National SCIENCE Challenges

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Brief Evidence Reviews for the Well Child Tamariki Ora Programme

Report submitted to MoH on 11 December 2019

Whakapūpūtia mai ō mānuka,
kia kore ai e whati

Cluster the branches of the manuka,
so they will not break

Foreword

The Ministry of Health is responsible for the development of policy advice on children's health and the future direction of the Well Child Tamariki Ora (WCTO) programme. The WCTO programme is the universal health service in New Zealand, which is responsible for protecting and improving the health and wellbeing of children from birth to 5 years of age. This is achieved through health and development screening and surveillance, whānau care and support, and health education.

The current programme is based on the evidence available at the time of the last programme update in 2007. Therefore, the Ministry of Health is reviewing the current WCTO Framework and associated Schedule (developed in 2002) to ensure that WCTO services meet the current needs of children and their whānau, and address the issues they face. The present review was initiated in 2019 and is the second review of the programme, as the first was carried out in 2006. In preparation for this review, the Ministry of Health has commissioned an evaluation of the recent literature on some of the new and emerging issues for preschool children, as well as possible ways to address them.

The purpose of this review includes ensuring that the programme is underpinned by the latest research and evidence. This is particularly pertinent to the current Schedule of Universal Contacts delivered, and one of the work-streams of the review is to consider the timing, content, and intensity of the Schedule, and associated additional contacts. This work stream will support the development of an integrated framework of universal wellbeing contacts for the pregnancy to 24 years of age life course.

The Ministry of Health require the brief evidence reviews (BERs) to synthesise relevant evidence about what works in key areas for children, including development, vision, hearing, emotional and mental health, and growth. The BERs adopted the He Awa Whiria – Braided Rivers approach and include consideration of what will work for Māori tamariki and whānau, and Pacific children and families within each domain. The BERs have helped to identify any knowledge gaps where further work and research may be needed, to inform further development of the WCTO programme.

The WCTO review is a key health contribution to the Government's Child and Youth Well-being Strategy. It forms part of the Ministry of Health's work programme to transform its approach to supporting maternal, child, and youth well-being.

The Ministry of Health have commissioned A Better Start: E Tipu E Rea National Science Challenge to undertake 11 health related BERs that will inform the WCTO review and decision making on the future core service schedule, and additional health and social services for children in New Zealand. The aim of the BERs is to ensure that decisions are grounded in, and informed by, up-to-date evidence. BERs are intended to synthesise available evidence and meet time constraints of health care decision makers. Internationally health technology agencies have embraced rapid reviews, with most agencies internationally offering these alongside standard reviews. These 11 BERs that we have conducted have been performed in a very short time which was a very challenging task.

A Better Start is a national research programme funded by the Ministry of Business Innovation and Employment (MBIE). The objective of A Better Start is to improve the potential for all young New Zealanders to lead a healthy and successful life. To achieve this, A Better Start is researching methods and tools to predict, prevent, and intervene so children have a healthy weight, are successful learners, and are emotionally and socially well-adjusted. A Better Start consists of more than 120 researchers across 8 institutions.

The BERs cover 11 domains critical to the WCTO programme, which are: neurodevelopment (#1); parent-child relationships (#2); social, emotional, and behavioural screening (#3); parental mental health problems during pregnancy and the postnatal period (#4); parental alcohol and drug use (#5); excessive weight gain and poor growth (#6); vision (#7); oral health (#8); adverse childhood experiences (#9); hearing (#10); and family violence (#11). The BERs have synthesised relevant evidence about what works in key areas for children across these domains, which were assessed with careful consideration of what will work for Māori tamariki and whānau and Pacific children and families. They have also identified knowledge gaps where further work and research may be needed to inform further development of the WCTO programme.

Within each domain, a series of 6–14 specific questions were drafted by the Ministry of Health, and subsequently refined with input from the large team of researchers assembled by A Better Start. A Better Start established discrete writing teams to undertake each BER. These teams largely consisted of a post-doctoral research fellow and specialty expert, often in consultation with other experts in the field. Subsequently, each BER was peer reviewed by at least two independent experts in the field, as well as two Māori and a Pacific senior researcher. In addition, senior clinical staff from the Ministry of Health have reviewed each BER. These were then revised to address all the feedback received, checked by the editors, and finalised for inclusion in this report.

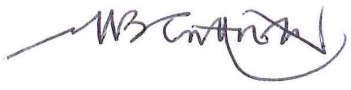
Whilst each of these domains are reviewed as discrete entities, there is considerably inter-relatedness between them. In particular, neurodevelopmental problems can be impacted by parent-child relationships, parental mental health, and pre- and postnatal drug exposure. Similarly, children who have problems with growth, vision, or oral health may also have neurodevelopmental disorders.

