

NATIONAL CHILDREN'S VISION SCREENING PROJECT

Final Report

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The participants who provided their time and professional knowledge throughout the public consultation process, in each Australian state and territory.

TABLE OF CONTENTS

GLOSSARY	ii
LIST OF FIGURES / TABLES	ii
1. EXECUTIVE SUMMARY	1
1.1. Screening tests and screening programs.....	1
2. INTRODUCTION	8
2.1. Aims of the Project / Steps involved.....	10
2.2. Screening tests and screening programs.....	11
3. METHODOLOGY	13
3.1. Project Advisory Group	13
3.2. Literature Review	16
3.3. Consultations	19
4. FINDINGS.....	22
4.1. Literature Review	22
4.2. Project Advisory Group	25
4.3. Consultations	30
5. DISCUSSION	36
6. DIRECTIONS FROM THE LITERATURE AND CONSULTATION	43
7. REFERENCES	49
8. APPENDICES.....	53
Appendix one: Literature Review	
Appendix two: Discussion Paper	
Appendix three: Consultations	
a) Expression of Interest registration form for focus group consultations	
b) Consultation Participant Matrix (by Profession)	
c) Consultation Data Summary	
Appendix Four: Characteristics of Visual Activity Tests	

GLOSSARY

CCCH	Centre for Community Child Health
NHMRC	National Health & Medical Research Council
NEHI	National Eye Health Initiative
National Eye Health	National Framework for Action to Promote Eye Health & Prevent Avoidable Blindness & Vision Loss
CERA	Centre for Eye Research Australia
RANZCO	Royal Australian & New Zealand College of Ophthalmologists
Child & Family Health Nurse	This term is used in reference to community-based nurses across Australia. Each state / territory has a slightly different title for nurses responsible for developmental checks in early childhood and monitoring of maternal health, including <i>Maternal & Child Health Nurse</i> in Victoria, and <i>Child & Parenting Nurse</i> in Tasmania.

LIST OF FIGURES / TABLES

Table 1: Project Advisory Group Membership	14
Table 2: Criteria for Screening Programs	40
Figure 1: Steps of the proposed screening program	7
Figure 2: Criteria for a Screening Program, Wilson, J.M. and Jungner, Y.G. (1968)	17
Figure 3: Steps of the proposed screening program	47

1. EXECUTIVE SUMMARY

The Centre for Community Child Health (CCCH) at the Murdoch Childrens Research Institute received funding under the Australian Government Department of Health and Ageing, Eye Health Demonstration Grants program to evaluate the effectiveness of vision screening in Australian children aged 0 – 16 years, to consult with interest groups and stakeholders regarding recommendations for vision screening in Australia and to report back to government with final recommendations and guidelines for children’s vision screening.

The project arose as a result of the National Health and Medical Research Council’s 2002 review (Child Health Screening and Surveillance: A critical review of the evidence). The review had been influential in informing the conceptual thinking around early identification of vision conditions, but had not translated into the development of a national approach to preschool and school vision screening for children across Australia. A systematic approach that not only reviewed the current research, but worked with state and territory health departments and other key stakeholders to translate this research into practical recommendations of changes was required, and is the main aim of the CCCH Vision Screening Project.

At present, all Australian states and territories have systems in place to offer testing of children’s vision to some degree. While some states/territories offer universal screening of all children prior to or following school entry, others offer only targeted screening for at-risk children or those with an obvious vision concern. Much of the screening or assessment that currently occurs prior to a child entering school relies on parents or caregivers being vigilant in taking their child along to regular checks, usually with child health nurses; many of these checks have a poor uptake rate.

1.1. Screening tests and screening programs

Screening *tests* differ from screening *programs*, and criteria provided by Wilson and Junger (1968) are useful in assessing a program to determine its suitability for a screening program. An important consideration for a screening program is that it supports the target population from their enrolment in the program through the referral pathway, and into treatment. A screening test is one component of the screening program, and a visual acuity test is the major example of a screening test considered in this report.

METHODOLOGY

The CCCH Vision Screening Project involved five key steps:

1. The establishment of a Project Advisory Group and development of a detailed workplan.
2. The completion of a systematic literature review.
3. The examination of the research evidence and the development of flexible best practice models of vision screening for key age groups.
4. National consultations with state and territory health departments and service providers to present the effectiveness literature; to examine current screening practices; to receive feedback on proposed vision screening models and to determine future action.
5. Report on the directions supported by the evidence and consultations (through this Final Report) regarding the key components of a coordinated national childhood vision screening program, which has the flexibility to adapt to system / workforce variances in each state and territory.

The three key objectives of the literature review were to determine:

- *Is a screening program the most appropriate method to use to detect vision conditions in children?*
- *What types of vision screening programs appear to be effective and therefore what properties or processes do programs require in order to be effective?*
- *At what age/s and how often should children attend a vision screen, if screening is deemed an effective method by which to detect vision conditions?*

The Project Team met with the Steering Group, and later with the Project Advisory Group to discuss the findings from the consultations. The suggestions that are included in section 6 of this report take into consideration the directions provided by the formal evidence, as well as the consultation data, and the expert opinion of the Project Advisory Group.

KEY FINDINGS

The findings of the National Children's Vision Screening Project outline the numerous components of a comprehensive vision screening program, highlighting

the complexity of developing such a program for the Australian context. There are various programs currently in place across the country that aim to assess children's visual acuity, and identify risk factors for vision impairment; however, members of the Project Advisory Group and consultation participants agreed that an opportunity exists to modify current practice in some jurisdictions, aligning practice with evidence from the literature.

Is vision screening supported by the literature?

The prevalence rates for amblyopia and other vision impairments documented in the literature were validated by expert consultation. The prevalence rates highlight the fact that vision impairment is an important health problem in Australia and provide a rationale for a screening program. Expert and public consultation also raised functional vision as being an associated issue that is not thoroughly addressed in the literature.

There was strong expert and public support to continue the vision check that is current practice during the neonatal period, however, further research is required to determine the most suitable age for this check, and if a follow-up check is advisable.

Prevalence data, natural history, and research evidence highlight early identification of amblyopia as being the major focus of any childhood vision screening program.

There was low level evidence to support visual acuity screening on one occasion between 18 months and 5 years. The evidence suggested that visual acuity testing is more reliable from 3.5 years of age. Expert and community consultation supported screening at about 4 years as the best balance between reliability/accuracy and early diagnosis aiding successful treatment.

An opportunity exists for research to be conducted to further investigate the effectiveness of treatment at different ages; further research concerning the possibility that some vision conditions will 'self-correct'; as well as the impact amblyopia and functional vision impairment has on a person's quality of life.

Visual acuity tests

There are a range of suitable tests being used in current vision checking programs in Australia. This was not a specific focus of the literature review; however, the Project Advisory Group outlined criteria for suggested tests to ensure quality. The public

consultation data varied in the type of test considered most suitable, as mainly the professionals involved in vision checks strongly supported the test that they were using at present. In many cases, this test had been chosen to meet the needs of the demographics of the area involved in the screening program. For example, matching LEA symbols was considered the most appropriate test to use in the Northern Territory, and New South Wales have chosen a linear Sheridan-Gardiner for their screening program. Those involved in primary screening strongly support a suite of tests from which to choose, to enable them to meet the needs of their community.

The literature and expert opinion were supported by public consultation opinion that testing vision using a visual acuity chart is acceptable to the population as it is not invasive and is widely used as part of existing practice.

Treatment for the disease

The options for treatment of amblyopia discussed in the literature review include patching and the prescription of spectacles, or glasses. Treatment is advised for children under the age of seven, as a child's visual pathway is still developing and there is opportunity for very successful correction.

The advice received from the public consultation process supported the commencement of treatment prior to school entry (approximately age four) as the most appropriate. This advice was offered in consideration of the natural development of vision, as well as the Australian context where children from age five (dependant on the jurisdiction) will enter school. The school playground is acknowledged as a site for potential bullying of children who are involved in treatment such as patching, and as a result, child compliance with treatment may decrease.

The Project Advisory Group suggested a co-management system between optometrists and ophthalmologists is a suitable model for management of children identified by the proposed universal program, especially in areas such as the Northern Territory that rely upon ophthalmologists to visit from other states. The public consultation data strongly advocates for workforce development and training as a necessary aspect if a screening program was to be implemented across Australia.

There was varying opinion regarding the most suitable visual acuity level to utilise as the cut-off for onward referral given the lack of data on the functional and quality of life impacts of mild vision impairment. Whilst the literature recommended a visual acuity of less than 6/9, the World Health Organisation defines vision impairment as visual acuity of less than 6/18 in the better eye. The Project Advisory Group could not initially reach consensus on whether less than 6/9 or less than 6/12 is the most appropriate. However, since current practice in Australia refers children with a visual acuity of less than 6/9 (as evident from the public consultations), the Project Advisory Group was guided by this convention when advising that referral for a vision assessment would be indicated by a visual acuity of less than 6/9 or two or more lines of difference between the two eyes.

Cost considerations

There is minimal formal evidence available to verify the cost-effectiveness of a vision screening program, with only a few studies conducting a formal economic analysis. The Project Advisory Group and the public consultation participants were not suitably qualified to provide further clarification on the issue.

The consultation data strongly suggested that the primary barriers for families in engaging with the treatment stage of the proposed screening program are financial. The formal evidence and the evidence obtained through consultation both suggest that any screening program should incorporate follow-up procedures to facilitate compliance, in an effort to remove or reduce the barriers encountered by families.

DIRECTIONS SUPPORTED BY LITERATURE AND CONSULTATION

- A universal vision screening program for all Australian children in the year prior to commencing formal school is supported by the literature and consultation. The most appropriate age for visual acuity testing is when a child is four years old (with a range from 3.5 to 5 years of age).
- It is advised that the red reflex check for an infant be retained as part of a universal health check.
- A co-management system is suggested for screening, evaluation and treatment. This would involve child and family health nurses, optometrists, orthoptists and GPs as primary screeners; and collaboration between

optometrists, orthoptists, and ophthalmologists for further evaluation, diagnosis and treatment, to utilise available resources. It is strongly suggested that an eye-health professional is responsible for further evaluation where indicated by the primary screen.

- There was strong support for training and workforce development to be a critical consideration for the implementation of a national screening program.
- A visual acuity level of less than 6/9 in either eye, and/or two lines difference, between the eyes for a four year old requires onward referral. A visual acuity level in a four year old of less than 6/18 in either eye requires a priority / urgent referral.
- Children who are considered to be at risk of vision impairment (Indigenous children; premature infants; and children with a developmental delay or disability) should be included in a universal screening program, however, a scheme is necessary to ensure these children receive a comprehensive eye-examination.

Further research

The Project Advisory Group and the Project Team were challenged by the lack of formal evidence in some areas of vision screening and identified the following areas for future research:

- The importance of a follow-up check of the red-reflex (newborn check), and the most appropriate age that this should be conducted.
- Further evidence is required concerning functional vision for school-age children. Questions still exist around the level of visual-acuity required for an appropriate level of functional vision, and the impact of other vision conditions affecting visual function.
- There is an opportunity to further investigate the impact of a reduced level of vision on a person's quality of life, perhaps focusing on different life stages eg. middle childhood; adulthood; retirement.
- The efficacy of interventions. For example, how effective prescribed treatment of patching in children age eight is, considering issues such as compliance, as well as improved vision.

- An economic analysis of a vision screening program for children using quality of life data and considering the details of the Australian context.

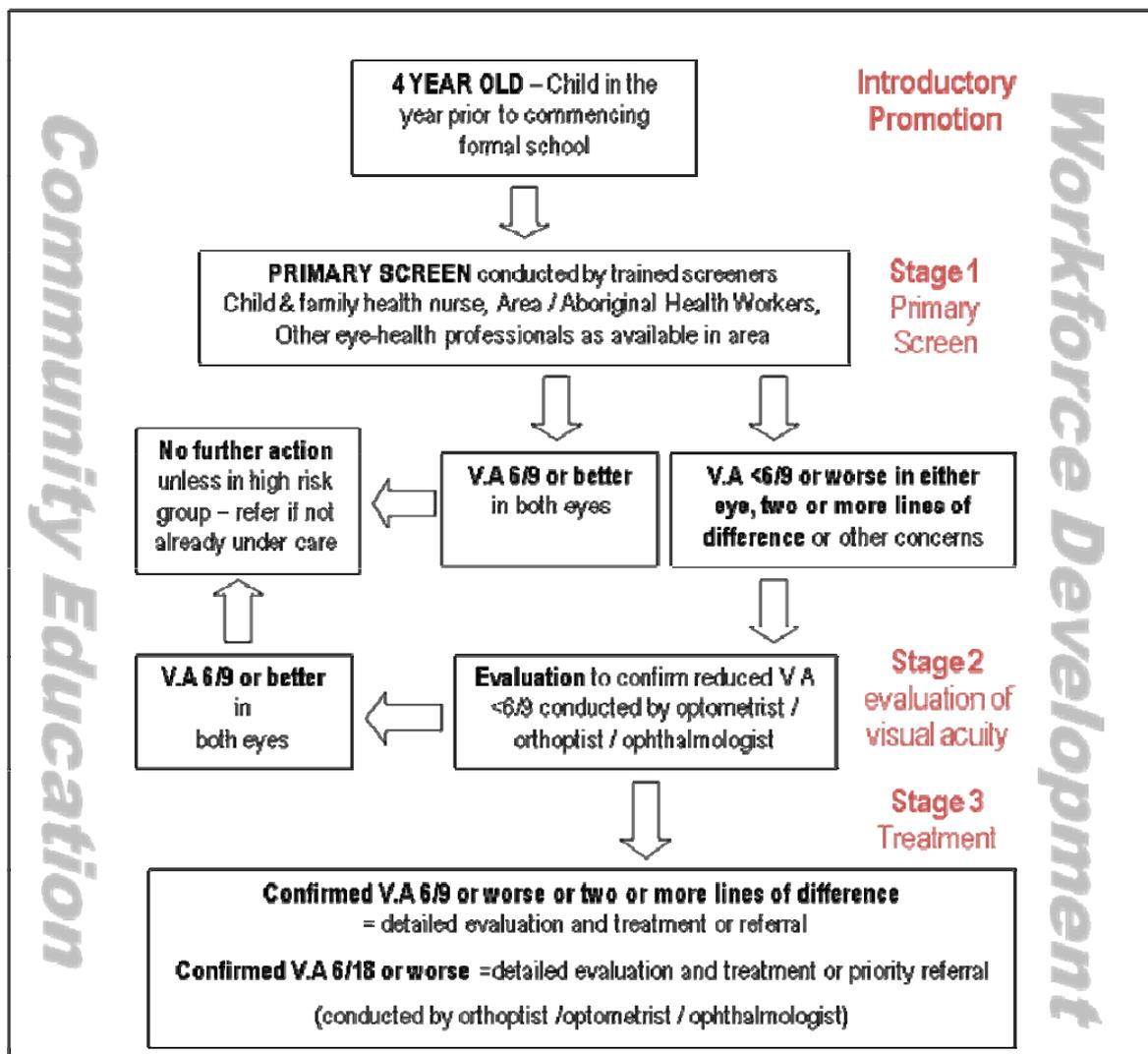
Dissemination of the Final Report

The Project Team and Project Advisory Group propose that this Final Report be made available for wider consideration and professional use. The following websites were identified as possible ways to disseminate the report:

- Centre for Community Child Health
- Vision 2020
- RANZCO

Figure 1 demonstrates the referral pathway and professionals responsible for each stage in the screening program.

Figure 1: Steps of the proposed screening program



2. INTRODUCTION

In July 2004 the Australian Health Ministers' Conference agreed on the need to develop a National Eye Health Plan for Australia to promote eye health and reduce the incidence of avoidable blindness. This initiative represents Australia's response to World Health Assembly resolution WHA56.26 on the elimination of avoidable blindness in member countries. Although Australia has excellent eye health care services in comparison to most other countries, there is scope for further improvement in the systems and quality of care.

The *National Framework for Action to Promote Eye Health and Prevent Avoidable Blindness and Vision Loss* (National Eye Health Framework) was developed to provide a structure for governments, health professionals, non-government organisations, industry and individuals to work in partnership. The National Eye Health Framework was endorsed by Australian Health Ministers in November 2005.

In accordance with the World Health Assembly resolution, the focus of the National Eye Health Framework was on the proactive elimination of avoidable blindness and vision loss in Australia, rather than on the reactive provision of treatment services. Avoidable blindness and vision loss refer to vision impairment due to conditions that are potentially preventable through the modification of known risk factors, or for which effective treatments exist to restore sight or prevent further vision loss.

The key areas for action for the National Eye Health Framework were the following:

- Reducing the risk of eye disease and injury
- Increasing early detection
- Improving access to eye health care services
- Improving the systems and quality of care
- Improving the underlying evidence base

Information regarding the National Eye Health Framework, and the document, can be located at:

<http://www.health.gov.au/internet/main/publishing.nsf/Content/ageing-eyehealth-framework.htm>

In the 2006-07 Federal Budget the Australian Government provided funding of \$13.8 million over four years for a National Eye Health Initiative (NEHI) to promote eye health and to strengthen eye health care service delivery. The NEHI will fund a range of activities, including:

- Eye health promotion activities to encourage Australians to look after their eyes
- An eye health demonstration grants program

Activities funded under the Eye Health Demonstration Grants Program are intended to support the implementation of the National Eye Health Framework. Funding was made available for demonstration projects that trialled and evaluated new approaches to the delivery of eye health care to support the implementation of the National Eye Health Framework. This component of the National Eye Health Initiative aimed to identify, trial and evaluate strategies to:

- Overcome inefficiencies in the delivery of eye health care
- Improve access to eye health care, particularly for marginalised and disadvantaged groups, including people in rural and remote communities and Aboriginal and Torres Strait Islanders
- Improve the quality and safety of eye health care

Funding was provided to projects that had the potential to enhance the delivery of eye health care and improve the quality and safety of care. Priority was given to proposals that targeted marginalised and disadvantaged people or groups at particular risk of eye disease and injury.

Murdoch Childrens Research Institute's Centre for Community Child Health (CCCH) received funding under the Eye Health Demonstration Grants program to evaluate the effectiveness of vision screening in Australian children aged 0 – 16 years, to consult with interest groups and stakeholders regarding their suggestions for vision screening in Australia and to report back to government outlining the directions from the evidence and consultation for a children's vision screening program. The National Health and Medical Research Council's 2002 review (Child Health Screening and Surveillance: A critical review of the evidence) had been influential in informing the conceptual thinking around early identification of vision conditions, but

had not translated into the development of a national approach to preschool and school vision screening for children across Australia. A systematic approach that not only reviewed the current research, but worked with state and territory health departments and other key stakeholders to translate this research into practical suggestions for change was required, and is the main aim of the CCCH Vision Screening Project.

2.1. Aims of the Project / Steps involved

The CCCH Vision Screening Project involved six key steps:

1. The establishment of a Project Advisory Group and a detailed workplan.

A Project Advisory Group was established to advise on the planning and implementation of the project, and includes representation from CanDo4Kids, the Centre for Eye Research Australia (CERA), Optometrists Association Australia, the Orthoptic Association of Australia, Royal Australian and New Zealand College of Ophthalmologists (RANZCO) and Vision 2020 Australia. Joint meetings between the CCCH Project Team and the Project Advisory Group were organised throughout the project term.

A detailed workplan, including timelines, was developed for the project and submitted to the Department of Health and Ageing.

2. The completion of a systematic literature review.

A systematic literature review was conducted to identify current Australian and international literature on the effectiveness, including cost effectiveness, of childhood vision screening, carried out prior to and during school years. The literature review also included a table of current practice in relation to vision screening programs in Australia. (Follow this link for a copy of the literature review: http://www.rch.org.au/ccch/resources.cfm?doc_id=10545).

3. The examination of the research evidence and the development of flexible best practice models of vision screening for key age groups.

The literature was analysed and gaps in the research were identified in consultation with recognised experts in the field of vision and eye health (the Project Advisory Group and associated networks).

Evidence on the following components of vision screening programs were considered by the Project Advisory Group and CCCH Project Team: recommended tools; most appropriate age(s) to screen; most appropriate screening personnel, and follow-up or referral pathways. The following vision conditions were examined: cataracts and other serious but uncommon disorders of the eye in early infancy; amblyopia; refractive error and the conditions that may contribute to it including strabismus and hyperopia; binocular vision and accommodative disorders.

4. The development of a Discussion Paper to present the evidence obtained through a review of the literature; and to guide the discussion and feedback sought through the national consultations.
5. National consultations with state and territory health departments and service providers to present the effectiveness literature; to examine current screening practices; to receive feedback on proposed vision screening models and to determine future action.
6. Reporting on the directions supported by the evidence and consultations (through this Final Report) regarding the key components of a coordinated national childhood vision screening program, which has the flexibility to adapt to system / workforce variances in each state and territory.

At present, all Australian states and territories have systems in place to offer testing of children's vision to some degree. While some states/territories offer universal screening of all children prior to or following school entry, others offer only targeted screening for at-risk children or those with an obvious vision concern. Much of the screening or assessment that currently occurs prior to a child entering school relies on parents or caregivers being vigilant in taking their child along to regular checks, usually with child health nurses; and many of these screening procedures have a poor uptake rate.

2.2. Screening tests and screening programs

Screening *tests* differ from screening *programs*, and criteria provided by Wilson and Junger (1968) as referred to on page 17 of this report, are useful in assessing a program to determine its suitability for a screening program. An important consideration for a screening program is that it caters for the target population from

their enrolment in the program through the referral pathway, and into treatment. A screening test is one component of the screening program, and a vision test using a visual acuity chart is the major example of a screening test considered in this report.

3. METHODOLOGY

The National Children's Vision Screening Project consisted of three main, interrelated stages that were undertaken separately; the Literature Review (Appendix 1), consultation with the expert Project Advisory Group, and consultation with eye-health professionals and Government representatives in each Australian state and territory. Although the stages were executed separately, there was a close relationship between each stage and the suggestions and conclusions from each stage informed the subsequent stages.

The project's stages were largely determined by the funding received under the Eye Health Demonstration Grants program. The funding was provided for evaluation of the effectiveness of vision screening in Australian children aged 0 – 16 years (presented in the Literature Review), and to consult with interest groups and stakeholders regarding their recommendations for vision screening in Australia. Consultation with the Project Advisory Group occurred at key stages throughout the project, and state and territory consultations were held with interest groups and stakeholders.

The final phase in the project involves reporting back to government outlining the directions supported by the evidence and consultations regarding children's vision screening – this final report. The Project Team has adopted a systematic approach for the duration of the project, which not only reviewed the current research, but worked with state and territory health departments and other key stakeholders to translate this research into practical suggestions.

Each project stage is outlined in more detail in the following sections.

3.1. Project Advisory Group

The Project Advisory Group was established during the proposal and set-up stages of the project, to provide expert guidance at key stages throughout the project. The Group was represented by seven organisations specialising in eye health (including optometry, orthoptics, and ophthalmology), sensory impairment, and community health for children. Each organisation was also a member of Vision 2020 Australia, the peak body for the eye health and vision sector. Membership included:

Table 1: Project Advisory Group Membership

Organisation	Representative/s
CanDo4Kids	Claire Cotton Marie Steinke
Centre for Eye Research Australia (CERA)	Associate Professor Jill Keeffe Professor Hugh R Taylor AC
Vision 2020 Australia	Jennifer Gersbeck Sue Heward Sophie Plumridge
Optometrists Association Australia	Rod Baker Joseph Chakman Kirsty Machon Shirley Loh
Royal Australian and New Zealand College of Ophthalmologists (RANZCO)	Associate Professor Frank Martin
Orthoptic Association of Australia	Dr (Connie) Konstandina Koklanis

The role of the Project Advisory Group was to provide expert advice to the project team regarding vision screening and eye health practices throughout the project term, including:

- Consultation and expert review for the preparation and delivery of:
 - Project methodology
 - Systematic literature review
 - Discussion paper
 - Vision screening model options

- Final report (including suggestions and directions supported by evidence and consultation)

The Project Team and the Project Advisory Group met at key stages throughout the project, and the Team also sought advice and further information from members of the Project Advisory Group in between these meetings.

The Project Advisory Group guided the Project regarding:

- Defining the boundaries of the project, to determine the scope for the research methodology.
 - The literature review included an age range of 0 to 16 years, and the following conditions: cataracts, and other serious but uncommon disorders of the eye in early infancy; amblyopia; refractive error and the conditions that may contribute to it including strabismus and hyperopia, binocular vision, accommodative disorders, and refractive errors.
- Reviewing, and providing feedback regarding the Literature Review. Meetings were held with the Project Advisory Group throughout the review period, and the Group suggested studies that could be included in the review.
 - The Project Advisory Group circulated draft versions through their professional networks so that the Project Team could obtain further external comment.
- Identification of possible individuals and organisations for invitation to participate in national consultations.
- Reviewing, and providing feedback regarding the Discussion Paper.
 - Determining if vision screening can be supported by the findings from the literature review, in consideration of the Australian context.
 - Developing final screening model options for discussion at the consultations.
- Reviewing, and providing feedback regarding the Consultation Summary.
 - Directions and suggestions as supported by evidence and consultation to include in the Final Report.

3.2. Literature Review

Over a period of six months, the CCCH Project Team conducted a literature review of the evidence on the effectiveness of vision screening programs, both in Australia and internationally. The literature review was commissioned to evaluate screening programs designed to detect vision conditions such as diminished visual acuity, amblyopia, strabismus or squint, refractive error, cataracts and glaucoma.

The three key objectives of the literature review were to determine:

- *Is a screening program the most appropriate method to use to detect vision conditions in children?*
- *What types of vision screening programs appear to be effective and therefore what properties or processes do programs require in order to be effective?*
- *At what age/s and how often should children attend a vision screening, if screening is deemed an effective method by which to detect vision conditions?*

To identify this evidence, literature, studies and trials were retrieved from a variety of sources including standard clinical databases, published systematic reviews, through hand searching of key articles, and via consultation with expert reviewers. Expert reviewers (members of the Project Advisory Group) were asked to identify any studies over and above those found by the search detailed above that (a) met the review trial criteria, (b) were new and promising in the field or (c) offered a specifically Australian perspective.

The focus of the search was on identifying screening 'programs'; that is, studies evaluating not only screening, but also screening personnel, referral pathways, treatment and consideration of outcomes.

The Project Team identified and adopted Wilson and Junger's (1968) [1] framework for evaluating screening programs (Figure 2). If screening programs do not meet the Wilson and Junger criteria, not only can there be unnecessary costs to the economy supporting the program, there can also be unnecessary costs to participants involved in the screening. For example, false positive results can cause intrapersonal angst and personal expense, while false negative results can lead to a mistrust of the system. Inadequate follow-up or treatment facilities can render the initial screening program irrelevant. Hence, all components of the screening criteria

outlined by Wilson and Jungner are important and should be taken into consideration.

Figure 2: Criteria for a Screening Program, Wilson, J.M. and Jungner, Y.G. (1968)

Criteria for a Screening Program	
Knowledge of disease	The condition must be an important health problem
	The condition must have a recognisable latent or early symptomatic stage
	The natural course of the condition, including development from latent to declared disease, should be adequately understood
Knowledge of test	There must be a suitable test or examination
	The test or tests must be acceptable to the population
	Case finding should be a continuing process and not a "once and for all" project
Treatment for disease	There must be an accepted treatment for patients with recognised disease
	Facilities for diagnosis and treatment must be available
	There must be an agreed on policy concerning whom to treat as patients
Cost considerations	The costs of case finding (including diagnosis and treatment of patients diagnosed) must be economically balanced in relation to possible expenditures on medical care as a whole

The search for guidelines or policies on vision screening, the cost effectiveness or economic evaluations of vision screening, and prevalence of vision disorders were also included in the search criteria. Criteria were limited to studies in English and studies published from 1990 onwards.

Studies considered for inclusion were systematic reviews, randomised controlled trials, pseudo-randomised controlled trials, comparative studies with concurrent controls or comparative studies without concurrent controls. Also included in the search for literature were guidelines or policies on vision screening, economic evaluations of vision screening and prevalence of vision conditions.

The review examines the effectiveness of vision screening programs for the general population. The review did not focus on specific groups who are at high risk of developing a vision disorder, including children born prematurely, children in remote indigenous communities, and children with multiple disabilities. These children

require separate assessment, diagnosis and follow-up treatment and care, regardless of their participation in a universal vision screening program.

The Project Team identified a number of limitations to the literature review, including a lack of high-quality randomised controlled trials; and limited duration of follow-up, restricting the ability to determine the effectiveness of the outcomes from screening programs. Therefore, it was not possible on the basis of the evidence provided in the literature review alone to suggest a clear framework for a national vision screening program.

Upon completion of the literature review, the Project Advisory Group was asked to comment on whether they thought that, based on the evidence alone, vision screening was supported within the Australian context. The suggestion from the group was for provision of vision screening in children, with input into the components of a vision screening program, including age at screening, screening personnel, at-risk groups and referral criteria.

The literature review and the expert analysis and practice based evidence provided by the Project Advisory Group were used to develop a Discussion Paper to guide the subsequent consultation process.

Economic Analysis

During the initial stages of the project, the Project Team determined that in order to make informed decisions about best practice models for vision screening programs in Australia, an economic analysis of the screening models conceptualised by the Team would be beneficial. The Centre for Community Child Health held discussions with Deakin University regarding the undertaking of an economic analysis for the project, and following approval from the project's Department of Health and Ageing liaison officer, proceeded to set up such an analysis.

The Project Team, however, was informed in September 2008 that Deakin University was no longer able to undertake an economic analysis of vision screening in Australia. While the completion of an economic analysis was not a requirement of this project under its original terms, an analysis would have supplemented the work of this project and provided Government with a greater understanding of the costs and benefits of vision screening. It is therefore unfortunate that this work was not carried out.

Discussion Paper

A Discussion Paper was prepared by the Project Team for the scheduled national consultations outlining directions and suggestions for the future requirements of children's vision screening in Australia and the information sought through the consultation process. The motivations for advancing a Discussion Paper on childhood vision screening were to:

1. present evidence obtained via a thorough review of the literature;
2. generate discussion and seek feedback on evidence-based (where possible) and expert guidance recommendations regarding the composition of vision screening programs, including appropriate age/s for screening, screening personnel, screening tests and referral pathways and
3. generate discussion and seek feedback on screening options that could be implemented consistently across all Australian states and territories (with appropriate exceptions for high-risk populated areas requiring tailored interventions).

The suggestions regarding the composition of a potential national vision screening program based on a combination of evidence drawn from the literature review and the expert opinion of the Project Advisory Group, are included in the Discussion Paper, alongside questions for the future consideration of health professionals, interest groups, stakeholders and community service organisations. The questions that guided the face to face and written consultations are included on page 14 of the Discussion Paper (Appendix 2).

3.3. Consultations

A key stage in the National Children's Vision Screening Project was to liaise with relevant eye health professionals in each Australian state and territory. In accordance with the project outline, the Project Team planned to organise twelve consultations in November and December 2008. The intended audience included optometrists, orthoptists, ophthalmologists, general practitioners, academics, child and family health nurses, others involved in current programs such as Aboriginal Health Workers, representatives from non-government organisations concerned with sensory impairment and advocacy, and government representatives.

The aim of these consultations was to discuss and obtain feedback on the evidence from the Literature Review, which was presented to the consultation participants in the form of a Discussion Paper, as well as to develop an understanding of current practice within the states and territories. Potential participants were approached in two ways:

1. Via a general 'expression of interest' registration form sent out to professional organisations and associations (see Appendix 3a).
2. Via personal invitations sent out to contacts the Project Team and Project Advisory Group had made throughout the project.

The Discussion Paper was sent to each individual who expressed interest in the project.

The consultations were initially scheduled in each Australian capital city, as well as in regional areas of New South Wales, Queensland, and Western Australia. However, due to the feedback received with expressions of interest, it was not feasible to visit each of the original locations. The Project Team experienced the following challenges:

- Tasmania – the original date conflicted with the RANZCO Conference, however, minimal interest was expressed in the alternative date offered. A teleconference was proposed but did not proceed due to lack of response from professionals. The Project Team was able to collect information outlining the vision screening program being implemented in Tasmania in 2009 and this data has been incorporated into the Consultation Summary (Appendix 3 c).
- Regional NSW, QLD, & WA – a small number of expressions of interest were received from regional areas including offers to participate in the consultation in the capital city in their state, either in person or via teleconference. The parties did not take up this option when offered however a limited number of written responses were received, and these have been incorporated into the Consultation Summary.

The option to provide a written response was provided to all participants/groups that had expressed an interest in the project and consultation process.

Detailed information is included in Appendix 3 b) outlining the professional groups who participated in each consultation, as well as the professional groups who provided written responses.

The consultations were facilitated by the project's Chief Investigator, Dr Martin Wright, and supported by a project officer, either Megan Keyes or Angela Morcos. The meetings were recorded for later transcription and data analysis. Participants received the Discussion Paper prior to the consultations so that they had an opportunity to familiarise themselves with the project and the findings from the literature before the meeting. An overview of the project, the directions from the literature and the advice from the Project Advisory Group was presented to the consultation participants through discussion and supported by a PowerPoint slide presentation.

The Project Team met with the Steering Group, and later with the Project Advisory Group to discuss the findings from the consultations. The directions and suggestions included in Section 6 of this report take into consideration the directions provided by the formal evidence, as well as the consultation data, and the expert opinion of the Project Advisory Group.

4. FINDINGS

Findings from each stage of the project have been summarised under the headings:

- Literature Review
- Project Advisory Group
- Consultations

The findings detailed below have been presented in summary form, the comprehensive findings are presented in the Literature Review, the Literature Review Discussion Paper and the Consultation Discussion Paper appended to this report.

4.1. Literature Review

In Australia, the prevalence of amblyopia in children ranged from 1.4% to 3.6%, [2-5] while strabismus ranged from 0.3% to 7.3%, [2, 6] and refractive error ranged from 1% to 14.7%. [2, 6-11] These rates show large variations, suggesting that further research is required to consolidate these figures and to determine what effect current screening practice has on prevalence rates. However, the figures do suggest that the prevalence of these conditions is significant among Australian children.

The NHMRC criteria were used to evaluate research examining vision screening programs. Largely due to the study designs used to trial vision screening effectiveness (i.e., non-randomised controlled trials, observational studies, and retrospective reports), most evidence identified in the literature review was categorised as “low quality”. If more studies of a higher quality (e.g. systematic reviews or randomised controlled trials) had been identified, a higher level of confidence in the directions derived from the evidence could have been held. In the absence of higher quality evidence, suggestions were made with caution and expert opinion has been sought from a wide variety of sources.

Is vision screening supported by the literature?

Overall, there was a lack of evidence from the literature review to conclusively evaluate the effectiveness of screening programs. Despite this, the majority of papers reviewed supported some form of vision screening for children.

Newborn screening

While the literature review identified few studies that focused exclusively on screening during the neonatal period, and no direct evidence could be taken from those studies, studies that were identified suggested that a vision check should occur as close to birth as possible, and ideally within the first three months of life.[12, 13]

Other screening age/s

The evidence identified by the literature review indicated that screening was a viable method of detecting vision conditions in children, and suggested that the ideal age for vision screening is no earlier than 18 months of age (with the exception of the newborn check) and no later than five years.[14-22] As the level of visual acuity is more difficult to assess in children younger than three, vision screening guidelines advise that screening occur after three years of age.[23-26] Screening at an older age, such as eight to ten years or 13 – 15 years, was shown to detect very few or no new cases of eye pathology, and was therefore not preferred practice.[5, 27] The role of screening to identify functional vision disorders that may affect learning was not examined. There was an absence of studies evaluating screening at school entry, particularly as an alternative to preschool screening.

Screening personnel

Overall, the evidence identified by the literature review was in favour of orthoptists or nurses conducting primary vision screens.[28-35] However, whether this is appropriate in the Australian context requires further assessment of the relevant Australian workforce's capability and this was explored in the consultation process. There were few international studies that considered the use of optometrists in the screening process and they currently play a significant role in Australia.

If employing nurses as primary screeners, the literature suggested that adequate training in screening techniques be made available so as to increase the sensitivity and specificity¹ of the program.[36] The literature also proposed that a program of

¹ The sensitivity of a test is the proportion of people with the condition who are correctly identified by a positive test result; a measure of the true positive rate. The specificity of a test is the proportion of people who do not have the condition who are correctly identified by a negative test result; a measure of the true negative rate (NHMRC, *Child Health Screening & Surveillance: A Critical Review of the Evidence*. 2002, p.225)

secondary screening be considered, whereby any questionable or positive results are referred for evaluation prior to referral for possible treatment.[37, 38] Again, whether this is appropriate in the Australian context would require further analysis of workforce capacity and costs.

Referral criteria

The literature review determined that the appropriate referral (or pass/fail) criterion for use in vision screening is dependent in part upon the age of the children screened. However, the majority of studies used referral criteria of less than 6/9 in each or either eye for four to six year old children.[39-41] One study noted that a referral criteria of less than 6/12 in either eye reduced over-referrals.[42] Referral rates, using the criterion of 6/9 in the worst eye, ranged from 4.8% to 39.6% of children screened.[40, 42] Greater referral rates would be expected in younger children with this visual acuity cut-off.

Referral pathways and follow-up procedures

The evidence determined that any screening program should incorporate follow-up procedures to facilitate compliance with evaluation and treatment. It was noted that this was particularly vital in vulnerable or disadvantaged communities where families may not understand the results of screens, may have limited resources to attend screenings or treatment facilities, and/or may not understand the importance of treatment to future vision potential.[12, 43-49]

At-risk groups

Throughout the process of conducting the literature review, it was determined that groups such as children born prematurely, the remote indigenous population, and children with multiple disabilities were not considered suitable candidates for general vision screening programs as their risk for developing vision conditions is much higher than that of the general population. It was determined that building an eye health program to meet the needs of high-risk groups would require further detailed consultation with appropriate professionals in these communities, and was thus considered outside of the scope of the literature review.

Cost considerations

The cost of a screening program is obviously an important component involved in considering screening viability. The majority of studies reported that vision screening had a positive cost:benefit ratio, and therefore concluded that early screening saved future healthcare costs.[50-57] However, one recent high quality economic analysis concluded that vision screening was not cost effective – when there was no value placed on the loss of vision in one eye.[58] This highlighted a major factor limiting economic analyses – a lack of scientific evidence describing the utility, or effect of adverse vision outcomes such as loss of vision in one eye.

Unfortunately, the literature review did not identify any Australian evaluations of vision screening costs in relation to screening in childhood.

Participation rates

The evidence suggested the adoption of other methods to increase general awareness of vision conditions and to increase the propensity for parents and teachers to assess children outside of the screening period. For example, education and marketing campaigns were reportedly successful in increasing general awareness of vision and increasing the number of children attending vision screenings.[48]

4.2. Project Advisory Group

The expert Project Advisory Group considered the evidence presented in the Literature Review with a view to making suggestions for the consultation phase and to guide the final project outcome.

Is vision screening supported by expert consultation?

With little guidance from the evidence in this area, the Project Team and Project Advisory Group initially could not reach consensus on whether a vision screening program for children could be proposed. However, it became apparent that this was largely due to differing views as to what constituted a ‘screening program’. That is, did screening necessarily warrant a stand-alone program or did a vision screen performed as part of an existing health consultation constitute a screen?

Upon agreeing that a vision screen could be conducted in conjunction with other scheduled health checks, attendees also reached consensus that some form of

vision screening was necessary. Expert advisors cited three main reasons for this conclusion (based on the crucial criteria for screening programs as developed by Wilson and Jungner in 1968): (1) vision is an important health consideration; (2) vision screening can detect latent or early symptomatic stages of a vision condition; (3) early diagnosis of vision conditions often results in a better prognosis; and (4) Australia is faced with an ageing population with eye disease. Further, while there was limited evidence to confirm the effectiveness of vision screening programs, there was also little evidence to suggest that vision screening programs were not effective.

Newborn screening

Again, there was little guidance from the evidence to determine whether vision screening should be carried out during the neonatal period. However, the consensus of the CCCH Project Team and the Project Advisory Group was that a vision check during the neonatal period was crucial, as this enabled the detection of rare, treatable diseases that, if left untreated, could have severe consequences for the child's future health and wellbeing. Once again, there was also a lack of evidence to support the removal of a neonatal check.

Other screening age/s

The consensus of the Project Advisory Group was that a further vision check should be conducted with children between the ages of three to six months, and that a screen should be conducted at four years (with an allowable range from 3.5 years to five years). Although there was no evidence from the literature to support a check in children aged three to six months, the expert group felt this component of a screening program was necessary to ensure that any conditions missed at the newborn check were detected (as they would still be treatable), and to allow for an early assessment of visual behaviour (e.g. fixing and following), providing further scope to detect visual concerns.

There was some evidence identified in the literature to support the screening of children aged between 18 months and five years of age. Upon review of this evidence, the expert advisory group advised that programs aim to screen children at approximately four years of age, but not younger than 3.5 years (due to the decreased ability of children to complete the screening test) or older than five years (due to concerns about efficacy of treatment and compliance with treatment).

The expert advisory group also felt that three main questions should be asked at the four year old screen: “Do you have any concerns about your child’s vision?”, “is there a history of vision impairment in your family?”, and “is your child already seeing a vision health practitioner?”. While the responses to these questions would not affect whether or not a screen was conducted, responses would provide valuable data for evaluation and referral purposes. The expert advisory group noted that, while there was low-level evidence to support a screen at this age, there was also no evidence to support the removal of this screen, which already forms part of current practice in many Australian states and territories (albeit using different protocols, ranging from simple to more comprehensive screenings).

It is important to note that current vision screening or surveillance practices in many Australian states and territories provide for a substantial number of checks on vision to take place between birth and the age of six years. For example, including the maternal and child health checks that all parents in Victoria are encouraged to attend, there are 12 opportunities for surveillance of visual development for children’s vision (ranging from questions asked of parents about vision concerns, to basic checks for appropriate vision behaviours, to testing visual acuity), and therefore 12 opportunities for onward referral if a concern is raised or is visible to the health professional. It was suggested that the number of set occasions that a health professional directly checks vision be reduced to the three occasions outlined above. It was noted that parents should also be informed that whenever they suspect their child may have a vision problem, they should promptly raise these concerns with their general practitioner or eye health practitioner. It was advised that resources are focused on ensuring these two checks and one screen are conducted accurately and thoroughly.

Screening personnel

The literature identified nurses as being capable of successfully administering screening programs, if provided with appropriate training and resources. Many international studies also propose orthoptists as the ‘screener of choice’ in order to increase the sensitivity and specificity of screens.

Given the structure of the Australian eye health professional workforce, the expert advisory group suggested it was likely that child and family health nurses would have

contact with children at around four years of age through other existing health checks and therefore may be best placed to be primary screeners in a vision screening program. Current attendance rates at these checks are often low however, and many are at the younger end of the proposed age range for vision screening. The advisory group advised that individual states and territories would need to look at their workforce capacity and make an individual assessment of resources. The expert advisory group felt that the most important proposal regarding screening personnel was that training was adequate and consistent across the states and territories.

Screening tests

Comparison between, or evaluation of specific vision screening tests was not included in the literature review search, therefore expert opinion was sought from the advisory group. The consensus reached by the group was that the Sheridan Gardiner was considered the gold standard test for children aged four years and above and that LEA symbols were appropriate to use with younger children.

Referral criteria

As noted, the screening programs outlined in the literature review generally used a referral criteria of less than 6/9 in each or either eye for children aged four to six years. However, this criterion was not universally accepted by the expert advisory group. In fact, the issue of referral criteria created substantial debate amongst the group, and full consensus was not reached.

Specifically, attendees were unable to agree on whether children should be referred for further visual assessment if they achieved results of less than 6/7.5, less than 6/9 or less than 6/12 during a screen. It was noted that the World Health Organisation defined vision impairment as visual acuity of less than 6/18 in the better eye. Two options – either less than 6/9 or less than 6/12 – generated the most agreement. Regardless of which option was favoured, a two line or more difference between eyes was also felt to be a suitable criterion for referral.

Given the low quality of the evidence available in the literature and the inability of the expert advisory group to reach consensus on this matter, no suggestion was made until further information was gathered from other eye health professionals during national focus group consultations.

Referral pathways and follow-up procedures

The evidence identified in the literature review demonstrated that clearly outlined and appropriately resourced referral pathways are crucial to the success of vision screening programs. The expert advisory group agreed that referral pathways should be consistent (where possible, allowing for differences in workforce structures across the states and territories), clearly outlined and as straightforward as possible.

At-risk groups

As noted, children who are born prematurely or children with multiple disabilities are at greater risk of developing vision conditions and therefore require in-depth assessment, even if they participate in a screening program.

The expert advisory group concluded that children in remote indigenous populations be screened as per other rural populations for the vision conditions outlined in this paper. However, in addition to screening for conditions such as amblyopia and strabismus, children in remote indigenous populations require health checks and educational programs tailored towards the detection and the prevention of trachoma, in particular. While these additional checks and programs are beyond the scope of this discussion paper, it is likely that these may co-exist with a screening program in remote indigenous populations.

Cost considerations

The literature presented some inconsistencies in analyses of the cost effectiveness of screening; some of which were due to different values used to calculate the effects on wellbeing of vision impairment or loss. The expert advisory group felt that cost effectiveness needed to be evaluated in the Australian context before suggestions on cost could be made.

Participation rates

Ensuring a high participation rate in any screening program is difficult. The evidence indicates that resources are required to promote screening programs to participants, or parents of participants.

Integrating a vision screen into an existing health check or program may facilitate higher participation rates, particularly if other highly regarded services such as immunisation are provided. On the other hand adequate vision screening requires a

certain amount of time and the cooperation of an attentive child. This may be better achieved with a stand-alone vision program. It was suggested that, if vision screens are to be integrated with health checks, existing systems around these checks should be strengthened (incorporating adequate and appropriate training, awareness campaigns, and so on) to encourage high attendance rates. Stand-alone screening programs may need to carefully consider screening locations (do the screeners go to the children, or do the children come to the screening?), as well as targeted education campaigns for parents and caregivers.

Cost also becomes an important factor in participation rates. Consideration must be given not only to the costs of attending a screen (including costs to parents incurred by travelling to a screening location and taking time off from work), but also to the costs of any treatment or intervention that results from a positive screen. It was advised that ideally, intervention costs for families should be kept to the minimum level possible.

4.3. Consultations

The information gathered in the consultation period was consistent with the results of the findings of the expert Project Advisory Group and while some differences emerged between and within states and territories there was significant agreement across the jurisdictions.

Is vision screening supported by consultation?

The information gathered in the consultations strongly supported the screening of children's vision, with no participant objecting to such a program in Australia. Many participants presented anecdotal evidence supporting vision screening.

There was general consensus amongst the participants that reduced vision places children at a disadvantage within the Australian education system. It was also generally agreed that any child who is unable to achieve a visual acuity of 6/9 is at a disadvantage within a classroom environment, when there are children in the same environment with a visual acuity of 6/6 or better.

It was argued that untreated amblyopia can lead to blindness when unilateral amblyopia is combined with degenerative eye conditions or trauma (which is even more likely to occur in the presence of amblyopia) affecting the good eye – therefore

the early identification of amblyopia (amongst other vision impairments) is an important public health consideration. The participants strongly supported the screening of children's vision around the age of school-entry (i.e. 4 – 6 years) as an effective method of identifying amblyopia at an early stage where treatment is likely to be the most effective. Additionally, the impact that vision impairment has on a person's mental health and well-being was criticised as not being addressed in the literature.

