Alberta STE Report

The Safety and Effectiveness of Preschool Vision Screening

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THE SAFETY AND EFFECTIVENESS OF PRESCHOOL VISION SCREENING

Alberta STE Report: Policy-driven Health Technology Assessment reports that include an analysis of the social and system demographics, technological effectiveness and economic implications of a health technology. The reports are written under contract with the Alberta Health Technologies Decision Process and contextualized for use in Alberta.

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EXECUTIVE SUMMARY

Technology Effects and Effectiveness

Background

Common vision conditions in preschool children (aged from birth to 6 years) include amblyopia, strabismus, and refractive errors. Visual impairment associated with these conditions may result in irreversible vision loss and reduce quality of life, function, and school performance. Preschool vision screening (PSVS) for these conditions has been used to identify, at a critical period of visual development, affected children who may benefit from early interventions to correct or improve vision. However, the value of implementing PSVS programs and the optimum protocol for administering them have been, and continue to be, the subject of scientific and health policy discussion.

Objectives

This review focused on the best evidence available on the use of PSVS to detect vision conditions in asymptomatic preschool children (aged from birth to 6 years; not necessarily considered at risk for developing visual impairment) to:

- determine the safety and efficacy/effectiveness of PSVS
- compare the safety and effectiveness of universal and targeted PSVS
- determine the best practice for conducting PSVS

Results

According to results reported by five recently published systematic reviews:

- The available primary research studies do not provide rigorous evidence or clear indications of benefit or lack of benefit from PSVS. Only one study was available that directly compared the benefit of screening with no screening, and only a few studies were available that compared PSVS strategies of varying intensity or screening strategies conducted at different ages. Most studies showed limited robustness of results.
- Studies that would enable an estimate of potential harms from PSVS are still lacking.
- The best available evidence suggests a positive impact of universal PSVS on amblyopia prevalence in children. However, the implication of improved visual acuity (for example, any potential impact on school performance and/or quality of life) was not considered.
- There are no studies comparing the effect of universal PSVS versus targeted PSVS.
- The best practice for conducting PSVS remains unclear.
- Many questions about PSVS and its utility are still unanswered.

Conclusions

Though there is no doubt of the importance of all children having perfect or near-perfect functional vision, there is not sufficient rigorous evidence to conclusively evaluate the effectiveness and safety of using PSVS (universal or targeted) for the detection of vision conditions that commonly occur at an early age (before 6 years). The results from five recently published systematic reviews did not clarify the extent to which PSVS assists in reduction of the prevalence of vision conditions that

commonly cause visual impairment in childhood, or if PSVS is the best method by which to reduce the prevalence of these vision conditions. Furthermore, the evidence on the potential harms of PSVS remains limited.

Future well-designed research is warranted to rigorously assess the utility of PSVS.

Methodology

Research studies reporting on the safety and efficacy/effectiveness of using PSVS for visual impairment in asymptomatic preschool children were identified through a comprehensive, systematic search of the literature published in English between January 2007 and March 2012. The search included: The Cochrane Library, NHS Centre for Reviews and Dissemination Databases (EED, HTA, DARE), PubMed, EMASE, CINAHL, and the web sites of various health technology assessment (HTA) agencies, evidence-based resources, and clinical practice guidelines sites.

For the purpose of this review, selected to formulate the evidence base on the safety and efficacy/effectiveness of PSVS (universal or targeted) were only published reports of systematic reviews and HTA studies. Individual primary research studies (of any design) published subsequent to the selected systematic reviews and HTA studies were not included. One reviewer performed the study selection and extracted the data from the selected studies. An informal quality assessment for all selected research studies was completed during the final study selection process. The evidence was qualitatively synthesized and presented in summary tables.

Economics Analysis

Objective and Method

The objective was to assess, through a review of the published economic literature, the cost-effectiveness of various strategies used in the screening of preschool vision.

Results

When examining studies that compared universal vision screening with no screening, results from a limited number of studies indicate that the cost per case detected ranges from €727 (approximately £600) to £73,000 depending on the specific characteristics of screening, clinical setting, prevalence of disease, cost components, and age at which screening is conducted. When outcomes are measured in terms of quality-adjusted life-years (QALYs), the cost per additional QALY gained ranged between £500,000 and £11 million, depending on the age of the child at screening. While vision screening is associated with improvements in health outcomes it does not provide a net cost saving to the health system; the evidence, while limited, suggests that additional health benefits do not outweigh additional costs.

Conclusion

Limited economic evidence has been published informing the cost-effectiveness of vision screening in preschool aged children.

ABBREVIATIONS

AHRQ	Agency for Healthcare Research and Quality
ALSPAC	Avon Longitudinal Study of Parents and Children
CADTH	Canadian Agency for Drugs and Technologies in Health
CI_{95}	95% confidence interval
CPG	clinical practice guideline
CPS	Canadian Pediatric Society
CRD	Center for Reviews and Dissemination
CVI	Children's Vision Initiative
D	diopter(s)
ESEL	*Eye see … Eye Learn* program
HRQoL	health-related quality of life
HTA	health technology assessment
IHE	Institute of Health Economics
IQWiG	Institut für Qualität und Wirtschaftlichkeit im Gesundheitswesen (Institute for Quality and Efficiency in Health Care)
LogMAR or **logMAR**	logarithmic minimal angle of resolution
LR	likelihood ratio
mo	month(s)
MTI	medical technology and innovations
NHS	National Health Service
NLR	negative likelihood ratio
NNS	number needed to screen
NPV	negative predictive value
OR	odds ratio
PLR	positive likelihood ratio
PPV	positive predictive value
PSVS	preschool vision screening
QoL	quality of life
QALY	quality-adjusted life-year
QHES	quality of health economic studies
QUADAS	quality assessment of diagnostic accuracy studies

RCT	randomized controlled trial
RR	relative risk
Sn	sensitivity
Sp	specificity
SR	systematic review
UK	United Kingdom
US(A)	United States (of America)
USPTF	United States Preventive Services Task Force
VA	visual acuity
VIP	vision in preschoolers
vs.	versus
y	year(s)
WHO	World Health Organization
wk	week(s)

GLOSSARY

The glossary terms listed below were obtained and adapted from the following sources:[1]

www.health.gov.bc.ca/library/publications/year/2010/Provincial_vision_screening_training_manual.pdf

http://opto.ca/about-optometry/terminology/

www.eyeglossary.net/

www.health.state.mn.us/divs/fh/mch/webcourse/vision/glossary.cfm

www.azdhs.gov/diro/admin_rules/guidancedocs/GD-100-PHS-WCH_VisionScreeningGuidelines.pdf

www.aoa.org/x9757.xml

www.biology-online.org/dictionary

Accommodation: The adjustment of the eye for seeing at different distances, accomplished by changing the shape of the crystalline lens through action of the ciliary muscle, thus focusing a clear image on the retina.

Accommodative dysfunction: An eye-focusing problem unrelated to aging changes in the lens of the eye.

Amblyopia: Reduced vision (visual acuity) in one or both eyes in the absence of ocular disease (without detectable anatomic damage in the eye or visual pathways), which occurs when the brain does not recognize input from the eye(s).

Ametropia: A refractive error in which parallel rays of light do not come into focus on the retina; includes hyperopia, myopia, and astigmatism.

Anisometropia: A condition in which there is a different type of refractive error between the two eyes.

Astigmatism: A vision condition (refractive error of the eye) in which, with accommodation suspended, the refracting power of the eye is not uniform in all directions such that incoming rays of light in a single eye do not come together to focus at a single point, but rather are focused at two or more points; this results in the formation of a distorted image and causes blurred vision.

Autorefractor: A new technology consisting of a small, portable, lightweight vision assessment system capable of detecting refractive errors.

Binocular: Pertaining to using both eyes simultaneously.

Binocular vision: The ability to use the two eyes simultaneously to focus on the same object and to fuse the two images into a single image.

Blindness: The legal definition of blindnessin Canada is: central visual acuity of 10/100 or less in the better eye after correction; or visual acuity of more than 10/100 if there is a field defect in which the widest diameter of the visual field subtends an angle no greater than 20 degrees; in the United States, the legal definition of blindness is: central visual acuity of 20/200 or less in the better eye after correction

Blind spot (physiological)**:** The sightless area within the visual fielled of a normal eye; an area that has no nerve receptors located at the back of the eye where the optic nerve enters the eye to supply nerve fibers and blood vessels to the retina.

Case study: Research that refers to the collection and presentation of detailed information about a particular participant or small group.

Cataract: A condition in which the crystalline lens of the eye, or its capsule, or both, become opaque, with consequent loss of visual acuity.

Central vision: A term used to connote the function of the eye that enables optimal perception of form, shape, clarity, and keenness of an image; it is a function of the cones of the retina.

Choroid: The choroid is the intermediate layer of the coat of the eyeball and lies between the retina and the sclera; it contains blood vessels that provide nourishment and cooling to the retina.

Colour disorder: A condition of the eye in which there is a diminution, absence, or unresponsiveness of photochemical receptors in the cones, or an alteration in the structure or function of the cones unrelated to colour receptors.

Colour vision: The perception of all specters of white light due to responsiveness of the cones in the fovea and macula, which contain photochemical receptors sensitive to red, green, or blue light.

Colour deficiency: The inability to perceive differences in colour, usually for red or green, rarely for blue or yellow; the condition exists in varying degrees from minor loss to complete colour blindness.

Colour vision deficiency: The inability to distinguish certain shades of colour or, in more severe cases, to see colours at all; a diminution or lessening of one of the three pigments in the colour-sensitive cones of the retina.

Cones: One of the two types of light-sensitive nerve endings scattered over the surface of the retina, which make it possible to transmit visual impulses to the brain.

Congenital: Present at birth.

Convergence: The process of directing the visual axes of the two eyes to a near point, with the result that the pupils of the two eyes are closer together; the eyes are turned inward.

Cornea: The anterior transparent portion of the outer coat of the eye through which light enters.

Crystalline lens: The eye's natural lens; a transparent, colourless body suspended in the anterior portion of the eyeball, between the aqueous and vitreous chambers, the function of which is to help bring the rays of light to a focus.

Cylinder: A measure of the power of astigmatism, or irregular focus of the eye; a display unit on an autorefractor device.

Depth perception: The ability to perceive the solidity of objects and their relative position in space.

Dilated pupil: An enlarged pupil, resulting from contraction of the dilator muscle or relaxation of the iris sphincter; it occurs normally in dim illumination, or may be produced by certain drugs or by blunt trauma.

Diopter: A unit of measurement denoting the amount a lens can bend a light ray; a unit used to designate the refractive power of a lens.

Diplopia (double vision): The perception of two images from one object; images may be horizontal, vertical, or diagonal.

Distance vision: The ability of the eye to see images clearly at a distance (often a great distance).

Distance vision chart: A wall-mounted, portable, or computer-based chart composed of optotypes arranged in lines of increasingly smaller size, designed to assess distance vision and other visual functions.

Divergence: The ability to relax convergence or the ability to turn the eyes out.

Emmetropia: The absence of refractive error.

Emmetropisation: The process by which the refraction of the anterior ocular segment and the axial length of the eye tend to balance each other to produce emmetropia.

Esophoria: A tendency of the eye to turn inward.

Esotropia: A manifest or observable turning inward of the eye (convergent strabismus or crossed eye).

Exophoria: A tendency of the eye to turn outward.

Exotropia: A manifest or observable turning outward of the eye (divergent strabismus or walleye).

Eye dominance: The tendency of one eye to assume the major function of seeing, being assisted by the less dominant eye.

Field of vision: The entire area that can be seen at one time without shifting the head or eyes.

Focus: The point at which rays are converged after passing through a refractive substance.

Fovea: A small depression in the retina at the back of the eye; the part of the macular area adapted for most acute vision.

Fundus: The inner surface of the posterior part of the eye.

Fusion: Coordination into one picture of the images seen by each eye individually.

Glaucoma: A group of eye disorders marked by increased intraocular pressure leading to progressive damage to the optic nerve and characterized by loss of nerve tissue, resulting resulting in vision loss.

Hyperopia (farsightedness): A refractive error in which the eyeball is too short from front to back or the refractive power of the eye is too weak, so parallel rays of light are brought to a focus behind the retina.

Hyperphoria: A tendency of one eye to deviate upward.

Hypertropia: A manifest or observable deviation upward of one of the eyes.

Iris: The part of the eye that gives it its colour; the coloured, circular membrane that regulates the amount of light entering the eye by changing the size of the pupil.

Lazy eye: A lay term for amblyopia and misaligned eye.

LEA symbols chart: A recognition chart used to test visual acuity in children; it uses four shapes familiar to a young child: heart, circle, house, and square.

Linear logMAR chart: A chart used to assess visual acuity; lines or symbols are placed on rows that gradually increase or decrease in size from top to bottom (logMAR refers to the log of the minimum angle of resolution).

Lens: A refractive medium of colourless transparent substance shaped so as to converge or scatter rays of light; responsible for accommodation (also termed crystalline lens).

Monocular: Pertaining to using or having one eye.

Myopic (nearsightedness): A refractive error in which the eyeball is too long or the refractive power is too strong, so that parallel rays of light are focused in front of the retina.

Near vision: The ability to perceive distinctly objects at normal reading distances, about fourteen inches from the eyes.

Near vision chart: A wall-mounted, portable, or computer-based chart composed of optotypes arranged in lines of increasingly smaller size designed to assess near vision, particularly accommodative reflex.

Occlude: To cover one eye.

Occluder: An object that temporarily obstructs vision during vision screening or testing, preventing an eye from visualizing a focal point.

Occular alignment: The positioning of both eyes by the extraocular muscles so they are targeting the same focal object simultaneously, with the result that two images, one from each eye, fall on the same respective foveae (the eyes are said to be parallel).

Occular hypertension: An increase in the pressure inside the eye above the range considered normal, without any detectable changes in vision or damage to the structures of the eye.

Occlusion: The method of obscuring the vision of one eye, so as to force the use of the other eye.

Ophthalmologist: A licensed physician (medical doctor) who is trained and registered to provide total eye and vision care (specializing in diagnosis and management of refractive, medical, and surgical problems related to eye diseases and vision problems/disorders).

Ophthalmoscope: An instrument used in examining the interior of the eye.

Optician: A professional (technician) trained to supply, prepare, and dispense optical appliances, as well as to interpret prescriptions prepared by ophthalmologists and optometrists, and to fit, adjust, and adapt optical appliances.

Optic disc: The point of entry into the retina of the optic nerve; commonly known as the blind spot.

Optic nerve: The largest sensory nerve of the eye; it carries the impulses for sight from the retina to the brain.

Optometrist: A healthcare professional licensed to provide eye and vision care; a doctor in optometry (OD) specializing in the examination of the eyes and the prescribing of glasses, contact lenses, optical aids, and services for vision enhancement.

Orthoptics: The discipline and techniques dealing with the diagnosis of defective eye coordination, binocular vision, and functional amblyopia, and with providing the therapy necessary to re-educate and restore sensory and motor coordination.

Orthoptist: An eye and vision care professional trained to diagnose and manage ocular motility/eye movement disorders and associated vision problems; an orthoptist works with the ophtalmologist, performing investigative procedures appropriate to disorders of the eye and visual system and assisting with rehabilitating patients who have vision loss.

Patching: The covering of an amblyopic patient's preferred eye, to improve vision in the other eye.

Peripheral vision: The ability to perceive presence, motion, or colour of objects outside the direct line of vision.

Phoria: A root word denoting a latent deviation in which the eyes have a tendency to turn from the normal position, used with a prefix to indicate the direction of such deviation (hyperphoria, up; esophoria, in; exophoria, out).

Photophobia: An abnormal sensitivity to and discomfort from light.

Prospective (of future)**:** The strategy of maintaining a watch over a suspected population after an event.

Pseudo-randomized controlled trial: A clinical study similar to a randomized controlled trial, but without the use of a random allocation; the study design is less rigorous.

Ptosis: A drooping of the eyelid that, if significant, may interfere with vision.

Pupil: The opening at the center of the iris of the eye for the transmission of light.

Randomized controlled trial: A clinical study in which the unit of experimentation (for example, people or a cluster of people) is allocated to either an intervention (the factor under study) group or a control group, using a random mechanism (such as a coin toss, a random number table, or computer-generated random numbers), and in which the outcomes from each group are compared.

Refraction: The deviation of the course of light rays in passing from one transparent medium into another of different density; the bending of light rays to facilitate convergence on the retina; a test conducted to determine refractive errors of the eye and correction by glasses.

Refractive error: A defect in the eye that prevents light rays from being brought to a single focus exactly on the retina; an inability of the eye to focus the image.

Refractive active media of the eye: The transparent parts of the eye - cornea, aqueous, lens, and vitreous - that have refractive power.

Reliability number: A number that indicates the number of good readings obtained and their consistency, based on a 1 to 9 scale; the higher the number, the better the reliability.

Retina: The innermost coat of the eye, which receives the image and changes it into nerve impulses that are transmitted to the brain.

Retinoblastoma: A type of eye cancer, occurring in young children, which develops in the retina (the light sensitive lining at the back of the eye).

Screening: The application of rapid and simple test(s)/procedure(s) to a large population consisting of individuals who are undiagnosed and typically asymptomatic, to identify and separate those who are apparently well or unaffected - but who may be at risk of a disease/health problem/condition and who may require additional diagnostic procedures - from those who are unlikely to have the disease; screening typically results in either a "pass" or "refer" outcome and should be considered part of a continuum, in that a positive screening test result will result in a referral to appropriate health providers and services.

Sensitivity: The ability of a test to detect the disorder it was designed to detect; expressed as the percentage of positive results in those individuals with the disorder.

Sheridan Gardiner test: A measure of visual acuity that contains near vision and distance vision tests as well as reduced Snellen tests; testing depends on matching shapes rather than identifying or naming letters.

Snellen Chart: A chart used for testing central visual acuity; it consists of lines, letters, numbers, or symbols in graded sizes drawn to Snellen measurements; each size is labeled with the distance at which it can read by the normal eye; most often used in testing vision at a distance of 10 or 20 feet.

Specificity: The ability of a test to differentiate a normal condition from the disorder that the test was designed to detect; expressed as the percentage of negative results in individuals without the disorder.

Sphere: The power of the eye, which determines hyperopia and myopia; a display unit on an autorefractor device: negative numbers indicate myopia (nearsightedness) and positive numbers indicate hyperopia (farsightedness).

Squint: A lay term for strabismus; a condition in which the eyes are not aligned in parallel, causing a cross-eyed appearance.

Stereoacuity test: A measure of stereopsis and visual acuity.

Stereopsis: Binocular visual perception of three-dimensional space; depth perception or three-dimensionality that is possible only when both eyes are in alignment and perceive the same image clearly.

Stereoscopic vision: The ability to perceive the relative position of objects in space without such clues as shadow, size, and overlapping.

Strabismus: A manifest deviation of one or both eyes from the visual axis of the other, so that they are not simultaneously directed to the same object; misalignment of the eye (manifest or latent) in any direction; synonymous with tropia or squint.

Suppression: The condition in which sensations from one eye are involuntarily and unconsciously ignored or "suppressed" by the nervous system; when strabismus is present, suppression prevents the double vision that would otherwise occur due to the misalignment of the eyes; suppression over a period of time interferes with development of the eye and the development of normal binocular vision (see **Amblyopia**).

Systematic review: The systematic location, appraisal, and synthesis of evidence from scientific studies.

Tension, intraocular: The pressure of the fluids inside the eye against the outer structure.

Tropia: A root word denoting a manifest or observable deviation from normal of the axis of the eyes (strabismus), used with a prefix to denote the type of strabismus (for example, heterotropia, esotropia, exotropia).

Universal: Available and applicable to all without discrimination**.**

Visual acuity: Sharpness of vision with respect to the eye's ability to distinguish detail as an object is placed further away or as it becomes smaller in size; the state, condition, or effectiveness of central vision; acuity is measured as a fraction of normal vision.

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SECTION ONE: TECHNOLOGY EFFECTIVENESS/EFFICACY

Paula Corabian, BSc, MPH; Dagmara Chojecki, BSc, MLIS

INTRODUCTION

Common vision conditions in preschool children (aged from birth to 6 years) include amblyopia, strabismus, and refractive errors.[1–14] Vision/visual impairment associated with these conditions may result in irreversible vision loss and reduce quality of life, function, and school performance. Screening for these conditions can identify, at a critical period of visual development, affected children who may benefit from early interventions to correct or improve vision.

Preschool vision screening (PSVS) programs have been set up and used over the past few decades to detect visual impairment in childhood and to refer affected children for early treatment while vision improvement is still possible.[1–16] The value of such programs and the optimum protocol for administering them continue to be the subject of scientific and health policy discussion. The effectiveness and safety of PSVS have been debated, and no agreement currently exists regarding the age at which children should be screened, which test(s)/device(s) should be used, who should perform the screens, and what outcomes should be measured.

This review is focused on the best evidence available on the use of PSVS to detect vision conditions in asymptomatic preschool children (aged from birth to 6 years; not necessarily considered at risk for developing visual impairment) to:

- determine the safety and efficacy/effectiveness of PSVS
- compare the safety and effectiveness of universal and targeted PSVS
- determine the best practice for conducting PSVS

The scope of the report was defined as follows:

Population: asymptomatic preschool children screened in PSVS programs (universal or targeted)

Intervention: universal or targeted PSVS

Comparators: universal PSVS versus targeted PSVS, or universal PSVS versus no PSVS, or targeted PSVS versus no PSVS

Outcomes: diagnostic accuracy (sensitivity, specificity, positive and negative predictive values) of PSVS; impact on reversing visual impairment in children diagnosed with vision conditions; impact on developmental and educational outcomes in children diagnosed with vision conditions; impact on social and emotional development, functional capacity, and other developmental milestones (such as scholastic achievement) in children diagnosed with vision conditions; impact on quality of life in children diagnosed with vision conditions; risks and complications to preschool children and/or screeners from performing the screening itself; and adverse effects of false positive and false negative PSVS results.

