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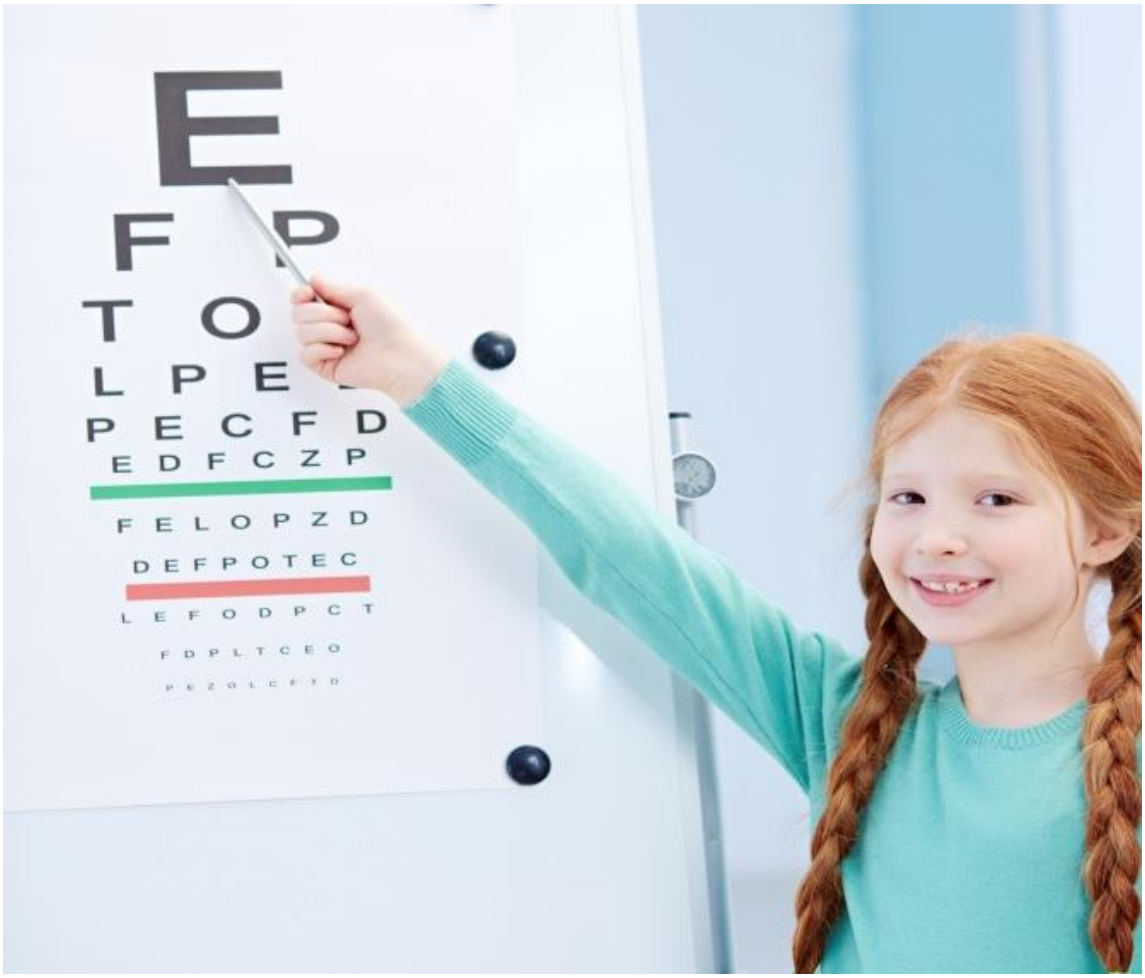
Effectiveness of Vision Screening Programs for Children Aged One to Six Years



SYSTEMATIC REVIEW OF REVIEWS
January 2016

Public Health Ontario

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Effectiveness of Vision Screening Programs for Children Aged One to Six Years

Authors

Diane Lu, MD, PhD, FCFP, MPH
Public Health and Preventive Medicine Resident
Queen's University

Elizabeth Birk-Urovitz, MD, CCFP
Public Health and Preventive Medicine Resident
University of Toronto

Ingrid Tyler, MD, FRCPC, MHSc, MEd
Public Health Physician
Health Promotion, Chronic Disease and Injury Prevention
Public Health Ontario

Parisa Airia, MD, MSc, CCFP, PhD, FRCPC
Former Public Health and Preventive Medicine Resident
University of Toronto

Heather Manson, MD, FRCPC, MHSc
Chief
Health Promotion, Chronic Disease and Injury Prevention
Public Health Ontario

Acknowledgements

Reviewers

Andrea Feller, MD, MS, FAAP, FACPM
Associate Medical Officer of Health
Niagara Region Public Health

Rosanna Pellizzari, MD, MSc, CCFP, FRCPC
Medical Officer of Health
Peterborough County-City Health Unit

Special Thanks

Natalie Bocking
Public Health and Preventive Medicine Resident
University of Toronto

Kara DeCorby, MSc,
Senior Product Development Advisor
HPCDIP

Phat Ha
Former Research Coordinator
HPCDIP

Carly Heung
Research Coordinator
HPCDIP

Sarah Muir, MPH
Research Coordinator
HPCDIP

Beata Pach, BA, MA, MIS
Manager Library Services
Knowledge Services

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EXECUTIVE SUMMARY

Background

In high-income countries, the most common causes of vision impairment in childhood are refractive errors, which impact visual acuity, and strabismus, which is misalignment of the eyes that can affect stereoacuity or depth perception. Without timely treatment, these conditions can lead to amblyopia ("lazy eye"), usually in one eye, potentially resulting in permanent vision loss. The identification of affected asymptomatic children before the age of approximately five to seven years may allow for effective amblyopia treatment during this critical period of development. Childhood vision screening programs have potential to detect these and other eye conditions, and thus benefit an affected child's visual and general development. However, there is variation in childhood vision screening programs and practices across jurisdictions. Professional, academic and public health organizations in Canada, the United States, the United Kingdom and other developed countries have vision screening recommendations that vary by route of delivery, method and age at time of screening. These variations, which may be linked in part to a lack of consistent evidence on the effectiveness of organized, universal vision screening programs, pose a challenge to those responsible for implementing, maintaining or terminating such screening initiatives.

Objectives

The objective of this systematic review of reviews is to summarize the evidence on the effectiveness of organized, universal vision screening programs for children aged one to six years.

Methodology

A systematic review of reviews (systematic reviews, systematic reviews of reviews, meta-analyses or summaries/guidelines) was completed using Ovid MEDLINE, Embase, and CINAHL databases. Included reviews examined the effectiveness of organized, universal vision screening programs for children one to six years of age.

Results

This systematic review is based on seven systematic reviews of moderate to high quality. It found that prevalence of amblyopia by age 6.5 to 8 years was reported to be lower in children screened more frequently between the ages of 8 to 37 months, compared to those screened less frequently or not at all, although the results were not always statistically significant. Within included reviews, only one RCT reported that the prevalence of amblyopia, refractive errors or strabismus was lower in preschool-screened versus non-screened groups, and that study had significant methodological limitations and featured non-RCT primary studies. The authors of all seven included systematic reviews suggested that robust, well-designed primary studies comparing vision screening to no vision screening for preschool children are needed to determine the effectiveness of organized, universal vision screening programs. No reviews were found which examined the broader consequences of undiagnosed vision conditions in

childhood, including short-term or long-term general health (including mental health) outcomes, bullying, school performance, or overall quality of life. Overall, there appears to be a lack of high-quality evidence to draw conclusions on the effectiveness of organized, universal vision screening programs for children aged one to six years.

Conclusions

This systematic review of reviews was unable to draw definitive conclusions regarding the effectiveness of organized, universal vision screening programs for children aged one to six years, largely due to an absence of robust primary studies within the review-level evidence included. The lack of high-quality evidence does not necessarily imply that such a screening program is not effective. It only suggests that until there is robust data, one must rely on other approaches to formulate policy and take action. In Canada and internationally, a number of approaches have been applied by various governmental and healthcare organizations to justify vision screening programs in early childhood. These frameworks include the WHO screening criteria, the population health approach and the precautionary approach. Decision makers have likely also been influenced by policy and action taken in other jurisdictions using an approach informed by what is being done in other jurisdictions. At this time, there is a variety of early childhood vision screening practices in place across the provinces and territories in Canada.

Recommendations

The best practices for conducting early childhood vision screening remain unclear based on this systematic review. Based on the best available evidence at this time, no definitive recommendation can be made for an organized, universal vision screening program for children aged one to six years in Ontario. Future well-designed research is warranted to draw conclusions on the effectiveness of such screening programs.

INTRODUCTION

In high-income countries, the most common causes of vision impairment in childhood are refractive errors, which impact visual acuity (“sharpness” of vision) and strabismus, which is misalignment of the eyes that can affect stereoacuity (depth perception).[1,2] Without timely treatment, these conditions can lead to amblyopia (“lazy eye”), usually in one eye, potentially resulting in permanent vision loss.[3,4] Childhood vision screening programs have the potential to detect these and other similar conditions, and thus benefit an affected child’s visual and general development.[1] However, there is variation in the nature of childhood vision screening programs and practices across jurisdictions.[5-14] Professional, academic and public health organizations in Canada,[15,16] the United States, [17,18] and the United Kingdom[13] have vision screening recommendations that vary by route of delivery, method and age at time of screening. These variations, which may be linked in part to a lack of consistent evidence on the effectiveness of organized, universal vision screening programs, pose a challenge to those responsible for implementing, maintaining or terminating such screening initiatives.

OBJECTIVE

The objective of this systematic review of reviews is to summarize the evidence on the effectiveness of organized, universal vision screening programs for children aged one to six years. Effectiveness of these programs for this review was defined as: 1) the ability to detect, prevent or mitigate amblyopia or other related vision impairments, such as refractive errors and strabismus (as applicable); 2) cost-effectiveness; and/or 3) ability to offer long-term health and/or psychosocial benefits. In relation to a program’s ability to detect, prevent or mitigate amblyopia or other related vision impairments, the prevalence and severity of these three common children’s visual disorders in those screened compared to those not screened (or less frequently screened) were explored.

