Tests and models for screening to prevent blindness in infants and children: a rapid review update of the evidence

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An Evidence Check review brokered by the Sax Institute for NSW Kids and Families

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This rapid review was brokered by the Sax Institute.

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CONTENTS

LIST OF ABBREVIATIONS

ATS HOTV	Amblyopia treatement study HOTV
CAT	Cardiff acuity test
CBT	Computer based test
CFHT	Child and Family Health Team
ETDRS	Early Treatment Diabetic Retinopathy Study
GA	Gestational age
LogMAR	Logarithm of the Minimum Angle of Resolution
MTI	Medical Technology and Innovations
NHMRC	National Health and Medical Research Council
NLR	Negative likelihood ratio
NPV	Negative predictive value
PAT	Pacific acuity test
PICO	Population Intervention Comparison Outcome
PLR	Positive likelihood ratio
PMA	Postmenstrual age
PNA	Postnatal age
PPV	Positive predictive value
RCTs	randomised controlled trials
REA	rapid evidence assessment
ROP	Retinopathy of Prematurity
SGT	Sheridan Gardiner Test
StEPS	Statewide Eyesight Preschooler Screening
TAC	Teller acuity cards

MAIN MESSAGES

This review examined programs and service models that deliver population-based screening and surveillance of vision for children aged 0-12 years. A rapid evidence assessment methodology was employed to obtain current (2004 onwards) evidence on the relative effectiveness and efficiency of vision screening in identifying reversible visual impairment (preventable blindness) in children up to 12 years of age. The review had three key aims:

Evaluate the efficacy of vision screening in identifying the presence of amblyopia in childhood (6-12 years of age).

Identify and evaluate vision screening tools for detecting amblyopia in preschool-aged children.

Evaluate the efficacy of vision screening in identifying the prevalence of preventable blindness amongst infants and neonates (<1 year of age).

Approaches that are supported:

- Screening for amblyopia in daycare/preschool settings, where good population coverage can be achieved, or in school settings, where universal coverage can be achieved.
- Screening with tools that provide high sensitivity and specificity for the age of the children to be screened.
- The use of the red eye reflex as a simple and cost effective way to screen for eye defects in infants.
- Targeted screening for high-risk subpopulations, including infants with a history of familial cataract or retinoblastoma, metabolic disorders linked to ocular pathologies, microphthalmia or eyelid hemangioma and those at risk of retinopathy of prematurity (ROP).

Approaches that are promising:

- Newer screening tools, such as autorefractors and photoscreeners, that are faster and easier to use. Testing at a population level is required.

Approaches that are not supported:

- Screening for amblyopia in children over the age of 7 years.
- Screening on amblyogenic risk factors alone

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EXECUTIVE SUMMARY

Background and Introduction

This Evidence Check, brokered by the Sax Institute, has been conducted for the Child and Family Health Team within NSW Kids and Families. The review has been undertaken with a focus on vision screening programs that can prevent blindness in infants and children (12 years and under) and an update on tests to detect amblyopia in preschool-aged children.

Universal screening for health conditions is intended to reduce the prevalence of a condition through early identification and referral for effective treatment. Vision screening has been implemented in many developed and developing countries around the world, to detect a range of structural or pathological problems that can affect vision in one or both eyes.

In the neonate, screening is used to detect abnormal eye alignment (strabismus), asymmetric refractive errors, congenital cataracts and retinal abnormalities such as retinoblastoma and retinopathy of prematurity (ROP). In early childhood, screening is used to detect amblyopia (or 'lazy eye') – a type of reduced vision that develops in childhood as the visual pathway matures.

It is generally accepted that earlier detection of vision problems leads to more effective treatment. However, it can be difficult for children to comply with screening requirements at a younger age and difficult to achieve universal coverage of a population. There is also a greater chance of the screen detecting problems that would resolve over time without the need for treatment. Therefore, vision screening programs need to balance the advantages of earlier detection with the need for high sensitivity (true positives) and specificity (true negatives).

In Australia, there is a lack of uniformity across states and territories as to how and when eye health and vision is assessed. Australian vision screening programs for children from birth to five years can differ in terms of the timing and frequency of screens, the screening test or tool used, the condition/s screened for and the qualifications of the practitioner/s conducting the screen.

In New South Wales, the main screening program is *Statewide Eyesight Preschooler Screening (StEPS)*; a free vision check for all 4 year olds and eligible 5 year olds, conducted through children's services (e.g. preschools and daycare centres).

Method

A rapid evidence assessment (REA) methodology was employed to obtain recent evidence (2004 onwards) on the following:

1. The efficacy of vision screening in identifying the presence of amblyopia in childhood (6-12 years of age).
2. The identification and efficacy of vision screening tools for detecting amblyopia in preschool-aged children.
3. The efficacy of vision screening in identifying the prevalence of preventable blindness amongst infants and neonates (<1 year of age).

Three separate literature searches were conducted. Each of the papers identified in the three searches was evaluated independently by two assessors against a number of criteria, namely (i) strength of the evidence presented (including assessment of the quality of the paper, risk of bias, quantity of evidence including statistical power and number of supporting papers, and NHMRC evidence ranking); (ii) overall strength; (iii) consistency (a judgement on the replicability of the results); (iv) cost effectiveness (efficiency); (v) generalisability (whether results could be generalised to the NSW population); and (vi) applicability (relevance to the NSW context). An overall ranking of the evidence presented by each paper was also determined.

Results

Search 1: efficacy of vision screening for amblyopia in children 6-12 years of age

The search for evidence on the efficacy of vision screening in identifying the presence of amblyopia in childhood yielded 749 papers. None of these papers met the criteria for inclusion. However, a number of guidelines, protocols and recommendations regarding best practice in current vision screening programs were identified through the search strategy. Generally screening for amblyopia is recommended prior to 7-8 years of age as there is a concern that the efficacy of treatment initiated beyond this age range may be diminished (1). Indeed, current paediatric and ophthalmological guidelines support screening at 3 to 5 years of age (2).

Search 2: identification and efficacy of vision screening tools

The second search – for evidence on the identification and efficacy of vision screening tools for detecting amblyopia in preschool-aged children – yielded 471 papers, of which 11 were determined to meet the criteria for inclusion (although the extent to which the papers met the criteria was variable). Analysis of these papers showed that there is a lack of evidence regarding the efficacy of available tests for preschool screening, and significant variation in the merits and drawbacks of each test. Clear evidence for the superiority of one test over another is currently lacking.

Search 3: efficacy of vision screening in infants and neonates

The third search – for evidence on the efficacy of vision screening in identifying the prevalence of preventable blindness amongst infants and neonates – yielded 329 papers, none of which met the criteria for inclusion. There was a lack of detailed data relating to the efficacy of screening tools used in this age group for preventable blindness specifically, namely retinoblastoma, congenital cataracts and retinopathy of prematurity. However, a number of guidelines, protocols and recommendations regarding best practice in current vision screening programs were identified through the search strategy. For retinoblastoma, clear evidence exists on the benefit of treatment when the disease falls within a specified range of severity (3). There is, however, currently lack of agreement on the timing of the initial screening test (the appropriate gestational age (GA) or birth weight) and the frequency of subsequent examinations. Screening programs directed at subpopulations of high-risk infants at risk of retinopathy or prematurity also appear to have a high efficacy in detecting pathology. Details regarding the efficacy of broader population-based screening programs for infants were lacking, in part due to the variability in such programs within and between countries.

Discussion and Recommendations

Overall, screening for amblyopia continues to be seen of value in preventing future blindness. This review highlights the importance of screening children early enough for interventions to be most effective and late enough to both enable universal population screening, using a tool that can accurately test children.

There were no studies to support routine screening of children over the age of 7 years. A number of papers supported the use of schools as universal platforms for vision screening due to their ability to reach whole populations.

There was insufficient evidence to suggest the newer, more expensive (and potentially more accurate) tools offered measurable benefit over the currently utilised cheaper and less complex tools. However, there were a number of promising screens that may prove valuable in the future with further testing at a population level.

A number of early (mostly weak) studies tested new ways of measuring refractive error in children under the age of one year, with some studies linking this to early detection of amblyopia. This would appear to be an area to watch in the future. The use of the red reflex test continues to be supported as a simple and effective way to screen for eye defects in neonates and infants. However, differentiating the red reflex as a screening test, versus good clinical care, remains a vexed issue.

There is support for targeted screening of certain subpopulations, such as high-risk infants.

In conclusion, this rapid review supports several recommendations, as below:

1. **Continue to implement vision screening for amblyopia in the preschool OR early school-age years (with 7 years as an upper limit).**

There should be some consideration of the best setting in which to achieve universal coverage of the population.

2. **Watch for forthcoming evidence regarding vision screening tools but there is insufficient evidence to support a change to current practice**

For current screening tools:
Further studies might address some of the existing confounding factors (e.g. variation in the visual acuity cut-offs employed by the test, lack of data comparing test results in the wider population, etc), allowing for a more accurate determination of the current recommended amblyopia screening tool/s

For newer screening tools:
Instruments that look promising need to be tested at the population level
New ways of measuring refractive error in children aged < 1 year may be important in the future.

3. **Implement targeted screening for high-risk infants.**

4. **Consider:**

Mechanisms are in place that ensure the completion of the red eye reflex test for all neonates through the NSW routine universal child and family health system and potentially augment through primary care (data systems may be necessary for this element).

Equitable access to diagnostic and treatment services post-screening.

BACKGROUND

The Child and Family Health Team (CFHT) within the NSW Kids and Families statutory health corporation has established a comprehensive and integrated framework for early childhood health/development screening and surveillance. Universal vision testing during critical periods of development for children has been determined a priority component of this holistic approach to child wellness and for assessing “readiness for school”.

Currently, the NSW Child Personal Health Record (“The Blue Book”) includes eye health surveillance at each health check, as well as screening activities at specific points – for example, red reflex for newborns, and vision screening at four years through the Statewide Eyesight Preschooler Screener program (StEPS). StEPS is a free vision check for 4 year olds and eligible 5 year olds conducted through children’s services (e.g. preschools, daycare centres).

Following the seventh year of the StEPS program, the CFHT requested an evidence update. This Evidence Check, brokered by the Sax Institute and conducted by the Centre for Community Child Health at the Murdoch Childrens Research Institute, involves a review of child vision screening in children 12 years and under, in terms of the efficacy of vision screening tools and programs.

INTRODUCTION

Screening is a non-diagnostic public health strategy that is intended to enable identification of a disease in an asymptomatic individual, thus permitting earlier diagnosis and treatment (4) (see below). Screening can be an efficient and cost-effective public health strategy for preventing disease (2). Beginning in infancy and progressing throughout childhood and into adulthood, vision screening has been used to detect a range of structural or pathological problems that can affect vision in one or both eyes. In this review we focus on vision screening programs that can prevent blindness in infants and children.

Neonatal Screening

In the neonate, screening is used to detect abnormal eye alignment (strabismus), asymmetric refractive errors, cataracts and retinal abnormalities such as retinoblastoma (5) (6). Early diagnosis of visual disorders permits timely treatment and the minimisation of functional impairment (7). Furthermore the provision of genetic counselling, and emotional, educational and developmental support can be facilitated through early detection. In recognition of this, established screening programs concerned with detecting visual impairment are common in developed countries. Nevertheless, there is limited knowledge of the efficacy of these programs. Congenital cataract is the most common treatable cause of visual impairment in infants and children (8), with a reported incidence in developed countires of 1-6 per 10,000 births. The prevalence of additional conditions that can be detected at such an early age is low. Retinoblastoma – a life-threatening condition for which the prognosis is affected by early detection and treatement (9, 10) has a reported incidence in the United States of between 1 per 14,000 to 1 per 34,000 births(11). Familial retinoblastoma is most commonly diagnosed at ophthalmologist screening examinations at 4.9 months of age, with most cases of retinoblastoma occurring in the first months and years

of life (5, 12). The consequences of failing to detect these disorders can therefore be severe, if not fatal (13). The most common test for neonatal vision screening is the red reflex. The ease of administration and ability of the test to detect a range of ocular and retinal abnormalities has resulted in its inclusion in recommendations for testing in the neonatal period (14). This raises the issue of use of a test as part of primary clinical care versus its implementation in a screening program that aims for saturation coverage. While a test can show ease of administration and high efficacy in detecting pathologies, and be included in recommendations such as those of the American Academy of Pediatrics, evidence shows that this does not always result in its implementation as a routine part of care. Less than 50 per cent of neonatal departments surveyed in one study from the USA routinely performed red reflex testing (14). This may argue for the inclusion of a test that addresses the criteria of screening in a formal screening program, thus aiming at full coverage, and facilitating the test's reach and subsequent efficacy.

Amblyopia in Childhood

With the continued maturation of the visual pathway following infancy, amblyopia – commonly known as 'lazy eye' – can develop if the brain does not recognise input from one or both eyes due to blurring or obstruction of the incoming image (1, 15). Amblyopia describes reduced vision that develops in childhood, "with no demonstrable abnormality of the visual pathway that is not immediately resolved by refractive correction" (1). Two common causes of amblyopia are strabismus (misalignment of the eye, commonly known as 'squint') and a difference in refractive error (or the ability of the eye to focus an image) (15). Indeed, amblyopia is the most common cause of monocular vision loss in children and the leading cause of monocular blindness in 20-70 year olds in developed countries (1, 2). It is not amenable to ready correction with refractive lenses, does not spontaneously remit, and can result in permanent visual loss. For the purposes of this review, amblyopia is defined diagnostically following Powell and Hatt (1) as reduced visual acuity of 6/9 on a Snellen chart or 0.2 on a logMAR, in either or both eyes.