Although the literature concluded that the majority of visual impairments are identified without a formal screening program in place, the participants expressed doubt that an opportunistic approach is the most effective way to ensure children with visual impairments have the opportunity for identification and treatment. The following reasons were listed:

- If children believe their vision is normal, they will not self-identify.
- Children may compensate (quite effectively) for poor vision; especially in the case of unilateral amblyopia.
- Vision problems can be mistaken for cognitive impairment (or symptoms from vision impairment are not attributed to vision problems).
- There are few observable signs of amblyopia, for the layperson.

Newborn screening

Assessing for congenital defects, particularly testing the red reflex, is a widely accepted and supported component of the various child and family health programs available in Australia, and the consultation data supported the literature to advise that this test be retained.

However, there was some discussion regarding the most appropriate developmental age for this test. Some participants believed that it should be conducted prior to the newborn leaving the hospital; whilst others believed that within the first six to eight weeks following birth was appropriate. It was reported that conditions are often identified in the few weeks following the birth, especially by parent concern.

Other screening age/s

In consideration of the principle of a universal screening program, the participants based their responses on a number of considerations:

- The most appropriate developmental age
 - Visual pathways development
 - Compliance – attention, literacy skills
- Engagement (ie. child and family health nurse visits; preschool; school)
- Opportunities for treatment (availability of, and time required to wait for evaluation and treatment services)

Children aged 3.5 – 5 years were suggested as an appropriate age range to include in a screening program. Current practice differs across Australia, however all states and territories aim to screen children’s vision either prior to, or in the first year of formal school. Overall, the participants supported some flexibility for the age of children screened and that this be determined by the most appropriate ways to engage with children and families (ie. preschool, or child and family health nurse visits).

The participants identified 3.5 years as the earliest appropriate age for a vision test in consideration of accuracy and compliance with the test.

Screening personnel

The themes identified within the consultation data indicated that the current involvement of child and family health nurses, optometrists and orthoptists as primary screeners was deemed appropriate by the participants for any future program, however the need for significant workforce development was strongly emphasised. The introduction of new screeners requires adequate initial and ongoing training.

There was agreement amongst child and family health nurses and eye health professionals, that if the primary screener is not an eye-health professional, then it is important that an eye-health professional conduct any further evaluation.

The benefits of involving a family’s general practitioner as an option for the initial screen were understood (as long as the screening procedures were supported by clear guidelines). However many participants felt that for a general practitioner to be required to make referral after the initial screen was not an efficient use of resources, and believed that a more appropriate and direct referral pathway could be developed.

It was suggested by the participants that the person involved in the evaluation stage be a suitably trained eye-health professional who is capable of making a diagnosis and appropriate treatment, or onward referral.

Referral criteria

The agreed visual acuity cut-off for onward referral was if there are two or more lines of difference or less than 6/9 visual acuity in either eye. However, most of the participants agreed that since there is an age variance in acuity, the referral cut-offs should be tailored accordingly to reflect this.

Referral pathways and follow-up procedures

The participants indicated that in order to maximise family engagement, referral pathways must be determined by the needs of, and resources available in the region and in consideration of the challenges provided by Australia's geographical size and population diversity and sprawl. Participants emphasised the need for treatment to be included in the referral pathway and funded as part of a vision screening program.

The participants identified the following points for consideration:

- The referral pathway must be clear, and relatively simple.
A 4 step referral process, such as nurse → orthoptist → GP → optometrist, may be a barrier to family engagement.
- Include a referral to an eye-health professional for evaluation and if necessary diagnosis and treatment as a second step.
- Consider geographic accessibility.
- The workforce needs to be developed at all stages of the referral pathway – primary screeners, as well as eye-health professionals conducting evaluation, diagnosis and providing treatment.

At-risk groups

The discussion focused on the principle of offering a universal screen, and that therefore these children should be included in the screening program; however, systems are required to ensure that they receive additional vision assessments.

There was general consensus that groups at higher-risk of visual impairments require a system that has clearly identified criteria for inclusion and is consistently monitored to ensure their engagement.

Cost considerations and participation rates

The consultation participants identified four main barriers that are currently perceived to be preventing maximum family engagement with services and further treatment. Whilst the specifics of each barrier differ both across and within states and territories, the main barriers are shared across the country.

- Cost:
 - The cost associated with consultation and / or treatment (ie spectacles, surgery) can be significant. There are current schemes for spectacle subsidisation across Australia but they are often restricted to low-income earners and proving eligibility can be a difficult and involved process.
 - There are costs for families associated with taking time off work to attend a child consultation, any travel and accommodation required, and child care for other children in the family.
- Understanding the importance of treatment:
 - Many consultation participants reported that parents have a common misunderstanding that a vision screen is diagnostic and the 'final step', resulting in lower rates of those following up with treatment.
 - This was noted as a particular concern for rural and remote Aboriginal communities in the Northern Territory where treatment options are not valued for their impact on visual impairment (ie. wearing glasses).
- Accessibility of services:
 - In order to increase engagement, families require services that are geographically accessible, and with reasonable waiting list times.
 - The consultation data indicated a correlation between a specific region, and families' ability to access the required primary care and specialist services. This is discussed further in the next section, however, it was

generally reported that as the child's needs required a more specialised professional (such as a paediatric ophthalmologist), the availability of professionals was significantly lower than primary screeners, and eye-health professionals involved in evaluation, particularly in rural and remote areas of Australia.

- Referral pathways
 - The numbers of steps in some current referral pathways were raised as a barrier to the following-up of treatment for vision impairment. The participants believed that a referral process with 3 – 4 steps involved would be a deterrent for families to continue with the process, particularly those with limited resources.
 - It was also noted that families often encounter **multiple** barriers to receiving treatment, such as cost and limited access geographically, to the required eye-health professionals.

Consultation participants raised the point that vulnerable families including those with limited resources would be likely to benefit most from a universal screening program.

5. DISCUSSION

The findings of the National Children's Vision Screening Project outline the numerous components of a comprehensive vision screening program, highlighting the complexity of developing such a program for the Australian context. There are various programs currently in place across the country that aim to assess children's vision, and identify risk factors for vision impairment; however, members of the Project Advisory Group and consultation participants agreed that an opportunity exists to modify current practice in some jurisdictions, aligning practice with evidence from the literature.

The objective of this project was to determine the effectiveness of vision screening in Australian children aged 0 – 16 years, and to provide advice and guidelines regarding the implementation of such a program.

The directions suggested by evidence and consultation outlined in chapter 6 of this report reflect the considerations for a universal vision screening program for Australian children. The three main stages of the project – the literature review, expert consultation, and public consultation – were central in developing the directions; with particular consideration to the Australian context. The project findings were also evaluated according to Wilson and Junger (1968) criteria for screening programs. This is discussed in further detail below and Table 2 summarises the evidence obtained from the literature, and expert and public consultations, according to the criteria.

Knowledge of the disease

Expert consultation validated the prevalence rates from the literature that highlight vision impairment as an important health problem in Australia, justifying a vision screening program. In addition to these rates, expert and public consultation raised functional vision as an associated issue that is not thoroughly addressed in the literature. Consideration was given to the relationship between reduced vision, functional vision, and educational outcomes, and both expert and public consultation emphasised the role that vision screening plays in the early detection of vision conditions, and the importance of early treatment for improved outcomes.

There was strong expert and public support for the vision check during the neonatal period, however, further research is required to determine the most suitable age for this check, and if a follow-up check is advisable.

The literature indicates vision impairment can be identified between the ages of 18 months to five years and that this is therefore an appropriate age to consider a screening program. Whilst the expert and public opinions concur with these findings, their suggestions take into account a child's compliance and developmental ability to participate in a vision screen. In consideration of these factors, it is acknowledged that a visual acuity test can be conducted from 3.5 years, however, four years is considered to be the most suitable age.

An opportunity exists to further investigate the effectiveness of treatment at different ages; further research concerning the possibility that some vision conditions will 'self-correct'; as well as the impact functional vision has on a person's quality of life.

Knowledge of test

The evidence obtained from the literature review, consultation with the Project Advisory Group, and public consultation; strongly supports a public education component within a universal screening program. There is some indication that parents and caregivers may perceive the screening test to be a comprehensive eye examination, or assessment; however, it is important for adults (parents, teachers and health professionals) to feel empowered to report concerns about a child's vision outside the schedule of the screening program.

The public consultation data also suggests that a community education program will help increase participation in the screening program by raising parents' awareness of the importance of eye-health, and the value of a screening program.

There are a range of suitable tests being used in current vision screening programs in Australia. This was not a specific focus of the literature review, however, the Project Advisory Group outlined criteria for a test that is considered 'gold standard'. The public consultation data varied in the type of test considered most suitable, as mostly the professionals involved in primary screening strongly supported the test that they were using at present. In many cases, this test had been chosen to meet the needs of the area involved in the screening program. For example, matching LEA symbols was considered the most appropriate test to use in the Northern

Territory, and New South Wales have chosen a linear Sheridan-Gardiner for their screening program. Those involved in primary screening strongly support a suite of tests from which to choose, to enable them to meet the needs of their community.

The literature and expert opinion was supported by public consultation opinion that vision testing using a visual acuity chart is acceptable to the population as it is not invasive and is widely used as part of existing practice.

Treatment for disease

The options for treatment discussed in the literature review include patching and the prescription of spectacles, or glasses. Treatment for amblyopia is advised for children under the age of seven, as a child's visual pathway is still developing and there is an opportunity for correction.

The advice from the public consultations deems the commencement of treatment prior to school entry (approximately age four) as the most appropriate. This advice was offered in consideration of the natural development of vision, as well as the Australian context where children from age five (dependant on the jurisdiction) will enter school. The school playground is acknowledged as a site for potential bullying of children who are involved in treatment such as patching, and as a result, child compliance with treatment may decrease.

Whilst treatment compliance is a significant consideration, the consultations also focused on an appropriate age and / or service platform on which to base a universal screening program. This is a particular challenge in the Australian context as there is no service used by all families prior to enrolling in the formal education system. Child and family health nurses have decreasing engagement with families as children become older, and at present, there is currently no universal preschool early education system.

The StEPS program in New South Wales targets all four year old children in the state, and the screening is conducted in some early childhood settings, in an effort to screen every child. Additionally, parents do not need to be present at the screen, however, a communication plan has been developed to inform parents / caregivers and obtain their consent prior to the screen, as well as providing them with feedback following the screen. The Project Advisory Group explained that the eye-health workforce in New South Wales, partly due to the availability of orthoptists, has the

capacity to provide a universal screening program, however this is not the case in other states and territories.

The Project Advisory Group suggested a co-management system between optometrists, orthoptists, and ophthalmologists as a suitable model for the proposed universal program, especially in areas such as the Northern Territory that rely upon ophthalmologists to visit from other states. The public consultation data strongly advocates for workforce development and training as a necessary aspect if a screening program were to be implemented across Australia.

There was varying opinion regarding the most suitable visual acuity level to utilise as the cut-off for onward referral and possible treatment. Whilst the literature supported a visual acuity of less than 6/9, the World Health Organisation defines vision impairment as visual acuity of less than 6/18 in the better eye. The Project Advisory Group could not initially reach consensus on whether less than 6/9 or less than 6/12 is the most appropriate. However, since current practice in Australia refers children with a visual acuity of less than 6/9 (as evident from the public consultations), the Project Advisory Group was guided by convention in their final recommendation of less than 6/9. Whether a child is subsequently treated will depend on a full assessment.

Cost considerations

There is minimal formal evidence available to verify the cost-effectiveness of a vision screening program, with only a few studies conducting a formal economic analysis. The Project Advisory Group and the public consultation participants were not suitably qualified to provide further clarification on the issue.

The consultation data strongly indicated that a significant proportion of the barriers that prevent families from engaging with the screening program through to the treatment stage are financial barriers. The formal evidence and the evidence obtained through consultation both suggest that any screening program should incorporate follow-up procedures to facilitate compliance, in an effort to remove or reduce the barriers encountered by families.

Table 2: Criteria for Screening Programs

Criteria for screening programs		Vision screening		
		Evidence	Expert opinion	Further consultation
Knowledge of disease	Condition must be an important health problem	<p>The prevalence of amblyopia in children ranged from 1.4% to 3.6%, while strabismus ranged from 0.3% to 7.3%, and significant refractive error ranged from 1% to 14.7%.</p> <p>A detailed evaluation was not performed of the long term impact of vision problems diagnosed in childhood.</p> <p>Links have been made between vision impairment and poor educational outcomes. It is suggested that vision impairment is correlated with lower visuocognitive and visuomotor skills, poorer reading ability and lower scores on achievement tests. However, visual deficits related to educational outcomes are often not identified during screening.</p>	<p>Experts cited three main reasons why vision screening for children should be continued: (1) vision is an important health consideration; (2) vision screening can detect latent or early symptomatic stages of a vision condition [58]; and (3) early diagnosis of vision conditions may result in a better prognosis.</p>	<p>There is argument as to the functional effect that a vision condition such as amblyopia has on the quality of life of a child. There is debate over the level of vision acuity at which functional impairment occurs, and whether or not loss of vision in one eye is an important health problem.</p> <p>Consultation data collected consistently indicated that over the long term amblyopia was considered a serious health problem and combined with risk of degenerative eye disease can lead to blindness. The impact on learning outcomes for young children was raised on several occasions.</p> <p>Concern was expressed that eye conditions are often mistaken for cognitive problems. The mainstream education system requires a certain level of visual acuity (tracking, vision, concentration) for delivery to be successful.</p>
	Condition must have a recognisable latent or early symptomatic stage	<p>Vision conditions have recognisable early symptomatic stages.</p> <p>With the exception of screening for congenital eye conditions, the evidence suggested that vision screening should occur between the ages of 18 months and five years, as this is when vision conditions have a recognisable symptomatic stage.</p> <p>[23-26]Screening between eight and 15 years was shown to detect very few or no new cases of eye pathology.</p>	<p>Experts recommended that a vision check during the neonatal period was crucial, to detect treatable diseases with recognisable early pre-symptomatic stages.</p> <p>A vision check between three and six months was proposed to detect any condition missed at the newborn check, and to assess visual behaviour.</p> <p>It was suggested that vision screening be carried out at age four (with a range from 3.5 to five years) as vision conditions are identifiable and children are generally more compliant with the testing process than at earlier ages.</p>	<p>Nil consultation required on whether vision conditions have early symptomatic stages; this has been confirmed by the evidence. However, the most appropriate timing for detection requires further debate.</p> <p>There was little evidence assessing vision at school entry. There was no evidence on the effectiveness of multiple screenings (e.g. screening at four years of age and at school entry).</p> <p>Consultation data indicated that eye conditions can be diagnosed in the period before school entry and while school entry may be the most convenient opportunity to catch all children, treatment at age 4 is more effective than treatment at age 6. Support for school aged screening is based on the ease of universal uptake.</p> <p>Strong support was evident for retaining the neonatal visual check for red reflex (often conducted by doctors prior to discharge from hospital).</p>

Criteria for screening programs		Vision screening		
		Evidence	Expert opinion	Further consultation
	The natural course of the condition, including development from latent to declared disease, should be adequately understood	There is evidence that some vision conditions will 'self-correct' without treatment. Further evidence on this is required.	Experts conceded that the natural course of all vision conditions is not fully understood.	Further consultation / research is required. Consultation found that further evidence is required.
Knowledge of test	Must be a suitable test or examination	This was not specifically examined by the literature review, although studies identified for the review incorporated the use of suitable screening tests.	The experts advised the use of a linear LogMAR chart. Sheridan Gardiner is considered gold standard; LEA symbols can be used with younger children.	Many different tests are used to measure visual acuity. Is the linear LogMAR most suitable and is Sheridan Gardiner most suitable of the logMARs?
	Test must be acceptable to the population	Tests are acceptable to the population, widely used and non-invasive.	Tests are acceptable to the population, widely used and non-invasive.	Nil consultation required.
	Case finding should be a continuing process and not a "once and for all" project	The evidence identified the importance of ongoing education amongst health care workers, teachers and parents to identify outside the screening period.	Parents should continue to be encouraged to report concerns regarding their children's vision to health professionals, within and outside of a formalised screening program.	Nil required.
Treatment for disease	Must be an accepted treatment for patients with recognised disease	The evidence outlines several treatments for children's vision conditions, such as patching, atropine treatment and spectacle correction. The evidence suggests that treatment is best administered in children younger than seven.	The expert group was not consulted on the specifics of this aspect of screening.	Further consultation may be required around the best treatment available, the possible adverse consequences of treatment (e.g. bullying) and the most appropriate age for treatment. Consultation data indicated that early treatment is preferable as child compliance decreases with age, and some of this can be attributed to the consequences of treatment (e.g. bullying).
	Facilities for diagnosis and treatment available	Facilities and personnel are available for treatment.	Facilities and personnel are available for treatment.	Available resources may determine the nature of any screening program and referral guidelines, see below.

Criteria for screening programs		Vision screening		
		Evidence	Expert opinion	Further consultation
	Agreed on policy concerning whom to treat as patients	<p>The evidence suggested that children aged between four and six years of age with visual acuity of less than 6/9 should be referred on for further assessment and treatment.</p> <p>The World Health Organisation defines vision impairment as visual acuity of less than 6/18 in the better eye.</p> <p>The percentage of children referred, using the criterion of 6/9 in the worst eye, ranged from 4.8 to 39.6 of all children screened.</p>	<p>The experts could not reach consensus on the referral criteria that should be used to determine who receives further assessment and treatment.</p> <p>Two options (either less than 6/9 or less than 6/12) generated most agreement. A two line or more difference between eyes was also felt to be a suitable criterion for referral.</p>	<p>Further consultation in this area is required.</p> <p>Consultation data identified that current practice in Australia refers a child in the year prior to, or first year of formal schooling for further assessment and treatment with a visual acuity of less than 6/9 and with two or more lines difference.</p> <p>Children with a visual acuity of 6/12 are treated and this was not accepted by the consultation participants as an appropriate visual acuity cut-off.</p>
Cost considerations	Costs of case finding (including diagnosis and treatment of patients diagnosed) must be economically balanced in relation to possible expenditures on medical care as whole	A number of studies reported on the costs versus benefits of screening and indicated that it was cost-effective, however few performed formal economic analyses. One study concluded that vision screening could be considered cost effective only if a value was placed on the loss of vision in one eye.	The expert group were not specifically consulted about cost considerations.	<p>Further analysis of the Australian context is required to determine cost considerations. Consultation in this area may provide some guidance.</p> <p>The consultation participants were not specifically consulted about cost considerations, however, they agreed that an economic analysis would be beneficial.</p>

6. DIRECTIONS FROM THE LITERATURE AND CONSULTATION

Is vision screening supported by the evidence and consultation?

The literature was inconclusive about the effectiveness of vision screening programs, but the Project Advisory Group, and consultation participants agreed in principle that a well-researched and standardised children's vision screening program would be beneficial. During the project, a report was released by the Australian Institute of Health and Welfare, *Eye Health Among Australian Children*, November 2008 (<http://www.aihw.gov.au/publications/index.cfm/title/10660>) as part of a series focusing on children's eye health in Australia. Two of the key findings from the report pertain to the context of this project: "along with allergies and asthma, eye disorders are the most common long-term health problems experienced by children"; and "there are more than 411 000 cases of long-term eye disorders among children in Australia. Most of these are long- and short-sightedness" (p. viii). These findings provide recent data from the Australian context which add to the evidence collected in the review of the literature, in support of a vision screening program for children.

All Australian states and territories currently have systems in place to offer testing of children's vision to some degree; however, there is an opportunity to develop a national, standardised, single vision screening program. A single, comprehensive screen with high coverage is preferable to multiple screens or checks. This may require some jurisdictions to modify their current practice and in some cases, this may result in a review of the vision surveillance component of the child and family health nurse schedule.

Newborn screening

It is acknowledged that a red reflex check of a newborn does not meet the criteria of a screen; however, the direction given by evidence and consultation is for this component of vision surveillance is retained, as in current practice. It is suggested that emphasis be placed on ensuring there is a universal approach to the newborn red reflex check and that the person conducting this check be appropriately trained.

Further research is required in this area to evaluate the effectiveness of this check at different ages, i.e. within the first week following birth, or within the child's first three months of life; as well as the need for a follow-up check within the first three to six months.

Screening age

A universal vision screening program for children in the year prior to their enrolment in the formal school system is considered to be the most appropriate age for participation in such a program. Four years of age is considered the ideal age, however, in consideration of the variance in school starting ages across Australia, it is acknowledged that children slightly younger and slightly older than four may be included in the program.

The age and / or developmental ability of a child can influence the type of test used. If children younger or older than four years are included in the program, protocols are recommended to guide professionals involved in implementing the screening program for these children.

Screening personnel

Australia's population diversity and geographical size present a challenge in requiring a specific eye-health professional at each of the stages in the screening program. Whilst optometrists, orthoptists, and ophthalmologists comprise Australia's eye-health workforce, there is unequal distribution of these professionals across the country. It is important that the screening program utilises the resources available in each jurisdiction (between and within each state and territory), and that professionals work collaboratively in a system of co-management.

Child and family health nurses are available in all states and territories, and with appropriate training, can be employed as primary screeners. An additional advantage of employing child and family health nurses as primary screeners is their existing relationships with families in the community, through the maternal and child health scheme. This may increase families' engagement with the screening program. General practitioners are also possible screening personnel.

Primary screeners require appropriate training and support to conduct the screen, and it is important that onward referrals are made to an eye-health professional for evaluation, diagnosis, and treatment where necessary.

Workforce development is necessary for a universal vision screening program.

Referral criteria

The suggested referral criteria for a 4 year old are less than 6/9 in either eye, and/or two or more lines difference. If either of these is found at the primary screen onward referral for evaluation by an orthoptist, ophthalmologist or optometrist is required. If the evaluation confirms visual acuity of less than 6/9 in either eye and/or two or more lines of difference between the eyes, referral or diagnosis and treatment is indicated. Less than 6/18 requires high priority referral and/or treatment.

Children from the risk categories with visual acuity within the normal range should be referred to an eye health professional for ongoing monitoring if they are not already in treatment.

Visual acuity test

The suggested criteria for a visual acuity test for four-year-old children are:

- A test that is 'crowded'. (As optotypes – letters or symbols – on a chart come closer together, the opposed edges appear to merge together, making them more difficult to discern than if the optotypes were presented individually.)
- A linear chart, rather than using a single optotype, ie. a line of letters on a chart, rather than singles letters displayed one at a time.
- An illuminated chart, to allow for adequate lighting.
- A test that is portable (to allow for population-based screening, including outreach programs) and that allows for testing at 3 metres and 6 metres in consideration of the availability of space.

A more detailed commentary of the characteristics of visual acuity tests is included in Appendix 4.

Referral pathways and follow-up procedures

The evidence from the consultations in particular suggest that the specific detail of the referral pathways and follow-up procedures are largely determined by the state or territory responsible for the program in their jurisdiction, taking into consideration the resources that are available, such as the availability of eye-health professionals and consultation clinics. However, in consideration that primary screeners in some regions will not be eye-health professionals, it is suggested that evaluation is

conducted by an ophthalmologist, optometrist or orthoptist where the principles of the screening program are maintained.

Providing feedback from the screen to a family's primary health care professional, such as a general practitioner, is considered to be good quality practice. A decision to involve them as a step in the referral pathway should take into consideration the number of steps in the pathway as multiple steps can be a barrier to participation and following up treatment.

At-risk groups

In response to the aim of a *universal* screening program, children who are considered to be at higher risk of vision impairment can, and should be included in the screening program, but in addition should be offered a comprehensive eye examination. The children who require a more comprehensive assessment are premature infants (birth weight less than 1500 grams); children with a developmental delay or disability; and Indigenous children living in rural and remote areas.

A universal screening program is not designed to meet the particular needs of these groups; however, it is important that these children are included. It is beyond the requirements of this project to outline the details of the vision assessment they require. This presents an opportunity for further research, to ensure these children receive the appropriate treatment.

Cost considerations and participation rates

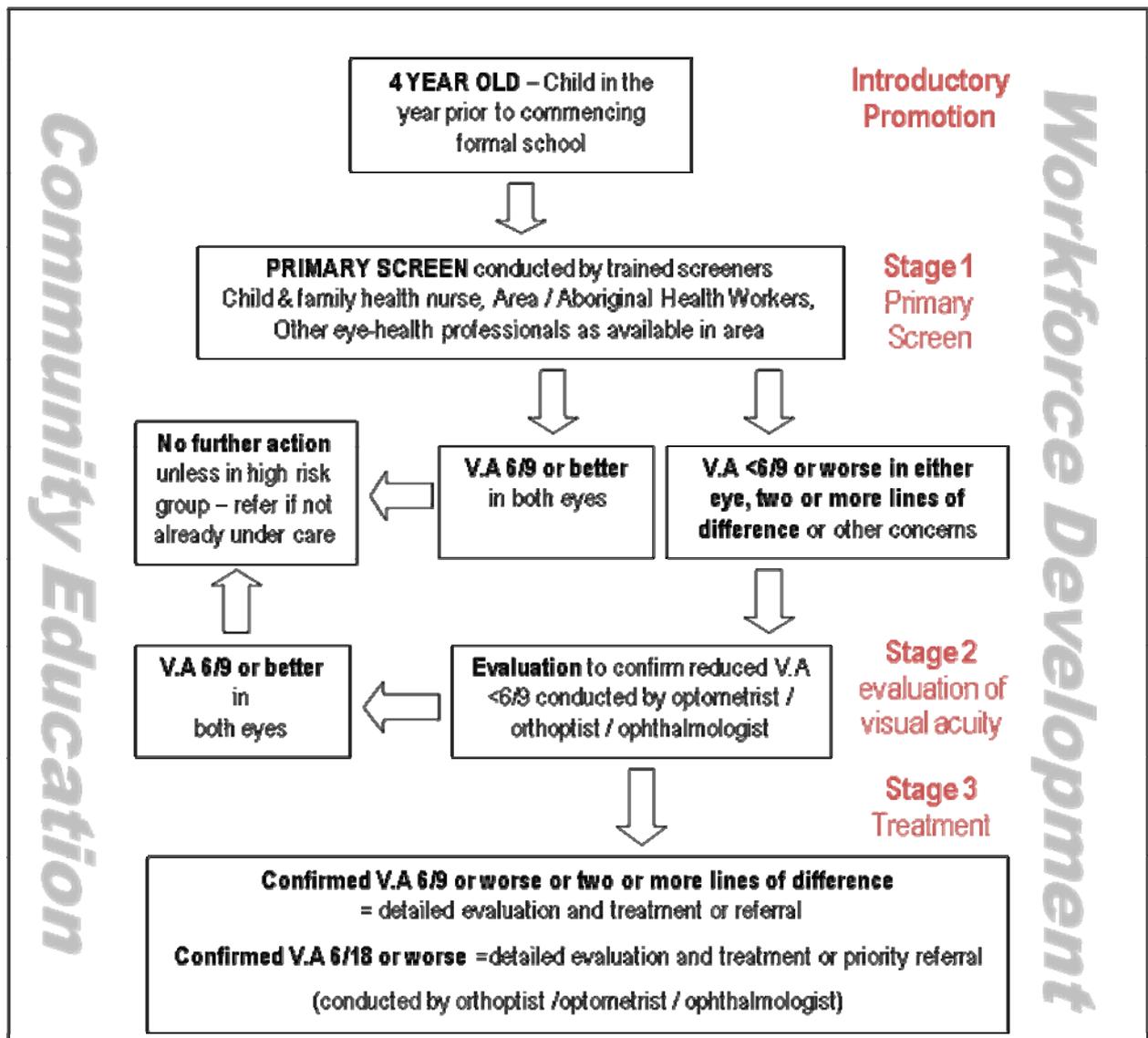
It was beyond the scope of this project to provide an economic analysis of a population-based vision screening program, however, cost considerations were identified at all levels of investigation – through the literature review, expert advice, and public consultation – as actual and potential barriers to participation in a screening program. As outlined earlier, the Project Team focused on screening *programs*, incorporating screening personnel, referral pathways and treatment.

If a national children's vision screening program is implemented in Australia, the formal and consultation evidence emphasises that it is important that the appropriate provisions are made to include the required resources to meet the demand of onward referrals and treatment. The barriers to participation in such programs are often multiple, and it is important that consideration is given to expenses incurred such as travel to an appointment, additional child care, and parking costs. The cost

of spectacles was raised as a specific barrier to treatment, and it is suggested that a means-tested co-payment is required from families who are eligible for low-cost glasses.

Figure 3 demonstrates the referral pathway and professionals responsible for each stage in the screening program.

Figure 3: Steps of the proposed screening program



Further research

The Project Advisory Group and the Project Team were challenged by the lack of formal evidence in some areas of vision screening and the following suggestions are made for future research:

- The importance of a follow-up check of the red-reflex (newborn check), and the most appropriate age that this should be conducted.
- Further evidence is required concerning functional vision for school-age children. Questions still exist around the level of visual-acuity required for an appropriate level of functional vision, particularly in the Australian compulsory education system.
- There is an opportunity to further investigate the impact of reduced visual-acuity on a person's quality of life, perhaps focusing on different life stages eg. middle childhood; adulthood; retirement.
- The efficacy of interventions. For example, how effective prescribed treatment of patching in children age eight is, considering issues such as compliance, as well as improved vision.
- An economic analysis of a vision screening program for children.

Dissemination of the Final Report

The Project Team and Project Advisory Group propose that this Final Report be made available for wider consideration and professional use. The following websites were identified as possible ways to disseminate the report:

- Centre for Community Child Health
- Vision 2020
- RANZCO

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8. APPENDICES

Appendix One: Literature Review

NATIONAL CHILDREN'S VISION SCREENING PROJECT

Literature Review

31 July 2008

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TABLE OF CONTENTS

1	MAIN MESSAGES	1
2	EXECUTIVE SUMMARY	3
	Purpose	3
	Methodology	4
	Findings	4
3	BACKGROUND.....	8
4	METHODOLOGY	10
4.1	Inclusion criteria	10
4.2	Identification of trials	10
4.3	Quality ratings for each study	12
4.4	Data analysis	13
5	LITERATURE	13
5.1	Prevalence of vision conditions in Australian and overseas children.....	13
5.2	Australian and international guidelines on vision screening practice	15
5.3	Current vision screening practice in Australia	16
5.4	Screening effectiveness.....	16
5.4.1	Overall summary – screening effectiveness	16
5.4.2	Neonates (0-1 month).....	17
5.4.3	Toddler age (1 month-3 years)	17
5.4.4	Preschool age (3-6 years).....	19
5.4.5	School age (6+ years)	21
5.4.6	Screening effectiveness – directions from the evidence	23
5.5	Screeener characteristics	24
5.5.1	Overall summary – screeener characteristics	24
5.5.2	Neonates (0-1 month).....	25
5.5.3	Toddler age (1 month-3 years)	25
5.5.4	Preschool age (3-6 years).....	26
5.5.5	School age (6+ years)	27
5.5.6	Screeener characteristics – directions from the evidence	28
5.6	Educational outcomes of vision screening	28
5.6.1	Overall summary – educational outcomes	28
5.6.2	Neonates (0-1 month).....	29
5.6.3	Toddler age (1 month-3 years)	29
5.6.4	Preschool age (3-6 years).....	29
5.6.5	School age (6+ years)	30
5.6.6	Educational outcomes – directions from the evidence	31
5.7	Treatment of vision conditions	32
5.8	Evaluation of referral criteria.....	34
5.9	Vision screening of Indigenous Australian children.....	35
5.10	Utilisation of eye care services and the cost of vision lost	36
5.11	Economic evaluations.....	36

6	LIMITATIONS OF STUDIES	39
7	DIRECTIONS FROM THE EVIDENCE	40
8	FURTHER RESEARCH	41
	SUMMARY AND CONCLUDING COMMENTS	42
APPENDIX A	LEVELS OF EVIDENCE.....	44
APPENDIX B	MESH SEARCH TERMS	45
APPENDIX C	AUSTRALIAN STATES AND TERRITORIES – CURRENT VISION SCREENING PRACTICE	47
APPENDIX D	CRITERIA FOR INCLUSION OF STUDIES.....	53
APPENDIX E	LITERATURE TABLES	55
APPENDIX F	AGREE INSTRUMENT FOR APPRAISING GUIDELINES FOR RESEARCH AND EVALUATION.....	94
APPENDIX G	AUSTRALIAN AND INTERNATIONAL GUIDELINES AND POLICY STATEMENTS ON CHILDREN’S VISION SCREENING	95
APPENDIX H	AUSTRALIAN EYE HEALTH PRACTITIONER WORKFORCE ...	98
APPENDIX I	ECONOMIC EVALUATION ASSESSMENT FORM	99
	GLOSSARY	101
	REFERENCES.....	105

1 Main messages

- Cataracts, refractive errors, amblyopia and associated conditions, such as strabismus, are vision conditions that can affect children and can, if left untreated, lead to poor outcomes in childhood including impaired learning and reading, and the risk of permanent loss of vision later in life.
- The prevalence of amblyopia in Australian children is reported to be between 1.4% and 3.6%; the prevalence of strabismus between 0.3% and 7.3%; and the prevalence of refractive error between 1% and 14.7%.
- Most Australian and international guidelines recommend vision screening for children in some form and many recommend a newborn screen.
- The effectiveness of children's vision screening has been reported on widely in the literature. However, only one randomised controlled trial evaluating the effectiveness of screening has been identified by this review.
- Vision screening in the newborn has not been well documented and is therefore lacking a solid evidentiary base. However, while disorders in the newborn are rare, the degree of impairment that can result from such conditions is high. Further research in this area is necessary. If they are to be performed, newborn screening programs need to be of high quality.
- The available evidence suggests that vision screening programs aimed at children aged 18 months to five years of age lead to improved visual outcomes. However, visual acuity is more difficult to measure prior to approximately three years of age.
- There are few studies examining screening following school entry. Those identified suggest that school screening is necessary only if preschool screening has not been conducted previously.
- There was no evidence to support multiple screening events.
- Children at high risk of vision disorders (such as children from remote indigenous populations, children with multiple disabilities and children born prematurely) require separate assessment and diagnosis. Screening programs are not appropriate for these populations.
- Barriers to follow-up care include financial, logistical (lack of a car or phone, family issues) and perceptual (results not believed, not seen as a priority).
- The evidence suggests that vision professionals such as orthoptists perform more accurate screens (in comparison to health visitors, nurses and general practitioners). However, with appropriate training and follow-up, nurses are capable of performing effectively as screeners and may be a more cost-effective option.
- Links have been made between vision impairment and poor educational outcomes. It is suggested that vision impairment is correlated with lower visuocognitive and visuomotor skills, poorer reading ability and lower scores on achievement tests. However, visual deficits related to educational outcomes are often not identified during screening.
- Referral criterion for diminished visual acuity of 6/9 for four up to six year olds is generally recommended to reduce over-referrals and false positive rates.

- Treatment for amblyopia from the age of three is recommended by the available literature, but it may not be detrimental to defer treatment from the age of four to the age of five years. Older children (seven years and above) can achieve improvements in visual acuity but may require lengthier treatment.
- Vision screening may be cost-effective, in terms of dollars per quality adjusted life year (QALY). However, this may depend on the value placed on loss of vision in one eye.
- In order to rigorously evaluate vision screening programs, future research is required. Future research needs to encompass high quality randomised controlled trials, particularly in relation to screening during the newborn period, screening at the preschool versus the school entry period, and the effects of treatment of amblyopia in school-aged children on quality of life. The effects of loss of vision in one eye also require study.

2 Executive Summary

Purpose

The National Children's Vision Screening Project has been funded by the Commonwealth Department of Health and Ageing to inform future policy by determining the effectiveness of vision screening for children aged from birth to 16 years in Australia. The literature review was commissioned to evaluate screening programs designed to detect vision conditions such as diminished visual acuity, amblyopia, strabismus or squint, refractive error, cataracts and glaucoma.

The review examines the effectiveness of vision screening programs for populations with a low to moderate risk of developing a vision condition. Populations who are at high risk of developing a vision disorder, including children born prematurely, children in remote indigenous communities and children with multiple disabilities, require separate assessment, diagnosis and follow-up treatment and care. Vision screening programs alone are not considered appropriate to meet the particular needs of these populations.

Vision screening is different to assessment and diagnosis, and this review focuses solely on the former. Screening consists of a test or tests, generally quick and easy to administer and score, that determine whether a child meets certain criteria considered normal or 'healthy' for his or her age group. A screen does not provide a definitive diagnosis, but determines who should and should not be referred on for a more comprehensive eye examination.

The decision to commence, terminate or modify a health screening program can be contentious. There are certain criteria that screening programs ought to meet in order to effectively identify health conditions, and in order to effectively refer on for reduction, treatment or amelioration of these conditions. The screening of vision in children has been widely debated in the literature, with researchers, eye experts, economists and other professionals divided over whether vision screening should occur at all. For those who believe an Australian vision screening program should be in place, there is a lack of consensus about how and when it should occur. There is a lack of evidence, or lack of consistent evidence, regarding when vision disorders can be detected, whether disorders detected can improve over time without treatment, at what age treatment is most effective, what tools or tests are the most accurate and effective measures of vision disorders and who is best placed (in terms of accuracy, availability and cost-efficiency) to conduct vision screens.

All Australian states and territories have systems in place to offer testing of children's vision to some degree. While some states/territories offer universal screening of all children prior to or following school entry, others offer only targeted screening for at-risk children or those with an obvious vision concern. Most of the screening or assessment that currently occurs prior to a child entering school relies on parents or caregivers being vigilant in taking their child along to regular checks, usually with child health nurses.

Given the inconsistency of vision screening approaches across Australia, and the general lack of or inconsistent evidence regarding these approaches to vision screening in Australia and internationally, the three key objectives of this literature review were to determine:

- *Is a screening program the most appropriate method to use to detect vision conditions in children?*
- *What types of vision screening programs appear to be effective and therefore what properties or processes do programs require in order to be effective?*
- *At what age/s and how often should children attend a vision screen, if screening is deemed an effective method by which to detect vision conditions?*

Methodology

The literature search focused on detecting studies that examined the effectiveness of vision screening programs for children aged from birth to 16 years. Trials were identified through a variety of sources including standard clinical databases, published systematic reviews, hand searches of key articles and via consultation with expert reviewers.

It is important to note that the level of evidence from studies identified for this review was generally low, with the majority falling into category III-3, and to a lesser extent, III-2 (see Appendix A for level definitions). This was largely due to the study designs used to test vision screening effectiveness (i.e., the use of non-randomised controlled trials, observational studies and retrospective reports as opposed to systematic reviews or randomised controlled trials). Consequently, the overall quality of the findings was low, implying that caution must be taken in the interpretation of results and formulation of directions from the evidence.

Findings

As the literature search was focused on screening programs, the studies identified generally evaluated a screening program, or particular component of a screening program, as opposed to comparing a screening program with an alternative method of vision health assessment.

The studies identified incorporated a large number of screening parameters that could be altered to increase or reduce a screening program's effectiveness, such as the age of children at screening (which varied from seven months to 15 years), the characteristics and qualifications of screening personnel and available referral pathways following screening, to name a few. Given the large variation in screening parameters, any directions taken from the evidence can only apply to programs designed with the same parameters. A screening program with changes to any one of these parameters could produce different effectiveness outcomes to that reported in the literature.

Whether or not screening for a non-terminal health condition is required in part depends on its prevalence in the community, and the outcomes associated with having the condition. In Australia, the reported prevalence of common eye conditions in children is 1.4% to 3.6% for amblyopia, 0.3% to 7.3% for strabismus and 1% to 14.7% for refractive error. These statistics show large variations and further research may be required to consolidate these figures. However, they suggest that vision conditions are relatively prevalent among Australian children.

Screening is one of numerous solutions that could be considered to detect and identify vision conditions in children; ranging somewhere along a spectrum that includes no formal detection process at one end (e.g., relying on parental or teacher identification as the basis of concern) and comprehensive detection and diagnoses processes at the other (e.g., using vision professionals such as optometrists, orthoptists or ophthalmologists to carry out detailed assessments of every child).

Some studies did examine the process of relying on parent and teacher identification. These studies generally found that the parent and teacher questionnaire method may be a useful tool for older school-aged children (i.e., those who have been missed by a previous screen), but may be of little assistance in identifying vision conditions in children younger than the critical age of eight years.

The review identified one study that considered the use of universal comprehensive eye examinations for children. The study concluded that this method would detect, treat and cure significantly more cases of amblyopia in children than a universal screening program, and would be more cost-effective. However, the cost-effectiveness component of the study was flawed in its use of monocular blindness as a cost comparator; a condition that does not always result from amblyopia. It is therefore difficult to recommend that Australian states and territories take this approach without further evidence and cost-analysis.

Most studies suggested that screening for visual acuity was feasible from approximately three years of age onwards, and that this was also the age at which treatment for amblyopia was both well received and effective. Other studies noted that foregoing treatment for amblyopia until age four or five was not detrimental, and that treatment after the age of seven or even 10 was still effective and was advisable if necessary.

Based on the limited evidence available, this would suggest that the recommended screening range for children is between three and five years of age. Though many guidelines recommend, and some current Australian practice adopts, screening at multiple points in time, there was no evidence identified to support multiple screenings (e.g., during the preschool years *and* at school entry).

While no studies focused solely on the neonatal period, the literature that did touch on this area suggested that screening for strabismus, cataracts and other eye conditions, such as retinoblastoma, be carried out as early as possible following birth, and at no later than three months of age. While uncommon, these neonatal vision conditions could have severe ramifications for the infant.

Conversely, screening children at eight and 10 years was shown to pick up very few new cases of visual abnormalities requiring treatment, provided that an earlier preschool screen or child health check had taken place. Likewise, screening in secondary school was not recommended given the small likelihood of detecting any further functionally significant eye pathology.

Undetected or untreated vision impairment was shown to have links with educational outcomes. The evidence suggested that infant children diagnosed with hyperopia had poorer visuocognitive and visuomotor skills up to around five years of age and that children diagnosed with ametropia at 4.6 years had poorer visuomotor skills, even though some of the children's vision had been corrected with glasses.

The academic performance at school age of some children diagnosed with visual deficits was reported to be compromised. Children with refractive errors obtained lower scores on achievement tests, and those with ocular motility deficits and hyperopia obtained poorer achievement scores. Further, children with deficits in visual motor, ocular motor, binocular, accommodative, and visual perception skills scored poorly on educational tests, and the majority of children who were academically and behaviourally at-risk had failed one or more visual tests. Visual deficits in school age children were also shown to be associated with reading problems.

Evidence regarding the characteristics and qualifications of the administrators of screening was largely derived from international studies, which often did not incorporate consideration of all eye health practitioners available in the Australian context (such as optometrists). The evidence available suggested that orthoptists were the 'screener of choice' in comparison to nurses, health visitors and general practitioners. Nurses were also deemed to be accurate and efficient screeners when provided with appropriate training and supervision.

Some studies reported that a secondary screen (following a positive or questionable result for a vision condition) prior to ophthalmological referral decreased the false positive rate and was a more cost-effective screening method. The secondary screen was also effective in reducing the age of presentation of amblyopia, and facilitated the early detection, referral and treatment of eye problems. The available evidence indicated that orthoptists may be best employed in this role of secondary screener.

As noted, an important component of a screening program is its inclusion of appropriate referral pathways following detection of relevant conditions. Studies that focused exclusively on the follow-up component of screening programs found that there were a number of barriers

preventing children and their families from complying with referral or treatment recommendations. This is concerning, given the potential long-term consequences of vision impairment or loss, and given the resources that screening programs consume.

Finally, the literature suggested that visual acuity in Aboriginal children was not necessarily poorer than in non-Aboriginal children. However, rates of endemic trachoma were reported to be high in Aboriginal communities. It was suggested that child health surveillance (where health issues are considered at multiple points in time with information from different sources) and community education may be more appropriate in remote Aboriginal communities than screening. Other high risk populations, such as children born prematurely or children with multiple disabilities, are not considered suitable candidates for screening programs as more in-depth diagnosis and assessment measures are required for these groups.

Conclusions

Overall, the available evidence suggested that vision screening between 18 months and five years of age was optimal. However, this evidence was derived largely from low quality trials not utilising randomised controlled procedures. There were few studies evaluating screening at school entry, particularly under conditions where preschool screening had not already taken place. The increased accuracy of screening as children get older and the accessibility that would be optimised by screening children at school would need to be balanced against the potential diminished effectiveness of treatment at a later age. There was no evidence supporting screening on multiple occasions (e.g. during the preschool years *and* at school entry).

Some studies also suggested that secondary screening (further screening prior to referral for assessment) by a vision professional following a primary screen by either a layperson or a nurse, was effective in the early detection, referral, and treatment of eye problems. Studies reported that while secondary screening could incur additional preliminary costs, it could potentially save costs in the long-term by reducing the number of false positive referrals made to hospitals or specialist clinics. Educating parents to be more aware of and attentive to their child's vision, or creating awareness campaigns to ensure that treatment is adhered to and cultural barriers to compliance are addressed and removed, could enhance the overall effectiveness of vision screening programs, according to some of the evidence identified.

Whilst vision pathology in the newborn is not common, conditions such as congenital cataracts and retinoblastoma can have a severe impact on vision, and delay of detection until conditions are clinically evident or identified via a later screening program could have detrimental consequences. Though evidence to support newborn screening was not identified, the literature supported neonatal screening, including provision of formal training and with clear referral guidelines. Regardless of age, the literature recommended that high-risk children be referred to an ophthalmologist, rather than rely on population screening.

Most studies concluded that orthoptists were the more accurate screening personnel, in comparison to nurses, health visitors and general practitioners; although the majority of studies from which these conclusions were drawn were not high quality randomised controlled trials and did not consider all screening personnel available in the Australian context. The studies examining nurses as screeners concluded that, while the sensitivity and specificity of screening by nurses may be lower than that of orthoptists or ophthalmologists, this did not preclude them from being considered valid primary screeners for a vision screening program, with appropriate training and referral protocols. This may be a more cost-effective process for administration of screening in the Australian context.

There were a number of reported barriers to follow-up care and treatment that reduced the effectiveness of documented screening programs, such as financial pressures and accessibility concerns. Future screening programs should address these barriers in the design of the program.

Further research consisting of high quality, randomised controlled trials is required in order to effectively evaluate screening programs in general, and to determine whether screening would lead to an increase in the treatment of correctable visual acuity deficits and subsequently a decrease in the prevalence of correctable visual acuity deficits for older children and adults. Future research should also focus on an evaluation of screening at school entry (in comparison to preschool screening), and provide a rigorous evaluation of newborn screening. Further research is required to explicate any relationship between vision impairment and educational outcomes. Further, research which aims to determine the 'value' of vision, or the impact on quality of life for vision loss in one eye, is vitally important. Likewise, the impact of treatment for vision impairment on quality of life must be explored. Without a sound evidence base incorporating all of these facets of screening for vision conditions, it is difficult to clearly state the effectiveness or otherwise of vision screening programs.

Again, it must be emphasised that the literature contained few robust trials for appropriate evaluation of vision screening programs. However, the available evidence suggested that vision screening be carried out between the ages of three and five years, which could incorporate the preschool years and/or first year of primary school. The screening pathway recommended by many studies was that screening be conducted by orthoptists or by appropriately trained nurses with orthoptists as secondary screeners, followed by referral to medical eye specialists if required.

3 Background

This literature review was conducted to support the aims of the National Children’s Vision Screening Project, which seeks to inform future policy by determining the effectiveness of vision screening for Australian children aged from birth to 16 years. The literature review was commissioned to identify studies on the effectiveness of screening programs designed to detect vision disorders including diminished visual acuity, amblyopia, strabismus or squint, refractive error, cataracts and glaucoma. The directions drawn from the evidence summarised in this literature review may assist in the development of the key components of a national vision screening program for children in Australia, if vision screening can be recommended by the evidence.