This review was undertaken to help inform policy makers in the Canadian province of Ontario. Currently, an organized, universal childhood vision screening program is not in place in this province. Instead, eye and vision screening is provided opportunistically through primary care providers at routine well baby and well child visits or through optometrist assessments, and/or via the Eye See…Eye Learn® (ESEL) program. [5]

BACKGROUND

CHILDHOOD VISION IMPAIRMENT: COMMON CONDITIONS AND CONSEQUENCES

Globally, approximately 19 million children under the age of 15 years have one or more vision impairments.[19] In the United States, vision impairment is estimated to affect 1%-5% of children.[4,20-23] Common causes of visual impairment in developed countries are:

1) Refractive errors,[19] which include myopia (impaired distance vision), hyperopia (impaired near vision) and astigmatism (impaired near vision and distance vision).[1,2] Most cases of pediatric hyperopia are mild[24] and resolve without intervention after nine months of age.[25,26] Astigmatism has also been shown to improve with age. In contrast, for myopia, a smaller proportion of cases will self-correct.[25]

2) Strabismus, which is characterized by the misalignment of the visual axes of the eyes resulting in one or both eyes turning inwards, outwards or upwards.[27] Strabismus has not been shown to self-correct, and may lead to significant vision impairment, such as poor depth perception (stereoscopic acuity).[4]

3) Amblyopia ("lazy eye"), is a result of interrupted or abnormal inputs into the nerve-based visual system at a critical developmental period.[28] It is caused by lack of timely treatment of refractive errors and strabismus,[3,4] or, less commonly, opacities (e.g. cataracts) and ptosis (lid "drooping").[29] As a result of these conditions, the brain eventually becomes unable to recognize normal visual inputs from the eye, and amblyopia develops, compromising vision,[15,30] sometimes irreversibly.[3] Amblyopia is most common in one eye, although amblyopia affecting both eyes is possible.[4] It has been shown that the severity of amblyopia is associated with the severity of the cause, and the age at which it develops.[2] Although there is still debate about the ideal timing of treatment for amblyopia, there is general consensus that beginning management, such as correction of the underlying cause,[31] patching and/or pharmacological treatment (atropine)[4] before the age of approximately five to seven years appears to be most effective.[1] Delays have been associated with worse outcomes, particularly in moderate and severe cases.[32] In fact, with untimely treatment or no treatment, amblyopia has been associated with a 2.6-2.7 times overall increased risk of vision impairment and an estimated lifetime risk of vision loss in the non-amblyopic eye of ≥1.2% (95% CI: 1.1%-1.4%).[1,33,34] Of note, amblyopia is recognized as the leading cause of blindness in a single eye among individuals aged 20-70 years in developed countries.[35] These are important considerations in the context of childhood vision screening and its possible benefits.

Unfortunately, there are relatively limited data available on the actual prevalence of refractive errors, strabismus and amblyopia among Canadian children. Results from a Newfoundland-based study suggested that of a sample of 946 children undergoing vision screening (mean age 4.2 years), approximately 14% had significant vision impairments. More specifically, the prevalence of hyperopia, strabismus and amblyopia was estimated at 4.8%, 4.3% and 4.7%, respectively.[36] Results from a 1977 Saskatchewan-based study estimated that approximately 8.3/1000 grade 1 schoolchildren had amblyopia.[37] Screening 383 children aged two and three years in 1998 through the "Vision First Check Program" in British Columbia demonstrated that the prevalence of hyperopia, astigmatism, strabismus, and amblyopia was 5.5%, 2.6%, 1.8%, and 1%, respectively.[38] In Australia, refractive errors and strabismus are thought to impact about 1%-14.7% and 0.3%-7.3% of preschool children, respectively.[12] The overall prevalence of amblyopia in the Australian population is estimated to be approximately 2-5%;[12] similar figures have been reported by studies performed in other high-income countries including Germany and the United States.[39,40]

There is some disagreement among the studies that have examined the social, psychological, or long-term outcomes associated with uncorrected refractive errors, strabismus and amblyopia. While a recent cohort study failed to find any association between vision impairment in childhood and childhood motor development, teenage self-esteem or adult socioeconomic status,[41] and a systematic review from 2011 concluded that additional research is needed to clarify both the immediate and long-term social, educational and psychological implications of amblyopia and its treatment,[42] some studies report that vision impairment in childhood has a significant impact on the development of motor, language, and cognitive function in children,[43] and on overall quality of life (QOL).[44] In addition, limited evidence has suggested there is a correlation between vision impairment in childhood and poor school performance and self-esteem,[33,45] and a national population-based study in the UK found that only approximately 1/3 (n=102) of adults who had lost vision in their non-amblyopic eye were able to maintain compensated employment.[1]

VISION SCREENING: RECOMMENDATIONS AND PRACTICE

Vision impairments, regardless of cause, may go undetected in early childhood due to a child's inability to recognize and/or complain about visual deficits,[46] and a wide variety of screening tests have been developed to help identify vision impairments in children. The specific tests used in each circumstance vary according to setting, the child's age, ease of use, and cost, among other factors. However, screening typically includes a number of tests aimed at detecting refractive errors and/or strabismus.

Tests for visual acuity (to assess for refractive error) include vision charts, such as the Snellen-based linear and LogMAR charts, and HOTV and Lea symbols charts (please see glossary). The sensitivity and specificity of visual acuity tests range between 9-100% and 8-100%, respectively, as reported by Mema and colleagues.[35] Autorefractors are newer tools which provide a computerized measurement of refractive errors by directing light to the retina (at the posterior portion of the eye) and measuring its reflection.[47] They have sensitivities and specificities of between 46-95%, and 53-100%, respectively.[35] Tests for ocular alignment and/or stereoacuity (to identify strabismus) include the commonly used cover-uncover test,[48] as well as the use of photoscreeners, which test for several conditions using optical images of the eye's red reflex to estimate refractive error, media opacity, alignment, and other specific parameters of the eye.[47] Childhood vision screening may also incorporate tests of extra-ocular (around the eye) muscle function, and/or colour vision assessment.[49]

This review did not aim to assess the effectiveness of individual vision screening tests; as such, further details regarding the specifics of these tests are not included in this report. The screening may occur in a variety of settings, including hospitals,[4] community locations (e.g. primary care, optometrist/ophthalmologist offices) or through public health and school-based programs.[49]

OVERVIEW OF RECENT NORTH AMERICAN CHILDHOOD VISION SCREENING RECOMMENDATIONS

Recent childhood vision screening recommendations from major North American professional, academic and public health groups show considerable variation among Canadian organizations, yet relative

consistency among American organizations. Of note, many of these groups' recommendations focus on vision screening in a broad and non-specific sense, rather than more narrowly on the specific implementation of vision screening initiatives, i.e., indicating whether the screening should be offered as part of a program, and whether it should be organized or opportunistic, universal or selective, school-based or otherwise.

Canadian Recommendations

The *BC Early Childhood Vision Screening Program Final Evaluation Report*, prepared by the Human Early Learning Partnership's Screening Research and Evaluation Unit at the University of British Columbia in August 2012,[50] recommended that the provincial Ministry of Health maintain universal kindergarten vision screening programs and further assess the effectiveness of their vision screening pilot programs for children aged three years. In contrast, in a September 2014 position statement on vision examination in preschool children, the Canadian Association of Optometrists (CAO) indicated that "current vision screening methods cannot be relied upon to effectively identify preschool children in need of vision care"[16(p.1)] and that "[vision screening] programs create a false sense of security for those children who 'pass' the screening, but who actually have a vision problem."[16(p.1)] In this statement, the CAO recommended that all children receive comprehensive eye and vision examinations performed by an optometrist or an ophthalmologist prior to entering school.[16] Somewhat different still, the Canadian Paediatric Society (CPS) recommended in a 2009 position statement (reaffirmed in February 2014) that children aged three to five years receive eye examinations and be tested for visual acuity using age-appropriate tools at routine well-child checks with their usual primary care providers. [51] This recommendation was reported with a Canadian Task Force on Preventive Health Care (CTFPHC) level of evidence rating of AII ("good evidence to recommend the clinical preventive action"[52(p.208),] and, of note, refers to vision screening, but not vision screening programs. As of December 2014, neither the Canadian Ophthalmological Society (COS) nor the CTFPHC had published evidence-based guidelines relating to vision screening in children.[53,54]

American Recommendations

In a 2011 recommendation statement regarding vision screening for children aged one to five years, the US Preventive Services Task Force (USPSTF) concluded that there was insufficient evidence to either recommend or discourage screening for children under three years of age (i.e. I statement/"no recommendation."[55(p.341)] However, the USPSTF recommended vision screening at least once for all children aged three to five years, in order to detect amblyopia or amblyopia precursor conditions (Grade B recommendation/"high certainty that the net benefit is moderate or there is moderate certainty that the net benefit is moderate to substantial."[55(p.342)] A 2013 joint statement of the American Association for Pediatric Ophthalmology and Strabismus (AAPOS) and the American Academy of Ophthalmology (AAO) reflected a similar position, but specifically refers to screening programs, rather than vision screening in general.[17] In this statement, in addition to recommending community and school screening programs involving screeners trained in vision screening techniques, the AAPOS and AAO recommended that primary care programs provide routine screening for visual acuity as early as can be tolerated by the child, generally at 3.5 to 4 years, and no later than five years.[17] Also supported was the elective use

of photoscreeners and autorefractors, either for children aged six months to three years, to detect amblyopia precursor conditions, or for children aged three to five years as an alternative to visual acuity screening using vision charts.[17] As of 2014, the American Academy of Pediatrics (AAP) screening recommendations reflect those of the AAPOS and the AAO.[17,18]

Early Childhood Vision Screening Practices in Ontario and Canada

Early childhood vision screening initiatives in Canada are varied among the provinces and territories in terms of their targeted age ranges, settings, and means of delivery. Examples of some of these initiatives include: organized, universal screening programs in schools;[6,7] opportunistic screening performed through primary care; and public health-led[8-10,56-59] and ESEL-type programs,[5,60] which are neither organized nor universal. There appears to be a lack of overall consensus on the preferred childhood vision screening approach. Details of a selection of early childhood vision screening practices for all Canadian provinces and territories may be found in Appendix A.

METHODS

SEARCH METHODS FOR IDENTIFICATION OF STUDIES

Public Health Ontario Library Services conducted searches in Ovid MEDLINE, Embase, and CINAHL were searched for studies (systematic reviews, systematic reviews of reviews, meta-analyses or summaries/guidelines) which examined the effectiveness of organized, universal vision screening programs for children one to six years of age. A detailed description of the search strategies used is included in Table B1 in Appendix B. In terms of inclusion and exclusion criteria (Table 1), only English language articles published between the first week of January 2004 and September 2014 were included. Since the intent of this review was to examine the effectiveness of organized, *universal* vision screening programs during early childhood, any studies regarding vision screening program(s) that targeted special or sub-populations, such as children with specific diseases (e.g. congenital glaucoma, developmental delay) were excluded. Although reference list searches were conducted for all included publications, a separate grey (unpublished) literature search was not performed.

Table 1 Study Inclusion/Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Organized, universal (population-based) vision screening program(s) for children (minimum age= one year, maximum age= six years), with respect to one or more of: a. Effectiveness b. Impact c. Associated evidence d. Other assessment or evaluation measure	Not relevant to topic of review, including vision screening program(s) that are targeted to special populations or sub-populations rather than being universal
English language publication	Non-English language publication
Systematic review or systematic review of reviews or meta-analysis or summary (i.e. guideline)	Single study or primary study
Published from the first week of January 2004-current (third week of September 2014)	Published in 2003 or prior

STUDY SCREENING, DATA EXTRACTION AND QUALITY APPRAISAL

A total of 1,738 articles were retrieved (Figure B1 in Appendix B). After removing duplicates, 1,579 articles remained for review. Two reviewers independently assessed titles and abstracts for relevance, and 1,538 were excluded because they were clinical case studies, reviews regarding clinical diagnosis and management, or publications unrelated to vision, or because they focussed on pathophysiology or

the effectiveness of individual vision screening tests (rather than vision screening programs). The abstracts of the 41 remaining articles were then assessed in detail with the assistance of a third reviewer. Following the three reviewers' independent assessments, 29 of these articles were excluded, as they were either not systematic reviews or summaries, or did not specifically discuss vision screening programs. The other 12 articles underwent full-text review before a total a total of seven systematic reviews were identified for final inclusion (Tables 2 and 3)[30,27,4,49,61-63] with five excluded (Table B2 in Appendix B).[35,64-67] Throughout these processes, all discrepancies in study selection were discussed between two or among three reviewers to come to consensus.