This review also aimed to determine the best practice for conducting PSVS and included the following elements of assessment:

- literature searches for the best and most recently reported scientific evidence on the safety and efficacy/effectiveness of using PSVS for detecting vision conditions in asymptomatic preschool children

- a summary of findings reported by published systematic reviews and health technology assessment (HTA) studies reporting on the safety and efficacy/effectiveness of PSVS for detecting vision conditions in asymptomatic preschool children
- a summary of the recommendations from relevant evidence-based clinical practice guidelines (CPGs) and consensus/position statements issued on conducting PSVS for this indication
- a summary of information on specific elements (such as age of screened children, screening tests/devices/technologies/procedures, screeners/screening personnel, and tests/devices/technologies/procedures used for confirmatory diagnosis) of Canadian PSVS programs, as provided by their protocols
- clinical input from Expert Advisory Group members about local context and clinical practice

The literature search strategy, data sources, and methods used for screening and reviewing the retrieved literature are described in more detail in Appendices T.A and T.B.

CLINICAL CONDITION: VISUAL IMPAIRMENT IN PRESCHOOL CHILDREN

Visual impairment during childhood can be caused by several disorders that occur during the first few months of life, including congenital cataracts, congenital glaucoma, and retinopathy of prematurity (ROP).[9,11,17–23] Although these disorders are rare, they are often bilateral and may lead to severe visual impairment. The most common causes of visual impairment in preschool children are: amblyopia and its associated ("amblyogenic") risk factors; strabismus not associated with amblyopia; and refractive error not associated with amblyopia (www.aoa.org).[2,4–8,11–13,24–31]

Amblyopia is defined as a reversible visual deficit in one or both eyes in the absence of any demonstrable abnormality of the visual pathway.[2,3,5–9,12–14,22,24–27,29,31–33] This vision condition usually occurs during the first six years of life and is characterized by abnormal processing of visual images in the brain during the critical period of vision development (while the visual system is still maturing). It typically affects one eye and is asymptomatic. Visual impairment associated with amblyopia is not immediately correctable with refractive lenses, is unlikely to resolve spontaneously, and can become irreversible.

Amblyopia is commonly classified according to its cause: strabismic (caused by strabismus or squint); stimulus deprivation (caused by cataract, ptosis, or other structural abnormalities); refractive (caused by optical or refractive error, including anisometropia, astigmatism, and hyperopia).[3,5,6,8,13,24,26,27,29,32]

The earlier during childhood the predisposing conditions manifest, the longer the duration, and the more severe the level of amblyopia may be. It is not uncommon for these types of amblyopia to co-exist.

Strabismus is characterized by an abnormal alignment of one or both eyes in any direction that can result in loss of the binocular vision required for fine depth perception (www.aoa.org).[2,6,7,10,18,27–29,31,34] It is one of the most common amblyogenic risk factors; it can also inhibit development of normal binocular vision in the absence of amblyopia and result in psychosocial consequences. Although strabismus often appears between birth and 21 months of age, it may develop as late as age of 6 years and may be constant or intermittent. The degree of strabismus may range from very small to a more obvious, cosmetically obtrusive misalignment.

Refractive errors occur when light rays entering the eyes meet in front of or behind the retina rather than directly on it, causing blurred vision for near and/or distant objects.[2,6,10,26,31,34] Refractive errors

include myopia (nearsightedness), hyperopia (farsightedness), astigmatism, and anisometropia (unequal refractive power in the eyes). Most often, amblyopia is the result of refractive errors. The chances of a child developing amblyopia are higher if he or she has a refractive error in one eye or if one eye is farsighted and the other is nearsighted.[32]

Colour deficiencies are the result of a defect in special cells on the retina called cones.[10] Children with colour deficiency have difficulty identifying certain colours; this vision defect is more common in boys than girls. Colour deficiencies are not sight-threatening and there is no correction for this condition.

Risk Factors

Factors placing preschool children at risk for developing visual impairment include prematurity and low birth weight; family history of amblyopia, refractive error, strabismus, congenital cataracts, metabolic or genetic disease; intrauterine infections; difficult or assisted labour; high refractive error; strabismus; anisometropia; known or suspected neuro-developmental disorders; and systemic disease associated with eye abnormalities.[6,9,12,14,17,18,20,27,35,36] Maternal smoking and use of drugs or alcohol during pregnancy are also associated with strabismus and amblyopia.[12,14,18,20,27]

Prevalence and Incidence

An estimated 19 million children under 15 years of age suffer from visual impairment.[37] Of these, 12 million children are visually impaired due to refractive errors. It has been estimated that "up to one in 10 to 20 young children will have common vision conditions that can lead to permanent vision loss."[38]

Prevalence rates reported for the most common vision conditions such as amblyopia, strabismus, and refractive errors vary by age, race/ethnicity, and family income across different countries (0.5% to 6% for amblyopia, 1% to 38% for strabismus, and 0.5% to 34% for refractive error).[2–6,8,9,11–15,20,22,24,26,28,29,32,34,36,39–41] This variation reflects the differences in the examined cohorts (clinical or population-based cohorts), the definition of pathology applied for the vision condition, the variation in the age at which children are screened and studied, and the differences in screening programs from which data are obtained (different settings, different tests, different screeners, and so on).

In North America, it has been estimated that 2% to 20% of children under the age of 5 years have clinically significant eye conditions.[41] In the Unites States, between 1% and 5% of preschool children have visual impairment.[6,7] It has been estimated that 5% to 7% of preschool children have significant refractive errors and 1% to 4% have amblyopia.[7,33,40] A population-based study found strabismus in about 2.5 % of over 6,000 children in Los Angeles County.[6] The incidence of congentital cataracts in the US is 1.2 to 6 cases per 10,000.[17]

The available Canadian studies reported amblyopia prevalence rates of 0.83 % and 4.7%.[12,14,24,31,42] Strabismus prevalence rates for 4-year-old children were between 1% and 4.3%.[24] A Canadian study of 4-year-old children reported prevalence rates of refractive error between 10.6% and 11.9%, and another Canadian study found lower rates of refractive error in children aged 4 years (hyperopia 4.8%, myopia 1.1%, astigmatism 3.1%, anisometropia 1.4%).[24] No information was found on the incidence and/or prevalence of congenital cataracts or ROP in Canada.

Burden

The reviewed literature suggests that visual impairment related to vision conditions that commonly occur during childhood can affect all aspects of a child's development (for example, emotional,

neurologic, cognitive, and physical); the effects often include low self-esteem, physical awkwardness, social alienation, and/or behavioural problems.[2,3,5–8,11–14,17,19,22–27,29,31,34,39,41,43] Visual impairment can interfere with a child's normal functional development and ability to concentrate, read, learn, and safely participate in childhood activities, which can reduce quality of life, affect school performance, and have a negative impact in adult life (due to adverse effects on educational and social development and limitations to career choice).

The presence of amblyopia affects visual acuity (VA), motor skills, reading speed ability, and the development of stereopsis (considered essential for three-dimensional vision), and may harm a child's school performance, emotional well-being, and later adult self-image (www.aoa.org).[2,3,5–8,11,12,14,17,22–28,31,34,41,43,44] Amblyopia is the most common cause of monocular visual impairment and vision loss among children and adults, and amblyopic individuals have an increased risk of severe vision loss or legal blindness from injury or disease to the healthy eye. Strabismus can also result in loss of stereopsis, leading to impaired depth perception, as well as to teasing and other psychosocial consequences.

The presence of colour vision abnormalities excludes individuals from certain jobs (for example, electrician, train driver).[39]

Vision conditions in preschool children are not always accompanied by recognizable symptoms, and changes in vision can occur without the child or the parents realizing it (www.aoa.org).[2,3,6,8,11,12,14,18,24,26,27,29,31,34,39,41,43–45] If left untreated, these conditions can lead to permanent vision loss, which can increase the risk for other impairments and disabilities and lead to substantial burden on the affected individuals, their families, and society (due to negative impacts on the economy and workforce, public health and healthcare resources, quality of life, and community health).

Early Detection and Diagnosis

Evidence suggests that the earlier an existing vision condition is detected and diagnosed, so that it can be treated during the critical stage of vision development (from birth to school entry), the less negative an impact it will have on the affected child's development and quality of life (www.aoa.org).[2,3,6,8,11,12,14,17–19,22,24–27,31,33,34,39,41,44,45]

The diagnosis of amblyopia and its predisposing conditions is performed by healthcare providers who specialize in ophthalmology and optometry and who have experience in dealing with infants, toddlers and young children (www.aoa.org).[17–19,26–28,33,35,36,41,44,46–48] Age-appropriate comprehensive pediatric eye and vision examinations include acquisition of an ocular history based on the patient's age, on parental observations, and on vision assessment performed as part of the physical examination to determine age-appropriate VA. Monocularity is assured by patching the non-tested eye. Pupils and peripheral fields are assessed in addition to making general observations of the child, including his or her neuro-status, head, orbits and ocular adnexa, and ocular media clarity. The eyes and eyelids are inspected for ptosis, corneal lesions, cataracts, and extraocular movements, and the red reflex is examined. The retina and optic nerve are also examined.

Treatment

Although the impact of living with untreated amblyopia and its predisposing conditions has yet to be thoroughly evaluated,[3,13,25–27,29] different treatment options aim to restore normal VA and to maximise binocular interaction.[3,5–9,12–14,18,24–29,32,33,46,48] Depending on the amblyopia's cause and level of severity, treatment options include prescription glasses to correct refractive errors, occlusive therapy (an eye patch), eye exercises (orthoptics), medication (eye drops containing a drug such as

atropine, to temporarily blur vision in the healthy eye), or a combination of these interventions. If a structural abnormality (such as a cataract or ptosis) is present, the underlying amblyogenic risk factor is treated first. After cessation of amblyopia treatment, surgery may be performed for refractory strabismus. The duration of treatment depends on the degree of vision loss and the rate at which the child regains vision.

Treatment is primarily office- and home-based with spectacles and/or contact lenses prescribed and fitted.[3,5,6,9,10,12–14,24,26–28,32,33,46,48] Patching and/or atropine penalization are carried out at home. Outpatient surgery may be provided for ocular media opacity or strabismus.[33,46]

The effect of treatment is measured by the extent of vision restoration.[3,6,7,12–14,24–29,32,33,42,46] The child's age at the onset of the vision condition, the type and severity of the diagnosed amblyopia (that is, the severity of the VA deficit at presentation), and the timing of treatment can influence the outcome. Compliance with prescribed treatment is also important. Predictors of low compliance or non-complaince include poor parental fluency in the national language, a low level of parental education, the child's poor VA at the start of treatment, and poverty. Psychological or other causes of low compliance or non-compliance include poor parental knowledge about amblyopia and perceived distress or lowered self-esteem in the child when the eye is patched.

It is believed that treatment for amblyopia and its predisposing conditions is more effective if provided during early childhood (prior to age of 7 years), despite some recently reported evidence suggesting that successful treatment is possible in older children.[3,7,12–14,24–29,33,42,46,49] Potential benefits of early intervention include increased effectiveness due to neural plasticity and, because vision loss is not as severe, better compliance with treatment and shorter duration of therapy.[28,42] Concerns that bullying of children may lead to poor compliance, especially with eye patching, further support earlier treatment.[5,10,12,14,25,29,46]

PRESCHOOL VISION SCREENING (PSVS)

Amblyopia is considered to be a developmental disorder that is most effectively treated during an early, sensitive period.[2–7,12–14,22,32,33,46] This understanding has been one of the main justifications for PSVS. Another main justification is that it provides an opportunity to correct any vision conditions and improve function, potentially promoting school performance during an important period of social and functional development and improving quality of life.

The main purpose of PSVS is to identify children who probably have or are at risk to develop amblyopia and should be referred for further assessment and appropriate follow up care.[2,6,8–10,12,14,17,19,29,31,35,39,41,46,48] Screening for amblyopia is usually based on identification of early diminished VA, or on the presence of predisposing conditions.

Experts and professional bodies emphasize that vision screenings are not comprehensive examinations, and that whether or not children benefit from PSVS depends on many factors.[2–4,6–8,10,11,24,32,41,46] PSVS can be helpful if early detection of targeted conditions makes it easier for parents and their child to manage the problem. Screening is useless if follow-up for early diagnostic confirmation and/or appropriate treatment is unavailable. To justify PSVS, valid, reliable, and efficient screening tests must be available for infants and young children. Also, accurate tests/methods should be available to reliably and promptly confirm diagnosis of targeted conditions. Early treatment should have more benefits for the child than treatment later on in life.

Potential harms of PSVS include psychosocial effects (such as labeling and anxiety), unnecessary referrals or use of early treatments due to false-positive screening results, and delay in the initiation

of appropriate early treatment due to false-negative screening results, with potential effects on long-term vision or function.[2,3,5–9,13,29,32,33,41,46]

Screening Tests

Various age-appropriate screening tests are used to detect visual impairment among preschool children.[2,4,6–8,17,19,22,24,29,30,32,36,41,46,48] VA tests include eye charts such as Snellen, Tumbling E, HOTV, Allen, and Lea Symbols. Ocular alignment/strabismus is tested using the corneal light reflex test, red reflex test, and cover–uncover tests, as well as stereoacuity tests (random-dot stereotests: Frisby, Random-dot E, Lang). Measurement of refractive error may involve static retinoscopy (with some modifications) and/or cycloplegic retinoscopy. A red reflex test with the direct ophthalmoscope is used for early detection of congenital cataracts. PSVS tests are non-invasive and are generally deemed to be safe.

Recent developments in technology and the desire to detect vision abnormalities before they cause amblyopia have led to the development of new methods for PSVS.[2,4,6–8,12–14,20,24,30,33,36,41,46] Primarily, these technologies involve either automated retinoscopy (automated refraction/autorefraction screening) or photoscreening (photorefraction screening). Autorefraction screening utilizes automated optical methods to detect refractive error. Photoscreening uses optical images to evaluate ocular alignment and refractive error, based on the appearance of the fundus and corneal light reflexes. The primary aim of the use of a photoscreener or autorefractor is the detection of refractive error, which means that it may detect an amblyogenic risk factor but not amblyopia itself. The presence of strabismus may also be detected.

Both traditional and newer PSVS methods have advantages and disadvantages. No consensus currently exists as to which method is most likely to detect children at risk for visual impairment and vision loss due to amblyopia and its predisposing conditions.[4,6–8,10,12–14,20,22,30,33,36,40,41,46] Traditional methods require comprehension and a child's cooperation and compliance. Photoscreeners and autorefractors attempt to avoid some of the difficulties faced when screening young children. Their use may reduce testing time, increase objectivity of screening, and enhance testability rates in younger children, who may be inadequately cooperative with traditional tests. However, these techniques are still evolving and are at various levels of validation. Potential major disadvantages include inconsistent performance and the relatively high initial cost associated with the instruments.

PSVS Programs

While many countries have systems in place to evaluate children's vision to some degree, PSVS structure and processes vary worldwide.[2,5–8,11–16,21,29,30,32–34,39,46,50,51] Important differences exist between and within countries in the content and implementation of PSVS programs, which can be part of a government healthcare system or private. Some jurisdictions offer universal screening while others offer only targeted screening for at-risk children or for those with an obvious vision concern. Protocols vary with regard to the tests used for vision and binocular function, thresholds for referral, the age at which children are screened, and screening frequency. Content of programs varies widely; however, most involve VA assessment. A variety of trained healthcare providers, including ophthalmologists, optometrists, orthoptists, optical technicians, pediatricians, family practitioners, public health nurses, and trained volunteers (professionals or lay persons), perform PSVS. Setting also varies.

These diferences reflect varying interpretations of the available evidence base on these important elements of PSVS programs, as well as variations in the aims and provision of healthcare and the

different roles of the professionals involved.[2,5–8,11–16,30,33,34,39,46,50] Economic viability considerations and allocation of resources to screening also add variability to PSVS processes.

PSVS in Canada

Recently conducted environmental scans on vision healthcare and services in Canada have highlighted the current limitations in statistics and data collection.[34,50] Although many jurisdictions collect information regarding vision conditions and vision healthcare and services, data collection is not consistent or easily retrievable. As well, national surveys haven't collected data consistently.[50] According to the Participation and Activity Limitation Survey by Statistics Canada, which collected data regarding visual impairments in children, in 2001, 9.4% of children (14,510) aged 5 to 14 years reported difficulty seeing, compared to 9.5% of children (16,680) in 2006. Data collected concerning children younger than 5 years is available, but is not considered reliable.[50]

The available data suggest that the leading causes of vision loss in Canadian children are amblyopia, ROP, and congenital causes such as cataract and glaucoma.[50] Aboriginal children appear to have a higher incidence of vision problems than children in the non-Aboriginal population.[34,44,50]

Canadian professionals involved in eye and vision care (including ophthalmologists, optometrists, orthoptists, opticians, nurses, researchers, administrators, and policy-makers) recently identified pediatric vision services, including vision examination and screening, as an increasing concern, because many children with serious vision problems are not examined until it is too late.[28,34,44,49,50,51,56] There is evidence to suggest that only 14% to 16% of Canadian children under 6 years of age receive an eye examination. Canadian optometrists reported that up to six out of 10 children experiencing reading difficulties have an uncorrected or undetected vision problem, and nearly 25% of school-age children have vision problems.[50,56]

Increasing early detection of vision conditions in pediatric population was recently identified as one of the vision health priorities by a number of Canadian professionals.[50] However, currently there is a lack of agreement around vision screening and examination in this population among the national professional bodies, including the Canadian Paediatric Society, the Canadian Association of Optometrists, the Canadian Ophthalmological Society, and the Opticians Association of Canada(http://opto.ca).[22,28,34,43,49,50,53,58]

Vision screening for preschool children has been and continues to be the focus of much debate in Canada.[2,12,14,28,34,43,44,49,50,54] No national standard is in place for PSVS,[34,50,53] and recently published reports showed a wide variation among jurisdictions in PSVS practices, methods, and personnel used.[2,12,14,34,43,50,51] Most jurisdictions have available some form of vision screening or assessment for preschool children (see Table T.1).

Table T.1: PSVS in Canada[2,12,14,31,34,43,44,50,55]

Province/Territory	Current practice
Newfoundland and Labrador	Public health nurses conduct vision screening for children at age of 3 y and 9 mo to 4 y and 4 mo (eye alignment and motility, VA, stereopsis, Sheridan-Gardner, cover–uncover, corneal light reflex testing). Aboriginal preschool children's participation in screening protocols is unknown.
Nova Scotia	Public health nurses conduct screening for children at age of 4.5 to 5.5 y (VA testing) Aboriginal preschool children's participation in screening protocols is unknown.
New Brunswick	Public health nurses conduct vision screening for children at age of 3.5 y (visual inspection of eyes, VA, stereopsis, Randot , HOTV tests) Aboriginal preschool children's participation in screening protocols is unknown.
Prince Edward Island	Public health nurses conduct vision screening for children at birth, 2 mo, 4 mo, 6 mo, 12 mo, 15 mo, 18 mo, 4 to 4.5 y (omprehensive ision ealth istory, rief ision ealth istory, arent-completed questionnaire, external inspection, papillary examination/light response; observation for alignment; corneal light reflex; cover–uncover test; distance VA; stereopsis, Frisby stereotest, LEA symbols). Aboriginal preschool children's participation in screening protocols is unknown.
Quebec	Screening conducted by public health nurses in kindergarten children or by family MD (no information is available about examination types/tests used) Aboriginal preschool children's participation in screening protocols is unknown.
Ontario	Primary care providers conduct vision screening as part of 18 mo "well baby" visit, with subsequent testing at ages of 2 y to 3 y and 4 y to 5 y (red reflex, corneal light reflex, cover-uncover tests). An ESEL pilot program was introduced in 2009 in the Public and Catholic School Boards in the Hamilton–Wentworth District. The pilot is set to expand into the Windsor/Essex, Peel, Halton, and Thunder Bay regions in 2010. Aboriginal preschool children's participation in vision screening protocols is unknown.
Manitoba	The Manitoba Association of Optometrists implemented a pilot ESEL program in 2008 with Pembina Trails School Division to encourag parents to have their kindergarten children see an optometrist during the kindergarten year (no information is available about examination types/tests used).
Saskatchewan	During early childhood assessments and immunization appointments, public health nurses recommend to families to contact an optometrist to obtain a full eye examination for their child (no information is available about examination types/tests used). An ESEL pilot program was coordinated within the Greater Saskatoon Catholic School Division between November 2008 and December 2009 to motivat parents to obtain an eye examination for kindergarten children before starting school. Aboriginal preschool children's participation in ESEL is unknown.
Alberta	The ESEL program encourages parents of to obtain comprehensive eye health and vision examinations for their kindergarten children through local optometrists or ophthalmologists before school (complete eye exam by optometrist or ophthalmologist). Aboriginal preschool children's participation in ESEL program is unknown.
British Columbia	Public health staff (public health nurses, health unit aides, trained screeners, trained First Nations community health staff) conduct screening of kindergarten children (SureSight vision screeners and preschool Randot Stereotest; few health units use HOTV charts for VA testing). ntend to discontinue kindergarten screening once universal 3 y-old coverage is met. The *a-b-See* program functions as a province-wide preschool eye health initiative similar to the ESEL program, to identify vision conditions and raise awareness among parents, teachers, and children. Aboriginal preschool children's participation in screening protocols is unknown.