Treatment initiated while the visual pathway is still maturing (during the first 7 to 8 years of life), increases the possibility for amblyopia to be reversed with no permanent long-term effects on vision (1). However, the problem lies in detecting amblyopia in the first instance. In most cases, amblyopia affects only one eye, which can make detection more difficult for parents, caregivers or untrained professionals. Detection is necessary because, left untreated, amblyopia can have negative effects in childhood and into adulthood. Visual impairment can impact on wellbeing by limiting career choices, affecting educational and social development and increasing the risk of total blindness if the healthy eye is injured (1, 15). Due to the consequences of undetected and untreated amblyopia, screening for amblyopia has been introduced in many countries worldwide. It is recognised that the assessment of visual acuity by means of non-invasive testing provides the most effective means of identifying amblyopia (15).

Preschool/Primary School Age Vision Screening

Vision screening for amblyopia is often conducted when children are between 3 and 5 years of age. At this age, children are old enough to be cooperative during the screening process and if amblyopia is detected, not too old for treament to be successful. Vision screening of children, however, does require consideration of instruments that are tailored to the age and cognitive ability of the child (15). Screening of children also provides administrative challenges in terms of accessing all Australian children.

The identification of ambylogenic risk factors has been incorporated into some vision screening programs. These include factors such as include ptosis, media opacity, fundus pathologies, strabismus, and refractive error. Although the prevalence of ambylogenic risk factors has been estimated at between 10-20 per cent (16, 17), the rate of diagnosed amblyopia is only 2 per cent. The prevalence of risk factors thus vastly overestimates the number of children who will subsequently develop amblyopia. Instrument-based screening may be used as an alternative to traditional (chart based) screening methods for children from 3 to 5 years of age, although traditional methods are an easier and less expensive option for children over 5 years of age. However, instrument-based screening has not currently been incorporated into recommendations for mass screening.

The Aim

This rapid review addresses three aims:

1. Evaluate the efficacy of vision screening in identifying the presence of amblyopia in childhood (6-12 years of age)
2. Identify and evaluate the efficacy of vision screening tools for amblyopia in preschool-aged children
3. Evaluate the efficacy of vision screening in identifying the prevalence of preventable blindness amongst infants and neonates (<1 year of age).

METHOD

This literature review utilised an REA methodology. The REA is a research methodology that uses similar methods and principles to a systematic review, but makes concessions to the breadth and depth of the process, in order to be completed within a short timeframe. Rigorous methods for locating, appraising and synthesising the evidence related to a specific topic are utilised by the REA. However, the methodology places a number of limitations in the search criteria and in how the evidence is assessed. For example, REAs often limit the selection of studies to a specific time frame (e.g. the last 10 years), and limit selection of studies to published, peer-reviewed, English studies (therefore excluding unpublished pilot studies, difficult-to-obtain material and non-English language studies). The REA can help inform policy and decision makers more efficiently by synthesising and ranking the evidence in a relatively short space of time, although it is not necessarily as exhaustive as a well-constructed systematic review or meta-analysis.

Defining the Research Question

The components of the question for this review were defined in terms of the population, the screening and surveillance models, and the outcomes (refer to Appendix 1). Operational definitions were established for key concepts, and specific inclusion and exclusion criteria were defined for selection of studies for this review (18).

Screening can be defined as:

> The presumptive identification of unrecognised disease or defect by the application of tests, examinations or other procedures which can be applied rapidly. Screening tests sort out apparently well persons who probably have a disease from those who probably do not. A screening test is not intended to be diagnostic. Persons with positive or suspicious findings must be referred to their physicians for diagnosis and necessary treatment (18).

This definition requires extension in terms of the administration of the screening program and follow-up of participants with a positive screening result (19). Screening involves two aspects; the test and the incorporation of the test into a program.

A screening test is “any measurement aimed at identifying individuals who could potentially benefit from intervention. This includes symptoms, signs, lab tests, or risk scores for the detection of existing or future disease” (20). Traditionally, a screening test does not provide a diagnosis.

Screening Program

Screening programs involve single or multiple tests being conducted on a population that lacks the signs or symptoms of a disease or condition, but which may have a characteristic that puts them at increased risk of that condition, and for whom early detection and treatment would be of benefit (21). Age is the primary risk factor for amblyopia.

Types of Screening

Mass or population screening involves the screening of a whole population. This differs from opportunistic screening where a screening test is administered, usually by a primary health care provider, when contact is made for an unrelated problem. This review reports on mass screening programs only.

Types of Outcome Measurements

Primary Outcomes

1. Evaluating the efficacy of vision screening in identifying the presence of amblyopia in childhood (6-12 years of age).

   The primary outcome is the prevalence of amblyopia in screened versus comparable non-screened populations, 12 months after screening.

2. Evaluating the efficacy of vision screening tools for the detection of amblyopia in preschool-aged children.

   The primary outcome is the accuracy of screening tools for amblyopia in preschool-aged children.

3. Evaluating the efficacy of vision screening in identifying the prevalence of preventable blindness amongst infants and neonates (<1 year of age).

   The primary outcome is the accuracy of screening for preventable blindness in children under 1 year of age.

Secondary Outcomes

There were no secondary outcomes for this review.

Search Strategy

The following databases were used to identify relevant literature related to this topic: Ovid MEDLINE, CINAHL (EBSCO), PsycInfo, and Cochrane library.

Study types included systematic reviews, randomised controlled trials, evidence from well-designed pseudo-randomised controlled trials and comparative studies with concurrent controls (non-randomised experimental trials, cohort studies and case-control studies). Level III-3 studies and below were excluded. Thus, comparative studies without concurrent controls, evidence from case studies, and opinions and consensus from expert committees where the conclusions do not arise from scientific investigations, were excluded.

The guidelines, meta-analyses or systematic reviews that satisfied the quality assessment were used to guide the search criteria going forward. Thus, due to a Cochrane review on this topic in 2009 (1), which performed a systematic search of the literature up to August 2008, primary research studies earlier than 2008 would not be assessed.

No manual searches were conducted.Grey literature was also excluded due to time limitations.

Search Terms

The search terms were included in searching the Title/s, Abstract/s, MeSH terms, and Keywords lists. These terms were adjusted according to the requirements of the database in question. An example of the search strategy, as it applied to the Medline database, is included for reference (Appendix 2).

Aim 1

- *Vision Disorders OR Refractive Errors OR Retinopathy of Prematurity OR Cataract OR Glaucoma OR Retinoblastoma OR Vision/ Binocular OR Strabismus OR Visual Acuity OR Amblyopia OR lazy eye OR Strabismus OR squint OR astigmatiiam OR meridonal OR Anisometropia OR Ammetropia) AND (vision screening OR sheridan gardiner OR snellen OR LogMAR OR glasgow acuity card OR lea symbol OR hotv OR red reflex OR Vision Tests OR vision screen)*

Aim 2

- *(Vision Disorders OR Refractive Errors OR "Retinopathy of Prematurity" OR Cataract OR Glaucoma OR Retinoblastoma OR Vision/ Binocular OR Strabismus OR Visual Acuity OR Amblyopia OR lazy eye OR Strabismus OR squint OR astigmatism OR meridonal OR Anisometropia OR Ammetropia) AND (vision screening OR sheridan gardiner OR snellen OR LogMAR OR glasgow acuity card OR lea symbol OR hotv OR red reflex OR Vision Tests) AND (sensitivity and specificity OR reproducibility of results OR observer variation)*

Aim 3

- *(Vision Disorders OR Refractive Errors OR "Retinopathy of Prematurity" OR congenital ocular anomaly OR congenital cataract OR cataract OR Retinoblastoma OR Vision/ Binocular OR Visual Acuity) AND (vision screening OR red reflex OR corneal light reflex OR cover-uncover test OR vision tests) AND (mass screening)*

Paper Selection

After conducting searches, studies were evaluated according to a range of inclusion and exclusion criteria, with included studies broadly complying with the following:

- Date of publication: last 10 years, or dating from the most recent systematic review, whichever is latest
- Language: English only
- Age range of participants: according to the specific question
- Study type: level III-2 evidence or above (see Appendix 9)
- Location: developed country
- Study group: mass or population screening.

The inclusion/exclusion criteria specific to each question is provided in Appendix 4.

Information Management

Papers identified via filtering and key word searches were imported into EPPI-Reviewer 4 software. Further refinement was required to ensure that only high quality and relevant publications were included for data extraction. A screening process was adopted to code for eligibility using content from the title and abstract; the screening form is presented in Appendix 4 All records were screened according the eligibility criteria and decisions to "include" or "exclude" were double-checked by a second reviewer for quality control purposes. Full-text versions of all studies identified as meeting eligibility requirements were obtained and uploaded to the software. The full-text reports were then screened for inclusion by two independent reviewers. In the case of discrepancies, discussions were held and a consensus reached. Papers meeting the inclusion criteria were subject to data extraction.

The following information, where possible, was extracted for studies that met the inclusion criteria:

- Sample characteristics
- Objective of the screening model or program
- Vision-related issue/condition tested
- Vision-assessment method used
- Instrumental requirements
- Operational and administration parameters
- Workforce and capacity issues
- Evaluation/cost data.

Evaluation of the Evidence

Five key components contributed to the overall evaluation of the evidence; these are listed and defined below, including the overall rankings applicable for each component.

Strength of the evidence

Quality and risk of bias

This refers to how well the studies were conducted; how the participants were selected, allocated to groups, managed and followed-up; and how the study outcomes were defined, measured, analysed and reported. An assessment of the quality and bias of each individual study was conducted by two independent reviewers using, where possible, standard means to evaluate quality and bias. Appendix 5 gives an example of the criteria used to evaluate non-RCT observational studies – Systems to Rate the Strength of Scientific Evidence. An overall grading was applied to each individual study of "Good", "Fair", or "Poor". In instances where there was discrepancy between reviewers, discussions were held and a consensus was reached (see Appendices 5-7).

Quantity of evidence

This refers to the number of studies included as the evidence base for each ranking. The quantity assessment also took into consideration the statistical power of the studies, in terms of the number of participants in relation to the frequency of the outcomes measures.

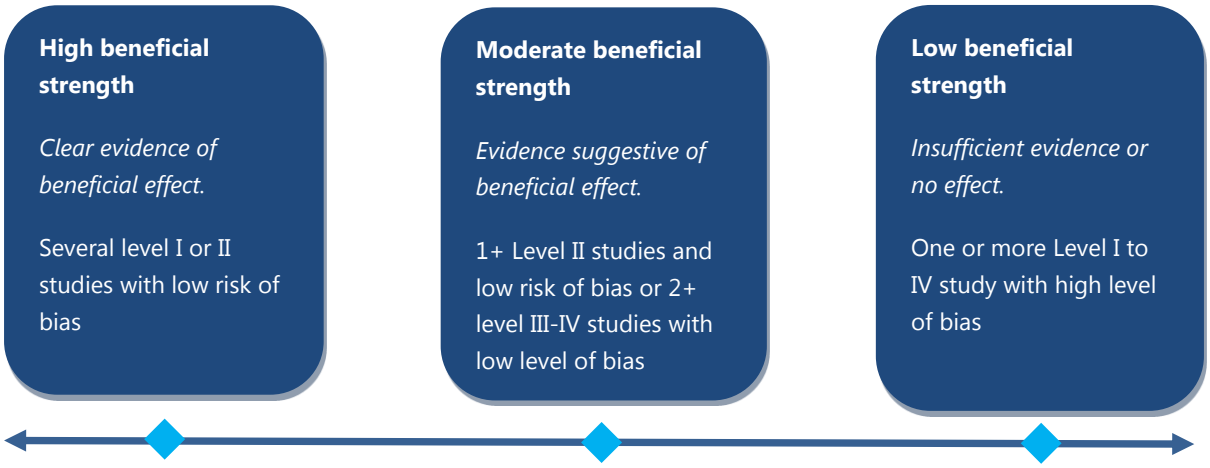
Small, underpowered studies that are otherwise sound were included in the evidence base, if their findings were in accordance with the overall trends of evidence.

Level of evidence

This reflects the best study types for the research question, assessed using the NHMRC hierarchy of evidence. The most appropriate study design to answer the questions of this review is level II evidence (see Appendix 9). Studies at levels III and IV are progressively less robust.

