eye exam before school entry. PEI is still using the HOTV in children 5 to 4 ½ years but intends to replace it with the Lea Symbols test and intends the Random dot E test with the Frisby stereo test on the basis of recommendations arising from a recent review. In Newfoundland/Labrador Sheridan-Gardner tests and cover/uncover tests are used along with corneal light reflexes. The age at testing recently decreased from 4.5 to 3 and may change again to 3.5. Vision screening at 4-6 years in the Northwest Territories includes an illiterate E test or symbol chart and a stereoscopic fly as well as corneal light reflex and cover/uncover tests.

Nova Scotia has a screening program that has been supported by research conducted with the Department of Opthalmology at Dalhousie University. Chiu et al compared a modified

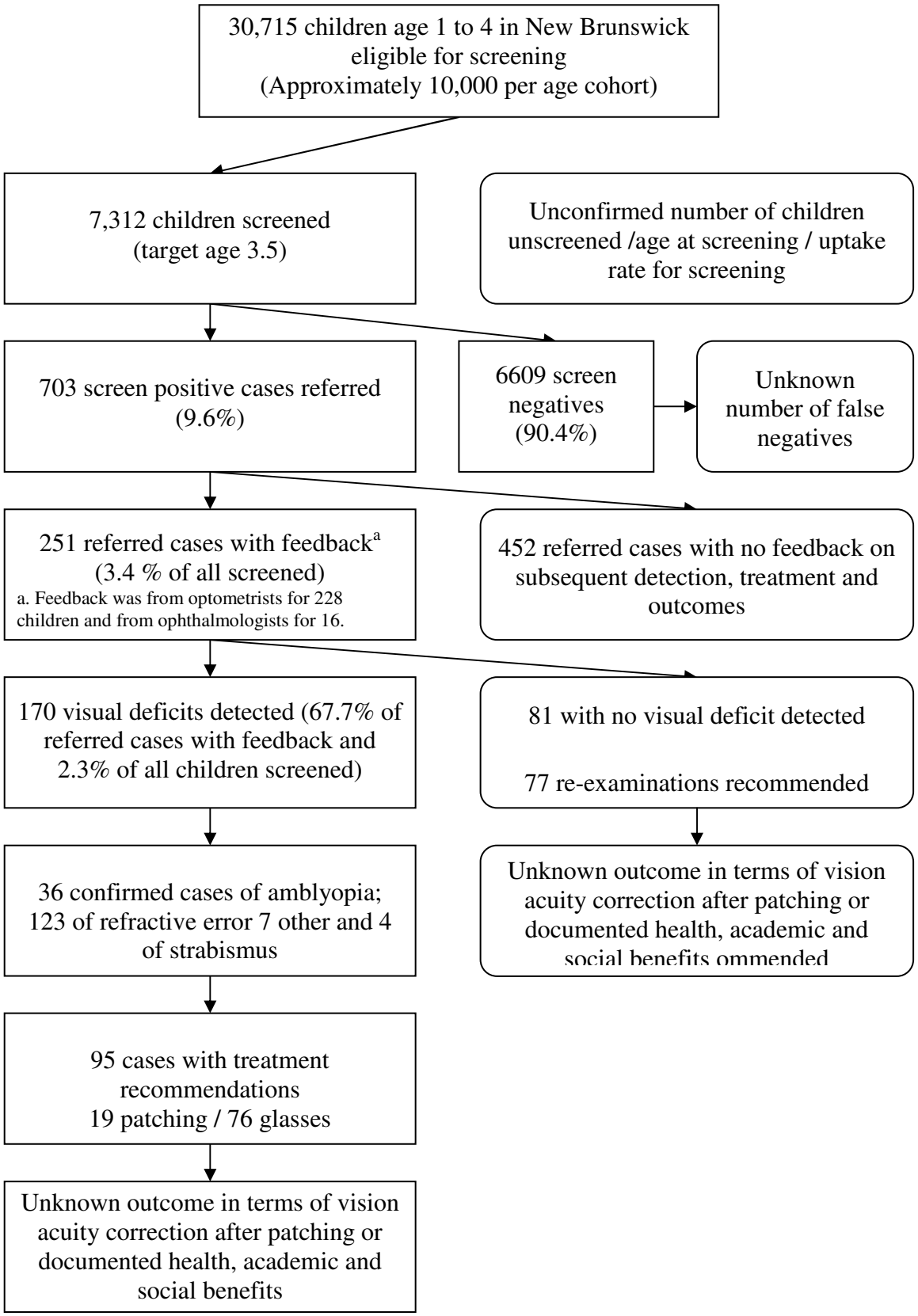
protocol administered by public health nurses over two summers with full orthoptic and ophthalmologic evaluations.(17) The test results of 178 children aged 3 to 4 years screened were used to calculate test parameters by age. The study found:

> In children <41 months old, the screening test NPV [negative predictive value] was 90%, specificity, 68%, and sensitivity, 75%. In comparison, children >/=41 months old had screening test NPV of 96%, specificity, 95%, and sensitivity, 50%.(17)

This study confirms that it is feasible to obtain acceptable screening test parameters using public health nurses in a systematic approach.

New Brunswick provided operational data of screening by public health nurses. The flow chart depicted in Figure 1 demonstrates the numbers of patients flowing through a screening program that could be expected in British Columbia if a systematic screening program was instituted. The problem with this type of data is that it doesn't reveal what happens to the children who are not screened, to those who screen negative, to those for which there is no follow-up after referral or results of treatment.

Figure 1. New Brunswick experience with preschool screening



Optometry: Like British Columbia, Alberta pays for an annual exam for children under age 19. In the 4 to 6 age cohorts, 30,207 exams were reimbursed for a total annual cost of 1.28 Million. Preschool vision screening does not appear to be on the primary care agenda in Alberta at the present time. The Alberta primary care initiative was started in 2004 and so this may be forthcoming.

Coordinated programs: The Alberta Association of Optometrists and the Ministry of Children and Education have partnered on a pilot program "Eye see…Eye learn" that provides optometry exams to school children at school start. It reports a detection rate of 25% of children with a visual problem with refractory errors being the most common. As this rate is much higher than the 5.5% reported in the literature for all visual problems, the 25% rate suggests a low threshold to qualify and therefore many 'problems' that may not require detection. The program receives sufficient government funding to support 2 full time coordinators. Even though the sensitive period for amblyopia has passed based on the period of most rapid development of the optical system, optometrist argue that amblyopia detected at school age is still treatable and the correction of refractive errors prevents the frustration and poor academic performance if poor vision becomes an obstacle to learning.

Provider attitudes in Ontario

A study set in Ontario surveyed optometrists, public health administrators, pediatric ophthalmologists, and orthoptists to reveal their general opinion on preschool screening, screening standards and practices, provider experience with preschool screening, and barriers. (38) The majority of respondents were no longer involved in preschool screening because of "lack of sufficient funding, public education, organization of screening, training, and government support." (38, p. 548) Overall the study found both support for structured screening programs but recommended they needed to be "structured, be supported, have quality control, and be evaluated". (38, p. 548)

4.2 International preschool vision screening programs

4.2.1 Sweden and Israel

In the absence of randomized controlled trials, studies of populations that have been exposed to organized and well documented preschool vision screening programs provide limited evidence of program effectiveness. Here is the USPSTF description of key evidence from Sweden and Israel:

> Prevalence rates of amblyopia in screened and unscreened populations. Sweden has an aggressive vision screening program, with repeat screening beginning with objective measures in infancy and extending to formal measures through 10 years of age. A retrospective cohort study found that by 10 years of age, the prevalence of amblyopia is 0.03%. This rate, which is much lower than the 3% rate found in the other prevalence studies, suggests that screening may reduce amblyopia. Similarly, a study in Israel found that the prevalence of amblyopia in 8-year-old children who received screening, including retinsoscopy, between 1 and 2.5 years of age was 1%, compared to 2.6% in an unscreened population.(5, p. 23)

What were the features of the screening programs that produced these results? One used physicians or nurses for examinations and the other ophthalmologists or orthoptists. Sweden has a national visual screening system from birth. Paediatricians provide a newborn

examination in maternity wards. General practitioners provide a 'general examination' of the 'ocular media and ocular alignment' at 6-12 weeks, 6 months, 18 months and 36 months. Nurses use HVOT charts at 3 meters at age 4 years at child health care centres. Surveillance continues through a school program.(39) It follows them that if BC were to implement nurse visual acuity screening combined with regular physician examination from birth to 36 months and adequate follow-up treatment, the prevalence of amblyopia to 0.03% might similarly be reduced by age 10.

The study from Israel was conducted in primary health care clinics where children receive basic examinations, immunization and follow-up care. Screening examinations were done, not nurses or physicians, but by ophthalmologists or orthoptists using rapid retinoscopy in addition to history, observation, cover/uncover tests in children between 1 and 2 ½.(40) If this practice approach were emulated in BC, the prevalence of amblyopia in school aged children might be reduced to less than 1%.

4.2.2 United Kingdom

UK policy makers have recognized the need for a national program of child health surveillance providing guidance on care standards to replace practices that have 'arisen haphazardly' and without rigorous evaluation.(41) An increased emphasis on "health promotion, increasing responsibilities of general practitioners, and reconsideration of the roles of health visitors[18] and school nurses" is envisioned within the UK national child health program.(41, p. 258)

Orthoptists have played a larger role in the UK than in Canada in providing routine vision testing in formal school vision screening programs. For example, in a prominent UK population based randomized trial conduced on a longitudinal cohort the control group was offered an orthoptic screen at 37 months compared with intensive orthoptic screening at 8, 12, 18, 25, 31, and 37 months. This study found that visual acuity improved by 1 line in the intensively screened group and that children in the control group were four times more likely to stay amblyopic. Current recommendations advise that preschool vision screening be conducted by orthoptists or by professionals trained and supported by orthoptists. The UK approach assumes a systemic approach using orthoptist staff ancillary to ophthalmologists integrated within the primary care system.