Nunavut	Screening is conducted primarily by public health nurses, community health nurses, community health representatives for children at age of 4y to 6 y (light reflex and VA testing)
Yukon	Public health nurses and primary health care nurses (registered nurses working in an expanded role), depending on the community, conduct screening in pre-kindergarten children (eye motility, VA, and steropsis testing).
Northwest Territories	Public health nurses conduct screening in preschool children (VA testing; Illiterate E test or symbol chart, stereoscopic fly, corneal light reflex, cover-uncover). Aboriginal preschool children's participation in screening protocols is unknown.

ESEL – *Eye See … Eye Learn* program; MD – medical doctor; mo – month(s); VA – visual acuity; y – year(s)

A survey of the Chief Medical Officer of Health of each Canadian province/territory, recently conducted by Mema and colleagues,[12,14] found that seven jurisdictions have an organized public health PSVS program and six do not. Jurisdictions that reported offering public health PSVS included British Columbia, Nova Scotia, Northwest Territories, Yukon, Prince Edward Island, Newfoundland and Labrador, and New Brunswick. Jurisdictions that reported not having screening programs were Quebec, Ontario, Saskatchewan, Nunavut, and Alberta. Manitoba reported that vision screening was a voluntary program for school divisions and it was therefore classified as not having a provincial program.

In jurisdictions where PSVS is offered, VA testing is the preferred method for screening, which focuses on children between 3 and 6 years of age (Table T.1).[2,12,14] HOTV test (a test that involves identification of the letters H, O, T, and V on a chart) is the most commonly used method of VA testing in Canada.[2] Other screening tests include stereopsis and eye alignment for strabismus (see Table T.1). Personnel administering the screening tests are mainly public health nurses. According to Mema and colleagues, "In jurisdictions where organized public health programs do not exist, concerns are raised with respect to physician compliance with amblyopia testing recommendations, and the impact on coverage and test appropriateness of delegating vision testing *qua* screening to optometrists."[12,14]

Details were available for only one of the organized public health vision screening programs available in Canada: the Provincial Early Childhood Vision Screening Program in British Columbia.[31,34,54,55] The goal of this program is universal vision screening to detect amblyopia, strabismus, and refractive errors in children before age of 6 years, and to facilitate care for those with identified visual impairment. The program is delivered by health authority public health staff/personnel and includes: vision screening of children in kindergarten by public health staff, with referral to vision care specialists for diagnostic testing and follow up; piloting vision screening for 3-year-olds to support earlier detection of vision disorders in this age cohort; and case finding for vision concerns in the early childhood population, with referral to vision care specialists for diagnostic testing and follow up.

When the pilot program for 3-year-old children is fully implemented in all health authorities, the vision screening program will transition to 3-year-olds. In 2009–2010, 90% of kindergarten children in British Columbia had their eyes screened by public health staff and 19% of the screened children were referred for diagnostic follow up.[56]

A Vision Screening Training Manual was developed for the Provincial Early Childhood Vision Screening Program in British Columbia.[31] The manual identifies several screening tools for vision screening of preschool children: the Welch Allyn SureSight Vision Screener® in combination with the Randot Preschool Stereotest or the HOTV Vision Chart in combination with the Randot

Preschool Stereotest®. Use of the SureSight Vision Screener®, and Randot Preschool Stereotest® or HOTV, in children younger than 36 months is at the discretion of the Health Authority and is based on professional judgement of the screening personnel. Provincial SureSight referral criteria has not been established for children younger than 36 months of age.

In some of the jurisdictions where public health PSVS is not offered, the local association of optometrists, in partnership with schools, runs a program advocating for children's visual assessment.[2,12,14,28,34,43,44,45,50] One example is the *Eye See … Eye Learn* (ESEL) awareness program first implemented in Alberta in 2003 and more recently piloted in Saskatchewan, Manitoba, and Ontario. The ESEL program is introduced to all kindergarten children and focuses on prevention, early detection, and management of eye and vision conditions. A similar program is the *a-b-See* program**,** which started in 2003 in British Columbia.

Annual free comprehensive optometry exam is offered to children in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia, Nunavut, Northwest Territories, and Yukon.[2,12,14,28,50,57] Screening is offered in all provinces where children's optometric exams are not covered, and in some with funded optometric coverage.[12] One jurisdiction reported that their local public health screening program had been discontinued as a consequence of optometry coverage.[12,14]

The participation of Aboriginal preschool children in the vision screening protocols available in Canada is unknown.[34]

According to a recently completed assessment of the system capacity for infant and preschool screening in Alberta, "very little is occurring with regards to vision screening in the province and very limited information is available."[51] There "is very little formal vision screening of infant and preschoolers currently being conducted in Alberta," and "the assumption that Public Health Nurses are screening vision at 9, 12, and 18 months was not evident in reported practice across the province. If vision screening is an area that is considered for future implementation of comprehensive screening, there is little current capacity and very little to build upon."

The small amount of informal vision screening that is performed within public health settings is not consistently available consistently to all Albertans.[51] Screening is performed in public health clinics or offices in most Alberta Health Services zones and in clients' home in the South Zone. Initial screen is administered by public health nurses in most zones except in the South Zone where screening is administered by parent educators (parents as teachers). In some immunization clinics, nurses attempt to integrate vision screening by using the corneal light reflex and tracking during their appointments with infants. Other screening tools include the blink reflex, the pupillary light reflex, cover–uncover, and reaching for objects.

The capacity to perform PSVS has been identified as a specific challenge related to this type of screening in Alberta.[51] Most public health programs indicated that they have no capacity to add vision or any other additional screening to their existing programs. It was noted that "if there is to be an assigned mandate for vision screening, decisions should be made to standardize the screening tools and processes, and there should be formal recommendations on when to refer to optometry versus ophthalmology."

The campaign run in Alberta through the ESEL program encourages parents of kindergarten children to take advantage of the free, annual optometry exam offered in the province.[12,14] Following the pilot of the program in 2003–2004, the examination rate increased from 14% to 45%.[12,14,44,50]

Guidelines and Position Statements on PSVS

The literature search identified eleven guidelines and position statements that provided recently developed or reaffirmed recommendations on the topic of vision screening and examination during childhood in North America.[21,22,28,35,36,47,48,53,58–61] The following section summarizes the recommendations regarding the use of vision screening and examination for preschool children.

Recommendations in Canada

The Canadian Paediatric Society (CPS) recommends vision screening to detect amblyopia, strabismus, and other vision conditions in all children younger than 5 years of age.[22] A complete examination of skin and external eye structures, red reflex, signs of posterior eye disease for newborns to 3 months of age are recommended to be performed during infant and well-child visits. This type of examination is also recommended at ages of 6 months to 12 months, when ocular alignment (corneal light reflex and cover/uncover tests), ocular fixation, and following target should also be tested. For children aged 3 to 5 years VA testing should be completed in addition to testing of red reflex, corneal light reflex, ocular alignment, ocular fixation, and following target. "Any infant or child with abnormalities on examination, or who does not pass visual screening, should be referred for further assessment. Infants and children with risk factors, such asdevelopmental delay, should also be fully examined by a well-trained eye care professional."

According to CPS, "Routine comprehensive professional eye examinations of healthy children with no risk factors have no proven benefit."[22]

A guideline was recently developed for the frequency of typical optometric eye examinations in Canada, as described by the Canadian Association of Optometrists.[52] According to this guideline, infants and toddlers (aged from birth to 24 months) should undergo their first eye examination between the ages of 6 and 9 months. Preschool children (2 to 5 years of age) should undergo at least one eye examination between the ages of 2 and 5 years.

The Alberta Association of Optometrists and the Alberta College of Optometrists also recommend that children have their first eye exam at 6 months of age, another at 3 years of age, and one prior to entering elementary school.[28,47] According to the Canadian Association of Optometrists, the Alberta Association of Optometrists, and the Alberta College of Optometrists, although vision screening is considered useful, it has limitations and it should not replace a complete/comprehensive eye and vision examimantion performed by an optometrist or ophthalmologist (http://opto.ca).[28,47]

According to the Canadian Ophthalmological Society, all newborns should have their eyes checked in the hospital for vision problems, such as the presence of cataracts or lack of visual response.[58] All children should have their vision checked between the ages of 3.5 and 4.5 years, to detect common treatable problems such as strabismus, amblyopia, or the need for glasses.

Recommendations in the United States

The US Preventive Services Task Force (USPSTF) revised their 2004 guideline in 2011 which recommended vision screening to detect amblyopia, strabismus, and VA defects in children younger than 5 years of age.[48] The revised guideline currently recommends vision screening for all children at least once between 3 and 5 years of age to detect the presence of amblyopia or its risk factors. USPSTF no longer recommends vision screening for children younger than 3 years of age because the available evidence was considered insufficient to assess the balance of benefits and harms of vision screening for this age group. The revised guideline does not recommend an optimal screening interval or a specific type of screening tool.

The revised USPSTF recommendations have generated some controversy.[20,62] Experts voiced concern about the finding of insufficient evidence for vision screening in children under age of 3 years. They also noted that the revised guideline does not address the issue of red reflex tests in young children, an omission that may cause clinicians to miss cataracts and retinoblastomas.

According to the updated guideline on "Preventive services for children and adolescents" by the Institute for Clinical Systems Improvement (ICSI)[59] vision screening could be recommended for children under the age of 3 years and must be recommended for all children aged 3 to 5 years. Screening should be used to detect amblyopia, strabismus, and defects in visual acuity. By age of 5 years, vision screening should be performed in the clinic or school as part of preschool screening.

The American Academy of Family Physicians (AAFP) also recently revised their recommendations for clinical preventive services.[61] Similar to USPSTF and ICSI, the AAFP recommends vision screening for all children at least once between the ages of 3 and 5 years to detect the presence of amblyopia or its risk factors.

The American Optometric Association recommends scheduling the first comprehensive eye and vision examination at 6 months of age in asymptomatic/risk free children.[35] If no abnormalities are detected at this age, the next examination should be scheduled at 3 years of age. The recommendations for infants and toddlers include VA testing (fixation preference tests, preferential looking visual acuity test), refractive error/refraction testing (cycloplegic retinoscopy, near retinoscopy), and assessment of binocular vision and ocular motility (using cover test, Hirschberg test, Krimsky test, Brückner test, versions, near point of convergence).[35] Tests for preschool children should include VA (Lea symbols, Broken Wheel Acuity Cards, HOTV), refraction (static retinoscopy, cycloplegic retinoscopy), binocular vision, accommodation, and ocular motility tests (cover test, positive and negative fusional vergences, near point of convergence, stereopsis, monocular estimate method retinoscopy, versions).

According to the American Academy of Ophthalmology, age-appropriate eye and vision evaluations should be performed during the newborn period and at all subsequent health supervision visits.[60] From birth to 3 months of age, examination should include red reflex, external inspection, and pupil examination. Infants aged 3 to 6 months should be tested for their ability to fix and follow and for red reflex, in addition to undergoing external inspection and pupil examination. Children aged 6 to 12 months should undergo the same tests, as well as testing for alternate occlusion and corneal light reflex. Recommendations for children aged 3 and 4 years include a VA test (monocular; using figures, letters, "tumbling E" or optotypes, LEA symbols, vision testing machines), corneal light reflection/cover–uncover test, red reflex examination, external inspection, and pupil examination. These tests should be repeated at age of 5 years. If abnormalities are detected by screening, a comprehensive medical eye examination should be performed.

Children who do not pass a screening should be referred for a comprehensive ophthalmic evaluation after the first screening failure.[60] If a child is unable to cooperate for vision testing at 3 years of age, a second attempt should be made within 6 months. If the child is 4 years old, a second attempt should be made within a month.

According to a recently reaffirmed joint policy statement of the American Academy of Pediatrics, the American Association of Certified Orthoptists, the American Association for Pediatric Ophthalmology and Strabismus, and the American Academy of Ophthalmology, all children should have eye examinations during the newborn period and at all subsequent routine health supervision visits, by undergoing age-appropriate evaluations.[36] Newborns should be examined for ocular structural abnormalities, such as cataract, corneal opacity, and ptosis. "All children who are found to

have an ocular abnormality or who fail vision assessment should be referred to a pediatric ophthalmologist or an eye care specialist appropriately trained to treat pediatric patients."[36]

VA testing is recommended for all children starting at 3 years of age.[36] If a child is unable to cooperate for vision testing, a second attempt should be made after 4 to 6 months. For children aged 4 years and older, the second attempt should be made in 1 month. Children who cannot be tested after repeated attempts should be referred for an eye evaluation to an ophthalmologist experienced in the care of children.

Eye evaluation in the physician's office should include ocular history, vision assessment, external inspection of the eyes and lids, ocular motility assessment, pupil examination, and red reflex examination for children from birth to 3 years of age.[36] For children aged 3 years and older, the recommendations include ocular history, vision assessment, external inspection of the eyes and lids, ocular motility assessment, pupil examination, and red reflex examination, as well as age-appropriate VA measurement, and ophthalmoscopy. The recommendations include Snellen letters, Snellen numbers, "tumbling E" test, HOTV test, Allen figures, and LEA symbols for distance visual acuity examination in children aged 3 to 5 years. The cross-cover test, the Random Dot E stereo test, and the simultaneous red reflex test (Brückner test) are recommended for examination of ocular alignment. The red reflex is recommended for testing ocular media clarity (for cataracts, tumors, and so on).

Vision assessment in children younger than 3 years or in any nonverbal child is accomplished by evaluating the child's ability to fix and follow objects.[36] The assessment should be performed binocularly and then monocularly. If poor fix and following are noted binocularly after 3 months of age, a significant bilateral eye or brain abnormality is suspected and referral for more formal vision assessment is advisable. It is important to ensure that the child is awake and alert, because disinterest or poor cooperation can mimic a poor vision response.

Available Research Evidence

A comprehensive literature search was conducted to identify the most recently published systematic reviews (SRs) or health technology assessment (HTA) studies that examined the research evidence on the safety and efficacy/effectiveness of using PSVS to detect vision conditions in asymptomatic preschool children. Selected for data extraction were only reports of SRs and HTA studies that, by virtue of design and quality of reporting, were most likely to provide the best level of evidence. Individual primary research studies (of any design) published subsequent to the selected SRs and HTA studies are not included. A detailed description of the literature search strategy is provided in Appendix T.A.

Figure T.1 in Appendix T.A outlines the research study selection process for this review.

The literature search identified 185 citations. After screening of titles and abstracts, 100 citations were excluded from the final selection process. The full text of 85 potentially relevant articles was retrieved and further evaluated for inclusion in the review. The application of the selection criteria to 12 full-text articles retrieved as potentially relevant research studies resulted in five being excluded (main reasons for their exclusions are listed in Table T.B.1, Appendix T.B).

Five SRs[3–5,7,8] were selected for the review. Two other SRs[6,24] were identified as multiple publications of two selected SRs.[7,8] Although the multiple publications were not included as unique studies, any relevant information that the authors provided was included when appropriate.

Four of the selected SRs[3,5,7,8] addressed questions on the benefits and harms of PSVS (programs) for detection of amblyopia and its predisposing conditions, as compared to no screening in terms of patient-relevant outcomes. Two SRs[4,7] specifically addressed the diagnostic accuracy of the test/procedures/devices used alone or in combination in PSVS.

All selected studies[3–5,7,8] fulfilled the criteria for a systematic review by:posing a clear question *a priori*identifying the relevant literature;extracting the data and assessing the methodological quality or risk of bias of the primary research in a reproducible fashion;qualitatively or quantitatively summarizing and analyzing the reviewed evidence; and byexploring the sources of variation in the results from study to study.

Objectives and selection criteria varied across the selected systematic reviews and there was little overlap among their included primary research studies. Only papers reporting results from one large (n = 3490), randomized trial nested within a population-based cohort study conducted in the United Kingdom (the Avon Longitudinal Study of Parents and Children [ALSPAC]) and its follow up studies[63–65] were included in all selected SRs. The ALSPAC study used mothers' dates of birth to assign children to intervention group (pseudo-randomization) and was rated as having fair or medium methodological quality.

The following commentary summarizes the findings on the safety and efficacy/effectiveness of PSVS as reported by the selected SRs. Details from the selected SRs are provided in Appendix T.C (Tables T.C.1 and T.C.2).

Safety

The selected systematic reviews could not infer evidence or clear indications of harm or lack of harm through PSVS from their included primary research studies.[3,5–8,24]

In the most recently conducted systematic review, Chou et al.[6,7]reported that the available evidence on harms of PSVS is limited. Reviewers found only one study (the ALSPAC study) that evaluated the potential psychosocial effects of screening.[6,7] In this large population-based cohort the result for children offered screening at 37 months of age showed 50% reduced odds of being bullied at the age of 7.5 years, compared with those who were not offered screening. Benefits were observed among children who had received patching treatment (adjusted OR, 0.39 [95% CI, 0.16 to 0.92]), but not among those treated with eyeglasses. The reviewers did not identify other controlled studies on psychosocial effects of screening.

In the other primary research studies considered by Chou et al.[6,7] in their systematic review, false-positive rates varied depending on the prevalence of the target condition. In populations with a prevalence of visual conditions of less than 10%, six of seven studies that performed the reference standard in all children reported false-positive rates greater than 70%. The evaluated screening tests included the Retinomax autorefractor, Random Dot E test, and various combinations of clinical screening tests. In studies with a prevalence of target visual conditions of at least 20%, false-positive rates ranged from 5% to 39%. No studies that evaluated the effects of unnecessary corrective lenses on long-term vision or functional outcomes were identified. Neither were any studies identified on rates of unnecessary treatment for amblyopia or its risk factors following participation in a PSVS program.

The systematic review recently conducted by Schmucker et al.[5] "has been unable to provide information on the adverse effects of population based preschool vision screening programmes." The reviewers considered this as "an important omission as concerns about harm exist, particularly from disruption of normal eye development, temporary loss of visual acuity in the non-amblyopic

eye and costs associated with further evaluation of children with false-positive screening results." Although the potential psychological impact on the child or its family is also little explored, "the frequency of these possible damaging effects is primarily dependent on the quality regulations and quality assurance measures in a screening programme."

Neither could the Cochrane review recently conducted by Powell and Hatt[3] identify any "studies attempting to evaluate the possible harms associated with screening or quantifying the impact of living with amblyopia."

Efficacy/effectiveness

In 2011, Chou et al.[6,7] published the results from their systematic review conducted to update the 2004 USPSTF recommendations on screening to detect amblyopia, strabismus, and defects in visual acuity in preschool children (aged 1 to 5 years of age). The 2011 systematic review examined evidence regarding the association of screening for visual impairment among children (aged 1 to 5 years) with improved health outcomes, the accuracy of risk factor assessment, the accuracy of screening tests, the effectiveness of early detection, the effectiveness of treatment, and the harms of screening and treatment.

The reviewers found no randomized controlled trial (RCT) that evaluated PSVS versus no screening.[6,7] A pseudo-RCT (the ALSPAC study, rated as fair quality)[63,64] revealed that intensive, periodic orthoptist screening (a clinical examination, age-specific VA testing, and cover–uncover test) from 8 through 37 months of age reduced amblyopia prevalence at age of 7.5 years by ~1% compared with one-time screening at 37 months of age. However, the difference was statistically significant only for one of two pre-stated definitions for amblyopia (amblyopia A, 1.45% vs 2.66%, relative risk [RR]: 0.55 [95% confidence interval (CI): 0.29–1.04]; amblyopia B, 0.63% vs 1.81%, RR: 0.35 [95% CI: 0.15– 0.86]). VA at age of 7.5 years in the amblyopic eye in patched children was better in the intensive-screening group than in the one-time screening group by an average of ~1 Snellen line (mean logMAR: 0.15 [95% CI: 0.08–0.22] vs 0.26 [95% CI: 0.17– 0.35]; $P<0.001$). The major methodologic shortcoming of this trial was high loss to follow-up (close to 50%).

A large prospective cohort study[65] (which used the birth cohort from the ALSPAC study; classified as fair quality because of high loss-to-follow-up) revealed that one-time orthoptist screening at 37 months of age was associated with no significant difference in amblyopia risk at age of 7.5 years compared with school-entry screening when using any of the three prestated amblyopia definitions.[6,7] In three poor quality retrospective cohort studies, PSVS was associated with improved school-aged vision outcomes compared with no screening. No study evaluated school performance or other functional outcomes.

Chou et al.[6,7] found no RCT that compared outcomes of PSVS in different age groups. In the ALSPAC study[63,64] screening was initiated earlier in one group (at the age of 8 months) compared with the control group (at age of 37 months). However, Chou et al.[6,7] could not determine whether differences in outcomes had to be attributed to the earlier age at which screening was started or to the increased frequency of screening that also took place. Chou et al.[6,7] also included one poor-quality retrospective cohort study and found no difference between screening at ages of 2 to 4 years versus screening before age of 2 years in risk for at least mild visual impairment (defined as VA worse than 20/40). However, according to Chou et al.[6,7] the estimates were imprecise (RR: 3.10 [95% CI: 0.72–13]) and based on a very small sample of screened children. Another retrospective cohort study found that the rate of false-positive screening examinations was about twice as high in children screened at age 1.5 years compared with those screened at age 3.5 years.[6,7]

No answer could be provided for key question 2 ("What is the accuracy and reliability of risk-factor assessment for identifying children aged 1 to 5 years at increased risk for vision impairment?") (Table T.C.2, Appendic T.C).[6,7] The reviewers could not indentify any study that evaluated the accuracy or reliability of using demographic or clinical features to identify children at higher risk for visual impairment prior to screening, and no study evaluated outcomes of targeted versus universal PSVS.

Thirty-one studies evaluating the diagnostic accuracy of various PSVS tests were included by Chou et al.[6,7] to address the key questions 3 and 3.a (Table T.C.2, Appendic T.C). Four studies evaluated VA tests (Lea symbols and HOTV tests), three evaluated stereoacuity tests (Random Dot E and Randot Stereo Smile II tests), one evaluated the cover–uncover test, four evaluated combinations of clinical tests (VA, stereoacuity, and ocular alignment), 12 evaluated autorefractors, and 15 evaluated photoscreeners. Cycloplegic refraction was included in the reference-standard examination in all but five studies. Four studies were rated poor quality and 23 were rated fair quality. The most frequent methodological shortcomings of the included primary research wereexclusion of noncompliant children or those with uninterpretable screening results failure to describe random or consecutive enrollment of subjects high or unclear rate of screening failures failure to enroll a representative spectrum of subjects.