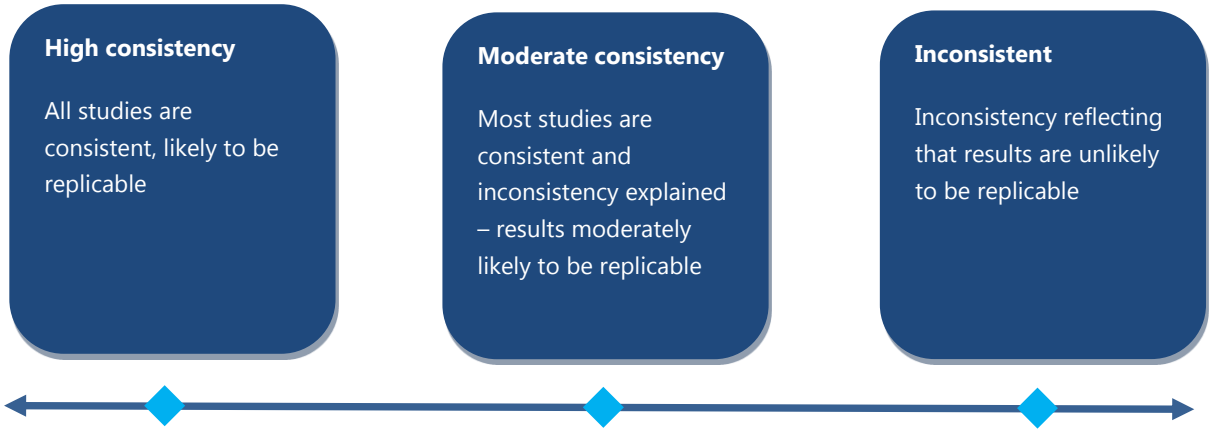
Overall strength

In consideration of the accumulated evidence for related papers a judgement was reached about the strength of the evidence base, taking into account the quality and risk of bias, quantity of evidence and level of evidence. This was determined by two independent raters and consensus reached in the event of any rating discrepancy.



Consistency

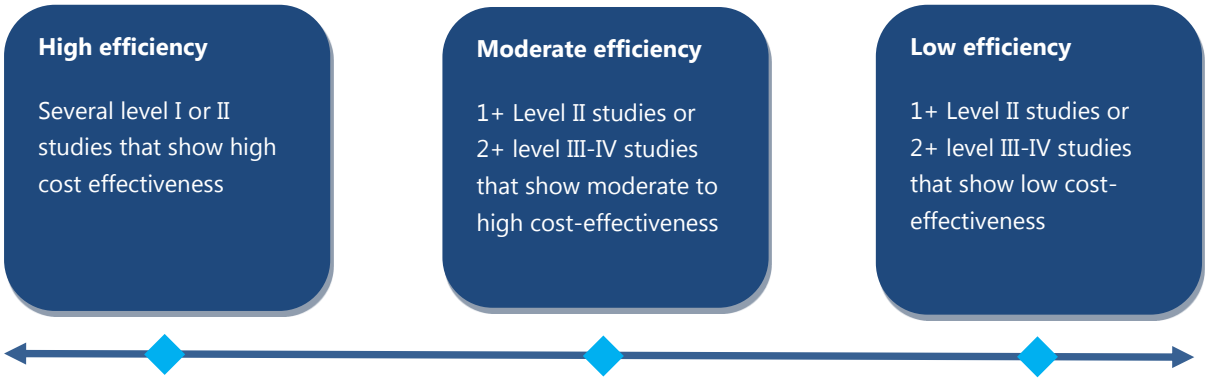
A judgement was made as to whether the findings were consistent across the included studies (including across a range of study populations and study designs).



Cost Effectiveness (Efficiency)

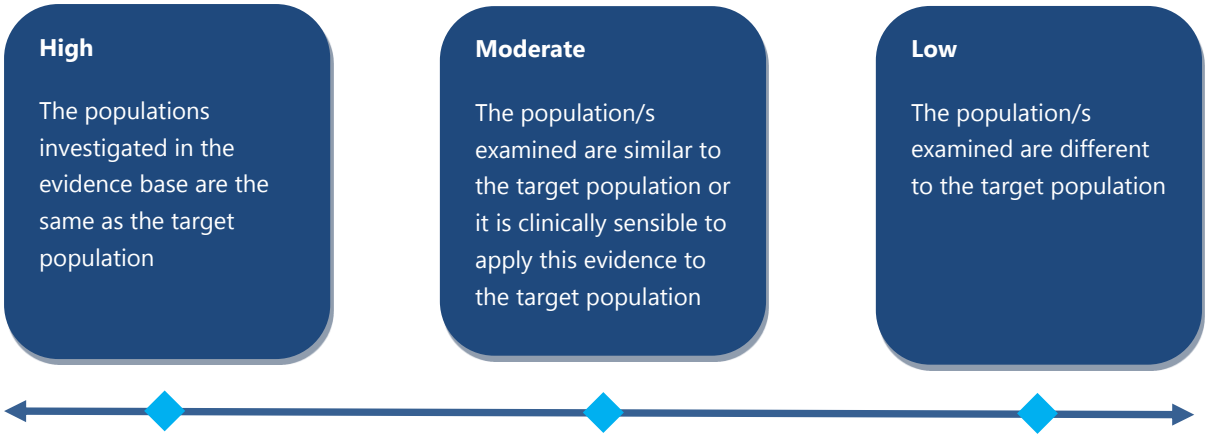
Efficiency is a measure of the economy with which an intervention of known efficacy and effectiveness is carried out. This is frequently used synonymously with cost-effectiveness,

which in most cases is appropriate. As well as the actual costs of a screening program, a measure of efficiency or cost-effectiveness must consider the costs of any potential harms of the intervention versus the benefits, and the opportunity costs of other interventions that are foregone in favour of the program in question.



Generalisability

Generalisability refers to how well participants and settings can be generalised to the NSW population. Population issues that might influence the relative importance of recommendations include gender, age or ethnicity, baseline risk, or the level of care (e.g. community or hospital). This is particularly important for evidence from randomised controlled trials (RCTs), as the setting and entry requirements for such trials are generally narrowly based and may not be representative of all the patients to whom the recommendation may be applied in practice.



Applicability

A judgement on the applicability is determined by whether the evidence base is relevant to the NSW context, or to specific local settings (rural, cities). Factors that may reduce the direct application of study findings to the Australian or more local settings include organisational factors (e.g. availability of trained staff, clinic time, specialised equipment, tests or other resources) and cultural factors (e.g. attitudes to health issues, including those that may affect compliance with the recommendation).

Ranking the Evidence

An overall ranking of the evidence is determined by considering the criteria above – strength of evidence, consistency, cost effectiveness, generalisability, and applicability. The total body of evidence was ranked into four categories ”Supported”; “Promising”; “Unknown” and “Not supported”. Agreement was sought between two independent raters.

Supported	Promising	Unknown	Not supported
Clear, consistent evidence of benefit	Evidence suggestive of benefit but more evidence needed	Insufficient evidence. –More research needed	Evidence of no effect or negative effect

RESULTS

Aim 1: Evaluate the efficacy of vision screening in identifying the presence of amblyopia in childhood (6-12 years of age)

Results of the Search

The search strategy yielded a total of 862 references, including 713 references from Ovid MEDLINE, 64 from CINAHL (EBSCO), 46 from PsycInfo, and 39 from the Cochrane library. After duplicates were removed, 749 titles remained. The full text of these titles was retrieved and screened. No papers were identified that addressed this question while also fulfilling the inclusion criteria. This was typically due to study design such as lack of a control group, or lack of data specific to the target age range.

As no trials were included in the review, none were assessed according to methodological quality.

Effect of Screening

There were no trials that compared the prevalence of amblyopia amongst children from 6 to 12 years of age in a screened versus unscreened population.

However, the search strategy uncovered a number of guidelines, protocols and recommendations that provided an overview of current research regarding best practice in current screening programs.

A 2008 Cochrane systematic review on the effectiveness of vision screening for reducing the prevalence of amblyopia did not identify any data from trials reporting on the prevalence rates of amblyopia in screened versus unscreened populations of children (screened prior to or at the time of school entry) (1). The optimal protocol for screening in this age group is thus currently unclear as there is insufficient evidence for assessment of the impact of screening on prevalence rates of amblyopia.

Coverage rates for screening have been raised as a potentially significant issue in a number of papers (1, 22, 23), whereby the efficacy of screening is diminished significantly when coverage rates fall. One study demonstrated no demonstrable benefits of screening for amblyopia when attendance rates fall below 70 per cent (23). In Australia, there is not universal attendance by preschool-age children at daycare, preschool, child and family health appointments, or the Healthy Kids Check where screening could be carried out. Screening children at an older age (6–12 years) could therefore increase coverage of the population, and by extension reduce under- and over-referrals. Indeed, attendance rates of 58 per cent have been recorded for preschool screening in the UK compared with 95 per cent amongst school-age children (22). Reduced coverage significantly reduces the efficacy of a screening program. The increased coverage of school-based screening programs is offset, however, by the potential for diminished visual outcomes in response to treatment in children in which amblyopia has been detected later.

The **critical period of vision** is known to be in the first 7 to 8 years of life. This constitutes the period in which the visual pathways and subsequent cortical connections are maturing

and consolidating. Inadequate input, as may occur in amblyopia through mechanisms such as blurred or poorly defined images, may irrevocably diminish the development of these pathways if left untreated beyond this critical period. No statistically significant benefit in visual response to treatment has been detected through school-entry screening compared with preschool screening (24). However, it is likely that screening programs to detect amblyopia conducted on children aged 7 years or older may provide reduced benefit. Furthermore, a review of the available research provided insufficient evidence of undiagnosed visual impairment amongst children aged 8 to 10 and beyond 13 years of age, thus suggesting the limited value of screening programs amongst older children.

Aim 2: Identify and evaluate the efficacy of vision screening tools for amblyopia in preschool-aged children

Results of the Search

The search strategy yielded a total of 594 references, including 462 references from Ovid MEDLINE, 81 from CINAHL (EBSCO), 12 from PsycInfo, and 39 from the Cochrane library. After duplicates were removed, 471 titles remained. The full text of these titles was retrieved and screened. Eleven remained after full text screening. Cycloplegic refraction was included as the reference standard in eight of the eleven articles (Appendix 8). Two of the studies were rated as poor quality (25, 26), with the remainder rated as fair (27-35). The extent to which the studies met the quality checklist was variable (Appendix 9). None of the studies included detailed descriptions of the study population, sample size justification, detailed inclusion/exclusion criteria, power calculations and inability to identify whether the sample was random or consecutive. The majority of studies did not include a representative sample, as they were drawn from a population of children with previously suspected or identified visual impairment. Almost half of the studies failed to apply the reference standard to all patients. Conversely, the screening tests were generally well described, with clearly defined predefined screening cut-offs (Appendix 10).

Types of Visual Acuity Testing

Three studies examined visual acuity tests (Lea symbols, HOTV tests, EDTRS linear charts, and Computer-Based Tests). One looked at stereoacuity, which is the ability to detect the depth or distance of an object (Random Dot Stereo Butterfly test). Six studies examined autorefractors, which are machines that automatically determine the correct glasses or contact lenses prescription (PlusoptiX SO4, Sure Sight Vision Screener and the Autorefractor AR-20 type R), while a single study tested Photoscreeners (MTI photoscreener). A Photoscreener is a camera that takes images of an undilated eye.

Visual acuity screening

One study of fair quality compared the use of Lea Symbols and ATS HOTV as part of the Vision in Preschoolers Study (35). The results for the two screening tools showed no statistically significant differences in detecting the difference disorders, or across the three age groups (3 year olds, younger 4 year olds, and older 4 year olds). For Lea symbols, sensitivity for detecting at least one of amblyopia, strabismus, significant refractive error or unexplained visual acuity was low (0.57-0.65), with screening cut-offs set to achieve a 0.90 specificity. By contrast, sensitivity for detecting any one of the group one conditions (amblyopia, strabismus or refractive error at the more severe end of the spectrum) was

higher (0.73- 0.83). Likelihood ratios were moderate for detecting at least one condition (PLR: 5.7- 6.5; NLR: 0.38-0.43), and stronger for detecting any condition (PLR: 7.3-8.3; NLR: 0.18-0.3). For ATS HOTV symbols, sensitivity for detecting at least one condition was low (0.46-0.57), with screening cut-offs set to achieve 0.90 specificity. By contrast, sensitivity for detecting any one of the group one conditions was higher (0.57-0.80). Likelihood ratios were moderate for detecting at least one condition (PLR: 4.6-5.7; NLR: 0.47-0.6), and stronger for detecting any condition (PLR: 5.7-8.0; NLR: 0.38-0.88).

Another study of fair quality examined the comparability of results of the ATS HOTV with the HOTV logMAR and ETDRS screening tools in children over 60 months of age, within the context of a wider study examining the testability for different age ranges of preschool children (31). Information regarding sensitivity, specificity, and likelihood ratios could not be calculated. There was a statistically significant difference between test results using the ATS HOTV and HOTV logMAR ($P<0.0001$). The mean difference was calculated at -0.1 logMAR (95% CI: -0.09 to -0.11), being one line higher using the ATS chart, with 95% confidence limits ranging from -0.22 (-0.21 to -0.24) to 0.04 (0.03 to 0.05). A similar statistically significant difference was detected in the results of screening when comparing the ATS HOTV and ETDRS. The mean difference was calculated at -0.12 logMAR ($P<0.0001$, 95% CI: -0.12 to -0.13), being one line plus one letter, with 95% confidence limits ranging from -0.27 (-0.26 to -0.28) to 0.019 (0.01 to 0.03).