Therefore, this review seeks to answer the following questions:

- *Is a screening program the most appropriate method to use to detect vision conditions in children?*
- *What types of vision screening programs appear to be effective and therefore what properties or processes do programs require in order to be effective?*
- *At what age/s and how often should children attend a vision screen, if it is deemed an effective method by which to detect vision conditions?*

To answer these questions, it is first important to note what screening is and what it is not. Over 30 years ago, Wilson and Jungner[1] developed a framework for evaluating screening tests or programs for the World Health Organisation (see Figure 1). This framework is still frequently adopted as the base benchmark against which a screening program should be assessed prior to roll-out. It is important to note that a screening program consists of and requires more than just a suitable screening test.

Figure 1. Criteria for a Screening Program, Wilson, J.M. and Jungner, Y.G. (1968)[1]

Criteria for a Screening Program	
Knowledge of disease	The condition must be an important health problem
	The condition must have a recognisable latent or early symptomatic stage
	The natural course of the condition, including development from latent to declared disease, should be adequately understood
Knowledge of test	There must be a suitable test or examination
	The test or tests must be acceptable to the population
	Case finding should be a continuing process and not a "once and for all" project
Treatment for disease	There must be an accepted treatment for patients with recognised disease
	Facilities for diagnosis and treatment must be available
	There must be an agreed on policy concerning whom to treat as patients
Cost considerations	The costs of case finding (including diagnosis and treatment of patients diagnosed) must be economically balanced in relation to possible expenditures on medical care as a whole

“A screening program is not a means of diagnosing vision problems, but uses collected data to refer students with possible problems for further evaluation and treatment. The distinguishing characteristic, then, is intervention, which is an essential component of a screening program” (*Colorado Department of Education*).[2]

If screening programs do not meet the Wilson and Jungner criteria, not only can there be unnecessary costs to the economy supporting the program, there can also be unnecessary costs to participants involved in the screening. For example, false positive results can cause intrapersonal angst and personal expense, while false negative results can lead to a mistrust of the system. Inadequate follow-up or treatment facilities can deem the initial screening program irrelevant. Hence, all components of the screening criteria outlined by Wilson and Jungner are important and should be taken into consideration.

Screening, however, is not the only method by which vision disorders in children can be identified. While this review focuses on the effectiveness of screening, the literature also identified some alternatives to screening that are also worth noting. For example, the use of parent or teacher identification of vision conditions has been explored. However, the results of a survey study by Thyer[3] found that primary school teachers in New South Wales lacked confidence and felt ill-prepared to take on a role of identifying children’s health problems.

At the other end of the spectrum, there is the option of foregoing screening for more comprehensive and diagnostic procedures conducted by eye specialists. As this review only identified one study that had reported on this alternative, and the discussion related to cost-effectiveness only, little interpretive comment can be made. The feasibility of this model in the Australian context would need to be evaluated in accordance with workforce availability and economic modelling.

Thus, while acknowledging that there are alternatives to vision screening programs, the purpose of this literature review is to evaluate vision screening in terms of the three questions outlined earlier. More specifically, by drawing on a critical evaluation of peer-reviewed published literature, electronic publications, websites and expert consultation, this literature review aims to:

- identify vision screening guidelines, protocols, and/or recommendations that are published in Australia and overseas
- outline the characteristics of vision screening programs currently in practice in Australia
- identify whether vision screening programs are effective, in terms of the criteria used to evaluate screening programs
- examine whether vision screening programs prevent/minimise vision conditions and their consequences
- identify whether vision screening program effectiveness is modified by the characteristics of the screener (i.e., different screening personnel)
- identify the optimal age for a vision screening program
- identify the ideal visual acuity level at which to refer children from screening for further examination and/or diagnosis
- identify information on the cost effectiveness of vision screening programs
- identify variations in a screening program that may be required for application in Indigenous and/or remote populations

4 Methodology

Trials were identified from a variety of sources including standard clinical databases, published systematic reviews, through hand searching of key articles, and via consultation with expert reviewers. We asked expert reviewers (members of the Project Advisory group) to identify any studies over and above those found by the search detailed below that (a) fitted the review trial criteria, (b) were new and promising in the field or (c) offered a specifically Australian perspective.

Below is a detailed summary of the inclusion criteria, search strategies used to identify the trials, and how the quality of each study was rated.

4.1 Inclusion criteria

The search focused on detecting studies that examined the effectiveness of vision screening programs for children aged from birth to 16 years. This included studies incorporating the use of age appropriate screening tests administered by various personnel, including laypeople. The focus of the search was on identifying screening 'programs'; that is, studies evaluating not only screening, but also screening personnel, referral pathways, treatment and consideration of outcomes. The search for guidelines or policies on vision screening, the cost effectiveness or economic evaluations of vision screening and prevalence of vision disorders were also included in the search criteria. Criteria were limited to studies in English and studies published from 1990 onwards.

Studies initially considered for inclusion were:

- Systematic reviews
- Randomised controlled trials (RCTs)
- Pseudorandomised controlled trials

Few studies meeting these criteria were identified. In order to be able to draw some directions from the evidence, the inclusion criteria were expanded to include the following types of non-randomised controlled trials (non-RCTs):

- Comparative studies with concurrent controls
 - Non-randomised experimental studies
 - Cohort studies
 - Case-control studies
 - Interrupted time series with a control group
- Comparative studies without concurrent controls
 - Historical control studies
 - Two or more single-arm studies
 - Interrupted time series without a parallel control group

The following studies were excluded:

- Case series

See Appendix A for the 'Designation of levels of evidence' table (NHMRC 2000).

4.2 Identification of trials

Studies were identified using the following strategy:

1. A search was conducted of published literature in the databases of Medline, CINAHL and Embase from 1990-2008. See Appendix B for the MeSH terms used in the search.

This yielded 461 abstracts of which 36 were selected for potential inclusion. The search was restricted to RCTs only.

2. A second search of the above databases was conducted using the same MeSH terms, but adding the criteria for non-RCTs. This yielded 1346 additional abstracts, of which 33 were selected for potential inclusion.
3. A hand search was conducted for any RCTs or non-RCTs meeting the inclusion criteria. Nine relevant studies were extracted from the following reviews: Child Health Screening & Surveillance: A critical review of the evidence. Prepared by CCCH, RCH for the NHMRC; Screening for Visual Impairment in Children Younger than Age 5 Years: A Systematic Evidence Review for the US Prevention Services Task Force; Snowdon, S. K. and S. L. Stewart-Brown (1997). "Preschool vision screening." Health Technology Assessment 1(8): i-iv.).
4. A search of the Cochrane Database of Systematic Reviews was conducted. Two relevant reviews were found.
5. A search of published guidelines from 1990 – 2008 in the Clin-evidence (also incorporating National Guidelines), MDCConsult and TRIP databases using the search terms "vision screening guidelines children" in various combinations produced 71 papers, which were reduced to 11 potential inclusions.
6. A request for further literature was sent out to eye health and other relevant professionals via members of the Project Advisory group and via members of the National Community Child Health Council. This yielded the following:
 - Two literature reviews that lead to the implementation of the Statewide Eyesight Preschooler (StEPS) program in NSW: Models of Service for Preschool Vision Screening, and Vision Screening Tools, courtesy of Robyn Davies, Senior Policy Officer for StEPS (28 studies in total)
 - Qualitative data collected by Dr Merri Paech, Lecturer, University of South Australia, on a vision screening study of high school students in South Australia (1 study)
 - A summary of published research papers to 2005 relevant to community child health, on vision screening and outcomes from treatment of amblyopia, compiled by Dr Jann Marshall, Department of Health, Government of Western Australia (86 studies in total)
 - Information on Western Australian vision and eye health screening tests and standards of practice, courtesy of Mark Drake, Assistant Director, Child & Adolescent Health Service, WA Department of Health (1 study)
 - Information on the Western Australian universal vision assessment schedule, courtesy of Mark Drake (1 study)
 - UK guidelines developed by National Institute for Health and Clinical Excellence (NICE)
 - Literature review completed by the Optometrists Association Australia (vision problems in children and vision screening success, both in Australia and overseas), courtesy of Patricia Kiely PhD, Research Officer (total of 102 studies)
 - Referral to the Optometric Clinical Practice Guideline: Paediatric Eye and Vision Examination (American Optometric Association 2002) available at: <http://www.aoa.org/documents/CPG-2.pdf>, which reviews the general literature on paediatric vision and addresses preschool and school age child assessment and conditions, courtesy of Patricia M Kiely PhD, Research Officer, Optometrists Association Australia (1 study)

- Information on the Literacy Pathways Program study (Southern Tasmania), supplied by Kylie Smith PhD Candidate, Menzies Research Institute (total of 3 studies)
 - Literature update on vision screening compiled and forwarded by Tim Fricke Researcher, International Centre for Eyecare Education Limited (total of 16 studies)
7. A request was sent out to various State and Territory contacts in Australia regarding current vision screening practice in each state and territory. The following information was received (see also Appendix C for further details):
- Referral to the child health record for NSW data on current vision screening practices by child health nurses
 - Referral to the child health record for Victoria for current vision screening practices by child health nurses
 - Queensland Health Guidelines for using screening and surveillance in the early detection of childhood health conditions, including guidelines taken from the Child and Youth Health Practice Manual
 - Information from the Tasmanian Child Health Record on current vision screening practices by child health nurses
 - Information from the Northern Territory on their proposed 'Under 5' schedule and their 'Healthy School-Aged Kids' program for remote areas, including the proposed vision screening practices of nurses, allied health workers and doctors
 - Information on current vision screening practices by community nurses, paediatricians and general practitioners in South Australia
 - Information on current vision screening practice in the Australian Capital Territory

4.3 Quality ratings for each study

If a study met the initial inclusion criteria and was directly related to an assessment of screening program effectiveness, including the longer-term outcomes of screening (e.g. educational success) and the personnel required to administer a successful program, it was assigned a quality rating using the National Medical Health & Research Council (NHMRC) recommendations from the 2000 report "How to review the evidence: systematic identification and review of the scientific literature" (See Appendix D, Box 1).

Using the NHMRC recommendations, there were four areas of quality rating for an intervention study: 1) method of treatment assignment, 2) control of selection bias after treatment assignment, 3) blinding of outcome assessment and 4) the quality of outcome assessment.

Bias can occur in any of these four areas and affect the interpretation of the study's results. For example, random allocation of children to the intervention or control arm of a trial is essential, as parents of children perceived to be at greater health risk may seek out the intervention if given a choice. When considering selection bias after treatment assignment, losing >15% of the study sample at follow-up or failing to report the effectiveness of the intervention according to how the intervention was received is important. Finally, in terms of outcome assessment, an 'intention to treat' analysis means that the outcomes have been analysed according to the way children were initially randomised (i.e., the way they were intended to be treated). Serious bias can occur if this is not done. For example, if some children from the intervention group did not receive the intervention (and this often occurs in 'real life') but the study reported only on those who did receive the intervention, then the effectiveness of the intervention could be artificially inflated.

Virtually all studies are open to bias. Many of the studies in this review made non-blinded assessments of the outcomes: that is, most outcomes were reported back to children and parents and most children and parents were aware if they or their child had received an intervention or not. However, as some studies did use blinding (either of the participant, the

assessor, or both), criterion three was used to determine quality ratings. Criterion four was included in the determination of quality ratings, but was not given a high weighting as all studies included a standardised assessment of the child.

A study was designated as 'high' quality if criteria 1 and 2 were fully met, 'moderate' quality if one or more of the criteria were partly met (e.g. received a 'B' or 'C' rating), and 'low' quality if neither criteria 1 nor 2 was met (see Appendix D, Box 2 for a full list of criteria and associated quality ratings).

Systematic reviews were assessed using criteria created by the Centre for Community Child Health in their review of child health surveillance and screening (see Appendix D, Box 3). Criteria 2 and 3 were deemed more important than Criteria 1 and 4 in assessing the quality of a systematic review, thus were weighted more heavily in the evaluation. A rating of 'A' was high quality, 'B' medium quality, and 'C' low quality. If the score was the same for both criteria 2 and 3, this was the overall quality rating i.e., C and C would equal a low quality study. If the score was either A and B, or B and C, then Criteria 1 and 4 were consulted. Unless both Criteria 1 and 4 were rated A, the lower rating out of Criteria 2 and 3 applied. The median score was chosen if the rating was A and C, or C and A (see Appendix D, Box 4).

4.4 Data analysis

Two members of the project team initially evaluated each paper to determine its eligibility for inclusion. Disagreements occurred on 49 of the studies, and were subsequently resolved through discussion and consensus.

Two researchers independently extracted data from the included studies and rated their quality. Prior to extracting data from the papers, both reviewers evaluated a selection of papers to determine consistency in evaluation and quality ratings. Any discrepancies apparent were discussed and rectified. A total of two RCTs, 38 Non-RCTs and 11 systematic reviews were included in the literature summary on the effectiveness of vision screening.

5 Literature

The majority of the literature identified by the search centred on three of the key themes identified as crucial to the study; the effectiveness of screening programs, the effectiveness of different screening personnel and the influence on educational outcomes should vision conditions fail to be detected. Literature on these three themes were categorised according to age group: neonate, toddler, preschool and school-age plus. Appendix E contains a full summary in table format of all RCTs and non-RCTs covering these themes.

Summaries of the other key themes, such as prevalence of vision conditions and optimal age of treatment, have been included in the body of this review, with more detailed material included in tables in Appendix E for ease of reference.

5.1 Prevalence of vision conditions in Australian and overseas children

Amblyopia

A study in south-eastern Australia conducted between 1980 and 2000 estimated that the incidence of infantile glaucoma was rare, at 1 in 30,000 births.[4] The prevalence of amblyopia in Australia for six year old children involved in the Sydney Myopia Study was reported in one study to be 1.4% (for those without eyestrain symptoms) and 3.6% (for those with eyestrain symptoms),[5] In another study, these figures were 1.8% (taking into account all children previously diagnosed and treated) and 0.5% (non-correctable visual impairment).[6]

Two United Kingdom studies found comparably low prevalence of amblyopia, reporting rates of 0.5% (in Weston-super-Mare) and 1.1% (in Southmead)[7] for children screened at six

weeks to 3.5 years, and 2.5% for children screened at 3.5 – 5.5 years.[8] A Singaporean study of children screened at 4 – 4.5 years reported the incidence of amblyopia to be 1.8%.[9]

A Canadian study, which screened four year old children over a three year period, found the prevalence to average around 1.0% over the three years.[10] Another Canadian study reported a higher incidence for four year olds at 4.7%,[11] while the Vision in Preschoolers Study Group (VIP) in the United States reported prevalence of 5.3% for children aged three to five years.[12] For children slightly older in the United States (four to eight years of age), the incidence of amblyopia was 3.9%.[13]

The prevalence of amblyopia for children 12 years of age in the Sydney Myopia Study was 1.9% (including all children previously diagnosed and treated) and 0.9% (non-correctable visual impairment).[14] The results from the United Kingdom for eight and 10 year olds were also low in relation to both mild amblyopia 0.8% and marked amblyopia 0.6%.[15]

Strabismus

The prevalence of strabismus in six year olds in the Sydney Myopia Study was 1.8% (for children without eyestrain symptoms) and 7.3% (for children with eyestrain symptoms),[5] but was as low as 0.3% in another study of children three to 12 years in Victoria and New South Wales.[16] A study in the United Kingdom of children screened at 8.1 months found a low incidence of strabismus at 0.6%,[17] as did a study in Holland of children aged nine months to two years (0.8%),[18] and a study in the United States of children aged six months to 3.9 years (0.2%).[19]

Another study in the United Kingdom of children aged 3.5 – 5.5 years also reported a low incidence of strabismus (at 1.0%),[8] However, prevalence rates in the United States were higher, with strabismus being detected in 7.1% of one to five year old children, 15.4% of one to six year old children,[20] 2.1%[12] and 3.9%[21] of three to five year old children, and 3.1% of four to eight year old children[13]. Rates reported in Canada for four year olds were 1.0% - 1.4%[10] and 4.3%.[11] In children aged eight to nine years of age in Northern Ireland the prevalence of strabismus was 4.0%.[22]

Refractive error

The prevalence of refractive error (including myopia, hyperopia, anisometropia, and astigmatism) for four year old children in New South Wales was reported to be 1.0%[23] (myopia) for children screened from 1990 to 1994 and 2.3%[24] (myopia) for those screened from 1998 to 2004. The Sydney Myopia Study found that 2.5% of children screened at six years had significant hyperopia, 7.3% had mild hyperopia, and 1.4% had myopia.[25] In an investigation of six year olds without eyestrain symptoms, 2.8% had hyperopia, 1.4% had myopia, and 6.8% had astigmatism, whereas in children with eyestrain problems, 7.3% had hyperopia, 2.3% had myopia, and 8.2% had astigmatism.[5] Another paper reporting results of the Sydney Myopia Study found that 13.2% of six year olds screened had moderate hyperopia.[26] Junghans et al.[16] found that out of 2490 children aged three to 12 years who completed at least one of four vision tests, 3.3% had hyperopia >1.50D, 4.1% had myopia >-0.75D and 2% had astigmatism >1D.

In children aged 8.1 months in the United Kingdom, anisometropia was detected in 2.1% of the population,[17] while refractive error in three to 5.5 year olds was reported to be 1.7%[8] and 1.2%.[27] In Holland, refractive error in children aged nine months to two years was reported to be only 0.5%.[18]

Higher rates of refractive error were generally found in the United States in children one to five years (high hyperopia 32.8%, myopia 5.5%, astigmatism 18.3%, anisometropia 28.6%), one to six years (high hyperopia 16.3%, myopia 2.0%, astigmatism 29.8%, anisometropia 34.2%),[20] three to five years (refractive error 5.1%),[12] five to seven years (refractive error

6.1%),[28] and six years (myopia 4%).[29] Two United States studies obtained lower rates with children six months to 3.9 years (high hyperopia 0.3%, high myopia 0.03%, astigmatism 0.3%, and anisometropia 0.5%),[19] and children four to eight years (myopia 3.1%, astigmatism 2.5%, and anisometropia 2.6%).[13]

The prevalence of refractive error was high (at 14.0%) in a Singapore study of children 4 – 4.5 years,[9] a Canadian study of four year olds (refractive error 10.6% - 11.9%),[10] and studies from China and Hong Kong of children five to seven years (myopia: rural China 5%, Chinese Malays 24%, urban Hong Kong 30%).[30-34] Another Canadian study found lower rates of refractive error in children aged four years (hyperopia 4.8%, myopia 1.1%, astigmatism 3.1%, anisometropia 1.4%).[11]

For 12 year old children in the Sydney Myopia Study, the prevalence of refractive error was quite high with 5.0% relating to hyperopia, 12.8% to myopia, and 9.4% to astigmatism.[26, 35] A New South Wales study found that 8.3% of 12 year olds had myopia when screened between 1990 to 1994[23] and 14.7% when screened between 1998 to 2004.[24]

For children aged eight to 10 years in Ireland, the prevalence of refractive error was fairly low with hyperopia at 3.4%, myopia at 1.4%, and astigmatism at 3.4%. [22] A study in the United Kingdom reported a high rate of myopia in eight and 10 year olds at 8.2%. [15] A United States study obtained a rate of 5.4% for refractive error in children screened eight to 10 years of age, and 7.4% for children screened at 11 – 13 years,[28] whilst another United States study for 12 year olds reported the rate of myopia to be 20%. [29] Studies from China and Hong Kong of children 11 - 12 years found high rates of myopia (rural China 23%, urban China 40%, Chinese Malays 47%, urban Hong Kong 57%). [30-34]

Summary

The significant variations in prevalence reflect in part the use of different tests, different definitions of pathology, and the natural history of vision disorders in children whereby there is often a change with increasing age. This is independent of the increasing accuracy of testing with increasing developmental ability.

Therefore, while the aforementioned studies provide an indication of the prevalence of vision disorders in Australia and overseas, it would be remiss to justify a screening program or otherwise on the basis of prevalence rates alone. Prevalence is certainly one of the key factors to take into consideration, but should be considered in conjunction with the quality of life and various other aspects of life that may be impacted by a vision disorder. The effectiveness of screening programs should be evaluated in the context of both prevalence and outcomes (e.g., educational) associated with having a vision disorder. Such outcomes will be outlined further on in this review.

5.2 Australian and international guidelines on vision screening practice

Fourteen guidelines or position statements were identified on the topic of vision screening. Guidelines were evaluated for quality using the Appraisal of Guidelines for Research and Evaluation (AGREE) instrument, developed by The AGREE Collaboration in 2001 (see Appendix F). Guidelines were rated and given a score out of 100 for each of the following categories: scope and purpose; stakeholder involvement; rigour of development; clarity and presentation; applicability and editorial independence. For this review, particular weight was placed on the ratings given to rigour of development and stakeholder involvement.

Overall, all of the guidelines recommended screening for children. The majority of the higher quality guidelines recommended a screen sometime during the newborn to three months of age period (generally, an inspection and a red reflex) and a major screen during the 'preschool' years (ranging from ages 2.5 to five years). Some guidelines recommended further

screening during the school years (either every year or every two years after the age of five). Other recommendations were as follows:

- that testing for visual acuity should commence at three years
- that vision screening should occur at the age of three years only if an appropriate test is developed to reduce the high number of false positives
- that any vision difficulties suspected between one and six weeks of age should be referred directly to an ophthalmologist
- that any abnormal screens be referred on for a secondary screen or full diagnosis
- that community health nurses conducting screening programs should refer for orthoptic review where possible, before referring to a general practitioner or ophthalmologist

See Appendix G for a summary table of all guidelines and policy statements.

5.3 Current vision screening practice in Australia

All Australian states and territories have systems in place to offer assessment of children's vision to some degree, from birth through to the adolescent years and beyond. However, the methods used to conduct these assessments or screenings and the personnel used to conduct them varies across Australia. While some states/territories offer universal screening of all children prior to or following school entry, others offer only targeted screening for at-risk children or those with an obvious vision concern. Most of the screening or assessment that currently occurs prior to a child entering school relies on parents or caregivers being vigilant in taking their child along to regular checks with child health nurses. For a detailed description of current vision screening practices in Australia, see Appendix C.

5.4 Screening effectiveness

5.4.1 Overall summary – screening effectiveness

In this review, studies were identified that looked not only at the effectiveness of screening programs per se, but also at the effectiveness of the screening process; a process that includes the lead-up to screening (marketing and engagement) and the follow-up after screening (referral pathways and treatment compliance). Ideally, studies included information about testing, treatment and outcomes.

Eight systematic reviews on screening effectiveness were identified; one of high quality, four of medium quality, and three of low quality. One randomised controlled trial of medium quality, and seventeen non-randomised controlled trials met our inclusion criteria. Three of the non-randomised controlled trials were of medium quality, and 14 were of low quality.

The evidence available reported that early vision screening, and subsequent early treatment, led to improved visual outcomes[36-38] and lower prevalence of amblyopia.[39-44] The ages of children screened in the studies ranged from seven months to 10 years. Screening children at eight and 10 years was shown to identify very few new cases of visual abnormalities requiring treatment, with most having been detected at the five year school vision screen.[15] School nurse screening in secondary school (13 – 15 years) failed to detect any new cases of eye pathology in one study.[45]

Two systematic reviews of the literature on the effectiveness of vision screening programs reported that no randomised controlled trials fitted their criteria. The reviews concluded that screening may still be valuable, but that this value had yet to be properly identified.[46, 47] Other systematic reviews recommended that: screening for strabismus should be performed in the neonatal period, at six months, at three years, and at five to six years;[48] that inspection of eyes should occur during the neonatal period;[48] that high-risk children should be referred to an ophthalmologist;[48] that parents should be taught to be more attentive to their child's vision;[48] that screening of visual acuity should be performed as early as possible;[48] and that screening of children for refractive errors should be conducted at a

community level and integrated into school health programs, accompanied by awareness campaigns to ensure that the corrections are used and compliance barriers are addressed and removed.[49]

One systematic review and four non-randomised controlled trials outlined the social, economic, and political barriers that contributed to the underutilisation of vision screening among preschool and school-aged children.[49-53] One study suggested that strategies were required to achieve earlier diagnosis and increase the proportion of cases of congenital and infantile cataract detected through screening in the first three months of life.[54]

Two studies demonstrated that the introduction of a secondary screen was effective in reducing the age of presentation of amblyopia associated with microtropia or no strabismus,[55] and the early detection, referral, and treatment of eye problems.[56]

Four studies examined the use of questionnaires administered to teachers, parents and/or students as screening tools.[45, 57-59] Finally, two studies reported that appropriate marketing strategies could increase the number of preschoolers who received vision care[60] and decrease the age at which amblyopia and strabismus were detected.[61]

Many of the recommendations made in the literature were based on medium to low quality studies with no control group. In considering these recommendations for future research or policy decisions, the quality of the study and the nature of the data obtained (primary, or secondary in the case of reviews) need to be taken into account.

5.4.2 Neonates (0-1 month)

No relevant studies were identified.

5.4.3 Toddler age (1 month-3 years)

One randomised controlled trial and four non-randomised controlled trials evaluated the effectiveness of screening programs in detecting refractive errors, the effects of early correction on visual outcomes, the mode and detection of congenital and infantile cataracts, and the impact of introducing a secondary orthoptic screen. Two further non-randomised controlled trials examined the impact of marketing strategies on increasing participation rates and decreasing the age at which vision conditions were detected.

A study in the United Kingdom examined two different screening programs on infants aged seven to nine months (Cambridge Infant Vision Screening program).[36] The first program used an isotropic photorefractor with cycloplegia and a standard orthoptic examination (n=3166). The second program used the VRP-1 isotropic videorefractor, which was followed-up by refraction under cycloplegia (n=5091). Both programs demonstrated consistency between infants identified at screening and retinoscopic refractions at follow-up. The first program found that children who were hyperopic in infancy were 13 times more likely to become strabismic, and six times more likely to show acuity deficits by four years of age, compared to a control group. Wearing a partial spectacle correction reduced these risk ratios to 4:1 and 2.5:1 respectively. Thus, cycloplegic refraction in infancy had a high predictive value for identifying children at risk of strabismus and amblyopia.

A follow-up study of this cohort at seven years of age showed that, for the first program, infants with +3.5D or more of hyperopia who did not wear a spectacle correction had, by four years, a high prevalence of strabismus (21%) compared with emetropic controls (1.6%).[37] In infant hyperopes who wore a partial spectacle correction, the prevalence of strabismus was reduced to 6.3% from 21%, while amblyopia was reduced to 28.6% from 68%.

In the second program, infant hyperopes greater than +4D, who were not corrected, showed much higher prevalence of strabismus (17%) and amblyopia (68%) than emetropic controls

(0.5% and 0.5%). Those who wore a spectacle correction had a significantly reduced rate of amblyopia (17.1%), however the prevalence of strabismus was not significantly reduced in the treated group. In both programs, 'intention to treat' analysis showed significantly improved acuity results for the group assigned spectacle correction, irrespective of compliance. The authors concluded that photo/videorefractometry can successfully screen infants for refractive errors, with visual outcomes improved through early refractive correction. The authors also added that this depended on adequate skills and organisation for delivering the program and in follow-up (confirming refractions, prescribing corrections, and encouraging and monitoring compliance). Both the original and the follow-up study were of low quality.

A randomised controlled trial was conducted in 2001 to assess the effectiveness of preschool vision screening in the United Kingdom.[39] Participants were part of the Avon Longitudinal Study of Parents and Children (ALSPAC). The control group received visual surveillance at eight and 18 months by health visitors and family doctors, which included observing visual behaviour and administering a cover test (n=1461). The intervention group was assessed at eight, 12, 18, 25 and 31 months by an orthoptist testing for visual acuity, ocular alignment, stereopsis, and non-cycloplegic photorefractometry (n=2029). Mothers' dates of birth were used to determine assignment of children to the intervention group, a method of randomisation that could be improved upon. Further, due to the intensive nature of the testing involved, the authors acknowledged that the intervention program was not designed to be practicable. However, it was found that the intervention program detected more children with amblyopia than the control program (1.6% versus 0.5%), and the intervention program was more specific (95% versus 92% for the control group program). Photorefractometry was the most sensitive component of the program (>95%).

A 2002 follow-up study was conducted with the same cohort to assess the outcome of treatment for amblyopia.[40] It was found that the intensive screening protocol (screening at eight, 12, 18, 25, 31 and 37 months), was associated with better acuity in the amblyopic eye and a lower prevalence of amblyopia at 7.5 years of age, in comparison to screening at 37 months only (0.6% versus 1.8%). The authors concluded that earlier treatment for amblyopia led to a better outcome than later treatment, supporting the principle of preschool vision screening. It should be noted however, that only half of the sample was followed-up, which may have biased the results.

A comparison of eight year old children in Israel who either had received screening for vision defects at 1 - 2.5 years (808 children) or had not (782 children), found that the prevalence of amblyopia was much higher in the children who had not been screened (2.6%) compared to those who had received screening (1%) (p=0.0098).[41] The screening was detailed and performed by an ophthalmologist or an orthoptist and consisted of a corneal reflex test, fixation-and-following test, ductions and versions examination, cover-uncover test, alternate cover test and retinoscopy without cycloplegia. The screening program sensitivity was 85.7% and specificity 98.6%, with a positive predictive value 62.1% and negative predictive value 99.6%, indicating an effective screening program.

Rahi and Dezaux[54] conducted a cross-sectional study to determine the mode of detection and timing of ophthalmic assessment of a nationally representative group of children with congenital and infantile cataract in the United Kingdom. It was found that 47% of the children newly diagnosed with congenital or infantile cataract were detected through examinations from birth to eight weeks. Fifty-seven per cent had been examined by an ophthalmologist, but 33% were not assessed until after their first birthday. The authors concluded that strategies were required to achieve earlier diagnosis and increase the proportion of cases detected through screening in the first three months of life.

Smith et al.[55] investigated the impact of changes to vision screening in Leicester, United Kingdom. Before 1988, health visitors referred children suspected of having a vision problem to their GP who would refer them on to an ophthalmologist. This system allowed delay, drop out and error. The new system involved children being referred directly from primary screening to a secondary orthoptic screen, in order to reduce drop out and to offer a trained

assessment of the child's problems. The introduction of the secondary screen resulted in the mean age of presentation of amblyopia associated with microtropia or no strabismus being reduced from 6.6 years to five years. No change in age of presentation for amblyopia was associated with large angle of strabismus. Prior to the introduction of the program, children from more deprived areas presented later, whereas this association was not found after the secondary screen was introduced. Thus, following changes to the system, children were referred earlier, and those from deprived areas were not overlooked. However, the design of the study was limited in that children started treatment in different years, thus there were no pure birth cohorts. Further, the screening experience may have varied within the two groups, as data was collected from children attending an orthoptic clinic in 1983 and 1992.

Filipovic et al.[61] attached an ophthalmologic screening card to children's vaccination cards to examine whether this reduced the age at which children were first admitted to the Department of Paediatric Ophthalmology. After the screening card was introduced, the mean age at which amblyopia and strabismus were detected decreased significantly, from a mean of 4.4 years to a mean of 2.5 years.

Bradley and Riederer[60] conducted a pilot of the Vision First Check Program to determine whether appropriate marketing strategies could result in a substantially higher number of two and three year old children receiving a thorough vision assessment. Screening was provided voluntarily by optometrists, and follow-up by public health personnel. Marketing materials were displayed in optometrists and family physicians' offices, in health units and in libraries. The study concluded that the Vision First Check Program was successful in increasing the number of two and three year old children receiving vision care.

5.4.4 Preschool age (3-6 years)

Four systematic reviews were identified that evaluated the effectiveness of vision screening in reducing rates of amblyopia, the effectiveness of screening for strabismus and subsequent treatment, the effectiveness of primary orthoptic screening, and barriers that contributed to the underutilisation of vision screening. Five non-randomised controlled trials were identified that looked at visual outcomes after screening and subsequent treatment, the effectiveness of secondary screening, the effectiveness of using a teacher questionnaire and some barriers to follow-up care post-screening.

A systematic review was conducted to evaluate the effectiveness of vision screening in reducing the prevalence of amblyopia in screened versus unscreened children before or as they entered school.[47] No randomised controlled trials were identified that fitted the criteria. The authors concluded that the absence of such evidence could not be taken to imply that vision screening is not necessary - simply that screening has yet to be tested in rigorous trials. They concluded that the optimum protocol for conducting screening remained unclear, and that there appeared to be no detrimental effect in terms of visual outcome on leaving screening until school entry. This in fact appeared to improve the participation rate achieved.

A low quality review by Weinstock et al.[48] examined the clinical classification of strabismus, described the timing and method of strabismus screening examinations, and discussed principles of treatment. The main recommendations from the review were that (a) primary care physicians should screen all low-risk children, (b) high-risk children (low birth weight, family history of strabismus, congenital ocular abnormality, or systemic conditions with vision threatening ocular manifestations) should be referred to an ophthalmologist for screening, (c) screening should be performed in the neonatal period, at six months, and at three years (Grade A recommendation), as well as at five to six years (Grade B recommendation), and (d) these screening examinations should include inspection, examining visual acuity, determining pupillary reactions, checking ocular alignment, testing eye movements, and ophthalmoscopy.

Weinstock et al.[48] reported that strabismus is a common problem affecting four per cent of school-aged children and that, untreated, up to 50% of patients with heterotropias would

develop permanent vision loss in the deviated eye. The authors also reported that improperly aligned eyes would impede normal binocular vision and stereoscopic depth perception, which could interfere with a child's ability to read, play sport and relate to others. This social dysfunction could continue into adulthood and affect self-image, employment, and relationships. The study recommended that all cases of manifest strabismus and all symptomatic cases of latent strabismus should be referred to an ophthalmologist promptly. The report stated that amblyopia could be successfully treated, that binocular vision and depth perception could develop normally if strabismus and amblyopia were detected early and that lives could be saved if serious cases of ocular disease were identified promptly. However, no evidence was provided to substantiate these claims.

A systematic analysis of screening programs used to detect visual dysfunction in Sweden and Canada was performed in 1995, and the performance of these programs was found to be favourable.[62] Based on analysis and evaluation, the review made seven main recommendations: (1) that inspection of eyes and preferably examination of the red reflex with an ophthalmoscope should occur in the neonatal period; (2) that children at high-risk for ocular and visual disorder should be examined by an ophthalmologist; (3) that teaching parents to examine the eyes and vision of their children may make them more attentive to the visual development of their children, and that staff at paediatric departments and child health care centres should be alert to symptoms and signs of visual defects; (4) that paediatric exams should include detection of squint and that fundoscopy should be undertaken when there is a clinical indication; (5) that screening of visual acuity should be performed as early as possible, that a screening test of monocular visual acuity in four year old children can be reliably performed by non-ophthalmic personnel, allowing for re-testing if children are uncooperative, and that this screening test should be repeated by school nurses during first grade of school and at regular intervals during the school years; (6) that children who screen positively should be seen by orthoptists, and in some cases ophthalmologists, without delay; and (7) that there is a need for a better preschool acuity test that can be used at age 2.5 - 3 years.

A systematic review[63] and a survey study[50] addressed the barriers which contributed to the underutilisation of vision screening among preschool age children. It was found that a variety of social, economic and political barriers prevented children from receiving proper vision screening. Social barriers included ignorance, inconvenience, language, and lack of providers, while political barriers arose from the disproportionately small amount of funding allocated to preventative medicine. Financial barriers primarily affected low income families to the extent that low income, minority, and uninsured families were at high risk of not utilising vision screening. Both studies concluded that in order to address barriers to follow-up care, parents needed to be fully aware of the objectives and benefits of vision screening. Paediatricians or primary care providers should also be re-introduced to the importance of vision screening among preschoolers. Once children receive comprehensive vision screening, appropriate networking needed to be established to help with follow-up of children with referrals to specialists.

A retrospective cohort study, using the same birth cohort as Williams et al.[39] (ALSPAC), assessed the visual outcomes of children in the United Kingdom aged 7.5 years who either did or did not receive preschool vision screening at three years of age (n=6081).[42] Children were screened by an orthoptist using a monocular vision test, a cover test, and an assessment of binocularity or a test of strabismus, or both. More children were offered preschool screening (24.9%) than those who actually attended (16.7%). Children who received preschool screening had a 45% lower prevalence of amblyopia compared to those who did not receive preschool screening (1.1% of 1,019 screened versus 2.0% of 5,062 not screened). Once all children who were offered the screening (whether or not it took place) were included in the analysis, amblyopia was still less common in the children offered preschool screening, but was not statistically significant.

The study indicated that, while a vision screening program can be effective, the effectiveness can be affected by the number of children who actually receive screening. It was also reported

that children screened at preschool (3.1 years) had slightly better outcomes following treatment than children screened at school entry (preschool group mean visual acuity 0.14 LogMAR, school-entry group 0.2 LogMAR). This beneficial effect was significant for straight-eyed amblyopia, but not amblyopia associated with squint. The authors also noted that the cohort under-represented children from very deprived families, families of Asian extraction, and families where the mother was a teenager at time of birth. Thus, findings may not be generalisable to these populations.

A retrospective review conducted in the United Kingdom in 1991 examined vision screening by orthoptists during 1987-88 with 5,162 children aged three to four years.[38] The review examined for gross abnormalities, corneal reflections, abnormalities of ocular movements and binocular convergence. Orthoptists also used the cover test for strabismus, prism reflex test for abnormality of binocular function and Sheridan Gardiner 7 letter test for visual acuity. Of those screened, 309 were referred and 233 received treatment (218 were prescribed spectacles, 87 were prescribed occlusion treatment, and 10 were listed for surgery). The number of children who improved in terms of lines on a standard Snellen chart after treatment was: 18 (4+ lines); 34 (3 lines); 67 (2 lines); 49 (1 line); 30 (no improvement); 30 (no results). As the review was undertaken in a disadvantaged health district, results may be less generalisable.

A retrospective study was undertaken in the United Kingdom to evaluate a community orthoptic service, which served as a secondary assessment prior to hospital follow-up.[56] A total of 2,600 children were evaluated. Primary vision screening at 3.1 years by orthoptists working in local clinics led to the referral of 140 children (6.3%). One hundred and fifteen (85.8%) of those seen at hospital were identified as having an eye problem, and of these, 82 (61.2%) required immediate treatment. The community orthoptist request service referred 70 (17.8%) children. Sixty (95.2%) children were identified as having an eye problem, and of these, 42 (66.7%) required immediate treatment. The authors concluded that primary screening was an efficient and effective way for early referral of specific targeted eye problems, the majority of which had been undetected. Had there only been a request service available, the eye problems would not have been identified until school age. Providing the request service allowed children with suspected eye conditions to be confirmed and referred immediately to hospital. Filtering referrals via a community orthoptic service allowed hospital resources to be utilised more efficiently by reducing the number of false referrals; and enabled effective early treatment of vision problems.

Finally, Concannon and Robinson[57] evaluated the effectiveness of a questionnaire designed to enable teachers to assess children's vision. Twenty-two primary schools in northern Sydney were selected for the study (n=1345, children aged four to six years). Visual assessments conducted by nurses were compared to reports from teachers. It was found that only five out of 42 children (4%) identified by the teachers' reports were considered by the nurse to have a vision problem. A further 31 children identified by the nurses' screen as having a vision problem were missed by teachers. It was concluded that teachers' reports were an unreliable and unsatisfactory alternative to screening by school health nurses.

5.4.5 School age (6+ years)

Two systematic reviews examined the effectiveness of vision screening in schools, and the global magnitude of visual impairment caused by uncorrected refractive error. Ten non-randomised controlled trials examined various topics including the effectiveness of screening and treatment in reducing amblyopia, the detection of new defects at 8 – 10 years following screening at five years, the efficacy of screening in secondary schools, the effectiveness of parent and student questionnaires in detecting vision conditions and the barriers to receiving adequate follow-up care.

A systematic review was conducted to evaluate the effectiveness of school vision screening programs in reducing the prevalence of undetected, correctable visual acuity deficits due to refractive error.[46] The authors did not find any randomised controlled trials that met their

inclusion criteria, thus no formal analysis was performed. In order to report on current practice, the authors identified observational, cross-sectional, and cohort studies. The authors concluded that there were no robust trials available to measure the effectiveness of vision screening, therefore the value of vision screening had yet to be properly identified.

The authors noted that the potential for screening to be harmful should also be acknowledged. They reported that the consequences of administering programs with poorly defined parameters for intervention included undue cost and inconvenience in regards to false referrals, and unnecessary treatment. However, the authors acknowledged that where primary eye care services were very scarce, screening in schools allowed the opportunity to identify problems that would otherwise be missed. Again, it was concluded that there was a clear need for well-planned randomised control trials to be implemented to measure the effectiveness of vision screening.

A review of the literature was conducted on the global magnitude of visual impairment caused by uncorrected refractive errors for people aged five years and over.[49] The study concluded that: (a) screening of children for refractive errors should be conducted at a community level and integrated into school health programs, accompanied by awareness campaigns and the removal of barriers to compliance; (b) refractive corrections needed to be made more accessible and affordable for all ages; (c) eye-care personnel should be trained in refraction techniques and teachers and school health-care workers should also receive training and information programs; (d) reliable and affordable equipment for refractive assessments should be developed; and (e) impairment and outcomes should be monitored at a national level to identify communities in need and to evaluate the most cost-effective interventions..

A retrospective study conducted in Sweden in 2001 followed 3,126 children from birth to 10 years of age.[43] Children were screened at age four, 5.5, seven and 10 years by nurses at Child Health Care Centres or at schools. At four and 5.5 years, monocular vision was tested using the HOTV-chart, while at seven years children were tested with a Line E-chart or HOTV-chart, and at 10 years Monoyer's linear letters were used. It was found that the screening and subsequent treatment of amblyopia decreased the prevalence of the condition. The difference in the number of amblyopes between screening and non-screening was most pronounced for the lower visual acuities. The screening tests at four and 5.5 years (HOTV-chart) had a sensitivity of 92% and specificity of 97%.

Another retrospective study using the same birth to 10 years cohort as Kvarnstrom et al.[43] examined the various ophthalmological conditions detected in a Swedish vision screening program for children.[44] Ametropia (any refractive error) was mainly detected at four years, when visual acuity tests were first performed. Manifest strabismus was in many cases detected before age four, while microtropia (small angle heterotropia) was detected at four years. The prevalence of amblyopia was reduced to 0.2% from 2% by screening and treatment, and the majority of patients with amblyopia increased their visual acuity with treatment, indicating that screening and treatment can reduce the prevalence of amblyopia.

A prospective study of school vision screening tests was undertaken on 1,809 children aged eight and 10 years in Cambridge, United Kingdom.[15] The authors examined whether a significant number of new defects of vision were detected. It was found that only 15 (0.83%) of the children tested had a newly diagnosed problem requiring treatment. Almost all children with marked visual abnormalities had already been detected before school entry, either at the five year school vision test or on another occasion.

A United Kingdom study examined the effectiveness of vision screening on 1,069 secondary school students aged 13 – 15 years.[45] The screening was carried out by school nurses using the Snellen chart. It was found that 3.8% of children failed the vision screening test. There was no evidence to suggest that failing vision screening increased across the age range. Less than 1% of children were prescribed glasses, and no new cases of eye pathology

were found. However, this study obtained a lower sample size than expected, which decreased the power of the study.

Scherrer and Stevens[58] conducted a comparison of nurse screenings and screenings using a parental and student questionnaire, with students aged 10 – 11 years (n = 191). The study was undertaken in six schools from two large rural cities in New South Wales. It was found that the questionnaire method exhibited a relatively low error rate when data from both parent and student were combined. Only two of 191 students would have been overlooked if the questionnaire was the only method used to screen. However, the study was limited in that the sample was small, the socioeconomic group contained well-educated students and parents, and the children were older and therefore better able to provide information on their own health. The prevalence rate of vision disorders may also have been lower in this sample to begin with, due to possible prior screenings and treatment.

Edgecombe et al.[59] found that the inclusion of simple questions directed at parents about their child's visual history on the School Entrant Health Questionnaire (SEHQ) could provide useful vision screening information to school nursing personnel. In a similar study, Jewell et al.[45] asked parents to complete a questionnaire concerning their children's past eye history. This was a large (n=1069) United Kingdom study of children aged 13 - 15 years and their parents. It was reported that 38% of secondary school children with abnormalities identified by screening had already been self-detected or detected by a family member. Caution should be taken in generalising these findings due to the age of the children in this study and therefore the greater time period allowed for the child or family to detect problems.

Three studies looked at the reasons why children identified as having a vision condition during a screen did not always attend appointments for follow-up care or treatment.[51-53] The studies concluded that the major barriers to follow-up care or treatment compliance fell into three major categories: (1) financial – cost and money concerns; (2) logistical – lack of a car or phone, an inability to plan ahead and/or family issues; and (3) perceptual – results not believed or not seen as a priority. Other reasons for non-compliance included a lack of general community awareness about vision impairment and some adolescents' reluctance to wear glasses.[51]

5.4.6 Screening effectiveness – directions from the evidence

Overall, there is a lack of evidence to conclusively evaluate the effectiveness of screening. However, the evidence available suggests that if screening is to be conducted, then doing so at an earlier age (from 18 months to five years), is more likely to lead to improved visual outcomes. Screening at an older age, such as eight to ten years or 13 – 15 years, was shown to detect very few or no new cases of eye pathology, which would suggest this is not recommended practice. There was an absence, however, of studies evaluating screening at school entry, which may be the ideal time to improve coverage via increased accessibility to a larger number of participants.

The evidence also suggested a secondary screen (a referral screen after a primary screen and prior to a follow-up screen), was an effective component of early detection, referral, and treatment of eye problems. While this would incur additional initial costs, it is possible that it would save costs in the long-term by reducing the number of false positive referrals made to hospitals or specialist clinics. Secondary screening appeared to be most important when the initial screening was carried out by non-vision health professionals. The effectiveness of vision screening programs could also be enhanced by the use of strategies such as teaching parents to be more attentive to their child's vision, or creating awareness campaigns to ensure that the corrections are used and cultural barriers to compliance are addressed and removed.

The evidence evaluating teacher, parent and student questionnaires as an alternative or an adjunct to other vision screening tools suggested that while parent and student questionnaires were useful tools to use with older school-aged children, teacher questionnaires were not

accurate tools for collecting information. Little has been revealed about the usefulness of questionnaires in general on children younger than the critical age of eight years. Further research is required in this area before a proper comparison and analysis against other methods of screening could be conducted.

While none of the literature identified focused solely on screening in the neonatal period, the studies that touched on this area suggested that screening for strabismus and cataracts (as well as other vision disorders of the newborn) be carried out as early as possible following birth, and no later than three months of age. At any age, the literature recommended that high-risk children should be referred to an ophthalmologist.

The effectiveness of screening programs in any age group depends in part upon adequate participation from children and their families. The literature suggested that low income families in particular were often not aware of: (a) screening programs available to them, (b) the conditions detected by screening programs and the possible benefits of detecting these conditions early and/or, (c) the financial assistance that may be available to them for screening, follow-up care and treatment. A screening program is also only as effective as its follow-up care with regards to participants who obtain a positive result for a vision condition. However, it appeared that there were a number of barriers to follow-up care and treatment that reduced the effectiveness of screening programs overall. Future screening programs should seek to address these barriers in their program design.

Once again, it is noted that the evidence outlined was based on trials of medium to low quality, in accordance with this review's rating system, and thus caution should be taken in deriving any directions from the studies. However, it is also noted that the current lack of evidence does not imply that vision screening is not effective, simply that programs have yet to be rigorously tested.