Two reviewers independently carried out data extraction for the seven included systematic reviews (Tables 2 and 3). Any differences in data extraction were discussed by the two reviewers, with guidance from the third reviewer as required, to arrive at an overall consensus. Data extraction was aimed at examining the effectiveness of organized, universal vision screening programs for children aged one to six years. Wherever possible, reviewers recorded epidemiologic measures of disease frequency and/or indicators of severity for the three most common vision impairments in children –refractive errors, strabismus and amblyopia—in screened versus unscreened (or less frequently screened) populations. For two of the systematic reviews, cost-effectiveness analyses were described and included in data extraction. Given the heterogeneity of the seven systematic reviews' included studies and the narrative approach of the included reviews, meta-analysis was not done. Quality appraisal of the systematic reviews was independently carried out by two reviewers using the "Assessing the Methodological Quality of Systematic Reviews" (AMSTAR) Checklist (Table C1 in Appendix C).[68] There was 89.6% agreement between the two reviewers doing quality appraisal, with any discrepancies discussed and resolved by consensus.

RESULTS

Seven systematic reviews published from 2008 to 2011 examined the effectiveness of organized, universal childhood vision screening programs for one and six year olds. Excluded papers which were not systematic reviews included reports drafted for specific governmental organizations, such as the BC Ministry of Health Services,[69] Alberta Health,[70] and the UK National Screening Committee (UK NSC).[71] A detailed summary of the seven included systematic reviews is shown in Tables 2 and 3. Of note, two Cochrane Collaboration reviews found zero high quality studies meeting their specific inclusion criteria.[49,61] Two primary studies were consistently referred to in the five remaining (non-Cochrane) systematic reviews,[30,27,4,62,63] (Table 4). In certain instances, systematic review authors had some varied interpretations of the overlapping studies. However, because our approach to synthesizing data remained consistently a review of reviews, our data extraction and analysis pertaining to these overlapping studies was based on the content of the reviews rather than the individual studies themselves. Although no primary research studies published after 2008 were included by any of the systematic reviews, a comprehensive literature review published in 2013 confirmed that no additional primary studies related to this question for children between four and five years of age were published between 2008 and 2012.[71] Thus we are confident that given existing reviews' comprehensive searches, the important studies available for the time frame of our search were located and would have been considered via the included reviews considered here.

In a 2008 systematic review by Carlton and colleagues,[27] seven relevant studies were identified which examined the impact of preschool vision screening on treatment outcomes in children aged four to five years. The prevalence of amblyopia by age 7.5 years was reported to be lower in those children screened "intensively" at the ages of 8, 12, 18, 31 and 37 months, compared to those screened only once at 37 months of age based on a randomized-controlled trial (RCT) by Williams et al.[72] and a prospective longitudinal study.[73] Based on the Williams et al. RCT[72] and two other non-RCTs,[74,75] Carlton et al. described that visual acuity outcomes post-amblyopia treatment showed superior results for an intensive or more frequently screened preschool group (multiple times at 8, 12, 18, 31 and 37 months), compared to a less intensive or less frequently screened preschool group (once at 37 months), a non-screened preschool group, and a school-screened group. The purpose of the increased- frequency screening program was based on the premise that children develop visual disorders at different ages of development. With a higher screening frequency, it was anticipated that children with vision disorders detected at an earlier age would also be initiated on treatment at an earlier age. Carlton et al. concluded that the evidence demonstrated an impact of vision screening programs on children in this age group. However, they cautioned that the programs differed widely in those who were screened, the nature of the screening tests and in the type of personnel who were screening. This heterogeneity in the primary studies limited their interpretation of results and subsequent conclusions. Moreover, additional analyses carried out by Carlton et al. demonstrated that while amblyopia cases prevented through screening at three or four years of age could come at a low absolute cost, the estimated cost per quality-adjusted life year (QALY) gained was concluded not to be cost-effective, unless vision loss in one eye was taken into account.

In 2009, two revised Cochrane reviews were published that examined vision screening for amblyopia in childhood[49] and for correctable visual deficits due to refractive error in school-age children and adolescents.[61] Neither of these systematic reviews found any high quality RCTs which robustly analyzed the impact of existing vision screening programs on reducing the prevalence of amblyopia or of previously undetected but correctable visual acuity deficits due to refractive errors in screened versus unscreened children. The authors stated that the absence of good quality evidence for the effectiveness of such screening programs does not mean that vision screening is not beneficial. Rather, it simply suggests that the impact of this screening intervention has not yet been adequately tested in robust trials. The conclusion from both of these articles was that no good quality evidence was found that can be used to justify the introduction of such vision screening programs for children.

Schmucker and colleagues[62] included five studies in their 2009 systematic review, which focused on determining whether screening for amblyopia in children up to the age of six years leads to better vision outcomes, and whether preschool vision screening programs were effective. The authors reported that the only included RCT did not demonstrate a significant difference in the prevalence of amblyopia or strabismus between those screened at three years old versus those not screened by the age of six years. In this systematic review,[62] the Williams et al. study[72] was also included, but it was referred to as a pseudo-RCT (due to intervention group selection through pseudo-randomization), and it was also described as being reported in two separate publications.[72,76] Schmucker et al. indicated that findings from the Williams et al. study and from a retrospective cohort study suggested that earlier or more intensive/frequent preschool screening was significantly associated with an absolute reduction in the prevalence of amblyopia by age 7.5-8 years. However, limitations of their included studies as noted by the review authors included the following: 1) Those studies reporting significant results considered only a proportion of the originally recruited children in their analysis; 2) the definition of outcome (amblyopia) varied across studies; 3) blinding of the outcome assessor, comparison of study groups, and consideration of confounding factors occurred in less than 50% of the studies; and 4) other outcome measures such as school performance, cognitive impairment and QOL were not adequately evaluated by their included primary studies. The authors stated that due to methodological weaknesses of the reviewed literature, a conclusion could not be drawn to state that preschool vision screening is either effective or ineffective.

In 2010, a systematic review was undertaken by Mathers and colleagues[63] to determine: 1) the effectiveness of children's vision screening programs; 2) at what age children should attend vision screening; and 3) what form vision screening programs should take to be most effective. Seven relevant papers were included, four of which were primary studies and three of which were systematic reviews. One of the systematic reviews was the review by Carlton et al.[27] mentioned previously, and the other two were the Cochrane reviews mentioned previously.[49,61] Mathers et al. reported that the prevalence of amblyopia was lower in children at the age of eight years who had received screening by three years' old than those who did not, based on two moderate quality, non-RCTs. Similar to two other systematic reviews,[27,62] it was also reported that the Williams et al. study[72,76] suggested that the group which received more intensive and repeated screening between 8 and 37 months of age had a lower prevalence of amblyopia at age 7.5 years than the group with the usual once-only screening at 37

months. According to Mathers et al., the Williams et al. study[72,76] also suggested that the frequently screened group had better visual acuity in the amblyopic eye post-treatment at 7.5 years of age. Based on their assessment, Mathers et al. concluded overall that available evidence supports the effectiveness of vision screening for children aged three to five years. However, the authors also cited differences in screening tests and the type of personnel used for screening amongst the primary studies, limiting their ability to compare studies. Since most studies had a limited period of follow-up, it was concluded that this made it difficult to determine how these vision screening programs influenced long-term childhood or adult outcomes.

The purpose of a 2011 systematic review by Chou et al.[4] was to determine the impact of screening children aged one to five years for impaired visual acuity on health outcomes. This review comprised part of an update for the USPTSF. Chou et al. reported on the Williams et al. study;[72] however, in their analysis, which also described related prospective cohort results[74] as being associated with the same study, they indicated that although visual acuity post-amblyopia treatment at 7.5 years of age was better by an average of one Snellen line in the intensive or frequent screening group (screening at 8, 12, 18, 31, and 37 months) versus the once-only screening at 37 months of age group, there was *no* significant difference in amblyopia risk by 7.5 years old, except when taking into account one specific pre-stated definition of amblyopia (interocular difference in visual acuity greater than or equal to 0.3 log MAR). Four other primary studies demonstrated that there was a lower prevalence of refractive errors, strabismus or amblyopia by 6 to 12 months prior to school entry or by age seven to eight years in those children who had preschool vision screening versus no preschool screening. From the primary studies reviewed, the authors concluded that the evidence on effectiveness of preschool vision screening for improving visual acuity or other clinical outcomes is limited and does not adequately address the question of whether screening is more effective than no screening. Noted limitations were that the included retrospective cohort studies had methodological shortcomings, including failure to adjust for potential confounders and varying lengths of follow-up.

Lastly, a 2011 systematic review by West and Williams reported on four relevant publications examining the prevalence of amblyopia in children with:[30] screening versus no screening; repeated preschool screening versus usual care (surveillance by a health visitor at 8 and 18 months of age); and preschool plus school-entry screening versus school-entry screening alone. Based on a low-quality retrospective cohort study, the review authors reported that screening before three years of age may be associated with lower rates of amblyopia by the age of eight years, compared to no screening. Similar to three other systematic reviews,[27,62,63] the West and Williams review reported that the Williams et al. study[72,76] suggested repeated vision screening under three years of age (8, 12, 18, 31, and 37 months) was associated with a lower prevalence of amblyopia at 7.5 years compared to less intensive screening one time at 37 months (high-quality evidence).[30] Similar to the Carlton et al.,[27] Mathers et al.,[63] and Chou et al. reviews,[4] the West and Williams review indicated that the Williams et al. study[72,76] showed repeated vision screening before 3 years of age improves visual acuity in the eye treated for amblyopia at 7 years of age, compared to less intensive screening (moderate-quality evidence).[30] Moreover, West and Williams reported that there was very low-quality evidence for the efficacy of combining preschool screening at age three years plus school-entry screening at age four to five years versus school-entry

screening alone in improving visual acuity in children at age seven years. However, this conclusion was based on a prospective cohort study that had limited power. From the included primary studies which varied in quality from very low to high, the authors concluded: "Although there was a benefit associated with the intensive intervention used in the RCT, such intensive intervention is not practicable in a clinical setting. Further research is needed to determine whether more practicable screening protocols could be cost-effective."[30(p.5)]

Summary

In three systematic reviews, amblyopia prevalence was reported to be lower in those children who received preschool vision screening (0.1%- 1.1%) compared to those who received no screening prior to school entry (1.7%-3.0%).[30,4,63] Five reviews cited three studies showing that the reported prevalence of amblyopia at 7.5-8 years of age was lower in a more intensive (frequent) screening program involving children ≤ 37 months of age (0.6%-1.5%) versus a less intensive screening program, including one-time only preschool vision screening (1.8%-2.7%);[30,27,4,62,63] however, this difference was not always statistically significant.[4] In four reviews, frequently screened children ≤ 37 months of age had better amblyopic eye post-treatment visual acuity outcomes at 7-7.5 years of age compared to less frequently screened children,[30,27,4,63] yet it is important to take into account that this particular conclusion was based on a single primary study.[72,76] In addition, as reported by Chou et al.,[4] only one low quality retrospective cohort primary study by Kohler and Stigmar from 1978 reported prevalence for all three common visual impairments (refractive errors, strabismus and amblyopia) at age seven years: 0.7% in screened children versus 5% in unscreened children, respectively.[77]

It should also be noted that none of the seven included systematic reviews reported on studies examining broader outcomes possibly related to undiagnosed vision conditions, including short-term or long-term general health (including mental health) consequences, bullying, school performance, or overall QOL.