A further study of fair quality compared a computer based test (CBT) (LazyeyeTest.org), against the Sheridan Gardiner Test (SGT) in kindergarten children (33). Relative to the SGT, the CBT had high sensitivity (0.88) and specificity (0.92), although there was no difference in referral rates between the two tests ($P=0.13$). The likelihood ratio was strong (PLR: 11, NLR: 0.13). A number of these test outcomes are summarised in Table 1.

Stereoacuity test

In a single fair-quality study of the Random Dot Stereo Butterfly test, results showed a PLR of 6.85 and NLR of 0.16, with a PPV of 40% for strabismus and 83.3% for all ocular conditions (32). Sensitivity and specificity were 0.96 and 0.86 respectively.

Autorefractors

In two fair-quality studies of the PlusoptiX SO4 Autorefractor (27, 28), the sensitivity and specificity were reasonably high (sens: 0.83-0.93, spec: 0.88-0.98). The likelihood ratios were strong (PLR: 16.6, NLR: 0.17).

A single fair quality study comparing the accuracy of the Palm-AR and Retinomax (29) found more moderate sensitivity of 0.74 and 0.78 respectively, with 0.90 specificity. The likelihood ratios were comparable and moderately strong for both instruments (PRL: Palm-AR 7.4, Retinomax 7.8, NLR: Palm-AR 0.28, Retinomax 0.24).

Two studies of fair quality, both part of the Vision in Preschoolers Study, examined the Sure Sight Vision Screener (30, 34). Using screening cut-offs set to achieve a 0.90 specificity, the results from Ying et al. reflected a low sensitivity overall for detecting amblyopia, strabismus, reduced visual acuity and any condition (0.49-0.61), although were better at detecting refractive error (sens: 0.82). This correlated with the findings from Silverstein et al.(34), with

0.59 sensitivity and 0.96 specificity. The likelihood ratios were moderate to strong throughout (PLR: 4.9-14.8, NLR: 0.2-0.56).

A poor quality study examined the autorefractometer AR-20 type R (26). Sensitivity, specificity and likelihood ratios could not be calculated for this study. Based upon the reported data, the use of the autorefractor trebled the rate of referral for further examination by an ophthalmologist, however did not alter the rate of diagnosis of amblyopia to any significant extent, leading the authors to conclude that use of the autorefractor in a Japanese national screening program was not currently warranted.

Photoscreeners

A single poor-quality study from the United States examined the performance of the MTI photoscreener in vision screening, including the PPV (25). The sensitivity was low at 0.55 at an unspecified specificity. The PLR could not be calculated, although the calculated PPV was high at 94.2 per cent.

Amblyogenic risk factors are currently identified primarily through the use of instrument-based screening. Devices include photoscreeners, such as the MTI photoscreeneer, iScreen or PlusoptiX, or handheld autorefractors including the SureSight and Retinomax (36). These devices have a high positive predictive value and are generally faster and more easily administered than traditional screening methods.

The majority of studies drew their sample from populations with suspected or proven visual impairment, thus preventing assessment of the accuracy of the tools across wider populations of children. There was also variability in the screening thresholds, and conditions targeted, limiting comparability between studies. A significant limitation of the majority of studies was the fact that only children who failed initial screening tests were generally administered a comprehensive eye examination with cycloplegic refraction, thus assuming a false negative rate of zero for these tests at the specified cut-off.

Also examined was a systematic review on the accuracy of screening tests for visual impairment for children aged 1 to 5 years of age, which included studies up to the third quarter of 2009 (37). The review found that substantial variability existed in both the diagnostic accuracy and choice of the screening tests included in the studies, and that inconsistencies occurred in the estimates of diagnostic accuracy. Nevertheless, it was clear that various tests are potentially amenable to use for vision screening in preschoolers, including those using visual acuity, stereoacuity, autorefractors or photoscreeners. Indeed, studies that involved analysis of tests from various categories demonstrated stronger likelihood ratios than studies involving single tests. **Clear evidence of the superiority of one test over another is currently lacking.** These results mirror those of this current review.

It is clear that a paucity of good evidence exists on the diagnostic accuracy and most appropriate choice of vision screening tools for children. Indeed, there is a variety of tests available and significant variation in the merits and drawbacks of each. A recent evidence-based, although not systematic, review by Anstice and Thompson (38) summarised some of the variation in the optotype tests for visual acuity for children as follows: Optoypes are standardised symbols for vision testing.

Table 1. Methods of Measurement of Recognition Visual Acuity in Preschool Children

Test	Mean Visual Acuity	Comments
Allen cards	Not stated	• design inadequacies e.g variable inter-line gap widths/shape cues • lack standardisation in design and appropriate responses • overestimate visual acuity in children with amblyopia by 1-2 lines
Wright cards	Not stated	• lack standardisation in design and appropriate responses • symbols larger than Snellen equivalent • overestimate visual acuity in children with amblyopia by 1-2 lines
Lea Symbols	• Variable • Mean 0.10 logMAR with crowding	• easy to use in children 3 years and over • sensitive to amblyopia, especially where coded forms used • may provide a higher estimate of visual acuity compared with other tests (e.g. Bailey-Lovie chart, ETDRS chart)
Patti Pics	Not stated	• lack of published data on its efficacy • widely used in clinical setting in North America • provides lower visual acuity measurements in adults than Lea symbols by one line of optotypes
Kay Pictures	• 0.10 logMAR under 4 yo • 0.05 logMAR children 4-5yo	• used in children aged 2-3 years • widely used in the UK. Europe • better score (0.074 +/- 0.036 logMAR) (statistically significant) different in children with amblyopia cf letter matching • produce better visual acuity measurements, cf adult letter chart • good repeatability (test-retest variability); (+/- 0.16 logMAR for children)

Test	Mean Visual Acuity	Comments

Sheridan-Gardiner test	-0.125 logMAR children aged 5-7	• easy to use, quick simplicity
		• used frequently in vision screening programs and private practice
		• problems with :
		  ○ irregular progression of letter sizes
		  ○ absence of (0.10 logMAR) line
		  ○ truncation of test at Snellen 6/6 acuity in the standard booklet
		  ○ measures of better visual acuity require the use of an additional booklet
		  ○ lack of contour interaction in the uncrowded version
		  ○ widely used in preschools although when used alone has low specificity/often has false positive referral rates

HOTV	Not stated	• good testability • high test-retest reliability of 93 per cent within 0.1 logMAR
Glasgow acuity cards	Not stated	• equal legibility with a 01 log unit progression between lines
ETDRS	Not stated	• high levels of test-retest probability in children 6 years and over (comparable to adult levels) • 100% ability to complete the test for 7 years and over • variable correlation with Lea symbols from correlation to 2-3 line variation between EDTRS and Lea symbols.

Aim 3: Evaluate the efficacy of vision screening in identifying the prevalence of preventable blindness amongst infants and neonates (<1 year of age)

Results of the Search

The search strategy yielded a total of 329 references, including 234 references from Ovid MEDLINE, 28 from CINAHL (EBSCO), 6 from PsycInfo, and 61 from the Cochrane library. After duplicates were removed, 60 titles remained. The full text of these titles was retrieved and screened. No papers were identified that addressed this question whilst also fulfilling the inclusion criteria.

Neonatal Screening Tests

The primary methods of screening in neonates and infants under 1 year of age include the red reflex, corneal light reflex and cover-uncover tests (15). The red reflex exmination has been proposed as the best test to be conducted in the neonatal period for the early detection of vision problems(39). The red reflex comprises the most common vision screening test of newborns across many countries (14) and allows early detection of cataracts, glaucome, retinblastoma, retinal abnormalities, refractive errors and other ocular pathologies. It has ease of application, is non-invasive and is able to detect a range of ocular abnormalities including cataracts and retinal pathologies. A recent study by Eventov et al reported on the implementation of the red reflex for vision screening in a neonatal hospital (14). Initial specificity for the red reflex examination during the implementation phase was reported at 42 per cent, with a low false positive rate of 0.0006% for over 11,000 patients. False negative results were not able to be calculated but were also likely to be low. It was expected that the specificity would increase with ongoing clinical experience. Overall however, in the retrieved papers, information on sensitivity and specificity was lacking.

A paper by Kahn et al (11) examined the impact of pharmacological dilation of the pupil on red reflex examination, particularly with reference to the detection of retinoblastoma. They found that red reflex examination with pharmacologically dilated pupils failed to detect retinoblastoma and there was no evidence to support this technique of screening for retinoblastoma. Furthermore, dilated pupil red reflex examination was also more likely to miss strabismus and amblyopia.

Various methods have been proposed for testing visual acuity in infants (38) including Teller acuity cards (TAC), the Cardiff Acuity Test (CAT) and the Pacific Acuity Test (PAT), which generally involve the preferential looking technique (grating). These may involve the use of square wave grating stimuli (TAC) or vanishing optoype pictures (CAT, PAT) to obtain estimates of resolution acuity based on psychophysical estimates. These utilise the principle that infants presented with patterned versus blank targets will preferentially focus on the patterned stimuli (grating). The efficacy of grating techniques for assessing visual impairment is debated. Close agreement has been found between grating acuities and the CAT in older children (38) and infants (40), with high testability. It has however been demonstrated that the CAT may fail to detect impaired visual acuity due to refractive errors and mild amblyopia (40). The development of tests such as PAT, which uses optotypes based around faces, has been developed in response to acuity results, which are more precise when based on vanishing optotype face patterns(41). Nevertheless, recent evidence

regarding the efficacy of PAT demonstrated that testability was only 44 per cent for children younger than 18 months with 96 per cent after this age.

Assessment of digital retinal images using an indirect opthalmoscopy imaging system (Keeler) has been studied for the detection of ROP (42). Sensitivity (>94 per cent) and specificity (>86 per cent) was high when compared with clinical examination. The Keller system has the added benefits of being portable and involving a skill (indirect ophthalmology) that is routine amongst ophthalmologists in contrast to ROP screening, which is not universally practised. The authors concluded that the Keeler system had potential as a screening tool for ROP (7).

An evaluation of the detection of blindness in infants and children in the UK suggested that the efficacy of screening programs to detect visual impairment differed significantly across different conditions(7). While less than half (47 per cent) of congenital cataracts were detected by means of screening examinations, over 90 per cent of ROP cases were identified. Differences in detection rates may in part be explained by variation in the screening techniques of the practitioners. Primary care physicians, for example, may have very low exposure to visual pathologies, which subsequently provides challenges for training and maintenance of skills.

Visual Screening Protocols

Current guidelines from the Canadian Task Force of Preventative Heath Care recommends red reflex inspection on all newborns (up to 3 months of age) to exclude lenticular opacities or major posterior eye disease (15), with any abnormalities prompting urgent referral to an ophthalmologist. Additionally it is recommended that a complete examination of the external eye be conducted. Any family history of hereditary ocular disease or children at high risk of retinopathy of prematurity are recommended for referral for a full ophthalmological examination. From 6 to 12 months of age, the red reflex and external eye examination may be repeated as required. Additionally, the corneal light reflex and cover-uncover tests should be used to assess ocular alignment and detect strabismum. Children of this age are also to be assessed using fixation and target following. Screening for ROP involves ophthalmological examination of dilated pupils with indirect and/or direct ophthalmoscopy of the entire retina using an infant gonioscopy lens (3). In the UK, by contrast, vision screening asessment comprises three components: a newborn examination conducted by a paediatrician, and an examination at 6-8 weeks of age undertaken by a primary care physician, and a vision screening examination at 4-5 years of age. There is subsequently considerable variation in the nature of screening programs both between and within countries, and in many cases national programs are not audited (7, 13).

A distinction is also made regarding universal screening of neonates and screening programs directed at subpopulations of high risk infants. Thus while red reflex is intended for all infants in order to screen for ocular abnormalities generally, high-risk infants, including those with a history of familial cataract or retinoblastoma, metabolic disorders linked to ocular pathologies, microphthalmia or eyelid hemangioma, should receive immediate referral for a full ophthalmological examination (14). Similarly, the patterns of detection of visual pathologies differ between the general population and these subpopulations. In a recent study from the UK, children with severe visual impairment or blindness were more likely to be detected by a paediatrician, whereas those with isolated visual loss were more likely to

be identified in a primary care setting (7). Furthermore 17-24 per cent of children with isolated severe visual impairment or blindness were detected at routine vision screening, whereas visual impairments associated with additional pathologies were more likely to be identified by targeted examinations by paediatricians and ophthalmologists because the children were considered high risk.

Timing of Screening

The timing of screening also differs across different national protocols. In the UK, for example, vision screening for the infant comprises examinations of the newborn and then at 6-8 weeks of age(7). This has yielded detection rates of over 50 per cent for key visual disorders. Furthermore, agreement on best practice regarding timing for specific disorders can be variable. A number of articles have addressed issues around the timing of screening in the context of retinopathy of prematurity (ROP)(3, 43). The recommended timing of screening for premature infants across national protocols is variable (3, 44-46) and may be subject to change. Thus screening guidelines in Sweden have been revised down from less than 33 weeks to less than 32 weeks over the last decade, with recent data recommending a further reduction in the upper limit of screening to infants with a GA of 30 weeks plus 6 days or less. Screening guidelines for this age group may, in addition, require continued revision depending on improvements in neonatal care, which result in improved outcomes and increased survival of premature infants at earlier gestational ages. In Sweden, recommendations for the commencement of screening for ROP have been modified to postmenstrual age (PMA) of 31 weeks rather than the previously accepted postnatal age (PNA) of of 5 weeks. The optimal timing for subsequent screening is also debated although screening is generally conducted at weekly or biweekly intervals until the ROP has regressed or the retina is fully vascularised (3, 11, 43). The criteria prompting screening must also be considered. For ROP, both GA and low birth weight have been considered as risk factors for the development of ROP, although recent evidence suggests GA to be the most important risk factor guiding screening protocols (43).