5.5 Screener characteristics

5.5.1 Overall summary – screener characteristics

Two systematic reviews were identified that compared the results achieved by different personnel in screening children for vision conditions. The first review, of medium quality, supported screening of children aged six years and over by school nurses with appropriate professional support and training by orthoptists.[64] The second review, of high quality, concluded that orthoptic screening programs performed better than health visitor or general practitioner screening programs in terms of yield and positive predictive value when screening children aged three to six years.[65]

One randomised controlled trial of medium quality evaluated the screening of three to six year old children. The study reported that nurses and lay screeners achieved similar results regarding sensitivity and specificity in the screening of preschool children.[12]

There were 11 non-randomised controlled trials that met the inclusion criteria; 10 of low quality and one of medium quality. In the age group of one month to three years, three studies concluded that screening by orthoptists was superior to screening by other medical personnel,[7] health visitors[66] and health visitors and general practitioners together.[67]

The seven studies examining screening in the three to six years age group compared different screening personnel, as well as different screening tests, making it difficult to amalgamate results. The studies reported that orthoptists were effective screeners;[68] that health visitors were just as effective as orthoptists;[27] that nurses achieved better results than teacher questionnaires,[57] similar results to optometrists,[69] and results of sufficient specificity and sensitivity to be considered primary screeners[10]; that parents were effective administrators of vision tests in the home,[70] and that referral and treatment rates differed substantially between lay screeners and primary care practitioners, although little information was provided as to why this was the case.[71]

The final non-randomised controlled trial, examining screening in children aged six years and over, concluded that nurses could perform the role of primary screener with appropriate training from other eye health professionals. It was reported that training was particularly required for the detection of strabismus[72] and it was hoped that this training would address the high false positive rate obtained by the nurses in the study.

The evidence summarised in this section was largely drawn from international studies where the workforce available to conduct vision screenings often differed from the Australian context. While theoretical directions can be drawn from the evidence available, the application of this evidence in the Australian context must be done with due consideration to the Australian eye health practitioner workforce and related economic systems (see Appendix H for a summary of the Australian eye health practitioner workforce).

5.5.2 Neonates (0-1 month)

No relevant studies were identified.

5.5.3 Toddler age (1 month-3 years)

In this age group, two non-randomised controlled trials and one controlled clinical trial evaluated how different screening personnel performed in the detection of amblyopia and/or refractive error. All studies were conducted in the United Kingdom.

The first study reported that the use of orthoptists as primary screeners improved detection rates of visual abnormalities (positive predictive value of 47.5% and false predictive value of 46.4%) and lowered the rate of false-positive referrals to secondary clinics as compared to 'other medical personnel' (positive predictive value of 14.4% and false predictive value of 82%).[7] The authors concluded that amblyopia screening should be conducted by orthoptists. However, there were potential limitations to the study which may have had bearing on the results. For example, the prevalence of amblyopia and squint may have differed between the orthoptist and the 'other' cohort; the arbiters of the screens were orthoptists themselves, so may have had more of a tendency to agree with other orthoptists; the vision screen by orthoptists did not take place in the context of a more detailed, broader health assessment, therefore the orthoptists may have received greater cooperation from children; and the tests used by orthoptists and the 'other medical personnel' differed slightly.

The second study, a controlled clinical trial, compared visual outcomes at seven years of age for children screened at three years of age by either orthoptists, health visitors or general practitioners.[66] Orthoptists tested visual acuity and ocular movements, and used a cover test, alternate cover test and prism test, whereas the health visitor screen only included an assessment of ability to pick up a thread and observation of any manifest squint. Screening by general practitioners involved the observation of manifest squint only.

It was found that the prevalence of amblyopia was similar in children screened by the different examiners (1.0% to 1.2%). Orthoptic screening did not significantly lower the age at which squint (excluding microtropia) presented (orthoptic 3.8 years, health visitor 3.9 years, general practitioners 4.1 years). However, orthoptic screening did have an effect on the age at which straight-eyed amblyopia and refractive errors presented (straight-eyed amblyopia: orthoptic 3.4 years, health visitor 5.6 years, general practitioners 4.5 years; refractive errors: orthoptic 3.8 years, health visitor 5.4 years, general practitioners 5.1 years).[66]

The authors concluded that more children with amblyopia were identified in the orthoptic screening cohort. However, limitations (such as the possibility of a difference in family history of squint across the cohorts) were noted. It was also reported that insufficient evidence was obtained to support the introduction of a nationwide primary orthoptic preschool vision screening program.[66]

The third study compared results obtained by three groups of personnel - orthoptists, health visitors, and health visitors and general practitioners combined - following screening of children aged five to nine months, and three years.[67] All three personnel groups produced equally poor results when screening children less than nine months of age. Orthoptists who screened children aged three years achieved a sensitivity of 100% and specificity of 97%, while health visitors achieved better specificity at 100%, but sensitivity of only 50%. Data was not available from the health visitors and general practitioners for their screening of three year olds for comparison.

While the results suggested that orthoptists were the superior screener, it should be noted that, again, screening methods differed between personnel. Orthoptists used cover tests, ocular movements, 20 dioptre base out prism tests, convergence, and Sheridan Gardiner letter matching or Kay Picture tests, while health visitors used squint checks and/or 'pick up a thread' tests only. The authors also referred to several other limitations that may affect the results of the follow-up to the study that was still occurring at the time of publication. It was thought that the limitations could have an impact on screening sensitivity, prevalence of amblyopia between cohorts and referral uptake.

5.5.4 Preschool age (3-6 years)

Within this age group, one systematic review and two randomised controlled trials were identified that compared the results of different personnel screening for refractive error and/or amblyopia.

A systematic review, consisting of one prospective controlled trial and 16 retrospective studies (observational studies and audits) of different screening programs, reported that orthoptic screening programs performed better than health visitor or general practitioner screening programs.[65] The mean referral rate was 6.7% for primary orthoptic programs and 3.9% for screening by health visitor or general practitioner. The positive predictive value ranged from 47.5% to 95.9% for orthoptic screening and from 14.4% to 61.5% for screening by health visitor or general practitioner. Despite these results, the authors concluded that no new preschool vision screening programs should be implemented unless they have been vigorously evaluated.

An observational study was conducted in Canada to assess the validity of preschool vision screening.[10] Public health nurses conducted tests of visual acuity, ocular alignment and stereoacuity to approximately 1,110 children each year over a three year period, and results were compared to those obtained from practitioner reports. The sensitivity of the nurse screen ranged from 60.4% to 70.9%, while specificity ranged from 69.6% to 79.9%. The positive predictive value was 21.6% to 32.3% and the negative predictive value was 92.6% to 95.3%. The percentage of children who failed vision screening ranged from 25.5% to 34.7% over the three year period. This study concluded that, based on the number of children detected with vision defects, the screening of children by public health nurses was valid and should be continued.

The Vision in Preschoolers (VIP) study compared the performance of nurse screeners with that of lay screeners in administering preschool vision screening tests to three to five year old children.[12] Results from both cohorts were then compared to results of a gold standard eye examination by an ophthalmologist or optometrist. It was found that the lay screeners achieved higher sensitivity with the single Lea Symbols test than did the nurses or lay screeners using the linear Lea Symbols. All other screening tests resulted in higher sensitivity when administered by the nurses compared to the lay screeners, although the differences were small and not statistically significant. The study concluded that similar results could be obtained by using either nurses or laypeople as screeners, but noted that these results should be replicated before being applied to the general population.

Six non-randomised controlled trials were found comparing the characteristics of different personnel who screened children in the three to six years age group. As outlined in the background of this literature review, one study tested the feasibility of using a questionnaire for teachers in place of the traditional screen conducted by school nurses for students in their first year of school.[57] Using the orthoptic screen as 'gold standard', the nursing screen showed excellent specificity and sensitivity, whereas the teacher questionnaire only yielded a 13.9% sensitivity rate. Given that the teacher questionnaire was unable to detect 86% of the visually impaired, the authors concluded that they would not recommend the questionnaire as a screening tool.

In another study, monocular visual acuity and stereopsis testing was implemented at four sites; two community-based sites with testing performed by lay volunteers and two primary care practice sites with testing performed by nursing staff or other office staff.[71] The results showed that significantly more children were referred and treated following a community-based screen than a primary care practice screen. Unfortunately, the authors could only speculate as to why this occurred, suggesting that perhaps lay screeners were more conservative, or that nurses and doctors lacked an understanding of the systematic screening of young children.

In a retrospective study in Cornwall, United Kingdom, orthoptists were reported to achieve a screening sensitivity of approximately 90% and specificity 99%, using comprehensive testing methods and referring at 6/9.[68] The study did not use a comparison group, and suggested that a future study should compare the orthoptists' performance with that of health visitors as primary screeners.

A United Kingdom study examined the effectiveness of preschool vision screening of 3 – 3.5 year olds by health visitors.[27] The study reported that screening by health visitors was as effective as screening by orthoptists. A retrospective review of the records of children identified with amblyopia following a school entry medical at five years was undertaken to detect possible failure of the earlier health visitor examination. Of the 33 children with amblyopia (out of 2,423 who were screened), it was possible to trace the health visitor record of 10 of these. There were only two children where an abnormality might have been missed by the health visitor at the three year check.

Parents of 21,906 children in Tokyo, Japan were sent a home vision test with a health examination notification.[70] The vision test comprised picture cards of familiar figures. The results showed that over 96% of children could complete the test and that 41 new cases of amblyopia were found, suggesting that parents could be successful early screeners. However, the program required that the home vision test be followed up with a professional eye examination or screen, particularly as it could not detect strabismus alone.

In the final study for this age group, 28 children aged five to six years were screened by a registered nurse and a week later, by an optometrist.[69] The five test items assessed visual acuity, hyperopia, convergence, binocular eye movement (tracking) and binocularity of vision. At least 86% agreement was achieved between the nurses and optometrists for each test. However, this result was based on a low number of participants, so may need to be replicated with a larger sample.

5.5.5 School age (6+ years)

One systematic review and one non-randomised controlled trial were found comparing nurses with orthoptists in detecting refractive error in children aged six years and over. The systematic review supported screening by school nurses with appropriate professional support and training by orthoptists[64]. It was found that nurses were highly accurate in screening for visual acuity, but may benefit from more assistance and training in detecting strabismus. The literature revealed positive outcomes associated with using parent and teacher referral methods for older children, but highlighted the lack of evidence supporting this method as an

alternative to professional screening at school entry. It was also noted that this was an inadequate method for younger children.

The non-randomised controlled trial compared the ability of nurses and orthoptists to conduct accurate screens of visual impairment in children attending Primary One in the United Kingdom.[72] The nurses achieved a positive predictive value of 40%, negative predictive value of 99%, sensitivity of 83% and specificity of 95%. The authors concluded that orthoptists conducted more accurate screens, but that all children with significant visual defects were detected by nurses (without specifying what constituted a 'significant visual defect'). The authors also recommended that the high false positive rate obtained by the nurses needed to be reduced and that the study should be replicated with a larger sample size.

5.5.6 Screener characteristics – directions from the evidence

While the papers identified across the three age groups (toddler, preschool and school age) were quite different in scope, a theme emerged that demonstrated some consistency in findings. Most studies concluded that orthoptists were the most accurate screening personnel, in comparison to nurses, health visitors and general practitioners. However, the majority of studies from which these conclusions were drawn were not of high quality and were not randomised controlled trials. Further, the testing tools and equipment used by the screeners may have confounded the results of the study, as orthoptists generally performed comprehensive tests with multiple instruments while nurses, health visitors, general practitioners and lay screeners were often limited to more basic tools or tests. As the evidence was largely drawn from international studies, not all personnel available in the Australian context were incorporated into the comparisons. Optometrists, for example, were a key professional body largely absent from the literature.

The majority of studies examining nurses as screeners concluded that, while the sensitivity and specificity of screening by nurses may be lower than that of orthoptists or ophthalmologists, this did not preclude them from being positioned as primary screeners for a vision screening program, with appropriate training and referral protocols. This may be a more cost-effective process to administer screening in the Australian context.

The use of a vision test administered by parents in the home was shown to have successful completion rates. However, this could not be used in isolation as children required a follow up vision screen or professional eye examination. The evidence suggested that questionnaires administered to teachers regarding their students' vision would not produce accurate results and therefore should not replace screening by nurses or eye health professionals.

5.6 Educational outcomes of vision screening

5.6.1 Overall summary – educational outcomes

Three non-randomised controlled trials of medium quality and seven non-randomised controlled trials of low quality met the inclusion criteria. The evidence showed that infants identified at screening with hyperopia had poorer visuocognitive and visuomotor skills up to around five years of age,[73, 74] and that children diagnosed with ametropia at 4.6 years had poorer visuomotor skills.[75] After wearing spectacles for six weeks, children with ametropia improved their visuomotor abilities.[75]

The academic performance of children diagnosed with visual deficits at school age was compromised. Children with refractive errors, ocular motility deficits and hyperopia obtained lower scores on achievement tests,[76, 77] Further, children with deficits in visual motor, ocular motor, binocular, accommodative, and visual perception skills scored poorly on educational tests,[78] and the majority of children who were academically and behaviourally at risk had failed one or more visual tests.[79] However, improvements were noted once children with vision problems had been identified and treated.

Visual deficits in school age children were also shown to be associated with reading problems, in that children with amblyopia had a significantly slower reading speed in comparison to normal sighted children.[11] Nonproficient readers were found to have significantly poorer visual efficiency abilities than proficient readers, however no differences were found between the groups for visual health.[80] Another study found that poorer accommodative facility was significantly associated with reading difficulty for preschool children aged five years of age.[81] It is noted, however, that many of the visual deficits identified and related to educational outcomes require detailed assessment and would not usually be identified as part of preschool or school-aged vision screening.

5.6.2 Neonates (0-1 month)

No relevant studies were identified.

5.6.3 Toddler age (1 month-3 years)

Two non-randomised controlled trials examined the relationship between visual dysfunction and developmental delay and motor skills.

Using the same cohort as Atkinson et al.,[36] Atkinson et al.[73] assessed the visual outcomes from the Cambridge Infant Vision Screening program and looked at the relationship between early vision and possible developmental delay. The program comprised non-cycloplegic videorefraction and orthoptic examination. Of the 5,142 children screened from 8.1 months of age up to 5.5 years of age, 71 were diagnosed as hyperopes. It was found that children identified at screening with significant hyperopic refractive errors showed consistently poorer performance on a range of visuocognitive and visuomotor tests up to age five years, compared to control children without significant refractive errors, although these differences were relatively small. The authors concluded that early hyperopia is associated with a range of developmental deficits that persist at least to age 5.5 years. The effects were concentrated in visuocognitive and visuomotor domains, rather than in the linguistic domain. The results of this longitudinal group were confirmed in a cross-sectional analysis, but this analysis did not represent the same set of individuals at each stage thus may be subject to some selection biases.

In 2005, Atkinson et al.[74] compared the motor skills of children tested at 3.5 years and 5.5 years using the same cohort as Atkinson et al.[36, 73] It was found that at 3.5 and 5.5 years of age, children who had been hyperopic in infancy performed significantly worse than controls on at least one test from each category of motor skill (manual dexterity, balance, and ball skills). The hyperopic group's mean total impairment score for motor competence was significantly higher than the control group's score (5.1% versus 0.9%). Distributions of scores showed that these differences were not due to poor performance by a minority but to a widespread mild deficit in the hyperopic group.

5.6.4 Preschool age (3-6 years)

One non-randomised controlled trial examined the cognitive abilities of children with ametropia following spectacle correction.

Roch-Levecq et al.[75] examined the cognitive abilities of low-income preschoolers in the United States with uncorrected ametropia (4.6 years, n=70) and the effects of spectacle correction after six weeks. Optometrists administered retinoscopy under cycloplegia and most children received autorefraction. Visual acuity was assessed before correction prior to cycloplegia and after correction under cycloplegia using the Allen Preschool Vision Test (near test) and the B-VAT PC version 2.3 (distance test). Compared to emmetropic controls, it was found that uncorrected ametropes scored significantly lower on the Visual-Motor Integration test (VMI), which assessed visual perception and hand-eye co-ordination, and most of the

Wechsler Preschool and Primary Scale of Intelligence-Revised (WPPSI-R) performance subsets, which required eye-hand coordination. After six weeks of wearing glasses, the ametropic group significantly improved on the VMI compared to the control group. The ametropic group also improved on the WPPSI-R, although results were not significant. The authors concluded that early identification and correction should optimise cognitive development and learning, at least in the studied sample. Caution should be taken in generalising results as the sample was small and restricted to low-income preschool children.

5.6.5 School age (6+ years)

Eight non-randomised controlled trials examined the relationship between visual deficits and educational attainment, academic performance, reading ability, and visual perception.

One study examined the relationship between hyperopia and educational attainment in a sample of 1,298 eight year old children in the United Kingdom.[76] School nurses administered the Snellen chart as well as the fogging test for hyperopia. A total of 166 children (12.8%) were referred to an ophthalmologist for failing the fogging test and 105 ophthalmic records of fogging test failures were obtained. It was found that National Foundation for Educational Research (NFER) scores of children with untreated refractive errors were lower than the respective scores of children with a less positive refractive state, the non-referred group, and the total sample. The Standardised Assessment Test results (SATs) followed a similar trend.

A retrospective study in the United States assessed the results of vision screens of five to 12 year old children in accordance with their ability to predict academic performance.[77] Second year optometric students, in conjunction with a faculty member of the State University of New York College of Optometry, screened 1,365 children in 1996-97 and 1,463 children in 1998-99. The screening battery was primarily based on the Modified Clinical Technique (MCT) which included distance and near visual acuity, hyperopia assessment, cover test, stereopsis, fusion, accommodation, and ocular motility as measured by the New York State Optometric Association's (NYSOA) King Devick test, and near point convergence. It was found that the King Devick test and the hyperopia assessment screening showed significant correlation with citywide achievement scores. Both of these tests were significant for predicting students in the lower 25% of the class for all grades in both years of screening.

Another United States study examined the relationship between performance on various vision tests and reading ability with children five to seven years of age (n=181).[81] The screening was performed by a school nurse, an optometrist, and an optometry student. The screening comprised the MCT, ± 2.00 D flipper lenses, Randot, Test of Visual Analysis Skills short form, Gardner Reversals Frequency test, noncycloplegic retinoscopy, Reduced Snellen or Allen figures, and cover testing. It was found that accommodative facility was significantly associated with successful reading performance for the children and that the relationship between accommodative facility and reading performance became more significant as age and grade increased. Failure on the MCT was significantly related to reading difficulty in five year olds. Stereoacuity worse than 100 sec arc, MCT failure plus stereoacuity worse than 50 sec arc or 100 sec arc, and decreased accommodative facility were predictive of reduced reading skill in children of average intelligence. The authors concluded that good visual and visual perceptive skills were significantly associated with whether a child would show successful or reduced reading performance.

A study in Israel compared visual and visual-information processing skills between a convenience sample of children aged 12 years and 7 months, with and without reading and academic problems and with and without visual defects.[80] Therapists experienced in paediatric assessment used MCT items, which were divided into two functional categories: (1) Visual Efficiency (i.e., saccades, visual tracking, cover test far and near, near point of convergence, suppression [Worth 4-Dot] and stereopsis) and (2) Visual Health (i.e., visual acuity far and near, retinoscopy, ophthalmoscopy, and colour vision). It was found that

nonproficient readers had significantly poorer visual efficiency abilities than proficient readers. In contrast, there were no significant differences between these groups with respect to MCT items reflective of visual health.

Significantly more nonproficient readers were referred as opposed to proficient readers (28% versus 4%). Further, participants who passed the MCT (no visual deficits) had significantly better academic scores than those who failed the MCT (had visual deficits). Children with visual deficits were compared to those without in relation to their visual-processing scores. It was found that children who passed the MCT performed significantly better on the Motor-Free Visual-Perception Test (MVPT-R) than children who failed the MCT. No significant differences were found between the two groups in relation to the Developmental Test of Visual Motor (VMI) Integration. The authors concluded that visual function significantly distinguished between children with and without mild academic problems, as well as between low and high visual-perception scores. Caution should be taken in generalising these results as the children represented a convenient sample of students, and factors other than those accounted for in the study may have impacted upon children's academic achievement, such as IQ, emotional status, the value of education bestowed upon children by their parents, and motivation.

A study was conducted in the United States to examine visual factors that significantly impacted upon academic performance.[78] Examinations were performed on 540 children aged six to seven years and 10 – 11 years by optometrists, consisting of a battery of tests. It was found that visual motor, ocular motor, binocular, accommodative, and visual perception skills were significant factors in children who scored poorly on the Iowa Test of Basic Skills educational test (ITBS). Race and social economic status were less significant predictors of some scores on the ITBS.

In another study, the NYSOA Vision Screening Battery was administered to 81 at-risk eight to 18 year old students to assess whether vision deficits contributed to academic difficulties.[79] A researcher administered the following tests: tracking, fusion, acuity-distance, stereopsis, acuity-near, convergence, hyperopia, colour vision, and visual motor integration. It was found that 85% (69) of all students failed one or more of the visual tests, with more participants failing the tracking subset than any other subtest 37% (30). A significant number of students failed visual acuity far and near, stereopsis, and visual motor integration. Students who were academically and behaviourally at-risk were more likely to fail the tracking test than students who were academically but not behaviourally at-risk (52% versus 27%). These same students were also more likely to fail visual acuity far and near, hyperopia, stereopsis, colour vision and visual motor integration. Ninety seven per cent of these students failed at least one subset.

A study in Austria compared the monocular and binocular reading performance of children with amblyopia to children with normal sight.[82] Children were aged 10 – 12 years (n=40). The examination comprised cover–uncover test and alternate cover tests, dynamic retinoscopy, convergence, motility, ophthalmoscopy, the Worth Four dot Test, and the Titmus Stereo test. In regards to the binocular maximum reading speed (MRS), there were significant differences between children with amblyopia and the normal sighted children. The controls achieved a binocular MRS of 200.4, or 11 words per minute (wpm), while the children with amblyopia achieved a binocular MRS of only 172.9, or 43.9 wpm. No significant differences were found between the two groups with respect to binocular logMAR visual acuity and reading acuity.

5.6.6 Educational outcomes – directions from the evidence

The studies detailed above, spanning an age group of 3.5 – 18 years, provided some evidence for a relationship between visual impairment and poor educational outcomes. The visual deficit outcomes outlined in the literature included visuocognitive and visuomotor deficits, poorer educational attainment and academic performance, and impaired reading ability. Most of the differences between control and intervention groups were significant.

The majority of the studies described were of low quality, and all were non-randomised controlled trials, thus caution must be taken in interpreting results. Potentially confounding variables, such as IQ and motivation, could have had some effect on the results. In addition, many of the conditions diagnosed were done so after in-depth assessment and would not be identified by most vision screening programs. However, the available evidence suggests that there may be a link between vision impairment and educational outcomes. Consequently, earlier detection and treatment may decrease the likelihood that educational outcomes will be compromised. Further research is needed into the relationship between vision impairment and educational outcomes before the utility of vision screening can be recommended based on educational gains.

5.7 Treatment of vision conditions

One of the factors influencing the age at which vision screening should take place, if vision screening is pursued, is the age at which treatment of vision conditions is effective. To this extent, the literature review incorporated a search for treatment effectiveness of the specified vision conditions.

Amblyopia

Seven randomised controlled trials were identified that evaluated different regimes in the treatment of amblyopia. In one study, 507 participants were randomised into either a treatment group (two to six hours of patching per day, plus near visual activities and atropine sulphate for children aged seven to 12 years) or an optical correction group (optical correction alone). Participants whose amblyopic eye acuity improved by two or more lines on a Snellen chart by 24 weeks were considered “responders”.^[83]

In the 7 - 12 year olds, 53% of the treatment groups were responders, compared with 25% of the optical correction group. In the 13 - 17 year olds, responder rates were 25% and 23% respectively.^[83] While this suggests that treatment for some children can still be effective after the age of seven, it appears that the likelihood of successful treatment reduces dramatically from the age of seven years (if not earlier).

Another study in Newcastle, United Kingdom, randomised 177 children aged three to five years into three groups; no treatment, glasses, and glasses with patching.^[84] Children in the full and glasses treatment groups had incrementally better uncorrected (without glasses) and corrected (with glasses) visual acuity at follow-up (4.3 to 6.5 years) compared with those in the no treatment group, but the effect was small. Full treatment had an effect on children with moderate acuity loss at baseline (6/18 to 6/36) but had no significant effect in the group of children with mild acuity loss (6/9 or 6/12). When all children received treatment six months after the end of the trial, there was no significant difference in acuity between the groups. The study concluded that children whose treatment is deferred from age four years until age five have the same acuity after treatment, but that fewer required any patching treatment.

A study carried out in Glasgow screened 712 children aged between 3.5 and 4.5 years, assigned treatment to those who required it, discharged them from the program at 7.5 years of age, and then followed up 255 of these children at age 12.3 years.^[85] It was found that 79% of the amblyopes improved or maintained their visual acuity after discharge but this was reduced to 42% after an age induced increase was compensated for. The authors concluded that the majority of amblyopes maintained or improved their visual acuity after discharge. Children who demonstrated deterioration of their amblyopia had usually improved well during the program and were commonly fixating eccentrically at follow-up.

Two studies compared patching regimens with atropine administration and found that an effect of both was similarly present throughout the age range of three years to seven years (noting that children over the age of seven years were not included in the study).^[83, 86]

Two further studies evaluated occlusion rates (measured in hours per day) with associated improvements in visual acuity. Stewart et al.[87] found that children less than four years of age required significantly less occlusion than older children. Children aged over six years of age required occlusion for more than three hours per day. This concurs with the results obtained by Awan et al.[88] who found that the visual acuity of eyes effectively patched for more than three hours per day improved significantly. However, Awan et al. found that age at treatment did not influence the visual outcome (noting that all participants in the study were less than eight years of age).

One quasi-randomised controlled trial investigated the effectiveness of full-time occlusion therapy in treating amblyopia in 11 – 15 year old children and found that the mean improvement was 4.6 Snellen lines (0.46 logMAR unit).[89]

A study by Newman et al.[90] found that treatment of amblyopia at an average age of 7.7 years resulted in 87.2% of straight-eyed amblyopic children and 64.3% of strabismic amblyopic children achieving improvement in visual acuity. The study concluded that most amblyopic children detected by a vision screening program achieved a good visual outcome with treatment.

A study of 12 year old Australian schoolchildren found that 84% who had been previously diagnosed with amblyopia had received treatment consisting of spectacle prescription, occlusion, atropine penalisation, or a combination of the three.[14] In this treated population, the presence of myopia (28%), hyperopia (51%) and astigmatism (44%) was significantly higher than in non-amblyopic children (12%, 4% and 9% respectively). However, only 27% of the amblyopic children were visually impaired in their amblyopic eye, while 50% of previously untreated children were visually impaired in their amblyopic eye.

Recurrence of amblyopia following cessation of treatment was found in two non-randomised controlled trials, but this effect could be reduced by weaning patching down to two hours per day prior to treatment cessation.[91] Recurrence was also associated with better visual acuity at time of cessation, improvement of amblyopic eye visual acuity during treatment, and previous recurrence.[92]

Refractive error

Two randomised controlled trials evaluated whether spectacle correction of infants' refractive errors, which has been shown to have beneficial effects in reducing strabismus and amblyopia, impeded normal visual development, or emmetropisation. The earlier study found that the process of emmetropisation appeared to have been impeded by the consistent wearing of spectacle correction from the age of six months.[93] The later study found that a small, temporary effect of refractive correction occurred between nine and 18 months of age, but had disappeared by 36 months.[94]

The US Preventive Services Task Force systematic evidence review found that it was unclear whether treating young children with refractive errors associated with amblyopia would prevent the development of amblyopia. The report concluded that treatment for the majority of eye conditions generally seemed most effective when initiated before the grade-school years, but that treatment of refractive errors not associated with amblyopia was nearly always successful and did not depend on the age of the child.[95]

Cataracts

One study evaluated the outcome of very early treatment of dense congenital unilateral cataract on newborns aged one to six weeks, and two to eight months. The results suggested that treatment initiated at one to six weeks of age maximised the opportunity for normal or near-normal visual development of a congenitally cataractous eye with little or no risk to the phakic fellow eye[96].

The US Preventive Services Task Force systematic evidence review found that treating children younger than age three years who had cataracts or strabismus may have prevented the development of amblyopia.[95]

Compliance with treatment

The Baltimore Vision Screening Project looked at whether the barriers to follow-up care could be reduced by providing on-site evaluation and minimal-cost treatment, thus increasing treatment compliance and hypothetically reducing vision disorder prevalence rates. However, the results showed that fewer than 33% of children had followed through on the recommendations (wearing spectacles) and fewer than 20% passed the follow-up screening test.[97]

Summary

Given the limited number of studies reporting on each condition, care needs to be taken in evaluating the results. However, in summary, the literature suggested that treatment at one to six weeks of age for cataract was better than treatment at two to eight months, and that any effects of refractive correction on emmetropisation may have disappeared by the age of 36 months. It also appeared that some older children (aged seven years and above) responded to treatment for amblyopia and could achieve improvements in visual acuity. However, older children may require longer occlusion rates per day and may also require longer total periods of occlusion or atropine treatment, which could, in turn, impact on their social well-being.

Generally, children appeared to respond well to treatment for amblyopia from the age of three, but it may be possible to defer treatment from the age of four to the age of five years without any major detrimental effects. Deterioration in visual acuity could occur following cessation of treatment, which may call for longer-term follow-up processes to be considered. Further study is required to determine why compliance with treatment rates was so low, even when treatment was provided at no, or very low, cost.

5.8 Evaluation of referral criteria

The sensitivity and specificity of screening programs can be influenced by the criteria that is set for the 'pass or fail' of a particular test. Many of the programs evaluated in the literature used different levels as the 'cut-off' for onward referral.

Hard et al.[98] examined the introduction of new referral criteria for preschool vision screening in Sweden. Prior to 1992, children with a visual acuity of less than 6/7.5 at four years of age were referred. Post 1992, children with a greater reduction in visual acuity (6/9 in both eyes or 6/9 in one eye and 6/7.5 in the other) were retested at 5.5 years and referred if their visual acuity was worse than 6/7.5. Visual acuity was tested by paediatric nurses using the HOTV chart. It was found that only a small number of the children with slightly reduced visual acuity who were retested at 5.5 years had visual defects that required treatment. In those who were treated, the results of the treatment were good. The authors concluded that children with visual acuity of 6/9 in each eye or 6/9 in one eye and 6/7.5 in the other at the age of four years rarely had visual problems that required treatment. The visual problems needing treatment were generally mild and could be treated, with good results, at the age of 5.5 years. Thus, the study concluded that the new screening criterion was appropriate.

A study by the same authors in Sweden, using a different cohort of six year old children (n=3885), compared the outcome of using either a referral criteria of 6/7.5 or 6/9.[99] It was found that children with visual acuity of 6/9 in the worse eye constituted 74.5% of those who had failed the screening. More than half of these were found to have visual acuity $\geq 6/7.5$ in the clinic. Many were not refractive in cycloplegia and only 6.7% were found to have significant ametropia. Of those 6.7%, 13.4% were prescribed glasses. The authors reported that six year

olds with a visual acuity of 6/9 rarely had defects that required treatment, therefore the screening criterion of 6/7.5 was probably too demanding for effective utilisation of resources. The study concluded that changing the screening criteria from 6/7.5 to 6/9 could substantially reduce over-referrals, but could also fail to identify some children who would benefit from glasses.

Lim et al.[9] assessed the appropriate referral criteria for a vision screening program in Singapore. Four year old preschool children were tested with Snellen or Sloan visual acuity charts and the Frisby stereotest. When the referral rate was changed to 6/12 instead of 6/9, referrals dropped from 39.6% to 26.7% and the positive predictive value improved from 35.4% to 48.3%.

A United Kingdom study of four year old children (n=8142) assessed the effectiveness of preschool screening using different referral criteria.[100] Children were screened by orthoptists using the Sheridan Gardiner singles chart, cover test, ocular movements, fusion and stereo testing. It was found that there was a high false positive rate when all children with worse than 6/6 visual acuity were considered (74.8%). The false positive rate reduced when children with worse than 6/9 were considered (38.5%) but this also incorporated a reduction of the true positive rate (worse than 6/6: 97.2%, worse than 6/9: 70.6%).

The majority of studies recommended a referral criterion of 6/9 for four to six year olds. This criterion was shown to reduce over-referrals and false positive rates compared to criteria of 6/6 or 6/7.5. A less stringent referral criterion (6/12 instead of 6/9) could fail to identify some children who would benefit from glasses, and could reduce the true negative rate. When one study re-set their referral criteria to 6/12 instead of 6/9 the positive predictive value improved from 35.4% to 48.3%. However, this was still an unacceptably low rate, perhaps indicative of an ineffective program overall.

5.9 Vision screening of Indigenous Australian children

Stocks et al.[101] conducted an eye health survey of the Anangu Pitjantjatjara of South Australia, and subsequently reported that young rural Aboriginal Australians had good visual acuity. The results from the 1990 survey showed that in the birth to 19 years age group almost every individual had 6/6 vision (n=348).

Blair et al.[102] reported on the Western Australia Aboriginal Child Health Survey. Out of 1,480 Aboriginal children aged 12 - 17 years, 11.3% had abnormal vision and 7.8% wore contact lenses or glasses, compared with 20.7% and 16% in non-Aboriginal 12 - 16 year olds. The prevalence of abnormal vision decreased as the level of relative isolation increased.

Paterson and Ruben[103] evaluated the effectiveness of a school screening program in meeting the needs of Aboriginal children in a rural district in the Northern Territory Top End. Seven hundred and seventy-four school age children were screened. It was found that 3% (23/694) failed visual acuity, and 61% of these were not followed-up (14/23). Furthermore, 1% (10/703) were found to have strabismus, although no new cases were identified by the program. Rates of trachoma reached 26%. The authors concluded that the school screening had a limited role in identifying and meeting the health needs of Aboriginal children in remote areas. They suggested that ongoing child health surveillance would be more appropriate.

The National Trachoma Surveillance and Reporting Unit in 2006 collected active trachoma data from the Northern Territory, South Australia and Western Australia.[104] Aboriginal children aged five to nine years were screened for signs of active trachoma. Reported prevalences ranged from 2.5% to 30% in the Northern Territory, 0% to 25% in South Australia and 18% to 53% in Western Australia. Currie and Brewster[105] reported that in the tropical north of Australia there were high rates of gonococcal conjunctivitis and endemic trachoma in Aboriginal children in remote communities.

Thus, while it appears that visual acuity in Aboriginal children is not necessarily poorer than in non-Aboriginal children, rates of trachoma are excessively high in this population. Educational and awareness campaigns and appropriate diagnosis and assessment are more appropriate for this population than general screening.

5.10 Utilisation of eye care services and the cost of vision lost

A report prepared by Access Economics Pty Ltd for the Centre for Eye Research Australia and the Eye Research Australia Foundation examined the economic impact and cost of vision loss in Australia from 1993-94 and 2004, and also projected costs out to 2020.[106]

The report found that the indirect costs of visual impairment outweighed the health costs by nearly 1.8:1. These indirect costs included: lost earnings for visually impaired and blind people (\$A1.8 billion in 2004); the cost of carers, including their lost productivity (\$A845 million); aids, equipment, home modifications and other indirect costs (\$A371 million); and losses associated with transfer payments such as taxation revenue foregone and welfare payments (\$A208 million). They also found that visual impairment led to a higher use of social services and admission to nursing homes, lower employment rates and social functioning, and increased mental illness and social isolation.

This correlates with findings from a previous study which showed that patients with glaucoma had significantly poorer adjusted mean scores on seven National Eye Institute Visual Functioning Questionnaire scales, including general vision, discomfort or pain in and around the eyes, difficulty with driving, decreased well-being due to vision, role limitations attributable to vision, difficulty with near vision and difficulty with distance vision activities.[107]

Access Economics also found that visual impairment increased the risk of death and decreased the quality and length of life. This morbidity and premature mortality in the visually impaired and blind population is estimated to cost the economy an additional \$A4.8 billion. Added to that was an additional \$A1.8 billion for treatment of eye diseases, which brought the total cost of vision impairment and blindness in Australia to \$A9.85 billion.[106] Neither evaluation, directly reported on the impact of vision disorders in children. The conditions leading to negative impacts on health and well-being in adults were in general age-related, and not those likely to be identified during vision screening in childhood.

The report noted that half of all visual impairment was correctable and that one quarter was preventable. According to the World Bank in Australia, interventions are considered cost-effective if they are under \$A112,000 per quality adjusted life year (QALY). [106] In the United States, this figure is \$50,000 per QALY.[108] The costs and cost-effectiveness of various international screening programs are outlined below (see 'Economic evaluations'). An evaluation of the costs associated with vision screening in Australia will commence shortly, with results expected by January 2009.

Ganz et al.[109] described the use and expenditure patterns of eye-care services for 48,304 children under 18 years of age in the United States from 1996-2001. It was found that children with diagnosed eye conditions had higher levels of health care use and expenditure than children without diagnosed conditions. It was also found that children with diagnosed eye conditions had higher use and expenditure levels for non-eye-related services.

5.11 Economic evaluations

An economic evaluation assessment form was used to determine the criteria for inclusion of cost-benefit and cost-effectiveness studies of vision screening in this review (see Appendix I). Ten studies were subsequently selected for inclusion.

A recent report by Carlton et al.[110] estimated the cost effectiveness of screening for amblyopia and strabismus in children aged three, four and five years by conducting a systematic review and economic evaluation. The data from the review informed the structure and implementation of an amblyopia screening model, which was analysed to estimate the cost and effects of six alternative screening options at the three different ages using alternative sets of tests. The reference case results showed that screening programs that included autorefraction dominated screening programs without autorefraction. Thus, analyses concentrated on screening programs that included autorefraction.

Carlton et al.[110] reported that screening at three or four years of age prevented cases of amblyopia and strabismus at a low absolute cost (of approximately £4,000 - 6,000). However, at the currently accepted values of a QALY (incremental gains cost less than £20,000 - 30,000), the authors reported that no form of screening for amblyopia was likely to be cost-effective.

The one parameter that did radically counter this conclusion was the impact of loss of vision in one eye on quality of life, and the fact that amblyopes were at increased risk of bilateral vision loss. However, in the absence of evidence on the long-term effects of unilateral vision loss, the authors reported that the prevention of the utility loss derived from the increased risk of bilateral vision loss in amblyopes was not sufficient to justify the use of resources on screening programs. The authors also reported that there was an increased probability of treated children being bullied at school. Sensitivity analyses indicated that small utility effects of bullying would improve the cost-effectiveness of early screening significantly. A prospective study of the utility effects of bullying would be useful to determine whether bullying decreases with reduced school-age treatment.

Konig et al.[111] conducted a study analysing the cost-effectiveness of orthoptic screening for amblyopia in German kindergartens. In this program, all children aged three years were examined by an orthoptist. Children with positive screening results were referred to an ophthalmologist for diagnosis.

According to the base analysis, the cost of one orthoptic screening test was 7.87 Euro compared to 36.40 Euro for an examination by an ophthalmologist. The total cost of the screening program in all kindergartens was 3.1 million Euro. The cost-effectiveness ratio was 727 Euro per case detected, but was found to be greatly influenced by the prevalence rate of the target condition along with the test specificity. The authors concluded that it was more cost-effective to re-screen non-cooperative children in kindergarten in the following year than to refer them to an ophthalmologist immediately (assuming that it was still effective to commence treatment at the time of the second screen).

In a similar but later study, Konig and Barry[112] concluded that testing for uncorrected monocular visual acuity with a pass threshold of 6/12 and <1 line difference between eyes produced the best average cost-effectiveness ratio of 876 Euro per detected case. This was in comparison to four other options: (2) same as 1, but pass threshold 6/9; (3) same as 1, plus cover tests and examination of eye motility and head posture; (4) same as 3, but pass threshold 6/9; and (5) refractive screening without cycloplegia using the Nikon Retinomax autorefractor. The most expensive option was visual acuity, cover test, examination of eye motility, and either direct referral to an ophthalmologist or re-screening for inconclusive results. Again, for all screening methods, it was more cost-efficient to rescreen children with inconclusive results than to refer them to an ophthalmologist directly.

In a further study on three year old children in German kindergartens, Konig et al.[113] found that the cost-effectiveness ratio was 924 Euro per detected case of amblyopia. Konig and Barry[114] estimated the long-term cost-effectiveness of a hypothetical screening program for untreated amblyopia in three year old children conducted by orthoptists in all German kindergartens in 2000. It was found that the incremental cost-effectiveness ratio (ICER) of

orthoptic screening was 7397 Euro per quality-adjusted life year (QALY). The authors suggested that decision makers should consider orthoptic screening based on the ICER.

Miller et al.[115] examined the comparative costs of conducting a 1,000-child screening program in a Native American indigenous population, with a target sensitivity of 90% using photoscreening, noncycloplegic autorefraction, autokeratometry, and Lea symbols distance visual acuity testing. It was found that screening with an autokeratometer (KERS) produced fewer unnecessary eye examinations than the number associated with LSVAS, and this smaller number was sufficient to offset the higher capital acquisition cost of the autokeratometer. For a large screening program of at least 2,052 children, the autorefractor screening method (NCARS) was financially more advantageous than the KERS in the number of unnecessary referrals generated compared with the higher acquisition cost. This program selected the KERS as the primary screening method.[115]

Joish et al.[116] conducted a study to determine the costs and benefits of visual acuity screening (VAS) or photoscreening in children aged six to 18 months, three to four years and seven to eight years of age in the United States. All of the benefit-to-cost ratios exceeded 1.0, meaning that all screening programs studied had benefits that exceeded the cost of screening. The total net benefit was highest for photoscreening in children of three to four years of age, and the least for VAS in children seven to eight years of age. The benefit-to-cost ratio was highest for the VAS in children three to four years of age, and least for photoscreening in infants six to 18 months of age. Sensitivity of the photoscreening instrument and VAS charts were the most influential variables in determining the most cost-beneficial program. The authors concluded that based on the best available data, the net benefit of photoscreening in three to four year old preschool children was greater than VAS in children seven to eight years, photoscreening in toddlers, and VAS in children three to four years of age. The net benefit to society was greatest when vision screening was performed in preschool children compared with school-aged children.

Magnusson and Persson[117] conducted a study to estimate, on a national basis in Sweden, the costs versus consequences of combined maternity ward and well-baby clinic eye screening compared to well-baby clinic screening alone. Two scenarios were created and compared regarding healthcare costs: visual acuity development and quality-adjusted life years (QALYs).

The total cost of the maternity ward and well-baby clinic screening scenario was 7.9 million SEK (in 2001) and that of the well-baby clinic screening scenario was 6.9 million SEK. The incremental cost-effectiveness ratio was estimated at 234,000 SEK/QALY, provided three more children per year were detected by mandatory maternity ward and well-baby clinic screening. The authors suggested that the incremental expense was cost effective and within acceptable levels of cost/QALY when compared with other widely accepted therapies across diverse medical specialities.[117]

Gandjour et al.[118] examined four different scenarios for their cost-effectiveness: (1) screening of high-risk children up to the age of one year (by ophthalmologists); (2) screening of all children up to the age of one year (by ophthalmologists); (3) screening of all children aged three to four years (by paediatricians or general practitioners); and (4) screening of children aged three to four years visiting kindergarten (by orthoptists).

The results suggested that screening of high-risk children by ophthalmologists had the lowest average cost per case detected but became dominated (less effective and more costly than an alternative) if a low (5.3%) probability of familial clustering of strabismus was assumed. Screening of all children up to the age of one year by ophthalmologists was the only strategy not dominated by others. Detection rates, including cases detected before screening, were between 72% and 78% for the strategies that screened all children.[118]

The model suggests that in Germany, both from a cost-effectiveness and a pure effectiveness point of view, screening all children up to the age of one year by ophthalmologists was the preferred strategy to detect amblyopia or amblyogenic factors. Screening all children between three and four years of age was economically less attractive both from the perspective of the health insurance and society. The inefficiency was due to the high number of cases already identified prior to screening, leading to the high number that needed to be screened to detect one additional case. The most effective screening, in terms of detection rates, was screening all children up to one year and all children between three and four years of age (78% detection rate). However, all strategies left a significant portion of children undetected.[118]

An analysis and report prepared for the Vision Council of America examined the impact and cost effectiveness of providing comprehensive eye examinations to all preschool-age children and comparing this to two options: (1) a system in which all preschool-age children received a vision screen and (2) the eye care that would be provided to children without the presence of a formal vision screening or eye examination program.[108] The study examined these options for the detection of amblyopia alone.

The analysis resulted in two main conclusions; (1) that eye examinations would detect, treat and cure significantly more cases of amblyopia in children than a universal screening program or the “usual patterns of care” that would exist without a formal vision screening program in place, and (2) that a universal comprehensive eye exam program would be highly cost effective and produce a greater return on investment than many other health care interventions.[108] The measure of cost effectiveness used was based on a comparison of the costs of interventions against the improvement in outcomes (QALYs) generated, and resulted in a cost of US\$18,390 per QALY. The authors acknowledged that gaps in the literature contributed to study limitations, but still maintained that the conclusions were robust across most model parameters. However, the use of monocular blindness to define costs is a limitation, given that not all children with amblyopia will develop this condition.

It is difficult to provide a cohesive summary of these studies, given that the papers examined various options (e.g., screening versus eye examinations, newborn screening versus preschool screening versus school screening, and so on) and were based on different economic systems.

While most studies deemed vision screening to be cost-effective in terms of dollars per QALY, the recent study by Carlton et al.[110] found evidence to the contrary. Two studies reported that comprehensive eye examinations by ophthalmologists were more cost-effective than screenings, while seven other studies reported that screenings were cost-effective. None of the studies provided different costing options by comparing two or more screening personnel, which certainly requires some thought in the Australian context. Without access to further research using Australian prevalence data and workforce parameters, it is not possible to take directions from the evidence on the economic costs and benefits of vision screening children in Australia.

6 Limitations of studies

Overall, there was a lack of rigorous controlled trials examining the effectiveness of preschool vision screening. Only two randomised controlled trials were identified and they were both of medium quality. The other types of studies reviewed were non-randomised controlled trials, observational studies, and retrospective reports (38 in total). The majority of those were classified as low quality (according to the criteria used to rate randomised controlled trials).

The populations screened often limited generalisation of results. For example, the Vision in Preschoolers Study Group (VIP), one of the two randomised controlled trials, screened children from the Head Start Program which consisted of selected children from low-income families.[12, 21] Unfortunately, results from this population cannot be generalised to the normal population.

Some studies used very small samples (e.g., n=28,[69] n=40,[82] n=70;[75]), while others evaluated programs that screened thousands of children in a community. The variation in power makes it difficult to compare the results of studies.

Other major variations in studies included the type of test that was employed to conduct the vision screen, personnel used to conduct the screens and the training and qualifications of the screening personnel. These differences made it even more difficult to compare the results and recommendations of studies.

Most studies had a limited duration of follow-up, making it difficult to determine how the screening programs influenced outcomes in childhood, let alone adult outcomes, such as increased occupational opportunities, or potential for improved adult vision. The majority of the studies reviewed measured the reduction of amblyopia as the primary outcome.

7 Directions from the evidence

Largely due to the study designs used to test vision screening effectiveness (i.e., non-randomised controlled trials, observational studies, and retrospective reports), most of the level of evidence obtained in this review was categorised as level III-3, with a lesser amount of evidence pertaining to level III-2 (see Appendix A for level definitions).

While there were few studies that focused exclusively on screening during the neonatal period, and no direct evidence could be taken from those studies, the literature identified suggested that a screen should occur within the first three months from birth, and ideally as close to birth as practicable. Given the lack of evidence, but the importance of detection, newborn screening would ideally occur alongside other standard health checks following birth.

The available evidence suggested that screening was a viable method of detecting vision conditions in children, and positioned the ideal age for vision screening at no earlier than 18 months and no later than five years (level of evidence – 1; quality – low). As visual acuity was more difficult to assess in children younger than three, vision screening guidelines recommended that screening occur after three years of age. In transferring these evidential recommendations into practice, the increase in accuracy and the optimised accessibility that would come with school-entry screening would need to be balanced against the potential for diminished treatment effectiveness by commencing treatment at a later age.