Evidence of low socioeconomic status connection--- (42-44)

4.2.3 Germany

A recent cost utility analysis from Germany used data from vision screening conducted by orthoptists. The age of kindergarten start in Germany is 3 years of age and therefore this analysis represents ages at the youngest end of the age range recommended by US but not UK evidence based review groups.(45) The study estimated an incremental cost-effectiveness ration of 7,397 Euros per quality-adjusted life year (QUALY) or about $11,000 CDN.(45) The analysis noted that the major piece of missing information that the analysis was sensitive to is the effect of amblyopia prevention on quality of life. People adapt to decreased vision in one eye may go on to lead lives of considerable academic, social and occupational

[18] A health visitor is a registered nurse with qualifications in obstetrics and midwifery, who visits new mothers and babies at home (www.babycentre.co.uk/glossary/H.html)

achievement. The analysis used expert assessments of the impact of amblyopia on quality of life as well as studies involving non condition specific estimates of visual impairment. The impact estimates therefore range through sensitivity analysis from as low as 0 impact with a 90% uncertainty interval to a high of 72,637 Euro/QUALY.(45) The authors argue that the case warrants decision makers attention.

4.2.4 USA

The USA has a patchwork of practice patterns over many jurisdictions with regards to preschool vision screening. Healthy People 2010, a set of national health goals, objectives, indicators and a database to facilitating tracking is intended to support improvement efforts across areas of priority. The 28th national goal which pertains to vision and hearing includes the objective of "increasing the proportion of preschool children who receive vision screening." (46, p. 425) A baseline was established using data from US National Health Interview Survey, National Center for Health Statistics and Centers for Disease Control Prevention. In 2002, it was estimated that 36 percent of preschool children aged 5 years and under had ever had their vision screened. A target of 52% was established. (http://www.healthyvision2010.org/exams/preschool.asp#data)

4.3.4.1 Kentucky

US states have used legislative power to mandate preschool vision screening. Kentucky was the first state to require a full optometric vision examination for all children on entry to the public school system. Published data on the first year of testing revealed that of the 5,316 children examined, 181 (3.4%) were diagnosed with amblyopia, 123 (2.31%) with strabismus and 44 other eye conditions. Corrective lenses were prescribed to 740 children (13.92%) with statistically more to children age 6 than younger children.(47) These percentages are greater than reported for BC by the First Check program pilot evaluation. Other states may follow. A state by state survey published in 1999 found that 15 states required vision screening for at least some preschool children while 34 states provided guidelines.(48)

4.3.4.2 US Charitable and advocacy groups

In addition to insured services, charitable groups in the US are also contributing to the move in the towards preschool vision screening. In the US Lions Clubs also may arrange for eye care professionals to conduct free vision screenings in hospital or health department settings. Some Lions districts have their own mobile van for vision screenings. The Lions Club website advised that children should have their vision tested at age three and provide information on the indicators of vision problems in children. Lions Clubs have a long tradition of been involved in fundraising and advocacy for the blind. (http://www.lionsclubs.org/EN/content/vision_services_screenings.shtml). Other advocacy group like Prevent Blindness America provide similar support.

5.0 The Options for Extending Vision Testing in British Columbia

5.1 Baseline: The current ad hoc system of preschool vision care

In the absence of a clearly dominant strategy for detecting vision deficits in preschool children, a variety of local strategies have been adopted. Public health is organized by regional health authorities in British Columbia. The major components of the current ad hoc approach are detailed below.

5.1.1 Fee for Service Coverage of Annual Comprehensive Eye Exams by a Vision Professional

A major strength of the BC system and many other Canadian jurisdictions is that the cost of an eye exam by an optometrists or ophthalmologists is fully covered by the BC Health Insurance plan. BC has had a longstanding policy of reimbursing both optometrist and ophthalmologists for an annual comprehensive eye exam for all children through age 18. This is not the case in the US where vision care advocates lobby for more extensive coverage by insurers.

BC optometrists see a relatively small proportion of the preschool population as Table 1 illustrates. Even if we assume that each paid service represents a different child then only about 14% of eligible preschool children had an optometry service reimbursed by the Medical Services Plan 2004/2005. Some of these billings represent children seen for follow-up of problems identified during a visit to the optometrists in a previous year and so 14% is an overestimate. The current billings also contain billings for examinations prompted by obvious deficits or signs of concern and therefore do not represent a screening population.

Table 1. Total optometry billings and paid services by age group for 2004/2005[a]

Age Group	Eligible for screening [b]	Paid Services	Billings
0-2	81,105	3,829	$163,793
3	41,238	6,154	$266,108
4	41,238	8,373	$360,538
5	46,786	10,679	$458,027
Total	210,367	29,035	$1,248,465

a) Calculated using a 15 month billing cut-off; b) Estimated using BC Population by Age and Gender, 1971-2004 (http://www.bcstats.gov.bc.ca/data/pop/pop/BCPopage.htm)

It may also be that those parents accessing services are better educated, informed and therefore of higher socio-economic status. There are not good BC data on who is accessing

services and whether utilization is for suspected or unsuspected problems. US studies report underutilization by families at higher risk for having children with visual defects by being of lower socio-economic status and therefore exposed to risk factors.(16) There is also evidence of decreased access to preschool screening in children from areas of 'lower socioeconomic grading' in the UK. (42-44)

Increasing uptake of optometric examinations is challenging. The First Vision Check was a pilot project initiated in 1998 by the BC Association of Optometrists and the BC Ministry for Children and Families in consultation with the former Vision Advisory Committee. Participating optometrists volunteered to provide free screening tests (no charge to parents or the provincial insurance plan) to 2 and 3 year olds. The endorsement of the public health care system was key to enrolling children in the First Vision Check program. Materials developed in partnership with the Communication Division of the Ministry for Children and Families included newspaper advertisements, press releases, letters of introduction to day care and provider facilities including first nation communities, desk cards for display by family physicians, health units and public places like libraries. Even so none of the 4 communities screened more than 25% of the eligible population during a 6 month period. (49)

5.1.2 Primary care: Physicians and public health nurses

Parents of preschool children access the services of the primary health care system in BC almost universally. Over 70% of BC children age 2 receive immunization as recommended by practice guidelines through the primary health care system. The system is made up of general practice physicians and public health nurses. Physicians are largely in group or solo private practice settings reimbursed by fee-for-service through BC Heath Insurance scheme. Public health nurses practicing in community clinics are funded and administered through the health regions. Doctors and nurses also provide many routine health care services to this age group. There has been no rigorous research on current vision care practice patterns for BC children. The following is a brief overview of current practices reported by key informant in health regions.

5.1.3 Identification of obvious or suspected vision problems without formal screen

Preschool children with obvious vision problems or family history of vision problems will likely have this problem identified by their parents, public health nurses or physicians at any age at which they appear at a public health clinic. Parents would then be advised to take the child to a vision professional for a comprehensive eye exam.

5.1.4 Referral of all preschool children for a comprehensive eye exam

In some BC jurisdictions public health nurses routinely advise parents to have children with ostensibly normal vision receive an eye exam from a vision professional – usually an optometrist. The age at which nurses report that this recommendation is offered varies from 1 ½ years, to 3 years to between 2 and 4 years.

5.1.5 Health information provision

Nurses in community clinics may provide parents with general health information that that contains advice on preschool vision screening: The BC Ministry of Health has 4 publications that inform parents about preschool vision testing. "Babies Best Chance: Parent's Handbook

on Pregnancy and Baby Care"; "Toddler's First Steps: A "Best Chance" Guide to Parenting Your Six-Month to Three-Year-Old" and "Child Health Passport" are available on the BC Ministry of Health website. (www.healthservices.gov.bc.ca/cpa/publications) These are being updated and reprinted to reflect the current ministry position and to ensure consistency with other publications and the BC Health Guide. Parent information does not typically provide a nuanced discussion on the limitations of the available scientific evidence.

5.1.6 Limited screening based on historical programs

Universal screening of kindergarten children by nurses and other lay examiners in the school system: One health authority continues historical vision screening programs in schools for kindergarten children and in outreach community programs that may include preschool children (like fall fairs).

Nurses in communities in which there are no vision professionals continuing to use screening tests: Public health nurses in small communities without access to vision professionals may still be administering screening tests to children they are seeing for other reasons.

5.1.7 Discontinued vision screening programs

Discontinued vision screening programs make up the background of experience with vision screening for children in BC that nurses, optometrists and physicians are familiar with. Even though Vision First Check has been discontinued some providers still believe it is continuing.

School age vision screening: Screening programs for school age children age 5 and older by school nurses that had occurred over decades in some jurisdictions in BC were largely discontinued in British Columbia in the mid 1990's to early 2000s. Personnel in health regions explain the stoppage of school vision screening with a three fold rationale: 1) lack of evidence of benefit; 2) insufficient resources to provide universal vision screening given other public health priorities; and 3) budget cuts.