Uptake of Screening Tests

Eventov-Freidman et al (14) reported on the uptake of red reflex testing for the detection of ocular pathologies in neonatal wards across Israel. Using survey methodology they detected a low uptake, with less than half of the 26 neonatology departments routinely performing the test. Reasons for failure of uptake included lack of staff and a reluctance to perform the ophthalmologist’s job.

Cost effectiveness of Neonatal Vision Screening

Cost effectiveness of vision screening programs have been also been investigated. Data regarding screening and treament for ROP collected from two neonatal intensive care departments over a 21 month period, demonstrated that screening was highly cost effective, with a cost of $650/quality-adjusted life years (47). A further study by Magnusson (48) examined cost and found that the cost of combined maternity ward and well baby eye screening versus well-baby clinic eye screening alone in Sweden. It found combined screening to be a cost effective strategy. These studies, while specific to the context in which they were conducted, nevertheless suggest that visual screening in the neonatal period is likely to be cost effective.

DISCUSSION

This review was undertaken to ascertain whether there had been advancements in vision screening in the last 10 years, with a particular focus on screening tools. Given that vision screening for preschool aged children has been universally implemented in NSW for the last seven years, it is timely to review potential changes to availability and accuracy of screening tests and any advancements in the literature.

Screening for amblyopia

Overall, screening for amblyopia in young children continues to be seen as of value (on balance) in preventing future blindness. While the studies were limited, this review highlights the importance of screening children for amblyopia at the right time in a child's life. It is important to consider *when* any interventions are likely to be effective. This includes taking into account the need for the screening to be early enough to influence the developing optic pathways in the brain, and therefore the success of treatment, and late enough to capture universal population screening with a tool that can accurately test children.

There were no studies to support routine screening of children over the age of 7 years; this appears to be the upper limit for screening programs in terms of the effectiveness of treatment. The importance of reach and uptake of the whole population was highlighted as the fundamental basis of success for any vision screening program (more so than the screening tool per se), with most papers supporting the use of schools as universal platforms for vision screening. It is worth noting that many countries (in contrast to the NSW model) do not have universal provision of any service platform prior to that time. As an aside there were also no studies to support screening on amblyogenic risk factors alone.

Vision screening tools for amblyopia in the preschool period

While vision screening tools are evolving, there was insufficient evidence to suggest the newer, more expensive, but potentially more accurate tools offered measurable benefit over the currently utilised cheaper and less complex tools. In particular, there was much emphasis in the literature on balancing the marginal benefit of more accurate screening tests against the more important issue of universal population capture, which more accurately reflects the effectiveness of the program. That said, there were a number of promising screens that may prove valuable into the future once their testing at a population level is complete. Of these, photo screeners may well be of some utility in the community-based setting of the NSW program (Appendix 11).

Evidence is gradually accumulating on the accuracy of various screening tests for visual acuity in preschoolers. Nevertheless, the choice of a single test is currently precluded due to the existence of a number of confounding factors. These include:

- age-related changes in visual development and the cognitive ability to perform the test
- a lack of data comparing test results in the wider population rather than in subsets of children with likely or recognised visual impairment
- the effects of test characteristics such as testing distance and test configuratio

- variation in the visual acuity cut-offs employed with the test
- between-study variation in the age of the tested population
- a lack of data on diagnostic accuracy.

Screening for preventable blindness in neonates and infants

The final element of this review considered the use of vision screening in neonates and infants (>1 year old) to prevent future blindness. While the previous elements of the review focussed on amblyopia, here we focussed on diseases and conditions more specific to the neonatal period. It is worth noting that there were a number of early studies testing new ways of measuring refractive error in children under the age of 1 year, with some studies linking this to early detection of amblyopia. These were excluded from the analysis (and were mostly weak studies), however this would appear to be an area worth watching over time.

The use of the red eye reflex seems to be supported as a simple and cost effective way to screen for eye defects. Given that the red eye reflex is essentially part of a clinical examination, differentiating it as a screening test versus good clinical care remains a vexed issue, especially in services that have universal provision. One study nevertheless suggested that universal application of the red reflex test to neonates would be more likely if it formed part of a screening program (rather than relying on good clinical practice alone). Its ability to easily and cheaply determine eye opacity would suggest it should be supported as a key element to the NSW program.

Targeted Surveillance

There was evidence to support targeted screening for certain subpopulations; particularly for high-risk infants (those with a history of familial cataract or retinoblastoma, metabolic disorders linked to ocular pathologies, microphthalmia or eyelid hemangioma and those at risk of ROP). The majority of the literature, however, focussed on opportunities for universal implementation.

Access to Assessment and Treatment Services

It was beyond the scope of his review to consider the issues related to access to assessment and treatment services yet these components are critical elements to providing a fully implemented screening program. While it is possible to establish a universal screening program, if children are unable to equitably access diagnostic and treatment services the program outcomes will not demonstrate a decrease in amblyopia across the population. We did not seek to evaluate the NSW program but would support mechanisms that ensure that these final elements of a screening program are considered.

RECOMMENDATIONS

In conclusion, this rapid review supports several recommendations, as below:

1. **Continue to implement vision screening for amblyopia in the preschool OR early school-age years (with 7 years as an upper limit).**

There should be some consideration of the best setting in which to achieve universal coverage of the population.

2. **Watch for forthcoming evidence regarding vision screening tools but there is insufficient evidence to support a change to current practice**

For current screening tools:
Further studies might address some of the existing confounding factors (e.g. variation in the visual acuity cut-offs employed by the test, lack of data comparing test results in the wider population, etc), allowing for a more accurate determination of the current recommended amblyopia screening tool/s

For newer screening tools:
Instruments such as photos screeners and autorefractors that look promising need to be tested at the population level.
New ways of measuring refractive error in children aged < 1 year may be important in the future.

3. **Implement targeted screening for high-risk infants.**

Including infants with a history of familial cataract or retinoblastoma, metabolic disorders linked to ocular pathologies, microphthalmia or eyelid hemangioma and those at risk of retinopathy of prematurity (ROP).

4. **Consider:**

Mechanisms are in place that ensure the completion of the red eye reflex test for all neonates through the NSW routine universal child and family health system and potentially augment through primary care (data systems may be necessary for this element).

Equitable access to diagnostic and treatment services post-screening

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APPENDICES

Appendix 1: Defining the Question – PICO Framework

PICO

The questions were formulated within a Population Intervention Comparison Outcome (PICO) framework. Application of a PICO framework helps to structure, contain and set the scope for the research question. Inclusion of intervention (screening models) and comparison components is dependent on the question asked, and may not be appropriate for all question types.

Aim 1.

The efficacy of vision screening in identifying the presence of amblyopia in childhood (6-12 years of age).

PICO format: In children between 6-12 years of age, what is the relative effectiveness and efficiency of vision screening programs in identifying amblyopia?

P Patient, Problem, Population	**I Intervention (*screening*)**	**C Comparison (*optional*)**	**O Outcome (*when defining "more effective" is not acceptable unless it describes how the intervention is more effective*)**
AGE 6-12 GENDER (no specification) DIAGNOSES (none excluded)	Effectiveness: the extent to which the model or program improved the desired outcomes when applied to the population. Efficiency: the cost-effectiveness of the model or program, inclusive of any harms, benefits and costs of the program to individuals and society.	Versus prevalence amongst unscreened populations	Programs and service models that deliver population-based screening and surveillance

Aim 2.

The efficacy of vision screening tools for detecting amblyopia in preschool-aged children (2-5 years of age).

PICO format: In children between 2-5 years of age, what is the relative effectiveness and efficiency of vision screening tools for identifying amblyopia?

P Patient, Problem, Population	**I Intervention (*screening*)**	**C Comparison (*optional*)**	**O Outcome (*when defining "more effective" is not acceptable unless it describes how the intervention is more effective*)**
AGE 2-5 GENDER (no specification) DIAGNOSES (none excluded)	Effectiveness: the extent to which the screening tool improved the desired outcomes when applied to the population. Efficiency: the cost-effectiveness of the screening tool, inclusive of any harms, benefits and costs of the program to individuals and society.		The identification of amblyopia

Aim 3.

An evaluation of the efficacy of vision screening in identifying the prevalence of preventable blindness amongst infants and neonates (<1 year of age).

PICO format: In neonates and infants up to 1 year of age, what is the relative effectiveness and efficiency of vision screening programs for identifying the prevalence of preventable blindness amongst infants and neonates?

P Patient, Problem, Population	**I Intervention (*screening*)**	**C Comparison (*optional*)**	**O Outcome (*when defining "more effective" is not acceptable unless it describes how the intervention is more effective*)**
AGE 0-1 year GENDER (no specification) DIAGNOSES (none excluded)	Effectiveness: the extent to which the screening tool improved the desired outcomes when applied to the population. Efficiency: the cost-effectiveness of the screening tool, inclusive of any harms, benefits and costs of the program to individuals and society.		The identification of the prevalence of preventable blindness amongst infants and neonates

Appendix 2: Information Retrieval

The following is an example of the search strategy conducted in Medline

Aim 3.

Step	Search Terms	No. of Records
1	exp Vision Disorders/	59663
2	exp Refractive Errors/	26303
3	"Retinopathy of Prematurity"/	4428
4	congenital ocular anomal$/	0
5	congenital cataract$/	0
6	Cataract/	23232
7	Retinoblastoma/	6098
8	Vision, Binocular/	5853
9	exp Visual Acuity/	62124
10	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9	156433
11	Vision Screening/	1750
12	red reflex.mp.	152
13	corneal light reflex.mp.	50
14	cover-uncover test.mp.	17
15	exp Vision Tests/is [instrumentation]	2544
16	(vis$ adj3 test$).tw.	14089
17	(vis$ adj3 screen$).tw.	3293
18	11 or 12 or 13 or 14 or 15 or 16 or 17	20086
19	10 and 18	6403
20	Vision Screening/ and exp *Vision Disorders/	761
21	mass screening/ and (exp *eye diseases/pc or *vision screening/)	452
22	19 or 20 or 21	6795
23	developing countries/	63351
24	(developing countr$ or third world or underdeveloped countr$ or under developed countr$).mp.	100239
25	exp africa/	196879
26	americas/ or exp caribbean region/ or exp central america/ or latin america/ or mexico/ or exp south america/	172296
27	europe/ or exp europe, eastern/ or exp transcaucasia/	231705

Step	Search Terms	No. of Records
28	antarctic regions/ or exp atlantic islands/ or exp indian ocean islands/ or exp pacific islands/	58959
29	New Guinea/	1709
30	asia/ or exp asia, central/ or asia, southeastern/ or borneo/ or cambodia/ or east timor/ or indonesia/ or laos/ or malaysia/ or mekong valley/ or myanmar/ or philippines/ or thailand/ or vietnam/ or asia, western/ or bangladesh/ or bhutan/ or india/ or middle east/ or afghanistan/ or iran/ or iraq/ or jordan/ or lebanon/ or oman/ or saudi arabia/ or syria/ or turkey/ or yemen/ or nepal/ or pakistan/ or sri lanka/ or far east/ or china/ or tibet/ or exp korea/ or mongolia/	350204
31	(Afghanistan or Albania or Algeria or Angola or Antigua or Argentina or Armenia or Azerbaijan or Bangladesh or Barbados or Barbuda or Belarus or Belize or Bhutan or Bolivia or Bosnia or Botswana or Brazil or Bulgaria or Burkina Faso or Burundi or Cambodia or Cameroon or Central African Republic or Chad or Chile or Colombia or Comoros or Congo or Costa Rica or Croatia or Cuba or Czech* or Congo or Djibouti or Dominica or Dominican or East Timor or Ecuador or Egypt or El Salvador or Equatorial Guinea or Eritrea or Estonia or Ethiopia or Fiji or Gabon or Gambia or Ghana or Grenada or Guatemala or Guinea-Bissau or Guyana or Haiti or Honduras or Hungary or India or Indonesia or Iran or Iraq or Ivory Coast or Jamaica or Jordan or Kazakhstan or Kenya or Kiribati or Kyrgyzstan or Laos or Latvia or Lebanon or Lesotho or Liberia or Libya or Lithuania or Madagascar or Malawi or Malaysia or Maldives or Mali or Marshall Islands or Mauritania or Mauritius or Mexico or Micronesia or Moldova or Mongolia or Montenegro or Morocco or Mozambique or Myanmar or Namibia or Nepal or New Guinea or Nicaragua or Niger or Nigeria or Korea or Oman or Pakistan or Palau or Panama or Papua New Guinea or Paraguay or Benin or China or Peru or Philippines or Poland or Cape Verde or Georgia or Kosovo or Macedonia or Yemen or Romania or Russia or Rwanda or Saint Kitts or Saint Vincent or Saint Lucia or Sao Tome Principe or Saudi Arabia or Senegal or Serbia or Seychelles or Sierra Leone or Slovak* or South Africa or Solomon Islands or Somalia or Sri Lanka or Sri-Lanka or Sudan or Suriname or Swaziland or Syria or Tajikistan or Tanzania or Thailand or Togo or Tonga or Trinidad or Tobago or Tunisia or Turkey or Turkmenistan or Uganda or Ukraine or Uruguay or Uzbekistan or Vanuatu or Venezuela or Vietnam or Samoa or Zambia or Zimbabwe).af.	3858798
32	23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31	4052225
33	22 and 32	1011
34	22 not 33	5784
35	limit 34 to "all infant (birth to 23 months)"	669

Step	Search Terms	No. of Records
36	(neonat* or infant*).af.	1156075
37	34 and 36	717
38	35 or 37	717
39	**limit 38 to (english and last 10 years)**	**234**

Appendix 3: Levels of Evidence Hierarchy

NHMRC Evidence Hierarchy: designations of 'levels of evidence' for Screening Intervention

Level	Screening Intervention
Level I	A systematic review of level II studies
Level II	RCT
Level III-1	Evidence obtained from well-designed pseudo-randomised controlled trials (alternative allocation or some other method)
Level III-2	A comparative study with concurrent controls: • Non-randomised, experimental trial • Cohort study • Case-control study
Level III-3	A comparative study without concurrent controls: • Historical control study • Two or more single arm study
Level IV	Evidence obtained from case studies
Level V	*The current tables exclude expert opinion and consensus from an expert committee as they do not arise from scientific investigation*

Appendix 4. Screening Form

Used to code the eligibility of references acquired through search paradigms.