According to Chou et al.[6,7] the diagnostic accuracy estimates for all tests evaluated in the included primary research studies suggest utility for identification of children at higher risk for specific visual conditions or amblyogenic risk factors. However, no test was consistently associated with both high sensitivity and specificity (> 90%). In the Vision in Preschoolers (VIP) study,[67] which is the largest study that directly compared the diagnostic accuracy of 11 different screening tests, the Random Dot E stereoacuity test, the Randot Stereo Smile Test II, iScreen, and Medical Technologies, Inc (MTI) photoscreeners were associated with lower sensitivity (at a similar specificity), compared with the Lea symbols test, the HOTV test, and the Retinomax and Power Refractor II autorefractors. However, the differences in the likelihood ratio and diagnostic odds ratio estimates among the evaluated tests were generally small (with overlapping confidence intervals).

In the VIP study,[67] crowded Lea symbols visual acuity testing was associated with a positive likelihood ratio (PLR) of 6.1 (95% CI: 4.8–7.6) and a negative likelihood ratio (NLR) of 0.43 (95% CI: 0.38–0.50).[6,7] The crowded HOTV test was associated with similar accuracy compared with crowded Lea symbols (PLR: 4.9 [95% CI: 3.9–6.1]; NLR: 0.52 [95% CI: 0.46–0.58]). The cover–uncover test was associated with a PLR of 7.9 (95% CI: 4.6 –14) and an NLR of 0.86 (95% CI: 0.82–0.90). Compared with the other tests, the cover–uncover test was associated with lower sensitivity and higher specificity. However, according to Chou et al.,[6,7] the VIP study[67] preferentially enrolled children with visual conditions (amblyopia prevalence of 3%; prevalence of any target visual condition 29%).

The available studies that evaluated various tests in various combinations generally reported stronger likelihood ratios than studies that evaluated individual tests of VA, streoacuity, or ocular alignment.[6,7] However, Chou et al.[6,7] considered the available evidence as insufficient to recommend a specific combination of tests.

Nine fair-quality studies evaluated screening tests for visual impairment in stratified age groups.[6,7] Most of the evidence was limited and inconsistent. Four studies found no definitive differences according to age, because testability generally exceeded 80% to 90% for children 3 years of age, with small increases through 5 years of age. Four studies found that testability rates were lower for most screening tests (Random Dot E test, Lea symbols test, and SureSight autorefractor for children 1 to

3 years of age, compared with children 3 to 5 years of age. One large, statewide screening study of the Medical Technology and Innovations (MTI) photoscreener found 94% testability by 1 year of age.

Based on their analyses, Chou et al.[6,7] concluded that direct evidence about the effectiveness of PSVS for improving VA or other clinical outcomes is still limited and does not adequately address the question of whether screening is more effective than no screening in children aged 1 to 5 years. "In terms of indirect evidence, a number of screening tests appear to have utility for identification of preschool-aged children with vision problems, and treatments for amblyopia or unilateral refractive error (with or without amblyopia) are associated with mild improvements in visual acuity compared with no treatment. Additional studies are needed to better understand effects of screening compared with no screening, to clarify the risk for potential unintended harms from screening (such as use of unnecessary treatments), and to define the optimal time at which to initiate screening during the preschool years."[6]

In 2010, Mathers et al.[8] published the results from a systematic review on the effectiveness of screening programs designed to detect conditions causing vision loss or dysfunction in children, including diminished VA, amblyopia, strabismus or squint, refractive error, cataracts, and glaucoma in children aged from birth to16 years.[8,24] Of the research studies included by Mathers et al, one pseudo-RCT (the ALSPAC study),[63,64] five non-RCTs (cohort studies, of which one is a follow up of the ALSPAC study[65]), and three secondary research studies provided evidence on screening effectiveness in children aged from 1 month to 6 years (see Table T.C.1, Appendix T.C). Reviewers found no relevant studies to evaluate the effectiveness of vision screening in infants aged from birth to 1 month.

According to Mathers et al.,[8,24] the evidence from the studies reporting on screening effectiveness for children aged from 1 month to 6 years indicated that early screening and treatment may lead to improved visual outcomes and a lower amblyopia prevalence. The ALSPAC study (rated as medium quality)[63] found a higher amblyopia detection rate in children screened at 8, 12, 18, 25, and 31 months of age by an orthoptist, than in children who were screened at 8 and 18 months of age by health visitors and general practitioners.Although the 2002 follow-up study conducted with the same birth cohort to assess the outcome of treatment for amblyopia[64] found that more intensive and repeated screening between 8 and 37 months of age resulted in better VA in the amblyopic eye and a lower amblyopia prevalence at age of 7.5 years, the investigators "acknowledged that the intervention program was not designed to be practicable."[24] However, it found that the intervention program detected more children with amblyopia than did the control program (1.6% versus 0.5%), and was more specific (95% versus 92% for the control group program). Photorefraction was the most sensitive component of the program (> 95%).

A higher amblyopia prevalence was reported by a 2000 retrospective cohort study conducted in Israel[66] (rated as medium quality) in children 8 years years of age who had not received prior screening, compared with children screened at ages 1 to 2.5 years (see Table T.C.1, Appendix T.C).[8,24] In this study, the screening was comprehensive, was performed by an ophthalmologist or an orthoptist, and consisted of a corneal reflex test, fixation-and-following test, ductions and versions examination, cover–uncover test, alternate cover test, and retinoscopy without cycloplegia. The screening program sensitivity was 85.7% and the specificity was 98.6%, with a positive predictive value of 62.1% and a negative predictive value of 99.6.

Hyperopia in infancy was linked to strabismus and VA deficits by age of 4 years based on results from a 1996 cohort study that examined two different screening programs in infants aged 7 to 9

months and a follow up study of this cohort (published in 2007).[8,24] Wearing a partial spectacle correction reduced the risk in the cohort study and infants who had not received this correction by age of 7 years showed higher prevalences of strabismus and amblyopia in a follow-up study (Table T.C.1, Appendix T.C). Both the original cohort study and the follow-up study were of low methodological quality.

Results reported by three secondary research studies included by Mather at al.[8,24] in their analysis of vision screening effectiveness in preschool age (from ages 3 to 6 years) do not provide a consistent picture. A 1995 systematic analysis (low quality) of screening programs in Sweden and Canada recommended that VA screening should be performed at around 4 years of age and then repeated throughout the school years. One 1998 systematic review (low quality) recommended that PSVS should occur during the neonatal period, at 6 months, at 3 years, and at 5 to 6 years. The Cochrane systematic review published by Powell and colleagues in 2005 (medium quality) found no RCTs to evaluate the effectiveness of vision screening for reducing amblyopia prevalence in screened versus unscreened children, and concluded that the optimum protocol for vision screening is unclear, and that there appeared to be no detrimental effect in terms of visual outcome on leaving screening until school entry.

In the 2003 prospective cohort study[65] (follow-up of the ALSPAC study,[63] also included by Mathers et al.[8,24] in their analysis), more children were offered PSVS (24.9%) than those who actually attended (16.7%). Children who received PSVS had a 45% lower prevalence of amblyopia compared to those who did not receive PSVS (1.1% of 1,019 screened versus 2.0% of 5062 not screened). When all children who were offered PSVS (whether or not it took place) were included in the analysis, amblyopia was still less common in these children, but the result was not statistically significant.[24] Children screened at preschool age (3.1 years) had slightly better outcomes following treatment than children screened at school entry (mean VA: 0.14 LogMAR and 0.2 LogMAR, respectively). This beneficial effect was significant for straighteyed amblyopia, but not for amblyopia associated with squint. The cohort under-represented children from very deprived families, families of Asian extraction, and families where the mother was a teenager at time of birth, so the findings may not be generalisable to these populations.[24]

A 1993 retrospective study reported on vision screening by UK orthoptists during 1987–88, who examined 5162 children aged 3 to 4 years for corneal reflections, abnormalities of ocular movements, and binocular convergence.[8,24] Orthoptists used the cover test for strabismus, prism reflex test for abnormality of binocular function, and Sheridan Gardiner letter test for VA. The screening resulted in 4.4% of children receiving treatment for a defect not previously detected. However, the retrospective review of data was undertaken in a disadvantaged health district, and its results may be less generalisable.

The majority of studies reviewed by Mathers et al.[8,24] concluded that orthoptists were the preferred screeners, in comparison with nurses, health visitors, and general practitioners. However, many studies still suggested that screening could be performed by nurses. According to Mathers et al.,[8] "experience in screening seems to play an important role, especially in sensitivity of detecting pathology, although in a number of studies, vision health professionals were using a wider range of tests than the non-vision health professionals. A future trial might incorporate consistent training of the most appropriately qualified personnel available within a jurisdiction in order to promote accuracy of the screening."

Mathers et al.[8,24] rated most of the studies included in their systematic review as having low methodological quality. The ALSPAC study, the only RCT included in the analysis of PSVS

effectiveness, was rated as having medium methodological quality. Evidence from the included systematic reviews was also largely based on non-RCTs. Some studies used samples of limited generalizability. Mathers et al.[8,24] identified major variations in their reviewed studies in terms of the type of test and personnel used, and personnel training and qualifications. These differences made it difficult for the reviewers to compare the results of the included studies. Most studies also had a limited follow-up duration, making it difficult to determine how the screening programs influenced long-term outcomes such as increased occupational opportunities or potential for improved adult vision.

Based on their results, Mathers et al.[8,24] concluded, "Screening of children 18 months to 5 years, and subsequent early treatment, led to improved visual outcomes. The benefit was primarily through treatment of amblyopia, with improved visual acuity of the amblyopic eye. However, the overall quality of the evidence was low. The implication of improved visual acuity (e.g. any potential impact on quality of life) was not considered. Without consideration of 'quality of life' values, such as loss of vision in one eye or possibility of future bilateral vision loss, the cost-effectiveness of screening is questionable."

In 2009 Schmucker et al.[5] published the results from their systematic review on the effectiveness of screening children younger than 6 years for amblyopia, which also identified a lack of rigorous controlled studies on this topic. This systematic review was conducted to determine whether PSVS for amblyopia leads to better vision outcomes and included one RCT, one pseudo-RCT (the ALSPAC study[63,64]) and three cohort studies (one of which is the 2003 follow up of ALSPAC study[65]) in the comparisons of PSVS programs of varying intensity and, in one case, for screening versus no screening. Measures such as school performance, cognitive impairment, and quality of life were not adequately evaluated in the reviewed studies. The evidence obtained from these studies did not provide a consistent picture with regard to the impact of PSVS on amblyopia prevalence either.

One 2000 RCT conducted in Sweden reported no difference in the amblyopia prevalence rate between PSVS (intervention group) and no PSVS (control group) (0.0% in the intervention group versus 0.1% in the control group; *p-value not reported*).[5] This study also reported a similar prevalence rate for strabismus at the age of 6.5 years in both groups (3.3% in the intervention group versus 3.8% in the control group; $p = 0.460$, Chi2-Test). A 1996 retrospective cohort study conducted in the UK also found a lack of effects on amblyopia prevalence rate at 7 years of age using an "intention-to-screen" approach. However, orthoptic screening (intervention group) detected more cases of amblyopia associated with microtropia and anisometropia than screening by a health visitor or general practitioner (control groups).

Results from the ALSPAC study and its follow up studies,[63–65] as well as results from the 2000 retrospective study conducted in Israel,[66] suggest that screening or intensive screening is significantly associated with an absolute reduction of between 0.9% and 1.6% in amblyopia prevalence rates at 6.5 to 8 years of age (relative reduction of between 45% and 62%) when compared to no screening or less intensive screening.[5] The 2000 retrospective cohort study[66] (which, according to Schmucker et al.,[5] is "the only study which compared screening versus no screening without implementing a current screening program") reported that the frequency of severe amblyopia (VA ≤ 5/15) was reduced by a factor of 17 in the screening group ($p < 0.001$). Results from the pseudo-RCT (the ALSPAC study) and the 2003 prospective cohort study[63–65] also showed that mean VA in the worse eye was better for children who had been treated for amblyopia in the intervention group than for similar children in the control group (0.15 versus 0.26 LogMAR $p < 0.001$; 0.14 versus 0.20 LogMAR $p = 0.002$, respectively).

However, according to Schmucker et al.,[5] the reliability of these findings is limited by the methodological weaknesses of these three studies. The 2000 retrospective cohort study[66] excluded approximately 20% and the ASPLAC study[63,64] excluded approximately 45% of the children originally recruited in their analysis, without giving any reasons for exclusion. In its publication, the 2003 follow-up of the ALSPAC study[65] only presented children who took part in the final assessment at age of 7.5 years. In addition, it showed by an "intention-to-screen" analysis that the improved outcome for individuals with amblyopia diminished when considering all children offered screening rather than only those who received it. In the remaining two retrospective cohort studies, it was not specified whether factors that could be associated with the main outcome were equally distributed between the groups. No study conducted prospective sample size planning and a retrospective power calculation indicated either that the groups had too little power to demonstrate effects or that only moderate effects could be detected.

Based on their results, Schmucker et al.[5] concluded, "Population based preschool vision screening programmes cannot be sufficiently assessed by the literature currently available." They went on to state, "The methodological weaknesses of the literature currently available cannot be used to state that preschool vision screening is not effective. But it shows that these programmes have not yet been tested in rigorously controlled trials. Current recommendations should be targeted to maximise coverage in established screening programmes.Therefore, future research work should be guided by the findings of this publication."[5]

Also in 2009, Schmucker et al.[4] reported the results from a systematic review conducted to evaluate the diagnostic accuracy of screening tests commonly used for the detection of amblyopia and its risk factors in unselected children younger than 6 years. The inclusion criteria were met by 27 studies (of which five evaluated more than one screening test). Twenty-six studies calculated test accuracy (sensitivity and specificity) using the number of children and one study referred to the number of eyes. A longitudinal study design was applied in two cohort studies (the ALSPAC study and the 2000 retrospective study conducted in Israel[63,66]), and a cross-sectional design was applied in 25 studies. The tests evaluated in these studies included VA charts and binocular vision tests (some of which were instrument-based tests).

The two longitudinal studies[63,66] compared an early screening examination with re-examination at a later age.[4] In the 2000 retrospective cohort study conducted in Israel,[66] which compared a screening program in children between 1 and 2.5 years of age with a re-examination at 8 years of age, the screening program showed a sensitivity of 86% and a specificity of 99%. The ALSPAC study[63] compared the use of single screening tests or test combinations between different age groups (screening at the ages of 8, 12, 18, 25, and 31 months of age versus screening at 37 months of age). Overall, the screening tests showed an increase of sensitivity with age (from 12 to 31 months), while specificity remained unchanged. Photorefraction showed a comparatively high sensitivity (61% at 12 months and 64% at 31 months). The sensitivity for the intensive screening program (screening at the ages of 8, 12, 18, 25, and 31 months of age) was 68%, whereas a current screening program (screening at 8 and 18 months of age) showed a sensitivity of 32%. Specificity was equally high for both programs (95% and 92%, respectively).

The cross-sectional studies reviewed by Schmucker et al.[4] evaluated different screening settings, VA tests, auto- or photorefractors, and stereo tests. According to the reviewers, the large variety of reference tests, the differing criteria for defining amblyopia and its risk factors and methodological limitations of these studies prevented a valid data interpretation.

Six cross-sectional studies compared different health professionals and/or different screening settings.[4] One of these studies evaluated whether there is a difference in the outcome when the STYCAR test (a VA test) is administered by a nurse or by an orthoptist. The examination by an orthoptist was regarded as "gold standard" (reference test). Nurse screening showed a sensitivity of 83% and a specificity of 95%. The remaining studies used different screening techniques between different health professionals in the index and reference groups. The definition for amblyopia and its risk factors differed between studies and within studies (that is, between the screening and reference test), which prevented a valid interpretation of the study results. Overall, the reported sensitivity ranged between 9% and 83%; specificity ranged between 68% and 99.5%.

The diagnostic accuracy of VA tests was evaluated in eight cross-sectional studies.[4] Overall, the sensitivity of VA tests ranged between 9% and 100%; specificity ranged between 8% and 100%. Two studies included VA testing in the reference examination. However, in one of these studies the threshold for reduced VA was not defined, and the other study compared the results of the R5 test with the results of the C Test and vice versa. Using both tests as a reference standard did not allow for a reliable comparison. The remaining studies examined whether a VA test can be used to detect strabismus and/or refractive disorders. Some of these comparisons showed a low sensitivity, which "may indicate that a visual acuity test is inappropriate to identify disorders other than reduced visual acuity and amblyopia."[4]

Nine cross-sectional studies determined the sensitivity and specificity of auto and photorefraction screening techniques (for the outcome measurement refractive error/detection of refractive error).[4] Overall, sensitivity estimates ranged between 46% and 95% and specificity values ranged from 53% to 100%. Most studies used cycloplegic retinoscopy as a reference test, a method that "can be regarded as a gold standard for the identification of refractive errors in children."[4] However, these studies used different criteria for defining hyperopia, myopia, astigmatism, and anisometropia, as well as using different age groups, which prevented a valid interpretation of the results. According to Schmucker et al.,[4] "The results of the studies, which used noncycloplegic retinoscopy as a reference test, are not reliable."

Stereo acuity tests were examined in seven cross-sectional studies.[4] Overall, the stereo acuity tests showed a wide range of sensitivity (between 14% and 100%) and a high specificity (between 76% and 99%). Five studies evaluated whether these tests can be used to (indirectly) detect reduced visual acuity, refractive disorders, and/or strabismus. One study compared the results of the Titmus test (index test) with the results of the TNO test (reference test). The Titmus test was designed to measure gross stereo acuity. Therefore, it is not surprising that the Titmus test showed a sensitivity of only 14% in this comparison. Another study reported a sensitivity of 100% for the small target suppression test and the small target random dot stereo test. "The reason for this finding is that the study population contained only one child with the target condition (true positive child)."[4]

All studies reviewed by Schmucker et al.[4] showed methodological limitations. A particular methodological limitation mentioned by the reviewers was that comparable reference standards were hardly applied and "an estimation of the accuracy of relevant diagnostic procedures on the basis of several studies was therefore not possible." In addition, a screening test was intended to fulfil two requirements, namely the identification of the manifest disease and its risk factors. However, for each risk factor different test procedures with different reference standards were applied. In addition, gold standards were only available for a few study outcomes.

Schmucker et al.[4] concluded, "diagnostic test accuracy can only be sufficiently investigated after establishing age-related values defining amblyopia, refractive errors, and strabismus. To address

these questions, we recommend a longitudinal study design in which children are examined either with a single screening test (e.g., a tool to study refractive errors and strabismus without cycloplegia) or a combination of different tests at different ages (e.g., at 3, 4, 5, and 6 years of age). A comprehensive examination by an ophthalmologist which includes cycloplegic retinoscopy should be used as a "gold standard" in such studies."

Also in 2009, Powell and Hatt published the results from a Cochrane review conducted to evaluate the effectiveness of performing vision screening for amblyopia in children before or as they start school.[3] The primary objective was to evaluate the impact of vision screening on amblyopia prevalence in comparable screened versus unscreened populations. Subgroup analyses were planned to determine the effect of the type of personnel conducting the testing, the age at screening, and the VA threshold at which participants are referred for further evaluation. Secondary objectives were to report available evidence regarding the disability associated with living with uncorrected amblyopia and to document reports of the potential harms and costs associated with screening.

Since Powell and Hatt[3] found no RCTs designed to compare amblyopia prevalence in screened versus unscreened populations of children, no data were collected or analysed in this Cochrane review. However, the reviewers discussed the findings from several non-RCT studies (including the 2002 and 2003 follow-up studies of the ALSPAC study[64,65]) because they described current practice in terms of amblyopia prevalence in screened cohort, coverage rates, age at screening, and threshold applied for failing screening.

Based on their review of the available evidence, Powell and Hatt[3] concluded that there is insufficient evidence from good quality trials to allow accurate measurement of the impact on the prevalence of amblyopia of screening children for this condition before or as they start school. The optimum protocol for conducting vision screening for amblyopia in this population remains unclear. Since they could not find enough evidence to determine whether or not screening programs reduce the proportion of older children and adults with amblyopia, the reviewers also stated that "there is, therefore, a need for some robust evaluation of the screening programs that are in place to see if they are truly effective or not. Any such evaluation would have to also look at how much screening programs cost and what effect untreated amblyopia has on quality of life."

DISCUSSION

The most common causes of visual impairment in preschool children (aged from birth to 6 years) are amblyopia, strabismus, and refractive errors.[2–9,11–14,24–29,32,34,39–41,50] In Canada, as in other countries, reported prevalence rates of these conditions in this population show large variations, and further research may be required to consolidate these estimates. However, they suggest that amblyopia and its predisposing conditions are relatively prevalent among Canadian preschool children. If left untreated, they can lead to permanent severe visual impairment and vision loss, which can lead to substantial burden on the affected individuals, their families, and society.

PSVS of amblyopia and its predisposing conditions can identify affected children at a critical period of visual development (before age of 7 years) who may benefit from early interventions to correct or improve vision.[1–14] However, PSVS is only one of the solutions that have been considered, which range somewhere along a spectrum that includes no formal detection process at one end (for example, relying on parental or teacher identification as the basis of concern) and comprehensive eye and vision examination and diagnostic confirmation processes at the other end (using optometrists, ophthalmologists, or orthoptists to carry out detailed assessments of every child).