Discontinuation of free eye screens by optometrists (First Vision Check): The First Vision Check pilot project that provided free screening exams to 2 and 3 year old children in 4 BC communities (Cranbrook, Prince George, Powell River, Sooke) has been discontinued. The BC optometrists were disappointed that the pilot was not extended and supported more through the public health system given that the pilot demonstrated increasing screening rates. During the years since the pilot results were published in 2000 (49) annual eye exams by optometrists for adults 18 to 64 were deinsured by the BC Medical Services Plan. Subsequently BC optometrists voted in their annual meeting to discontinue the First Vision Check program. With less pressure on the provincial funding envelop for optometry services there was less incentive for optometrists to provide free preschool screening tests.

The "Modified Clinical Technique"(MCT) was used as a screening test for 2 and 3 year olds in the pilot. (49) The MCT consists of a visual acuity test for 'illiterate' children (like Stycar), cover uncover test, retinoscopy, ophthalmoscopy and external inspection. Criteria for referral were specified. The MCT as a set of tests has some published evaluative data from the 1990s but does not appear to be currently under consideration for use in any jurisdiction.

The rationale for the First Vision Check program was that only 8% of 3 year old children were receiving eye exams by an optometrist or ophthalmologist, the available screening tests

were unreliable and school entry screening was being discontinued leaving a care gap. The purpose of the pilot was to determine whether higher numbers of 2 and 3 year olds could be tested with the First Vision Check program. (49)

An increase in testing rates was demonstrated: 4.7% for 3 year olds and 2.8% over the first 6 months. Uptake remained low however. The statistics for "Children Screened as a Percentage of their Age Cohort" ranged from 2.0% to 10.7% for 2 year olds and 9.1 to 25% for 3 year olds. (49) Of the 384 children tested in the Vision First Check, 4 (1.0%) were identified with amblyopia, 7 (1.8%) with strabismus, 31 (8%) with refractive errors (hyperopia or astigmatism), 7 (1.8%) with external ocular pathology. (49) Extrapolating this to an eligible 40,000 BC preschool children per year and doubling uptake to 50% implies roughly 200 children with amblyopia, 375 with strabismus and 1600 refractive errors would be identified. Some optometrists now believe it is confusing for the public to receive a screening test instead of a full eye exam from an optometrist.

5.2 Option 1: Fortify the current vision care system (with or without formal screening)

5.2.1 Description

Without adopting a province-wide screening program, the province could meet the mandate to: 'improve the vision function of children under age six' by fortifying the current ad hoc system. A focus on screening is based on the assumption that children with obvious problems and those most at risk are already receiving optimal vision care. If this is not the case then a focus on screening for subtle vision deficits in children with imperceptible vision problems could channel scarce resources to low risk healthy children while forgoing opportunities to make the greatest gains in high risk groups.

A description of this approach does not emerge from either the published research or experience of other jurisdictions but is based on a more generic approach to improving any type of care systematicly. A basic quality improvement approach would suggest a process involving key people in leadership positions who could develop and implement improvement strategies.

A. Gather baseline data to identify care gaps

There is little high quality data or analysis on vision care delivery in BC. The research on early childhood development in BC suggests that there are important gaps (See Section 2.2.3.5). A data driven quality improvement approach would developing an enhanced understanding of how well the current health care system is currently performing vision care for children under 6 years of age through primary data gathering. This could include the following analysis:

1. High risk infants (with a history of prematurity, neonatal use of O2, cerebral palsy and developmental delay) Are these children getting annual eye examinations? Are they tracked? Do we know where they live and whether vision testing is a component of their comprehensive care?

2. High risk communities i.e. low socio-economic status, isolate and rural communities. Do they have access to public health facilities, doctors, eye exams?

Do they have vision testing at school start? Do they get reading glasses if they need them?

3. High risk families: Is a history of amblyopia or strabismus identifying children for vision testing?

4. Referral pathways: Once a problem is identified are there any barriers to referral or follow-up?

5. Service adequacy: Is there sufficient and uniform access to comprehensive vision testing and follow-up treatment services?

This operational review could be complemented by a comprehensive study on amblyopia and strabismus in the province to determine age of diagnosis, treatment and visual and functional outcome. This type of investigation would reveal where children with visual defects are being missed (rural? poor? mild? high risk?).

B. Convene a collaborative of leaders to develop and implement a change process

Knowledgeable clinical and subject advisors could be convened to select, test, and implement change in care delivery. For example, a provincial vision advisory committee could be reconvened. A group like this could adopt one of many collaborative models to guide their processes like the popular PlanDoStudyAct approach.(51)

C. Potential areas to target for improvement

The survey of current practice suggests the following areas to consider and possibly target for improvement processes.

Human resources: Good human resource management practices are needed to establish clear roles and protocols after key decisions have been made about the parameters of a systematic provincial approach to vision screening. If a provider group is selected to administer vision screening it is still useful to think of all the available providers of vision care as part of a multidisciplinary team working together to improve vision care.

Administrative structures: Any systematic preschool vision screening needs to be integrated into the existing vision care system including secondary and tertiary levels of follow-up and care. For example, optometrists and physicians are considered primary care in that they may be the first contact for parents seeking eye care. Optometrists may also be considered secondary care in the context of a screening program that refers positive cases for comprehensive exams. Integration of vision care providers into primary health care teams could be done through increased information sharing including perhaps record sharing or shared care.

Information systems: Integrating vision examination data fields into emerging electronic records would support a systematic approach to preschool vision care. It may be feasible to build on immunization components under development. Ideally an electronic health record for BC preschool children would permit the tracking of the results of eye examinations, treatment and follow-up thereby making surveillance and alert functions possible.

Communications and public relations: Discrepancies in recommendations are potentially confusing for parents and could support or undermine uptake once a provincial strategy is

developed. These discrepancies are distributed in various media including child care information from BC government sources. This illustrates the importance of a coordinated communications and public relations strategy. As well a more sophisticated public may perhaps require a more nuanced discussion of the scientific evidence in support of recommendations.

Integration with policies to support early childhood development: Policy analysis suggests that relying only on health care to achieve health goals does not take into account the important impact of all the determinants of health that may affect children. The optimal development of vision includes factors that affect a woman's pregnancy and the family's ability to provide optimal child care.

5.2.2 Potential advantages and drawbacks

The main advantage of a fortified approach is that the system would prioritize and target resources to those preschool children with the most severe vision problems and/or those most at risk due to their medical, community or family circumstances. At risk preschool children are probably those for whom care can have the most impact.

The better information resources implied by a fortified approach would permit improvement strategies to be crafted with better knowledge of local circumstances. Information on actual practice patterns and barriers to care could provide a basis for future systematic and collaborative data collection.

A drawback of this approach is that the vision agenda and targeted resources could be overwhelmed and lost as part of routine care in the current approach because of the many demands on the whole system and the challenges of system change.

There does not appear to be a precedent for this approach to preschool vision screening. The evidence from early childhood development research in BC would argue for a broader and more multidisciplinary approach to supporting childhood health (www.earlylearning.ubc.ca). Research from the US also provides evidence of gaps in care for children generally and more specifically for children of low socio-economic status in accessing services and obtaining appropriate screening follow-up.(16)

The literature on successful implementation of quality improvements approaches in Canada, the US and UK support this approach. Nova Scotia provides the example of vision care algorithms developed to support diabetic vision screening.(52) This approach could be applied to vision care in preschool children.

Fortifying the current vision care delivery system builds on existing care infrastructure and personnel. Additional costs would be needed to convene leaders and develop information gathering and systemic solutions. All funding implications may not be obvious at the outset. A quality improvement approach engenders less resistance to change and better integration.

5.3 Option 2: Public health nurses conduct screening

5.3.1 Description

Systematized vision screening with tests could be conducted by public health nurses and physicians as part of routine child care visits and in child health clinics. A network of community clinics staffed by public health nurses are already in place throughout BC as part of community services under regional health authorities. Public health nurses could play a central role in systematizing vision screening through existing infrastructure. Nurses could 1) provide care directly as vision screening examiners; 2) supervise and facilitate clinics where screening tests are administered by trained technician or lay examiners; or 3) deliver an information /referral service directing the parents to ophthalmologists or optometrists.

5.3.2 Potential advantages and drawbacks

A major advantage of having preschool children screened within the primary health care system is that uptake rates are likely to be higher and therefore overall program effectiveness greater. Parents are already routinely accessing public health nurses services for immunization in the early preschool ages when treatment of amblyopia may be more effective and screening less accurate. Standardizing the ad hoc screening, case finding and referral patterns that are part of current practice patterns would ensure consistent care.

A second advantage of having public health nurses conduct systematized screening is that it supports primary health care renewal efforts. Reform is already in progress and therefore a coordinated screening program can build on the physical, administrative and human resource infrastructure in place. The coordination of screening efforts could include staff with designated coordination roles, staff training programs, the adoption and dissemination of screening standards, electronic tools and quality improvement processes.

A drawback of using nurses as examiners is that widespread training would be required to achieve the screening test standards comparable to those obtained in studies upon which recommendations rest. Given the need for training, it may be more efficient to use staff that are less expensive and/or who already have the requisite training.

Primary care physicians and public health nurses would appear to operating under conditions of limited capacity and so the additional demands of an expanded vision screening program would require either more staff with attendant costs or more efficient use of existing staff.

5.4 Option 3: A new role for technical staff or lay examiners

5.4.1 Description

A formal and standardized program of preschool vision screening could conceivably be staffed with non medical non vision professional staff. A combination of orthoptist and other technical vision related personnel such as opticians, ophthalmology or optometry assistants or even lay persons with experience working with children could be trained to do preschool vision screening and hired into the primary health care system.

Orthoptists are specifically trained in vision screening as well as in extending the efforts of ophthalmologists and so would be ideal candidates for formal programs. In theory at least it may be possible to recruit at least some of the orthoptists in practice in BC (<15) into the primary care infrastructure as trainers and/or examiners.