The evidence also pointed to the adoption of other methods to increase general awareness of vision conditions and propensity for parents and teachers to assess children outside of the screening period (level of evidence – 1; quality – low). For example, education and marketing campaigns have reportedly been successful in increasing general awareness of vision and the number of children attending vision screenings.[60]

Overall, the evidence was in favour of orthoptists or nurses conducting primary vision screens (level of evidence – 1; quality – high). However, whether this is appropriate in the Australian context requires further assessment of the relevant Australian workforce's capability. If employing nurses as primary screeners, the literature recommended that adequate training in screening techniques be made available so as to increase sensitivity and specificity (level of evidence – 1; quality – medium). The literature also recommended that a program of secondary screening be considered, whereby any questionable or positive results were referred for a second screen (perhaps by an orthoptist or optometrist) prior to referral to an ophthalmologist (level of evidence – 111-3; quality – low). Again, whether this is appropriate in the Australian context requires further analysis.

The referral criteria recommended for use in determining pass or fail of a vision screen was dependent upon the age selected for universal screening. The direction from the evidence was that at age three, visual acuity of less than 6/9 in either eye should be considered a fail.

At age four to six, visual acuity of 6/9 or less in either eye should be considered a fail and referred on for a secondary screen or further diagnosis.

As the evidence has shown, any screening program must take into consideration follow-up procedures that will be involved to facilitate compliance with secondary screens or treatment (level of evidence 1; quality – medium). This is particularly vital in vulnerable or disadvantaged communities where families may not understand the results of screens, may have limited resources to attend screenings or treatment facilities, and/or may not understand the importance of treatment to future vision potential.

As noted in the introduction to this literature review, groups such as children born prematurely, the remote Aboriginal population, and children with multiple disabilities are considered at high risk for certain vision conditions and therefore are not considered suitable candidates for a general vision screening program. Building an eye health program that would meet the needs of high-risk groups would require further detailed consultation with appropriate professionals in these communities and is beyond the scope of this literature review.

The cost of a screening program is obviously an important component involved in considering screening viability. The majority of studies reported that vision screening had a positive cost/benefit ratio; that early screening saved future healthcare costs. This review did not identify any Australian evaluations of vision screening costs in relation to screening in childhood. However, Deakin University have formed an agreement with the Murdoch Childrens Research Institute's Centre for Community Child Health to undertake an economic evaluation of vision screening in Australia in the near future. It is anticipated that results will be available by January 2009.

8 Further research

Currently, very few randomised controlled trials exist in the literature in regards to evaluating vision screening programs. Future research should encompass high quality randomised controlled trials in order to rigorously assess vision screening programs, and to determine whether vision screening leads to a substantial decrease in the prevalence of correctable visual acuity deficits. Once these studies have been completed, the effectiveness of vision screening programs in offering health gains can be better evaluated. Further evaluation of the impact of different screening methods administered by various personnel in a variety of settings is also required.

There is specifically a need for more trials examining the effectiveness of vision screening at school entry. Screening at school entry (as the first screen following newborn screening) has not been adequately compared with preschool screening. Screening at school entry affords convenience, equity and accuracy as children are easier to access, less likely to be missed and more able to cooperate. Future research should focus on comparing vision screening at either preschool or school entry to determine the best age period to detect and treat vision impairments. Research would also need to take into consideration the economic and practical implications of these time periods.

Research into newborn screening has been limited. Thus, the directions that have been provided by the evidence - to screen within the first three months from birth, and ideally as close to birth as practicable - are based on a small number of studies. Rigorous trials are required in the future to determine whether screening in the neonatal period is indeed a necessity. These trials should also aim to determine specific information about conditions to be screened for, age at screening and appropriate screening tools to use in the neonatal period.

There is also a need for further research into educational outcomes and vision screening. The majority of the studies were low quality, had confounding variables, and all were non-randomised controlled trials. Sound research is needed into the relationship between vision

impairment and educational outcomes before vision screening can be recommended based on improved educational achievement.

The value of vision screening is derived, in part, from the importance placed on normal vision in two eyes versus one eye, and also the impact of treatment for amblyopia on the family life and psychological well-being of the child, and on quality of life. Vision screening carries with it an implicit assumption that the child will benefit. Thus, there is a real need for research into the extent of disability attributable to vision impairment in one eye, and the possible impact of amblyopia treatment on well-being and quality of life. Without a sound evidence base that vision screening affords health gains, the ethical basis for implementation is poor.

Summary and concluding comments

In Australia, the prevalence of amblyopia in children ranged from 1.4% to 3.6%, while strabismus ranged from 0.3% to 7.3%, and refractive error ranged from 1% to 14.7%. These rates show large variations and further research may be required to consolidate these figures. However, they suggest that vision conditions are relatively prevalent among Australian children.

A review of the literature suggested that screening and subsequent treatment of visual impairment at an early age (from 18 months to five years), led to improved visual outcomes. However, the majority of evidence available was derived from low quality, non-randomised controlled trials.

Screening children of an older age, such as eight to ten years or 13 - 15 years, identified very few or no new cases of eye pathology, which would suggest this is not recommended practice. There was a lack of studies evaluating screening at school entry, which would be an ideal and convenient time to 'capture' a larger number of participants. The few studies identified that touched on neonatal screening recommended screening of the newborn between birth and three months of age, particularly for the detection of congenital cataracts. The literature recommended that high-risk children of any age should be referred to an ophthalmologist.

While most studies concluded that orthoptists were the most accurate screening personnel, the majority of studies examining nurses as screeners concluded that, with appropriate training and referral protocols, they could be effective and capable screeners. There was a lack of studies examining the role of optometrists as screeners.

Some studies reported that secondary screening (following a primary screen by non vision health professionals, and prior to referral and assessment), was shown to be effective in the early detection, referral, and treatment of eye problems. Studies also suggested that teaching parents to be more attentive to their child's vision, or creating awareness campaigns to ensure that corrections were used and cultural barriers to compliance were addressed and removed, could increase the effectiveness of vision screening programs.

There were a number of social, economic and political barriers to children seeking follow-up care and treatment post-screening. These undermined the effectiveness of vision screening campaigns. Any future screening programs should address these barriers in the design of the program.

Links were established in the literature between vision impairment and poor educational outcomes. It was suggested that vision impairment was correlated with lower visuocognitive and visuomotor skills, poorer reading ability and lower scores on achievement tests. However, many of the types of vision impairment considered would not usually be detected by community vision screening programs.

Overall, the best evidence from the available literature recommended that vision screening be implemented either in the preschool years, or by school entry at the latest. Best available evidence also directed that screening could be carried out by appropriately trained nurses, followed by secondary screening by an orthoptist prior to referral to an ophthalmologist. These directions incorporated consideration of screening sensitivity and specificity and cost-effectiveness. From the few studies available, it was recommended that neonatal screening should continue to be performed with efforts to optimise training of screeners, and referral practices. However, without the availability of research utilising higher levels of evidence (preferably levels I or II) and without available data on the cost-effectiveness of vision screening in the Australian context, it is difficult to state unequivocally that vision screening is the best method for detecting vision conditions in children.

Appendix A Levels of Evidence

NHMRC 2000 designations of levels of evidence

Level I: Evidence obtained from a systematic review of all relevant randomised controlled trials.

Level II: Evidence obtained from at least one properly designed randomised controlled trial.

Level III-1: Evidence obtained from well-designed pseudorandomised controlled trials (alternate allocation or some other method).

Level III-2: Evidence obtained from comparative studies (including systematic reviews of such studies) with concurrent controls and allocation not randomised, cohort studies, case-control studies, or interrupted time series with a control group.

Level III-3: Evidence obtained from comparative studies with historical control, two or more single-arm studies, or interrupted time series without a parallel control group.

Level IV: Evidence obtained from case series, either post-test or pretest/post-test.

Source: National Health and Medical Research Council. *How to use the evidence: assessment and application of scientific evidence. Handbook series on preparing clinical practice guidelines. Table 1.3: Designation of levels of evidence.* Canberra: NHMRC, February 2000: 8. Available at: www.health.gov.au/nhmrc/publications/pdf/cp69.pdf

Appendix B MeSH search terms

Vision Screening/

exp Vision Disorders/

exp Refractive Errors/

"Retinopathy of Prematurity"/

Cataract/

exp Glaucoma/

Retinoblastoma/

Vision, Binocular/

exp Strabismus/

exp Visual Acuity/

2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10

"sensitivity and specificity"/ or "predictive value of tests"/

"reproducibility of results"/

observer variation/

12 or 13 or 14

sheridan gardiner.mp.

snellen\$.mp.

LogMAR.mp.

glasgow acuity card\$.mp.

lea symbol\$.mp.

hotv.mp.

(photorefractio\$ or photo refraction\$ or photoscreening\$ or photo screening\$).mp. [mp=title, original title, abstract, name of substance word, subject heading word]

red reflex.mp. [mp=title, original title, abstract, name of substance word, subject heading word]

exp Diagnostic Techniques, Ophthalmological/

exp Vision Tests/is [Instrumentation]

16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25

*Vision Screening/ and (exp *Vision Disorders/ or exp *Refractive Errors/ or *"Retinopathy of Prematurity"/ or *Cataract/ or exp *Glaucoma/ or *Retinoblastoma/ or *Vision, Binocular/ or exp *Strabismus/ or exp *Visual Acuity/)

*Vision Screening/ and 15

(*Vision Screening/ or (exp *Vision Disorders/ or exp *Refractive Errors/ or *Retinopathy of Prematurity"/ or *Cataract/ or exp *Glaucoma/ or *Retinoblastoma/ or *Vision, Binocular/ or exp *Strabismus/ or exp *Visual Acuity/)) and (exp *Diagnostic Techniques, Ophthalmological/ or exp *Vision Tests/is)

(*Vision Screening/ or (exp *Vision Disorders/ or exp *Refractive Errors/ or *Retinopathy of Prematurity"/ or *Cataract/ or exp *Glaucoma/ or *Retinoblastoma/ or *Vision, Binocular/ or exp *Strabismus/ or exp *Visual Acuity/)) and (16 or 17 or 18 or 19 or 20 or 21 or 22 or 23)

*mass screening/ and (exp *Vision Disorders/ or exp *Refractive Errors/ or *Retinopathy of Prematurity"/ or *Cataract/ or exp *Glaucoma/ or *Retinoblastoma/ or *Vision, Binocular/ or exp *Strabismus/ or exp *Visual Acuity/)

27 or 28 or 29 or 30 or 31

1 or 32

limit 33 to (humans and english language and "review articles" and "all child (0 to 18 years)")

clinical trial.pt,sh.

randomi#e\$.ab.

placebo\$.ab.

exp clinical trials as topic/ or drug evaluation/

randomly.ab.

(trial or trials).ti.

35 or 36 or 37 or 38 or 39 or 40

exp animals/

humans/

42 not 43

41 not 44

33 and 45

limit 46 to (english language and "all child (0 to 18 years)")

34 or 47

Appendix C Australian states and territories – current vision screening practice

State/Territory	Age:	Condition/s screened for:	Tool/s used:	Referral criteria	Screened by:
Australian Capital Territory	1-4 weeks	Cataracts, observation	Family and nurse observation		Child health nurse
	6-8 weeks	Cataracts, ocular movements	Family and nurse observation, cover-uncover test		Child health nurse
	6 months	Cataracts, ocular movements	Family and nurse observation, cover-uncover test		Child health nurse
	12 months		Family and nurse observation, cover-uncover test		Child health nurse
	18 months		Family and nurse observation, cover-uncover test		Child health nurse
	3 years	Visual acuity at distance of three metres	Striker cards	Children need to see down to the smallest letter in the 3 x 3, otherwise referred to orthoptist.	Child health nurse
	5+ years (Kindergarten)	Visual acuity at distance of six metres	Vision box	If child is less than 6 years of age, refer at less than 6/9 in either eye. If child is 6 years of age or more, refer at less than 6/6 in either eye.	
New South Wales	Neonatal	Eye check	Examination, parental questionnaire about family history		
	1-4 weeks	Observation, corneal reflection, white pupil	Parental questionnaire on vision risk		Child & Family Health Nurse, GP or Paediatrician
	6-8 weeks	Observation, fixation, corneal reflections, response to occlusion	Parental questionnaire		Child & Family Health Nurse, GP or Paediatrician
	6 months	Observation, fixation, corneal reflections,	Parental questionnaire		Child & Family Health Nurse, GP or Paediatrician

		response to occlusion, ocular movements			
	12 months	Observation, fixation, corneal reflections, response to occlusion, ocular movements	Parental questionnaire		Child & Family Health Nurse, GP or Paediatrician
	18 months	Observation, fixation, corneal reflections, response to occlusion, ocular movements	Parental questionnaire		Child & Family Health Nurse, GP or Paediatrician
	2 years	Observation, fixation, corneal reflections, response to occlusion, ocular movements	Parental questionnaire		Child & Family Health Nurse, GP or Paediatrician
	3 years	Observation, fixation, corneal reflections, response to occlusion, ocular movements	Parental questionnaire		Child & Family Health Nurse, GP or Paediatrician
	4 years	Visual acuity tested monocularly	Sheridan Gardiner Matching Test, Brief parental questionnaire	Unavailable at present	Child & Family Health Nurse, GP or Paediatrician
Northern Territory (proposed schedule)	Neonatal	As per NHMRC			
	8 weeks	Following	Parental questionnaire		Nurse, Allied Health Worker
	6 months	Squint	Observation or otherwise suspected or identified		Nurse, Allied Health Worker to refer to GP
	18 months	Vision, eye contact			Nurse, Allied Health Worker
	4 or 5	Visual acuity	Lea chart	Refer if unable to read 3 symbols on the 6/12 line,	Nurses, Allied Health Workers as

	years			or, if 2 or more line difference between eyes, or, skips symbols within any line, or, obvious squint or other concern	part of the Healthy School-Age Kids program
	Remote areas	Trachoma			Nurses, Allied Health Workers as part of the Healthy School-Age Kids program
Queensland	Neonatal		Eye check, red reflex		Medical practitioners
	0-4 weeks	Vision	Assessing visual behaviour		
	2 months	Vision profile	Assessing visual behaviour		During 'well-child' visit (child health nurse)
	6 months	Vision profile	Assessing visual behaviour, Hirschberg test		During 'well-child' visit (child health nurse)
	12 months	Vision profile	Assessing visual behaviour		During 'well-child' visit (child health nurse)
	18 months	Vision profile	Assessing visual behaviour, Hirschberg test		During 'well-child' visit (child health nurse)
	2.5-3.5 years	Vision profile, corneal light reflex	Hirschberg test, vision – near cover test		During 'well-child' visit (child health nurse)
	4-5 years	Vision acuity (right and left)	Hirschberg test, cover near/far, Lea Symbols or HOTV letters with confusion bar (for 3.5 years plus), Linear STYCAR 5 letter chart with key-card for Prep students, 7 letter chart with/without key-card for Year 1 students	Unavailable at present	
	6-12 years (referred by parent)	Visual acuity	Snellen chart (or other appropriate chart)	Unavailable at present	
South Australia	1-4 weeks	Appearance, fixation, red reflex			Paediatrician or GP and visiting community nurse
	6-8 weeks	Appearance, fixation and following			Paediatrician or GP and health centre community nurse or community youth health orthoptist

	6-9 months	Appearance, fixation and following, corneal light reflex			Health centre community nurse with orthoptist review as required
	18 months	Appearance, fixation and following			Health centre community nurse with orthoptist review as required
	2-3.5 years	Appearance, fixation and following		Unless there is head turning, squinting, peering or eye turn, refer at 6/12. It is also important to observe near vision and print size required and refer if this out of the normal range.	Health centre community nurse with orthoptist review as required
	4-5 years	Distance visual acuity	Snellen test or HOTV test		Kindergarten or Health centre community nurse
Tasmania	1-2 weeks	Eye check	Parental questionnaire		Family and Child Health Nurse, GP or Paediatrician
	6-8 weeks	Corneal light reflections, fixation, following	Parental questionnaire		Family and Child Health Nurse
	6 months	Corneal light reflections, red reflex, corneal light reflexes	Parental questionnaire, cover test, ophthalmoscopy		Family and Child Health Nurse (corneal light reflections, cover test) and GP (red reflex, corneal light reflexes, cover test)
	18 months	Corneal light reflections, red reflex, corneal light reflexes	Parental questionnaire, cover test, ophthalmoscopy		Family and Child Health Nurse (corneal light reflections, cover test) and GP (red reflex, corneal light reflexes, cover test)
	3.5 years	Visual acuity R6/ L6/, corneal light reflections, eye movements, red reflex, corneal light reflexes, visual acuity	Parental questionnaire, cover test, ophthalmoscopy		Family and Child Health Nurse (visual acuity R6/ L6/, cover test, corneal light reflections), GP (ophthalmoscopy, eye movements, corneal light reflexes, visual acuity)
	5-12 years	Routine screening of vision in Prep, and routine screening of vision in Year 6	Distance vision test		Family and Child Health Nurses
Victoria	Neonatal	Eye examination			
	2 weeks	Eye examination			Maternal and Child Health Nurse, GP or Paediatrician
	4 weeks	Observation,			Maternal and Child Health Nurse,

		following			GP or Paediatrician
	8 weeks	Fixation, following			Maternal and Child Health Nurse, GP or Paediatrician
	4 months	Fixation, following	Tasks in Child Health Record		Maternal and Child Health Nurse, GP or Paediatrician
	6-8 months	Fixation, following	Tasks in Child Health Record		Maternal and Child Health Nurse, GP or Paediatrician
	12 months	Squint, head tilt, fixation, following	Tasks in Child Health Record		Maternal and Child Health Nurse, GP or Paediatrician
	18-21 months	Fixation, following	Tasks in Child Health Record		Maternal and Child Health Nurse, GP or Paediatrician
	2 years	Squint, fixation, following	Tasks in Child Health Record		Maternal and Child Health Nurse, GP or Paediatrician
	3.5 years	Squint, vision screen	MIST, tasks in Child Health Record	MIST 3 out of 5 for both eyes = pass Less than 3 out of 5 on either eye = fail and refer	Maternal and Child Health Nurse, GP or Paediatrician
	4-5 years	Vision screen	MIST, tasks in Child Health Record	MIST 3 out of 5 for both eyes = pass Less than 3 out of 5 on either eye = fail and refer	Maternal and Child Health Nurse, GP or Paediatrician
	School age (Prep) 4.5 - 6 years	Visual acuity, distance vision screen, parental questionnaire	Lea LogMAR symbols, Primary School Nursing Program School Entrant Health Questionnaire	Accepted limits are 3/4.8 or better in each eye separately, and less than 2 lines difference between eyes	School nurse
Western Australia	Neonatal	Visual appraisal	Red reflex (or Pupil Light reflex, Bruckner test)	Abnormalities (asymmetries) of the red reflex require urgent referral to a specialist ophthalmologist	Not stated
	6-8 weeks	Visual appraisal	Parental questionnaire, Red reflex (or Pupil Light reflex, Bruckner test)	Abnormalities (asymmetries) of the red reflex require urgent referral to a specialist ophthalmologist	Community Health Nurse (universal screening for red reflex)
	3-4 months	Visual appraisal	Parental questionnaire, Red reflex (or Pupil Light reflex, Bruckner test)	Abnormalities (asymmetries) of the red reflex require urgent referral to a specialist ophthalmologist	Community Health Nurse (universal screening for red reflex)
	8 months	Visual appraisal, eye movements, examination for strabismus, vision behaviours	Corneal light reflex test, Hirschberg test	Convergent or divergent squints to be referred to GP for onward referral	Community Health Nurse (universal screening for strabismus)
	18	Visual appraisal	Parental questionnaire	Convergent or divergent squints to be referred to	Community Health Nurse (will

	months			GP for onward referral	screen for strabismus, otherwise targeted screening only if there is a concern or family history)
	3 years	Visual appraisal	Parental questionnaire	Convergent or divergent squints to be referred to GP for onward referral	Community Health Nurse (will screen for strabismus, otherwise targeted screening only if there is a concern or family history)
	3.5-5 years	Visual appraisal, examination for strabismus, distance visual acuity, amblyopia	Cover test, corneal light reflex, Hirschberg test, Lea Symbols chart or 4 metre letter matching test	3.5 years = test to 6/9.5 VA = at least 6/12 for each eye Re-test in 3 months and refer if VA worse than 6/12 Re-test in 12 months if VA not 6/9.5 for each eye Re-test in 2 months and refer if child is not attentive or not concentrating	Community Health Nurse (universal screening)
				4 years = test to 6/7.5 VA = at least 6/12 for each eye, plus less than a 2 line difference between the eyes Re-test in 2 months and refer if VA worse than 6/12 Re-test in 12 months if child passes the VA but was skipping symbols and has a 1-line difference Re-test in 12 months for a child with 2-line difference Re-test in 2 months if child not attentive or not concentrating	Community Health Nurse
				5 years = test to 6/6 VA – at least 6/9.5 for each eye, plus less than a 2-line difference between the eyes Re-test in 2 months and refer if VA worse than 6/12 Re-test in 12 months if child passes VA but was skipping symbols and has a less than 1-line difference Re-test in 12 months for child with 2-line difference Re-test in 2 months and refer is child not attentive or concentrating	Community Health Nurse
				6 years = test to 6/6 VA = at least 6/9.5 for each eye Re-test in 2 weeks and refer if VA worse than 6/9.5 Re-test in 2 weeks and refer if child passes VA but was skipping symbols and has a 1-line difference Make referral without delay if child is not attentive or not concentrating	Community Health Nurse

Appendix D Criteria for inclusion of studies

Box 1: NHMRC 2000 checklist for appraising the quality of studies of interventions

Quality Criteria 1. Method of treatment assignment

- A. Correct, blinded randomisation method described OR randomised, double-blind method stated AND group similarity documented.
- B. Blinding and randomisation stated but method not described OR suspect technique (e.g., allocation by drawing from envelope).
- C. Randomisation claimed but not described and investigator not blinded.
- D. Randomisation not mentioned.

2. Control of selection bias after treatment assignment

- A. Intention to treat analysis AND full follow-up
- B. Intention to treat analysis AND <15% loss to follow-up
- C. Analysis by treatment received only OR no mention of withdrawals
- D. Analysis by treatment received AND no mention of withdrawals OR more than 15% withdrawals/loss to follow-up/post-randomisation exclusions

3. Blinding

- A. Blinding of outcome assessor AND patient and care giver
- B. Blinding of outcome assessor OR patient and care giver
- C. Blinding not done

4. Outcome assessment (if blinding not possible)

- A. All patients had standardised assessment
- B. No standardised assessment OR not mentioned

Source: modified from I Chalmers, Cochrane Handbook; available on the Cochrane Library CDROM *How to review the evidence* (cited in NHMRC additional levels of evidence and grades for recommendations for developers of guidelines. Pilot Program 2005-2007).

Box 2. Criteria allocated to studies and their associated quality ratings

High quality				Low quality			
1	2	3	4	1	2	3	4
A	A	A	A	C	C	C	B
B	B	B	A	D	D	A	A
				D	D	B	A
				D	D	C	A
Medium quality				D	D	C	B
C	C	B	A	C	C	C	B
C	C	C	A	C	D	D	A
B	D	B	A	C	D	C	A
C	D	B	A	D	C	C	A
C	D	A	B				
C	A	C	A				
D	C	B	A				

Box 3: Checklist for evaluating the quality of systematic reviews

Quality Criteria 1. Clearly defined question and inclusion criteria

- A. (high quality) A clear aim or research question AND a list of clear inclusion criteria was reported.
- B. (some limitations) A clear aim or research question OR a list of clear inclusion criteria was reported.
- C. (unsatisfactory quality) No aims or clear research questions were reported. It was unclear what had been done.

2. Comprehensive search

- A. (high quality) Electronic databases and one or more of the following were used: the 'grey' literature, internet sources, conference proceedings, hand searches, reference lists, technical reports, experts, theses, etc AND the search was not restricted to the English language literature only.
- B. (some limitations) More than 1 electronic database was used OR the search was restricted to the English language literature only.
- C. (unsatisfactory quality) Only 1 major electronic database was used (e.g., Medline).

3. Critical appraisal of the validity of studies reviewed

- A. (high quality) Explicit criteria for critical appraisal were stated and the findings of that appraisal were considered in the conclusions and recommendations.
- B. (some limitations) Critical appraisal was undertaken but explicit criteria were not stated.
- C. (unsatisfactory quality) No critical appraisal of the studies reviewed was reported.

4. Consistency of results

- A. (high quality) Homogeneity of results (i.e., all studies indicate positive/negative effects of similar magnitudes).
- B. (some limitations) Heterogeneity of size of effect but trend obvious (i.e., all studies indicate positive/negative effects, but of differing magnitudes).
- C. (unsatisfactory quality) Heterogeneity of direction of effect (i.e., some studies indicate positive effect, others negative).

Source: Review by the Centre for Community Child Health for NHMRC (*Child Health Surveillance and Screening: A Critical Review of the Evidence*).

Box 4. Criteria allocated to systematic reviews and their associated quality ratings

High quality		Low quality	
2	3	2	3
A	A	C	C
Medium quality		B	C
2	3	C	B
A	B		
B	A		
B	B		
A	C		
C	A		

Appendix E Literature tables

Table 1: Randomised Controlled Trials

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screener	Results
1 MONTH - 3 YEARS - screening effectiveness								
M	Williams et al. 2001[39] & Williams et al. 2002[40]*	Avon, West England, UK	8 months	3490 *2740	<p>Control: Received surveillance for visual problems by health visitors and family doctors. Exam involved:</p> <ul style="list-style-type: none"> Family history Cover test, with ad hoc referrals if there was suspicion of strabismus or reduced visual acuity. <p>Intervention: Received surveillance plus a program of visual testing by orthoptists.</p> <ul style="list-style-type: none"> Visual acuity was tested by: behaviour when either eye was occluded (all ages), Cardiff Cards (8, 12, 18, 25, 31 months) and Kay Picture test (25 and 31 months). Ocular alignment was tested by: cover test (all ages), stereopsis with Lang tests 1 and 2 (18, 25, 31 months) and Frisby test (12, 18, 25, and 31 months), and motor fusion with the 20 Dioptre base-out test (all 	<p>1. Intervention n=2,029</p> <p>2. Control n=1,461 (* Intervention n=1,914, control group orthoptic screening at 37 months only n=826)</p>	Health visitor, family doctor (control); orthoptist (intervention)	<p>Intervention program yielded more children with amblyopia (1.6% vs 0.5%) and was more specific (95% vs 92%) than the control program. Cover test and visual acuity tests were poorly sensitive until children were 37 months, but were always 99% specific. Photorefracton was more sensitive than acuity at all ages below 37 months (95% at 31 and 37 months). Intervention program was more sensitive than control program for detecting strabismus and straight eyed amblyopia. There were fewer false positive referrals from the intervention group than the control group (however, the intervention program was not designed to be practicable). Most cases of strabismus were not apparent until after age 25 months, and most cases of straight-eyed amblyopia could not be identified until at least 37 months.</p> <p>(*The intervention program was associated with better acuity in the amblyopic eye and lower prevalence of amblyopia at 7.5 years compared to the control group. Children treated for amblyopia were four times more likely</p>

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
					ages). <ul style="list-style-type: none"> • Stereopsis • Non-cycloplegic photorefraction Referral criteria for Kay Picture test result below 6/12 at 25 months and 6/9 at 31 months.			to remain amblyopic if they were screened at 37 months only than if they were screened repeatedly between 8 and 37 months. Children screened early could see an average of one line more with their amblyopic eye after treatment than children screened at 37 months).
3 - 6 YEARS - screener characteristics								
M	Vision in Preschoolers Study Group (VIP), 2005[12]	US	3-5 years	1452	<ul style="list-style-type: none"> • Retinomax Autorefractor • SureSight Vision Screener • Linear Lea Symbols VA at 10 ft • Single Lea Symbols VA at 5 ft • Stereo Smile II 	1. Failed Head Start vision screening n=785 2. Passed Head Start vision screening n=844	Nurse or lay screener	Nurse screeners achieved slightly higher sensitivities with the Retinomax, SureSight, and Stereo Smile II than the lay screeners; however, most differences were small and not significant. Nurse screeners achieved significantly higher sensitivity with the Linear Lea Symbols vs lay screeners. Lay screeners achieved higher sensitivity with Single Lea Symbols vs nurse or lay screeners using Linear Lea Symbols. Combining Stereo Smile II with each of the other tests did not result in improved sensitivities. Nurse and lay screeners could achieve similar sensitivity when specificity was set at 90%.

Table 2: Non-Randomised Controlled Trials

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
1 MONTH - 3 YEARS - screening effectiveness								
L	Atkinson et al. 1996[36] & Atkinson et al. 2007[37]*	Cambridge, UK	1st program: 6-8 months 2nd program: 8.1 ± 0.8 months, 7-9 months	1st 3166 2nd 5091	1st program: Basic orthoptic exam (Hirschberg test, cover test, ability to overcome 20 Δ prisms) and isotropic photorefracton with cycloplegia. 2nd program: Full orthoptic exam and four sets of videorefractive images without cycloplegia.	1st program 1. Met criteria for follow-up n=DK 2. Control group met no criteria for follow-up n=DK 2nd program as above.	Orthoptist	Both programs showed good agreement between infants identified at screening and retinoscopic refractions at follow-up, showing that photo- and video-refraction (with or without cycloplegia) can be effective methods for screening ametropia in infants/young children. For the 1st program, children who were hyperopic in infancy were 13 times more likely to become strabismic, and six times more likely to show acuity deficits by 4 years compared to controls. Wearing a partial spectacle correction reduced these risk ratios 4:1 and 2.5:1 respectively (*at 7 years improvement in strabismus was found for the 1st program only. Infant hyperopia was found to be associated with mild delays across many aspects of visuocognitive and visuomotor development.)
L	Bradley and Riederer 2000[60]	British Columbia, Canada	2-3 years	383	The purpose of the pilot was to determine whether the Vision First Check Program (using the MCT) would result in a substantially higher number of 2 and 3 year olds receiving a thorough	Screening group n=383	Optometrists	The Vision First Check program was successful in increasing the number of preschoolers receiving vision care. The program screened 2 year olds at 4.7 times the previous rate and 3 year olds 2.8 times.

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
					vision assessment than currently indicated by provincial government data.			
M	Eibschitz-Tsimhoni et al. 2000[41]	Haifa and Hadera, Israel	1-2.5 years	1590	Exam involved: <ul style="list-style-type: none"> • History • External inspection • Hirschberg corneal reflex test • Monocular fixation-and-following test • Ductions and versions exam • Cover-uncover test • Alternate cover tests 	1. Screened n=808 2. Not screened n=782	Ophthalmologist or an orthoptist	The prevalence of amblyopia in 8 year olds screened in infancy was 1.0% vs 2.6% for non-screened children. Prevalence of amblyopia with visual acuity of 6/12 or worse in the amblyopic eye was 0.1% for screened children vs 1.7% for non-screened children. Screening sensitivity was 85.7%, specificity 98.6%, positive predictive value 62.1%, and negative predictive value 99.6%.
M	Filipovic et al. 2003[61]	Rijeka, Croatia	5 years or less	200	An ophthalmologic screening card was attached to children's vaccination cards to examine whether this reduced the age at which children were first admitted to the Dept. of Paediatric Ophthalmology.	1. Screening card, 1990 group n=100 2. No screening card, 1980 group n=100	Neonatologists, and paediatricians or trained nurses	After the screening card was introduced, the mean age at which amblyopia and strabismus were detected decreased significantly from 4.4 to 2.5 years.
L	Rahi and Dezatuex 1999[54]	UK	0-12 months	248	Program to determine the mode of detection and timing of ophthalmic assessment of a nationally representative group of children with	Newly diagnosed cataract n=248	Paediatrician/or ophthalmologist	Congenital and infantile cataracts were not detected by a health professional before the child's 1st birthday in 29% of cases, despite recommendations to examine all newborn and young infants routinely.

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
					congenital and infantile cataract. Postal questionnaires were sent to paediatricians and ophthalmologists to determine who first suspected the child had an ocular defect, at what age, date and reason for contact with a health professional during which cataract was detected and age at first referral to, and first examination by, an ophthalmologist.			
L	Smith et al. 1995[55]	Leicester, UK	6 weeks to 3.5 years	412	The current program made improvements from 1988-1991. Before 1988, health visitors referred children suspected of having a vision problem to their GP who would refer them on to an ophthalmologist. The new system involved children being referred directly from primary screening to a secondary orthoptic screen.	1. 1983 cohort screened n=209 2. 1992 cohort screened n=203	Health visitors	After introduction of changes to the screening program, the mean age at presentation of amblyopia associated with microtropia or no strabismus reduced from 6.6 to 5.5 years. In 1983 there was a significant relationship between deprivation and age at presentation, with those from more deprived areas presenting later. No similar associations were found in children referred in 1992. There was no change in the mean age of presentation of amblyopia associated with large angle strabismus (3.3years) and no relationship between deprivation and age of presentation in 1983 or 1992.
3 - 6 YEARS - screening effectiveness								

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
L	Fathy and Elton 1993[38]	North Manchester, UK	3-4 years	5,162	Children were examined for: <ul style="list-style-type: none"> • Gross abnormalities • Corneal reflections • Abnormalities of ocular movements and binocular convergence • Cover test for strabismus • Prism reflex test for abnormality of binocular function • Sheridan Gardiner 7 letter test for visual acuity 	Screening group n=5,162	Orthoptists	As a result of screening, 4.4% of children received treatment for a defect not previously detected as a result of developmental surveillance or parents reporting their concerns. Treatment resulted in a considerable improvement in vision. 309 children were referred to an ophthalmologist, 284 (92%) attended. 233 were treated, 49 had a defect but were not treated, 2 no abnormality was confirmed, and 25 did not attend. 99 had a refractive error with no amblyopia, 119 had amblyopia with refractive error, 8 amblyopia with no refractive error. Detection rate of amblyopia was 25/1000, refractive without amblyopia 19/1000, and strabismus 44/1000.
L	Kemper et al. 2006[50]	US	3-5 years	62	A survey was administered to a randomly selected national cohort of primary care paediatricians and family physicians. They were asked to recruit parents whose preschool aged children had an abnormal vision	Parents n=62	Paediatricians and family physicians	Most, but not all parents knew that their child had an abnormal vision screening result (91.1%), and among these, most received follow-up eye care (75.6%). Most preschoolers received follow-up eye care within 2 months of screening. Barriers included lack of insurance coverage, inconvenience of follow-up, and lack of knowledge about benefits of early

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
					screening result.			intervention. Minority children and those with low family incomes were less likely to receive follow-up care.
L	Milne 1994[56]	Newcastle-Upon-Tyne, UK	3.1 years	2,600	<p>Primary vision screening: Vision screening:</p> <ul style="list-style-type: none"> • Sheridan Gardiner single optotype or Kay Picture test • Cover test • Ocular motility • Convergence • 20-dioptre base-out reflex test <p>Community orthoptist request service (Secondary): the Newcastle community orthoptic service also provided assessments for any child aged other than 3.1 years on request basis by GPs, health visitors, school nurses, and other professionals.</p>	<ol style="list-style-type: none"> 1. Routinely screened n=1,858 2. Recalled from previous visit n=349 3. Seen as request referrals n=393 	Orthoptists	<p>Primary vision screening at 3.1 years by orthoptists working in local clinics: 140 (6.3%) referred. 115 (85.8%) of those seen at hospital were identified as having an eye problem, of these, 82 (61.2%) required immediate treatment.</p> <p>Community orthoptist request service (Secondary): 70 (17.8%) referred. 60 (95.2%) were identified as having an eye problem, of these, 42 (66.7%) required immediate treatment.</p> <p>Raising the screening age from 35 to 37 months helped reduce the number of children being recalled, as more children in the lower age group were too immature to respond satisfactorily to the tasks required. Secondary orthoptic assessment can be very effective with 27 (100%) of the children who were referred under 34 months had a target eye condition; yet the service is cost effective with 323 (82.2%) not needing referral to hospital, therefore, reducing false referrals to hospital. High hospital attendance rate 98.4%.</p>

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
M	Williams et al. 2003[42]	Avon, West England, UK	1. 3 years	1,019	The orthoptist preschool screening exam included: <ul style="list-style-type: none"> • Monocular vision test (Kay Picture test or Sheridan Gardiner singles) • Cover test • Assessment of binocularity 20 dioptre prism or test of stereopsis, or both 	1. Children who received vision screening at 3 years n=DK 2. Children who did not receive vision screening at 3 years n=DK	Orthoptist	Preschool screening at 3 years was associated with an improved treatment outcome for individuals with amblyopia, however the improvement was clinically small and disappeared when considering all children offered screening rather than those who just received it. Of 6,081 children, 24.9% had been offered screening, 16.7% attended. The prevalence of amblyopia was approx 45% lower in children who received preschool screening than those who did not. Mean acuity in the worse seeing eye after patching treatment was better for amblyopia children who received preschool screening than those who did not. Effects did not persist in an intention to treat analysis. Treatment for amblyopia does improve visual acuity and on average, the results of treatment after screening are better for screening before 3 years than after 3 years and slightly better again after screening at 3 years than at school entry, especially for children with straight eyed amblyopia.
6+ YEARS - screening effectiveness								
L	Cummings 1996[15]	Cambridge, UK	8 and 10 years	1,809	Examined the outcome of vision screening in children and established whether such tests are necessary at a time when there are increasing	1. 8 year olds n=822 2. 10 year olds n=927		Of the 1,809 children in the study, 1,249 had perfect visual acuity recorded as 6/6 for both distant and near vision. For the other 560, defects (6/6 part or worse) of visual acuity were found in 34.6% of the

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screener	Results
					demands on limited resources.			1429 children in rural schools and 30% of the 380 children found in urban schools. Of the 560 classified as abnormal, most (68%) had been found on a previous occasion. Of the 181 new findings, 83% were in the less significant categories. Routine vision screening after 5 years identifies only a very small number of children with significant new abnormalities.

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeners	Results
L	Edgecombe et al. 1998[59]	Victoria, Australia	5-7 years	998 parents	The study described the analysis of data from the first testing of the School Entrant Health Questionnaire (SEHQ). The SEHQ is distributed each year to the parent(s)/guardian(s) of preparatory children enrolled in participating primary schools in Victoria, Australia. The SEHQ assists school nurses in developing a health profile of children.	Parents surveyed n=998	School nurses	The SEHQ was found to be reliable and valid to provide an excellent means of distinguishing those who had problems and needed intervention from those who did not. It was found that the majority of children were healthy, however there were a significant number of children with problems that would require intervention by a school nurse and/or referral to specialist services e.g., 49 parents did not understand that a 'turned eye' or strabismus could affect their child's vision. The SEHQ proved to be a useful adjunct for the school nursing assessment of children in prep.
L	Jewell et al. 1994[45]	Oxfordshire, UK	13-15 years	1,069	A school nurse used Snellen at 6 m for visual acuity.	1. 13 year olds n=371 2. 14 year olds n=377, 3. 15 year olds n=321	School nurse	It was found that 3.8% of children 13 - 15 years had visual acuity worse than 6/12 in one or both eyes (fail). There was no evidence that this percentage increased across the age range. Less than 1% were prescribed and wore glasses as a consequence of failing

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screener	Results
								vision screening and no new cases of eye pathology were detected. Questionnaire responses from parents suggested that approx 50% of children who did not wear glasses had had an eye exam in the previous 2 years. The proportion of secondary school children failing screening increased by less than 2% per year, implying that the majority who are likely to benefit from screening find their own way to an optometrist.
L	Kimel 2006[52]	Rockford, US	5-6 to 10-11 years	78	School nurses in the Rockford Public Schools gathered names of 175 English speaking students K-5th grade that had failed school vision screening and had not reported receiving follow-up eye exams. The parents of these children were interviewed.	Parents n=78	School nurses	Family issues, parental perceptions of vision problems and difficulty planning ahead were found to be significant barriers. Financial barriers - cost and money concerns 31%, no insurance coverage 11%, waiting for insurance 9%. Logistical barriers - appointment problems 22%, can't plan ahead 16%, no phone 11%, no car 9% 3. Social/family barriers - all adults work 45%, family issues 34%, large family 29%, parent disabled 13%, change in residence 11%. Perceptual barriers - do not believe results 38%, not a priority 38%, no need for an exam 29%, no interest in follow-up 18%. Factors that increase compliance: parent wears glasses, parent has at least a high school diploma/general equivalency diploma, at least one nonworking adult in the home, family income above 200% of federal poverty level, family has both a car

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
								and phone, and trust in the school nurse.
L	Kvarnstrom et al. 1998[43]	Huddinge, Lund, and Linkoping, Sweden	0-10 years	3,126	<ul style="list-style-type: none"> • At four and 5.5 years, monocular vision was tested using the HOTV-chart. • At seven years children were tested with a Line E-chart or HOTV-chart. • At 10 years the children's vision was tested using Monoyer's linear letters. 	Screening group n=3,126	School nurses	Attendance rate at 4 years was better than 99%. Sensitivity of 4 and 5.5 year screening was on average 92%, and specificity 97%. The average number of false negatives at 4 years was 5.6 in 1000 (0.56%). With this screening and subsequent diagnosis and treatment, the prevalence of amblyopia at different levels of visual acuity at age 10 years was 0.06% with visual acuity ≤ 0.1 , 0.9% with visual acuity ≤ 0.5 and 1.7% visual acuity ≤ 0.7 . The prevalence of deep and moderate amblyopia had been markedly reduced by screening and early treatment.
L	Kvarnstrom et al. 2001[44]	Huddinge, Lund, and Linkoping, Sweden	0-10 years	3,126	<ul style="list-style-type: none"> • At four and 5.5 years, monocular vision was tested using the HOTV-chart. • At seven years children were tested with a Line E-chart or HOTV-chart. • At 10 years the children's vision was tested using Monoyer's linear letters. 	Screening group n=3,126	School nurses	Ametropia (any refractive error) was mainly detected at 4 years, when the first visual acuity test was performed. Manifest strabismus was in many cases detected before age 4, while microtropia (small angle heterotropia) was detected at 4 years. Prevalence of amblyopia was reduced to 0.2% from 2% by screening and treatment, and the majority of patients with amblyopia increased their visual acuity with treatment, indicating that screening and treatment can reduce the prevalence of amblyopia.

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screener	Results
L	Mark & Mark 1999[53]	Durham (North Carolina), US	Grade 1, 4 & 7 (US)	232 parents	Each year in Durham Public Schools, vision screening is performed on students in grade 1, 4, & 7. If child has an abnormal screening test, they are re-tested and a second abnormal screen results in a referral letter being sent to parents recommending evaluation by an eye professional.	Parents surveyed n=232	School nurse	Most parents (90%) recalled receiving a referral letter from the school nurse. 65% of parents who recalled receiving a referral had taken their child to eye professional. 80% of these needed glasses. Reasons for no appointment: 25% lack of time, 24% lack of financial resources, 51% something else (43% children had glasses but refused to wear them, 18% had taken their child to eye doctor in the past year and didn't want to take them again that year, 14% forgot, 25% illness & waiting for insurance.

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeners	Results
L	Scherrer & Stevens 1997[58]	New South Wales, Australia	10-11 years	191	The study applied the experimental questionnaire method of school screening (the parent and children questionnaires that inquire about various aspects of their own and their child's health) to school students and their parents and then re-tested this group with the traditional one on one screening method.	Students returned questionnaires n=191	School nurses	It was found that the questionnaire method exhibited a relatively low error rate when data from both parent and student were combined. Only two of 191 students would have been overlooked if the questionnaire was the only method used to screen. The authors concluded that, while identifying the problems that do exist with the questionnaire (literacy levels of the students and parents need to be high, students need to be compliant in caring for the parent questionnaire, students need to be truthful and not bias their responses), it was shown to be a relatively accurate model and that it can be employed efficiently to allow the school nurse to expand her role into other areas.
L	Yawn et al. 1998[51]	Rochester, Minnesota, US	Over 6 years	94	Community focus groups to identify barriers that may delay seeking professional care following school vision screening.	Focus group=94	Not stated	Major barriers to delay of seeking follow-up eye care include lack of community awareness about the frequency and potential effect of refractive errors in children, a parental perception of inadequate communication between the schools and parents and community, high cost of corrective lenses, limited availability of convenient eye care appointments, and adolescents' reluctance to wear glasses. Lack of emphasis on school-age children's

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
								vision by primary care physicians, the medical community, and the media appear to compound these barriers.
1 MONTH - 3 YEARS - screener characteristics								
L	Bolger et al. 1991[7]	Southmead and Weston-super-Mare, UK	6 weeks to 3.5 years.	10,082	Vision checked as part of developmental screening. Screening test: visual acuity in both eyes, ocular movements.	1. Orthoptist screening n=5,176 2. Other medical personnel n=2,530	Orthoptist or other medical personnel	Screened by orthoptist: yield 2.4%, positive predictive value 47.5%, false positive value 46.4%. Screened by other medical personnel: yield 0.6%, positive predictive value 14.4%, false positive value 82%. False-positive 17 cases per 1,000 for orthoptists, 31 cases per 1,000 for other medical personnel. The use of orthoptists as primary screeners improved detection rates of visual abnormalities and lowered the rate of false-positive referrals to secondary clinics.
L	Bray et al. 1996[66]	Newcastle and Northumberland, UK	3 years	5,364	Screening carried out at 35 months by orthoptist in local clinic. History Visual acuity Kay Picture test or Sheridan Gardiner Cover test and alternate cover test, A 20 dioptr prism test (for binocular function) Ocular movements Home visit by health visitor at 30-36 months. History Ability of child to pick up	1. Orthoptic screening n=1,582 2. Health visitor screening n=2,081 3. GP screening n=1,701	Orthoptist, health visitor, or GP	Orthoptic screening detected many more cases of amblyopia assoc. with microtropia and anisometropia, but the overall amblyopia prevalence at 7 years was similar in <i>each</i> cohort. Orthoptic screening has no influence on the age of detection of squints or strabismic amblyopia, but achieves a sig reduction in age at which straight-eyed amblyopes and refractive errors present. Despite this, the study was unable to demonstrate differences in amblyopia rates between cohorts, but sample sizes and low rates of ascertainment of amblyopia in comparison groups, do not allow

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
					thread. Screening carried out at 30 months by GPs, CMOs, or HVs in local clinics. History Any manifest squint noted			definitive conclusions.
L	Jarvis et al. 1990[67]	Newcastle and Northumberl and, UK	Younger cohort 5-9 months, Older cohort 30-36 months	6,526	Northumberland: Younger cohort at 7-9 months squint check. Older cohort at 30-36 months squint check (also 18 month check) (by health visitor or GP). Orthoptist: Younger cohort at 5 months: <ul style="list-style-type: none"> • History • Observation • Cover test • Ocular movements • 20 dioptre base out prism test • Convergence Older cohort at 35 months as at 5 months plus acuity test (Sheridan Gardiner letter matching or Kay Picture test). (community orthoptist). Comparison (Newcastle):	1. Orthoptist screen younger (9 months) n=1,050 2. Orthoptist screen older (35 months) n=1,026 3. Health visitor younger (9 and 30 months) n=1,321 4. Health visitor older (30 months) n=1259 5. N'land squint younger (7-9 months) n=903 6. N'land squint older (30-36 months) n=967	Orthoptist, health visitor or GP and health visitor	Screening at 35 months by an orthoptist was superior to health visitor surveillance at 30 months and to the program of screening squint at 30-36 months (sensitivity 100% vs 50% vs 50%, incidence of treated target conditions 17 vs 3 vs 5 per 1,000 person years). In the orthoptist group, 13 children received treatment for straight eyed visual acuity loss from among 1,000 children whereas there were no such cases among 2,500 in the comparison areas. In the younger cohorts (5-9 month screening) all 3 programs showed equally poor results, only one of the eight treated target conditions arising from all 3,500 younger children being screen detected. Specificity was high for all groups and cohorts.