While most Canadian jurisdictions have systems in place to offer evaluation of children's vision to some degree, little consistency currently exists in how and when PSVS is conducted across provinces and territories.[2,12,14,34,43,50–55] Inconsistencies were found in the number and frequency of vision screens, the age at which screening is conducted, the screening methods used, the personnel conducting the screening, and the referral pathways used to follow up screening results. In Alberta, very little formal PSVS is being conducted currently. The Alberta Association of Optometrists advocates for kindergarten children to receive an optometry exam through the ESEL awareness program. However, a low uptake rate of only 45% has raised concerns about social inequalities in health care.[12,14]

A number of Canadian professionals involved in eye and vision healthcare support and have interest in the development of screening programs[2,12,14,34,43,49–51] and, according to the reviewed literature, there are important reasons why at least some form of vision screening is necessary in preschool children.[1–3,7,10–14,20,22,24,29,33,41] Based on the WHO criteria for screening programs: vision is an important health consideration; vision screening can detect latent or early symptomatic stages of commonly occurring vision conditions; early diagnosis of these vision conditions may result in a better prognosis; and, while there is limited evidence to confirm the effectiveness of PSVS, there is also little evidence to suggest that PSVS is not effective.

Given the inconsistency of PSVS approaches across Canada and Alberta,[2,12,14,34,43,49–51] and the general lack of or inconsistent evidence regarding the value of PSVS,[2,9,11,13,15,16,30,33,39,46,69] this rapid review focused on the most recently published best evidence to determine the safety and effectiveness of PSVS; compare the safety and effectiveness of universal and targeted PSVS; and determine the best practice for conducting PSVS.

Safety of PSVS

According to the selected systematic reviews,[3,5–8,24] primary research studies that would enable an estimate of potential harms of PSVS, either universal or targeted, are still lacking.

Effectiveness of PSVS

Based on the results from the selected systematic reviews,[3,5–8,24] it appears that the available primary research provides neither evidence nor indications of benefit or lack of benefit from PSVS (programs), either universal or targeted. Reviewers found no RCT that evaluated PSVS (universal or targeted) versus no screening in terms of any of the outcomes of interest. Neither did they find any RCT that compared outcomes of PSVS (universal or targeted) in different age groups.

Although the effectiveness of PSVS in terms of reduced amblyopia prevalence has been reported on widely in the literature, only one of the included primary research studies directly compared the benefit of screening with no screening and only a few studies compared screening strategies of varying intensity or screening strategies conducted at different ages.[3,5–8,24] In most cases, the results reported by the included primary research were inconsistent and were not reliably interpretable due to methodological shortcomings. However, despite these limitations, a positive effect of PSVS on amblyopia prevalence was consistently apparent.

The only RCT evaluating the effectiveness of PSVS (the ALSPAC study[63]) compared more intensive to less intensive PSVS rather than PSVS versus no PSVS.[3,5–8,24] The ALSPAC study found that repeated PSVS (from 8 through 37 months of age) reduced the prevalence of subsequent (school-aged) amblyopia by ~1% compared with one-time screening (at 37 months of age). The 2003 prospective cohort study, which used the birth cohort of the ALSPAC study,[7] found no significant difference between one-time screening at 37 months of age compared with school entry screening

on risk of amblyopia at 7.5 years of age but found a 50% reduction in the odds of being bullied.[6,7] A 2000 retrospective cohort study[66] found that PSVS (at ages of 1 to 2.5 years) was more effective than no screening in reducing amblyopia prevalence, but its findings were limited by important methodologic shortcomings.[3,5–8,24]

Few studies focused exclusively on screening during the neonatal period (from birth to 1 month of age), and those that did were of lower quality.[8,24] According to the reviewed literature and professional guidelines and position statements,[1,9,11,17–23,36,60] a check for congenital eye conditions should occur within the first 3 months of life. However, according to Mathers et al.,[8,24] further research is needed to determine how this should be performed, and whether it should be considered part of a screen or part of expected clinical practice.

Long-term, patient-relevant outcomes such as school performance and quality of life were not adequately evaluated in the primary research included in the selected systematic reviews.[3,5–8,24]

Diagnostic accuracy of PSVS tests

Although many diagnostic accuracy studies examining different tests to detect vision conditions in preschool children have been published, no single test or combination of tests has been shown to be superior for PSVS.[4,6,7] The diagnostic accuracy assessment of the PSVS tests was mainly based on cross-sectional studies. In the largest study that directly compared a number of screening tests (the VIP study[67]), differences in diagnostic accuracy estimates were generally too small to clearly distinguish superior from inferior tests.

Diagnostic accuracy of PSVS tests did not clearly differ in children stratified by age, although testability was generally lower in children aged 1 to 3 years,[4,6,7] with the potential exception of the MTI photoscreener.[6,7] Although combinations of various tests were generally associated with greater diagnostic accuracy when compared with individual tests, according to Chou et al.,[6,7] the available evidence is insufficient to recommend a specific combination of tests.

Universal PSVS versus targeted PSVS

None of the primary research studies included in the selected systematic reviews evaluated the outcomes (benefits and/or harms) of universal PSVS versus targeted PSVS.

Best practice for conducting PSVS

Professional association/society guidelines and position statements in Canada and the US generally recommend eye and vision examination and screening for children before they start school.[20–22,28,35,36,47,48,52,53,58–62] However, the specific age for initiation of vision examination and screening, and the particular testing methods that are recommended, vary. Given the lack of consistent and rigorous evidence, experts are still debating about the value of performing comprehensive vision examination versus formal vision screening in all preschool children, the content of vision screening and examination, who should administer the screenings, and how frequently they should be administered (www.aoa.org) (http://opto.ca).[1,2,12–14,16,22,28,50]

Based on results from the selected systematic reviews,[3–8,24] this rapid evidence assessment could not determine which is the best practice for conducting PSVS. Evidence on when to initiate PSVS is still limited. The threshold applied for failing vision screening appears to vary depending on practice patterns, the test used, and the age of the child at screening.[3,8,24] The referral criteria recommended for use in determining pass or fail of a vision screen were dependent upon the age selected for screening (generally less than 6/9 in either eye for a 3-year-old and 6/9 or less in either eye for a 4- to 6-year-old).[8]

Practice also varies regarding who performs PSVS screening for amblyopia and its predisposing conditions.[3–8,24] The available evidence suggested orthoptists as the "screener of choice" in comparison to nurses, health visitors, and general practitioners.[8,24] Nurses were also deemed to be accurate and efficient screeners when provided with appropriate training and supervision. However, the available evidence regarding the characteristics and qualifications of screeners was largely derived from international studies, which did not incorporate consideration of all professionals (for example, optometrists) involved in vision healthcare in the Canadian context.

Further research

The selected SRs[3–8,24] identified several important gaps in the evidence on PSVS for detection of vision conditions that commonly cause visual impairment in childhood. Overall, their authors agree that there is a lack of good evidence regarding the safety and effectiveness of PSVS and that a consensus needs to be reached for the definition of amblyopia and its risk factors. There are no RCTs showing that PSVS is effective for improving visual or other clinical outcomes when compared with no screening, and the only prospective cohort study found no clear benefit from screening. Almost all of the available primary research focused on the effects of PSVS on visual acuity.

All systematic reviews concluded that well-designed primary research studies are needed to better understand the effects of PSVS compared to no PSVS, to identify optimal methods for conducting PSVS, to identify who should perform the screenings, to clarify when to begin screening, to define appropriate screening intervals, and to develop effective strategies for linking preschool children who have vision impairment to appropriate care while avoiding unnecessary treatment.[3–8,24] Trials that also address function are needed to clarify how PSVS may affect school performance and other aspects of child development, as well as quality of life.

LIMITATIONS OF THIS REVIEW/REPORT

The present review has several limitations. The literature search was limited to published reports of articles and documents that were written in English. Proprietary reports were excluded. Only full-text articles were included.

Only five reports of systematic reviews (published from January 2007 onwards) were selected for data extraction, and no primary research studies (of any design) were considered. The focus on recently conducted systematic reviews ensures the inclusion of primary research data published prior to 2007. However, subsequently published primary research studies (which may have addressed some of the outstanding issues associated with the use of PSVS) are not included.

The review only summarizes the results from the selected systematic reviews; no attempt was made to formally appraise their methodological quality and assess the validity of their findings. However, selected were only systematic reviews and HTA studies that, by virtue of design and quality of reporting, are most likely to provide the best level of evidence on the topic of interest.

Also, the review only summarizes the recommendations from reports of relevant clinical practice guidelines and positions statements and does not appraise their scientific foundations.

This review was confined to an examination of the effectiveness and safety of PSVS for detecting the conditions of interest in asymptomatic preschool children. It did not focus on the diagnostic screening accuracy of the various tests/devices used within a PSVS program. Nor did it address the question on what sequence of use of the various tests/devices provides the best diagnostic screening accuracy within a PSVS program.

Social, ethical, or legal issues associated with the use of PSVS to detect the conditions of interest in asymptomatic preschool children were not considered in this review.

CONCLUSIONS

The results from five recently published systematic reviews suggest that, overall, rigorous evidence is still lacking to conclusively evaluate the effectiveness and safety of using PSVS (universal or targeted) for the detection of vision conditions that commonly occur at an early age (before 6 years). The available direct evidence, either in favour of or against using PSVS, remains limited. The extent to which PSVS assists in the reduction of prevalence of vision conditions such as amblyopia, strabismus, and refractive errors is still not clear. Consequently, whether PSVS, either universal or targeted, is the best method by which to reduce the prevalence of these vision conditions is also unclear. Furthermore, the evidence on potential harms of PSVS remains limited.

The best available evidence suggests a positive impact of universal PSVS on the prevalence of amblyopia in children. However, the implications of improved visual acuity (for example, any potential impact on long-term, patient-relevant outcomes such as school performance and/or quality of life) was not considered.

The best practice for conducting PSVS remains unclear. There is a lack of consistent evidence and consensus about how to conduct and when to start PSVS, what tools or tests are the most accurate and effective for detecting amblyopia and its predisposing conditions, and who is best placed (in terms of accuracy, availability, and efficiency) to conduct the screens.

Future well-designed research is warranted to conclusively determine the utility of PSVS.

APPENDICES

APPENDIX T.A: METHODOLOGY

Literature search

A research librarian from the Institute of Health Economics conducted the literature search between February 27 and March 26, 2012. The search was developed and carried out prior to the study selection process and was limited to English language publications and human studies published from January 2007 onwards.

In addition to the search strategy outlined in Table T.A.1, the bibliographies and reference lists of all retrieved articles were examined and Internet searches were conducted to retrieve grey literature. Grey literature searches were conducted to identify literature from non-indexed sources, health technology assessment reports, guidelines, government documents, and regulatory status information (that is, National Guidelines Clearinghouse, Health Canada, Google).

Table T.A.1: Search strategy

Database	Edition or date searched	Search Terms ††
MEDLINE (includes in-process and other non-indexed citations) OVID Licensed Resource	2002 – February 27, 2012	1 vision disorders/ or amblyopia/ or color vision defects/ 2 ocular motility disorders/ or strabismus/ or esotropia/ or exotropia/ 3 lens diseases/ or cataract/ or capsule opacification/ 4 clear ocular media.tw. 5 eye turn*.tw. 6 refractive errors/ or aniseikonia/ or anisometropia/ or astigmatism/ or corneal wavefront aberration/ or hyperopia/ or myopia/ or myopia, degenerative/or presbyopia/ 7 (amblyopia or strabismus or hyperopia or myopia or astigmatism or cataract* or refractive error* or visual acuity or visual perceptual difficult* or blind*).tw. 8 (vision adj1 (problem* or disorder* or impairment or disturbance or loss)).tw 9 (visual adj1 (disorder* or impairment or disturbance*)).tw. 10 (ocular adj1 (abnormalit* or alignment or disorder*)).tw. 11 eye condition*.tw. 12 refraction, ocular/ 13 visual acuity/ 14 contrast sensitivity/ or emmetropia/ 15 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 16 vision tests/ or color perception tests/ or vision screening/ or visual field tests 17 mass screening/ or multiphasic screening/ 18 (screen* or diagnos* or test or tests or testing).ti. 19 16 or 17 or 18 20 15 and 19 21 limit 20 to english language 22 (child* or pediatric* or paediatric* or preschool or pre-school or school-age or schoolage).tw. 23 22 and 21 24 limit 21 to "preschool child (2 to 5 years)" 25 23 or 24 26 meta-analy*.mp,pt. 27 ((systematic* adj2 review*) or Medline or pubmed or psychinfo or psycinfo or search*).tw. 28 (hta or health technology assessment).tw. 29 Technology Assessment, Biomedical/

		30 26 or 27 or 28 or 29 31 25 and 30 **48 results**
Embase		1 visual disorder/ or abnormal vision/ or amblyopia/ or aniseikonia/ or blurred vision/ or color blindness/ or color vision defect/ or congenital strabismus/ or exp refraction error/ or visual impairment/ 2 exp strabismus/ or eye movement disorder/ 3 exp cataract/ or lens disease/ 4 visual acuity/ 5 eye refraction/ 6 emmetropia/ 7 clear ocular media.tw. 8 eye turn*.tw. 9 (amblyopia or strabismus or hyperopia or myopia or astigmatism or cataract* cataract* or refractive error* or visual acuity or visual perceptual difficult* or blind*).tw. 10 exp blindness/ 11 (vision adj1 (problem* or disorder* or impairment or disturbance or loss)).tw. 12 (visual adj1 (disorder* or impairment or disturbance*)).tw. 13 (ocular adj1 (abnormalit* or alignment or disorder*)).tw. 14 eye condition*.tw. 15 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 16 exp vision test/ 17 visual system parameters/ 18 mass screening/ 19 (screen* or diagnos* or test or tests or testing).ti. 20 16 or 17 or 18 or 19 21 15 and 20 22 (child* or pediatric* or paediatric* or preschool or pre-school or school age or schoolage).tw. 23 21 and 22 24 limit 21 to (child or preschool child <1 to 6 years>) 25 23 or 24 26 meta analysis/ 27 "systematic review"/ 28 (search* or meta-analysis or medline or pubmed or psychinfo or psycinfo or (systematic* adj3 review*)).tw. 29 technology assessment.mp. or HTA.tw. 31 25 and 30 32 limit 31 to english language **76 results**
Cochrane Library		#1 MeSH descriptor Vision Disorders explode all trees #2 MeSH descriptor Amblyopia, this term only #3 MeSH descriptor Color Vision Defects, this term only #4 MeSH descriptor Ocular Motility Disorders, this term only #5 MeSH descriptor Strabismus explode all trees #6 MeSH descriptor Lens Diseases, this term only #7 MeSH descriptor Cataract explode all trees #8 clear ocular media #9 eye turn* #10 MeSH descriptor Refractive Errors explode all trees #11 (amblyopia or strabismus or hyperopia or myopia or astigmatism or cataract* or refractive error* or visual acuity or visual perceptual difficult* or blind*) #12 (vision NEXT/1 (problem* or disorder* or impairment or disturbance or loss)) #13 (visual NEXT/1 (disorder* or impairment or disturbance*)) #14 (ocular NEXT/1 (abnormalit* or alignment or disorder*)) #15 eye condition* #16 MeSH descriptor Refraction, Ocular, this term only #17 MeSH descriptor Visual Acuity explode all trees

		#18 (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17) #19 MeSH descriptor Vision Tests explode all trees #20 MeSH descriptor Mass Screening, this term only #21 MeSH descriptor Multiphasic Screening, this term only #22 (screen* or diagnos* or test or tests or testing):ti #23 (#19 OR #20 OR #21 OR #22) #24 (#23 AND #18) #25 (child* or pediatric* or paediatric* or preschool or pre-school or school-age or schoolage) #26 (#24 AND #25) **154 results**
Web of Science		#18 #16 AND #17 #17 TS=(meta-analysis OR metaanalysis OR search OR pubmed OR medline OR cinahl OR HTA OR "technology assessment" OR (systematic* SAME review*)) #16 #14 not #15 #15 TI=(dog OR dogs OR sheep* OR lamb OR lambs OR rat OR rats OR cats OR mice OR mouse OR murine OR rabbit* OR animal* OR pig OR pigs OR piglet* OR porcine) #14 #12 and #13 #13 TS=(child* or pediatric* or paediatric* or preschool or pre-school or school-age or schoolage) #12 #11 and #8 #11 #9 OR #10 #10 TI=(screen* or diagnos* or test or tests or testing) #9 TS= (vision test* or vision screening) #8 #1 or #2 or #3 or #4 or #5 or #6 or #7 #7 TS=(eye condition*) #6 TS=((ocular NEAR/1 (abnormalit* or alignment or disorder*))) #5 TS=((visual NEAR/1 (disorder* or impairment or disturbance*))) #4 TS=((vision NEAR/1 (problem* or disorder* or impairment or disturbance or loss or defect*))) #3 TS=((amblyopia or strabismus or hyperopia or myopia or astigmatism or cataract* or refractive error* or visual acuity or visual perceptual difficult* or blind*)) #2 TS=(eye turn*) #1 TS=(clear ocular media) **103 results**
CINAHL		S27 S24 or S26 S26 S23 and S25 S25 meta-analysis OR metaanalysis OR pubmed OR medline OR cinahl OR search* OR (systematic* AND review*) S24 S20 or S22 Limiters - Publication Type: Systematic Review S23 S20 or S22 S22 S19 and S21 S21 (child* or pediatric* or paediatric* or preschool or pre-school or school-age or schoolage) S20 S14 and S18 Narrow by SubjectAge: - Child, Preschool: 2-5 years S19 S14 and S18 S18 S15 or S16 or S17 S17 TI (screen* or diagnos* or test or tests or testing) S16 (MH "Health Screening") S15 (MH "Vision Tests") OR (MH "Color Perception Tests") OR (MH "Perimetry") OR (MH "Vision Screening") OR (MH "Visual Fields") S14 S1 or S2 or S3 or S4 or S5 or S6 or S7 or S8 or S9 or S10 or S11 or S12 or S13 S13 (MH "Visual Acuity") S12 (MH "Refraction, Ocular") S11 eye condition*

		S10 (ocular abnormalit* or ocular alignment or ocular disorder*) S9 (visual disorder* or visual impairment or visual disturbance*) S8 (vision problem* or vision disorder* or vision impairment or vision disturbance or vision loss) S7 (amblyopia or strabismus or hyperopia or myopia or astigmatism or cataract* or refractive error* or visual acuity or visual perceptual difficult* or blind*) S6 (MH "Refractive Errors") OR (MH "Astigmatism") OR (MH "Hyperopia") OR (MH "Myopia") OR (MH "Presbyopia") S5 eye turn* S4 "clear ocular media" S3 (MH "Lens Diseases") OR (MH "Cataract") S2 (MH "Ocular Motility Disorders") OR (MH "Strabismus") S1 (MH "Vision Disorders") OR (MH "Amblyopia") OR (MH "Blindness+") OR (MH "Color Vision Defects") OR (MH "Vision, Subnormal") **9 results**
Grey Literature		
Guidelines		
AMA Clinical Practice Guidelines www.topalbertadoctors.org/cpgs.php	March 23, 2012	Browsed list of topics **0 results**
NICE Guidance www.nice.org.uk/	March 23, 2012	Vision or visual or amblyopia or strabismus or myopia or refractive errors **0 results**
CMA Infobase http://mdm.ca/cpgsnew/cpgs/index.asp	March 23, 2012	Vision or visual or amblyopia or strabismus or myopia or refractive errors **1 result**
National Guideline Clearinghouse www. ngc.gov	March 23, 2012	Vision screening or visual acuity or vision tests or vision testing or amblyopia or strabismus or myopia or refractive errors **14 results**
Canadian Ophthalmology Society www.eyesite.ca/english/index.htm	March 23, 2012	Browsed list of topics **0 results**
Coverage/Regulatory/Licensing Agencies		
Alberta Health and Wellness www.health.gov.ab.ca	March 25, 2012	Vision screening or visual acuity or vision tests or vision testing or amblyopia or strabismus or myopia or refractive errors **0 results**
Health Canada www.hc-sc.gc.ca	March 25, 2012	Vision screening or visual acuity or vision tests or vision testing or amblyopia or strabismus or myopia or refractive errors **0 results**
Aetna Clinical Policy Bulletins www.aetna.com/about/cov_det_policies.html	March 26, 2012	Vision screening or visual acuity or vision tests or vision testing or amblyopia or strabismus or myopia or refractive errors **1 result**
HTA resources		
INESS www.inesss.qc.ca/	March 26, 2012	Vision screening or visual acuity or vision tests or vision testing or amblyopia or strabismus or myopia or refractive errors **0 results**

CADTH www.cadth.ca/index.php/en/	March 26, 2012	vision screening or visual acuity or vision tests or vision testing or amblyopia or strabismus or myopia or refractive errors **3 results**
Institute for Clinical and Evaluative Sciences (ICES), Ontario www.ices.on.ca/	March 26, 2012	vision screening or visual acuity or vision tests or vision testing or amblyopia or strabismus or myopia or refractive errors **0 results**
Health Technology Assessment Unit at McGill www.mcgill.ca/tau/	March 26, 2012	Browsed list **0 results**
Medical Advisory Secretariat www.health.gov.on.ca/english/providers/program/mas/mas_mn.html	March 26, 2012	Browsed list **0 results**
Dissertations		
Proquest Dissertations and Theses	March 26, 2012	Vision screening or visual acuity or vision tests or vision testing or amblyopia or strabismus or myopia or refractive errors **0 results**
Search Engines		
Google	March 26, 2012	Vision screening OR vision tests OR visual acuity OR vision testing OR amblyopia OR strabismus OR myopia OR refractive errors child OR children OR pediatric OR paediatric OR schoolage OR preschool OR school-age "review" – pubmed **12 results**
NHS Evidence	March 26, 2012	Vision screening or visual acuity or vision tests or vision testing or amblyopia or strabismus or myopia or refractive errors **2 results**

Note:

† **Limits:** Searches were limited to **publication dates** 2007–2012; **language**: English only; **studies**: systematic reviews and HTA studies only; human studies only. These limits are applied in databases where such functions are available.