Screen on title and abstract

Aim 1

Included:
1. INCLUDE Language: English language 2. INCLUDE Date: Include if published in 2008 or after 3. INCLUDE Age: Include if age of participants are 6 to 12 years of age inclusive 4. INCLUDE Study Type: Include if systematic reviews, randomised controlled trials, evidence from well-designed pseudo-randomised controlled trials and comparative studies with concurrent controls (non-randomised experimental trials, cohort studies and case-control studies) 5. INCLUDE Demographic Location: include if developed country 6. INCLUDE Study Group: Include if mass/population screening
Excluded:
1. EXCLUDE Language: Exclude if non-English 2. EXCLUDE Date: Exclude if published prior to 2008 3. EXCLUDE Age: Exclude if age of participants <6 yoa, >12yoa. 4. EXCLUDE Study Type: Exclude if comparative studies without concurrent controls, validation study, animal study, review paper, technical report, case studies, stand-alone methods paper 5. EXCLUDE Demographic location: Exclude if developing country 6. EXCLUDE Study Group: Exclude if specific disease/disorder/not population or mass screening 7. EXCLUDE Outcome: Exclude if outcome data does not report on the screening model or is inappropriate 8. EXCLUDE Unavailable: Exclude if full-text version is not readily available

Aim 2.

Included:
1. INCLUDE Language: English language 2. INCLUDE Date: Include if published in 2008 or after 3. INCLUDE Age: Include if age of participants is 3 to 5 years of age inclusive 4. INCLUDE Study Type: Include if systematic reviews, randomised controlled trials, evidence from well-designed pseudo-randomised controlled trials and comparative studies with concurrent controls (non-randomised experimental trials, cohort studies and case-control studies) 5. INCLUDE Demographic Location: include if developed country 6. INCLUDE Study Group: Include if mass/population screening
Excluded:
1. EXCLUDE Language: Exclude if non-English 2. EXCLUDE Date: Exclude if published prior to 2008 3. EXCLUDE Age: Exclude if age of participants <3yoa, >5yoa. 4. EXCLUDE Study Type: Exclude if comparative studies without concurrent controls, validation study, animal study, review paper, technical report, case studies, stand-alone methods paper 5. EXCLUDE Demographic location: Exclude if developing country 6. EXCLUDE Study Group: Exclude if specific disease/disorder/population or mass screening 7. EXCLUDE Outcome: Exclude if outcome data does not report on the screening tools or is inappropriate 8. EXCLUDE Unavailable: Exclude if full-text version is not readily available 9. INCLUDE based on title & abstract: Cannot be excluded so is marked as INCLUDE. Will require retrieval of full paper available

Aim 3.

Included:
1. INCLUDE Language: English language 2. INCLUDE Date: Include if published in 2004 or after 3. INCLUDE Age: Include if age of participants is less than 1 year of age 4. INCLUDE Study Type: Include if systematic reviews, randomised controlled trials, evidence from well-designed pseudo-randomised controlled trials and comparative studies with concurrent controls (non-randomised experimental trials, cohort studies and case-control studies) 5. INCLUDE Demographic Location: include if developed country 6. INCLUDE Study Group: Include if mass/population screening
Excluded:
1. EXCLUDE Language: Exclude if non-English 2. EXCLUDE Date: Exclude if published prior to 2004 3. EXCLUDE Age: Exclude if age of participants >1yoa. 4. EXCLUDE Study Type: Exclude if comparative studies without concurrent controls, validation study, animal study, review paper, technical report, case studies, stand-alone methods paper 5. EXCLUDE Demographic location: Exclude if developing country 6. EXCLUDE Study Group: Exclude if not population or mass screening 7. EXCLUDE Outcome: Exclude if outcome data does not report on the screening model or is inappropriate 8. EXCLUDE Unavailable: Exclude if full-text version is not readily available

Appendix 5: Quality & Bias Checklist for Observational Studies

Checklist for appraising the quality of Observational Studies*

*where not all criteria were relevant for each study they were assessed on the domains that applied and an overall rating ascertained

Completed		
Yes	No	
		1. Study Question
		Clearly focused and appropriate question
		Study population
		Description of study population
		Sample size justification
		2. Comparability of Subjects
		Specific inclusion/exclusion criteria for all groups
		Criteria applied equally to all groups
		Comparability of groups at baseline with regard to disease status and prognostic factors
		Study groups comparable to non-participants with regard to confounding factors
		Use of concurrent controls
		Comparability of follow-up among groups at each assessment
		3. Exposure or Intervention
		Clear definition of exposure
		Measurement method standard, valid and reliable
		Exposure measured equally in all study groups
		4. Outcome measures
		Primary/secondary outcomes clearly defined
		Outcomes assessed blind to exposure or intervention
		Method of outcome assessment standard, valid and reliable
		Length of follow-up adequate for question
		5. Statistical Analysis
		Statistical tests appropriate
		Multiple comparisons taken into consideration
		Modelling and multivariate techniques appropriate
		Power calculation provided
		Assessment of confounding
		Dose-response assessment if appropriate
		6. Results
		Measure of effect for outcomes and appropriate measure of precision
		Adequacy of follow-up for each study group
		7. Discussion
		Conclusions supported by results with possible biases and limitations taken into consideration

Appendix 6: Criteria for the appraisal of screening tests and screening programs

Criteria for a Screening Test

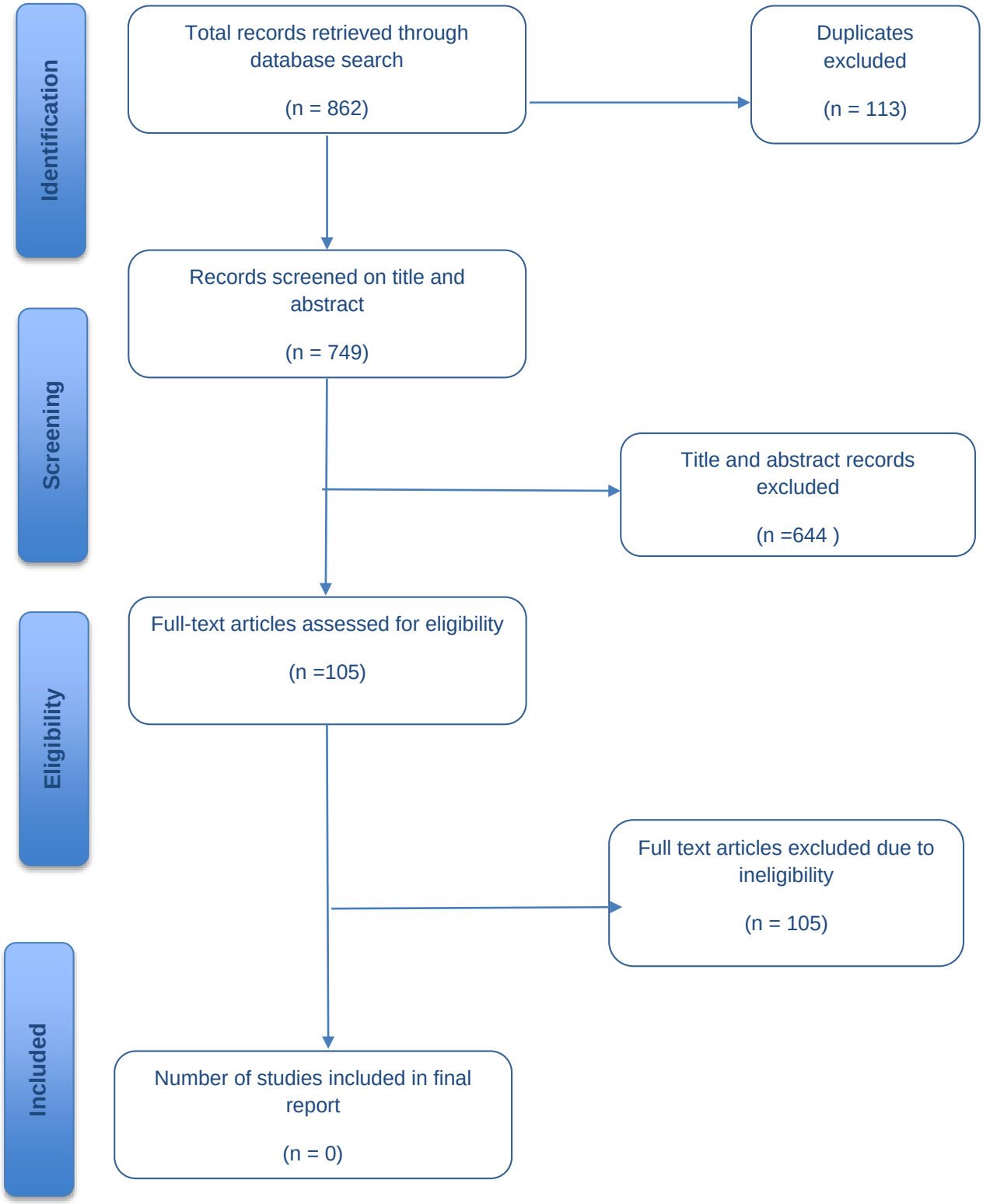
	Yes/No/Unknown
Simple, quick & easy to interpret	
Acceptable to public	
Accurate	
Repeatable	
Sensitive	
Specific	

Criteria for a Screening Program

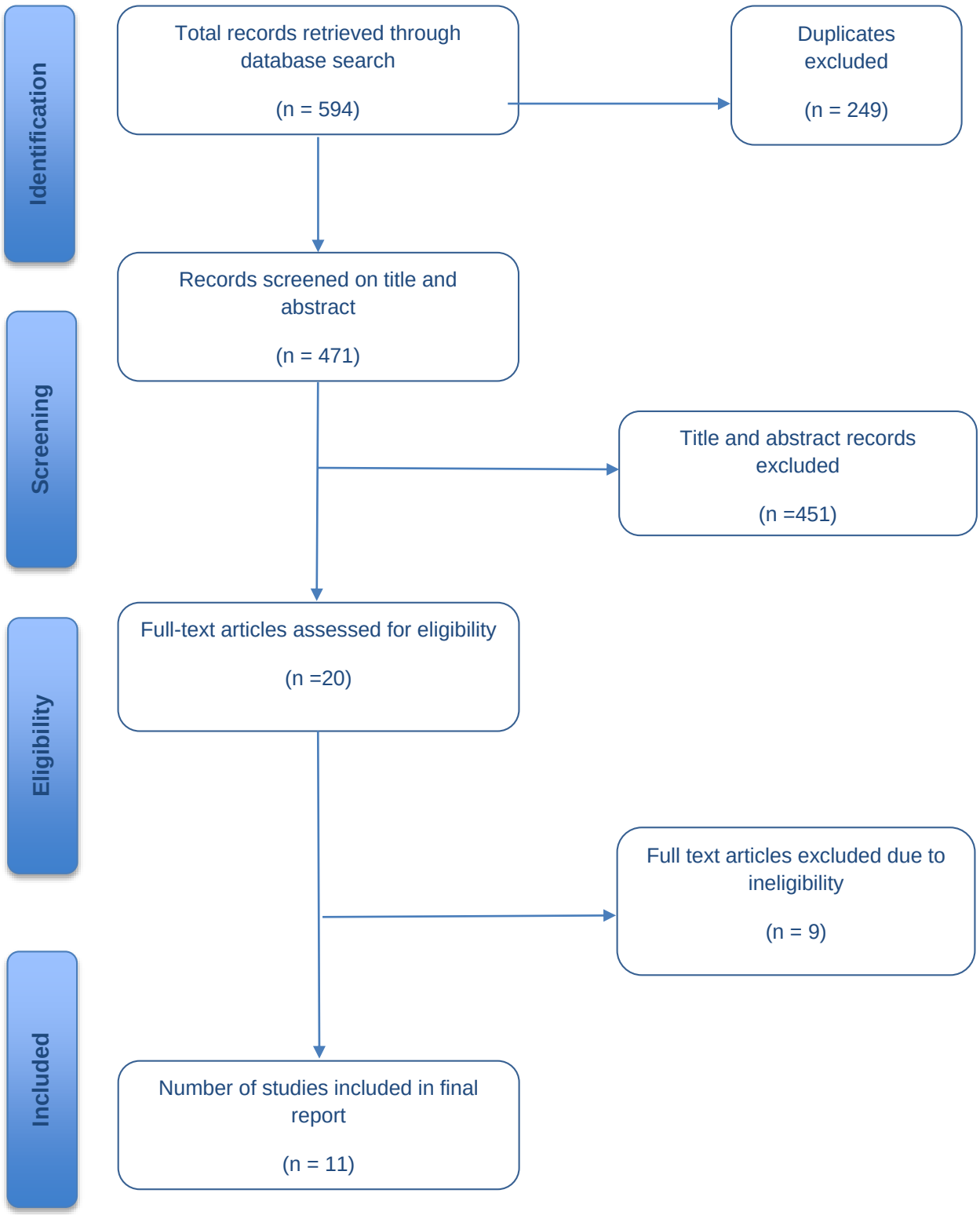
	Yes/No/Unknown
Important health problem	
Accepted treatment	
Facilities for diagnosis and treatment	
Latent or early symptomatic stage	
Suitable test or examination	
Test acceptable to the population	
Natural history adequately understood	
Agreed policy on whom to treat	
The cost of case-finding balanced with expenditure on medical care as a whole	