Table 2 Summary of Data Extraction for Systematic Reviews (n=7)-Review and Relevant Included Study Characteristics

Review/Reference	Years of Included Studies	Objective(s)	Type(s) of Included Studies	Total Sample Size -- # (Initially) Recruited // Age Groups When Initial Screening Occurred	Setting(s) for Initial Screening // Deficit(s) for Which Initial Screening Test(s) Were Done
* Carlton J, Karnon J, Czoski-Murray C, Smith KJ, Marr J. The clinical effectiveness and cost-effectiveness of screening programmes for amblyopia and strabismus in children up to the age of 4-5 years: a systematic review and economic evaluation. Health Technol Assess. 2008;12(25):iii, xi-194.[27]	-7 primary studies from 1978-2006	-To estimate cost-effectiveness of screening for amblyopia & strabismus in children ≤4-5y -To identify studies reporting on how treatment outcomes are influenced by vision screening programs	RCT, prospective & retrospective cohort, retrospective chart audit	-**Sample:** Cannot be reliably calculated -**Age:** ***8 mo*** to < 5y	-**Setting(s):** Not specified -**Deficit(s) screened⌂:** refractive errors/VA deficit , misalignment/ strabismus, decompensating heterophoria, abnormal ocular movements, binocular or stereopsis deficit, "any other abnormality" ⌂ reported for 2/7 studies
Powell C, Hatt SR. Vision screening for amblyopia in childhood. Cochrane Database Syst Rev. 2009;(3):CD005020.[49]	-0 included studies -Database searches from 1947-2008	-To evaluate the effectiveness of vision screening in reducing prevalence of amblyopia in comparable screened vs. unscreened populations -Subgroup analyses intended to gather more data on screening characteristics: personnel involved, age at screening, VA threshold leading to further evaluation	N/A	N/A; N/A	N/A; N/A
Powell C, Wedner S, Hatt SR. Vision screening for correctable visual acuity deficits in school-age children and adolescents. Cochrane Database Syst Rev. 2004;4:CD005023.[61]	-0 included studies -Database searches from 1966-2006	-To evaluate school-based vision screening programs' effectiveness in reducing prevalence of refractive error-related VA deficits that are undetected yet correctable -Subgroup analyses intended to gather more data on screening characteristics: personnel involved, threshold for screening "failure"	N/A	N/A; N/A	N/A; N/A
Schmucker C, Grosselfinger R, Riemsma R, Antes G, Lange S, Lagreze W, et al. Effectiveness of screening preschool children for amblyopia: a systematic review. BMC Ophthalmol. 2009;9:3.[62]	-5 included primary studies from 1996-2006	-To determine if screening for amblyopia in children ≤ 6y leads to better vision outcomes -To determine the effectiveness of a preschool vision screening program according to criteria of the UK National Screening Committee	Retrospective cohort, prospective cohort, RCT, pseudo-RCT	-**Sample:** Cannot be reliably calculated -**Age:** ***8 mo***-5y	-**Setting(s):** Not specified -**Deficit(s) screened⌂:** unilateral strabismus, significant refractive differences between the eyes (anisometropia) ⌂reported for 1/5 studies

Review/Reference	Years of Included Studies	Objective(s)	Type(s) of Included Studies	Total Sample Size -- # (Initially) Recruited // Age Groups When Initial Screening Occurred	Setting(s) for Initial Screening // Deficit(s) for Which Initial Screening Test(s) Were Done
* Mathers M, Keyes M, Wright M. A review of the evidence on the effectiveness of children's vision screening. Child Care Health Dev. 2010;36(6):756-80.[63]	-4 included primary studies & 3 included SR's from 1993-2008	-To determine: (1) the effectiveness of children's (0-16y) vision screening programs (2) at what age children should screened; & (3) which types of vision screening programs are most effective	SR, RCT, "non-RCT"	-**Sample:** Cannot be reliably calculated -**Age:** ***8 mo***-5y	-**Setting(s):** Not specified-**Deficit(s) screened:** VA deficits/refractive errors, ocular misalignment/deviation /strabismus, stereopsis or binocular deficits, ocular movement abnormalities, monocular fixation abnormalities, gross abnormalities
* Chou R, Dana T, Bougatsos C. Screening for visual impairment in children ages 1-5 years: update for the USPSTF. Pediatrics. 2011;127(2):e442-79.[4]	-5 included primary studies from 1978-2003	-To determine the effectiveness of screening children aged 1-5y ("preschool") for impaired VA on health outcomes	RCT, prospective cohort, retrospective cohort	-**Sample:** n=15027 (~5897 intervention/exposed, ~9119 control/unexposed) -**Age:** ***8 mo***-5y	-**Setting(s):** Hospital eye services clinic, preschool & school -**Deficit(s) screened:** VA deficits/refractive errors, ocular misalignment/ deviation/strabismus, ocular movement abnormalities, monocular fixation abnormalities, stereopsis or binocular deficits
* West S, Williams C. Amblyopia. BMJ Clin Evid. 2011;06:709.[30]	-3 included primary studies from 2000-2003	-Determining the effects of interventions to detect amblyopia early -Determining the effects of medical treatments for amblyopia	RCT, prospective cohort, retrospective cohort	-**Sample:** Cannot be reliably calculated -**Age:** ***8 mo***-5y	-**Setting(s):** Not specified **-Deficit(s) screened:** Not specified

*For these reviews, only a proportion of the included primary studies (or included SR's) are reflected in this table. These were the studies deemed relevant based on their focus/content, as described by the review authors.

mo= month(s), RCT=randomized controlled trial, SR=systematic review, VA= visual acuity, y=year(s)

Table 3 Summary of Data Extraction for Systematic Reviews (n=7)-Review Overall Findings, Conclusions and Limitations

Review/Reference	Overall Findings	Conclusions	Limitations
* Carlton J, Karnon J, Czoski-Murray C, Smith KJ, Marr J. The clinical effectiveness and cost-effectiveness of screening programmes for amblyopia and strabismus in children up to the age of 4-5 years: a systematic review and economic evaluation. Health Technol Assess. 2008;12(25):iii, xi-194.[27]	-RCT & prospective longitudinal studies: prevalence of amblyopia at 7-7.5y was ~1.8-3x higher in 1-time screening group (at 37 mo) vs. Intensive (frequent) screening group (between 8-37 months) (p=0.02 and 0.06, where stated) -For VA outcomes post-amblyopia treatment, 3 studies (including 1 RCT and 1 cohort study) showed superior results for PS-screened group vs. non-screened, less intensively PS-screened or school-screened groups (p-values from <0.001 to <0.05) -Additional analyses suggested that screening at 3 -4y prevented amblyopia cases at a low cost (£4000-6000), but any form of screening is unlikely to be cost-effective at currently accepted values of a QALY, except when loss of vision in 1 eye is taken into account	-Studies reporting on impacts of screening programs differ widely in terms of: content, population examined, personnel administering screening -Vision screening at age 3-4y is unlikely to be cost-effective, except if taking into consideration the possibility of vision loss in 1 eye	-Small n of some studies (e.g. retrospective chart review w/ n=50) -Questionable external validity w/ respect to non-European primary study -High degree of heterogeneity of screening programs examined
Powell C, Hatt SR. Vision screening for amblyopia in childhood. Cochrane Database Syst Rev. 2009;(3):CD005020.[49]	-No trials met inclusion criteria	-Absent evidence does not necessarily suggest vision screening programs are not effective for amblyopia prevention. It suggests that robust trials still need to be done. To allow for this, a consensus should be reached on the definition of amblyopia & there should be baseline data on age-appropriate vision tests	N/A
Powell C, Wedner S, Hatt SR. Vision screening for correctable visual acuity deficits in school-age children and adolescents. Cochrane Database Syst Rev. 2004;4:CD005023.[61]	-No trials met inclusion criteria	-Absent evidence does not necessarily suggest vision screening is not effective. It suggests that more research is required. Currently, introduction of new school vision screening programs not justified -School vision screening program effectiveness would be dependent upon geographic & socioeconomic factors. Thus, RCTs should be done in different settings to allow for assessment of vision screening harms & benefits	N/A
Schmucker C, Grosselfinger R, Riemsma R, Antes G, Lange S, Lagreze W, et al. Effectiveness of screening preschool children for amblyopia: a systematic review. BMC Ophthalmol. 2009;9:3.[62]	-3/4 non-RCTs◊: PS screening or earlier/more intensive PS screening is significantly associated w/ an absolute reduction in the prevalence of amblyopia of between 0.9%- 1.6% at 7.5y & 8y. In 1 study, results became non-significant after adjusting for confounding. ◊ Other non-RCT pertained to screener type; results are not included in detail in this review -The only RCT reported did not find a significant difference in the prevalence of amblyopia or strabismus between groups (PS screened [3y] vs. non-PS screened [4y]) by 6.5y	-The effectiveness of population-based PS vision screening programs for amblyopia cannot currently be adequately assessed	-No prospective n planning; 2 studies showed lack of power through retrospective calculations -Blinding of the outcome assessor, comparison of study groups, & consideration of confounders occurred in <50% of studies -Studies w/ significant results considered only a proportion of the originally recruited children in analyses -Definition of outcomes varied across studies