††, *, #, and ? are truncation characters that retrieve all possible suffix variations of the root word; for example, surg* retrieves surgery, surgical, surgeon, etc.

Search Strategy: # Searches Results

Selection of studies

One reviewer screened titles and abstracts. Full-text publications of relevant articles were retrieved. The same reviewer determined eligibility of studies according to the following predefined inclusion/exclusion criteria.

Inclusion criteria

Research studies were included if they met the following criteria:

Study design: systematic reviews and/or HTA studies reporting on the safety and effectiveness of PSVS for detecting vision conditions in asymptomatic preschool children (aged from birth to 6 years).

Note: A research study was selected if it met the following five criteria for a systematic review:[68]

- focused clinical question
- explicit search strategy
- use of explicit, reproducible, and uniformly applied criteria for article selection
- critical appraisal of the included studies
- qualitative or quantitative data synthesis

Population: asymptomatic preschool children (aged from birth to 6 years; not necessarily considered at risk for developing any of the conditions of interest) screened in PSVS programs (universal or targeted).

Interventions: universal or targeted PSVS to detect vision conditions in asymptomatic preschool children.

Comparators: universal PSVS versus targeted PSVS, universal PSVS versus no PSVS, or targeted PSVS versus no PSVS.

Outcomes: diagnostic accuracy (sensitivity, specificity, positive and negative predictive values) of PSVS**;** impact on reversing visual impairment in children diagnosed with the conditions of interest; impact on developmental and educational outcomes in children diagnosed with the conditions of interest; impact on social and emotional development, functional capacity, and other developmental milestones (such as scholastic achievement) in children diagnosed with the conditions of interest; impact on quality of life in children diagnosed with the conditions of interest; risks and complications to the preschool children and/or screeners from performing the screening itself; and adverse effects of false positive and false negative PSVS results.

Time frame: published from January 2007 onwards.

Only full, peer-reviewed articles were included because abstracts do not provide adequate detail on the review methodology. However, where appropriate, relevant information contained in abstracts of research studies was used to inform the section on "Available evidence."

Studies were included if the published report was publicly available. In the case of duplicate publications, the most recent and complete version was included.

Also considered for inclusion in this review were publicly available published reports of:

- evidence-based CPGs on conducting PSVS (developed in Alberta, in Canada, or in countries with developed market economies)
- consensus/position statements on conducting PSVS (Alberta or Canada)
- clinical reviews, overview articles, narrative and descriptive reviews, commentaries, and discussion papers presenting background information on the conditions of interest (etiology, prevalence, risk factors, and consequences as well as information on current management), on the advantages/disadvantages of various screening programs and protocols, on the screening tests/devices/technologies/procedures used for PSVS, and on PSVS programs in Canada and their protocols

An article was deemed to be an evidence-based CPG if it met the following criteria:

- it contained the word "guideline" or "recommendation" in its title or introduction, or contained specific guidance, in the form of advice or instructions, on how to conduct PSVS to detect the conditions of interest in asymptomatic preschool children

- it was developed by at least two authors
- it used an evidence-based approach in the process of developing the guidance (this means that the recommendations, advice, or instructions were based on a systematic review of the literature, were graded based on the strength of the supporting evidence, and reflected the consensus of the experts involved in the development of the guidance)
- it described the evidence-based approach used for the development of recommendations, advice, or instructions

Only articles reporting on research/analyses conducted in countries with developed market economies were considered since the health status and disease burden of individuals, the cultural and legal norms, and access to health care in countries with another status are likely to be too different from those of Canada to be clinically relevant. Countries deemed to have developed market economies, as defined by the United Nations, include Australia, Canada, Japan, New Zealand, the United States, and European countries (except for countries with market economies in transition) (http://unpan1.un.org/intradoc/groups/public/documents/un/unpan008092.pdf).

Only those publicly available, evidence-based CPGs, positions statements, and/or consensus documents developed by national bodies in Canada and other countries with developed market economies were considered.

Consensus statements and/or position statements containing recommendations based solely on expert opinion were included only if they were developed in Alberta or in Canada.

Exclusion criteria

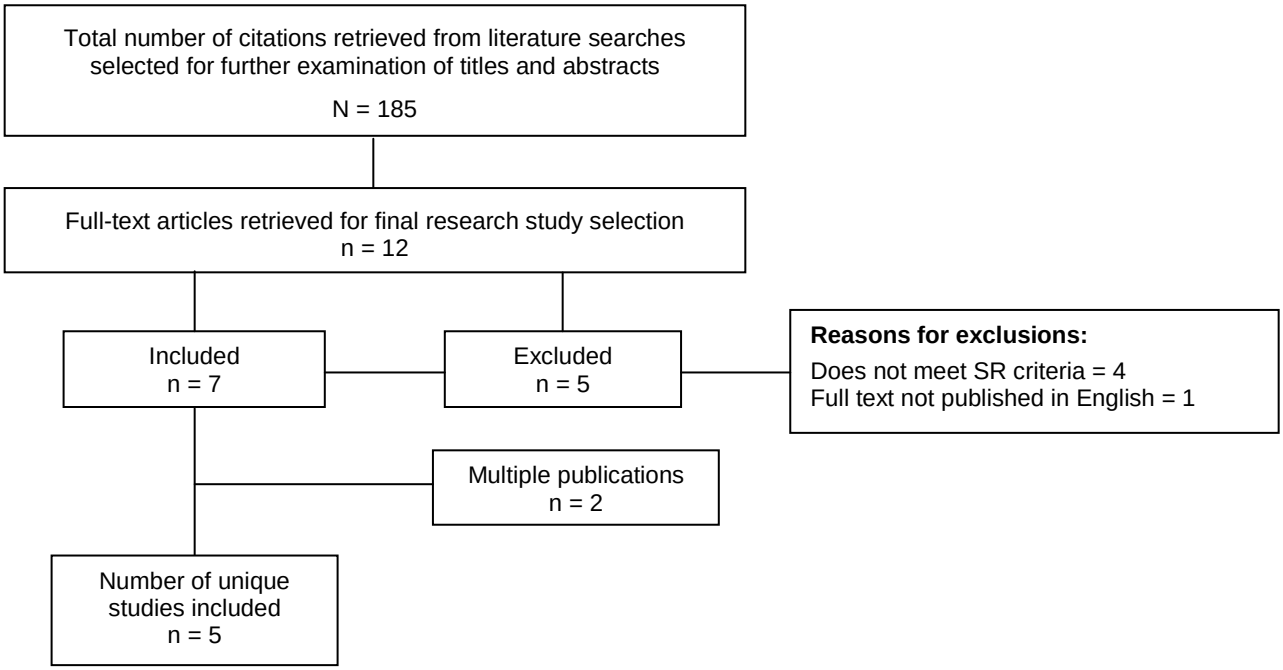
Excluded were:

- primary research studies (screening accuracy studies, randomized and non-randomized controlled studies, comparative studies, cohort studies, case-control studies, cross-sectional studies, case series, or case reports) reporting on the safety and efficacy/effectiveness of PSVS to detect the conditions of interest in asymptomatic preschool children;
- primary research studies (screening accuracy studies, randomized and non-randomized controlled studies, comparative studies, cohort studies, case-control studies, cross-sectional studies, case series, or case reports) reporting on the safety and efficacy/effectiveness of tests/devices/technologies/procedures used for PSVS to detect the conditions of interest in asymptomatic preschool children;
- systematic reviews, HTA studies, and primary research studies on the use of vision screening for detecting the conditions of interest in children older than 6 years;
- systematic reviews and primary research studies that involved preschool children and children older than 6 years, which did not separately report on the use of vision screening for detecting the conditions of interest in asymptomatic preschool children;
- PSVS program evaluation studies;
- PSVS process evaluation studies;
- conference abstracts, editorials, letters, technical reports, and book reviews.

Published reports of narrative and descriptive reviews, which summarized the research on the topic but lacked an explicit description of a systematic approach to the identification and interpretation of

evidence, were also excluded. They were considered only as a source of background information, where appropriate.

Figure T.1: Research study selection process



Data extraction

One reviewer abstracted the data from the published reports of the selected systematic reviews. Main characteristics, findings and conclusions from these studies and details of their methodology were summarized in Table T.C.1 and Table T.C.2 (see Appendix T.C).

For studies in which the reporting of the methodology was unclear, their authors or the agencies that produced the published reports were not contacted for further information. These studies were excluded from data extraction for not meeting all the criteria for a systematic review (see Table T.B.1).

Methodological quality assessment

Due to time constraints, a formal critical appraisal of the methodological quality of the selected research studies was not performed. An informal methodological quality assessment of the selected research studies was conducted in the selection process by applying the five criteria from Cook et al.[68] However, no attempt was made to assess the validity of their findings.

Also, no attempt was made to appraise the scientific foundations of the selected CPGs.

Data synthesis

Due to time constraints, a comprehensive qualitative analysis was not conducted.

External review

The members of the provincial Expert Advisory Group assembled for this project reviewed the draft report.

APPENDIX T.B: EXCLUDED STUDIES

The application of the selection criteria for research studies described in Appendix T.A resulted in 5 full text articles being excluded from data extraction and synthesis. Table T.B.1 lists the excluded full-text reports of the retrieved research studies and indicates the main reasons for their exclusion.

Table T.B.1: Excluded full text articles

Main reason for exclusion: *The study did not meet the SR criteria* (n = 4)
Dunfield L and Keating T. *Preschool vision screening (Structured abstract).* SO: Ottawa: Canadian Agency for Drugs and Technologies in Health (CADTH), 25. 2007. Canadian Agency for Drugs and Technologies in Health (CADTH).[2]
Lagreze WA. Vision screening in preschool children: do the data support universal screening? *Deutsches Arzteblatt International* 2010;107(28-29):495-99. 2010.[9]
Mema SC, McIntyre L, and Musto R. Childhood vision screening in Canada: public health evidence and practice. *Canadian Journal of Public Health* 2012;103(1):40-5.[12]
Carlton J, Karnon J, Czoski-Murray C, Smith KJ, and 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 Technology Assessment (Winchester, England)* 2008;12(25):iii, xi-iii,194.[29]
Main reason for exclusion: The full text of the study was not published in English (n = 1)
German Institute for Quality and Efficiency in Health Care (IQWiG). Screening for visual impairment in children younger than 6 years. Final report S05-02. Version 1.0. Cologne: IQWiG. April 2008. [Executive summary in English] [Full text in German][69]

Multiple Publications of Studies Included in the Overview

Of the seven included articles,[3-8,24] two[6,24] were identified as multiple publications of two selected systematic reviews[7,8] (Table T.B.2), that is, cases in which the same study was published more than once or part of the data from an original report was republished. Although the multiple publications[6,24] were not considered to be unique studies, any information they provided was included with the data reported in the main studies.[7,8]

Table T.B.2: Multiple publications

Multiple publications of studies included in the review (n = 2)
Chou R, Dana T, and Bougatsos C. Screening for visual impairment in children ages 1-5 years: systematic review to update the 2004 U.S. preventive services task force recommendation (Provisional abstract). SO: Agency for Healthcare Research and Quality, i. 2011. Agency for Healthcare Research and Quality[6] **Associated publication of** Chou R, Dana T, and Bougatsos C. Screening for visual impairment in children ages 1-5 years: update for the USPSTF. *Pediatrics* 2011;127(2):e442-e479.[7]
Mathers M, Keyes M, Wright M. National children's vision screening project. Literature review. Canberra AUS: Murdoch Childrens Research Institute; 2008[24] **Associated publication of** Mathers M, Keyes M, Wright M. A review of the evidence on the effectiveness of children's vision screening. *Child: Care, Health and Development* 2010;36(6):756-80.[8]

APPENDIX T.C: SELECTED SYSTEMATIC REVIEWS

Abbreviations

AHRQ	Agency for Healthcare Research and Quality
ALSPAC	Avon Longitudinal Study of Parents and Children
CI_{95}	95% confidence interval
CRD	Center for Reviews and Dissemination
D	diopter(s)
FN	false negative
FP	false positive
GP	general practitioner
HRQoL	health-related quality of life
IQWiG	Institut für Qualität und Wirtschaftlichkeit im Gesundheitswesen (Institute for Quality and Efficiency in Health Care)
KQ	key question
LogMAR or **logMAR**	logarithmic minimal angle of resolution
LR	likelihood ratio
mo	month(s)
MTI	Medical Technology and Innovations
NLR	negative likelihood ratio
NNS	number needed to screen
OR	odds ratio
PEDIG	Pediatric Eye Disease Investigator Group
PLR	positive likelihood ratio
PPV	positive predictive value
PSVS	preschool vision screening
QoL	quality of life
QUADAS	quality assessment of diagnostic accuracy studies
RCT	randomized controlled trial
ROC	receiver operating characteristic(s)
RR	relative risk
Sn	sensitivity
Sp	specificity

SR	systematic review
SS	statistically significant
UK	United Kingdom
US(A)	United States (of America)
USPSTF	United States Preventive Services Task Force
VA	visual acuity
VIP	vision in preschoolers
vs.	versus
y	year(s)
wk	week(s)

Table T.C.1: Selected systematic reviews (characteristics, main findings, and conclusions)

Study	Study's characteristics*	Study's search results,* main findings,* and conclusions**
Chou et al (2011)[6,7] **Type:** AHRQ Evidence Synthesis Report **Country:** US	**Included studies:** studies of screening tests (RCTs and controlled observational studies for question #1 and question #4); studies on accuracy or yield of risk-factor assessment for targeted screening, or clinical outcomes associated with targeted vs. universal screening (RCTs and controlled observational studies for question#2); studies on diagnostic accuracy of a screening test compared with a credible reference standard (for question #3) **Excluded studies:** studies of screening tests not used or available in primary care settings or not intended to detect amblyopia and/or amblyogenic risk factors, or studies not attempting to perform reference standard in all patients, or a random sample; systematic reviews; non-English language studies **Participants:** children aged 1–5 y evaluated in primary care or community-based settings and who are without known impaired VA or obvious symptoms of impaired VA **Intervention:** screening to detect amblyopia, amblyogenic risk factors, or refractive errors **Comparator(s):** not clearly specified **Outcome(s) and outcome measures:** VA, long-term amblyopia, school performance, function, QoL (question#1); diagnostic accuracy or yield of risk-factor assessment, clinical outcomes (question #2); Sn, Sp, PPV, NPV, LR, diagnostic ORs (question #3); psychological distress, labeling, anxiety, other psychological effects, FP results, adverse effects on non-impaired eye vision (question #4)	**Search results:*** Five cohort studies (one prospective published in 2003, four retrospective published in 1978, 1980, 2000, 2008) and one pseudo RCT (published in 2001, 2002) for KQ1 and KQ1a (fair to poor quality); 31 diagnostic accuracy studies (published between 1987 and 2009; various PSVS tests compared to a reference standard) for KQ3 and KQ3a (good to fair quality); one cohort study (published in 2001, 2002) and seven diagnostic studies (published in 1990, 1995, 1999, 2001, 2003, 2004) for KQ4 (poor quality). **Main Findings*** Safety *KQ4:* One population-based cohort study found a 50% reduction in the odds of being bullied at age of 7.5 y among children offered screening at 37 mo compared with those who were not offered screening. In populations with a prevalence of visual conditions of < 10%, 6 of 7 studies reported FP rates of > 70%. Efficacy/Effectiveness: *KQ1:* One large pseudo-RCT found intensive, periodic orthoptist screening at 8, 12, 18, 25, 31, and 37 mo to be associated with reduced likelihood of amblyopia at 7.5 y compared with one-time orthoptist screening at 37 mo by ~1%. A prospective cohort study found one-time orthoptist screening at 37 mo associated with no significant difference in risk of amblyopia at 7.5 y compared with school-entry screening when using any of 3 prestated definitions for amblyopia. Three retrospective cohort studies found PSVS associated with improved school-aged vision outcomes when compared with no screening. *KQ1a:* No RCT directly compared outcomes of PSVS in different age groups. *KQ2:* No study evaluated accuracy or reliability of risk-factor assessment in PSVS, and no study evaluated outcomes of targeted vs. universal PSVS. *KQ3:* Diagnostic accuracy estimates for all evaluated tests suggest utility for identification of children at higher risk for amblyogenic risk factors or specific visual conditions. Combinations of tests (VA, stereoacuity, and ocular alignment) generally showed superior LRs when compared with LRs of individual tests. *KQ3a:* Four studies found no clear differences in diagnostic accuracy of various PSVS tests in different age groups. Testability using common VA tests, stereoacuity tests, photoscreening, and autorefractors generally exceeds 80%–90% in children ≥3 y of age, with small increases through 5 y of age. Four studies found substantially lower testability with andom ot E stereotest, Lea symbols, VA testing, and SureSight autorefractor in children aged 1–3 y, compared with those aged 3–5 y. One large study of statewide screening with the MTI photoscreener found that testability was 94% at 1 y of age. **Conclusions**** "Although treatments for amblyopia or unilateral refractive error can improve vision in preschool-aged children and screening tests have utility for identifying vision problems, additional studies are needed to better understand the effects of screening compared with no screening." "Direct evidence on the effectiveness of preschool vision screening for improving visual acuity or other clinical outcomes remains limited and does not adequately address the question of whether screening is more effective than no screening. However, good evidence on diagnostic accuracy and treatments suggest that preschool vision screening could lead to increased detection of visual impairment and greater improvement in visual outcomes than if children were never screened."

* Study characteristics, search results, and main findings for questions regarding the safety and effectiveness of PSVS
** Conclusions stated by the author(s) and quoted directly from the published report

Table T.C.1: Selected systematic reviews (characteristics, search results, main findings, and conclusions) (cont'd)

Study	Study's characteristics*	Study's search results,* main findings,* and conclusions**
Mathers et al (2010)[8,24] **Type:** Systematic review funded by the Australian Government's Department of Health and Ageing **Country:** Australia	**Included studies:** SRs; RCTs; pseudo-randomized controlled trials, and non-RCTs (comparative studies with and without concurrent controls) **Excluded studies:** case series **Participants:** children aged from birth to 16 y **Intervention:** not clearly specified **Comparator(s):** **Outcome(s) and outcome measures:** screening outcomes (not clearly specified)	**Search results:*** Two RCTs, 33 non-RCTs, and eight SRs were included; of all included studies, one RCT (reported in two articles published in 2001 and 2002), five non-RCTs (prospective and retrospective cohort/comparative studies, published in 1993, 1996, 2000, 2003, and 2007), and three SRs (published in 1995, 1998, and 2005) provided evidence on screening effectiveness in children aged from 1 mo to 6 y. **Main Findings*** Safety: No results reported. Efficacy/Effectiveness: *Infant age (birth to 1 mo):* No relevant studies were found to evaluate effectiveness of vision screening. *Toddler age (1 mo to 3 y):* One RCT found a higher amblyopia detection rate in children assessed at 8, 12, 18, 25, and 31 mo by an orthoptist than in children screened at 8 and 18 mo by health visitors and GPs. More intensive and repeated screening between 8 and 37 mo of age resulted in better VA in amblyopic eye and lower amblyopia prevalence at age of 7.5 y. A higher prevalence of amblyopia was found in children aged 8 y who had not received prior screening, compared with children screened in infancy (aged 1–2.5 y) by a retrospective cohort study (2.6% vs.1%, p=0.0098). Hyperopia in infancy was linked to strabismus and VA deficits by age of 4 y by results from a cohort study that compared 2 screening programs used in infants and a follow-up of this cohort. Children who were hyperopic in infancy were 13 times more likely to become strabismic and six times more likely to show VA deficits by 4 y of age, when compared to a control group. Wearing a partial spectacle correction reduced the risk ratios to 4:1 and 2.5:1, respectively. Infants who had not received this correction by age of 7 years showed higher prevalence of strabismus and amblyopia. *Preschool age (3 to 6 y):* A 1995 SR recommended that VA screening be performed at ~ 4 y of age, and then repeated throughout the school years and a 1998 SR recommended that screening should occur during neonatal period, at 6 mo, 3 y, and at 5–6 y. In one 2003 prospective cohort study, screening preschool children resulted in a 45% lower amblyopia prevalence at age of 7.5 y than in those who did not receive the screening. Results from a 1993 retrospective cohort study reported that screening of children aged 3–4 y by orthoptists resulted in 4.4% of children receiving treatment for a defect not previously detected. **Conclusions**** "The available evidence supported children's vision screening in the preschool period (3–5 years), but not subsequently at school entry or in the later primary school years. Screening by orthoptists, or non-vision health professionals (such as nurses) with appropriate training and the option for secondary screening, was suggested by the evidence. Referral criteria and outcomes used in the studies reviewed did not necessarily reflect or measure the effects of the vision condition on functional vision. Future studies should consider functional vision in order to appropriately evaluate the benefits of screening."