Appendix 7: PRISMA Flow chart representing the number of records retrieved at each stage of the rapid review assessment process

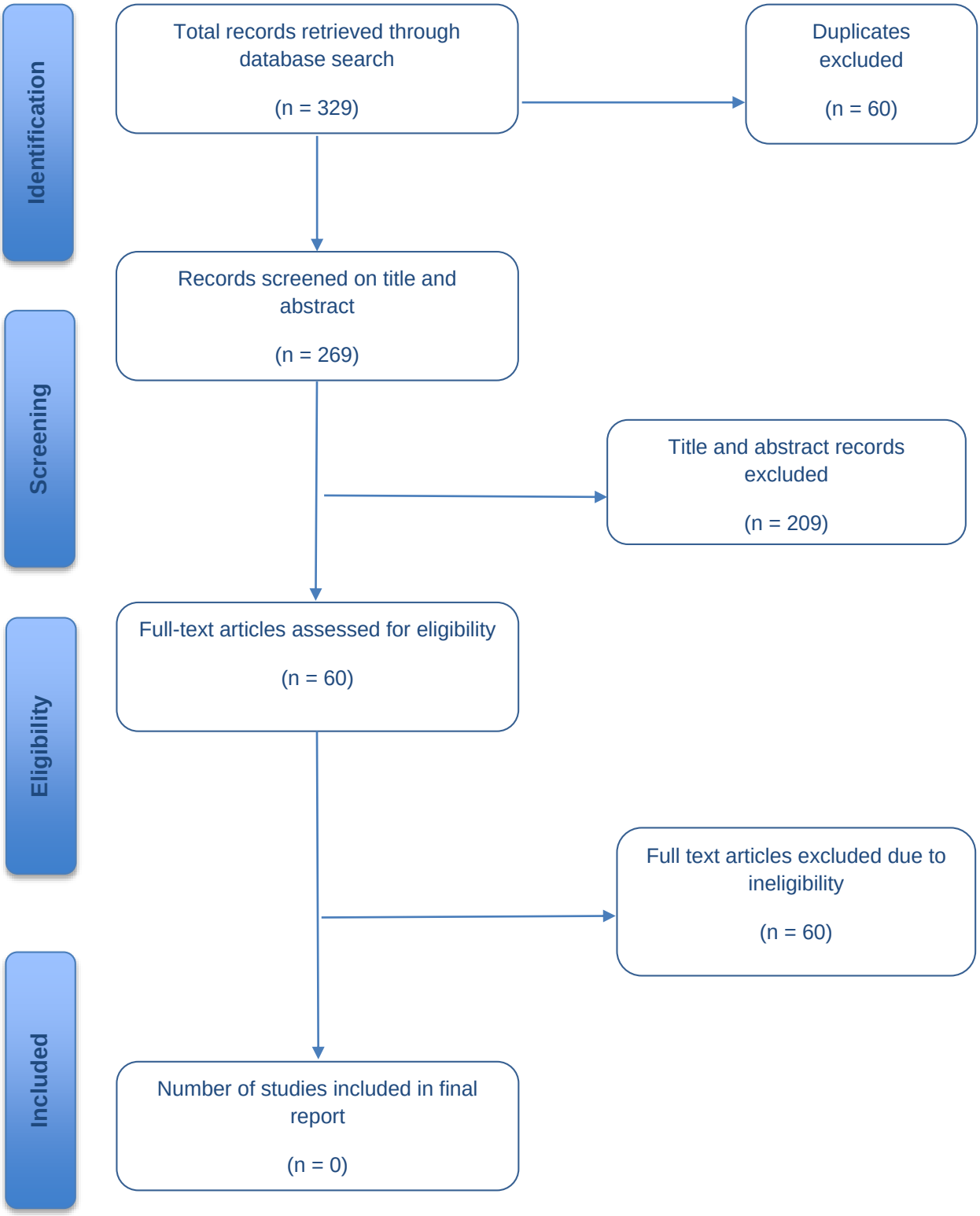
Aim 1.



Aim 2.


Identification
Screening
Eligibility
Included
Total records retrieved through database search
(n = 594)
Duplicates excluded
(n = 249)
Records screened on title and abstract
(n = 471)
Title and abstract records excluded
(n =451)
Full-text articles assessed for eligibility
(n =20)
Full text articles excluded due to ineligibility
(n = 9)
Number of studies included in final report
(n = 11)

Aim 3.


Identification
Screening
Eligibility
Included
Total records retrieved through database search
(n = 329)
Duplicates excluded
(n = 60)
Records screened on title and abstract
(n = 269)
Title and abstract records excluded
(n = 209)
Full-text articles assessed for eligibility
(n = 60)
Full text articles excluded due to ineligibility
(n = 60)
Number of studies included in final report
(n = 0)

Appendix 8: Evidence Summary

Aim 2.

Summary of Evidence: Preschool/Daycare Setting

Study	Sample Characteristics	Study Details	Condition	Method/tool	Operational Matters	Workforce Issues
Arthur (2009)	Origin of study • Canada Study setting • Kindergarten Age group • 4-5 yoa Sample characteristics of study group • no recruitment exclusion criteria • n=306	Description of study type • Cross Sectional	Vision-related issue/condition tested • Risk factors for amblyopia	Vision assessment method • PlusoptiX S04 photoscreener • Comprehensive eye examination with cyloplegic refraction	Operational and administration parameters • mail out of information/consent information • availability of photoscreeners and minimal additional equipment (table, laptop) • additional equipment to perform comprehensive eye examination including slit lamp and visual acuity cards	Workforce and capacity issues • Staff • Training screening performed by dental assistants Trained physician at Hospital of Ophthlamology
Leone (2012)	Origin of study • Australia	Description of study type • Cross Sectional	Vision-related issue/condition tested • Risk factors for amblyopia	Vision assessment method • ATS HOTV • LogMAR HOTV	Operational and administration parameters • visual acuity equipment • additional equipment to perform comprehensive eye examination including	Workforce and capacity issues • Staff • Training orthoptists or doctors trained in the study

Study	Sample Characteristics	Study Details	Condition	Method/tool	Operational Matters	Workforce Issues
	Study setting • Kindergarten Age group • 2-6.5 yoa Sample characteristics of study group • Range of Ethnicity/SES • n=2461			• ETDRS linear chart • Comprehensive eye examination with cyloplegic refraction	slit lamp and visual acuity cards	protocol
Schlenker (2009)	Origin of study • Canada Study setting • Kindergarten Age group • 4-5 yoa Sample characteristics of study group • no recruitment	Description of study type • Prospective masked cross-over study	Vision-related issue/condition tested • Risk factors for amblyopia	Vision assessment method • Sheridan Gardiner Test (SGT) • Computer-based test (CBT) (LazyeyeTest.org) • Comprehensive eye examination with cyloplegic refraction	Operational and administration parameters • child rescreened by another set of volunteers if met the referral criterion • CBT only allowed the right eye to be tested first	Workforce and capacity issues • Staff • Training SGT: trained medical student volunteers CBT: untrained medical student volunteers • full eye examination conducted by ophthalmologist

Study	Sample Characteristics	Study Details	Condition	Method/tool	Operational Matters	Workforce Issues
	exclusion criteria • n=70					
Silverstein (2009)	Origin of study • USA Study setting • preschools, day care centres, other public locations Age group • 1-5 yoa Sample characteristics of study group • no recruitment exclusion criteria • n=15,749	Description of study type • Cross Sectional	Vision-related issue/condition tested • Risk factors for amblyopia	Vision assessment method • SureSight Vision Screener • Comprehensive eye examination with cyloplegic refraction for referred children	Operational and administration parameters • repeated testing if the criterion met for referral up to three times before referral made	Workforce and capacity issues • Staff • Training trained Lions Club volunteers • gold standard eye examination performed by ophthalmologists
Longmuir (2010)	Origin of study • USA Study setting • local state registered childcare centres or through collaborations with state-sponsored	Description of study type • Cross Sectional (retrospective)	Vision-related issue/condition tested • Risk factors for amblyopia	Vision assessment method • MTI photoscreener • Comprehensive eye examination with cycloplegic refraction	Operational and administration parameters • volunteers run centres and offer free screenings • slides presentations, training manuals, screenings forms and	Workforce & capacity issues • Staff Volunteer paediatric ophthalmologist, and two full time paid employees (program coordinator and office coordinator), six

Study	Sample Characteristics	Study Details	Condition	Method/tool	Operational Matters	Workforce Issues
	organisations including Empowerments programs and churches, libraries Age group • 4-5 yoa Sample characteristics of study group • no recruitment exclusion criteria • n=147,809				photographs provided to trainers •efficacy of trained volunteers in administering the test monitored through retake rates	part-time employees (photoreader, follow-up coordinator, three office assistants, database manager); Volunteers trained by district trainers with three-hour training session; Used a part-time follow up coordinator to maintain follow up rate • Training trained volunteers; eye examination by optometrists/ ophthalmologists

Summary of Evidence: Primary Care Setting

Study	Sample Characteristics	Study Details	Condition	Method/tool	Operational Matters	Workforce Issues
Bloomberg (2013)	Origin of study • USA Study setting • Eye Clinic Age group • 54-72 moa Sample characteristics of study group • no recruitment exclusion criteria • n=99	Description of study type • Comparative study with concurrent controls • Retrospective cohort study	Vision-related issue/condition tested • Risk factors for amblyopia	Vision assessment method • PlusoptiX S04 photoscreener • Comprehensive eye examination with cyloplegic refraction	Operational and administration parameters • availability of photoscreeners and minimal additional equipment (table, laptop) • additional equipment to perform comprehensive eye examination including slit lamp and visual acuity cards	Workforce and capacity issues • Staff orthoptist or ophthalmic technician
Ciner (2011)	Origin of study • USA Study setting • Screening Centre	Description of study type • Cross Sectional	Vision-related issue/condition tested • Risk factors for amblyopia	Vision assessment method • Retinomax Autorefractor • Palm-AR Autorefractor • Comprehensive eye examination with cyloplegic refraction	Operational and administration parameters •room set up for vision screening GSE examinations conducted in specially equipped vans at the screening centre	Workforce and capacity issues • Staff • Training trained non-eyecare professional screeners; Gold standard eye examination (GSE); optometrists/

Study	Sample Characteristics	Study Details	Condition	Method/tool	Operational Matters	Workforce Issues
	Age group • 3-5 yoa Sample characteristics of study group • children participating in the Head Start Program; children at high risk of a vision disorder • n=306					ophthalmologists
Cyert (2010)	Origin of study • USA Study setting • Vision in Preschoolers Clinical Centres Age group • 3-5 yoa Sample characteristics of study group • children participating in the Head Start	Description of study type • Cross Sectional	Vision-related issue/condition tested • Risk factors for amblyopia	Vision assessment method • Lea Symbols • HOTV • Comprehensive eye examination with cyloplegic refraction	Operational and administration parameters •room set up for vision screening GSE examinations conducted in specially equipped vans at the screening centre	Workforce and capacity issues • Staff • Training optometrists/ ophthalmologists