Use of orthoptists implies the oversight of more highly trained and paid ophthalmologist that orthoptists are trained to assist. Ophthalmologists are less available for preschool screening given their role as the most highly trained and scarce providers of specialized eye care. Under any option it is the ophthalmologists who would do the most sophisticated diagnostic testing, research and full range of therapeutic responses including surgical correction.

5.4.2 Potential advantages and drawbacks

The VIP study demonstrated that even lay persons perform as well as nurses in producing screening test parameters equivalent to that of vision professionals. The major advantage is the more efficient use trained personnel. The salary costs of technical and lay screeners are less and there is some evidence that they can screen as accurately as vision professionals given the requisite training and organizational support.

If it were possible to obtain the orthoptists needed to cover the needs of a provincial preschool screening program, the approach would be more efficient. Primary care physicians and public health nurses would appear to operating under conditions of greater demand than capacity. A completely orthoptist-led model would be difficult to reproduce in BC however given that there are less than 15 practicing orthoptists in the province. This is too few to administer all the screening tests that a systematic provincial program would require. The existing training program produces few graduates (not more than1 a year). Extending the program would take many years as so implementing this option would be limited by the dearth of orthoptists. The provincial experience with orthoptists in discontinued school screening programs that ran for a number of years in Vancouver was apparently positive and demonstrated the useful role that technical personnel could play.

5.5 Option 4: Full optometric diagnostic eye examinations in lieu of screening

5.5.1 Description

The preferred approach of the BC Association of Optometrists would be universal and comprehensive optometry eye examinations for all preschool children between ages 2 to 6 with age 3 as a target. The BC Medical Services Plan Optometry Payment Schedule will reimburse an annual full optometric diagnostic examination up to age 18. Referral from primary care physicians and public health nurses could increase testing uptake. Parent information and reminders could be integrated into primary care. Exams would be conducted primarily in private optometry practices but also conceivably in a number of other outreach settings such as day care centres over even community child wellness clinics.

5.5.2 Potential advantages and drawbacks

Optometrists are highly trained in vision examination and follow-up. The network of optometrists in BC is not as pervasive as the primary care network of physicians and public health nurses although certainly more extensive than ophthalmologists. Unlike screening tests, optometry exams are diagnostic. The false positive and negative test results that are the inevitable consequence of simpler and non diagnostic screening tests would not occur in as large numbers although given the challenges of the paediatric testing will likely still result in cases being missed.

The challenge is to provide coverage to a large enough proportion of the preschool population with diagnostic exams in order to have an equivalent or greater impact than population screening strategies. Screening tests miss more cases compared to diagnostic testing but may identify more cases overall if they are applied to a larger proportion of the population. While much of the population of BC is in close geographical proximity to an optometrist it is not clear how coverage would be achieved in areas that currently do not have easy access to optometry services. A provincial survey would be required to identify communities without access and develop remedial strategies.

Optometry practice standards for diagnostic examinations exceed the requirements of most screening protocols and so much of the same impact could be obtained by less costly personnel. Using universal optometry exams implies that the costs of a formal screening approach such as the expense of training examiners and coordinating care within the public health system would largely be forgone. Other resources would be required to integrate optometrists into primary health care system infrastructure by endorsing comprehensive testing in lieu of screening.

There is no research from the peer reviewed literature that supports this option. An analysis produced by Abt Associates puts forward a compelling argument that comprehensive eye exam are cost efficient compared to other accepted interventions in routine use. The authors acknowledge that the estimates of quality of life gains are not based on research but expert opinion. As well this analysis was paid for by the industry that has a commercial interest in promoting eye wear. The analysis was conducted for Vision Council of America, an organization with the explicit purpose of lobbying for eye care and expanding the use of vision care products within North American markets. (53)

The experience from other jurisdictions like Alberta and Kentucky do not directly apply to preschool screening generally as they pertain to testing required for school start at the upper range of preschool. The evidence is that many vision impairments are detected by these programs and that uncorrected vision is an impediment to learning. Still these approaches are not well supported by systematic research reviews or evidence based recommendations.

The resource implications of optometry billing to the provincial insurance plan are modest under current policies. One annual optometric exam for children with apparent normal vision is already on the BC fee schedule for children to age 18. The annual cost of reimbursing one exam is $44.84. The annual cost would be approximately $1.8 Million if each of the approximately 40,000 children per preschool age cohorts were tested once. Total current billings for optometric testing in ages 3 to 6 are closer to $1M ($1,084,673 for 25,206 tests). Under any approach of increasing the detection of preschool vision impairments, optometry services will increase due to the increase in referral for comprehensive examinations.

5.6 Summary of approaches

Four approaches are outlined to make distinct key differences in approaches that have been implemented in other jurisdictions or contexts. Table 2 provides a comparison to highlight supportive evidence from experience or research as well as areas that will impact resource utilization. Given that there is not conclusive evidence of the highest quality that formal preschool vision screening program improves long-term outcomes, no option emerges as dominant. While targeting well children will generate the largest number of cases there is also a risk of overlooking vulnerable populations including those with obvious problems but barriers to access.

The variety of providers, practice patterns, recommendations and information resources is confusing to parents who are trying to make the best decisions for their children. Each of the options outlined requires extensive communication and public relations support to increase testing uptake from the low baseline rates in the preschool age cohorts. This implies information provision to make the provincial standards of testing and reimbursement transparent for professionals, parents and the public. Implementing this option would require coordinated efforts to streamline testing and referral could include monitoring the success of the program. Information systems could support these requirements.

There are approximately 40,000 in each preschool age cohort that could be tested once or more in the target ages of 2,3,4 or 5 years. The optimal age to target screening varied in recommendations based on the evaluative framework used. At the younger age range, detection falls within a sensitive period of rapid neuro-development of the vision system. After age 3 this begins to slow and the visual system becomes less ‘plastic’. Along a spectrum as the age at detection increases treatment becomes more difficult and less effective but relative effectiveness evidence on test performance and treatment is better because the programs have been in place longer and measurement easier.

Looking at screening narrowly without taking the broad determinants of child health and health care into consideration may lead to vulnerable children continuing to fall through the vision care system. Research from the Human Early Learning Partnership (HELP) program, a multidisciplinary research consortium based in BC, indicates that children in high risk neighbourhoods have barriers to timely access. This type of evidence provides support for broad and multidisciplinary approaches to preschool vision screening policy development.

The question of the 'right' provider seems to depend on availability, the choice of comprehensive versus screening tests and the specific organization and resource base of the health care system. Although screening examinations are not as effective as diagnostic examinations they may reach more children and therefore do more good. If even lay persons can be trained to do vision screening as the literature suggests, then using highly trained vision and medical professionals to provide screening tests may not be necessary to achieve acceptable screening test parameters. Providing comprehensive eye examinations instead of screening tests is advocated by optometrists and implies more intensive use of highly trained and expensive personnel.

Table 2. A Comparison of four approaches to enhancing systematic vision screening in preschool children

Strategy	Supportive Evidence: Experience from other jurisdictions	Supportive Evidence: Research	Resource implications
1. Fortify existing vision care	None specific for vision screening as this approach has no precedent Canada / USA quality improvement process implementation Nova Scotia vision care algorithms developed	Little data on vision care in preschool children Evidence of gaps in care in BC and US literature for example, in follow-up after screening and accessing services for children of low socio-economic status	Builds on existing care infrastructure and personnel Additional costs of convening leaders, information gathering and solutions (unknown at the outset) May engender less resistance to change and better integration
2. Screening by public health nurses with referral to ophthalmology and optometry	Nova Scotia/ New Brunswick/ Sweden/ USA	Vision in preschoolers (VIPS) study Decreased prevalence in Swedish jurisdictions with longstanding screening protocols	Builds on existing care infrastructure and personnel Added costs of primary care nursing wages and training program Coordination costs including information system and social marketing materials
3. A new role for technical or lay examiners	UK/ Germany	UK Williams RCT and decreased prevalence VIP equivalence of lay examiners German cost utility analysis	Added costs of hiring technical staff and training program Coordination costs including information system and social marketing materials
4. Universal diagnostic exams by optometrists	Alberta and Kentucky at school entry	Abt cost utility analysis	Fee for service test costs of the examination Public health system may need to supplement optometry testing to provide universal access, coordinate referrals, communication and public relations

If detection and treatment in the under 3 years age group is more effective than the over 3 years age range as some of the clinical research suggests, then the optimal age range for detecting amblyopia could include even younger preschool children than either taskforce recommended. Simons, a prominent US amblyopia researcher has criticized the UK recommendation because the 4 to 5 year age range was based in part on evidence of greater test accuracy in older age groups. In his expert opinion starting treatment as soon as possible after amblyopia onset leads to the best outcomes. This suggests an argument for screening within a sensitive period that occurs in 2 year olds during the rapid development of movement that is coordinated with vision. Two year olds cannot readily participate with the available screening tests though. The available research base, systematic review and recommendations do not fully deal with this issue.

Also are compelling are arguments that support sustainable health care through primary care reform and broad policy development to address the determinants of child health that are not most effectively remedied through health care provision.

5.7 Limitations of the analysis

Good economic evaluations are not available to estimate the relative cost effectiveness of the various options for enhancing vision care in British Columbia. It would be useful to be able to compare the cost per case of visual deficit detected. When overhead and personnel costs are part of global budgets it is difficult to estimate the cost implications to the public health care system of implementing a systematic approach to preschool vision testing though it seems reasonable to assume that the marginal costs of producing additional units of output in the form of screening tests would be comparable to the costs of similar services currently provided.