* Study characteristics, search results and main findings for questions regarding the safety and effectiveness of PSVS
** Conclusions stated by the author(s) and quoted directly from the published report

Table T.C.1: Selected systematic reviews (characteristics, search results, main findings, and conclusions) (cont'd)

Study	Study's characteristics*	Study's search results,* main findings,* and conclusions**
Schmucker et al. (2009)[5] **Type:** Paper based on a systematic review commissioned by IQWiG **Country:** Germany	**Included studies:** considered RCTs, non-randomized intervention studies, controlled cohort studies **Excluded studies:** studies that included children with specific diseases (such as diabetes, dyslexia, deafness, or congenital diseases) and organic eye defects (such as congenital glaucoma, cataract, or retinoblastoma) **Participants:** children from the general population up to age of 6 y **Intervention:** universal PSVS **Comparator(s):** screening vs. no screening; different screening strategies **Outcome(s) and outcome measures:** amblyopia prevalence rate measured by VA; HRQoL (e.g., psychosocial/emotional impairment, labelling, social isolation); cognitive and educational development; adverse effects related to screening (due to FP or FN results)	**Search results:*** One RCT (published in 2000), one pseudo-RCT (published in 2001 and 2002), one prospective cohort study (published in 2003, 2005, and 2006), and two retrospective cohort studies (published in 1996, 2000) were included; all were limited quality studies. **Main Findings*** Safety Adverse effects of screening have not been adequately investigated in the reviewed literature. Efficacy/Effectiveness: One RCT (PSVS at age 3 y vs. no PSVS) showed no difference in prevalence rates for amblyopia and strabismus, at age 6.5 y between screening and no screening groups. One retrospective cohort study (orthoptic screening vs. health visitor screening vs. GP screening at age 2.5-3 y) reported similar effects on amblyopia prevalence at age 7 y (1.1% for orthoptist screening vs. 1.0% for health visitor screening vs. 1.2% for GP screening, *p-value not reported*). Two cohort studies (one prospective, PSVS at age 37 mo vs. no PSVS; one retrospective, PSVS at ages 1 to 2.5 y vs. no PSVS) and one pseudo-RCT (intensive screening at ages 8, 12, 18, 25, 31, and 37 mo vs. less intensive screening at age 37 mo) showed screening significantly associated with absolute reduction in amblyopia prevalence rate between 0.9% and 1.6% (relative reduction: between 45% and 62%). One retrospective cohort study (screening at ages 1 to 2.5 y vs. no screening) reported SS difference between screened and not-screened children in prevalence of amblyopia (VA ≤ 5/10 in amblyopic eye) at age 8 y (1% vs. 2.6%; p< 0.01), and prevalence of severe amblyopia (VA ≤ 5/15 in amblyopic eye) at age 8 y (0.1% vs. 1.7%; p < 0.001). **Conclusions**** "The methodological weaknesses of the literature currently available cannot be used to state that preschool vision screening is not effective. But it shows that these programmes have not yet been tested in rigorously controlled trials. Current recommendations should be targeted to maximise coverage in established screening programmes. In future research work screening studies should be developed to compare screened children with children who did not undergo screening (ideally in randomised controlled trials without the implementation of a current screening programme in the control group)." "Population based preschool vision screening programmes cannot be sufficiently assessed by the literature currently available. However, it is most likely that the present systematic review contains the most detailed description of the main limitations in current available literature evaluating these programmes. Therefore, future research work should be guided by the findings of this publication."

* Study characteristics, search results and main findings for questions regarding the safety and effectiveness of PSVS
** Conclusions stated by the author(s) and quoted directly from the published report

Table T.C.1: Selected systematic reviews (characteristics, main findings, and conclusions) (cont'd)

Study	Study's characteristics*	Study's search results,* main findings,* and conclusions**
Schmucker et al. (2009)[4] **Type:** Paper based on a systematic review commissioned by IQWiG **Country:** Germany	**Included studies:** studies (any design) comparing a vision screening test with a reference test (gold standard) and providing data to calculate Sn and Sp **Excluded studies:** studies that included children with specific diseases (such as diabetes, dyslexia, deafness, or congenital diseases) and organic eye defects (such as congenital glaucoma, cataract, or retinoblastoma); studies reporting only PPV or NPV; studies evaluating only feasibility and reliability of a vision screening test **Participants:** children from the general population up to age of 6 y **Intervention:** vision screening test **Comparator(s):** any reference test (gold standard) **Outcome(s) and outcome measures:** diagnostic accuracy (Sn and Sp)	**Search results*:** Twenty-seven primary research studies (published between 1975 and 2006); 5 studies evaluated more than one screening test and there were 32 comparisons in all 27 studies; most studies were of limited quality; a longitudinal study design was applied in 2 studies and a cross-sectional design was applied in 25 studies. **Main Findings*** Safety No results reported. Efficacy/Effectiveness: Two longitudinal studies compared an early screening examination with a re-examination at a later age. Results from one 2000 retrospective cohort study (index test: retinoscopy + strabismus test at 12 and 30 mo; reference test: reexamination at 96 mo using retinoscopy + VA test) reported Sn of 86% and Sp of 99 % for screening. Results from a 2001 longitudinal study (index test: intensive orthoptic screening at 8, 12, 18, 25, and 31 mo; reference test: less intensive orthoptic screening at 37 mo using same tests and test combinations as index test) reported Sn of 68% and Sp of 95% for intensive screening. Eight cross-sectional studies evaluated diagnostic accuracy of VA tests. Overall, the Sn ranged between 9% and 100%, and the Sp between 8% and 100%. Nine cross-sectional studies reported estimates of Sn between 46% and 95% and estimates of Sp between 53% and 100% for auto- and photorefractors. Seven cross-sectional studies examining stereo acuity tests, reported estimates of Sn between 14% and 100% and estimates of Sp between 76% and 99%. **Conclusions**** "Diagnostic test accuracy of preschool vision screening tests can only be sufficiently investigated after establishing age-related values defining amblyopia, refractive errors and binocular disorders. To address these questions, we recommend a controlled longitudinal study design."

* Study characteristics, search results, and main findings for questions regarding the safety and effectiveness of PSVS
** Conclusions stated by the author(s) and quoted directly from the published report.

Table T.C.1: Selected systematic reviews (characteristics, search results, main findings, and conclusions) (cont'd)

Study	Study's characteristics*	Study's search results,* main findings,* and conclusions**
Powell & Hatt, 2009[3] **Type:** Cochrane systematic review **Country:** UK and US	**Included studies:** RCTs, cluster-randomized trials **Excluded studies:** studies including participants with a pathological barrier to vision; studies including screening for vision conditions other than amblyopia **Participants:** children screened before they started school or as they entered school **Intervention(s):** screening by formal VA testing (using any screening protocols) **Comparator(s):** no screening **Outcome(s) and outcome measures:** amblyopia prevalence at 12 mo from screening and at other periods of follow-up; coverage rates achieved in different settings defined by percentage of target population that was screened	**Search results:*** No trials designed to compare amblyopia prevalence in screened vs. unscreened children were found. **Main Findings*** Safety No data were available for analysis. Efficacy/Effectiveness: No data were available for analysis. **Conclusions**** "The lack of data from randomised controlled trials makes it difficult to analyse the impact of existing screening programmes on the prevalence of amblyopia. The absence of such evidence cannot be taken to mean that vision screening is not beneficial; simply that this intervention has not yet been tested in robust trials. To facilitate such trials normative data on age-appropriate vision tests need to be available and a consensus reached regarding the definition of amblyopia. In addition, the consequences of living with untreated amblyopia have yet to be quantified and a cost-benefit analysis carried out." "The optimum protocol for carrying out screening remains unclear. Some evidence on the outcomes of orthoptic treatment following screening is available. There seems to be no detrimental effect in terms of visual outcome to leaving screening until school entry and this appears to improve the coverage achieved (Bray 1996; Clarke 2003; Williams 2003). At present there is insufficient evidence from good quality trials to allow the impact of screening for amblyopia on the prevalence to be accurately measured." "There is a clear need for more reliable evidence of the effectiveness of vision screening programmes in reducing the prevalence of amblyopia. To facilitate this process normative values for commonly-used vision tests need to be available and a consensus reached as to what level of visual acuity deficit constitutes amblyopia in the context of age at testing and vision test used. Data of current screening practices including costs, coverage, and positive predictive values need to be collected. The introduction of new screening programmes may provide opportunities to conduct randomised controlled trials to allow this intervention to be evaluated." "Although the objective of this review was to assess the impact of screening on the prevalence of amblyopia it is probable that screening for amblyopia will also detect children with reduced vision resulting from other causes such as uncorrected refractive error or anomalies, for example nystagmus or cataract. It would be useful to collect data to ascertain the percentages of other conditions detected. This may be particularly important to children who would not have access to eye care professionals in the absence of screening. More evidence is needed to elucidate the implications of living with uncorrected amblyopia and the effects of the early provision of glasses on the development of refractive error."

* Study characteristics, search results and main findings for questions regarding the safety and effectiveness of PSVS
** Conclusions stated by the author(s) and quoted directly from the published report

Table T.C.2: Selected systematic reviews (objective and methods)

Study	Study's objective and methods
Chou et al. (2011)[6,7]	**Objective:** The objective was to determine the effectiveness of screening preschool aged children for impaired visual acuity on health outcomes. The key questions were: 1. Is vision screening in children aged 1−5 y associated with improved health outcomes?1a. Does effectiveness of vision screening in children aged 1−5 y vary in different age groups?2. What is the accuracy and reliability of risk-factor assessment for identifying children aged 1−5 y at increased risk for vision impairment?3. What is the accuracy of screening tests for vision impairment in children aged 1−5 y?3a. In children aged 1−5 y, does accuracy of screening tests for vision impairment vary in different age groups?4. What are the harms of vision screening for children aged 1−5 y?5. What is the effectiveness of treatment for vision impairment in children aged 1−5 y?6. What are the harms of treatment for children aged 1−5 y at increased risk for vision impairment or for vision disorders? **Methods:** Searched were Ovid Medline (from 1950 to July 2009), and the Cochrane Central Register of Controlled Trials and the Cochrane Database of Systematic Reviews (through the third quarter of 2009). Electronic searches were supplemented with reviews of reference lists and by consulting experts. Selected were studies that pertained to screening, diagnosis, and treatment of visual impairment in children 1 to 5 years of age. Two reviewers evaluated each study to determine eligibility for inclusion. The review was limited to published, English-language studies. Data from full-text articles were abstracted by one investigator and verified by a second investigator. VA was converted from Snellen to logMAR measurements by using published conversion charts. Two authors independently rated the internal validity of each included study as "good," "fair," or "poor" on the basis of USPSTF criteria (developed on the basis of the number, quality, and size of studies, consistency of results, and directness of evidence). Discrepancies in quality rating were resolved by discussion and consensus. For diagnostic accuracy studies, the diagti procedure in Stata 10 (Stata Corp, College Station, TX) was used to calculate Sn, Sp, and likelihood ratios. PLR is defined as the odds of a visual condition among subjects with the risk factor *present* compared with those without the risk factor. NLR is defined as the odds of a visual condition among subjects *without* the risk factor present compared with those with the risk factor present. PLRs >10 and NLRs <0.1 were classified as "large/strong," PLRs >5 and <10 and NLRs >0.1 and <0.2 were classified as "moderate," PLRs >2 and <5 and NLRs >0.2 and <0.5 were classified as "small/weak," and PLRs >1 and <5 and NLRs >0.5 and <1 were classified as "very small/very weak." The applicability to populations likely to be encountered in primary care screening settings was evaluated on the basis of recruitment from primary care settings, the prevalence of visual conditions, and the severity of visual impairment Studies of diagnostic test accuracy were not pooled. Meta-analysis was not performed. A draft report was distributed for review by external experts not affiliated with USPSTF and final report was revised based on received comments. This systematic review was conducted by the Oregon Evidence-Based Practice Center under contract to AHRQ (who funded the research under a contract to support the work of the USPSTF).

Table T.C.2: Selected systematic reviews (objective and methods) (cont'd)

Study	Study's objective and methods
Mathers et al. (2010)[8,24]	**Objective:** The specific objectives were (1) to determine the effectiveness of vision screening programs for children (0 to 16);(2) if deemed effective, what age children should attend a vision screen(3) what form programs should take to be most effective. The aim was to identify studies on the effectiveness of screening programs designed to detect conditions causing vision loss or dysfunction in children, including diminished visual acuity, amblyopia, strabismus or squint, refractive error, cataracts, and glaucoma. **Methods:** Search of Medline, CINAHL and Embase (from 19902008) was conducted to identify RCTs, pseudorandomized controlled trials and non-RCTs and a search of the *Cochrane Database of Systematic Reviews* was conducted to identify systematic reviews. A hand search of three review papers was also conducted. A request for literature was made to eye health and other relevant professionals in Australia via members of the National Children's Vision Screening Project Advisory group and the National Community Child Health Council. The search focused on studies examining the effectiveness of vision screening programs for children aged from birth to 16 years. Studies evaluating not only screening, but also screening personnel, referral pathways, treatment and consideration of outcomes were identified. The search was limited to studies in English and studies published from 1990 onwards. bstracts of potentially eligible papers were assessed independently by two reviewers for inclusion. Papers were included for further evaluation if they provided assessment of a screening program, compared results obtained by different screening personnel or examined possible effects of failuretoscreen (e.g. educational outcomes). Disagreement was resolved through discussion and consensus. Two researchers independently extracted data from included studies and rated their quality. Data were extracted on general characteristics of the paper (author/date, study location) and sample (age, gender, recruitment method, sampling frame and sample size), aspects of the program (program type, definition of each intervention group), clinical issues (conditions screened for, screening outcomes), methodological characteristics (design type, length of follow-up), results and service implications (number of screens, length, screening providers, program cost and program site). A quality rating using the National Health and Medical Research Council 2002 recommendations was assigned for included primary research studies. Systematic reviews were assessed using criteria created by the Centre for Community Child Health. This literature review was funded by the Australian Government's Department of Health and Ageing.
Schmucker et al. (2009)[5]	**Objective:** This SR focuses on the question of whether screening for amblyopia in children up to age of 6 years leads to better vision outcomes (benefit assessment in terms of patient-relevant outcomes of screening for visual impairmentuniversal vision screening in children up to the age of 6 years). **Methods:** Medline (Ovid), Embase, CINAHL, PSYCHinfo, Cochrane Central (CDSR, DARE, NHS EED, HTA), PSYNDEXplus, Social SciSearch, GIN and Medion were searched (from inception until December 2007) for RCTs, non-RCTs and cohort studies. The search strategy was based on combinations of medical subject headings and keywords and was not restricted to specific languages or years of publication. The searches were supplemented by hand searching the bibliographies of included studies and reviews. Enquiries were sent to manufactures of screening instruments. Titles and abstracts were reviewed using specific inclusion criteria. Full papers of appropriate studies were obtained for detailed evaluation. Authors of studies were contacted if data were unclear or appeared incomplete. All stages of study selection, data extraction and quality assessment. Disagreement during the selection, extraction, and assessment process was resolved through discussion and consensus. A modified quality evaluation tool of the Center for Reviews and Dissemination (CRD) was used for evaluation of included studies. Information about number and age of participants, intervention, sample size planning, blinding of outcome assessor, group comparability, confounding factors, transparency of patient flow, definition of amblyopia and statistical significance of results was abstracted. Results are presented in a narrative form. No meta-analysis or sensitivity-analysis was performed. The project was referred by the Federal Joint Committee (*Gemeinsamer Bundesausschuss*, Siegburg, Germany) to the IQWiG, Cologne, Germany). IQWiG commissioned the review prepared from Kleijnen Systematic Reviews Ltd and the German Cochrane Center. IQWiG prepared the final version of the full study report on which this paper is based and funded the researchers and authors, respectively. The preliminary report was posted on the IQWiG website for comments.

Table T.C.2: Selected systematic reviews (objective and methods) (cont'd)

Study	Study's objective and methods
Schmucker et al. (2009)[4]	**Objective:** This SR evaluates the diagnostic accuracy of PSVS tests for the detection of amblyopia and its risk factors. **Methods:** Medline (Ovid), Embase, CINAHL, PSYCHinfo, Cochrane Central (CDSR, DARE, NHS EED, HTA), PSYNDEXplus, Social SciSearch, GIN and Medion were searched (from inception until December 2007) based on combinations of medical subject headings and keywords. No limitation to a specific study design, year of publication or language was applied. The searches were supplemented by hand searching the bibliographies of included studies and reviews. Enquiries were sent to manufactures of screening tests. Four inclusion criteria were applied to evaluate diagnostic accuracy of PSVS tests (also called "index test). Studies were included if they compared a vision screening test with a reference test (gold standard) in children from the general population. In addition, the studies had to provide sufficient data to calculate diagnostic accuracy (Sn and Sp). Every reference test (a widely accepted test, gold standard test) and each study design was eligible. Full-text articles for studies that satisfied the inclusion criteria were assessed using the QUADAS checklist. All stages of study selection, data extraction and quality assessment. Disagreement during the selection, extraction and assessment process were resolved through discussion and consensus. Reviewers used 2×2 tables to calculate test Sn and Sp. Results are presented in a narrative way. No meta-analysis was performed. The project was referred by the Federal Joint Committee (*Gemeinsamer Bundesausschuss*, Siegburg, Germany) to IQWiG Cologne, Germany. IQWiG commissioned the review to be prepared by Kleijnen Systematic Reviews Ltd and the German Cochrane Center. IQWiG prepared the final version of the full study report on which this paper is based, and funded the researchers and authors. The preliminary report was posted on the IQWiG website for comments.

Table T.C.2: Selected systematic reviews (objective and methods) (cont'd)

Study	Study's objective and methods
Powell & Hatt, 2009[3]	**Objective:** The primary objective was to evaluate the impact of vision screening for amblyobia in childhood on the prevalence of amblyopia in comparable screened versus unscreened populations. Subgroup analyses were planned to determine the effect of the type of personnel conducting the testing, the age at screening, and the visual acuity threshold at which participants are referred for further evaluation. Secondary objectives were to report available evidence regarding the disability associated with living with uncorrected amblyopia and to document reports of the potential harms and costs associated with screening. **Methods:** Searches of the Cochrane Central Register of Controlled Trials (CENTRAL), The Cochrane Library (Issue 3, 2008), MEDLINE (January 1950 to August 2008) and EMBASE (January 1947 to August 2008) were conducted to identify RCTs and cluster-randomised trials comparing amblyopia prevalence in screened versus unscreened children (last searched on 15 August 2008). No language or publication date restrictions were placed on these searches. No handsearching was done. Two authors independently assessed the titles and abstracts identified by searches to determine eligibility for inclusion. Full text copies of potentially eligible studies were obtained and, where necessary, trial authors were contacted. The methodological quality of included studies was planned to be assessed by examining selection bias detection bias attrition bias and performance bias. The intention was that two authors independently would extract data using the Cochrane Eyes and Vision Group data collection form and enter data into the RevMan 5.0 software. Selected studies were to be checked for heterogeneity by examining the characteristics of included studies looking for poor overlap of the confidence intervals on the forest plot the result of the chi squared test. If appropriate, a meta-analysis was planned (using RevMan 5.0). Also planned were four sensitivity analyses. Sub-group analyses were planned to examine the impact on size and direction of effect of failure threshold, screening personnel, and age of participants at screening. No trials met the inclusion criteria, none were assessed for quality and no data were extracted or analysed. No data were available for analysis and no meta-analysis was performed. The Cochrane Eyes and Vision Group prepared and executed the electronic search strategies. No internal sources. External sources of support were Christian Blind Mission, Germany and Sight Savers International, UK.

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SECTION TWO: ECONOMICS ANALYSIS

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OBJECTIVE AND SCOPE

The objective is to assess the cost-effectiveness of the various strategies used in the screening of preschool vision (PSVS).

METHOD

A review was conducted of the published economic literature on the cost-effectiveness of alternative strategies for PSVS.

Search Strategy

Selected databases were searched for economic evaluation studies of PSVS. Databases searched include Medline, EMBASE, CINAHL, Cochrane Database of Systematic Reviews, Web of Science, and grey literature. To supplement the electronic searches, reference lists of retrieved articles were also reviewed to find further studies. The literature search summary is presented in Appendix E.1.

Selection Criteria

The search was limited to human and English-language publications. Eligible studies met the following predefined inclusion/exclusion criteria:

Inclusion Criteria:

Study design: Health technology assessment reports, systematic reviews, and economic evaluation studies, including studies of cost-effectiveness, cost-utility, or cost-benefit

Population: preschool-aged children (< 6 years)

Interventions and comparators: various vision screening strategies (note that studies had to report the specific vision tests used)

Language: English

Search period: from 2007 onward

Exclusion Criteria:

Abstracts, case studies, narrative reviews, letters, and editorials

Studies that reported the cost and outcomes of only one PSVS strategy (without a comparator)

Newborns and children aged ≥ 6 years

Outcomes of interest

Outcomes of interest included:

- the number of correctly detected cases referred for follow-up/confirmatory testing
- the number of correctly identified non-cases not referred for follow-up/confirmatory testing
- the proportion of children whose vision disorders were diagnosed within a follow-up period

- the additional cost per health outcome gained

Quality Assessment

A formal quality assessment of full economic studies was conducted with the Quality of Health Economic Studies (QHES) instrument[1]. The QHES instrument is designed to evaluate the quality of health economics, including cost-minimization, cost-effectiveness, and cost-utility analyses. It includes a scoring system to weight scores across 16 criteria. Scores are aggregated to provide a summative quality index. The quality index ranges from 0 to 100, with a score of 75 or greater indicating acceptable quality. Note that a quality assessment was only conducted for primary economic studies and not for studies already reviewed in previously published reports.

Data Extraction

Data extracted from primary economic studies included study objective, PSVS strategies under investigation, cost components, health outcome measures, results and conclusions.

RESULTS

Search Results

Seventy-nine references were identified in the literature search. After reviewing the titles and abstracts/summaries, 26 were retrieved for further review. Of the 26 studies, two HTA reports[2,3] met the final inclusion/exclusion criteria. One report[2] was conducted by the Canadian Agency for Drugs and Technologies in Health (CADTH) and reviewed full studies on cost-effectiveness analysis published before 2007. The other[3] is a primary study assessing the cost-effectiveness of PSVS in the UK, along with a brief review of studies published before 2007. (See Appendix E.2 for data extraction from the study and Appendix E.3 for the quality assessment scores of included studies.)