Study	Sample Characteristics	Study Details	Condition	Method/tool	Operational Matters	Workforce Issues
	Program; children at high risk of a vision disorder • n=1142					
Matsuo (2009)	Origin of study • Japan Study setting • regional public health centres Age group • 3.5 yoa Sample characteristics of study group • no recruitment exclusion criteria • n=265	Description of study type • Cross Sectional	Vision-related issue/condition tested • Risk factors for amblyopia	Vision assessment method • Autorefractor AR-20 type R • Comprehensive eye examination with cyloplegic refraction	Operational and administration parameters • hand held autorefractor • materials for visual acuity testing	Workforce and capacity issues • Staff • Training Visual acuity: family members/nurses; refraction by trained examiner; eye examination by paediatrician/doctor; full examination by ophthalmologist
Moll (2009)	Origin of study • USA Study setting • paediatric	Description of study type • Cross Sectional	Vision-related issue/condition tested • Risk factors for amblyopia	Vision assessment method • Random Dot Stereo Butterfly Test • Comprehensive eye examination with	Operational and administration parameters • visual acuity equipment • additional equipment to perform comprehensive eye examination including slit	Workforce and capacity issues • Staff • Training ophthalmologist

Study	Sample Characteristics	Study Details	Condition	Method/tool	Operational Matters	Workforce Issues
	ophthalmologist's office Age group • 3-6 yoa Sample characteristics of study group • children referred to a paediatric ophthalmologist from outside screening program • n=306			cyloplegic refraction	lamp and visual acuity cards	
Ying (2010)	Origin of study • USA Study setting • Vision in Preschoolers Clinical Centres Age group • 3-4 yoa	Description of study type • Cross Sectional	Vision-related issue/condition tested • Risk factors for amblyopia	Vision assessment method • SureSight Vision Screener • Comprehensive eye examination with cyloplegic refraction	Operational and administration parameters •room set up for vision screening GSE examinations conducted in specially equipped vans at the screening centre	Workforce and capacity issues • Staff • Training optometrists/ ophthalmologists

Study	Sample Characteristics	Study Details	Condition	Method/tool	Operational Matters	Workforce Issues
	Sample characteristics of study group • children participating in the Head Start Program; children at high risk of a vision disorder • n=1452					

Appendix 9: Evaluation of the Evidence for Aim 2

Study	Setting	Study Type	Level of Evidence	Overall Paper Grading	Screening Test	Screening Program
Arthur et al 2009	Kindergarten	Cross Sectional	Level IV	Fair	**Simple, quick & easy to interpret** • no **Acceptable to public** • yes **Accurate** • yes **Repeatable** • yes **Sensitive** • yes **Specific** • yes	**Important health problem** • yes **Accepted treatment** • yes **Facilities for diagnosis and treatment** • yes **Latent or early symptomatic stage** • yes **Suitable test or examination** • yes **Test acceptable to the population** • yes **Natural history adequately understood** • yes **Agreed policy on whom to treat** • yes **The cost of case-finding balanced with expenditure on medical care as a whole** • unknown

Study	Setting	Study Type	Level of Evidence	Overall Paper Grading	Screening Test	Screening Program
Bloomberg et al (2013)	Eye clinic	Cohort Study	Level III-3	Fair	**Simple, quick & easy to interpret** • yes **Acceptable to public** • yes **Accurate** • yes **Repeatable** • unknown **Sensitive** • yes **Specific** • yes	**Important health problem** • yes **Accepted treatment** • yes **Facilities for diagnosis and treatment** • yes **Latent or early symptomatic stage** • yes **Suitable test or examination** • yes **Test acceptable to the population** • yes **Natural history adequately understood** • yes **Agreed policy on whom to treat** • yes **The cost of case-finding balanced with expenditure on medical care as a whole** • unknown
Ciner et al (2011)	Screening Centre	Cross Sectional	Level III-3	Fair	**Simple, quick and easy to interpret** • yes **Acceptable to public** • yes **Accurate**	**Important health problem** • yes **Accepted treatment** • yes

Study	Setting	Study Type	Level of Evidence	Overall Paper Grading	Screening Test	Screening Program
					• unknown **Repeatable** • unknown **Sensitive** • Yes **Specific** • Yes	**Facilities for diagnosis and treatment** • yes **Latent or early symptomatic stage** • yes **Suitable test or examination** • yes **Test acceptable to the population** • yes **Natural history adequately understood** • yes **Agreed policy on whom to treat** • yes **The cost of case-finding balanced with expenditure on medical care as a whole** • unknown
Cyert et al (2010)	Vision in Preschoolers Clinical Centres	Cross Sectional	Level III-3	Fair	**Simple, quick and easy to interpret** • yes **Acceptable to public** • yes **Accurate** • no **Repeatable** • unknown **Sensitive** • yes **Specific**	**Important health problem** • yes **Accepted treatment** • yes **Facilities for diagnosis and treatment** • yes **Latent or early symptomatic stage** • yes

Study	Setting	Study Type	Level of Evidence	Overall Paper Grading	Screening Test	Screening Program
					• yes	**Suitable test or examination** • yes **Test acceptable to the population** • yes **Natural history adequately understood** • yes **Agreed policy on whom to treat** • yes **The cost of case-finding balanced with expenditure on medical care as a whole** • unknown
Leone et al (2012)	Kindergarten	Cross Sectional	Level III-3	fair	**Simple, quick and easy to interpret** • unknown **Acceptable to public** • yes **Accurate** • unknown **Repeatable** • unknown **Sensitive** • unknown **Specific** • unknown	**Important health problem** • yes **Accepted treatment** • yes **Facilities for diagnosis and treatment** • yes **Latent or early symptomatic stage** • yes **Suitable test or examination** • yes **Test acceptable to the population** • yes

Study	Setting	Study Type	Level of Evidence	Overall Paper Grading	Screening Test	Screening Program
						Natural history adequately understood • yes **Agreed policy on whom to treat** • yes **The cost of case-finding balanced with expenditure on medical care as a whole** • unknown
Longmuir et al. (2010)	Local state registered childcare centres or through collaborations with state-sponsored organisations including Empowerment programs and churches, libraries	Cross sectional (retrospective)	Level III-3	poor	**Simple, quick and easy to interpret** • no **Acceptable to public** • yes **Accurate** • yes **Repeatable** • unknown **Sensitive** • unknown **Specific** • unknown	**Important health problem** • yes **Accepted treatment** • yes **Facilities for diagnosis and treatment** • yes **Latent or early symptomatic stage** • yes **Suitable test or examination** • unknown **Test acceptable to the population** • yes **Natural history adequately understood** • yes **Agreed policy on whom to treat** • yes

Study	Setting	Study Type	Level of Evidence	Overall Paper Grading	Screening Test	Screening Program
						The cost of case-finding balanced with expenditure on medical care as a whole • unknown
Matsuo et al. (2009)	Regional public health centres	Cross Sectional	Level III-3	Poor	**Simple, quick and easy to interpret** • yes **Acceptable to public** • yes **Accurate** • no **Repeatable** • unknown **Sensitive** • unknown **Specific** • unknown	**Important health problem** • yes **Accepted treatment** • yes **Facilities for diagnosis and treatment** • yes **Latent or early symptomatic stage** • yes **Suitable test or examination** • no **Test acceptable to the population** • yes **Natural history adequately understood** • yes **Agreed policy on whom to treat** • yes **The cost of case-finding balanced with expenditure on medical care as a whole** • unknown

Study	Setting	Study Type	Level of Evidence	Overall Paper Grading	Screening Test	Screening Program
Moll et al. (2009)	Paediatric ophthalmology offices	Cross sectional	Level III-3	fair	**Simple, quick and easy to interpret** • yes **Acceptable to public** • yes **Accurate** • no **Repeatable** • unknown **Sensitive** • yes **Specific** • yes	**Important health problem** • yes **Accepted treatment** • yes **Facilities for diagnosis and treatment** • yes **Latent or early symptomatic stage** • yes **Suitable test or examination** • no **Test acceptable to the population** • yes **Natural history adequately understood** • yes **Agreed policy on whom to treat** • yes **The cost of case-finding balanced with expenditure on medical care as a whole** • unknown
Schlenker et al. (2010)	Kindergarten	Prospective masked cross over study	Level III-3	Fair	**Simple, quick and easy to interpret** • yes **Acceptable to public** • yes **Accurate**	**Important health problem** • yes **Accepted treatment** • yes

Study	Setting	Study Type	Level of Evidence	Overall Paper Grading	Screening Test	Screening Program
					• yes **Repeatable** • yes **Sensitive** • yes **Specific** • yes	**Facilities for diagnosis and treatment** • yes **Latent or early symptomatic stage** • yes **Suitable test or examination** • yes **Test acceptable to the population** • yes **Natural history adequately understood** • yes **Agreed policy on whom to treat** • yes **The cost of case-finding balanced with expenditure on medical care as a whole** • unknown
Silverstein et al (2009)	Preschools, day care, other public locations	Cross sectional	Level III-3	Fair	**Simple, quick and easy to interpret** • yes **Acceptable to public** • yes **Accurate** • yes **Repeatable** • yes **Sensitive** • unknown	**Important health problem** • yes **Accepted treatment** • yes **Facilities for diagnosis and treatment** • yes **Latent or early symptomatic stage** • yes

Study	Setting	Study Type	Level of Evidence	Overall Paper Grading	Screening Test	Screening Program
					Specific • unknown	**Suitable test or examination** • unknown **Test acceptable to the population** • yes **Natural history adequately understood** • yes **Agreed policy on whom to treat** • yes **The cost of case-finding balanced with expenditure on medical care as a whole** • unknown
Ying et al (2010)	Vision in Preschoolers Clinical Centres	Cross sectional	Level III-3	Fair	**Simple, quick and easy to interpret** • yes **Acceptable to public** • yes **Accurate** • yes **Repeatable** • yes **Sensitive** • yes **Specific** • yes	**Important health problem** • yes **Accepted treatment** • yes **Facilities for diagnosis and treatment** • yes **Latent or early symptomatic stage** • yes **Suitable test or examination** • yes **Test acceptable to the population** • yes

Study	Setting	Study Type	Level of Evidence	Overall Paper Grading	Screening Test	Screening Program
						Natural history adequately understood • yes **Agreed policy on whom to treat** • yes **The cost of case-finding balanced with expenditure on medical care as a whole** • unknown

Appendix 10 Criteria for the appraisal of Diagnostic Accuracy

Aim 2

Study	Representative Spectrum	Random or Consecutive Sample	Screening test adequately described	Screening cutoffs predefined	Credible reference standard	Reference standard applied to all screened patients	Same reference standard applied to all patients	Reference Standard and screening examination interpreted independently	High rate of uninterpretable results or non-compliance with screening test	Analysis includes patients with uninterpretable results or noncompliance	Rating criteria
Arthur et al 2009	Yes	Cannot tell	Yes	Yes	Yes	Yes	Yes	Yes	No	NA	fair
Bloomberg et al 2013	No	Cannot tell	Yes	Yes	Yes	Yes	Yes	Yes	No	No	fair
Ciner et al 2011	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	fair
Cyert et al 2010	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	fair
Leone et al 2012	Yes	Cannot tell	Yes	No	Yes	Yes	Yes	Unclear	No	No	fair
Longmuir et al 2010	No	Cannot tell	Yes	Yes	Yes	No	Yes	Yes	Unclear	No	poor
Matsuo et al 2009	No	Cannot tell	Yes	Yes	No	No	No	Yes	Yes	No	poor
Moll et al 2009	No	No	Yes	Yes	Yes	Yes	Yes	No	No	Yes	fair
Schlenker et al 2010	Yes	No	Yes	Yes	Yes	Yes	Yes	Unclear	No	Yes	fair
Silverstein et al 2009	Yes	Cannot tell	Yes	Yes	Yes	No	Yes	Yes	No	Yes	fair
Ying et al 2010	No	Cannot tell	Yes	No	Yes	Yes	Yes	Yes	No	No	fair

Appendix 11: Citation List by Ranking

Aim 2: Vision screening tests

Type of Program/ Service Model	Studies	Method/Tool
Supported		
Promising		
• Preschool/Daycare Setting • Primary Care Setting	• Arthur et al 2009	• PlusoptiX S04 photoscreener • Comprehensive eye examination with cyloplegic refraction
	• Schlenker et al 2010	• Sheridan Gardiner Test (SGT) • Computer-based test (CBT) (LazyeyeTest.org) • Comprehensive eye examination with cyloplegic refraction
	• Cyert et al 2010	• Lea Symbols • HOTV • Comprehensive eye examination with cyloplegic refraction
	• Moll et al 2009	• Random Dot Butterfly Test • Comprehensive eye examination with cyloplegic refraction
	• Bloomberg et al 2013	• PlusoptiX S04 photoscreener • Comprehensive eye examination with cyloplegic refraction
Unknown		
• Preschool/Daycare Setting	• Leone et al 2012	• ATS HOTV • LogMAR HOTV • ETDRS linear chart • Comprehensive eye examination with cyloplegic refraction
	• Longmuir et al 2010	• MTI photoscreener • Comprehensive eye examination with cycloplegic refraction
Not Supported		
• Preschool/Daycare Setting • Primary Care Setting	• Silverstein et al 2009	• SureSight Vision Screener • Comprehensive eye examination with cyloplegic refraction for referred children
	Ciner et al 2011	• Retinomax Autorefractor • Palm-AR Autorefractor

Type of Program/ Service Model	Studies	Method/Tool
	• Matsuo et al 2009	• Comprehensive eye examination with cyloplegic refraction • Autorefractor AR-20 type R • Comprehensive eye examination with cyloplegic refraction