Review/Reference	Overall Findings	Conclusions	Limitations
* Mathers M, Keyes M, Wright M. A review of the evidence on the effectiveness of children's vision screening. Child Care Health Dev. 2010;36(6):756-80.[63]	Primary studies: -1 RCT: Children frequently screened (8-37 mo) vs. screened 1-time (37 mo) had lower prevalence of amblyopia at 7.5 y & better VA in the amblyopic eye post-treatment at 7.5y -Non-RCTs: 2 studies comparing screening at ≤3y vs. no screening at this age showed lower prevalence of amblyopia in the former group at 7.5y & 8y (~45%-61% lower). 1 of these studies indicated that a VA of 6/12 or worse in amblyopic eye for former group vs. latter group was 0.1% vs. 1.7%. Other study indicated mean VA in worse eye after patching treatment (at age 7.5y) was better in the former vs. the latter group; however, the effects did not persist in intention to treat analysis SR's -Vision screening could be cost-effective if vision-loss in 1 eye & heighted risk of vision loss in both eyes are taken into account in QOL analysis. For vision-loss in 1 eye, screening at both 3y &4y could cost-effective if accounting for cost gained per QALY -For other 2 SR's: no RCTs fit review criteria	-RCT: screening at 18 mo-school age yielded high detection rates, especially for amblyopia, and may have greatest impact. Non-RCTs have similar conclusion: screening between the ages of 3 & 5y is effective & reliable -Supportive of screening in the PS period (3–5 y), but not at school entry -Additional studies needed to clarify QOL & related economic advantages	-Only 1 (relevant) RCT identified, & is of medium quality. SR evidence mostly drawn from non-RCTs -Difficult to compare study results due to heterogeneity among studies, e.g. vision tests & personnel used, personnel training/qualifications -Majority of studies had relatively short follow-up
* Chou R, Dana T, Bougatsos C. Screening for visual impairment in children ages 1-5 years: update for the USPSTF. Pediatrics. 2011;127(2):e442-79.[4]	-2 studies examining outcomes between screened groups (intensive vs. 1-time at 37 mo, 1-time at 37 mo vs. school-entry) showed no significant difference in amblyopia risk at 7.5y, except for 1 amblyopia definition (interocular difference in acuity greater than or equal to 0.3 logMAR) in 1 study (0.6% vs. 1.8%, respectively, RR 0.35, 95% CI 0.15-0.86). 1 of these studies showed VA at 7.5y in the amblyopic eye post-treatment was better in intensive screening group by average of ~1 Snellen line (p<0.001) -3 studies examining PS-screening vs. no screening showed PS screening associated w/ improved school-aged vision outcomes compared to no screening. Specifically: a) Amblyopia at 8y: 1% vs. 2.6%; RR 0.39 (95% CI 0.17-0.87); b) RR for at least mild impairment (VA 20/40 or worse) at school entry: 10% vs. 15%, RR 0.68 (95% CI 0.52-0.89); c) RR for newly diagnosed vision disorder, amblyopia, or strabismus at 7y: 0.7% vs. 5% w/ RR 0.15 (95% CI 0.08-0.31)	-Evidence regarding the effectiveness of vision screening in this age group for improving VA or other clinical outcomes is limited -Evaluation of school performance, other related outcomes not found -Further research needed to determine whether screening more effective than no screening	-Retrospective cohort studies: failure to adjust for potential confounders & varying duration of follow-up -No study evaluated school performance or other functional outcomes -High loss to follow-up of ~50% in 1 fair-quality randomized trial nested w/in a cohort study
* West S, Williams C. Amblyopia. BMJ Clin Evid. 2011;06:709.[30]	-Prevalence of amblyopia (age 8y) --> 5/808 (1%) w/ screening in infancy, 20/782 (3%) w/ no screening. p = 0.0098 -PS repeated screening vs. usual care (surveillance by health visitor at 8 & 18mo): A) % of children identified as being amblyopic (worse than 6/12), 7.5y --> 6/1088 (1%) w/ repeated screening, 15/826 (2%) w/ usual care. P=0.02. B) p< 0.01 for % of children identified as having amblyopia by 3y (2% vs. 1%, repeated vs usual). C) Mean VA in the treated eye, 7.5y --> 0.26 logMAR units (repeated), 0.15 logMAR units (usual). P <0.001 -PS + school-entry screening vs. school-entry screening only: % of children with VA of amblyopic eye worse than 6/12 , 7.5 y --> 1.3% w/ no offer of PS screening (screen at 4-5y), 1.2% w/ offer of PS (screen at 3y) p=0.59	-Screening <3y may be associated with lower rates of amblyopia by 8y; low-quality evidence -Repeated screening <3y increases the detection rates of amblyopia by 3y & 7.5y; high-quality evidence -Repeated screening <3y may improve VA at 7y; moderate-quality evidence -Uncertain if screening at 3y & at school entry (4-5y) more effective for improving VA at 7y; very-low quality evidence	-Quality of primary studies/interventions ranged from high to very low (& ≥1 study with limited power) -Repeating screening from RCT may be beneficial but is impractical

*For these reviews, only a proportion of the included primary studies (or included SR's) are reflected in this table. These were the studies deemed relevant based on their focus/content, as described by the review authors.

~=approximately, mo= month(s), n=sample size, PS=preschool, QALY=quality adjusted life year, QOL=quality of life RCT=randomized controlled trial, RR= relative risk, SR=systematic review, VA= visual acuity, w/=with, y=year(s)

Table 4. Relevant Primary Studies (n=12) Included in the Five Selected Systematic Reviews with >0 Studies Meeting Their Inclusion Criteria

Systematic Review ↓	Relevant Included Primary Study →	**Kohler & Stigmar (1978). (77)**	**Feldman et al. (1980). (78)**	**Edwards et al. (1993). (75)**	**Fathy & Elton (1993). (79)**	**Bray et al. (1996). (80)**	**Newman et al. (1996). (81)**	**Eibschitz-Tsimhoni et al. (2000). (82)**	**Rasmussen et al. (2000). (83)**	**Harrad et al. (2002). (73)**	**Williams et al. (2001) (76) and/or Williams et al. (2002). (72)**	**Williams et al. (2003). (74)**	**Bui & Donahue (2006). (84)**
Carlton et al. (2008).[27]		X		X			X			X	X	X	X
Schmucker et al. (2009).[62]						X		X	X		X	X	
Mathers et al. (2010).[63]					X			X			X	X	
Chou et al. (2011).[4]		X	X					X			X	X	
West & Williams (2011).[30]								X			X	X	

DISCUSSION

In developed countries, the most prevalent causes of vision impairment in childhood are refractive errors and strabismus,[1,2] and either one of these conditions, without timely treatment, may lead to amblyopia.[3] The identification of affected asymptomatic children before the age of approximately five to seven years may allow for effective amblyopia treatment during this critical period of development.[1] Given the heterogeneity in the types of early childhood vision screening programs being offered throughout Canada and the varied recommendations made by different professional health and eye care organizations, this systematic review of reviews was undertaken to examine the currently available evidence.

SUMMARY

This review found that the prevalence of amblyopia by age 6.5 to 8 years was reported to be lower in children screened more frequently between the ages of 8 to 37 months compared to those screened less frequently or not at all, although the results were not always statistically significant. Within included reviews, only one RCT with significant methodological limitations and non-RCT primary studies reported that the prevalence of amblyopia, refractive errors or strabismus was lower in preschool screened versus non-screened groups. The authors of all seven included systematic reviews suggested that robust, well-designed primary studies comparing vision screening to no vision screening for pre-school children are needed in order to determine the effectiveness of organized, universal vision screening programs.[30,27,4,49,62,63] No reviews were found which examined broader consequences of undiagnosed vision conditions in childhood, including short-term or long-term general health (including mental health) outcomes, bullying, school performance, or overall QOL. Overall, there appears to be a lack of high-quality evidence to conclusively determine the effectiveness of organized, universal vision screening programs for children aged one to six years.

LIMITATIONS

This review has several limitations. The literature search was limited to indexed English language systematic reviews, systematic reviews of reviews, meta-analyses and summary-level evidence (guidelines) published 2004-2014 and examining the effectiveness of organized, universal vision screening programs for children one to six years old. Only seven systematic reviews met inclusion criteria, with two of these seven reviews finding zero included studies and contributing no additional data. The included reviews featured primary studies published only up to 2008 and not later. The unavailability of new primary studies after 2008 was confirmed by a review of databases.[71] Although included systematic reviews were of moderate to high quality (Table C1), there was significant heterogeneity in the design and quality of the primary studies included within them, which ranged from low-moderate, and also variation in the reviews' interpretation of these studies. For example, the central Williams et al. study[72,76] included in the systematic reviews was referred to as a RCT in four reviews,[30,27,4,63] but as a pseudo-RCT in the fifth review.[62] Moreover, reviews were based on relatively few and, to some extent, overlapping primary studies (Table 4), and they referred to different vision

screening procedures, tests and threshold criteria. As a result, comparisons between studies are made with caution.

FOUR APPROACHES TO AID IN PROGRAM IMPLEMENTION DECISION-MAKING

As this review found limited evidence supporting the effectiveness of organized, universal vision screening programs in early childhood, one may consider other frameworks that could be applied in the process of deciding whether or not to implement a program of this type. The lack of high-quality evidence does not necessarily imply that such a screening program is not effective. It only suggests that until there is robust data, one must rely on other approaches, including action taken in other jurisdictions, in formulating policy and taking action. We identified four such approaches (screening, population health, precautionary, and comparative), which are described below.

World Health Organization (WHO) Screening Approach

The WHO has developed criteria for assessing the appropriateness of screening programs.[85] Application of these criteria to early childhood vision screening programs in particular is as follows:

- Based on prevalence data and the potential for significant and undesirable outcomes, common childhood vision conditions (refractive errors, strabismus and amblyopia) are viewed by some eye healthcare professionals as important health problems.[71] Refractive errors and strabismus can also lead to amblyopia without timely treatment, and permanent vision loss may result.[3]

- The natural histories of refractive errors, strabismus and amblyopia are understood, and all have recognizable latent stages.[3]

- Visual acuity tests as screening tools are simple, safe and likely acceptable to children and parents.[13] These include visual acuity and stereoacuity tests, and the use of auotorefractors, for which overall sensitivity improves with increasing age of the child.[35] Facilities and personnel are generally available for treatment of refractive errors, strabismus and amblyopia in middle- and high-income countries.

- Identification of a child with a vision disorder needs to result in physician referral for further investigation and diagnosis. The child should have follow-up for any identified visual defect, including evaluation of treatment. This would fulfill the WHO screening criterion that case-finding needs to be continuous and not a once-only process.

- There is no currently organized process for managing and monitoring a vision screening program with an agreed set of quality assurance standards in Canada, the U.S., Australia or the UK.[12,65,71] As well, there is no evidence-based policy indicating exactly which individuals should be offered treatment, since there is no known, agreed-upon cut-off level for visual acuity impairment. Variability in thresholds used to define childhood amblyopia reflects the challenges for healthcare professionals in defining a level of visual acuity that is clinically and functionally meaningful. Although eye patching, surgery and corrective glasses are acceptable treatment

options to children and parents,[13] it is not widely accepted which of these is the most appropriate treatment.

- Although the opportunity costs of a screening program should be economically balanced in relation to the possible expenditures on medical care, presently, evidence for the cost-effectiveness of organized, universal vision screening programs for children one to six years old is limited.[27]

Three countries, Australia, the U.S., and the UK have all used this approach as the basis for making their recommendations for screening of children three to five years of age; this is elaborated upon in the comparative approach section of this document.[11-13,71]

Population Health Approach

A population health approach to organized, universal vision screening would focus on improving the health of children by reducing health inequities within this population group. Health care equity is based on "making high quality health accessible to all"[86(p.13)] and enabling "equal utilization for equal need."[86(p.8)] Under this approach, eligibility and access to vision screening and treatment for any diagnosed visual disorder is universal and equal for all children, regardless of their demographics.[87] Despite the paucity of good quality evidence for the effectiveness of pre-school vision screening programs, a number of healthcare organizations from the U.S., Australia, the UK, and Canada support the development of such screening programs using this approach.[11-13,69,70] For example, an Australian report on their national children's vision screening project emphasized the benefit of universal screening to children[12] based on the premise that health inequities occur in accessing this type of program when voluntary enrollment is left to the discretion of parents and families.[35] It was also noted in a 2007 report on vision screening for children in the UK that parents of lower socio-economic levels are less likely to be aware of free vision screening testing that is available to children under the age of 16.[88]

While most provinces and territories in Canada have systems in place to offer free evaluation of children's vision through health insurance plans, there is a lack of uniformity and consistency in the availability of organized screening programs. Manitoba and British Columbia offer school-based vision screening programs to address healthcare access inequities. In addition, some initiatives such as the UK National Health Services and the Eye See…Eye Learn® (ESEL) program in Canada address health inequity by providing free glasses to children with diagnosed vision disorders.[5,88]

Precautionary Approach

Given the lack of robust evidence demonstrating the effectiveness of organized, universal vision screening in early childhood, the precautionary approach has been used by policy-makers and healthcare professionals to justify organized, universal vision screening in early childhood.[89] The precautionary approach is based on the premise that decision makers have a duty to prevent harm or potential harm when it is within their power to do so, even in situations involving uncertain scientific evidence.[90] Those advocating this approach in support of vision screening programs emphasize that such programs may be important to ensure that children with vision impairments are diagnosed and treated within the critical development period, thus helping to avoid or mitigate amblyopia, vision loss or other

related outcomes, even in the face of uncertain scientific evidence regarding the effectiveness of these programs.[11-13,67,71,69] The impact of preventing vision loss on overall QOL cannot be directly measured. However, according to a WHO report, in 2011, global vision loss accounted for an estimated 31.4 million years of healthy life lost due to disability.[91]

There are four main components to the precautionary principle:[92]

- "Damage condition" refers to an effect which may be "irreversible, catastrophic, serious."[92(p.3)] In the case of undetected and untreated amblyopia, this equates to possible permanent vision loss in the affected eye.