In the absence of high quality clinical trials of preschool vision screening as an intervention the indirect evidence that must be reviewed is vast. This report has relied on the systematic reviews conducted to support major national organizations that make recommendation to guide policy development. The research is a fast moving target with new publications emerging continuously. This report has not undertaken a systematic review of primary research nor a comprehensive update.

Appendix 1. Preschool vision screening recommendations based on systematic reviews

USA Pediatric Vision Laboratory, The Wilmer Institute, Johns Hopkins University School of Medicine
Mar/Apr 2005 (Simons 2005)(4)

Amblyopia screening and treatment are efficacious, but cost-effectiveness concerns remain… Successful treatment can be achieved in at most 63-83% of patients. Treatment outcome is a function of initial visual acuity and type of amblyopia, and a reciprocal product of treatment efficacy, duration, and compliance. Age at treatment onset is not predictive of outcome in many studies but detection under versus over 2 - 3 years of age may be. Multiple screenings prior to that age, and prompt treatment, reduce prevalence. Would a single early cycloplegic photoscreening be as, or more, successful at detection or prediction than the multiple screenings, and more cost-effective?…There may be a physiologic basis for better age-indifferent outcome than tapped by current treatment methodologies…. Multivariate screening using continuous-scale measurements may be more effective than traditional single-test dichotomous pass/fail measures....

USA Preventive Services Task Force, May 2004 (5)

The USPSTF recommends screening to detect amblyopia, strabismus, and defects in visual acuity in children younger than age 5 years. (B recommendation[19])

USA, The American Public Health Association, January 2001 (32)

[APHA] Encourages a regular comprehensive eye examination schedule as opposed to just screening based on the onset of strabismus and amblyopia should be set, so that all children have exams performed at approximately age 6 months, 2 years, and 4 years;

Encourages all children's health insurance programs to provide vision care benefits.

Encourages health insurers to educate parents on the value of adhering to the comprehensive eye exam schedule through the use of health care providers, health education and health promotion professionals as an important part of preventive health care just as vaccination, physical exam, hearing, and dental exams are;

Encourages pediatricians to recommend all children receive exams which have the ability to detect all cases of strabismus, amblyopia, and refractive errors, and refer children at high risk including but not limited to children born prematurely, children with developmental deficits, and children with family histories of strabismus and amblyopia;

Requests all children's health programs require monitoring in their quality assurance programs to insure that young children's eye and vision needs are met.

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[19] A B grade recommendation is defined by the USPSTF as follows: The USPSTF recommends that clinicians routinely provide [the service] to eligible patients. *The USPSTF found at least fair evidence that [the* service] *improves important health outcomes and concludes that benefits outweigh harms.*

USA Maternal and Child Health, Bureau and the National Eye Institute Task Force on Vision Screening in the Preschool Child, 2000
(13)

Interim Screening Recommendations

The panel concluded its work by confronting the question of what recommendations should be made for preschool screening at the present time, before the research [outlined above] has been completed. Although a variety of recommendations have been published by various organizations5,24 (Table 1), the panel believed that the recommendations are inconsistent and, therefore, confusing. In particular, as shown in Table 1, different tests are recommended by different agencies with little guidance for the selection and implementation of the test.31 The panel, therefore, constructed a set of interim recommendations to detect amblyopia and amblyopiogenic factors using assessment of visual acuity and stereopsis (Table 2). The recommendations are more explicit with regard to the specific tests and methodology to be used than are previous such recommendations, to assist personnel responsible for undertaking screening. However, it should be emphasized that these recommendations are conditional and not based on adequate validation data, since such data are not yet available.

The recommendations are intended for use with 3- and 4-year-old children, since fewer than one half of 3-year-olds are screened in pediatric practices with current methods.32 The most direct way to detect amblyopia (monocular decreased vision) is to assess monocular visual acuity. For visual acuity assessment, the tests recommended are HOTV, Lea symbols, or tumbling E charts, because they allow screening of younger children (see Fig 1). Isolated optotypes with surround bars are also acceptable (see Fig 2). In addition, a testing procedure and passing criteria are specified. Stereopsis testing is included to detect strabismus as an amblyopiogenic factor. A specific test, the Random Dot E, is recommended (see Fig 3). Again the testing procedure and passing criteria are specified. (Further details of testing procedures can be found in the complete Proceedings from the Panel.24 All tests are commercially available.)

UK Child Health Sub-Group Report on Vision screening, National Screening Committee, May 2005 (30)
It is recommended that all children should be screened for visual impairment between four and five years of age. This should either be conducted by orthoptists or by professionals trained and supported by orthoptists. Once this programme is in place, the school entry vision screening programme should cease. No other preschool vision screening can be justified. (Screening for ocular anomalies at birth and 6-8 weeks should continue.)

Canada/ UK[20] Effective Public Health Practice Project, Public Health Research, Education and Development Program, City of Hamilton, Social and Public Health Services, 2001 (33)

The advantages of pre-school vision screening for minor vision conditions has not been demonstrated. Major vision defects are identified without screening.

Implications for Practice

Accurate and full information on the research evidence for screening and treatment outcomes must be given to parents having to make decisions for their children.

Implications for Policy

Preschool screening for both speech and vision cannot be recommended based on research evidence…

Coordinate and evaluate screening as a single program to improve efficiency and cost-effectiveness and to identify their interactive effects.

Areas of overlap in occurrence of conditions or risk factors may permit streamlining but no studies have produced such evidence.

UK Health Services Research Unit, University of Oxford, September 1997 (34)

There is a lack of good quality research into the natural history of the target conditions, the disabilities associated with them, and the efficacy of available treatments. We believe that this evidence is essential to support a screening programme for a non-fatal condition for which there have been no rigorously controlled trials. An invitation to preschool vision screening carries with it the implicit assumption that screening is going to benefit the child. In the absence of sound evidence that the target conditions sought in these programmes are disabling and that the interventions available to correct them do more good than harm, the ethical basis for such interventions is very insecure.

Australia Centre for Community Child Health, Royal Children's Hospital Melbourne for the National Health and Medical Research Council. March 2002 (31)

Insufficient evidence to make a recommendation for or against preschool visual acuity screening

Programs of preschool or school entry visual acuity screening should not be instituted. What to do when such programs are already in existence is more problematic. Further research into visual acuity screening is required (see Chapter 8: Summary of Further Research Recommendations). On the basis of current evidence, we suggest that in such cases there be community discussion and education. The aim should be to replace visual acuity screening programs with greater support for visual acuity evaluation as part of a comprehensive assessment when children are identified to have a learning or behavioural problem.

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[20] Based on systematic review by the NHS Centre for Reviews and Dissemination,University of York

Appendix 2: Interpretations of the evidentiary basis of preschool vision screening in major reviews

USA Pediatric Vision Laboratory, The Wilmer Institute, Johns Hopkins University School of Medicine, Mar/Apr 2005 (Simons 2005)(4)

Interpretation of much of the amblyopia literature is made difficult by: inaccurate visual acuity measurement at initial visit, lack of adequate refractive correction prior to and during treatment, and lack of long-term follow-up results.

"Older population studies (Köhler 1978; Vinding 1991) and prospective (Anker, 2002; Anker 2000, Harrad 2002; Clarke 2003; Eibschitz-Tsimboni 2000; Friedburg 1996; Kvarnström 2001; Kvarnström 1998; Lanttau 2002; Lannerstrand 1996; Ohlsson 2001; Richardson 2003; Williams 2002; Williams 2001) have demonstrated that amblyopia screening and treatment are in fact effective in terms of clinical outcome and in the sense of reducing amblyopia prevalence. A long-term (7-year) follow-up study demonstrated that even infant vision screening that did not include refractive evaluation had a substantially better positive predictive value than a variety of other pediatric screening measures, such as for hearing impairment, congenital heart malformations, and developmental hip dysplasia.(Juttman 2001; Kvarnström 2003; Lanttau 2002) (One recent prospective study that questioned the utility of treatment of milder forms of amblyopia did not report how its baseline screening acuity measurements were made (Clarke 2003) other than noting in a letter that "standard Snellen based screening tests" (Clarke 2004, p 7) were used. Because the patient sample was too young for Snellen chart acuity, isolated optotype Snellen E acuity is presumably referred to, which has the familiar problems of single-optotype tests (section III.I.) and makes evaluation of the study's crowded-test-based outcome results difficult. (For further comment, see references Bacal 2003; Bacal 2004; Clarke 2005; Dutton 2003; Harrad 2004; OBrien 2004; Srinivas 2004)

Nonetheless, the cost-effectiveness aspect of both screening (Barry 1998; Gandjour 2004; König 2000; König 2002; König 2002; Schlichtherle 2000; Simonsz 1992; Sireteanu 1993; Stewart-Brown 1998 and treatment (Beaucamp 1999) of amblyopia remains a concern in this era of competing demands on limited health resources and declining reimbursements. Several factors play into determining cost effectiveness; screening accuracy and participation (Juttmann 2001; Moseley 2003; Williams 2003), compliance with treatment (section III.D), efficacy at long-term follow-up (section III.B), and functional significance of amblyopia at a given level of visual acuity (König 2004) (section I.I). Thus, for instance, an advisory group in the United Kingdom has recommended discontinuing screening for strabismus and amblyopia in infants and children less than 4 years of age, while mandating it for all 4-5 year olds, based on the rationale of the greater accuracy of visual acuity-based screening possible in the older age group.(Rahi 2002; Rahi 2001) The success of a program in Sweden based on multiple early screenings in reducing amblyopia prevalence, and related findings (see section III.E.), and the success of an early screening and prophylactic intervention program (section VII.A), however suggest just the opposite, that maximally efficacious treatment is achieved through detection and treatment as soon as possible after amblyopia onset.