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeners	Results
					Younger cohort at 9 months standard check, 'doubt about infant or personal/family history of squint'. Older cohort at 30 months standard check, pick up a thread (health visitor).			
3 - 6 YEARS - screener characteristics								
M	Concannon and Robinson 1997[57]	Sydney, Australia	4-6 years	1,345	Tested the feasibility of using a questionnaire for teachers in place of the traditional screen conducted by school nurses on students in their first year of school.	1. Screened group n=1,087 2. Control group n=258	Nurse	Using the orthoptist as the standard, the nursing screen showed excellent specificity and sensitivity (100%). Using the nurses' results as the standard, the questionnaire sensitivity was 13.9% and specificity 96.5%, indicating a high false negative rate, with 86% of the visually impaired being missed by the teacher's questionnaire.
L	Hartmann et al. 2006[71]	US	3-4 years	3 years 1,258 4 years 1,613	Two programs: 2 sites worked with primary care practices (testing performed by nursing staff) and 2 sites worked with community based programs (lay volunteers). Community based: <ul style="list-style-type: none"> • HOTV • LEA chart • HOTV cards with bars 	1. Community based (lay volunteers) 3 year olds n=DK 2. Community based (lay volunteers) 4 year olds n=DK 3. Primary care (staff) 3 year olds n=DK 4. Primary care (staff) 4 year olds	Nursing staff or lay volunteers	The rate of successful screening for 3 year olds was 80%, and 4 year olds 94%. Referral rates for the community based program were 31% for 3 year olds, and 28% for 4 year olds. Referral rates for the primary care program were 4% for 3 year olds, and 5% for 4 year olds. The overall follow-up rates were relatively low. 56% who were referred did not receive a follow-up exam, or the follow-up results were not communicated to the referral source. Initially, volunteers and staff

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
					<ul style="list-style-type: none"> • Random Dot E (3 year olds were required to pass a critical line 6/12 and 4 year olds 6/9). <p>Primary care: same as above plus</p> <ul style="list-style-type: none"> • Vision history • External inspection of eye • Ophthalmoscopic exam (Red reflex check) • Tests for ocular muscle motility and eye muscle imbalances (Corneal light reflex, Fixation/tracking, Unilateral cover test) 	n=DK		embraced the program and training. However, sustaining a high level commitment to consistent implementation of the protocol was difficult.
L	Paech and Calabretto 1999[69]	SA, Australia	5-6 years	28	<p>Children were screened individually by a RN (registered nurse) using OVSF (Oyarzum Vision Screening Kit), and re-screened a week later by the optometrist. OVSF contains a battery of 5 tests.</p> <ul style="list-style-type: none"> • Visual acuity was assessed by the Lea Symbols Chart • Hyperopia by the Wand 	Screening group n=28	Nurse	13 (46%) of the children failed one or more tests. The largest numbers of failures occurred in the tracking test. The RNs had good screening skills when compared with the optometrists with at least 86% agreement achieved for each test. The optometrist was faster than the RN.

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
					<ul style="list-style-type: none"> • Converge by the Prism • Tracking by the pencil topper • Binocularity with the Red Bear test. 			
L	Robinson et al. 1999[10]	Oxford County, Canada	4.4 years	1866	<p>Screening by public health nurse versus screening by eye care practitioner of parent's choice.</p> <ul style="list-style-type: none"> • Visual acuity • Ocular alignment • Stereoacuity 	<p>1. Screened as a 'fail' n=1,017</p> <p>2. Control group n=849</p>	Public health nurses	Vision screening of preschool children can be delivered effectively by public health nurses as part of the overall screening programs conducted in a health fair design. Sensitivity ranged from 60.4% to 70.9%, while specificity ranged from 69.6% to 79.9%. The positive predictive value was 21.6% to 32.3% and the negative predictive value was 92.6% to 95.3%
L	Spowart et al. 1998[72]	Glasgow, UK	Primary one students (no age specified)	766	Comparison of screening results between school nurses and orthoptists	Tested by nurses and orthoptists n=766	Nurses and orthoptists	Prevalence of decreased visual acuity for nurse screening was 8.6%, but only 4.2% for orthoptist testing. For nurses, positive predictive value was 40%, negative predictive value was 99%, sensitivity was 83%, and specificity was 95%. Orthoptists were more accurate visual screeners than others, but all children with significant visual defects were detected by the current screening system (by nurses). The authors concluded that nurses should continue to be the primary screener, despite the high false positive rate.

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
L	Thorburn and Roland 2000[27]	Warrington, North West England, UK	3-3.5 years	2,041	Health visitors carried out a test of visual acuity in all children aged 3-3.5 years as part of a routine child health surveillance review. Vision screening was undertaken using a Stycar single letter matching test at 3 m, testing each eye separately. Children were referred to the community orthoptic service. Vision screening was repeated as part of the school entry assessment at age 5. Visual acuity was tested using Keener mark 2 OAT at 6 m, each eye tested separately. Children were referred to the orthoptic service.	1. 3-3.5 year old referrals n=227 2. 5 year old referrals n=181	Health visitors	Of the 2041 children screened, 12% were referred. Amblyopia was found in 11 children, five children had squints without amblyopia, and 25 had significant refractive errors. Possible failure of early screening was found in only 2 children. A high proportion of children referred required ongoing orthoptic follow-up or treatment (63% true positive at orthoptist level, 28% at gold standard level).
L	Wormald 1991[68]	Cornwall, UK	1st cohort 4.3 years, 2nd cohort 4.4 years	598	<ul style="list-style-type: none"> • History • Distance vision Measured with Snellen at 6 m with card (Sheridan Gardiner at 6 m or Kay Picture test used if co-op was poor) • Head posture • Convergence to nose • Cover test, near and distance • Prism cover test 	1. 1980 cohort n=298 2. 1982 cohort n=300	Community orthoptists	Community orthoptists achieved a sensitivity of about 90% and specificity of 99%. Sensitivity: 87.2% (1980), 92.64% (1982). Specificity: 99.58% to 99.64%(1980), 99.64% to 99.69% (1982). Predictive positive value 93.46% (1980), 94.96% (1982), negative value 99.12% to 99.25% (1980), 99.46% to 99.54% (1982).

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
					<ul style="list-style-type: none"> • 20 dioptre base out (occasionally 10) • Ocular movements • 9 positions of gaze • Stereoscopic vision: Wirt fly test and pictures of animals 			
L	Yazawa et al. 1992[70]	Tokyo, Japan	3 years 1 month	21,906	Home vision test. The test kit contained a picture card, instructions and an answer sheet. Tissue paper and plastic tape were used to patch alternately the eye not being tested.	Screening group n=21,906	visual acuity (amblyopia)	96.4% of the children were able to complete the home test. Results disclosed below-normal acuity in 407 children (1.9%). 0.19% of amblyopia and 0.22% of strabismus were reported after referrals to hospitals or private practitioners. Over 96% of children could complete the test and 41 cases of previously undetected amblyopia were found.
1 MONTH - 3 YEARS - screening outcomes								
L	Atkinson et al. 2002[73]	Cambridge, UK	8.1 months	137	<p>Vision screening: non-cycloplegic videorefraction and orthoptic examination. Measures of cognitive, motor and language skills:</p> <ul style="list-style-type: none"> • Atkinson Battery of Child Development for Examining Functional Vision • Henderson Movement Assessment Battery for 	<p>1. Hyperopes n=71</p> <p>2. Control n=66</p>	Orthoptist	Children identified at infant screening with significant hyperopic refractive errors showed consistently poorer performance on a range of visuocognitive and visuomotor tests up to age 5 years, compared to control children without significant refractive errors.

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
					Children, <ul style="list-style-type: none"> • The Griffiths Child Development Scales, • MacArthur Communicative Development Inventory • British Picture Vocabulary Studies 			
L	Atkinson et al. 2005[74]	Cambridge, UK	8.1 months	453	Vision screening: non-cycloplegic videorefraction and orthoptic examination. Those meeting criteria for focussing error (misaccommodation on the target in one or both eyes), and/or failure on orthoptic exam were invited for a follow-up appointment one month later.	1. Hyperopic group 3.5 years n=110, 5.5 years n=99 2. Control group (visually normal) 3.5 years n=131, 5.5 years n=113	Orthoptist	Hyperopic group performed significantly worse than the control group at both ages. Overall and on at least one test from each category of motor skill (manual dexterity, balance and ball skills). Differences were due to widespread mild deficit in hyperopic group.
3 – 6 YEARS – screening outcomes								
L	Roch-Levecq et al. 2008[75]	San Diego, US	4.6 years	70	Cycloplegia was induced. After 30 minutes, children received retinoscopy and most had autorefraction and manifest refraction. Visual acuity was assessed before correction prior to cycloplegia and after correction under cycloplegia at near using the Allen Preschool	1. Uncorrected ametropia n=35 2. Emmetropia controls n=35	Optometrists	At baseline, uncorrected ametropes scored significantly lower on the Visual-Motor Integration test (VMI), which assesses visual perception and hand-eye co-ordination, and most of the WPPSI-R performance subsets requiring eye-hand coordination, compared to emmetropic controls. However, after six weeks of wearing glasses, the ametropic group significantly improved on the VMI compared to the control group. The

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screener	Results
					Vision Test and at far using B-VAT PC version 2.3.			ametropic group also improved on the WPPSI-R, but was not significant.
6+ YEARS - screening outcomes								
M	Goldstand et al. 2005[80]	Jerusalem, Israel	12 years, 7 months	71	<p>Comparing visual and visual-information processing skills between children with and without mild reading and academic problems and examining the incidence of visual deficits among them.</p> <p>Screening tests used:</p> <ul style="list-style-type: none"> • Altaire Reading Screening Test (quick screen for reading ability) • Tivka Reading Test (analyses basic phonological skills as well as comprehension and proficiency in silent reading and recitation in Hebrew language) • The Modified Clinical Technique • The Developmental Test of Visual-Motor Integration 	<p>1. Proficient readers n=46</p> <p>2. Nonproficient readers n=24</p>	Occupational therapists	Nonproficient readers had significantly poorer Visual Efficiency abilities than proficient readers did. However, there were no significant differences between these groups with respect to Visual Health.

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeners	Results
					<ul style="list-style-type: none"> • The Motor-Free Visual Perception Test • The Revised Conners • Parent and Teacher Rating Scale • Academic Performance Questionnaire 			
L	Johnson et al. 1996[79]	New York, US	8-18 years	81	<p>New York State Optometric Association Vision Screening Battery (NYOSA)</p> <ul style="list-style-type: none"> • Tracking • Fusion • Acuity-Distance • Stereopsis • Acuity-Near • Convergence • Hyperopia • Colour Vision • Visual Motor Integration 	<p>1. Academically and behaviourally at risk n=33</p> <p>2. Academically at risk only n=48</p>		85% (69) of all students failed one or more of the visual tests, with more children failing the tracking subset than any other subset 37% (30). A significant number of students failed visual acuity far and near, stereopsis, and visual motor integration. Students who were academically and behaviourally at risk were more likely to fail the tracking test than students who were academically but not behaviourally at risk (52% vs 27%). They were also more likely to fail visual acuity far and near, hyperopia, stereopsis, colour vision and visual motor integration. 97% of these students failed at least one subset.
M	Kulp and Schmidt 1996[81]	Cleveland, Ohio, US	Kindergarten 5.7 years, First grade 6.8 years	181	<ul style="list-style-type: none"> • Modified Clinical Technique (MCT) • ±2.00 D flipper lenses with red/green suppression check for accommodative facility • Randot for stereoacuity • Test of Visual Analysis 	Kindergartners n=90, 1st graders n=91	School nurse, optometrist, and an optometry student	Accommodative facility was predictive of successful reading performance in 7 year olds, first graders, and in the entire group when age or grade was controlled. The relationship between accommodative facility and reading performance became more significant as age and grade increased. Failure on the MCT was significantly

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
					Skills (TVAS) Short Form <ul style="list-style-type: none"> • Gardner Reversals • Frequency Test for visual perceptual skills • Retinoscopy (noncycloplegic) assessed refractive error • Near visual acuities assessed with Reduced Snellen or Allen figures • Distance visual acuities were assessed independently by school nurse. • Cover testing to assess phoria • Randot testing to measure stereoacuity 			associated with decreased reading skill in 5 year olds. Stereoacuity worse than 100 sec arc, MCT failure plus stereoacuity worse than 50 sec arc, and accommodative facility were predictive of reduced reading skill in children of average intelligence. The addition of stereoacuity to the MCT screening would make the results more useful to educators.
L	Krumholtz 2000[77]	New York (US)	5-12 years	1996-97: 1,365 1998-99: 1,463	Based on Modified Clinical Technique (MCT) and some tests used from New York State Optometric Association's (NYSOA) vision screening battery: <ul style="list-style-type: none"> • Distance and near visual acuity • Hyperopia assessment 	1. Screened 1996-97 n=1,365 2. Screened 1998-99 n=1,463	Second year optometric students, in conjunction with a faculty member of the State University of New York	Twenty nine percent of children screened in 1996-97 were referred. This matched the referral rate in 1998-99. Screening in 1998-99 yielded a higher referral rate (35%) in functional vision tests vs visual acuity screening procedures than the screening in 1996-97 (30%). King Devick test and hyperopia assessment showed significant correlation with citywide achievement test scores. Both tests were

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screener	Results
					<ul style="list-style-type: none"> • Cover test • Stereopsis • Fusion, accommodation and ocular motility measured with the NYOSA King Devick test, and near point of convergence (NPC) • (ophthalmoscopy and colour vision also performed, but not included in article) 		College of Optometry	significant for predicting those students in the lower 25% of the class for all grades in both years of screening. More than 70% of kids who were seen in 96-97 and received glasses, were still using their glasses.
M	Maples et al. 2003[78]	Oklahoma, US	6-7 years and 10-11 years	540	<ul style="list-style-type: none"> • Visual acuity far and near • Disease screening with binocular loupe, transilluminator, and direct ophthalmoscope • Cover test both far and near • Phoria both far and near with Howell card and binocular \pm D AC/A at near with near Howell Card • Near stereo with Wirt circles and autorefractor • Near point of accommodation blur out and recovery with the 	Vision tested n=540		VMI and Wold were the most robust predictors of academic success. Other tests were also significant predictors of academic performance: visual acuity, visual-auditory processing, ocular motor, binocular skills, accommodative skills, and refractive status. Visual motor, ocular motor, binocular, accommodative, and visual perception skills were significant factors in children who scored poorly on the Iowa Test of Basic Skills educational test (ITBS).

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screener	Results
					dominant eye <ul style="list-style-type: none"> • Accommodative rock \pm D Flippers, monocularly and binocularly with polaroid suppression check for binocular testing <ul style="list-style-type: none"> • Nearpoint of convergence break and recover • Nott retinoscopy • Prism bar ranges base in/base out at near • Prism flippers 8 base out/8 base in at near • Maples Ocular Motor Test • Developmental Eye Movement Test (DEM) • Motor Free Visual Perception Test (MVPT) • Wold Sentence Copy Test • Visual Motor Integration Test (Beery) 			
L	Stifter et al. 2005[82]	Austria	11.6 years	40	<ul style="list-style-type: none"> • Cover–uncover test and alternate cover tests • Dynamic retinoscopy • Convergence • Motility • Ophthalmoscopy • Worth Four dot Test 	1. Unilateral amblyopia n=20 2. Normal sighted controls n=20	Not stated	In regards to the binocular maximum reading speed (MRS), there were significant differences between children with amblyopia and the normal sighted children. The controls achieved a binocular MRS of 200.4 (11) wpm (words per minute), while

Quality L, M, H	Study Author/date	Study location	Age/Age range	Sample size	Description of study	Intervention groups (n=)	Screeener	Results
					<ul style="list-style-type: none"> • Titmus Stereo test 			the children with amblyopia achieved only a binocular MRS of 172.9 (43.9) wpm. No significant differences were found between the two groups with respect to binocular logMAR visual acuity and reading acuity.
L	Williams et al. 2005[76]	Rhondda Cynon Taff, UK	8 years	1,298	<p>Community paediatric service in Rhondda Cynon Taff provides a conventional vision screening program:</p> <ul style="list-style-type: none"> • Distance acuity at 7-8 years (Snellen 6 m), referral: vision 6/9 or worse in either eye to orthoptist (under 8 years) or optometrist (over 8 years). • Colour vision screening on boys at 11-12 years offered on a demand basis. • Preschool program: selective vision screening of high risk population (squint, defective visual acuity, relevant family history) by orthoptist. • For this study, fogging test for hyperopia was used. 	Fail Fogging test n=166	School nurses	166 fogging test failures were referred for ophthalmic assessment. Ophthalmic tests on 105 children provided accurate diagnosis of vision defects, for reference to their education scores. 50% of children examined by optometrists required an intervention (prescription change, glasses, referral). Mean NFER score (education score) for children with refractive errors were lower than the respective scores of children with a less positive refractive state, the non-referred group, and the total sample. SATs followed a similar trend. A high proportion of fogging test failures (16%) and confirmed hyperopes (29%) had been referred to an educational psychologist, and the latter group contributed substantially to the poor education scores.

Table 3: Systematic Reviews

Quality L, M, H	Study Author/date	Findings/ Recommendations	Clearly defined research question and inclusion criteria (A,B,C)	Comprehensive search (A,B,C)	Critical appraisal of the validity of studies reviewed (A,B,C)	Consistency of results (A,B,C)
M	Castanes (2003) [63]	The objective of the review was to determine the social, economic, and political barriers which contributed to the underutilisation of vision screening among preschool age children. It was found that a variety of barriers existed which prevented children from receiving proper vision screening. Social barriers included ignorance, inconvenience, language, and lack of providers. Financial barriers affected low income families. Political barriers resided in the disproportionately small funding of preventative medicine. Low income, minority, and uninsured families were at high risk of not utilising vision screening.	B	A	B	B
L	Lennerstr and et al. (1995) [62]	The aim of the review was to perform a systematic analysis of the screening programs for detection of visual dysfunction. The performance characteristics of the screening programs used in Sweden and Canada were evaluated and found to be very favourable. Based on analysis and the evaluation, the following recommendations were made: 1) Inspection of eyes in the neonatal period and examination of the red reflex with the ophthalmoscope should occur. 2) Children at high risk for ocular and visual disorder (i.e., born before 32 weeks of age, or with genetic disease, hearing deficit and/or neurological and mental disorder), should be examined by an ophthalmologist. 3) Staff at paediatric departments and child health care centres should be familiar with the visual development of the normal baby and should be alerted to symptoms and signs of visual defects. 4) Paediatric exams should include detection of squint. 5) A screening test of monocular visual acuity in 4 year old children could be reliably performed by non-ophthalmic personnel after proper training. The screening test should be repeated by school nurses during first grade of school, and at regular intervals during the school years. 6) Children who screen positively should be seen by ophthalmologists, and in some cases orthoptists, without delay. 7) There was a need for a better preschool acuity test that could be used at age 2.5-3 years. 8) Colour vision screening was recommended and should be carried out between 9 and 13 years of age.	B	C	C	B
M	Pattison and Plymat (2001) [64]	The purpose of the literature review was to summarise the literature on vision screening in preschools and schools. It was found that parent and teacher referral methods of screening were less than satisfactory, and professional screening of all children at school age should be continued. This should be carried out by nurses if they are adequately trained by orthoptists.	B	A	C	B

Quality L, M, H	Study Author/date	Findings/ Recommendations	Clearly defined research question and inclusion criteria (A,B,C)	Comprehensive search (A,B,C)	Critical appraisal of the validity of studies reviewed (A,B,C)	Consistency of results (A,B,C)
M	Powell et al. (2004) [46]	The objective of the review was to evaluate the effectiveness of vision screening programs in schools in reducing the prevalence of undetected, correctable visual acuity deficits due to refractive error in school-age children. The authors did not find any randomised controlled trials that met their inclusion criteria. It was concluded that there were no robust trials available that allowed the effects of vision screening to be measured. The absence of evidence of effectiveness did not imply that screening was not valuable, simply that any value had yet to be properly identified. The possibility of doing harm should also be considered. The authors stated that there was a real need for robust randomised control trials to be implemented to measure the effectiveness of vision screening.	A	B	N/A	N/A
M	Powell et al. (2005)[47]	The aim of the review was to evaluate the effectiveness of vision screening in reducing the prevalence of amblyopia in screened versus unscreened children before or as they entered school. No randomised controlled trials were located that fitted the criteria. The authors concluded that the absence of such evidence could not be taken to imply that vision screening was not necessary; simply that screening had yet to be tested in rigorous trials. The optimum protocol for carrying out screening remained unclear. There appeared to be no detrimental effect in terms of visual outcome on leaving screening until school entry and this appeared to improve the coverage achieved.	A	B	N/A	N/A
L	Resnikoff et al. (2008)[49]	A review of the literature was conducted on the global magnitude of visual impairment caused by uncorrected refractive errors in 2004 for people aged 5 years and over. The authors concluded that: 1) Screening of children for refractive errors should be conducted at a community level and integrated into school health programs, accompanied by education and awareness campaigns to ensure that the corrections were used and cultural barriers to compliance were addressed and removed. 2) Cost of refractive corrections was still high compared to personal and family resources in many regions, thus corrections should be made accessible and affordable for all ages. 3) Eye-care personnel should be trained in refraction techniques. Teachers and school health-care workers should also receive training and information programs. 4) Reliable and affordable equipment for refractive assessments should be developed. 5) Refraction services should be integrated with eye-care systems and included as part of cataract surgery services. 6) Impairment and outcomes should be monitored at national levels to identify communities in need and to evaluate the most cost-effective interventions. 7) The unmet need of correction of presbyopia should also be addressed.	A	A	C	B

Quality L, M, H	Study Author/date	Findings/ Recommendations	Clearly defined research question and inclusion criteria (A,B,C)	Comprehensive search (A,B,C)	Critical appraisal of the validity of studies reviewed (A,B,C)	Consistency of results (A,B,C)
H	Snowdon and Stewart- Brown (1997)[65]	The objective of the review was to evaluate the effectiveness of preschool vision screening. One prospective controlled trial and 16 retrospective studies (observational studies and audits) of different screening programs were found. It was reported that orthoptic screening programs performed better than health visitor or GP screening in terms of program yield and positive predictive value. The mean uptake rate was 64.8%. The mean referral rate was 6.7% for primary orthoptic screening programs and 3.9% for screening by health visitor or GP. The positive predictive value ranged from 47.5% to 95.9% for orthoptic screening and from 14.4% to 61.5% for screening by health visitor or GP.	A	A	A	A
L	Weinstock et al. (1998)[48]	The aim of the review was to examine the clinical classification of strabismus, to describe the timing and method of strabismus screening examinations, and to discuss principles of treatment. The main findings were that primary care physicians should screen all low-risk children. High risk children (low birth weight, family history of strabismus, congenital ocular abnormality, or systemic conditions with vision threatening ocular manifestations) should be referred to an ophthalmologist for screening. Screening should be performed in the neonatal period, at 6 months, and at 3 years (Grade A recommendation), as well as at 5 to 6 years (Grade B recommendation). Screening exams should include inspection, examining visual acuity, determining pupillary reactions, checking ocular alignment, testing eye movements, and ophthalmoscopy.	B	C	C	B

Table 4: Prevalence studies (Australia)

Study Author/date	Age	Sample size	Amblyopia	Diminished visual acuity	Strabismus	Hyperopia	Myopia	Astigmatism
Robaei et al. (2005)[25] Sydney Myopia Study	6 years Uncorrected visual acuity	1,738	-	Uncorrected: 71 (4.1%) Presenting: 54 (2.8%), worse eye	-	Significant: 43 (2.5%) Mild: 125 (7.3%)	24 1.4%	-
Robaei et al. (2006a)[6] Sydney Myopia Study	6 years	1,739	13 (0.7%) 32 (1.8%), including those successfully treated	-	-	-	-	-
Ip et al. (2006)[5] Sydney Myopia Study	6 years With eyestrain symptoms	220	8 (3.6%)	-	16 (7.3%)	16 (7.3%)	5 (2.3%)	18 (8.2%)
	Without eyestrain symptoms	1,242	17 (1.4%)	-	22 (1.8%)	34 (2.8%)	17 (1.4%)	84 (6.8%)
Robaei et al. (2006b)[35] Sydney Myopia Study	12 years	2,353	-	10.4% Uncorrected (at least 1 eye)	-	116 (5.0%) (overall)	300 (12.8%) (overall)	220 (9.4%) (overall)
Robaei et al. (2006c)[119] Sydney Myopia Study	12 years	2,353	-	Uncorrected: 268 (11.4%) Presenting: 117 (5.0%), worse eye		Uncorrected: 19 0.8% Presenting: 11 0.5%	Uncorrected: 208 8.8% Presenting: 67 2.8%	Uncorrected: 81 3.4% Presenting: 32 1.4%

Study Author/date	Age	Sample size	Amblyopia	Diminished visual acuity	Strabismus	Hyperopia	Myopia	Astigmatism
Robaei at al. (2008)[14] Sydney Myopia Study	12 years	2,353	44 (1.9%)	-	-	-	-	-
Ip et al. (2007)[26] Sydney Myopia Study	6 years	1,724	-	Unilateral uncorrected: 71 (4.1%)	-	Moderate: 227 13.2%	-	-
	12 years	2,340	-	Unilateral uncorrected: 268 (11.4%)	-	Moderate: 116 (5.0%)	-	-
Junghans et al. 2002[16] NSW & VIC	3 - 12 years	2,697	-	-	8 (0.3%)	-	-	2%
Junghans and Crewther (2003)[23] visiting the Vision Education Centre at the University of NSW 1990-94	4 years	2,535 4 -12 yrs	-	-	-	-	1%	-
	12 years	-	-	-	-	-	8.3%	-
	4-12 years	-	-	-	-	-	6.5%	-

Study Author/date	Age	Sample size	Amblyopia	Visual acuity	Strabismus	Hyperopia	Myopia	Astigmatism
Junghans and Crewther (2005)[24] visiting the Vision Education Centre at the University of NSW 1998-2004	4 years	-	-	-	-	-	2.3%	-
	12 years	-	-	-	-	-	14.7%	-
	4-12 years	-	-	-	-	-	8.4%	-
Mackinnon et al. (2004)[4] South-eastern Australia between 1980-2000 The incidence of infantile glaucoma was estimated to be 1 in 30,000 births.								

Table 5: Prevalence studies (international)

Study Author/date	Age	Sample size	Abnormal find	Amblyopia	Diminished visual acuity	Strabismus	Hyperopia	Myopia	Astigmatism	Cataract	Refractive error	Anisometropia	Squint
Anker et al. (2003)[17] Cambridge, UK	8.1 months	5,142	-	-	-	29 0.6%	-	-	-	-	-	108 2.1%	-
Juttman (2001)[18] Rotterdam, Holland	9 months - 2 years	4,072	160 4.0%	-	-	33 0.8%	-	-	-	-	20 0.5%	-	-
Bolger et al. (1991)[7] UK	6 weeks - 3.5 years	Southmead 7,105	-	81 1.1%	-	-	-	-	-	-	-	-	75 1.1%
		Weston-super-Mare 2,977	-	14 0.5%	-	-	-	-	-	-	-	-	8 0.3%
Arnold and Donahue (2006)[20] US	Alaska, US 1-5 years	14,000	-	-	-	58 7.1%	High: 266 32.8%	45 5.5%	148 18.3%	6 0.7%	-	232 28.6%	-
	Tennessee, US 1-6 years	100,827	-	-	-	524 15.4%	High: 554 16.3%	67 2.0%	1015 29.8%	5 0.2%	-	1164 34.2%	-
Donahue et al. (2000)[19] Tennessee, US	6 months - 3.9 years	15,059	-	-	-	31 0.2%	High: 48 0.3%	High: 4 0.03%	48 0.3%	-	-	80 0.5%	-

Study Author/date	Age	Sample size	Abnormal find	Amblyopia	Diminished visual acuity	Strabismus	Hyperopia	Myopia	Astigmatism	Cataract	Refractive error	Anisometropia	Squint
Lim et al. (2000)[9] Bedok, Bukit Batok & Geylang, Singapore	4--4.5 years	450	-	8 1.8%	-	-	-	-	-	-	63 14.0%	-	-
Vision in Preschoolers Study Group (2005)[12] US	3-5 years	1,452	-	77 5.3%	-	31 2.1%	109 9.7%	19 1.3%	195 13.6%	-	74 5.1%	-	-
Newman and East (1999)[8] Cambridge, UK	3.5-5.5 years	597	-	15 2.5%	-	6 1.0%	-	-	-	-	10 1.7%	-	-
Vision in Preschoolers Study Group (2007)[120] US	3-5 years	4,040	-	-	-	157 3.9%	-	-	-	-	-	-	-
Thorburn and Roland (2000)[27] UK	3-3.5 years	2,041	-	-	-	-	-	-	-	-	25 1.2%	-	-
	5 years	2,423	-	-	-	-	-	-	-	-	51 2.1%	-	-

Study Author/date	Age	Sample size	Abnormal find	Amblyopia	Diminished visual acuity	Strabismus	Hyperopia	Myopia	Astigmatism	Cataract	Refractive error	Anisometropia	Squint
Drover et al. (2008)[11] Newfoundland, Canada	4.2 years	946	-	4.7%	-	4.3%	4.8%	1.1%	3.1%	-	-	1.4%	-
Preslan and Novak (1996)[13] Baltimore, US	4-8 years	680	68 10%	27 3.9%	-	21 3.1%	-	21 3.1%	17 2.5%	-	-	18 2.6%	-
Robinson et al. (1999)[10] Ontario, Canada	4.4 years	Year 1 1,174	-	12 1.0%	-	14 1.2%	-	-	-	-	124 10.6%	-	-
		Year 2 1,110	-	10 1.0%	-	15 1.4%	-	-	-	-	132 11.9%	-	-
		Year 3 1,150	-	14 1.2%	-	12 1.0%	-	-	-	-	128 11.1%	-	-
Yawn et al. (1996)[121] Rochester, Minnesota, US	5 years	2,601	1.2%	-	-	-	-	-	-	-	-	-	-
	13 years	1,829	9.1%	-	-	-	-	-	-	-	-	-	-
Donnelly et al. (2005)[22] Northern Ireland	8-9 years	1,582	198 12.5%	-	-	63 4.0%	54 3.4%	22 1.4%	53 3.4%	-	-	-	-

Study Author/date	Age	Sample size	Abnormal find	Amblyopia	Diminished visual acuity	Strabismus	Hyperopia	Myopia	Astigmatism	Cataract	Refractive error	Anisometropia	Squint
Cummings (1996)[15] Cambridge, UK	8 & 10 years	1,809	-	Mild: 15 0.8% Marked: 11 0.6%	-	-	-	148 8.2%	-	-	-	-	-
Jewell et al. (1994)[45] Oxfordshire, UK	13 years	371	-	-	VA worse than 6/12: 1 or both eyes: 2.7%	-	-	-	-	-	-	-	-
	14 years	377	-	-	VA worse than 6/12: 1 or both eyes: 3.7%	-	-	-	-	-	-	-	-
	15 years	321	-	-	VA worse than 6/12: 1 or both eyes: 5.3%	-	-	-	-	-	-	-	-
Bailey (1998)[28] Texas, US	5-7 years	Total: 391	-	-	9 2.3%	-	-	-	-	-	24 6.1%	-	-
	8-10 years	-	-	-	12 3.1%	-	-	-	-	-	21 5.4%	-	-
	11-13 years	-	-	-	15 3.8%	-	-	-	-	-	29 7.4%	-	-
Blum et al. (1959)[29] (study in 1993)	6 years	-	-	-	-	-	-	4%	-	-	-	-	-

Study Author/date	Age	Sample size	Abnormal find	Amblyopia	Diminished visual acuity	Strabismus	Hyperopia	Myopia	Astigmatism	Cataract	Refractive error	Anisometropia	Squint
California, US	12 years	-	-	-	-	-	-	20%	-	-	-	-	-
Zhang et al. (2000)[30]; Chung et al. (1996)[31]; Lam and Goh (1991)[32]; Fan et al. (2004)[33]; Yap et al. (1998) China & Hong Kong	5-7 years	DK	-	-	-	-	-	Rural China: 5% Chinese Malays: 24% Urban Hong Kong: 30%	-	-	-	-	-
	11-12 years	DK	-	-	-	-	-	Rural China: 23% Urban China: 40% Chinese Malays: 47% Urban Hong Kong: 57%	-	-	-	-	-
Ganz et al. 2006[122] US	Under 18 years	46,042	6.8%	-	-	-	-	-	-	-	-	-	-
Reskinoff et al. (2008)[49] 5 - 15 years: visual impairment global prevalence 1.0%													

Appendix F AGREE Instrument for appraising guidelines for research and evaluation

	Strongly Agree 4	Agree 3	Disagree 2	Strongly Disagree 1
Scope and Purpose				
The overall objective(s) of the guideline is (are) specifically described				
The clinical question(s) covered by the guideline is (are) specifically described				
The patients to whom the guideline is meant to apply are specifically described				
Stakeholder involvement				
The guideline development group includes individuals from all the relevant professional groups				
The patients' views and preferences have been sought				
The target users of the guideline are clearly defined				
The guideline has been piloted among target users				
Rigour of development				
Systematic methods were used to search for evidence				
The criteria for selecting the evidence are clearly described				
The methods used for formulating the recommendations are clearly described				
The health benefits, side effects and risks have been considered in formulating the recommendations				
There is an explicit link between the recommendations and the supporting evidence				
The guideline has been externally reviewed by experts prior to its publication				
Clarity and presentation				
The recommendations are specific and unambiguous				
The different options for management of the condition are clearly presented				
Key recommendations are clearly identifiable				
The guideline is supported with tools for application				
Applicability				
The potential organisational barriers in applying the recommendations have been discussed				
The potential cost implications of applying the recommendations have been considered				
The guideline presents key review criteria for monitoring and/or audit purposes				
Editorial independence				
The guideline is editorially independent from the funding body				
Conflicts of interest of guideline development members have been recorded				

Source: The Appraisal of Guidelines for Research and Evaluation (AGREE) Collaboration 2001.

Appendix G Australian and international guidelines and policy statements on children's vision screening

Author/Organisation (Year)	Name	Appraisal score	Recommendations
American Academy of Ophthalmology (2002)[123]	Pediatric eye evaluations	RD*: 95 SI#: 58	0-3 months: red reflex, inspection. 3-6 months: fix and follow, red reflex, inspection. 6-12 months: fix and follow, red reflex, inspection, alternate occlusion, corneal light reflex. 3 years: visual acuity (monocular), corneal light reflex, cover/uncover, red reflex, inspection. Repeat these tests at 5 years of age and every 1 to 2 years after age 5. If abnormalities detected, perform comprehensive medical eye examination.
American Academy of Pediatrics (2002)[124]	Red reflex examinations in infants	RD: 29 SI: 17	0-2 months: red reflex (pediatrician or trained primary care clinician). Abnormal result followed up by: (a) red reflex preceded by pupil dilation with eye-drop or spray or (b) examination by ophthalmologist, including ocular fundus examination using indirect ophthalmoscopy after pupil dilation.
American Academy of Pediatrics (2003)[125]	Eye examination in infants, children and young adults by paediatricians	RD: 57 SI: 58	0-3 years: ocular history, vision assessment, external inspection of the eyes/lids, ocular motility assessment (corneal reflex test, cross cover test, random dot E test), pupil examination, and red reflex examination. 3-5 years: visual acuity (Snellen letters, Snellen numbers, Tumbling E, HOTV, picture tests – Allen figures, Lea symbols, ocular alignment (cross cover test, Random dot E test, simultaneous red reflex test/Bruckner test), ocular media clarity (red reflex). 6+ years: as per 3-5 years. Visual acuity testing recommended from age 3. Uncooperative children aged 4 years and older to be retested 1 month later. Referral of uncooperative children or abnormal results to paediatric ophthalmologist or eye care specialist.
American Optometric Association (2002)[126]	Paediatric eye and vision examination	RD: 38 SI: 33	0-2 years 11 months: patient history, visual acuity (fixation preference tests, preferential looking visual acuity test), refraction (cycloplegic retinoscopy, near retinoscopy), binocular vision and ocular motility (cover test, Hirschberg test, Krinsky test, Bruckner test, versions, near point of convergence). Preschool aged: as above, except visual acuity with Lea symbols, broken wheel acuity cards, HOTV test, refraction with static retinoscopy, cycloplegic retinoscopy, accommodation and ocular motility with cover test, positive and negative fusional vergences, near point of convergence, stereopsis, monocular estimation method retinoscopy, versions. School aged: as Preschool aged, except visual acuity with Snellen, modified for children 6-8 years, subjective refraction, ocular motility as Preschool aged but also with accommodative amplitude and facility.
American Public	Improving early	Not	Encourages comprehensive eye examinations at 6 months, 2 years and 4 years (as

Author/Organisation (Year)	Name	Appraisal score	Recommendations
Health Association (2001)[127]	childhood eyecare	reviewed as a guideline (policy statement)	opposed to just screening) based on the onset of strabismus and amblyopia. Encourages paediatricians to recommend all children receive exams which have the ability to detect all cases of strabismus, amblyopia, and refractive errors, and refer children at high-risk.
Colorado Department of Education (2006)[2]	Guidelines for school vision screening programs: Kindergarten through to Grade 12	RD: 29 SI: 25	K: history and observation, distance visual acuity and alternate cover test. Grade 1: as above, plus lens, near vision card, near point convergence, stereo/depth and colour vision. Grades 2, 3, 5, 7, 9 and Special Education: medical history, observation and distance visual acuity test. New or referred students: full array of tests.
Community Paediatrics Committee (1998)[128]	Vision screening in infants, children and youth	RD: 29 SI: 16	0-3 months: examination of external eye structure, red reflex, corneal light reflex, tests for signs of posterior eye disease. 6-12 months: as above, plus ocular alignment, fixation and following. 3-5 years: as above, plus visual acuity with optotype test (E acuity card or Allen chart) Referral criteria = less than 6/9. Visual acuity assessed every 2 years until age 10, then every 3 years (Snellen chart).
Friedman and Kaufman(2003)[129]	Guidelines for paediatrician referrals to the ophthalmologist	RD: 38 SI: 25	Refer to ophthalmologist: (1) children with no eye complaints, no eye findings, no significant family ocular history, no systemic risk factors for eye diseases, but are aged 4 years. (2) children with no eye complaints, no eye findings, but a positive family history of hereditary eye disease. (3) children with no eye complaints, no eye findings, but positive for a systemic disease (either confirmed or ruled out) with possible ocular involvement. (4) children with positive ocular complaints and no eye findings. (5) children with positive eye findings or failed vision or eye screening.
Hartmann et al. (2001)[130]	Maternal and child health bureau and national eye institute task force on vision screening in the preschool child. Preschool vision screening: summary of a task force report	Not reviewed (interim guidelines only)	3-4 years: monocular visual acuity (HOTV, Lea symbols, tumbling E charts or isolated optotypes with surround bars). Stereopsis testing for detection of strabismus (Random Dot E test).
Missouri Department of Health and Senior Services (2004)[131]	Guidelines for vision screening	RD: 43 SI: 25	0-2 years: functional assessments at any visit. 3 years: visual acuity, then yearly through age 7, then at least every 2 years. Priority screening: new, referred, special education and high-risk students. Grades 3, 5, 7, 9 and 11: screen as resources permit.

Author/Organisation (Year)	Name	Appraisal score	Recommendations
Ressel (2003)[132]	Practice guidelines; AAP releases policy statement on eye examinations	RD: 29 SI: 25	0-3 years: fix and follow (binocularly and monocularly), ocular history, family history, corneal reflex test, cross cover test, random dot E test. 3 years: visual acuity. Uncooperative children tested in another 4-6 months, unless aged 4 years or older, in which case retested after 1 month.
Royal Australian and New Zealand College of Ophthalmology (RANZCO) (2006)[133]	Position statement – eye examinations	Not reviewed (position statement, not guideline)	Children: all newborn's eyes examined by skilled professional. All children screened by age 5 years, or earlier if family history or outward signs Puberty to age 39: eye examination if experience any ocular symptoms, such as visual changes, flashes of light, pain and so on.
Royal Australian and New Zealand College of Ophthalmology (RANZCO) and Orthoptic Association of Australia (OAA) (Year: Not stated)[134]	Guidelines for Paediatric Vision Screening	RD: 71 SI: 50	Newborn and 6 weeks: eye health check, red reflex using ophthalmoscope by paediatrician or trained medical officer, referral if problems suspected or high-risk infant. 0-3 years: at-risk children only, screening by orthoptist if family history, developmentally delayed, turned eye, frequently closing one eye, excessive squinting or clumsiness. School entry: visual acuity at 6 m by nurse with Sheridan Gardiner linear vision chart. Referral if less than 6/9 to orthoptist.
US Preventative Services Task Force (2005)[95]	Screening for visual impairment in children younger than five years	RD: 71 SI: 17	The USPSTF found no direct evidence that screening improves visual acuity in preschool children. However, it found fair evidence that screening tests have 'reasonable accuracy' in identifying strabismus, amblyopia, and refractive error. Also, more intensive screening compared to usual screening leads to improved visual acuity, and early detection and treatment of amblyopia and amblyogenic risk factors can improve visual acuity. The USPSTF found no evidence of harms of screening, and judged the potential for harms to be small. These recommendations are 'B level' which indicates that fair evidence was found that the outcomes of preschool vision screening can outweigh the harms, and this service should be provided

* RD = Rigour of Development

#SI = Stakeholder Involvement

Appendix H Australian eye health practitioner workforce

Profession	Total workforce	Registered	Can test vision	Can prescribe glasses	Can prescribe contact lenses	Services can be provided under Medicare	Referral required?
Ophthalmologist[135]	10221	Yes	Yes	Yes	Yes	Yes	Yes
Optometrist[136]	39502	Yes	Yes	Yes	Yes	Yes	No
Orthoptist*[137]	2813	Not mandatory	Yes	With current referral/under supervision: varies between States	No	No	Provide secondary or tertiary care

*This figure represents the number of orthoptists registered with the Australian Orthoptic Board. It may not be representative of the number of orthoptists currently practising.

Appendix I Economic evaluation assessment form

	Yes	Can't tell	No
Was a well-defined question posed in answerable form?			
Did the study examine both costs and effects of the service or program?			
Did the study involve comparisons of alternatives?			
Was the viewpoint of the analysis stated, and was the study placed in any decision-making context?			
Was a comprehensive description of the competing alternatives given: who did what to whom, where and how often?			
Were any important alternatives omitted?			
Was (should) a 'do nothing' alternative (be) considered?			
Was there any evidence that the programs' clinical effectiveness had been established?			
Was this done through a randomised controlled trial? If not, how strong was the evidence of effectiveness?			
Were all the important and relevant costs and effects for each alternative identified?			
Was the range of costs and effects wide enough for the research question at hand?			
Did it cover all relevant viewpoints (e.g. patients, health service, society)?			
Were capital as well as operating costs included?			
Were costs and effects measured accurately in appropriate physical units (e.g. hours of nursing time, life-years gained)?			
Were any identified items omitted from measurement? If so, did this affect the subsequent analysis?			
Were there any special circumstances (e.g. shared use of resources) that made measurement difficult? If so, were these handled appropriately?			
Were costs and consequences valued credibly?			
Were sources of values identified (e.g. market prices, patients' valuations...)?			
Were market values used for changes involving resources gained or depleted?			
Where market values were absent (e.g. volunteer labour), were adjustments made to approximate market values?			
Was the valuation of consequences appropriate for the research question (i.e. was the appropriate analysis used – cost-effectiveness, cost-benefit, etc)?			
Was an incremental analysis of costs and consequences of alternatives performed?			
Were the additional incremental costs generated by one alternative over another compared to the additional effects, benefits or utilities generated?			
Were costs and consequences adjusted for differential timing?			
Were costs and effects occurring in the future adjusted (i.e. 'discounted')?			
Was there any justification for the discount rate used?			
Were a range of discount rates used, including no zero?			

Was a sensitivity analysis performed?			
Was there any justification for the range of values for key study parameters used in the sensitivity analysis?			
Were study results sensitive to changes in values within the assumed range?			
Did the presentation and discussion of study results include all issues of concern to users?			
Were the conclusions of the analysis based on some overall index or ratio of costs to effects (e.g. cost-effectiveness ratio)? If so, was the index interpreted intelligently or mechanistically?			
Were the results compared with those of others who have investigated the same question?			
Did the study discuss the generalisability of the results?			
Did the study discuss or take account of other important factors in the decision under consideration (e.g. ethical or equity issues)?			
Did the study discuss issues of implementation, such as the feasibility of adopting the 'preferred' solution in practice?			

Source: Adaptation of a checklist produced by Drummond, M., Stoddart, G., Torrance, G. in *Methods for the Economic Evaluation of Health Care Programmes*. Oxford: Oxford University Press, 1987. Adapted by Appelby, J. (1997). Critically appraising economic evaluations. *Evidence-Based Health Policy and Management*, 1 (3), 54-55.

Glossary

Vision terms

Accommodation: The adjustment of the focus of the eye for varying distances to allow a sharp image to be formed on the retina. This occurs by altering the shape of the lens.

Amblyopia: Reduced visual acuity in the absence of organic disease, which cannot be improved by spectacles.

Ametropia: A condition such as hypermetropia, myopia or astigmatism in which a refractive error prevents the eye from focusing light on the retina.

Anisometropia: A difference in refractive error of the two eyes. In a clinical context, anisometropia is used to describe a clinically significant refractive error between the eyes.

Aqueous humour: The transparent fluid that circulates in the eye chamber between the back of the cornea and the front of the iris and pupil.

Astigmatism: Refractive error which prevents light rays from coming to a single focus on or near the retina.

Binocular: Involving or using both eyes, or relating to vision using both eyes.

Binocular single vision: The simultaneous use of both eyes so that each eye contributes to a common singular perception.

Cataract: An eye disease in which part or all of the lens becomes 'opaque', eventually causing total loss of sight.

Congenital: Describes an unusual condition present at birth.

Conjunctivitis: Inflammation of the conjunctiva (membrane covering the internal eyelid and visible white part of the eye) caused by infection, injury, or allergy.

Cortical blindness: The total or partial loss of vision in a normal-appearing eye caused by damage to the visual area in the brain's occipital cortex.

Cover-uncover test: A test used to detect squint. Each eye is covered in turn while the child is asked to fixate on a target, and the tester observes the movements of the eye.

Cycloplegic drugs: Drugs that block action of the ciliary muscle, preventing accommodation. The pupil also dilates.

Dioptre (D): Unit of measurement of the power of a lens.

Diplopia: Double vision or seeing two images of the one object simultaneously.

Emmetropia: Light rays are brought to a focus on the retina without using accommodation.

Glaucoma: An eye disorder that may be associated with high pressure within the eyeball that leads to damage of the optic disc.

Goniotomy: An operation to treat glaucoma by cutting into the narrow angle between the back of the cornea and the root of the iris to allow drainage of aqueous humour.

Heterotropia: An alignment of the eyes that differs from the usual.

Hypermetropia (long sightedness): Refractive error when the focal point of light rays is behind the retina when the eye is not accommodating.

Hyperopia: Long-sightedness, as above.

Intermittent squint: Manifest squints apparent at some times or distances but the visual axes are aligned at others.

Latent squint (heterophoria): With both eyes open the visual axes are aligned. When one eye is covered, the undercover eye deviates. When the cover is removed, the eye comes back into alignment.