- Knowledge of a known relationship between the activity and the damaging effect is the second component. With childhood vision screening, undiagnosed and untreated amblyopia can result in irreversible vision impairment and vision loss.

- Action is to be taken to remedy the damaging condition. In this example, early treatment of amblyopia identified in preschool children would be the implementable measure.

- The fourth component refers to the obligation to implement a remedial action for an identified condition. In this example, this would refer to implementation of a preschool vision screening program.

The precautionary approach recognizes and acknowledges that other decision-making principles, such as the population health approach, may also play a role in the decision-making process, as in the case of childhood vision screening.

In regard to childhood vision screening, the precautionary approach is also based on societal values of protecting children from harm, given their usual inability to self-advocate and possibly the inability of parents to advocate on their children's behalf.

> "What is considered an 'acceptable risk' or sufficient evidence to act is a function not only of the level of risk and the strength of evidence and uncertainty, but also of the magnitude, reversibility and distribution of the risk, the availability of opportunities to prevent risk, the public's risk aversion, society's culture and values, and the pros and cons of alternative options."[93(p.5)]

Rather than prevalence or severity of amblyopia being the one deciding factor with this approach, it is the value that society places on protecting and advocating for children's health and wellbeing. As a result, society is left with the responsibility to protect vulnerable individuals, such as children, by providing early childhood vision screening programs, even in the absence of current scientific evidence of effectiveness.

Comparative Approaches

In the absence of robust evidence supporting the effectiveness of organized, universal vision screening programs for children, many government and healthcare organizations have used one or more of the previously discussed approaches (WHO screening, population health, precautionary) in establishing their programs, while remaining cognizant of comparable best practices in other jurisdictions. Globally, there is a wide range of pre-school vision screening practices for children, with variations in: the age and frequency of testing, the screening test(s) and screening personnel, and the degree of organization, from ad hoc voluntary testing to developed, standardized programs.[11-14,50,65,94,95]

Canada

In Canada, Manitoba and British Columbia have implemented organized, universal early childhood vision screening programs.[6,7] British Columbia made its recommendations based on a 2005 literature review.[69] Seven years later, a similar report on the safety and effectiveness of preschool vision screening was produced for Alberta based on a systematic review of systematic reviews.[70] Although authors found preschool vision screening showed a favourable impact on reducing the prevalence of amblyopia in children, they were unable to make a recommendation advocating for the implementation of an organized, universal vision screening program in preschool children. In 2012, BC published an evaluation report of its Early Childhood Vision Screening Program.[50] The effectiveness of the program was not addressed in this report, which did outline screening coverage and processes, follow-up for a positive screening test and detection of vision problems post-screening.

Sweden

Since approximately 1981, Sweden has provided an organized, universal screening program for eye disease and visual dysfunction in children based on the population health perspective.[94] This screening is part of a child's general examination performed at Child Health Centres, and visual acuity is measured beginning at age four and again at 7 and 10 years of age. A longitudinal and retrospective study found that refractive errors were primarily detected at the age of four. However, the prevalence of severe amblyopia, defined as visual acuity $\leq$ 0.3, decreased from 2% to 0.2% with screening.[94] The premise of Sweden's comprehensive vision screening practices for children is that it is important for amblyopia to be detected before maturation of the visual system results in treatment resistance. The aim of treatment is to improve and restore vision in the affected eye, and also to prevent visual impairment of blindness later in life, should the unaffected eye become diseased or injured.[67,96]

South Korea

In South Korea, an organized preschool vision screening program has been implemented since 1997, and it became nationwide in 2001. It is reported that in screened kindergarten children between three and five years of age, the prevalence of amblyopia and refractive errors is 0.5% and 1.6%, respectively.[14] Advocacy for organized, universal vision screening in this country is based on the premise that such a program reduces the prevalence and/or severity of vision impairment caused by the three common childhood visual disorders (amblyopia, strabismus and refractive errors) through early detection and treatment.

Australia

The National Children's Vision Screening Project completed a systematic review of the literature examining the effectiveness of vision screening programs.[12] Based on this report, an expert project advisory group was established which recommended that universal visual screening for children occur one year prior to their enrolment in school at the age of four years. As of 2013, there is heterogeneity throughout this country with respect to the types of organized, universal children's vision screening programs being offered, including variation in the age of screening, the screening tests and types of screening personnel used.[65] For example, New South Wales has a Statewide Eyesight Preschooler Screening program (StEPS) that provides free, universal vision screening to four year olds identified through preschools, childcare and other children's services by local health districts.[95] Between 2010 and 2011, 88% of eligible four year-old children were offered screening, of which 72.1% were screened. The prevalence of diagnosed amblyopia was 0.7%.[95] Australia has used elements of both the WHO screening and population health approaches in justifying their implementation of childhood vision screening programs.

United States

In 2011, the USPSTF recommended vision screening for all children, at least once between the ages of three and five years (Grade B recommendation/"high certainty that the net benefit is moderate or there is moderate certainty that the net benefit is moderate to substantial).[55(p342)] This recommendation was based on applying some elements of the WHO screening criteria and the precautionary approach, according to the following rationale:[11] The prevalence of amblyopia was estimated at 2%-4%. If left undiagnosed and untreated, amblyopia can result in irreversible vision loss. Evidence supports that vision screening tools are able to accurately detect common childhood vision disorders (amblyopia, strabismus, refractive errors) and early treatment for amblyopia can result in moderately improved visual acuity outcomes. Potential harms of screening children older than three years included psychosocial effects, such as anxiety from diagnoses and false positive results that resulted in unnecessary treatment. Moreover, the USPSTF report suggested that further studies were needed to examine long-term benefits and harms of preschool vision screening, including QOL, school performance, labelling and mood disorders associated with a diagnosis of a visual disorder.

In the US, a vision screening examination prior to school entry and/or during school is required in all but nine states.[97] This type of legislated policy attempts to address health care access inequity by ensuring that children are screened using an organized and universal approach.

United Kingdom

Although universal opportunistic childhood vision screening programs offered by various providers, including orthoptists, general practitioners and nurses have existed for several decades in the UK, a systematic review of the literature published in 1997 brought into question the validity of continuing this clinical practice.[98] Recommendations made by Hall and Elliman in 2003[99] resulted in the UK National Screening Committee (UK NSC) 2005 recommendation for vision screening by orthoptists for children between four and five years old.[88] In November 2013, the UK NSC recommended that this opportunistic screening be continued. It was suggested that amblyopia would be the most prevalent condition

diagnosed at this age, but that strabismus and refractive errors could also be detected.[13] This recommendation resulted from an external review of vision screening in children aged four to five from earlier that year, conducted by Solebo and Rahi;[71] this study, which reviewed the literature from 1995-2012 and also used elements of the WHO screening approach, found no robust evidence to support changes to the UKNSC 2005 recommendations, such as making the programs organized. The authors noted that amblyopia is the main etiology of visual loss in children of this age group, although the ultimate importance and magnitude of impact of this condition remained to be clarified. Also highlighted was that the risk of visual loss in the unaffected eye, although uncommon, is higher among those with amblyopia than the general population.[67]

CONCLUSION

This review, based on seven systematic reviews of moderate to high quality, did not allow for definitive conclusions regarding the effectiveness of organized, universal vision screening programs for children aged one to six years, largely due to an absence of robust primary studies. However, the current absence of good evidence only suggests that the value of these programs has not (yet) been demonstrated through high-quality primary studies, and does not necessarily mean that they are ineffective.

Future well-designed research is warranted to conclusively determine the effectiveness of such screening programs. The prevalence of common visual impairments including hyperopia, strabismus and amblyopia was estimated in Canada at 4.8%, 4.3% and 4.7%, respectively. However, vision impairments, regardless of cause, may go undetected in early childhood due to a child's inability to recognize and/or complain about visual deficits. Childhood vision screening programs have the potential to detect these and other similar conditions, and thus benefit an affected child's visual and general development.

Overall, the best practices for conducting early childhood vision screening remain unclear. In Canada and internationally, a number of approaches have been applied by various governmental and healthcare organizations to justify organized, universal vision screening programs in early childhood. These include application of the WHO screening criteria, the population health approach and the precautionary approach. Despite the paucity of good quality evidence for the effectiveness of pre-school vision screening programs, a number of healthcare organizations from the U.S., Australia, the UK, and some Canadian jurisdictions support the development of such screening programs using the population health approach to focussing on improving the health of children by reducing health inequities within this population group. Those advocating the precautionary approach in support of vision screening programs emphasize that such programs may be important to ensure that children with vision impairments are diagnosed and treated within the critical development period, thus helping to avoid or mitigate amblyopia, vision loss or other related outcomes, even in the face of uncertain scientific evidence regarding the effectiveness of these programs. Decision makers have likely also been influenced by policy and action in other jurisdictions using the comparative approach.

However, there remains great variation in early childhood vision screening practices. Canada is one such example, with heterogeneity throughout the provinces and territories. At this time, no definitive recommendation can be made for an organized, universal vision screening program for children aged one to six years in Ontario.