Evidence from the Economic Literature

As noted above, the UK HTA report (2008)[3] conducted a primary cost-effectiveness analysis of various screening options for amblyopia and strabismus, from the perspective of the UK national health service (NHS); it was conducted with a lifetime time horizon (that is, it included downstream impacts of screening). The screening alternatives assessed included visual acuity testing and cover tests with and without autorefraction for children aged 3, 4, and 5 years. These studies were compared with studies that did no screening. The health outcomes measured included the number of amblyopia cases prevented and a general measure of health-related quality of life measured in quality adjusted life years (QALY). The cost components included in the study were the costs of the screening programs, diagnostic tests, and treatment for refractive error, strabismus and amblyopia. The cost associated with blindness and rapidly deteriorating vision was also considered. Results indicated that, per 10,000 children screened, compared to screening at age 5:

- screening at age 3 prevented 12 to 15 cases of amblyopia regardless of whether autorefraction was included
- screening at age 4 prevented one to two cases when using autorefraction and 10 cases when not using autorefraction

Outcomes measured in QALYs followed a similar pattern.

Incremental costs per amblyopia case prevented were:

- £3,500 when moving from no screening to screening at age 3 without autorefraction

- between £5,000 and £7,000 when moving to screening at age 4
- £57,000 and £73,000 when moving to screening at age 5

Incremental costs per QALY gained were:

- £500,000 when moving from no screening to screening at age 3
- between £8.5 and £11 million when moving from screening at age 4 to screening at age 5

The authors concluded that screening with autorefraction dominated screening without autorefraction, and that screening at ages 3 or 4 was associated with a low cost per amblyopia case prevented. However, when outcomes are measured in terms of QALYs, none of the screening options are likely to be cost-effective. The study was assessed with a quality score of 87.

Altogether, between the CADTH and the UK HTA reports that qualified as economic evaluations and also met our inclusion/exclusion criteria, four PSVS studies were reviewed.[2,3] Three studies[4-6] assessed the cost-effectiveness of alternative vision screening strategies for any untreated visual deficits for a population of 3-year-old kindergarten students in Germany. Two[4,5] of the three studies compared universal screening by an orthoptist to no screening. Orthoptic screening consisted of the cover test, monocular visual acuity, stereopsis, ocular motility, inspection of head posture, and the Brückner test. Positive results are referred to an ophthalmologist. The studies were conducted from a payer perspective and cost components included the cost of screening (including labour, materials, and travel) and the cost of ophthalmologic examinations. The time horizon for the analysis was from initial screen to diagnosis. The cost per case detected ranged from €727 to €924.

The third study[6] of kindergarden students compared five alternative screening strategies:

(a) visual acuity test at a threshold of ≥ 0.5

(b) visual acuity test at a threshold of ≥ 0.6

(c) visual acuity test at a threshold of ≥ 0.5 with a cover test

(d) visual acuity test at a threshold of ≥ 0.6 with a cover test

(e) autorefractor testing

Each screening strategy was further subdivided by whether positive results were directly referred to an ophthalmologist or whether referral was made to an ophthalmologist only if there was a positive result from a rescreening conducted at age 1. This provided a total of 10 alternative strategies. The perspective, time horizon, and cost components were identical to that mentioned above. The potentially cost-effective strategies were:

- strategy (a) with rescreening
- strategy (b) with rescreening
- strategy (d) with rescreening
- strategy (d) without rescreening

The cost per additional case detected was:

- €1,058 from strategy (a) with rescreening to strategy (b) with rescreening
- €1,359 from strategy (b) with rescreening to strategy (d) with rescreening

- €13,448 from strategy (d) with rescreening to strategy (d) without rescreening

Another study[7] involving children in the Germany setting assessed the cost-effectiveness of alternative vision screening strategies for detecting amblyopia or amblyogenic factors. Alternatives compared included:

(a) screening of high risk children up to age 1 by an ophthalmologist

(b) screening of all children up to age 1 by an ophthalmologist

(c) screening all children aged 3 to 4 by a pediatrician or general practitioner

(d) screening of children aged 3 to 4 visiting kindergarten orthoptists

Screening consisted of visual acuity tests, a stereo acuity test, a cover test and a Hirschberg test. All positive results were referred to an ophthalmologist. The analysis was conducted from a social perspective and considered all direct medical costs and the costs associated with lost productivity/travel time of caregivers. The time horizon for the analysis was from initial screening to diagnosis. Results indicated that the screening all children up to age 1 by an ophthalmologist was the only strategy not dominated by other alternatives.

DISCUSSION

Limited economic evidence has been published to inform the cost-effectiveness of alternative vision screening strategies for preschool aged children. Furthermore, the significant heterogeneity between studies makes it difficult to assess whether any key themes emerge. When examining studies that compare universal vision screening with no screening, results from three studies[3-5] indicate that the cost per case detected ranges from €727 to £73,000, depending on the specific characteristics of screening, clinical setting, disease prevalence, cost components, and the age at which screening is conducted. When outcomes are measured in terms of QALYs, the cost per additional QALY gained ranges between £500,000 and £11 million, depending on age of screening.[3]

What can be gathered from these findings is that while vision screening is associated with improvements in health outcomes, it does not provide a net cost saving to the health system. Consequently, determining whether universal vision screening is cost-effective is dependent on whether the additional health benefits outweigh the additional costs. Based on one study that assessed health outcomes in terms of QALY (which is considered a final health outcome) and also accounted for downstream impacts of earlier detection, universal vision screening was associated with an extremely high cost per additional QALY gained, and would be deemed not cost-effective by conventional cost-effectiveness thresholds.

Two studies examined alternative strategies of vision screening against each other. However, no clear conclusion can be drawn from the studies. While one study concluded that screening of 1-year-old children by an ophalmologist is the most cost-effective strategy,[7] other studies concluded that screening by an ophalmologist was found to be one of many potential cost-effective strategies.[6] Again, the limited number of studies and the heterogeneity between these studies in terms of methodology and specific details regarding the screening strategies preclude the ability to make reliable statements regarding what the evidence tells us.

It is also important to discuss the generalizability of these studies to the Alberta setting. To conduct an assessment of generalizability would require comparing the vision screening services provided to preschool aged children across Alberta with those described in the studies. In a recent assessment of capacity to provide infant and preschool screening services in the Alberta,[8] it was determined that

limited formal vision screening for preschoolers is currently provided in Alberta. At most, small pockets of informal screening services are provided in some parts of the province or to particular populations, with limited consistency pertaining to the specific visual tests used during the assessment. Given that cost-effectiveness is affected by a multitude of factors—including epidemiology, clinical setting, clinical practice, cost components, and specific components comprising vision screening services—and combining this with the limited data and consistency of screening services provided in the province, generalizability of the results to the Alberta setting is unlikely.

In conclusion, limited economic evidence is published informing the cost-effectiveness of vision screening in preschool aged children. The published economic evidence seems to indicate that universal vision screening in preschool aged children is associated with improved health outcomes but at additional costs to the health system. Furthermore, the cost per additional unit of outcome gained was highly variable and unlikely to be generalizable to Alberta.

APPENDICES

Appendix E.1: Literature Search Summary: Preschool Vision Screening Search-Economics

The IHE research librarian conducted the literature search. There were no date limits, but the search was limited to economic studies. The search was developed and carried out prior to the study selection process. In addition to the strategy outlined below, reference lists of retrieved articles were reviewed for potential identification of studies.

Database	Edition or date searched	Search Terms ††
MEDLINE (includes in-process and other non-indexed citations) OVID Licensed Resource	March 8, 2012	1 vision disorders/ or amblyopia/ or color vision defects/ 2 ocular motility disorders/ or strabismus/ or esotropia/ or exotropia/ 3 lens diseases/ or cataract/ or capsule opacification/ 4 clear ocular media.tw. 5 eye turn*.tw. 6 refractive errors/ or aniseikonia/ or anisometropia/ or astigmatism/ or corneal wavefront aberration/ or hyperopia/ or myopia/ or myopia, degenerative/ or presbyopia/ 7 (amblyopia or strabismus or hyperopia or myopia or astigmatism or cataract* or refractive error* or visual acuity or visual pereceptual difficult* or blind*).tw. 8 (vision adj1 (problem* or disorder* or impairment or disturbance or loss)).tw. 9 (visual adj1 (disorder* or impairment or disturbance*)).tw. 10 (ocular adj1 (abnormalit* or alignment or disorder*)).tw. 11 eye condition*.tw. 12 refraction, ocular/ 13 visual acuity/ 14 contrast sensitivity/ or emmetropia/ 15 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 16 vision tests/ or color perception tests/ or vision screening/ or visual field tests 17 mass screening/ or multiphasic screening 18 (screen* or diagnos* or test or tests or testing).ti. 19 16 or 17 or 18 20 15 and 19 21 limit 20 to english language 22 (child* or pediatric* or paediatric* or preschool or pre-school or school-age or schoolage).tw. 23 22 and 21 24 limit 21 to "preschool child (2 to 5 years)" 25 23 or 24 26 exp "Costs and Cost Analysis"/ 27 (cost* or economic* or expensive*).tw. 28 (expenditures or price or fiscal or financial or burden or efficiency or pay or valuation or spending or resource*).ti. 29 26 or 27 or 28 30 25 and 29 **170 results**

Embase	March 12, 2012	1 visual disorder/ or abnormal vision/ or amblyopia/ or aniseikonia/ or blurred vision/ or color blindness/ or color vision defect/ or congenital strabismus/ or exp refraction error/ or visual impairment 2 exp strabismus/ or eye movement disorder 3 exp cataract/ or lens disease/ 4 visual acuity/ 5 eye refraction/ 6 emmetropia/ 7 clear ocular media.tw. 8 eye turn*.tw. 9 (amblyopia or strabismus or hyperopia or myopia or astigmatism or cataract* or refractive error* or visual acuity or visual pereceptual difficult* or blindness).tw. 10 exp blindness/ 11 (vision adj1 (problem* or disorder* or impairment or disturbance or loss)).tw. 12 (visual adj1 (disorder* or impairment or disturbance*)).tw. 13 (ocular adj1 (abnormalit* or alignment or disorder*)).tw. 14 eye condition*.tw. 15 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 16 exp vision test/ 17 visual system parameters/ 18 mass screening/ 19 (screen* or diagnos* or test or tests or testing).ti. 20 16 or 17 or 18 or 19 21 15 and 20 22 (child* or pediatric* or paediatric* or preschool or pre-school or school-age or schoolage).tw. 23 21 and 22 24 limit 21 to (child or preschool child <1 to 6 years>) 25 23 or 24 26 Health economics/ or exp economic evaluation/ or exp health care cost/ or cost/ 27 (cost* or economic* or expensive*).tw. 28 (expenditures or price or fiscal or financial or burden or efficiency or pay or valuation or spending or resource*).ti. 29 or/26-28 30 25 and 29 **198 results**
Cochrane Library	March 12, 2012	#1 MeSH descriptor Vision Disorders, this term only #2 MeSH descriptor Amblyopia, this term only #3 MeSH descriptor Ocular Motility Disorders, this term only #4 MeSH descriptor Color Vision Defects, this term only #5 MeSH descriptor Strabismus explode all trees #6 MeSH descriptor Lens Diseases, this term only #7 MeSH descriptor Cataract explode all trees #8 clear ocular media #9 eye turn* #10 MeSH descriptor Refractive Errors explode all trees #11 (amblyopia or strabismus or hyperopia or myopia or astigmatism or cataract* or refractive error* or visual acuity or visual pereceptual difficult* or blind*) #12 (vision NEXT/1 (problem* or disorder* or impairment or disturbance or loss)) #13 (visual NEXT/1 (disorder* or impairment or disturbance*)) #14 (ocular NEXT/1 (abnormalit* or alignment or disorder*)) #15 eye condition* #16 MeSH descriptor Refraction, Ocular, this term only #17 MeSH descriptor Visual Acuity explode all trees #18 (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17)

		#19 Mass Screening #20 Multiphasic Screening #21 MeSH descriptor Multiphasic Screening, this term only #22 (screen* or diagnos* or test or tests or testing):ti #23 (#19 OR #20 OR #21 OR #22) #24 (#23 AND #18) #25 (child* or pediatric* or paediatric* or preschool or pre-school or school-age or schoolage) #26 (#24 AND #25) #27 (cost* or economic* or expenditures or price or fiscal or financial or burden or efficiency or pay or valuation or spending):ti,ab,kw #28 (#26 AND #27) **196 results**
Web of Science	March 12, 2012	# 21 (#20) AND Language=(English) # 20 #19 and #16 # 19 #17 or #18 # 18 TI =(cost* or economic* or expenditures or price or fiscal or financial or efficiency or pay or valuation) # 17 TS=(cost-benefit or benefit-cost or cost effectiv* or cost utility or economic evaluat* or economic analys* or cost analys* or costs analys* or "cost of illness") # 16 #14 not #15 # 15 TI=(dog OR dogs OR sheep* OR lamb OR lambs OR rat OR rats OR cats OR mice OR mouse OR murine OR rabbit* OR animal* OR pig OR pigs OR piglet* OR porcine) # 14 #12 and #13 # 13 TS=(child* or pediatric* or paediatric* or preschool or pre-school or school-age or schoolage) # 12 #11 and #8 # 11 #9 OR #10 # 10 TI=(screen* or diagnos* or test or tests or testing) # 9 TS= (vision test* or vision screening) # 8 #1 or #2 or #3 or #4 or #5 or #6 or #7 # 7 TS=(eye condition*) # 6 TS=((ocular NEAR/1 (abnormalit* or alignment or disorder*))) # 5 TS=((visual NEAR/1 (disorder* or impairment or disturbance*))) # 4 TS=((vision NEAR/1 (problem* or disorder* or impairment or disturbance or loss or defect*))) # 3 TS=((amblyopia or strabismus or hyperopia or myopia or astigmatism or cataract* or refractive error* or visual acuity or visual pereceptual difficult* or blind*)) # 2 TS=((eye turn*)) # 1 TS=((clear ocular media)) **92 results**
CINAHL	March 12, 2012	S25 S23 and S24 S24 economic* or cost* S23 S20 or S22 S22 S19 and S21 S21 (child* or pediatric* or paediatric* or preschool or pre-school or school-age or schoolage) S20 S14 and S18 Narrow by SubjectAge: - Child, Preschool: 2-5 years S19 S14 and S18 S18 S15 or S16 or S17 S17 TI (screen* or diagnos* or test or tests or testing) S16 (MH "Health Screening") S15 (MH "Vision Tests") OR (MH "Color Perception Tests") OR (MH "Perimetry") OR (MH "Vision Screening") OR (MH "Visual Fields") S14 S1 or S2 or S3 or S4 or S5 or S6 or S7 or S8 or S9 or S10 or S11 or S12 or S13 S13 (MH "Visual Acuity") S12 (MH "Refraction, Ocular")

		S11 eye condition* S10 (ocular abnormalit* or ocular alignment or ocular disorder*) S9 (visual disorder* or visual impairment or visual disturbance*) S8 (vision problem* or vision disorder* or vision impairment or vision disturbance or vision loss) S7 (MH "Refractive Errors") OR (MH "Astigmatism") OR (MH "Hyperopia") OR (MH "Myopia") OR (MH "Presbyopia") S6 eye turn* S5 "clear ocular media" S4 (MH "Lens Diseases") S3 (MH "Cataract") S2 (MH "Ocular Motility Disorders") OR (MH "Strabismus") S1 (MH "Vision Disorders") OR (MH "Amblyopia") OR (MH "Blindness+") OR (MH "Color Vision Defects") OR (MH "Vision, Subnormal") **27 results**
Grey Literature		
Guidelines		
US Preventive Services Task Force	March 12, 2012	Browsed list of topics **1 result**
Institute for Clinical Systems Improvement	March 12, 2012	Browsed list of topics **1 result**
American Optometric Association	March 12, 2012	Browsed list of topics **6 results**
American Academy of Ophthalmology	March 12, 2012	Browsed list of topics **3 results**
Michigan Quality Improvement Consortium	March 12, 2012	Browsed list of topics **1 result**
Cincinnati Children's Hospital Medical Center	March 12, 2012	Browsed list of topics **1 result**
American Academy of Family Physicians	March 12, 2012	Browsed list of topics **1 result**
Coverage/Regulatory/Licensing Agencies		
Alberta Health and Wellness	March 12, 2012	Browsed list of topics **1 result**
Aetna www.aetna.com/cpb/medical/data/600-600/0689.html	March 12, 2012	Browsed list of topics **1 result**
HTA Resources		
CADTH	March 12, 2012	Browsed list of topics **3 results**

Search Engines		
Google	March 12, 2012	Browsed list of topics **12 results**
Cost Studies	March 12, 2012	Browsed list of topics **6 studies**

Note:

††, *, #, and ? are truncation characters that retrieve all possible suffix variations of the root word; for example, surg* retrieves surgery, surgical, surgeon, and so on.

Search Strategy: # Searches Results

Appendix E.2: Summarized evidence from selected studies

#	Item	Description
1	Study[3]	Authors/publish year: Carlton et al/2008; country: UK; study type: CUA/CEA; setting: community; study perspective: NHS
	Objective	The objective was to assess the cost-effectiveness of various screening options for amblyopia and strabismus.
	Population	Children aged 3, 4, and 5 years
	Intervention	The screening options were visual acuity testing and the cover tests with and without autorefraction for children aged 3, 4, and 5 years. These options were compared with no screening.
	Time horizon/ discount rate	Lifetime/3.5%
	Currency/price year	£/2006
	Outcomes measure	QALY and the number of amblyopia cases prevented.
	Cost components	The analysis considered the cost of screening, including staff time and administration, diagnostic tests, and the treatment for refractive error, strabismus, and amblyopia. The cost associated with blindness and rapidly deteriorating vision was also considered.
	Results	
	Outcomes	For a population of 10,000 children, screening for children aged 5 compared with children aged 3 prevented 12 to 15 cases of amblyopia, regardless of whether autorefraction was included. Screening at age 5 versus age 4 prevented one to two cases if using autorefraction and 10 cases when not using autorefraction. QALY results followed a similar pattern to the amblyopia cases prevented.
	Costs	For a population of 10,000 children, the lifetime cost was £570,000 for no screening, £870,000 to £1,000,000 for screening at ages 3 to 5 without autorefraction, and £1,000,000 to £120,000,000 for screening at ages 3 to 5 with autorefraction.
	Marginal analysis	Incremental costs per amblyopia case prevented were £3,500 when moving from no screening to screening at age 3 without autorefraction, between £5,000 and £7,000 when moving to screening at age 4, and £57,000 and £73,000 when moving to screening at age 5. Incremental costs per QALY gained were £500,000 when moving from no screening to screening at age 3, and between £8.5 and £11 million when moving from screening at age 4 to screening at age 5. Sensitivity analysis showed that the utility effect of loss of vision in one eye had significant impact on the results.
	Conclusion	Screening with autorefraction dominated screening without autorefraction. The screening at ages 3 or 4 was conducted at low cost per amblyopia case prevented. However, considering the cost per QALY gain, none of the screening options was likely to be cost-effective.

Note: Data extraction was not conducted on studies already reviewed by the two HTAs.[2,3]

Appendix E.3: QHES Instrument

#	Questions	QHES Scores[3]
1	Was the study objective presented in a clear, specific, and measurable manner?	**7**
2	Were the perspective of the analysis (societal, third-party payer, etc.) and the reasons for its selection stated?	**4**
3	Were variable estimates used in the analysis from the best available source (that is, randomized control trial—best, expert opinion—worst)?	**6**
4	If estimates came from a subgroup analysis, were the groups pre-specified at the beginning of the study?	**1**
5	Was uncertainty handled by: (a) statistical analysis to address random events, and (b) sensitivity analysis to cover a range of assumptions?	**9**
6	Was incremental analysis performed between alternatives for resources and costs?	**6**
7	Was the methodology for data abstraction (including the value of health states and other benefits) stated?	**5**
8	Did the analytic horizon allow time for all relevant and important outcomes? Were benefits and costs that went beyond 1 year discounted (3% to 5%) and justification given for the discount rate?	**7**
9	Was the measurement of costs appropriate and the methodology for the estimation of quantities and unit costs clearly described?	**8**
10	Were the primary outcome measure(s) for the economic evaluation clearly stated and did they include the major short-term justification given for the measures/scales used?	**6**
11	Were the health outcomes measures/scales valid and reliable? If previously tested valid and reliable measures were not available, was justification given for the measures/scales used?	**4**
12	Were the economic model (including structure), the study methods and analysis, and the components of the numerator and denominator displayed in a clear, transparent manner?	**8**
13	Were the choice of economic model, main assumptions, and limitations of the study stated and justified?	**5**
14	Did the author(s) explicitly discuss direction and magnitude of potential biases?	**0**
15	Were the conclusions/recommendations of the study justified and based on the study results?	**8**
16	Was there a statement disclosing the source of funding for the study?	**3**
	TOTAL POINTS	**87**

Note: A quality assessment was not conducted on the studies already reviewed by the two HTAs.[2,3]

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Author Contribution Statements

Paula Corabian contributed to study conception and design, data analysis and interpretation, and approved the final version for publication.

Christa Harstall contributed to study conception and design, revision of manuscript for critical content, and approved the final version for publication.

Charles Yan contributed to study conception and design, statistical analysis, economic expert review of the literature, revision of manuscript for critical content, and approved the final version for publication.

Anderson (Andy) Chuck contributed to study conception and design, statistical analysis, economic expert review of the literature, manuscript preparation, and approved the final version for publication.

This review focused on the best evidence available on the use of PSVS to detect vision conditions in asymptomatic preschool children (aged from birth to 6 years; not necessarily considered at risk for developing visual impairment) to determine the safety and efficacy/effectiveness of PSVS, compare the safety and effectiveness of universal and targeted PSVS, and to determine the best practice for conducting PSVS, as well as to assess the cost-effectiveness of various strategies used in the screening of preschool vision.

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