Another aspect involved here is the fact that "the total cost of treating amblyopia… is miniscule compared to that of most interventions for restoring vision for other ophthalmologic disorders" [289] An index based on the formula: (cost of treatment)/([number

of lines of visual acuity improvement] \x [number of years of life expectancy]) showed amblyopia treatment in children to be 44 times more cost effective than cataract surgery and 85 times more cost effective than macular hole surgery in adults. [443] However, arriving at a means of evaluating amblyopia treatment cost effectiveness more globally relative to other health care has to date proven somewhat problematic, heavily influenced by the assumptions made and algorithms used, [43 68 274 359] such as a model based on isolated optotype screening, [273] or analyses done from the perspective of third-party insurers. [274, 359] (The significance of the perspective chosen is illustrated in a study that found amblyopia treatment valued significantly higher by patients than by physicians. [43])

USA Preventive Services Task Force, May 2004(5)

The USPSTF found no direct evidence that screening for visual impairment in children leads to improved visual acuity. However, the USPSTF found fair evidence that screening tests have reasonable accuracy in identifying strabismus, amblyopia, and refractive error in children with these conditions; that more intensive screening compared with usual screening leads to improved visual acuity; and that treatment of strabismus and amblyopia can improve visual acuity and reduced long-term amblyopia. The USPSTF found no evidence of harms for screening, judged the potential for harms to be small, and concluded that the benefits of screening are likely to outweigh any potential harms.

UK Child Health Sub-Group Report on Vision screening, National Screening Committee, May 2005 (30)

Highlights of evaluation using standard criteria for screening[21]:

1. The condition should be an important health problem. YES

Vision defects include amblyopia (3% of children), refractive error (hypermetropia, astigmatism, rarely myopia), and strabismus (3-6%). Together the conditions are common, and although there is little evidence of the burden of disability, amblyopia is a barrier to some careers and leaves individuals effectively one-eyed if the good eye is lost through disease or injury. The public common sense perception is that two good eyes must be better than one hence there is a risk litigation if amblyopia is "missed"

2. The epidemiology and natural history of the condition, including development from latent to declared disease, should be adequately understood and there should be a detectable risk factor, disease marker, latent period or early symptomatic stage. YES

Amblyopia can be associated with squint (70-80%) and / or anisometropia (different refractions between eyes) – 20-30%. Ideally strabismic amblyopia should be treated before the age of 3 years but some improvement can be obtained later than this. Anisometropic amblyopia can be successfully treated later than this but early treatment probably gives better results. However effect the size of benefit for treatment at age 3.5 versus 4, 4.5 or 5 is likely to be small so that although early diagnosis is desirable differences in the costs of screening at different ages are important. The most economic approach should be adopted unless there are compelling reasons to the contrary. …

[21] If a numbered criteria is not included then it was not applicable for the topic of preschool vision screening.

5. There should be a simple, safe, precise and validated screening test.

The minimum test is a visual acuity measurement, with each eye tested separately (since amblyopia affects only on eye in most cases). It is essential to use a line of letters, not single letters. Children can co-operate with this from about 3 – 3.5 onwards but only at age 4 can most children co-operate so testing at younger ages raises recall rates substantially. Testing is not easy and results are poor except if done by trained person – for practical purposes this means an orthoptist or optometrist. Orthoptists can use additional tests to confirm or assess borderline results – the role of these in the screening process needs clarification.

6. The distribution of test values in the target population should be known and a suitable cut-off level defined and agreed. NO.

The distribution of values in the population is known, however there is still debate as to the level of impairment that requires treatment. Minor levels of impairment probably do not require intervention, both because compliance may be low, but also because it may have little beneficial effect.

8. There should be an agreed policy on the further diagnostic investigation of individuals with a positive test result and on the choices available to those individuals. NO

This is an important issue. There is no point in screening if there is long delay before diagnosis and treatment, since the main aim is early treatment of amblyopia. The best option is fast track clinics which may be staffed by orthoptists and optometrists. Ophthalmologists are not essential for this level of clinic. Complex cases would need to be referred to outpatients. One potential hazard is that children referred for usually minor defects might otherwise obstruct the referral of less common but more serious and urgent cases.

10. There should be an effective treatment or intervention for patients identified through early detection, with evidence of early treatment leading to better outcomes than late treatment. NO

There is evidence that early intervention has a beneficial effect.

11 There should be agreed evidence based policies covering which individuals should be offered treatment and the appropriate treatment to be offered. NO

See 6 above.

13 There should be evidence from high quality Randomised Controlled Trials that the screening programme is effective in reducing mortality or morbidity. YES (SOME)

There is emerging evidence that good screening and treatment result in lower incidence of significant permanent vision loss.

16. The opportunity cost of the screening programme (including testing, diagnosis and treatment, administration, training and quality assurance)) should be economically balanced in relation to expenditure on medical care as a whole (ie. value for money). YES

Screening is relatively low cost and substantially reduces other eye clinic costs by ensuring more appropriate referrals and keeping many cases away from eye OPD altogether. However, if there were to be a pre-school screen in 3 – 3.5 year olds coverage would be <70% and another universal test in school would be needed. This would be much less cost –effective.

This is one of the reasons for recommending abandoning the preschool test once a high quality 4-5 year old screening programme is in place.

17. There should be a plan for managing and monitoring the screening programme and an agreed set of quality assurance standards. NO

In most places this is poor. National standards are being considered.

18. Adequate staffing and facilities for testing, diagnosis, treatment and programme management should be available prior to the commencement of the screening programme.

There current programme already puts a significant burden on these resources and the improvements suggested should, if anything, reduce these.

20 Evidence-based information, explaining the consequences of testing, investigation and treatment, should be made available to potential participants to assist them in making an informed choice. NO.

These are often lacking and need to be improved.

USA The American Public Health Association, January 2001(32)

Recognizing that visual development from birth through school age has sensitive and critical periods where abnormalities can lead to permanent impairments, especially in the development of binocular vision, an important part of human vision; and

Realizing that conditions such as strabismus (ocular misalignment) including esotropia (crossed eyes) and exotropia (outward turned eyes) occur in up to 6.7% of children prior to age 51-5 and anisometropia (significant difference in refractive prescription between the eyes) has a 1% prevalence and clinically significant hyperopia (farsightedness) a prevalence of 3-6%; and

Noting that clinically significant hyperopia causes almost half of all cases of esotropia and over 90% of cases of anisometropia, and that these and strabismus are responsible for nearly all amblyopia, the leading visual impairment in children, with a prevalence of up to 4.5%; and

Noting that the majority of eye and vision conditions in infancy and preschool ages are not obvious on gross examination and go undetected until children can read standard letter acuity charts around age 5 years; and

Noting that decreased binocular vision and depth perception can lead to problems in gross motor and fine motor development, and that uncorrected hyperopia is associated with deficits in visual perceptual skills, reading readiness, intelligence quotient, and reading achievement, and correction of hyperopia by age 4 improves the expected reading achievement later in school; and

Realizing that infant and early comprehensive childhood eyecare is a neglected area, that less than half of pediatricians perform even limited vision screenings, and pediatric screening when performed is usually limited to a light reflex test which will not detect most strabismus, hyperopia or anisometropia; and

Noting that despite previous APHA resolutions and United States Public Health Service Preventive Services Task Force Guidelines, there is a paucity of public health preschool vision screening programs and those programs that exist have low sensitivity and specificity for the above conditions; and

Recognizing that the American Academy of Pediatrics, the American Academy of Ophthalmology, The American Association for Pediatric Ophthalmology and Strabismus, the American Optometric Association, the U.S. Public Health Service and Prevent Blindness America agree that screening under age 3 is not successful but there is ample evidence that amblyogenic conditions should be detected and treated as early as possible; and;

Realizing that despite intensive efforts to develop eye screening devices such as photorefraction there is at this time no valid screening method for detecting most strabismus, amblyopia, and hyperopia prior to age; and

Noting that reducing blindness and vision impairment in children ages 17 years and under is an objective in Healthy People 2010; therefore [the APHA document goes on to make the recommendations which are presented in Appendix 1].

USA Maternal and Child Health, Bureau and the National Eye Institute Task Force on Vision Screening in the Preschool Child, (Hartmann, April, 2000) (13)

Lack of Data on Validity and Effectiveness of Current Screening Methodologies and Programs

The panel expressed concern about the lack of scientific data addressing the validity of currently available screening methodologies, the effectiveness of the programs that are being used to implement these methodologies, and the adequacy of follow-up and treatment of children identified by screening programs. Members acknowledged an urgent need for large-scale, generalizable studies aimed at answering basic questions about the reliability and validity of commonly used screening methods, as well as new technologies, such as photoscreening. The panel also emphasized the importance of monitoring both the costs and benefits of a screening program, compared with the cost of leaving visual impairments undetected, and recommended that research be conducted to provide objective data on the functional implications of amblyopia.

One of the forces driving the convening of the expert panel was the increasing availability and implementation of photoscreening in preschool settings. Photoscreening, in principal, represents one of the most dramatic developments in the history of preschool vision screening.8 This technique can be applied in early infancy and opens up the possibility of detecting risk factors in a “latent” period before the onset of amblyopia itself. Photoscreening has several advantages over conventional screening techniques. Most notably, it is easier to use with these often difficult-to-test individuals than typical recognition acuity tests and the resulting photographs (or video images) can provide a quantifiable objective measure. Nonetheless, current photoscreening technologies typically require some degree of interpretation of the results by the examiner. Furthermore, photoscreeners measure amblyopia risk factors not amblyopia itself and, therefore, the efficacy of detecting amblyopiogenic risk factors before the onset of amblyopia must be compared with that of more traditional vision screening programs designed to detect amblyopia once it has developed.