LogMAR scale: Scale used to measure visual acuity. Refers to the log of the minimum angle of resolution.

Manifest squint (heterotropia): With both eyes open the visual axis of one eye is deviated from the fixation point. It may be constant or intermittent.

Microsquint (microtropia): A small angle heterotropia usually of 10 prism dioptres or less, associated with amblyopia, eccentric fixation, or anomalous retinal correspondence.

Microtropia: see *Microsquint*

Myopia (short sightedness): Refractive error where light rays come to focus in front of the retina.

Nystagmus: An involuntary rhythmic movement of the eyes, usually from side to side, caused by some illnesses that affect the nerves and muscles behind the eyeball.

Occlusion: Obscuring the vision of one eye, totally or partially, to prevent or reduce visual stimulation.

Ophthalmologist: A medical doctor who is educated, trained and registered to provide total care of the eyes, from performing comprehensive eye examinations to prescribing corrective lenses, diagnosing diseases and disorders of the eye, and carrying out the medical and surgical procedures necessary for their treatment.

Optic Nerve Hypoplasia: The failure of the optic nerve to grow or develop fully.

Optometrist: Primary eye care practitioner trained to assess the eye and the visual system, and diagnose refractive disorders and eye disease. An optometrist prescribes and dispenses corrective and preventative devices and works with other eye care professionals to ensure that patients are referred appropriately for diagnostic and therapeutic needs. Optometrists also prescribe drugs for certain eye conditions and monitor long-term eye conditions.

Orthoptist: Specialises in diagnosing and managing disorders of eye movements and associated vision problems. An orthoptist performs investigative procedures appropriate to disorders of the eye and visual system and assist with rehabilitating patients with vision loss. Orthoptists also diagnose refractive disorders and prescribe glasses on referral from an ophthalmologist or optometrist.

Presbyopia: Progressive reduction in the eye's ability to alter focus, with consequent difficulty in reading at the normal distance, associated with ageing.

Refractive error: The powers of the corrective lenses needed to focus a distant object on the retina in the absence of accommodation.

Retinoblastoma: A malignant tumour of the eye, usually resulting from a genetic disorder and appearing in early childhood.

Snellen scale: Scale used to measure visual acuity.

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

Stereoacuity: The ability to detect differences in distance using stereoscopic cues that is measured by the smallest difference in the images presented to the two eyes that can be detected reliably.

Stereopsis: The blending of two slightly different images seen by both eyes into one single image, resulting in a three-dimensional image.

Strabismus: The misalignment of the visual axes of the two eyes (manifest or latent).

Trachoma: A contagious bacterial eye disease in which scar tissue forms inside the eyelid, eventually causing it to curve inwards and the eyelashes to scrape the eye and cause infection.

Visual acuity: The finest detail that an eye can distinguish using LogMar or Snellen scales.

Epidemiological terms

Controlled clinical trial: A clinical study that compares people getting treatment (treatment group) to people who do not receive this treatment (control group).

False negatives: Participants who receive a negative test result, but who really do have the condition.

False positives: Participants who receive a positive test result, but who actually do not have the condition.

Intention to treat: An intention to treat analysis requires that participants be analysed in the groups they were randomised into, regardless of whether they complied with the treatment they were given.

Negative predictive value: Proportion of participants who received a negative test result and who did not have the condition.

Non-randomised controlled trial: 1. A comparative study with concurrent controls: Non-randomised, experimental trial; Cohort study; Case-control study; Interrupted time series with a control group. 2. A comparative study without concurrent controls: Historical control study; Two or more single arm study; Interrupted time series without a parallel control group.

Positive predictive value: Proportion of participants who received a positive test result and who did have the condition.

Prevalence: Occurrence rates.

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

Screening: Presumptive identification of unrecognised disease/defect by the administration of tests, exams or other procedures which can be applied promptly to a whole population.

Sensitivity (true positive): Proportion of children with the condition in a population who are correctly identified by the screen.

Specificity (true negative): Proportion of children without the condition in a population who are correctly identified by the screen.

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

Yield: The proportion of children in a screened population who are found to have a condition.

Common screening tests

Corneal reflex test (Hirschberg test): Test performed by shining a light in the person's eyes and observing where the light reflects off the corneas. In a person with normal ocular alignment the light lands on the centre of both corneas. For an abnormal result, the examiner can detect if there is an exotropia (abnormal eye is turned out), esotropia (abnormal eye is turned in), hypertropia (abnormal eye higher than the normal one) or hypotropia (abnormal eye is lower than the normal one).

Cover-uncover test: A test to detect strabismus; the person's attention is directed to a small fixation object, one eye is covered and after a few seconds, uncovered; if the uncovered eye moves to see the picture, strabismus is present.

HOTV chart: Test to measure visual acuity. Chart made up of the letters "H", "O", "T", and "V". The child needs to match the indicated symbols on a wall chart with those on the response card.

Lea Symbols: A complete set of visual acuity tests for near and far distance vision. LEA symbols are based on four symbols: circle, square, house, and apple. The child needs to match the indicated symbols on a wall chart with those on the response card.

MIST (Melbourne Initial Screening Test): The test has been designed as a simplified vision screening test for 3.5 to 4.5 year olds to be performed by maternal and child health nurses in Victoria. It is a letter matching test, and has a pass/fail method of assessment rather than a threshold of visual acuity. There are 5 test letters.

Photoscreening: A vision screening technique used to screen for amblyogenic factors in one or both eyes in children. Using a camera or video system appropriately equipped for photoscreening, images of the pupillary reflexes (reflections) and red reflexes (Brückner test) are obtained. The child is asked to fixate on an appropriate target long enough for the photoscreening. Data are then analysed by the evaluator, reviewing centre, or computer for amblyogenic factors.

Red reflex: The red reflex refers to the reddish-orange reflection from the eye's retina that is observed when using an ophthalmoscope or retinoscope. Many eye problems may be detected by this test, such as cataracts and retinoblastoma.

Sheridan Gardiner test: Measures visual acuity. Contains both near vision and distance vision tests and reduced Snellen tests. Testing depends on matching shapes rather than identifying or naming letters.

Snellen chart: A chart for testing visual acuity, usually consisting of letters, numbers, or pictures printed in lines of decreasing size which a person is asked to read or identify at a fixed distance.

Treatment terms

Atropine: A poisonous alkaloid obtained from the deadly nightshade plant that can be used as a muscle relaxant.

Occlusion: Something that obstructs or occludes (in this case, obstruction of the eye).

Patching: A method of occlusion (i.e. to place a patch over the eye).

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Appendix Two: Discussion Paper

NATIONAL CHILDREN'S VISION SCREENING PROJECT

Discussion Paper

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Prepared for:

Commonwealth of Australia

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This Discussion Paper has been prepared on behalf of the Commonwealth Government of Australia for public comment. The Discussion Paper aims to obtain feedback from eye health professionals, stakeholders and interest groups to assist Government to better understand and assess the costs and benefits of aligning vision screening programs for children aged 0-16 years across all Australian States and Territories. The Discussion Paper does not represent agreed policy by participating States and Territories.

Foreword

This Discussion Paper has been prepared by the Centre for Community Child Health's (CCCH) National Children's Vision Screening Project Team, Murdoch Childrens Research Institute. The paper sets out recommendations for the future requirements of children's vision screening in Australia.

The underlying rationale for any form of screening is that it should identify health problems of importance that are detectable and treatable. While cost should not be an immediate barrier to implementation of a screening program, it is an important consideration that must be weighed up against the consequences to health and wellbeing that may result if screening was not conducted. The costs of implementing other methods to detect the health problem (such as comprehensive, individual examinations) should also be weighed against the cost of screening.

The motivations for advancing a Discussion Paper on childhood vision screening are to: (a) present evidence obtained via a thorough review of the literature; (b) generate discussion and seek feedback on recommendations that could be implemented consistently across all Australian states and territories (with appropriate exceptions for high-risk populated areas requiring tailored interventions) and (c) generate discussion and seek feedback on evidence-based (where possible) and expert guidance recommendations regarding the composition of vision screening programs, including appropriate age/s for screening, screening personnel, screening tests and referral pathways.

It has been well documented that evidence, particularly evidence of a high quality, regarding the effectiveness of children's vision screening is limited. The CCCH Project Team and its associated expert advisors have taken care to assess the evidence that is available, and to address any gaps in the evidence using expert opinion by consensus. However, widespread consultation, feedback and comment on the recommendations set out in this paper will be critical in informing refinements to the proposals made to the Federal Government.



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Background to this Discussion Paper

In July 2004 the Australian Health Ministers' Conference agreed on the need to develop a National Eye Health Plan for Australia to promote eye health and reduce the incidence of avoidable blindness. This initiative represents Australia's response to World Health Assembly resolution WHA56.26 on the elimination of avoidable blindness in member countries. Although Australia has excellent eye health care services in comparison to most other countries, there is scope for further improvement in the systems and quality of care.

The *National Framework for Action to Promote Eye Health and Prevent Avoidable Blindness and Vision Loss* (National Eye Health Framework) was developed to provide a structure for governments, health professionals, non-government organisations, industry and individuals to work in partnership. The Framework was endorsed by Australian Health Ministers in November 2005.

In accordance with the World Health Assembly resolution, the focus of the National Eye Health Framework was on the proactive elimination of avoidable blindness and vision loss in Australia, rather than on the reactive provision of treatment services. Avoidable blindness and vision loss refer to vision impairment due to conditions that are potentially preventable through the modification of known risk factors, or for which effective treatments exist to restore sight or prevent further vision loss.

The key areas for action for the National Eye Health Framework were the following:

- Reducing the risk of eye disease and injury
- Increasing early detection
- Improving access to eye health care services
- Improving the systems and quality of care
- Improving the underlying evidence base

Information regarding the National Eye Health Framework, and the Framework, can be located at: <http://www.health.gov.au/internet/main/publishing.nsf/Content/ageing-eyehealth-framework.htm>

In the 2006-07 Federal Budget the Australian Government provided funding of \$13.8 million over four years for a National Eye Health Initiative (NEHI) to promote eye health and to strengthen eye health care service delivery. The NEHI will fund a range of activities, including:

- Eye health promotion activities to encourage Australians to look after their eyes
- An eye health demonstration grants program

Activities funded under the Eye Health Demonstration Grants Program are intended to support the implementation of the National Eye Health Framework. Funding was made available for demonstration projects that trialled and evaluated new approaches to the delivery of eye health care to support the implementation of the National Eye Health Framework. This component of the National Eye Health Initiative aimed to identify, trial and evaluate strategies to:

- Overcome inefficiencies in the delivery of eye health care
- Improve access to eye health care, particularly for marginalised and disadvantaged groups, including people in rural and remote communities and Aboriginal and Torres Strait Islanders
- Improve the quality and safety of eye health care

Funding was provided to projects that had the potential to enhance the delivery of eye health care and improve the quality and safety of care. Priority was given to proposals that targeted marginalised and disadvantaged people or groups at particular risk of eye disease and injury.

Murdoch Childrens Research Institute's Centre for Community Child Health (CCCH) received funding under the Eye Health Demonstration Grants program to evaluate the effectiveness of

vision screening in Australian children aged 0 – 16 years, to consult with interest groups and stakeholders regarding recommendations for vision screening in Australia and to report back to government with final recommendations and guidelines for children’s vision screening. The National Health and Medical Research Council’s 2002 review (Child Health Screening and Surveillance: A critical review of the evidence) had been influential in informing the conceptual thinking around early identification of vision conditions, but had not translated into the development of a national approach to preschool and school vision screening for children across Australia. A systematic approach that not only reviewed the current research, but worked with state and territory health departments and other key stakeholders to translate this research into practical recommendations of changes was required, and is the main aim of the CCCH Vision Screening Project.

The CCCH Vision Screening Project involves five key steps; three of which were completed prior to the development of this Discussion Paper. These three steps were:

- 1 The establishment of a Project Advisory group and a detailed workplan.

A Project Advisory group was established to advise on the planning and implementation of the project, and includes representation from CanDo4Kids, the Centre for Eye Research Australia (CERA), Optometrists Association of Australia, the Orthoptic Association of Australia, Royal Australian and New Zealand College of Ophthalmologists (RANZCO) and Vision 2020 Australia. Joint meetings between the CCCH Project Team and the Project Advisory group were and are to be organised throughout the project term.

A detailed workplan, including timelines, was developed for the project and submitted to the Department of Health and Ageing.

- 2 The completion of a systematic literature review.

A systematic literature review was conducted to identify current Australian and international literature on the effectiveness, including cost effectiveness, of childhood vision screening, carried out prior to and during school years. The literature review also included a table of current practice in relation to vision screening programs in Australia. (Follow this link for a copy of the literature review: http://www.rch.org.au/ccch/resources.cfm?doc_id=10545).

- 3 The examination of the research evidence and the development of flexible best practice models of vision screening for key age groups.

The literature was analysed and gaps in the research were identified in consultation with recognised experts in the field of vision and eye health (the Project Advisory group and associated networks).

Evidence on the following components of vision screening programs were considered by the Project Advisory group and CCCH Project Team: recommended tools; most appropriate age(s) to screen; most appropriate screening personnel, and follow-up or referral pathways. The following vision conditions were examined: cataracts and other serious but uncommon disorders of the eye in early infancy; amblyopia; refractive error and the conditions that may contribute to it including strabismus and hyperopia; binocular vision and accommodative disorders.

Following the submission of this Discussion Paper, the final two steps in the project will be undertaken:

1. Conducting national consultation with state and territory health departments and service providers to present the effectiveness literature; to examine current screening practices; to receive feedback on proposed vision screening models and to determine future action.

2. Making recommendations on the key components of a coordinated national childhood vision screening program (if determined effective through the pre- and during school years) which has the flexibility to fit with system/workforce variances in each state and territory. This will also include recommendations on the establishment of a national database and ongoing evaluation framework. It is envisaged that the program(s) endorsed by the project advisory group will be put forward through the relevant Ministerial committees for consideration by the Federal, State and Territory governments of Australia.

Contents

1. KEY MESSAGES	1
2. EXECUTIVE SUMMARY	3
2.1 Introduction.....	3
2.2 Methods.....	3
2.3 Findings from the literature review.....	3
2.4 Recommendations.....	4
2.5 Summary.....	5
3. INTRODUCTION	6
4. METHODS	7
5. FINDINGS FROM THE LITERATURE REVIEW	8
6. RECOMMENDATIONS	10
7. SUMMARY	13
8. QUESTIONS FOR FOCUS GROUP CONSULTATIONS	14
9. NEXT STEPS	15
10. APPENDICES	16
11. GLOSSARY	18
12. REFERENCES	20

1. Key messages

This Discussion Paper outlines the available evidence on the effectiveness of vision screening for children aged from birth to 16 years in Australia. It also summarises key recommendations on children's vision screening put forward by the CCCH Project Team and the Project Advisory group, and outlines key questions that will be asked of interest groups, stakeholders and other health and vision representatives in future national focus group consultations.

Currently, there is little consistency in how and when vision screening is conducted across Australian states and territories. The review found inconsistencies in the number of vision checks, age at which screening is conducted, the tools or procedures that are used, the personnel who conduct the screening and the referral pathways used to follow up screening results.

The available evidence on the prevalence of common vision conditions in children is inconsistent, ranging from 1.4% to 3.6% for amblyopia, 0.3% to 7.3% for strabismus, and 1% to 14.7% for refractive error.

Evidence from Australian studies suggests that in the absence of a formalised, standardised screening program, most vision conditions requiring treatment are detected in children by school entry. The evidence was inconclusive with respect to the formal and informal mechanisms by which vision problems are identified.

The available evidence suggests that vision screening should be conducted at no earlier than 18 months of age (with the exception of newborn checks for congenital vision conditions) and no later than five years. Eye health professional association guidelines recommend that screening occur after three years of age in order to be able to screen for visual acuity.

Studies were identified suggesting that newborn checks for congenital eye conditions should be conducted as close to birth as possible.

Members of the expert Project Advisory group recommended that a check in the neonatal period with a follow-up check at three to six months, and a screen at four years be conducted. The expert group felt that these checks and screens should be retained or implemented unless or until further evidence to the contrary was identified.

The Project Advisory group considered that the Sheridan Gardiner was the gold standard test of visual acuity for children aged four years and above and that LEA symbols were appropriate to use with younger children.

The international evidence was in favour of orthoptists or nurses conducting primary vision screens. However, the Advisory Group noted that there are a range of available professionals in the Australian workforce currently providing screenings, as well as primary, secondary and tertiary eye care. This includes not only nurses, orthoptists and GPs, but a large number of optometrists already providing primary eye care for children, and high quality tertiary care through referral to ophthalmologists. Therefore, the most appropriate personnel to undertake screenings, and the most appropriate referral pathways following screening, may well be different in the Australian context, and this issue will require further analysis to ensure we use our available work force to its best capacity.

The literature review determined that many studies used visual acuity of less than 6/9 in each or either eye as their referral criteria when screening children aged four to six years. However, the expert advisory group could not reach consensus on whether this was the most appropriate referral criteria for the purposes of detecting vision conditions that would cause functional impairment in children's lives. Further research and consultation in this area is required.

There are a number of barriers in place preventing many children from receiving or complying with treatment, post-screen. Procedures need to be in place to facilitate compliance with secondary screens or treatment.

Many studies reported that early screening saved future healthcare costs. However, one recent study concluded that children's vision screening was not cost-effective. Further analysis is required in this area.

Future research should encompass high quality randomised controlled trials in order to rigorously assess vision screening programs, and to determine whether vision screening leads to a substantial decrease in the prevalence of correctable visual acuity deficits.

2. Executive summary

2.1 Introduction

The National Children's Vision Screening Project is intended to inform future policy by determining the effectiveness of vision screening for children aged from birth to 16 years in Australia. The project consists of three major stages: (1) the conduction of a literature review summarising current evidence on the effectiveness of vision screening; (2) the facilitation of national focus group consultations with eye health professionals, stakeholders, interest groups and community service organisations; and (3) the development of a final report to be presented to the Federal Government in March 2009, outlining the recommendations arising out of the literature review and focus group consultations.

This Discussion Paper has been drafted to inform consultation participants about the results of the literature review, the directions that have been drawn from the literature review, and the initial comments and recommendations that have been made by the Project's advisory group of eye health experts. This Discussion Paper also puts forth questions to future focus group participants in preparation for discussion at the consultations.

2.2 Methods

The CCCH Project Team conducted a literature review of the evidence on the effectiveness of vision screening programs, both in Australia and internationally. The aim of the literature review was to identify: (1) Whether screening is the most effective method by which to detect vision conditions in children; (2) what types of screening programs are effective; and (3) at what age/s vision screening should occur (if it should occur). Evidence was gathered to address these questions via online searching of databases, hand searching of published literature and consultations with expert reviewers.

The literature review focused on screening 'programs', incorporating screening personnel, referral pathways, treatment and consideration of outcomes. Also included in the search for literature were guidelines or policies on vision screening, economic evaluations of vision screening and prevalence of vision conditions. Only studies published after 1990 and written in English were included. Restrictions were also placed on the type of study design that would be included (e.g. case studies were excluded).

Upon completion of the literature review, the CCCH Project Team held a meeting with Project Advisory group members to discuss outcomes of the review. Prior to the meeting, attendees were asked to comment on whether they thought that, based on the evidence, vision screening could be recommended for use in Australia. The meeting commenced with discussion around this question. Upon reaching consensus, the discussion progressed to address all of the separate components of vision screening programs (including personnel, age at screen and so on).

2.3 Findings from the literature review

Due to the types of study designs used in many vision screening evaluations (e.g. non-randomised controlled trials), most of the evidence obtained was categorised as "low quality". Due to an absence of "high quality" evidence available in the literature, recommendations were made with caution. Expert opinion has been, and will continue to be, sought from a wide variety of sources.

Overall there was a lack of evidence to conclusively evaluate the effectiveness of screening. Despite this, the majority of papers reviewed recommended some form of vision screening for children. Some limited evidence was found for the continuation of newborn vision checks, and for the screening of children aged between 18 months and five years of age.

Overall, the evidence identified by the literature review was in favour of orthoptists or nurses conducting primary vision screens, a finding that requires further analysis in the context of the

Australian workforce capacity. In the literature, the criteria on which screening personnel should refer on for further investigation was generally set at less than 6/9 in each or either eye for four to six year olds.

The evidence suggested that any screening program should incorporate follow-up procedures to facilitate compliance with secondary screens or treatment, particularly for vulnerable or low-income families. However, it was determined that groups such as children born prematurely, the remote Aboriginal population, and children with multiple disabilities were not considered suitable candidates for general vision screening programs, due to the greater risk of vision conditions developing in these groups.

The majority of studies reported that vision screening had a positive cost:benefit ratio, therefore concluding that early screening saved future healthcare costs. However, one recent, high quality study concluded that vision screening could be considered cost effective only if value was placed on the loss of vision in one eye (which is the subject of debate as functional impact in such situations may be limited).

The evidence suggested the adoption of other methods, such as education and information campaigns, to increase general awareness of vision conditions and to increase the propensity for parents and teachers to refer assess children outside of the screening period.

2.4 Recommendations

Recommendations were based on a combination of the literature review evidence and expert opinion. While there was limited evidence to confirm the effectiveness of vision screening programs, there was also little evidence to suggest that vision screening programs were not effective. It was therefore recommended that some form of vision screening was necessary, unless or until evidence to the contrary was identified.

It was recommended that neonatal vision checks continue, as this surveillance detects treatable diseases that, if left untreated, could have severe consequences for the child's future health and wellbeing. There was also no evidence identified to support the removal of neonatal vision checks. The PAG recommended that a vision check also be conducted with children between the ages of three to six months so that serious conditions were less likely to be missed.

A vision screen was recommended at four years (with an allowable range from 3.5 years to five years). It was suggested that these three opportunities for vision surveillance and screening are all that is formally required to detect vision conditions in children and that therefore resources should be allocated to ensure they are conducted accurately and thoroughly.

It was recommended that individual states and territories consider their workforce capacity and make an individual assessment of resources in determining which personnel should conduct children's vision screening. While evidence from the literature suggested that nurses and orthoptists were the most efficient and effective screening personnel, the expert advisory group felt that it was more important to ensure any nominated screening personnel were adequately and consistently trained across all jurisdictions.

The consensus reached by the expert advisory group was that the Sheridan Gardiner was considered the best test to use with children aged four and above, while LEA symbols were appropriate to use with younger children. Consensus was not reached on the issue of referral criteria. Two options – either less than 6/9 or less than 6/12 – generated most agreement. Regardless of which option was favoured, a two line or more difference between eyes was also felt to be a suitable criterion for referral. It was noted that further research in this area is generally required, and further consultation is needed before a recommendation can be put forward.

It was recommended that referral pathways be consistent (where possible, allowing for differences in workforce structures across the states and territories), clearly outlined and as straightforward as

possible. This may involve the removal of some steps in the referral process between different professions if possible.

It was noted that children born prematurely or children with multiple disabilities are at greater risk of developing vision conditions and it was therefore recommended that these populations receive in-depth assessment, rather than screening. The expert advisory group recommended that children in remote indigenous populations be screened as per other rural populations for the vision conditions outlined in this paper, as well as have access to additional checks and education programs aimed at the detection and prevention of trachoma, in particular.

It was noted that cost effectiveness needed to be evaluated in the Australian context before recommendations on cost could be made. It was also noted that consideration must be given to not only the costs of attending a screen (including costs to parents incurred by travelling to a screening location and taking time off from work), but also to the costs of any treatment or intervention that resulted from a positive screen. It was recommended that intervention costs for families should be kept to the minimum level possible.

2.5 Summary

The extent to which screening assists in the reduction of vision conditions is still not clear. As a result, whether screening is practically and economically the best method by which to reduce the prevalence of vision conditions is also unclear. Further, the extent to which children's general health and wellbeing are negatively affected by vision conditions requires further research and clarification.

Overall, the evidence either in favour of or in opposition to vision screening for children is limited. However, as screening practices already exist in most Australian states and territories, evidence justifying the removal of children's vision screening would certainly need to be available and of equally high quality as that justifying the continuation of screening, if this option were to be considered.

The Centre for Community Child Health will be organising national focus groups from October to December 2008, to present the research findings and to seek responses on the recommendations outlined in this paper. This represents the next key stage in the National Children's Vision Screening Project.

3. Introduction

The National Children's Vision Screening Project has been funded by the Commonwealth Department of Health and Ageing to inform future policy by determining the effectiveness of vision screening for children aged from birth to 16 years in Australia. The project is a national, collaborative, multi-disciplinary initiative involving Australia's leading researchers, CanDo4Kids, CERA, the Optometrists Association of Australia, the Orthoptic Association Australia, RANZCO, Vision 2020 Australia, state and territory health and education departments, other eye health and vision care service providers, maternal and child health and other community health providers (as relevant in each state or territory).

The writing of this Discussion Paper comprises one component of the project that will be a total of 18 months in duration, from inception (completion of a literature review) to conclusion (recommendations to government policy makers). In addition to time spent identifying evidence throughout the literature review process, numerous hours of the project will be spent consulting nationally with eye health professionals, child health professionals, interest groups and other stakeholders to ensure that the project's conclusions and recommendations are practicable as well as evidence-based.

Following the establishment of the CCCH Project Team and the external expert Project Advisory group, the National Children's Vision Screening project's literature review commenced. The review's purpose was to identify evidence on the effectiveness of screening programs; programs designed to detect vision disorders such as including diminished visual acuity, amblyopia, strabismus or squint, refractive error, cataracts and glaucoma. It was intended that the directions drawn from the evidence, as summarised in the literature review, would assist in determining whether vision screening was considered effective. If vision screening was considered effective upon review of the evidence, then the findings of the literature review were also intended to assist in the development of key components of a national vision screening program for children in Australia.

Upon completion of the literature review, the CCCH Project Team and the Project Advisory group met to discuss the findings of the review and to recommend best practice for vision screening in Australia. These recommendations, based on a combination of evidence drawn from the literature review and the expert opinion of qualified eye health professionals, are put forth in this Discussion Paper, alongside questions for the future consideration of health professionals, interest groups, stakeholders and community service organisations.

4. Methods

Over six months, the CCCH Project Team conducted a literature review of the evidence on the effectiveness of vision screening programs, both in Australia and internationally. The aim of the literature review was to identify evidence on the following questions:

- *Are screening programs the most appropriate method to use to detect vision conditions in children?*
- *What types of vision screening programs appear to be effective and therefore what properties or processes do programs require in order to be effective?*
- *At what age/s should children attend a vision screen, if screening is deemed an effective method by which to detect vision conditions?*

To identify this evidence, trials were retrieved from a variety of sources including standard clinical databases, published systematic reviews, through hand searching of key articles, and via consultation with expert reviewers. Expert reviewers (members of the Project Advisory group) were asked to identify any studies over and above those found by the search detailed above that (a) met the review trial criteria, (b) were new and promising in the field or (c) offered a specifically Australian perspective.

The focus of the search was on identifying screening 'programs'; that is, studies evaluating not only screening, but also screening personnel, referral pathways, treatment and consideration of outcomes. The search for guidelines or policies on vision screening, the cost effectiveness or economic evaluations of vision screening and prevalence of vision disorders were also included in the search criteria. Criteria were limited to studies in English and studies published from 1990 onwards.

Studies considered for inclusion were systematic reviews, randomised controlled trials, pseudo-randomised controlled trials, comparative studies with concurrent controls or comparative studies without concurrent controls.

A request for literature relevant to the Australian context was sent out to eye health and other relevant professionals via members of the Project Advisory group and members of the National Community Child Health Council. The literature review also incorporated material regarding current vision screening practice in Australia.

Upon completion of the literature review, the CCCH Project Team organised a meeting with Project Advisory group members to discuss the outcomes of the review. Prior to the meeting, attendees were asked to comment on whether they thought that, based on the evidence alone, vision screening could be recommended for use in the Australian context. The meeting commenced with discussion around this question and, once consensus was reached, progressed into discussion about all of the separate components involved in a vision screening program, including age at screening, screening personnel, at-risk groups and referral criteria.

5. Findings from the literature review

In Australia, the prevalence of amblyopia in children ranged from 1.4% to 3.6%,[1-4] while strabismus ranged from 0.3% to 7.3%,[1, 5] and refractive error ranged from 1% to 14.7%.[1, 5-10] These rates show large variations, suggesting that further research is required to consolidate these figures and to determine what effect current screening practice has on prevalence rates. However, the figures do suggest that there is a degree of prevalence of vision conditions among Australian children.

Largely due to the study designs used to trial vision screening effectiveness (i.e., non-randomised controlled trials, observational studies, and retrospective reports), most of the level of evidence identified in the literature review was categorised as “low quality”. If more studies of a higher quality (e.g. systematic reviews or randomised controlled trials) had been identified, a higher level of confidence in the recommendations derived from the evidence could have been held. In the absence of higher quality evidence, recommendations were made with caution and expert opinion has been and will continue to be sought from a wide variety of sources.

Is vision screening recommended?

Overall, there was a lack of evidence from the literature review to conclusively evaluate the effectiveness of screening. Despite this, the majority of papers reviewed recommended some form of vision screening for children.

Newborn screening

While the literature review identified few studies that focused exclusively on screening during the neonatal period, and no direct evidence could be taken from those studies, studies that were identified suggested that a vision check should occur as close to birth as possible, and ideally within the first three months of life.[11, 12]

Other screening age/s

The evidence identified by the literature review recommended that screening was a viable method of detecting vision conditions in children, suggesting that the ideal age for vision screening is no earlier than 18 months of age (with the exception of the newborn check) and no later than five years.[13-21] As visual acuity was more difficult to assess in children younger than three, vision screening guidelines recommended that screening occur after three years of age.[22-25] Screening at an older age, such as eight to ten years or 13 – 15 years, was shown to detect very few or no new cases of eye pathology, and was therefore not recommended practice.[4, 26] There was an absence of studies evaluating screening at school entry, particularly as an alternative to preschool screening.

Screening personnel

Overall, the evidence identified by the literature review was in favour of orthoptists or nurses conducting primary vision screens.[27-34] However, whether this is appropriate in the Australian context requires further assessment of the relevant Australian workforce's capability. There were few international studies that considered the use of optometrists in the screening process and they currently play a large role in Australia.

If employing nurses as primary screeners, the literature recommended that adequate training in screening techniques be made available so as to increase the sensitivity and specificity of the program.[35] The literature also recommended that a program of secondary screening be considered, whereby any questionable or positive results are referred for a second screen prior to referral to an ophthalmologist.[36, 37] Again, whether this is appropriate in the Australian context would require further analysis of workforce capacity and costs.

Referral criteria

The literature review determined that the referral (or pass/fail) criteria recommended for use in vision screening was dependent in part upon the age of the children screened. However, the majority of studies used referral criteria of less than 6/9 in each or either eye for four to six year old children.[38-40] One study noted that a referral criteria of less than 6/12 in either eye reduced over-referrals.[41] Referral rates, using the criterion of 6/9 in the worst eye, ranged from 4.8% to 39.6% of children screened.[39, 41]

Referral pathways and follow-up procedures

The evidence determined that any screening program should incorporate follow-up procedures to facilitate compliance with secondary screens or treatment. It was noted that this was particularly vital in vulnerable or disadvantaged communities where families may not understand the results of screens, may have limited resources to attend screenings or treatment facilities, and/or may not understand the importance of treatment to future vision potential.[11, 42-48]

At-risk groups

Throughout the process of conducting the literature review, it was determined that groups such as children born prematurely, the remote indigenous population, and children with multiple disabilities were not considered suitable candidates for general vision screening programs as their risk for developing vision conditions is much higher than that of the general population. It was determined that building an eye health program to meet the needs of high-risk groups would require further detailed consultation with appropriate professionals in these communities, and was thus considered outside of the scope of the literature review.

Cost considerations

The cost of a screening program is obviously an important component involved in considering screening viability. The majority of studies reported that vision screening had a positive cost:benefit ratio, and therefore concluded that early screening saved future healthcare costs.[49-56] However, one recent high quality study concluded that vision screening could be considered cost effective only if value was placed on the loss of vision in one eye.[57]

Unfortunately, the literature review did not identify any Australian evaluations of vision screening costs in relation to screening in childhood.

Participation rates

The evidence suggested the adoption of other methods to increase general awareness of vision conditions and to increase the propensity for parents and teachers to assess children outside of the screening period. For example, education and marketing campaigns were reportedly successful in increasing general awareness of vision and increasing the number of children attending vision screenings.[47]

6. Recommendations

The following recommendations are derived from the literature review evidence and expert opinion. In making these recommendations, the CCCH Project Team and the Project Advisory group were conscious of applying greater weight to higher quality evidence identified in the literature, where it was available.

Is vision screening recommended?

With little guidance from the evidence in this area, the CCCH Project Team and Project Advisory group initially could not reach consensus on whether vision screening for children could be recommended. However, it became apparent that this was largely due to differing views as to what constituted a 'screening program'. That is, did screening necessarily warrant a stand-alone program or did a vision screen performed as part of an existing health consultation constitute a screen?

Upon agreeing that a vision screen could be conducted in conjunction with other scheduled health checks, attendees also reached consensus that some form of vision screening was necessary. Expert advisors cited three main reasons for this conclusion (based on the crucial criteria for screening programs as developed by Wilson and Jungner in 1968): (1) vision is an important health consideration; (2) vision screening can detect latent or early symptomatic stages of a vision condition [58] early diagnosis of vision conditions often results in a better prognosis; and (3) early diagnosis of vision conditions may result in a better prognosis. Further, while there was limited evidence to confirm the effectiveness of vision screening programs, there was also little evidence to suggest that vision screening programs were not effective.

Newborn screening

Again, there was little guidance from the evidence to determine whether vision screening should be carried out during the neonatal period. However, the consensus of the CCCH Project Team and the Project Advisory group was that a vision check during the neonatal period was crucial, as this enabled the detection of treatable diseases that, if left untreated, could have severe consequences for the child's future health and wellbeing. Once again, there was also a lack of evidence to support the removal of a neonatal check.

Other screening age/s

The consensus of the CCCH Project Team and Project Advisory group was that a further vision check should be conducted with children between the ages of three to six months, and that a screen should be conducted at four years (with an allowable range from 3.5 years to five years). Although there was no evidence from the literature to support a check in children aged three to six months, the expert group felt this recommendation was necessary to ensure that any conditions missed at the newborn check were detected (as they would still be treatable), and to allow for an early assessment of visual behaviour (e.g. fixing and following), providing further scope to detect visual concerns.

There was some evidence identified in the literature to support the screening of children aged between 18 months and five years of age. Upon review of this evidence, the expert advisory group decided to recommend that programs aim to screen children at approximately four years of age, but not younger than 3.5 years (due to the decreased ability of children to complete the screening test) or older than five years (due to concerns about efficacy of treatment and compliance with treatment).

The expert advisory group also felt that two main questions should be asked at the four year old screen: "Do you have any concerns about your child's vision?", and "is your child already seeing a vision health practitioner?". While the responses to these questions would not affect whether or not

a screen was conducted, responses would provide valuable data for evaluation and referral purposes. The expert advisory group noted that, while there was minimal evidence to support a screen at this age, there was also no evidence to support the removal of this screen, which already forms part of current practice in many Australian states and territories (albeit in different forms and with different levels of implementation).

It is important to note that current vision screening or surveillance practices in many Australian states and territories provide for a substantial number of checks on vision to take place between birth and the age of six years. For example, including the maternal and child health checks that all parents in Victoria are encouraged to attend, there are 12 opportunities for children's vision to be checked (ranging from questions asked of parents about vision concerns, to basic checks for appropriate vision behaviours, to tests of visual acuity), and therefore 12 opportunities for onward referral if a concern is raised or is visible to the health professional. It is recommended that the number of set occasions that a health professional directly checks vision be reduced to the three occasions outlined above, with provision for parents to raise concerns on any other occasion if they suspect a vision problem. It is recommended that resources are focused on ensuring these two checks and one screen are conducted accurately and thoroughly.

Screening personnel

The literature identified nurses as being capable of successfully administering screening programs, if provided with appropriate training and resources. Many international studies also recommended orthoptists as the 'screeener of choice' in order to increase the sensitivity and specificity of screens.

Given the structure of the Australian eye health professional workforce, the expert advisory group suggested it was likely that child and family health nurses would have contact with children at four years of age through other existing health checks and therefore may be best placed to be primary screeners in a vision screening program. However, again, the advisory group recommended that individual states and territories would need to look at their workforce capacity and make an individual assessment of resources. The expert advisory group felt that the most important recommendation regarding screening personnel was that training was adequate and consistent across the states and territories.

Screening tests

The type of test that should be used to conduct a vision screen was not included in the literature review search, therefore expert opinion was sought from the advisory group. The consensus reached by the group was that the Sheridan Gardiner was considered the gold standard test for children aged four years and above and that LEA symbols were appropriate to use with younger children.

Referral criteria

As noted, the screening programs outlined in the literature review generally used a referral criterion of less than 6/9 in each or either eye for children aged four to six years. However, this criterion was not universally accepted by the expert advisory group. In fact, the issue of referral criteria created substantial debate amongst the group, and full consensus was not reached.

Specifically, attendees were unable to agree on whether children should be referred for further visual assessment if they achieved results of less than 6/7.5, less than 6/9 or less than 6/12 during a screen. It was noted that the World Health Organisation defined vision impairment as visual acuity of less than 6/18 in the better eye. Two options – either less than 6/9 or less than 6/12 – generated the most agreement. Regardless of which option was favoured, a two line or more difference between eyes was also felt to be a suitable criterion for referral.

Given the low quality of the evidence available in the literature and the inability of the expert advisory group to reach consensus on this matter, no recommendation will be put forth until further

information can be gathered. This includes advancing this question to other eye health professionals during national focus group consultations.

Referral pathways and follow-up procedures

The evidence identified in the literature review demonstrated that clearly outlined and appropriately resourced referral pathways are crucial to the success of vision screening programs. The expert advisory group agreed that referral pathways should be consistent (where possible, allowing for differences in workforce structures across the states and territories), clearly outlined and as straightforward as possible.

At-risk groups

As noted, children who are born prematurely or children with multiple disabilities are at greater risk of developing vision conditions and therefore require in-depth assessment, rather than screening.

The expert advisory group recommended that children in remote indigenous populations be screened as per other rural populations for the vision conditions outlined in this paper. However, in addition to screening for conditions such as amblyopia and strabismus, children in indigenous populations require health checks and educational programs tailored towards the detection and the prevention of trachoma, in particular. While these additional checks and programs are beyond the scope of this discussion paper, it is likely that these may co-exist with a screening program in remote indigenous populations.

Cost considerations

The literature presented some inconsistencies in analyses of the cost effectiveness of screening; some of which was due to different values used to calculate the effects on wellbeing of vision impairment or loss. The expert advisory group felt that cost effectiveness needed to be evaluated in the Australian context before recommendations on cost could be made.

Participation rates

Ensuring a high participation rate in any screening program is often difficult. The evidence indicates that resources are required to 'market' screening programs to participants, or parents of participants.

Integrating a vision screen into an existing health check or program may facilitate higher participation rates, particularly if other highly regarded services such as immunisation are provided. On the other hand for adequate vision screening a certain amount of time is required and a cooperative, attentive child. This may be better achieved with a stand-alone vision program. It is recommended that, if vision screens are to be integrated with health checks, existing systems around these checks should be strengthened (incorporating adequate and appropriate training, awareness campaigns, and so on) to encourage high attendance rates. Stand-alone screening programs may need to carefully consider screening locations (do the screeners go to the children, or do the children come to the screen?), as well as targeted education campaigns for parents and caregivers.

Cost also becomes an important factor in participation rates. Consideration must be given to not only the costs of attending a screen (including costs to parents incurred by travelling to a screening location and taking time off from work), but also to the costs of any treatment or intervention that results from a positive screen. Ideally, it is recommended that intervention costs for families should be kept to the minimum level possible.

7. Summary

Providing a recommended course of action for vision screening in children is a complex task. Though none would doubt the importance of all children having perfect or near-perfect functional vision, the literature review did not clarify the extent to which screening assists in the reduction of vision conditions, or if screening is practically and economically the best method by which to reduce the prevalence of vision conditions. Further, the extent to which children's general health and wellbeing are negatively affected by vision conditions is not clear.

Overall, the evidence either in favour of or in opposition to vision screening for children is limited. There is some evidence, of low quality, that suggests newborn vision checks and screening during the preschool years is valuable. Consultations with our expert eye health advisory group resulted in a recommendation for a further check for congenital eye conditions in children aged three to six months. As screening or surveillance practices already exist in most Australian states and territories, evidence justifying the removal of children's vision screening would certainly need to be available and of equally high quality as that justifying the continuation of screening.

In the absence of high quality evidence, it is important that eye health professionals, stakeholders, interest groups and community health organisations are presented with the available evidence for screening and the recommendations to date on how screening could be implemented in Australian states and territories, and are provided with an opportunity to respond. To assist this process, the available evidence, the expert opinions put forth by the CCCH Project Team and the Project Advisory group, and the gaps in the evidence identifying where future research is required, have been set out against Wilson and Jungner's general criteria for screening programs in a one page summary (see Appendix 1). The CCCH will be organising national focus groups from October to December 2008 to seek consultation on the above recommendations; this represents the next key stage in the National Children's Vision Screening Project.

8. Questions for focus group consultations

1. Based on your understanding of the evidence, do you think vision screening can and should be recommended for children in Australia? What are the reasons for your response?

- If yes, do you feel that vision screening should be conducted;
 - a. At birth?
 - b. At three to six months?
 - c. At four years?
 - d. At any other age/s?

What are the reasons for your response/s?

- If no, should there be any formal process to identify children with vision conditions?
2. If vision screening continues, or is implemented, what does that mean for your practice?
3. If vision screening is discontinued, or is not implemented, what does that mean for your practice?
4. Do you foresee any problems arising in your jurisdiction if a vision screen for four year old children was implemented as the primary or only vision screen for children?
5. Do you think a four year old vision screen should be implemented as a stand-alone program, or integrated with another health check? Why?
6. If a four year old screen was implemented, to what extent would you recommend a 'back-up' screen (e.g. at school entry)?
7. What would you recommend the visual acuity level should be for onward referral from a screen?
- a. Less than 6/7.5
 - b. Less than 6/9
 - c. Less than 6/12
 - d. Less than 6/18
 - e. Other

What are the reasons for your response?

8. What recommendations, if any, would you make regarding the type of test/s that should be used for vision screening?

9. Next steps

The next step in the National Children's Vision Screening Project is to conduct national focus group consultations with relevant eye health professionals, interest groups, stakeholders and community health organisations. The CCCH project team is endeavouring to undertake a minimum of twelve workshops in order to present the literature review findings, present the status of current practice, discuss possible options for a coordinated vision screening program and consider any issues regarding a coordinated vision screening program as raised in this Discussion Paper.

Following the conclusion of these consultations, a final report will be prepared for the Federal Government, which will outline the recommendations of the CCCH Project Team and the Project Advisory group on vision screening practice in Australia. It is anticipated that this report will be presented to Government on 31 March 2009.

10. Appendix 1

Criteria for screening programs		Vision screening		
		Evidence	Expert opinion	Further consultation
Knowledge of disease	Condition must be an important health problem	<p>The prevalence of amblyopia in children ranged from 1.4% to 3.6%, while strabismus ranged from 0.3% to 7.3%, and refractive error ranged from 1% to 14.7%.</p> <p>A detailed evaluation was not performed of the long term impact of vision problems diagnosed in childhood.</p> <p>Links have been made between vision impairment and poor educational outcomes. It is suggested that vision impairment is correlated with lower visuocognitive and visuomotor skills, poorer reading ability and lower scores on achievement tests. However, visual deficits related to educational outcomes are often not identified during screening.</p>	<p>Experts cited three main reasons why vision screening for children should be continued: (1) vision is an important health consideration; (2) vision screening can detect latent or early symptomatic stages of a vision condition [58]; and (3) early diagnosis of vision conditions may result in a better prognosis.</p>	<p>There is argument as to the functional effect that a vision condition such as amblyopia has on the quality of life of a child. There is debate over the level of vision acuity at which functional impairment occurs, and whether or not loss of vision in one eye is an important health problem.</p>
	Condition must have a recognisable latent or early symptomatic stage	<p>Vision conditions have recognisable early symptomatic stages.</p> <p>With the exception of screening for congenital eye conditions, the evidence suggested that vision screening should occur between the ages of 18 months and five years, as this is when vision conditions have a recognisable symptomatic stage.</p> <p>Screening between eight and 15 years was shown to detect very few or no new cases of eye pathology.</p>	<p>Experts recommended that a vision check during the neonatal period was crucial, to detect treatable diseases with recognisable early pre-symptomatic stages.</p> <p>A vision check between three and six months was recommended to detect any condition missed at the newborn check, and to assess visual behaviour.</p> <p>It was recommended that vision screening be carried out at age four (with a range from 3.5 to five years) as vision conditions are identifiable and children are generally more compliant with the testing process than at earlier ages.</p>	<p>Nil consultation required on whether vision conditions have early symptomatic stages; this has been confirmed by the evidence. However, the most appropriate timing for detection requires further debate.</p> <p>There was little evidence assessing screening at school entry.</p> <p>There was no evidence on the effectiveness of multiple screenings (e.g. screening at four years of age and at school entry).</p>
	The natural course of the condition, including development from latent to declared disease, should be adequately understood	<p>There is evidence that some vision conditions will 'self-correct' without treatment. Further evidence on this is required.</p>	<p>Experts conceded that the natural course of all vision conditions is not fully understood.</p>	<p>Further consultation / research is required.</p>

Knowledge of test	Must be a suitable test or examination	This was not specifically examined by the literature review, although studies identified for the review incorporated the use of suitable screening tests.	The experts recommended the use of the Sheridan Gardiner test for children aged four years and above, and the LEA symbols for younger children.	Many different tests are used to measure visual acuity. Is the Sheridan Gardiner most suitable for children aged four years and above? Are LEA symbols most suitable for younger children?
	Test must be acceptable to the population	Tests are acceptable to the population, widely used and non-invasive.	Tests are acceptable to the population, widely used and non-invasive.	Nil consultation required.
	Case finding should be a continuing process and not a "once and for all" project	The evidence identified the importance of ongoing education amongst health care workers, teachers and parents to identify outside the screening period.	Parents should continue to be encouraged to report concerns regarding their children's vision to health professionals, within and outside of a formalised screening program.	Nil required.
Treatment for disease	Must be an accepted treatment for patients with recognised disease	The evidence outlines several treatments for children's vision conditions, such as patching, atropine treatment and spectacle correction. The evidence suggests that treatment is best administered in children younger than seven.	The expert group was not consulted on the specifics of this aspect of screening.	Further consultation may be required around the best treatment available, the possible adverse consequences of treatment (e.g. bullying) and the most appropriate age for treatment.
	Facilities for diagnosis and treatment available	Facilities and personnel are available for treatment.	Facilities and personnel are available for treatment.	Available resources may determine the nature of any screening program and referral guidelines, see below.
	Agreed on policy concerning whom to treat as patients	The evidence suggested that children aged between four and six years of age with visual acuity of less than 6/9 should be referred on for further assessment and treatment. The World Health Organisation defines vision impairment as visual acuity of less than 6/18 in the better eye. The percentage of children referred, using the criterion of 6/9 in the worst eye, ranged from 4.8 to 39.6 of all children screened.	The experts could not reach consensus on the referral criteria that should be used to determine who receives further assessment and treatment. Two options (either less than 6/9 or less than 6/12) generated most agreement. A two line or more difference between eyes was also felt to be a suitable criterion for referral.	Further consultation in this area is required.
Cost considerations	Costs of case finding (including diagnosis and treatment of patients diagnosed) must be economically balanced in relation to possible expenditures on medical care as whole	A number of studies reported on the costs versus benefits of screening and indicated that it was cost-effective, however few performed formal economic analyses. One study concluded that vision screening could be considered cost effective only if a value was placed on the loss of vision in one eye.	The expert group were not specifically consulted about cost considerations.	Further analysis of the Australian context is required to determine cost considerations. Consultation in this area may provide some guidance.