GLOSSARY

Amblyopia: A condition commonly referred to as "lazy eye" whereby the brain does not properly recognize visual input from the eye, resulting in reduced vision in the absence of ocular disease. There are 3 main forms of amblyopia, according to cause: strabismic amblyopia (due to strabismus), refractive amblyopia (due to refractive errors) and stimulus deprivation amblyopia (due to cataracts or ptosis).[15,30]

Anisometropia: A condition in which there is a difference in the degree of refractive error between the eyes.[27]

Astigmatism: A condition characterized by abnormal curvature of the cornea or lens that affects both near and distance vision. It is one type of refractive error.[100,101]

Autorefractor: A computerized instrument that provides a rapid objective measurement of refractive errors by directing light to the retina (at the posterior portion of the eye) and measuring its reflection.[47]

Cataract: A condition characterized by opacity or "clouding" of the normally clear lens of the eye.[102]

Health inequality: A difference in health status experienced by different groups in society, regardless of their cause.[103]

Health inequity: A difference in health that is not only unnecessary and avoidable but, in addition, is considered unfair and unjust.[86]

Heterophoria: A tendency for the eyes to deviate from one another, thus affecting alignment of the visual axes. It is distinct from strabismus (see below) in that the eyes are kept in alignment through the fusion mechanism. Fusion is the process in which visual stimuli are integrated into a single image even though they are seen separately by each eye.[104]

Hyperopia: A condition commonly known as "farsightedness." It is characterized as a refractive error in which the parallel rays of light focus behind the retina, leading to impaired near vision.[27]

HOTV chart: A simplified wall chart used for visual acuity testing in young children consisting of four, left-to-right symmetrical letters—H, O, T, and V.[105]

Latent period: An interval during which a disease or condition can be detected prior to the onset of symptoms.[106]

Lea Symbols Test: A method of visual acuity testing in young children consisting of four left-to-right symmetrical symbols—apple, house, circle, and square.[105]

Logarithmic Minimum Angle of Resolutions (LogMAR) chart: A method of measuring visual acuity similar to the more commonly known Snellen-based linear chart (see below), but expressed in logarithmic units.[107]

Myopia: A condition commonly known as "nearsightedness." It is characterized as a refractive error in which the parallel rays of light focus in front of the retina, leading to impaired distance vision.[27]

Opportunistic screening: Screening that occurs when a patient requests a screening test from their health professional, or a health professional offers a screening test to a patient on an *ad hoc* basis. This form of screening is generally not formally assessed or monitored.[108]

Ophthalmologist: A medical doctor specializing in diagnosis, and medical and surgical treatment of eye disorders.[109,110]

Optometrist: A professional who is trained to determine whether individuals need glasses and contact lenses, prescribe optical correction, and screen for abnormalities of the eye.[109,110]

Organized screening program: A structured screening program initiated and managed by a centralized health organization, a government agency and/or public health that includes: a clear screening policy with a specified target population, methods and screening intervals (if applicable), a means of providing follow-up and treatment for patients with abnormal results, a quality assurance structure, and a surveillance system for the condition(s) in question.[111,112] This is in contrast to opportunistic screening, which is generally not formally assessed or monitored.[108]

Orthoptist: An individual who is trained to examine patients with eye problems especially those related to ocular motility, binocular vision, amblyopia or strabismus. He/she can also perform vision screening of children in schools and community health centres.[109,110]

Patching: A form of amblyopia treatment that involves occlusion of vision of the unaffected eye to promote use of the amblyopic eye. Patching is generally undertaken after the refractive error or other amblyogenic factor(s) is/are resolved.[113]

Photoscreener (or photorefractor): An instrument that uses optical images of the eye's red reflex to estimate refractive error, media opacity, ocular alignment, and other specific parameters of the eye.[47]

Precautionary approach (or precautionary principle): A principle which asserts that decision-makers have a duty to prevent harm or potential harm, when it is within their power to do so, even in situations involving uncertain scientific evidence.[90]

Ptosis: A condition characterized by a dropping down of the eyelid due to dysfunction of one or both eyelid retractor muscles. It often affects peripheral vision and may also impact central vision in more significant cases. Ptosis may be congenital (less common) or acquired.[114]

Refractive error: A condition characterized by the inability of an eye to bring parallel rays of light to focus on the retina, resulting in a decrease in visual acuity. The three types of refractive errors include myopia (impaired distance vision), hyperopia (impaired near vision) and astigmatism (impaired near vision and distance vision).[115] Anisometropia is a condition involving a difference in the degree of refractive error between the eyes.[27]

Screening: A process of identifying apparently healthy people who may be at increased risk of a disease or condition. They can then be offered information, further tests and appropriate treatment to reduce their risk and/or any complications arising from the disease or condition.[116]

Snellen-based linear chart: A chart consisting of letters of different sizes that are arranged from largest (top line) to smallest (bottom line) and are read from a distance of 20 feet. A measurement is calculated by indicating the distance at which the chart is read (20 feet) over the size of the smallest line read. For example, a normal visual acuity is considered to be 20/20 on the Snellen chart.[107]

Strabismus: A condition also known as "heterotropia." It is characterized by the misalignment of the visual axes of the eyes that may affect binocular vision and depth perception. This results in one or both eyes turning inwards, outwards or upwards.[27] Strabismus is distinct from heterophoria (see above) in that the eyes are *not* maintained by the fusion mechanism.[104]

Stereoacuity (or stereoscopic acuity or stereopsis): A state characterized by the ability to visually recognize depth based on differences in the images created by the eyes.[117]

Universal screening: Screening that targets *all* individuals with certain general characteristics, such as age (or age range) and/or gender, within a specified jurisdiction or population. This is in contrast to selective screening, which does not target all individuals, but rather focusses on individuals with one or more unique characteristics.[118]

Visual acuity: A term that refers to the sharpness or clarity of vision. It is a measure of the eye's spatial visual discrimination.[27]

Appendices

Appendix A: Overview of a selection of Early childhood vision screening practices in Ontario and Canada

Vision Screening in Ontario

In Ontario, an organized, universal childhood vision screening program is not in place. Instead, opportunistic screening is provided through: primary care providers at routine well-child visits, optometrists, and/or via the Eye See…Eye Learn® (ESEL) program.[5]

At routine well-child visits, as per the aforementioned 2009/2014 re-affirmed CPS Position Statement,[51] it is recommended that primary care providers assess children aged one to five years for cataracts, retinoblastoma (cancer of the retina), and amblyopia precursor conditions (namely strabismus), and additionally assess the visual acuity of children aged three to five years.[48] The ESEL program offers eye and vision assessments at local optometrists' offices for junior kindergarten children from certain publicly-funded school districts.[5,119] It also provides one complimentary pair of glasses to children who require them.[5] As of July 2014, ESEL was offered to children in 17 Ontario School Districts and expansions to eastern Ontario and northern Ontario were planned for 2015.[119] The ESEL program is supported by the Ontario Association of Optometrists (OAO), partially funded by the Ministry of Health and Long-Term Care[5] and also has corporate sponsorship. Under the Ontario Health Insurance Plan (OHIP), eye examinations, such as those performed by physicians or by optometrists, are covered once annually for individuals under 20 years of age.[120]

Other Provinces with an Established ESEL Program or Near-equivalent: Saskatchewan, Québec and Alberta

In Saskatchewan, as part of the early childhood programs through publicly-funded schools, "pre-kindergarten" children are provided with vision screening via community partnerships and integrated services,[121] such as ESEL.[5]

Québec's "Participe pour voir" ("Join and See") program is similar to the ESEL program. "Join and See" is offered to students of selected elementary schools. This program is run by la Fondation des maladies de l'œil (the Eye Disease Foundation) in collaboration with a number of program partners, including l'Ordre des Optométristes du Québec, corporate sponsors, and local Lions Clubs.[60] Eligibility of elementary schools is determined by data from the Ministère de l'Éducation, du Loisir et des Sports. In addition to providing vision screening, the "Join and See" program offers financial support for children in need of corrective glasses.[60]

In Alberta, the provincial health authority (Alberta Health Services) recommends that parents have their children undergo initial vision screening prior to the beginning of kindergarten and ideally by age three years,[122] and an ESEL program has been implemented in this province.[5] Moreover, Alberta Health

Services also recommends that children have annual vision testing up until age 18.[122] The cost of these exams is covered by the Alberta Health Care Insurance Plan (AHCIP).

Provinces with Organized, Universal School-based Vision Screening Programs: Manitoba and British Columbia

In Manitoba, a government-supported, organized, universal school-based vision screening program has been implemented; screening is offered to kindergarten and grade 1 students, as well as to students who are in grade 3 and above.[6] As part of this program, children in kindergarten and grade 1 undergo screening for the following conditions: abnormal stereoacuity, vertical or lateral heterophorias (tendency for the eyes to deviate from one another, but only at rest,[104] and visual acuity deficits (including myopia and hyperopia).[6]

Similarly, in British Columbia, the Early Childhood Vision Screening Program has been established to "identify possible visual defects (amblyopia, strabismus, refractive errors) in preschool age children and/or kindergarten age children."[7(p.5)] As discussed previously, while the main focus of this organized, universal school-based program is on kindergarten children, screening for children three years of age is being piloted to explore earlier detection of vision abnormalities.[123] The Ministry of Health for the province of British Columbia is responsible for the stewardship of the program,[7] and screening is carried out by public health staff.[123]

Vision Screening in The North: Yukon, Northwest Territories, and Nunavut

In the Yukon, community health nurses conduct school-based vision testing for children in rural areas.[8] As of June 2012, the Association of Yukon School Councils, Boards and Committees indicated that there was a plan to re-implement a trained parent-volunteer initial vision screening program in Whitehorse schools.[8]

In the Northwest Territories, the Yellowknife Public Health Unit offers a vision screening program for children in kindergarten as part of comprehensive public health initiative that aims to screen for hearing, speech and vision conditions and to provide outstanding vaccines.[56] Parents are asked to book appointments directly with the Yellowknife Public Health Unit.[56] Similarly, parents of children entering kindergarten in Iqaluit (Nunavut) are requested to book appointments with Iqaluit Public Health in order to receive health assessments and vaccines to begin school.[57] In addition to vision screening and vaccine administration, hearing and developmental screening are carried out, as are dental assessments.[57]

Vision Screening in the Maritimes: Newfoundland and Labrador, Prince Edward Island, Nova Scotia and New Brunswick

Newfoundland and Labrador offers a form of comprehensive screening, similar to the screening described for Yellowknife and Iqaluit, above. As part of the Preschool Health Check (PSHC) in Newfoundland and Labrador, community health nurses perform vision, developmental and hearing screening for children who have reached their fourth birthday.[58] Outstanding vaccines are also provided as part of the PSHC as needed.[58] As well, community health nurses perform school-based baseline vision screening for children up to grade 6.[124,125]

On Prince Edward Island, public health nurses conduct pre-school health clinics in numerous locations on the Island that involve, among other elements, screening for vision, hearing, speech, and developmental issues.[9] However, in the 2014 PEI provincial budget tabled in early April, a new ESEL program was proposed that would run in conjunction with the PEI Association of Optometrists beginning in Fall 2014.[126]

In Nova Scotia, children participate in the "Enhanced Vision Screening Program" when starting school.[10] This screening is performed by public health staff.[10] Similarly, in northern and southeastern areas of the New Brunswick, Réseau de Santé Vitalité (Vitalité Health Network), a regional health authority, provides vision screening to children 3.5 years of age through local public health offices.[59] These screenings are performed by public health nurses[59] Also offered in New Brunswick is the "Healthy Smiles, Clear Vision" program. This program, implemented in September 2012, is part of the province's dental and vision plan for children aged 0 to 18 years of low income families.[127] With respect to vision coverage, the program offers yearly vision exams to eligible children, as well as corrective lenses and frames, as necessary.[127]

Appendix B: Search Strategy

Table B1: Ovid MEDLINE, Embase, and CINAHL Search Strategies

Database:

- Ovid MEDLINE

Search Strategy:

Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1946 to Present

#	Searches	Results
1	(review or systematic review or pooled or meta analysis or meta analyses or metaanalysis or metanalysis or summar* or synthes*).mp.	3,266,388
2	(Screen* or Test* or Diagnos* or Assess* or Program*).mp.	6,617,895
3	(Assess* or Compar* or Effect* or Efficacy or Evaluat* or Evidence or Impact).mp.	10,425,726
4	Vision, Ocular/ or Vision Disorders/ or Amblyopia/ or Astigmatism/ or Strabismus/ or Hyperopia/ or Myopia/ or Visual Acuity/ or Vision Screening/ or (squint* or eyesight or strabism* or refractive error* or hypermetropia or (vision adj2 screening)).mp. or ((Eye* or sight* or vision* or visual) and (Problem* or Defect or Impair* or Deficit* or Reduc*)).mp.	254,633
5	child/ or child, preschool/ or infant/ or Child Day Care Centers/ or schools/ or schools, nursery/ or (preschool* or infant* or toddler* or kindergarten or school* or nursery or daycare or day care or child* or boy* or girl*).mp.	2,557,787
6	1 and 2 and 3 and 4 and 5	2,074
7	2 and 3 and 4 and 5	16,176
8	limit 7 to (meta analysis or "review" or systematic reviews)	1,253
9	6 or 8	2,134
10	limit 9 to (english language and yr="2004 -Current")	1,241
11	remove duplicates from 10	1,162