Current research indicates that caution should be applied in the use of photoscreening devices in preschool vision screening. Adequate validation studies are lacking for most devices in this

rapidly evolving field, and studies comparing the merits of different instrument designs are almost completely absent. Research using novel technology requires representative screening populations, real-world screening settings, and masked clinical gold standard comparison examinations. Compounding the problem of evaluation of new devices is the basic science question of just which amblyopiogenic conditions a photoscreener should be detecting. Conditions such as esotropia and media opacification are well-established as risk factors for amblyopia, but the type and extent of refractive error that actually produce amblyopia and the importance of the age of appearance of such risk factors are not adequately specified by current research. Furthermore, although the correction of refractive error poses no risk to an adult, question has been raised as to whether it may interfere with the normalization of refractive errors, known as emmetropization, that occurs in infants and young children.

Australia Centre for Community Child Health, Royal Children's Hospital Melbourne for the National Health and Medical Research Council.

March 2002(23)

Summary of Further Research Recommendations

VISION

Assessment of the extent of disability and burden of disease attributed to amblyopia, and the benefits and harms of amblyopia treatment.

A clearer understanding of the relative risks associated with different levels of refractive abnormalities (and the potential use of different cutoff levels in screening) such as hypermetropia, astigmatism and myopia.

The potential role of family history and parental observation questionnaire instruments in targeted screening in the Australian context.

Understanding about the current level of 'usual care' in order to be able to evaluate the added effects of vision screening programs.

High quality evaluations of selected screening measures (such as the HOTV chart with confusion bars), and of the most appropriate age(s) for screening.

If such evidence suggested that vision screening were warranted, and that there were vision screening tests with adequate characteristics, then further controlled research (preferably by RCT) in community samples would be required.

Canada/ UK Effective Public Health Practice Project, Public Health Research, Education and Development Program City of Hamilton, Social and Public Health Services, 2001[22] (33)

21 studies were found that examined the burden of these 3 vision deficits. The quality of the literature on visual defects and disability was insufficient to establish a causal link. The

[22] This group adopted the systematic review produced by the NHS Centre for Reviews and Dissemination, University of York.

evidence that labels amblyoplia as disabling is weak. However, there is strong clinical opinion that there are benefits to screening and treatment.

The advantages of pre-school vision screening for minor vision conditions has not been demonstrated. Major vision defects are identified without screening.

Implications for Research

The true impact on child health of amblyoplia and speech and language delays must be established.

- The optimal outcomes due to early detection and treatment must be researched.

- Due to ethical requirements, few untreated controls designs are appropriate for studies.

UK Health Services Research Unit, University of Oxford, September 1997(34)

There is a lack of good quality research into the natural history of the target conditions, the disabilities associated with them, and the efficacy of available treatments. We believe that this evidence is essential to support a screening programme for a non-fatal condition for which there have been no rigorously controlled trials. An invitation to preschool vision screening carries with it the implicit assumption that screening is going to benefit the child. In the absence of sound evidence that the target conditions sought in these programmes are disabling and that the interventions available to correct them do more good than harm, the ethical basis for such interventions is very insecure.

There is a need to research the following areas:

The extent of disability attributable to the target conditions.

The prevalence of blindness or partial sight attributable to amblyopia in the UK.

The prognosis for vision in the amblyopic eye following loss of vision in the better eye.

The impact of orthoptic treatment on family life and the psychological wellbeing of the child.

The effectiveness of orthoptic treatment for amblyopia on vision and quality of life. This should be a randomised controlled trial in which the control group is not treated, using health outcome measures defined in studies of disability. This would also provide data on the natural history of amblyopia. Trials undertaken in groups of children aged three to four and five to seven would determine whether screening in the preschool years confers any benefit over screening at school entry.

The effectiveness of treatment of non cosmetically obvious squints and refractive errors in this age group.

Purchasers and providers should be appraised of the results of this review and advised not to implement new preschool vision screening programmes unless they have been rigorously evaluated.

The National Screening Committee should consider whether to recommend that existing vision screening programmes be discontinued. From an ethical point of view, it is appropriate to continue screening only in the context of a controlled trial of treatment such as that described…

Canada, BC Office of Health Technology Assessment, University of British Columbia, 1995(2)

[V]ision screening programs, although relatively harmless to conduct and potentially contributing to the discovery of very serious visual disorders, cannot be supported by direct medium and long-term effectiveness evidence. That is, controlled trials have not established that children detected through any vision screening program are ultimately better off because of the screening effort. Instead, evidence of testing validity and treatment efficacy for vision screening can only be supported by indirect evidence. Indirect evidence means, in this instance, that causality must be inferred through linking evidence for various program elements, rather than established through a completed screening program evaluation…

[W]hile the weight of scientific evidence favours vision screening in general and at a much earlier age than school entry (preferably under age 3) the evidence does not establish whether a particular population will be better off with either a school entry or a preschool program. Population benefit depends on the trade off between treatment effectiveness and population coverage for any target age. Thus, instituting new or altering old programs requires empirical study to establish optimum population benefit…

Therefore, while acknowledging that condition detection is an inadequate endpoint and that treatment effectiveness is weakly established for screen detected children, the weight of indirect evidence seems sufficient to conclude in favour of vision screening benefit versus harm…

Central question: Is screening for vision-threatening ocular conditions, primarily amblyopia and strabismus, supported by direct or indirect scientific evidence?

Answer for direct evidence: No. Controlled trials have not established the overall efficacy of effectiveness of vision screening programs.

Answer for indirect evidence: Yes. Several observational studies have examined vision screening program components. Cohort studies from Canada and Sweden illustrate that vision screening done at various ages, from infant to early school entry, and by using various techniques, from observation to sophisticated photo-refraction, successfully detect unsuspected cases of amblyopia and strabismus.

Furthermore, other longer-term primarily descriptive studies show that most treatment of screen detected vision-threatening disorders at least result in some improvement in the vision in the most affected eye. As well, most of these studies indirectly support the screening effort by showing greater treatment benefit with earlier diagnosis. Treatment durability and likelihood of stereopsis as an adult are seldom studies in these long term screening program assessments.

In addition, the longer-term treatment studies also show that:

False positives, while costly to the medical system, are of minimal cost to children. They lead only to non-invasive, usually definitive optometric or ophthalmologic examination.

False negatives may give parents a false sense of security that could potentially lead to increased risk of long-term visual impairment.

Other indirect evidence is provided by basic science and epidemiological evidence It shows that amblyopia and strabismus are suited to screening efforts because they are common (combined prevalence of 5%)(and hae a substantial latent phase. The latent phase refers to the time period during human visual development, similar to that found using various animal models, where normal cerebral cortical development depends on clear binocular retinal images. Except in a few instances, the actual latent phase of the various forms of amblyopia has not been studies directly in humans and can only be inferred retrospectively through assessing treatment response. Treatment response varies among studies at least in part due to the wide variety of amblyopia definitions and specific outcome measures used. Nevertheless, a clinically detectable and potentially manageable latent disorder phase is supported by various longitudinal studies.]

Finally, amblyopia and strabismus are also suited to a screening effort because these conditions often do not result in recognizable symptoms. That is, young children, without an established normal visual reference point have no reason to report unilateral visual impairment.

Appendix 3: Preschool vision screening recommendations of professional or voluntary associations

American Academy of Family Physicians, 2004

Current based on 2004 US Task Force on Preventative Services review (See Appendix 1 and 2)(33) The AAFP *recommends* screening to detect amblyopia, strabismus, and defects in visual acuity in children younger than age 5 years.

United States of America Abt Associated for the Vision Council of America, Sept, 2004 (53)

Providing eye exams to all preschool-age children would detect, treat and cure significantly more cases of a potentially devastating eye condition than the vision screening methods recommended by many in the medical community, a new study shows…conducting eye exams on all preschoolers is highly cost-effective and produces greater return on investment than many other common medical interventions. The study sponsored by the Vision Council of America, was developed with an advisory panel that included experts in ophthalmology, pediatric medicine, optometry and public health.

Using our base case estimates of all model parameters, the evidence supporting the cost effectiveness of comprehensive exams is strong and compelling. Using base case parameters, the incremental cost effectiveness (in terms of cost per QALY) of comprehensive exams was $18,390 relative to vision screening and $12,985 relative to usual eye care in the absence of a screening program. This is well below the conventional thresholds used to determine whether a particular intervention is a reasonable expenditure.

We used sensitivity analysis to examine how the factors used in the model might make exams more or less cost effective. Under a wide range of scenarios, comprehensive eye exams appear to be highly cost effective relative to either vision screening programs or usual eye care. While there are significant gaps in the literature that limit the reliability of study findings, this basic conclusion was robust across the entire range that we considered for most model parameters, suggests that policymakers may wish to give serious consideration to programs that would increase the number of preschool children that receive a comprehensive eye exam and educating them about the important differences between comprehensive exams and vision screenings.

The study's conclusions are driven to a large extent by the finding that treatment for amblyopia is highly cost effective. The cost per QALY associated with amblyopia treatment (separate from detection of amblyopia) was only about $1,800, suggesting that the screening/exam program that gets the most children into treatment is the most cost effective intervention, particularly given the cost difference between exams and screening programs and the prevalence of amblyopia in the population. Given our model parameters, the additional costs associated with comprehensive exams are offset by the gains that result from the additional children who are successfully treated due to comprehensive exams.