11. Glossary

Accommodation: The adjustment of the focus of the eye for varying distances to allow a sharp image to be formed on the retina. This occurs by altering the shape of the lens.

Amblyopia: The loss or lack of potential to see clearly in one or both eyes, due to deviation, defocus or deprivation during the formative years.

Binocular single vision: The simultaneous use of both eyes so that each eye contributes to a common singular perception.

Case study: A form of qualitative research which refers to the collection and presentation of detailed information about a particular participant or small group, frequently including the accounts of participants themselves.

Cataract: An eye disease in which part or all of the lens becomes 'opaque', eventually causing total loss of sight.

Comparative studies: Studies in which intact groups are compared on some dependent variable. The researcher is not able to manipulate the independent variable, which is frequently some inherent characteristic of the subjects, such as age or educational level.

Congenital: Describes an unusual condition present at birth.

Glaucoma: An eye disorder that may be associated with high pressure within the eyeball that leads to damage of the optic disc.

Hyperopia: Long-sightedness.

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

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

Ophthalmologist: A medical doctor who is educated, trained and registered to provide total care of the eyes, from performing comprehensive eye examinations to prescribing corrective lenses, diagnosing diseases and disorders of the eye, and carrying out the medical and surgical procedures necessary for their treatment.

Optometrist: Primary eye care practitioner trained to assess the eye and the visual system, and diagnose refractive disorders and eye disease. An optometrist prescribes and dispenses corrective and preventative devices and works with other eye care professionals to ensure that patients are referred appropriately for diagnostic and therapeutic needs. Optometrists also prescribe drugs for certain eye conditions and monitor long-term eye conditions

Orthoptist: Specialises in diagnosing and managing disorders of eye movements and associated vision problems. An orthoptist performs investigative procedures appropriate to disorders of the eye and visual system and assist with rehabilitating patients with vision loss. Orthoptists also diagnose refractive disorders and prescribe glasses on referral from an ophthalmologist or optometrist.

Project Advisory group: A group of eye health and vision professionals called upon to provide advice and expertise on the National Children's Vision Screening Project.

Pseudorandomised controlled trials: Similar to the randomised controlled trial, without the use of a random allocation. This design is less rigorous.

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

Refractive error: The powers of the corrective lenses needed to focus a distant object on the retina in the absence of accommodation.

Screening: Presumptive identification of unrecognised disease/defect by the administration of tests, exams or other procedures which can be applied promptly to a whole population.

Sensitivity: Proportion of children in a population who truly have a designated disorder, who are so identified by the screen.

Sheridan Gardiner test: Measure of visual acuity. Contains both near vision and distance vision tests and reduced Snellen tests. Testing depends on matching shapes rather than identifying or naming letters.

Specificity: Proportion of children in a population who truly are free of a designated disorder, who are so identified by the screen.

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

Strabismus: The misalignment of the visual axes of the two eyes (manifest or latent).

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

Trachoma: A contagious bacterial eye disease in which scar tissue forms inside the eyelid, eventually causing it to curve inwards and the eyelashes to scrape the eye and cause infection.

Visual acuity: Clarity of vision. Acuity is measured as a fraction of normal vision – 'perfect' vision is 6/6.

WHA56.26: World Health Assembly resolution on the Elimination of Avoidable Blindness.

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Appendix Three: Consultations

a. 'Expression of Interest' registration form for focus group consultations

Calling for expressions of interest from eye health, vision and nursing professionals...

...for participation in national focus group consultations on best practice in vision screening for Australian children aged 0 – 16 years.

The Centre for Community Child Health is currently undertaking a project on the effectiveness of vision screening programs for children in Australia. This project is supported by the Department of Health and Ageing under an Eye Health Demonstration Grants program.

The aim of the project is to determine whether vision screening is the most effective way to detect vision conditions in children. The project is comprised of three main tasks:

1. Completion of a literature outlining current evidence on the topic of vision screening effectiveness
2. Consultation with eye health, vision and nursing professionals to present the findings of the literature review and discuss recommendations for children's vision screening in the Australian context
3. Presentation of a report to the Federal Government outlining recommendations for the future of vision screening programs in Australia

We will be holding focus groups in Brisbane, Sydney, Canberra, Melbourne, Adelaide, Perth and Darwin throughout November and December 2008. Some regional consultations will also be available.

If you would like to be involved in this consultation process, please register your interest by clicking on the following link and filling in your details:

http://www.surveymonkey.com/s.aspx?sm=MUN8II_2f9dDGMuSpd4W7GRg_3d_3d

If you are unable to attend a focus group, but would like to read and provide a comment on the discussion paper, please follow the above link to provide your details.

Please forward this email to other colleagues you feel may be interested.

Thank you for your interest, and we will be in touch with you shortly.

The National Children's Vision Screening Project Team
Centre for Community Child Health
Royal Children's Hospital, Melbourne

Appendix Three: Consultations

b. Consultation Participant Matrix (by Profession)

CONSULTATION PARTICIPANTS (BY PROFESSION)								
STATE/ TERRITORY	Optometrist	Orthoptist	Ophthalmologist	University / Research	Child & Family Health Nurse	Children's Community Health & Advocacy Groups	Government	Nurse (Registered / Practice / Educator)
VICTORIA	3	1 1 (paediatric)	2 2 (paediatric)	1 optometrist 1 orthoptist (combined role with practice)			1	
NSW	2 1 (paediatric)	2		1			1	
ACT	1	2				1	1	1 (registered)
QLD					1 (manager)			1 1 (clinical)
WA		1	1 1 (paediatric)	1		2	4	1 (nurse educator)
TASMANIA								<i>Written only</i>
NT		1			1		1	
SOUTH AUSTRALIA		2	1	2 1 (school principal)	1	2		
WRITTEN RESPONSES		1	1 (paediatric ophthalmologist)		1	1		

** Children's Community Health & Advocacy Groups refers to organisations such as Fred Hollows and Vision 2020.

Appendix Three: Consultations

c. Consultation Data Summary

FINDINGS FROM CONSULTATIONS

Introduction

A key stage in the National Children's Vision Screening Project involved consulting with eye health professionals, medical and primary care personnel and service providers, state and territory health departments and other stakeholders regarding the evidence presented in the National Children's Vision Screening Project literature review (a summary presented in the form of the Discussion Paper), the current practice across Australia's states and territories and the directions and priorities suggested by the Project Advisory Group.

While there was a lack of high-quality evidence available from the literature to support vision screening for children, there was also a lack of evidence to support the cessation of any current vision screening practices. After examining the Literature Review and current practice in the States and Territories, the Project Advisory Group agreed that the support for a national child vision screening program was justified and suggested directions and priorities for consultation.

Consultation was undertaken in seven states and territories, excluding Tasmania where it was not possible to engage with appropriate personnel. Consultation was undertaken on a workshop basis with participants from a wide range of professional backgrounds as outlined above. The consultation included a brief presentation on directions suggested by the evidence and the Project Advisory Group and a series of planned questions with respect to the suggested directions and priorities. The opportunity to gather further information about practice in each of the states and territories was also taken.

Support for a national vision screening program for children

The information gathered in the consultations strongly supported the screening of children's vision, with no participant objecting to such a program in Australia. It was noted by participants that collecting high quality evidence (through randomised-control

trials) to support vision screening and treatment was difficult due to ethical considerations and since treatment for amblyopia has been proven to be effective.

The literature review presented little evidence relating to the long term impact of vision impairment which may be ameliorated through vision screening, and concluded that the visual deficits found to negatively impact on educational outcomes are often not identified during screening. However, the anecdotal evidence provided in the consultations challenged this. Although this aspect of vision screening is beyond the scope of this project, it perhaps presents a gap in the literature and the participants strongly presented anecdotal evidence that supports the need for further research in this area.

The study conducted by Carlton, Karnon, Czoski-Murray, Smith, and Marr, (2008), and cited in the project's literature review, was specifically challenged by one participant because it examines the impact of amblyopia on a person's long term quality of life, but the participants in the study are only followed until 40 years of age. Since Australia's life expectancy is 79 – 87 years of age for the general population, and 17 years less than this for Indigenous Australians (AIHW, 2009), the relevance of the cost-effectiveness conclusions, reached through a quality of life analysis, was questioned.

There was general consensus amongst the participants that reduced visual acuity places children at a disadvantage within the Australian education system. Consultation participants cited specific issues, such as being able to see the board; keeping up with the pace of the classroom (instantly identifying words, rather than needing to re-read multiple times); and the use of technology (digital whiteboards, computers), as key challenges for children with reduced vision. It was also generally agreed that any child with visual acuity of less than 6/9 is at a disadvantage within a classroom environment, when there are children in the same environment with 6/6 visual acuity.

A small number of participants raised the challenges that alternative educational curriculums, such as those offered by Steiner Schools, may present for parents and teachers to identify vision problems if a vision screening program is not available. Children in these programs are typically not engaged for long periods of time in traditional-type lessons involving working on paper or a computer at a desk and

therefore may not present the symptoms of fatigue or lack of concentration to alert adults to poor vision. It was raised that this area may not be present in the literature because the increased enrolments in non-mainstream programs have only occurred in recent years.

Many of the participants provided anecdotes from their practice concerning patients whose lives have been impacted by vision impairment into adulthood. These anecdotes were used to provide support for vision screening for children. It was argued that untreated amblyopia can lead to blindness, when unilateral amblyopia is combined with degenerative eye conditions or trauma (which was considered to be even more likely to occur in the presence of amblyopia) affecting the good eye and therefore the early identification of amblyopia (amongst other vision impairments) is an important public health consideration. The participants strongly supported the screening of children's vision around the age of school-entry (ie 4 – 6 years) as an effective method of identifying amblyopia at an early stage where treatment is likely to be the most effective.

Additionally, the impact that vision impairment has on a person's mental health and well-being was criticised as not being addressed in the literature. A small number of practitioners discussed the impact that late presentation and treatment may have, particularly if it results in poorer outcomes. They reported a link that they perceived between vision loss in adulthood, unemployment and financial costs, and the patient's well-being.

Although the literature concluded that the majority of visual impairments are identified without a formal screening program in place, the participants expressed doubt that an opportunistic approach is the most effective way to ensure children with visual impairments have the opportunity for identification and treatment. The following reasons were listed:

- If children believe their vision is normal, they will not self-identify.
- Children may compensate (quite effectively) for poor vision; especially in the case of unilateral amblyopia.

- Vision problems can be mistaken for cognitive impairment (or symptoms from vision impairment are not attributed to vision problems).
- There are few observable signs of amblyopia, for the layperson.

The evidence gathered in the literature review is unable to distinguish between opportunistic and program based detection rates of eye problems, and without this information it is difficult to determine if screening is necessary to ensure as the maximum number of children with impairments are identified. Consultation participants raised the point that vulnerable families including those with limited resources would be likely to benefit most from a universal screening program.

The majority of consultation participants believed that a universal screening program - including referral and treatment pathways - would be a more cost-effective option than investment in treatment throughout adulthood, together with the costs associated with restricted employment options and reliance on social services. However, the challenges associated with economic and cost effectiveness studies were acknowledged. There was overall consensus amongst the participants that an economic analysis could help identify if a universal screening program is viable within the Australian context.

Current vision assessment practice in Australia

The following table reflects information provided by participants about current practice in their jurisdictions. It includes visual surveillance programs (such as those incorporated into child and family health services) and identified screening programs.

State / Territory	Ages of Vision Assessment	Test/s Used	Primary Screeners	Community Engagement	Referral Criteria	Referral Pathways
Queensland <i>Neonatal red reflex check is conducted.</i> <i>Stand-alone screening program</i>	6 mths; 12 mths 4.5 – 6 yrs	Assess visual behaviour; Hirschberg test Linear STYCAR 5 letter chart with key-card for Prep; 7 letter chart with/ out key-card for Yr 1	Child & family health nurse; GP School nurses	Community health clinics; GP clinic Schools (also back-up screening for children 'missed' + parent referrals)	- V.A 6/9 = pass. V.A <6/9 = fail. 2 lines difference - refer	- School nurse → GP / RCH clinic / optometrist GP → private paediatric clinic at RCH → RCH ophthalmology
New South Wales <i>Stand-alone screening program</i> <i>Neonatal red reflex check is conducted.</i>	4 yrs (StEPS) <i>Early health checks (0 – 3.5 yrs) include a vision surveillance component.</i>	Sheridan-Gardiner (LEA for 3 yr olds)	"Technical assistants" (trained screeners, some lay-people)	<ul style="list-style-type: none"> - Preschool services (long day care; preschools). - Area Health Services (AHS) have responsibility & thus flexibility in delivery. 	V.A 6/9 or better in both eyes = pass. V.A 6/9-1 or 6/9-2 either eye = follow-up in 12 mths. V.A 6/9-2 either eye = onward referral for further vision assessment. Obvious pathology = onward referral (if currently untreated). V.A 6/18 or less = high priority referral. AHS ensure child receives diagnostic assessment.	Primary screener ("technical assistant") ↓ Secondary screener (orthoptist or appropriate eye-health professional) ↓ Treatment as required <i>It was emphasised in the NSW consultation that there is flexibility in the referral pathways across the state, in an attempt to utilise available resources and increase participation.</i>

State / Territory	Ages of Vision Assessment	Test/s Used	Primary Screeners	Community Engagement	Referral Criteria	Referral Pathways
Australian Capital Territory <i>Neonatal red reflex check is conducted.</i> <i>Integrated School Health Screening (combined with hearing & growth)</i>	1 – 4 wks; 6 – 8 wks; 6 – 9 mths; 18 mths; 3 – 3.5 yrs 5 – 6 yrs (7 yr old child can be screened if screened later in the school year)	Parent questionnaire to identify concerns; family history. Sheridan-Gardiner; Snellen linear	Child & family health nurse School nurse	Community health clinic School	- V.A 6/9 both eyes 5 yr old = pass; re-test at 6 yrs recommended. V.A 6/9 in one eye = referral. V.A 6/6-1 acceptable for 5 – 6 yr old. Refer also: squint, asymmetric ocular movements, uneven light reflexes, unable to converge, ptosis.	- School nurse → GP / orthoptist / optometrists
Victoria <i>Neonatal red reflex check is conducted.</i> <i>Integrated</i>	2 wks; 4 wks; 4 mths; 12 mths; 18 - 21 mths; 2 yrs; 3.5 yrs; 4 - 5 yrs 5 – 6 yrs	Parent questionnaire; assess visual behaviour & relationship between vision + fine motor skills; MIST LEA?	Child & family health nurse School nurse	Community health clinic School	- -	- -

State / Territory	Ages of Vision Assessment	Test/s Used	Primary Screeners	Community Engagement	Referral Criteria	Referral Pathways
<p>Tasmania</p> <p><i>Neonatal red reflex check is conducted.</i></p> <p><i>Integrated with Child & Family Health checks</i></p>	1 – 2 wks; 6 – 8 wks; 6 mths; 18 mths; 3.5 yrs; 5 – 6 yrs (school entry)	<p>Parent questionnaire (all ages up to school); assess visual behaviour (all ages); following (6 – 8 wks); corneal light reflection (from 6 – 8 wks); cover / uncover test (from 6 mths); visual acuity (Sheridan-Gardiner:</p> <p>3.5 yrs; Snellen: 5 – 6 yrs)</p>	Child & family health nurse	Community health clinic	<ul style="list-style-type: none"> - Light reflection consistently unequal child <1yr = obvious strabismus. - Movement / flicker of uncovered eye when performing cover test - Light reflections remain unequal (eye turns) when tired or feeding – refer at 1 yr <p>3 – 4 yrs: 6/9 in both eyes = normal. Repeat test in 4 wks if concentration lost or small discrepancy. On re-test – test eye with lesser result first. Refer > 1 line difference: 6/6, 6/9, <6/9.</p> <p>5 yrs +: 6/6 in both eyes = normal. Repeat test in 4 wks if concentration lost or small discrepancy. On re-test – test eye with lesser result first, can use SG instead of Snellens. Refer <6/6 – 3.</p>	Nurse → GP / orthoptist → ophthalmologist. <i>Referral to ophthalmologist occurs via GP.</i>

State / Territory	Ages of Vision Assessment	Test/s Used	Primary Screeners	Community Engagement	Referral Criteria	Referral Pathways
South Australia <i>Neonatal red reflex check is conducted.</i> <i>Integrated with Child & Family Health checks</i>	1 – 4 wks; 6 – 8 wks; 6 – 9 mths; 18 mths; 2 – 3.5 yrs	Parent questionnaire; assess visual behaviour & appearance at all ages; corneal light reflex at 6 – 9 mths.	Child & family health nurse + Aboriginal health workers	Community health clinic	-	-
	4 – 5 yrs	Sheridan-Gardiner	Child & family health nurse	Community health clinic; preschools	4 of 6 correct at 6/9 = pass V.A 6/12 or 6/18 requires treatment	Nurse → orthoptist → GP → ophthalmologist Nurse → GP → ophthalmologist if significant difference between eyes
Northern Territory <i>Neonatal red reflex check is conducted.</i> <i>Trachoma screening for remote communities 5 – 15 yr olds, annually</i>	Child & family health checks	Parental questionnaire to identify concerns	Child & family health nurse; Aboriginal Health Workers; Regional Eye Health Co-ordinators	Community health clinic; school sites used in rural areas	-	-
	3.5 – 4 yrs (prior to school) <i>Integrated</i>	LEA Symbols; light reflex; cover / uncover test	As above	As above	V.A 6/9 = pass V.A 6/12 or 2 lines difference = fail	Eye health concerns → GP V.A concerns → optometrist

State / Territory	Ages of Vision Assessment	Test/s Used	Primary Screeners	Community Engagement	Referral Criteria	Referral Pathways
Western Australia	8 wks; 3 – 4 mths	Universal visual appraisal	Child & family health nurse	Community health centre	-	Nurse → GP → ophthalmologist
<i>Neonatal red reflex check is conducted.</i>	8 mths; 18 mths	Visual appraisal; movement; strabismus	Child & family health nurse	Community health centre	4 yrs: Test to 6/7.5. V.A 6/12 = pass. Refer with 2 lines difference. Re-test + refer V.A <6/12 in 2 mths. Re-test in 12 mths if passed but skipped symbols & 1 line difference Re-test in 12 mths 2 lines difference. Re-test in 2 mths if child non-compliant 5 yrs: Test to 6/6. V.A 6/9.5 = pass. Refer with 2 lines difference. Re-test + refer V.A <6/12 in 2 mths. Re-test in 12 mths if passed but skipped symbols & 1 line difference Re-test in 12 mths 2 lines difference. Re-test in 2 mths if child non-compliant 6 yrs: Test to 6/6. V.A 6/9.5 = pass. Re-test in 2 wks + refer V.A <6/9.5; or passed but skipped symbols & 1 line difference Immediate referral if child non-compliant.	Nurse → GP → ophthalmologist
<i>Integrated school entry screen</i>	4 – 5 yrs (universal vision + hearing + targeted developmental assessments)	4 page parental questionnaire; LEA or Sheridan-Gardiner (SG used historically)	'Vision' nurse (+ 'hearing' nurse) Remote area nurse in regional areas	School		

The 'Healthy Kids Check'

When consultation participants were asked about current vision assessment practices, many raised the vision assessment component of *The Healthy Kids Check* (Australian Government, Department of Health & Ageing, 2008). While there was support for a developmental health check, such as this one, some specific concerns were expressed:

- Lack of protocols, guidelines and support for the assessor (eg. does not specify distance at which to conduct the vision test), possibly compromising the test results.
- Does not meet the criteria for a universal screening program by encouraging the General Practitioner or Practice Nurse to test Visual Acuity *if necessary*.
- There is a poor uptake of *The Healthy Kids Check* across the country (except in the Northern Territory), and data on who it is reaching does not seem to be available.
- No data is shared between or within jurisdictions – primary screeners are unaware of who has seen their General Practitioner or Practice Nurse for *The Healthy Kids Check* which may result in unnecessary duplication of effort.

The participants discussed these issues as important considerations for a universal vision screening program and emphasised that they should be addressed prior to implementation of such a program. Emphasis was also placed on the need for adequate time to be allowed for a vision screen (as with all health consultations) and questioned the amount of time available for the vision component that is integrated into *The Healthy Kids Check*, as it currently exists.

Current barriers to engagement and treatment

The consultation participants identified four main barriers that are currently perceived to be preventing maximum family engagement with services and further treatment. Whilst the specifics of each barrier differ both across and within states and territories, the main barriers are shared across the country.

- Cost:
 - The cost associated with consultation and / or treatment (ie spectacles, surgery) can be significant. There are current schemes for spectacle

subsidisation across Australia but they are often restricted to low-income earners and proving eligibility can be a difficult and involved process.

- There are costs for families associated with taking time off work to attend a child consultation, any travel and accommodation required, and child care for other children in the family.
- Understanding the importance of treatment:
 - Many consultation participants reported that parents have a common misunderstanding that a vision screen is diagnostic and the 'final step', resulting in lower rates of those following up with treatment.
 - This was noted as a particular concern for rural and remote Aboriginal communities in the Northern Territory where treatment options are not valued for their impact on visual impairment (ie. wearing glasses).
- Accessibility of services:
 - In order to increase engagement, families require services that are geographically accessible, and with reasonable waiting list times.
 - The consultation data indicated a correlation between a specific region, and families' ability to access the required primary care and specialist services. This is discussed further in the next section, however, it was generally reported that as the child's needs required a more specialised professional (such as a paediatric ophthalmologist), the availability of professionals was significantly lower than primary screeners, particularly in rural and remote areas of Australia.
- Referral pathways
 - The numbers of steps in some current referral pathways was raised as a barrier to the following-up of treatment for vision impairment. The participants believed that a referral process with 3 – 4 steps involved would be a deterrent for families to continue with the process, particularly those with limited resources.
 - It was also noted that families often encounter **multiple** barriers to receiving treatment, such as cost and limited access geographically, to the required eye-health professionals.

Recommendations reflecting consultation participants views

The consultation data was useful in identifying practical and jurisdictional considerations in developing a nation-wide screening program. The consultation participants identified the age, tests and service-platforms that are the most appropriate for maximum engagement, a visual acuity cut-off for onward referral, referral pathways and resources required to implement a screening program, including personnel. The participants also identified possible community education and data collection strategies to support a nation-wide screening program. It is evident that a 'one-size-fits-all' approach will not suit the diversity of the Australian context, and participants suggested that a flexible approach would allow for the most efficient use of resources.

Ages

Neonatal

In the initial stages of the project, the components of a screening *program* (compared to a *test*) were clearly identified and an explanation was provided at the consultations. The participants acknowledged that whilst the *neonatal check* may be better described as good clinical practice rather than a screening program, retaining this component of the visual surveillance schedule was seen as imperative. Assessing for congenital defects, particularly testing the red reflex, is a widely accepted and supported component of the various child and family health programs available in Australia, and the consultation data supported the literature in recommending this test be retained.

However, there was some discussion regarding the most appropriate developmental age for this test. Some participants believed that it should be conducted prior to the newborn leaving the hospital; whilst others believed that within the first six to eight weeks following birth was appropriate. It was reported that conditions are often identified in the few weeks following the birth, especially by parent concern.

Consultation participants did emphasise that whenever the test is conducted, it is important that it is conducted thoroughly and not just a 'tick' on a checklist required to discharge the mother and baby. It was suggested that child and family health nurses could follow-up that a newborn vision check has been conducted when a family visits when their child is 3 – 6 months old.

The participants supported retaining a neonatal vision check – although congenital eye conditions are rare, it is important that the opportunity to identify them shortly after birth in the universal health system is taken.

Preschool Age

During the consultations, the participants were asked when they believed was the best time to implement a screening program for children for amblyopia, strabismus, refractive error, and diminished visual acuity (VA). Their responses were based on a number of considerations:

- The most appropriate developmental age
 - Visual pathways development
 - Compliance – attention, literacy skills
- Engagement (ie. child and family health nurse visits; preschool; school)
- Opportunities for treatment (waiting lists)

The following table outlines the suggestions made by the majority of the participants:

Age Range	Developmental Context	Opportunities for Participation	Treatment
3 – 4 years	Most appropriate age (3.5 – 4 yrs) <ul style="list-style-type: none"> - More reliable VA measurements. - Children are able to do a simple visual-acuity test from 3 yrs. 	Challenging <ul style="list-style-type: none"> - 3-5 yr old preschool programs, however, engagement is not universal. Allow a wider age range to increase engagement (ie 3.5 – 4.5 yrs). - Child & family health nurse visits, but current rates of engagement are low. 	Suitable <ul style="list-style-type: none"> - Current waitlists for follow-up screen (where necessary) vary across jurisdictions but can be up to 3 mths & 12 months for treatment. - Treatment with patches more is suitable than for 4-5 yr old.
4 – 5 years	Appropriate age <ul style="list-style-type: none"> - Vision testing can be accurately performed on most children. - Opportunity to diagnose & treat prior to school. 	Increased opportunities <ul style="list-style-type: none"> - The Universal Access to Early Childhood Education initiative aims to increase 4 yr old preschool participation. - Can be linked with immunisation schedule. 	Suitable <ul style="list-style-type: none"> - Current waitlists for follow-up screen (where necessary) vary across jurisdictions but can be up to 3 mths & 12 months for treatment. - Outcomes from screening at 5 yrs do not differ significantly from screening at 4 yrs. - Vision problems may have been undiagnosed for 4 – 5 yrs + 1 yr for treatment.

School entry (5 – 6 / 6 – 7 years)	- Increased co-operation & literacy skills.	Universal platform - Considering the differing ages of school entry across Australia and the current trend to delay school start until children are closer to 6 years.	Least appropriate - Due to length of time required for treatment. - Less time before the period of visual plasticity expires in which to intervene. - Major study has found cut-off age 5 for most effective treatment. - Some negative social consequences associated with treatment, ie. children with eye patches may be bullied at school.
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NB: This table represents the advantages and disadvantages of a screening program specifically for amblyopia, for children aged 3 – 5 years presented by the consultation participants. Emphasis was placed upon the wide range of developmental abilities that children of the same age may demonstrate, and the importance of considering this when designing a screening program.

Overall, consultation participants agreed that an age range of 3.5 – 5 years is the most appropriate age for a vision screening program, in consideration of the evidence, current practice and opportunities for engagement.

Screening at multiple points in time

Whilst in all state and territories the possibility of evaluation of vision in some form or other occurred at many points in time, in most situations greatest emphasis was placed on screening at one point in the preschool years, and in many cases there was a low participation rate. Participants in the focus groups in general agreed that working towards a high participation rate at one screen during childhood was a reasonable goal.

Tests

It is clear that the current practice around the test that is used across Australia differs according to the jurisdiction, and even down to individual screeners and child being tested. In each consultation, practitioners discussed the methods that they, and their colleagues, employed to individualise their vision screening or testing practice. As mentioned, many of the methods were individualised either for families, or for a wider community of people, however, common principles to determine test suitability were identified in the consultation data.

- Screeners require a suite of visual acuity charts from which to choose, in order to match the test to the child’s developmental ability.

For example, in NSW, it was felt that the most suitable test for 4 year olds is the

Sheridan-Gardiner, however, the LEA symbols were felt more suitable for this age group in the Northern Territory.

- The charts and associated materials need to be portable and allow for flexibility in delivery
- Adequacy of lighting is important, to ensure natural light does not vary the results
- Screeners require appropriate initial and ongoing training
- The chart should:
 - Measure visual acuity (avoid a pass / fail symbol set at a certain acuity)
 - Use a 'crowded' arrangement of letters, either in a row or a grid (see Appendix 4 for further information)
- There were differences of opinions regarding :
 - Using one or multiple lines
 - Use of a matching board
 - Using single letters
- A small number of participants discussed the opportunity to include near and distance monocular vision and near binocular vision, as well as amblyopia.

Current practice allows for a great degree in flexibility, allowing choice of test, and it is evident from the consultation data that due to Australia's geographical size and diversity, it is vital that this is a key consideration in the development of any screening program.

A small number of participants believe that including a near-distance test in a screening program is an important consideration, especially due to the increase in working closely with screens (computers; iPods) in the classroom.

Most participants felt that parents/caregivers should be asked about visual concerns when they were seen as part of current child health surveillance programs, and concerns followed up accordingly. In addition, all agreed that if parents had concerns there should be clear and accessible pathways to enable a full vision evaluation.

One participant offered information regarding current development of visual acuity and other vision screening tests. These technologies are being developed by the Lions Eye

Institute Ltd, Western Australia, are designed for ease of use by trained lay-people for a population base screening program, and include a database feature.

In summary, the consultation data clearly identified that a suite of visual acuity tests are required as a component of a universal screening program. This will allow professionals to choose the most suitable test for the circumstance. Participants were confident and comfortable with the specific tests they are currently using, however, they indicated the importance of high standard tests.

Visual Acuity Cut-off for Onward Referral

There was consensus amongst the consultation participants that a suitable visual acuity cut-off for onward referral was *if there are two or more lines difference between the eyes or less than 6/9 in any eye* (though there was some difference in the number of letters or symbols needing to be identified in order to constitute a pass on this criteria). They expressed that clear guidelines are required, particularly if the vision screening program will cater for an age range such as 3.5 – 5 years. For example, a child's age and developmental level need to be considered, a 5 year old child with vision of 6/12 requires more urgent attention than a 3.5 year old with the same vision, due to typical visual development.

It was generally agreed that it is more ethical if there is an over-referral rate for evaluation, especially if non-eye-health professionals are conducting the primary screen. One participant supported the 6/9 cut-off level because of the understanding that approximately 20% of amblyopes are mild and require a lower cut-off level to identify.

The participants were in support of having clearly defined referral criteria, including the opportunity to refer when there were concerns, even if passing the vision testing.

The agreed visual acuity cut-off for onward referral was if there are two or more lines of difference or less than 6/9 in either eye. However, most of the participants agreed that since there is an age variance in acuity, the referral cut-offs should be tailored accordingly to reflect this.

Screening Personnel

Primary Screeners

The participants made the following comments and suggestions regarding primary screening personnel:

- Initial and ongoing training is vital to ensure screening is conducted appropriately and accurately.
- It was suggested that the accreditation of screeners be considered, with clear protocols for practice.
- An 'umbrella' organisation, such as the state Children's Hospital could oversee the program in each state or territory.
- There were differences of opinion regarding the use of trained lay-people as screeners. However, if lay-people are employed as primary screeners, there was strong agreement that the referral process should refer children on to an eye-health professional, rather than a General Practitioner.
- Child and family health nurses are working well as the main current primary screeners, however, the workforce requires development if a universal screening program was implemented.
- Regional eye health co-ordinators and Aboriginal health workers were suggested as appropriate people to involve as primary screeners.
- A significant number of participants strongly expressed concern regarding a potential conflict of interest if primary screeners were also the provider of prescriptions as treatment. However, they also felt that an appropriate accreditation program and screening protocols would minimise this issue.

The themes identified within the consultation data indicated that the current involvement of child and family health nurses, optometrists and orthoptists as primary screeners was deemed appropriate by the participants for any future program, however the need for significant workforce development was strongly emphasised. The introduction of new screeners requires adequate initial and ongoing training.

Evaluation stage

There was agreement amongst child and family health nurses and eye health professionals, that if the primary screener is not an eye-health professional, then it is important that an eye-health professional conduct an evaluation. Child and family health nurses understand that it is not their role to make a diagnosis, and felt that an eye-health professional was an appropriate next step.

Accredited optometrists and orthoptists were suggested as capable of conducting an evaluation to confirm visual acuity. A participant reported that orthoptists working in the ACT's public health system as secondary screeners are valued by families and seen as 'bi-partisan'.

The principle of involving a family's General Practitioner as a step in the referral process leading to evaluation or assessment was understood as it involves the family's main health care professional; however some participants questioned the efficiency of use of resources and believed that a more appropriate referral pathway could be developed.

It was suggested by the participants that an evaluation be made by a suitably trained eye-health professional who is capable of making a diagnosis and appropriate treatment, or onward referral.

Referral Pathways

The referral pathways are dependent on a number of factors, and as just discussed, primarily upon who conducts the initial screen. As discussed, the direction identified from the consultation data, involves an eye-health professional as the secondary screener, especially if the initial screen is conducted by a trained lay-person, child and family health nurse, or other non-eye-health screener.

The participants identified the following points for consideration:

- The referral pathway must be clear, and relatively simple.
A 4 step referral process, such as nurse → orthoptist → GP → optometrist, may be a barrier to family engagement.
- Include a referral to an eye-health professional as a second step.
- Consider geographic accessibility
For example, in some jurisdictions, primary screeners can only refer to a GP or an optometrist, not an ophthalmologist, but an optometrist is not available in the area. In other areas, the primary screener can only refer to an ophthalmologist but it is more acceptable and accessible for parents to be referred to an optometrist.
- In order for the criteria for a screening program to be met, the referral pathway must include treatment, including opportunities to follow up families for treatment.

- If the Government provides a universal screen, it is important that they also remove any financial barriers to treatment and provide treatment as well. *Treatment may be as simple as a review in 3 months or convergence exercises, and not always treatment by an ophthalmologist.*
- The workforce needs to be developed at all stages of the referral pathway – primary and secondary screeners, as well as professionals providing treatment. *Current waiting times are a deterrent to treatment.*
- An appropriate system for collecting data is essential, and resources need to be made available to process data and use it to provide feedback to primary screeners, monitor and evaluate current programs and inform future practice. *It was mentioned in most jurisdictions that data has been collected for decades but resources to process the data are lacking.*

The participants indicated that in order to maximise family engagement, referral pathways must be determined by the needs of, and resources available in the region and in consideration of the challenges provided by Australia's geographical size and population diversity and sprawl. Participants emphasised the need for treatment to be included in the referral pathway and funded as part of a vision screening program.

Community Education

Community education is not a formal component of a screening program; however, the participants reported a need for a community education program to be incorporated into any screening initiative that is implemented for the following reasons:

- Raising general eye health awareness is important:
 - To enable parents and children to be conscious of vision health.
 - To empower parents to raise concerns with a professional.
- Raising awareness about the importance of vision screening:
 - This is of particular importance considering the increased demands on parents, such as adhering to a child and family health nurse visit schedule.
 - To alert parents to the dynamic nature of vision health, that the screen is only a 'snapshot', and that vision health may change over time.
- Raising awareness about the importance of treatment following screening.

- Clarify misconceptions
 - Parents may perceive the screen as a total / definitive / sufficient vision check.

Community education was identified by the participants as a necessary component of a vision screening program.

Resources

Due to the lack of consistency in the approach to vision screening across Australia, there are a range of resources that would be required in order to implement a universal program and the requirements of each jurisdiction differ.

The need that currently exists, and the need that was emphasised by all of the participants was the need for workforce development. It was reported that the current workforce is unable to meet the demands with current practice and since these programs are not reaching all children, a universal program will only increase demands. All levels of the workforce were reported as requiring development: ophthalmologists, orthoptists, optometrists, child and family health nurses, and others involved in primary screening such as General Practitioners.

- The orthoptist workforce was reported as lacking in Queensland, Western Australia, South Australia, and the Northern Territory.
- One public ophthalmology unit is available in the ACT.
- There are no resident paediatric ophthalmologists in the Northern Territory. Consultant ophthalmologists and registrars provide support for short periods of time.
- Referrals to GPs in rural Western Australia are not always practical as there may be no GP available, and no visiting GP. The ACT has the lowest rate in the country of bulk-billing GPs.
- Optometrists are easily accessible in urban areas of the Northern Territory but less available in rural and remote regions. It was also reported that the funding to encourage optometrists to practice in remote areas is often insufficient.

Consultation participants reported that there are insufficient numbers of eye-health professionals and that the distribution of professionals across the country is unequal,

resulting in some regions being unable to access services when required. This was raised by many participants and in all of the consultations, and discussed as a barrier to service engagement. In rural Australia especially, significant costs are currently incurred by families for travel, child care, accommodation and meals, in addition to service and treatment costs.

It was raised in each consultation that there is a real need for financial assistance for eye care for some families in Australia. Whilst there are some schemes available, they were reported as having strict eligibility criteria and the service system can be difficult to navigate. The participants believed that engagement with services and following up with treatment will improve if these financial barriers are relaxed, or removed.

Some areas of rural and remote Australia are currently employing creative ways to increase their engagement with families. Area and Aboriginal health workers, having the advantage of working with smaller populations, are able to 'get to know' their communities and therefore the approach to follow-up is individualised. Professionals in other regions reported that by developing relationships with families, they were able to better meet their needs, for example, if a parent attends a child and family health clinic for their 4 year old's immunisation and the nurse is aware they also have a 7 week old infant, the nurse will combine the developmental health checks to convenience the family.

To summarise, the most significant resource required across Australia is workforce development, at all levels. The participants reported that they will also require funding to acquire the required resources to implement the screening program, follow-up, outreach programs and additional methods to increase engagement. They indicated that resources to subsidise treatment and the provision of spectacles was of equal importance to workforce development and program funding.

Data Collection

Data collection was reported as a part of current practice in most states and territories across Australia. The participants believe that there is an opportunity to build upon current data collection systems to improve them, with emphasis on the development of a national database for vision screening as part of a wider health database.

The approach to data collection is currently inconsistent and the participants identified areas of information that are not currently included in the collection.

In the Northern Territory, there are a few different databases being used across the region and there is no consistent approach to data collection. Professionals in South Australia reported a lack of time and resources to process the data. The database in the ACT does not reflect those who have been referred but have never followed up treatment, nor does it reflect treatment.

The following suggestions were made:

- A database is important to gather evidence and data to fully assess the effectiveness of the program.
- A national database is important to improve the services that professionals can provide and ensure resources are allocated appropriately.
- To include a feedback system, providing feedback to primary screeners regarding diagnosis and treatment.

Considerations for children who may require 'more' than a universal screen

The introduction to the consultations outlined groups of children that the Project Advisory Group and project team decided during the inception of the project to require a more comprehensive vision assessment. These children include those who are born prematurely (birth weight <1500g), children with developmental delay or disability, and Indigenous Australians at risk of trachoma. It was also decided that it is outside the scope of this project to determine the specific requirements that these groups may have.

The discussion focused on the principle of offering a universal screen, and that therefore these children should be included in the screening program; however, systems are required to ensure that they receive additional vision assessments.

It was reported that in Glasgow, UK, children with a developmental delay or disability are screened first to ensure their engagement and that sufficient time is available for further referrals and treatment.

There was general consensus that groups at higher-risk of visual impairments require a system that has a clearly identified criterion for inclusion and is consistently monitored to ensure their engagement.

Children with developmental delay or disability

The participants believed that it is important for children with a developmental delay or disability to be included in a screening program to aid the identification of visual impairments; however, because this group can be more difficult to test, many require a more formal evaluation. There is a risk that if a child has a significant disability (such as cerebral palsy), there may be more focus on intervention for their physical disability and feeding, and vision becomes less of a priority.

A small number of primary screeners indicated that compliance is not always an issue as the child's peers can act as positive role models for the test.

Premature infants

The participants did not feel suitably qualified to make suggestions regarding the vision screening of premature infants.

Aboriginal communities

Indigenous Australians experience specific vision problems and professionals often encounter challenges to engagement in screening and treatment programs. The following themes were identified in the consultation data:

- Indigenous Australians should be included in a universal screening program.
- Screening should include trachoma screening where indicated.
- The incidence of eye-injuries was reported as high in Aboriginal communities.
- It is believed there may be a lower incidence of myopia – the averages reflected in statistics may not accurately reflect the prevalence rates of specific regions.
- The current practice of community nurses and Aboriginal health workers conducting the screens through outreach programs in the Northern Territory was reported as a successful method of engaging these communities. *These professionals 'know' who is in their community and target families who are not engaging with services.*
- Barriers to engagement may be slightly different for Aboriginal Australians.
 - Cost, accessibility and waiting times are common barriers. There is a lack of optometrists, orthoptists, ophthalmologists and no paediatric ophthalmologist is located in the Northern Territory.

- It is not yet culturally accepted to wear spectacles and there is a lack of understanding about degenerative eye conditions.
- Tests may be culturally inappropriate or irrelevant. Screeners are required to be flexible in their delivery to meet the individual needs of the child.

Further Research

The consultation participants confirmed the finding from the literature review that there is a lack of evidence from the literature on which to base their practice. Some expressed their frustration that the lack of data impedes their ability to strongly advocate for improvements to their vision screening practice. The following opportunities for further research were identified:

- There is an overall need to use data collection and evidence to place a scientific framework around vision screening.
 - This will include monitoring, evaluation, quality assurance, workforce development.
- Research is required in the area of functional vision and its impact on education.
 - This was identified in the 1998 NHMRC document, *A Guide to the Development, Implementation & Evaluation of Clinical Practice Guidelines*, but omitted from the 2002 report, *Child Health Screening & Surveillance: A Critical Review of the Evidence*. This research opportunity has not been followed up and still exists.
 - Evaluations of screening programs for school-age children are required, that aim to identify issues with functional vision, rather than only visual acuity.
- Research is required on the impact of vision impairment on a person's mental health and well-being (during childhood, as well as when older).
- Whilst randomised controlled trials might be the ideal means of determining the benefits of an intervention, it is possible that in some areas of vision research in children such a study design is no longer ethical. As a result, case studies and other designs could be used as a form of evidence and data collection. Direct comparison of the effectiveness of preschool versus school entry vision screening

would be helpful, as the logistics and coverage of school entry screening would often be better.

- A better understanding of the best way to facilitate identification of congenital vision problems is required, and in particular what if any follow-up to newborn evaluation is indicated.
- A greater emphasis is required on cost effectiveness evaluation, particularly incorporating the impact of vision problems on mental health and wellbeing.

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Appendix Four: Characteristics of Visual Acuity Tests

Introduction

Visual acuity

A variety of tests have been developed to assess visual acuity (VA), a measurement of the finest detail the visual system can detect.

Optotypes

Each test makes use of different optotypes, referring to the individual symbols or letters presented on the testing instruments. The main optotypes used are letters (such as H,O,T and V), or symbols (such the LEA symbols). Symbols generally are more readily acceptable to children, although letters can be used across the lifespan.

Testing charts

The main tests referred to in this project fall into four main categories: the Snellen chart, LogMAR chart, single line and single optotype tests. A fifth and unique test is the LEA crowded book. These tests differ in the pattern they present their optotypes (eg: the LEA logMAR chart makes use of LEA symbols arranged in a LogMAR pattern).

1. Snellen charts: Developed by Snellen in 1862, Snellen charts are amongst the most used charts to measure vision and VA. Due to space constraints, the lines for lower VA have fewer optotypes (due to their increased size). The Snellen chart features 11 lines of progressively smaller optotypes, ordered in an arithmetical pattern, leading to less accurate test results
2. LogMAR charts: Developed by Bailey and Lovie in 1976, the LogMAR chart has gained acceptance in clinical and research settings, for having a higher accuracy in VA testing compared to Snellen charts. The charts feature the same number of letters on each line, that progressively reduce in size according to a geometrical progression, leading to more accurate test results.
3. Single line tests: These test charts are single lines of optotypes calibrated to Snellen or LogMAR charts, used to test children who have problems dealing with the complexities of complete Snellen or LogMAR charts.
4. Single optotype tests: These tests present a single optotype, used when a patient is unable to deal with the complexities of single line tests, or Snellen and LogMAR charts.

5. LEA crowded book: A unique test is the LEA crowded book, in which 5 optotypes are arranged in a cross pattern. In a similar fashion to the single line tests, this is meant for patients for whom the complete LogMAR or Snellens charts are too complex.

Crowding

An important phenomenon in the context of testing VA is called “crowding”, which affects amblyopes much more extensively than non-amblyopes. As optotypes on a chart come closer together, the opposed edges appear to merge together, making them more difficult to discern than if the optotypes were presented individually.

This phenomenon is particularly important at the edges of charts, where optotypes are incompletely surrounded by other optotypes, meaning that crowding does not occur on all sides. Thus, optotypes on the edges are more visible than optotypes that are completely surrounded (and hence blurred) on all sides.

In addition, some tests such as single optotype tests lack the crowding phenomenon all together, thus resulting in a better level of vision than if a complete chart was used.

Matching

It is assumed that the target population of this project would have minimal literacy skills. To avoid false results, patients would be required to identify optotypes by pointing to a separate list of optotypes provided to them. However, patients who are sufficiently literate may rather name out the optotype.

	Age	Advantages	Disadvantages
Traditional Snellen charts	3 yrs +	<ul style="list-style-type: none"> - Notation is simple and understandable - Provides VA figure - Crowding phenomenon lower down the chart → accurate for mild VA loss 	<ul style="list-style-type: none"> - Reduced crowding on early lines → inaccurate results - Fewer large letters – less accurate for low vision - Many inconsistencies between lines → inaccurate results for larger letters - Notation is not sensitive
Sheridan Gardiner - Single letter test	2 – 5 yrs	<ul style="list-style-type: none"> - Better compliance and attention - Portable (single letter) - Prepares child for future letter charts - Short testing time - 	<ul style="list-style-type: none"> - Lacks crowding phenomenon → inaccurate results
LEA LogMAR chart - LogMAR Symbol chart	3 – 5 yrs (May be hard for younger patients)	<ul style="list-style-type: none"> - Crowding effect → more accurate - Multiple sets of symbols in bottom row to minimise memorising 	<ul style="list-style-type: none"> - May be too complex for younger children - Potentially confusing notation (VA better than 6/6 has negative score) - May be large and difficult to transport
LEA Crowded book - 5 Symbol arranged in a cross	3 – 5 yrs	<ul style="list-style-type: none"> - Simpler than LEA charts → Better attention of children - Crowding for middle symbol - Equal legibility of symbols - Better portability 	<ul style="list-style-type: none"> - Minimal crowding effect → inaccurate results
LEA Single Optotype - Single symbols	3 – 5 yrs	<ul style="list-style-type: none"> - Simplest test → Best compliance and attention - Most portable (single letter) - Equal legibility of symbols 	<ul style="list-style-type: none"> - Lacks crowding phenomenon → inaccurate results

HOTV LogMAR chart - LogMAR Letter chart	3 – 5 yrs (May be hard for younger patients)	<ul style="list-style-type: none"> - Letters are appropriate for age - Can be used in limited space (letters can be used in a mirror) - Standardised crowding effect → more accurate - Preparation for future letter charts 	<ul style="list-style-type: none"> - Charts may be too complex for younger children - Potentially confusing notation (VA better than 6/6 has negative score) - Charts may be large and difficult to transport
HOTV single line - 4 letters on a line	3 – 5 yrs	<ul style="list-style-type: none"> - Better attention of children than a complete chart - Letters are appropriate for age - Can be used in limited space (letters can be used in a mirror) - Horizontal crowding effect - Preparation for future letter charts 	<ul style="list-style-type: none"> - Lacks vertical crowding phenomenon → inaccurate results
MIST matching tests - Single letter pass/fail test (based on Sheridan Gardiner)	3 – 4.5 yrs	<ul style="list-style-type: none"> - Pass/fail test → easy interpretation and implementation - Quicker to perform than other VA tests 	<ul style="list-style-type: none"> - Lack of VA data for analysis - Lacks crowding phenomenon → inaccurate results

	Age	Advantages	Disadvantages
Red reflex - Ophthalmoscope based examination	0 – 2 yrs	<ul style="list-style-type: none"> - Detects significant conditions - If performed correctly, results are readily interpreted - Quick and easy to perform (if patient compliant) - Minimal equipment required 	<ul style="list-style-type: none"> - Patient may be non-compliant - Red reflex may be difficult to elicit