Database:

- Embase

Search Strategy:

Ovid Embase 1996 to 2014 Week 37

#	Searches	Results
1	(review or systematic review or pooled or meta analysis or meta analyses or metaanalysis or metanalysis or summar* or synthes*).mp.	2,996,213
2	(Screen* or Test* or Diagnos* or Assess* or Program*).mp.	6,216,652
3	(Assess* or Compar* or Effect* or Efficacy or Evaluat* or Evidence or Impact).mp.	9,052,338
4	exp vision/ or exp visual disorder/ or strabismus/ or visual acuity/ or vision test/ or (squint* or eyesight or strabism* or refractive error* or hypermetropia or (vision adj2 screening)).mp. or ((Eye* or sight* or vision* or visual) and (Problem* or Defect or Impair* or Deficit* or Reduc*)).mp.	335,241
5	child/ or preschool child/ or infant/ or day care/ or school/ or nursery school/ or (preschool* or infant* or toddler* or kindergarten or school* or nursery or daycare or day care or child* or boy* or girl*).mp.	1,512,749
6	1 and 2 and 3 and 4 and 5	4,336
7	2 and 3 and 4 and 5 and 6	4,336
8	limit 7 to "review"	2,110
9	6 or 8	4,336
10	limit 9 to (english language and yr="2004 -Current")	3,433
11	limit 10 to exclude medline journals	365
12	remove duplicates from 11	361

Database:

- CINAHL

Search Strategy:

EBSCOhost CINAHL Plus with Full Text

#	Query	Limiters/Expanders	Results
S10	S6 OR S7	Limiters - Published Date: 20040101-; English Language; Exclude MEDLINE records Search modes - Boolean/Phrase	94
S9	S6 OR S7	Limiters - Published Date: 20040101-; English Language Search modes - Boolean/Phrase	318
S8	S6 OR S7	Search modes - Boolean/Phrase	429
S7	S2 AND S3 AND S4 AND S5	Limiters - Publication Type: Meta Analysis, Meta Synthesis, Review, Systematic Review Search modes - Boolean/Phrase	174
S6	S1 AND S2 AND S3 AND S4 AND S5	Search modes - Boolean/Phrase	380
S5	((MH "Child") OR (MH "Child, Preschool") OR (MH "Infant") OR (MH "Child Day Care") OR (MH "Schools") OR (MH "Schools, Nursery")) OR ((preschool* OR infant* OR toddler* OR kindergarten OR school* OR nursery OR daycare OR "day care" OR child* OR boy* OR girl*))	Search modes - Boolean/Phrase	591,219
S4	((MH "Vision Screening") OR (MH "Vision Tests") OR (MH "Vision Disorders") OR (MH "Amblyopia") OR (MH "Astigmatism") OR (MH "Strabismus") OR (MH "Hyperopia") OR (MH "Myopia") OR (MH "Visual Acuity")) OR ((squint* OR eyesight OR strabism* OR "refractive error*" OR hypermetropia OR (vision N2 screening)) OR ((Eye* OR sight* OR vision* OR visual) AND (Problem* OR Defect OR Impair* OR Deficit* OR Reduc*)))	Search modes - Boolean/Phrase	32,353

#	Query	Limiters/Expanders	Results
S3	(Assess* OR Compar* OR Effect* OR Efficacy OR Evaluat* or Evidence or Impact)	Search modes - Boolean/Phrase	0
S2	(Screen* OR Test* OR Diagnos* OR Assess* OR Program*)	Search modes - Boolean/Phrase	1,425,923
S1	(review OR "systematic review" OR pooled OR "meta analysis" OR "meta analyses" OR metaanalysis OR metanalysis OR summar* OR synthes*)	Search modes - Boolean/Phrase	302,208

Figure B1: PRISMA Flow Sheet for Included and Excluded Studies

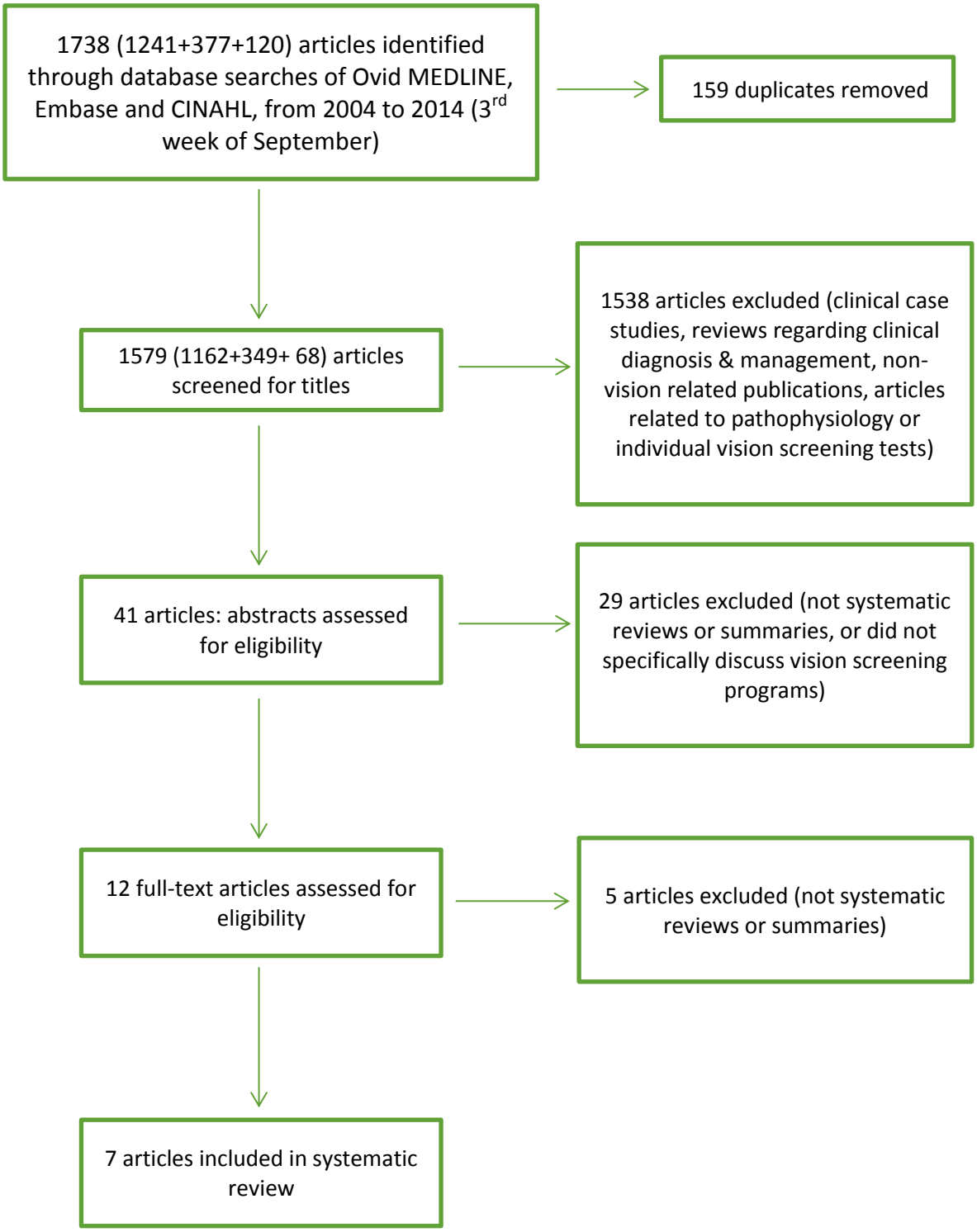

Table B2: Excluded studies After Full Text Review (n=5)

Article	Reason for Exclusion
Cools G, Houtman AC, Spileers W, Van Kerschaver E, Casteels I. Literature review on preschool vision screening. Bull Soc Belge Ophthalmol. 2009;313:49-63.[64]	A selective review of the literature, but not a systematic review.
Hopkins S, Sampson GP, Hendicott P, Wood JM. Review of guidelines for children's vision screenings. Clin Exp Optom. 2013;96(5):443-9.[65]	A review of the literature, but not a systematic review.
Lagreze WA. Vision screening in preschool children: do the data support universal screening? Dtsch Arztebl Int. 2010;107(28-29):495-9.[66]	A selective review of the literature, but not a systematic review.
Logan NS, Gilmartin B. School vision screening, ages 5-16 years: the evidence-base for content provision and efficacy. Ophthalmic Physiol Opt. 2004;24(6):481-92.[67]	A review of the literature, but not a systematic review.
Mema SC, McIntyre L, Musto R. Childhood vision screening in Canada: public health evidence and practice. Can J Public Health. 2012;103(1):40-5.[35]	An evidence-based public health approach to a literature review, but not a systematic review.

Appendix C: Quality Appraisal of Included Systematic Reviews

Table C1: Summary of Quality Appraisal of Included Systematic Reviews (n=7) Using AMSTAR Checklist (68)

Reference	1] A priori design	2] Duplicate study selection & data extraction	3] Comprehensive literature search	4] Status of publication used as an inclusion criterion	5] List of Studies (included & excluded)	6] Characteristics of the included studies	7] Quality of the included studies assessed and documented	8] Quality of the included studies used in formulating conclusions	9]Appropriate methods to combine the findings of studies*	10] Assessed likelihood of publication bias	11] Conflict of Interest	Total Yes (/11)	Quality Rating (high, intermediate, low)
Carlton et al. (2008).[27]	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	No	No	6	medium
Powell & Hatt (2009).[49]	Yes	Yes	Yes	Yes	Yes	N/A	N/A	N/A	N/A	N/A	N/A	5 | 5	high
Powell, Wedner & Hatt (2004).[61]	Yes	Yes	Yes	Yes	Yes	N/A	N/A	N/A	N/A	N/A	N/A	5 | 5	high
Schmucker et al. (2009).[62]	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	8	high
Mathers et al. (2010).[63]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	No	7	medium
Chou et al. (2011).[4]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	9	high
West & Williams (2011).[30]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	8	high

*Note re AMSTAR Question #9-Appropriate methods to combine the findings of studies:
None of the included reviews were meta-analyses, therefore none of the results were pooled. A "yes" rating was given if the review authors directly stated that they could not pool because of primary study heterogeneity/variability, of if data from the included primary studies were presented in sufficient detail such that heterogeneity/variability could be assessed and confirmed.

N/A ratings for Powell & Hatt[49] and Powell, Wedner & Hatt[61] reviews: Both systematic reviews had 0 studies meeting inclusion criteria, and thus none were included in the reviews. AMSTAR Ratings: high =8-11; medium= 4-7, low=0-3

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Public Health Ontario
480 University Avenue, Suite 300
Toronto, Ontario
M5G 1V2

647.260.7100
communications@oahpp.ca
www.publichealthontario.ca