United States of America Committee on Practice and Ambulatory Medicine, Section on Ophthalmology. American Association of Certified Orthoptists; American Association for Pediatric Ophthalmology and Strabismus; American Academy of Ophthalmology, American Academy of Pediatrics, April, 2003(56)

Early detection and prompt treatment of ocular disorders in children is important to avoid lifelong visual impairment. Examination of the eyes should be performed beginning in the newborn period and at all well-child visits. Newborns should be examined for ocular structural abnormalities, such as cataract, corneal opacity, and ptosis, which are known to result in visual problems. Vision assessment beginning at birth has been endorsed by the American Academy of Pediatrics, the American Association for Pediatric Ophthalmology and Strabismus, and the American Academy of Ophthalmology. All children who are found to have an ocular abnormality or who fail vision assessment should be referred to a pediatric ophthalmologist or an eye care specialist appropriately trained to treat pediatric patients.

All pediatricians and other providers of health care to children should be familiar with the joint eye examination guidelines of the American Association for Pediatric Ophthalmology and Strabismus, the American Academy of Ophthalmology, and the American Academy of Pediatrics (see Appendix below).

Every effort should be made to ensure that eye examinations are performed using appropriate testing conditions, instruments, and techniques.

Newborns should be evaluated for ocular structural abnormalities, such as cataract, corneal opacities, and ptosis, which are known to result in vision problems, and all children should have their eyes examined on a regular basis.

The results of vision assessments, visual acuity measurements, and eye evaluations, along with instructions for follow-up care, should be clearly communicated to parents.

All children who are found to have an ocular abnormality or who fail vision screening should be referred to a pediatric ophthalmologist or an eye care specialist appropriately trained to treat pediatric patients.

United States of America Committee on Practice and Ambulatory Medicine and Section on Ophthalmology, American Academy of Pediatrics, 2002(10)

Photoscreening is a vision screening technique used to screen for amblyogenic factors, such as strabismus, media opacities, and significant refractive errors, in 1 or both eyes in children.[5,6] Photoscreening has the potential to increase the currently low screening rates. Using a camera or video system appropriately equipped for photoscreening, images of the pupillary reflexes (reflections) and red reflexes (Brückner test) are obtained.[7]Other than having to fixate on the appropriate target long enough for the photoscreening, little cooperation is needed from the child. Data are then analyzed by the evaluator, reviewing center, or computer for amblyogenic factors, and positive findings are noted. Children who do not pass the test may be referred for a complete eye examination.

As a technique to screen for amblyogenic risk factors, photoscreening appears to offer certain conveniences and advantages over traditional methods of vision screening, especially in its availability to screen children who are the most difficult to screen but in whom the prevalence of **amblyopia** is higher than in the general pediatric population. This includes children at high

risk for eye problems, such as premature infants or children with developmental delays or a family history of eye problems.

Photoscreening does not represent a single technique or piece of equipment. Different optical systems can be used for photoscreening. Interpretation of screened images may be performed onsite or offsite in a reading center or with an automated system.

Each photoscreening system may have its own advantages and disadvantages, and it appears that results published in the literature for one system are not necessarily valid for others. Studies performed by different investigators using the same photoscreening apparatus may yield a wide range of results in sensitivity, specificity, and predictive values when onsite interpretation is required.[8–15] Likewise, it is not certain that data gathered about different groups of children or different settings can be extrapolated to other groups or settings.

In general, it is difficult to compare efficacies of various vision screening methods, such as stereoacuity testing, autorefraction, red reflex testing, and cover testing, and then determine if photoscreening has better positive and negative predictive values. This is attributable in part to lack of uniformity in pass-fail criteria for significant refractive errors.

More research is needed to establish how photoscreening can be best used. Photoscreening offers hope in improving vision screening rates in infants, preverbal children, and those with developmental delays who are the most difficult to screen. Photoscreening has not been shown to be superior to other vision screening tests currently used to screen 4- to 5-year-olds. In older children, currently available vision screening techniques can be used reliably.

British Columbia Association of Optometrists (BCAO)

Available Online August 2005 (www.optometrists.bc.ca)

VISION SCREENING POLICY
It is the policy of the British Columbia Association of Optometrists that effective vision screenings, though not a replacement for comprehensive ocular health examinations, do serve as a means to quickly identify those who most likely require professional vision care.

Vision Screening is an attempt to identify those people who need professional vision care from those who likely do not. Vision screening programs have merit when and wherever there exists a population of people who would otherwise not receive professional eye care. An effective program should assess vision, ocular motility, refractive error, internal and external ocular health. The Modified Clinical Technique (MCT), which is performed by an optometrist or an ophthalmologist, is recognized as the most effective vision screening technique.

All vision screening techniques are inferior to a thorough ocular health assessment by an eye doctor (optometrist or ophthalmologist). The administrators of any vision screening program must clearly inform those screened of the limitations of the screening. Furthermore, all people who fail the vision screening should have access to prompt diagnostic and treatment services.

The British Columbia Association of Optometrists encourages early identification of vision problems in children and supports effective vision screening programs to increase the percentage of children who receive timely vision care. For this reason, many members of the

BCAO have voluntarily agreed to provide no charge MCT vision screenings to 2 and 3 year olds throughout the province in a collaborative program with the provincial government. This program, called The Vision First Check, was first launched in 1998.[23] The earlier a problem is diagnosed the more effective will be the treatment intervention.

Community Paediatrics Committee, Canadian Paediatric Society (CPS)

Reaffirmed January 2005(54)

Vision screening in paediatrics*

A. Newborn to three months

A complete examination of the skin and external eye structures as well as the conjunctiva, cornea, iris and pupils is an integral part of the physical examination of all newborns, infants and children.

The red reflex should be inspected for lenticular opacities (cataracts) and signs of posterior eye disease (retinoblastoma).

Failure of visualization or abnormalities of the red reflex are indications for referral to an ophthalmologist.

Corneal light reflex should be tested to detect ocular misalignment.

B. Six to 12 months

Conduct examination as above.

Ocular alignment should again be observed to detect strabismus. The corneal light reflex should be central and the cover-uncover test normal.

Fixation and following are observed.

C. Three to five years

Conduct examination as above.

Visual acuity testing with an optotype test (eg, E acuity card or Allen chart) should be completed.

A child with visual acuity less than 20/30 should be referred to an ophthalmologist.

*Adapted from the American Academy of Ophthalmology Preschool Vision Screening Program recommendations, 1992.

[23] Although the Vision First Check was discontinued information on this program still appeared on the associations website in October, 2005.

The Canadian Association of Optometrists, August, 2004 (55)

The Canadian Association of Optometrists recommends that children have a comprehensive eye exam before their third birthday and again before starting school and every one to two years after that, to ensure continued good vision. If your child is older, remember, any age is a good age to have an exam by an eye care professional.

> "It is very important for children to be checked early before conditions such as lazy eye become a life-long condition" says Dr Morrow "The sooner vision disorders are identified and treated, the greater the chance for success." Classroom learning is 80% visual, so if a child isn't seeing well, they're not performing up to their potential. In addition to a regular eye health exam, look for everyday signs that your child may need help, such as: avoiding close work or reading, losing his or her place when reading, complaining of headaches, squinting, or red, itchy or watery eyes.

Vision Institute of Canada (Chiarelli, undated) (unpublished hard copy only)

Vision problems are common in children and, if untreated, may cause irreversible visual impairment before the age of six years. Recognition of risk factors and signs / symptoms of vision problems allows timely intervention to provide early examination, diagnosis and treatment. With appropriate testing procedures, a comprehensive evaluation of visual, refractive error, binocularilty and ocular health can be achieved in children too young to communicate their visual difficulties.

The Canadian Association of Optometrists and provincial Optometric Associations recommend eye examinations at age 6 months, 3 years, 6 years and then every 1-2 years through ages 6 to 17 years. These ages correspond to stages at which developmental and visual changes occur.

Canada Policy statement Children's Vision Initiative, Canadian Association of Optometrists, October 1993 (55)

The need for periodic optometric examination has been recognized for many years. Vision and ocular health conditions are not always accompanied by recognizable symptoms. There is often an increase risk to the patient if treatment is not initiated. Relying on the occurrence of obvious symptoms in order to initiate an eye examination exposes the patient to an unnecessary risk.

Many factors will influence the frequency of optometric examinations and only the examining optometrist, upon the analysis of all factors, can determine when a particular patient should return for another examination. However, certain guidelines have been established which can assist the patient in determining the need for examination.

Patients in each age group may be classified as being at low risk or high risk for ocular or vision problems. The minimum frequency of examination for those at low risk is as follows:
INFANTS AND TODDLERS (birth to 24 months) By age 6 months
PRESCHOOL (2 to 5 years) At age 3 and prior to school entry
SCHOOL AGE (6 to 19 years) Annually
…
The frequency of examination for those at high risk should be determined by the examining optometrist on the basis of the patient's health, ocular and visual status at the time of examination. Some of the factors which would indicate high risk are as follows:

Infants and Toddlers and Pre-school
Premature birth; low birth weight; mother having rubella; sexually transmitted disease, AIDS related infection; or other medical problems during pregnancy; mother having a history of substance abuse prior to or during pregnancy; family history of high refractive error or eye disease; turned eyes; or congenital eye disorders.

School Age
Children failing to progress educationally; children exhibiting reading and/or learning disabilities. CAO Policy Statements Online at
http://www.opto.ca/en/public/02_about_cao/02_05_01_ps_02.asp#link7

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