Most of the evidence available for these BERs comes from international studies with limited data from New Zealand, in particular there is limited information about Māori, Pacific, and disadvantaged families. These are the tamariki and whānau in whom the WCTO Programme services are more scarce, yet could potentially offer the greatest benefit.

The criteria for screening include the requirement for an effective and accessible intervention; the corollary is that screening should not be offered if there is no benefit to the individual being screened. The essential issue is therefore to identify those infants and preschool children and their whānau who would have better outcomes following intervention; this includes better outcomes for the whānau.

The current WCTO programme has had a greater emphasis on surveillance rather than screening. Many of the questions in the BERs address screening. A change in the WCTO programme that further extends into screening will require substantial upskilling of many WCTO providers, as well as redirection of resources. Importantly, Māori and Pacific iwi and community views must be considered before any new screening programmes are to be included.

It should be noted that a shift towards screening rather than surveillance may prevent health and behavioural problems. The economic benefits of prevention and early intervention are well documented, with early interventions showing that for every dollar spent there are substantial savings to health, social services, police, and special education resources.



Professor Wayne Cutfield
Director of A Better Start National Science Challenge
On behalf of the editors, authors and reviewers of the brief evidence reviews

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7 Vision screening in infancy and childhood

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Disclaimer

This brief evidence review was commissioned by A Better Start National Science Challenge (the Challenge) on behalf of the New Zealand Ministry of Health. It was prepared over a relatively short time based on the evidence available to the authors at the time of its preparation. The authors have made considerable efforts to perform a comprehensive and balanced evaluation of the existing evidence. However, this brief evidence review cannot be considered an exhaustive analysis of the existing peer-reviewed and grey literature on the topic, and it may not reflect the potentially conflicting views of all experts in the field. There could have been important omissions, and additional evidence might have also come to light since completion of this final draft. Thus, this brief evidence review should be considered with the appropriate caution. A previous version of this document was peer-reviewed by Māori and Pacific researchers and by independent experts in the field. Peer reviewers were anonymous, unless they have otherwise been identified by name. Please note that this brief evidence review does not represent the views of the Challenge or the Ministry of Health; rather, it reports the independent conclusions of the listed authors.

Vision is a potentially very broad domain encompassing a range of aetiologies and clinical presentations. The most common childhood vision conditions are refractive error and amblyopia which are suitable targets for universal screening. For this report, the authors were asked to focus on amblyopia (the main focus of the current population wide screening program in New Zealand), which can be severe and impact both eyes, but most often causes mild to moderate vision loss in one eye. Conditions that affect specific populations such as retinopathy of prematurity and cerebral visual impairment are beyond the scope of this review.

Conflicts of interest: Although unlikely to constitute a conflict, each author has a viewpoint from which they approached this work. Lisa Hamm is a vision science researcher involved in amblyopia research and development of open access resources for paediatric vision testing. Rebecca Findlay is an optometrist based at Counties Manukau DHB and PhD candidate at the University of Auckland. Joanna Black is an optometrist, vision science researcher, and Senior Lecturer based at the University of Auckland with interests in the areas of paediatric vision, amblyopia and refractive error.

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Abbreviations

B4SC	Before School Check
DHB	District health board
LMC	Lead maternity carer
RCT	Randomised controlled trial
VA	Visual acuity
VHT	Vision and hearing technician
VIP	Vision in pre-schoolers

Definitions

Amblyopia	Reduction in visual acuity in the presence of a risk factor and the absence of pathology
Anisometropia	Difference in prescription between the two eyes creating asymmetric focus
Astigmatism	Irregular curvature of the cornea or lens creating an unfocussed, distorted image
Hypermetropia	Long sightedness – when the eye is not in focus creating the need for excess ocular accommodation particularly when involved in near tasks
Myopia	Short-sightedness – when the eye is out of focus and distance vision is blurred
Strabismus	Abnormal ocular alignment or “squint”

Note: Definitions, including cut-off values and measurement protocols, differ between studies.

Summary

Childhood vision conditions should be detected and treated promptly to prevent amblyopia (abnormally developed visual pathways) and maximise educational outcomes. This report collates evidence about childhood vision screening, with a focus on amblyopia.

Internationally, the prevalence of amblyopia ranges from 0.5 to 5.3% with previous estimates from NZ of 3.5%. To prevent or minimise amblyopia, screening should be conducted as close to birth as possible using the red reflex test (to detect cataract), and during the preschool years, using visual acuity screening and/or autorefractors or photo screeners (to detect refractive error and potentially strabismus). These tests are non-invasive and fast, but test selection matters, and each test requires some training to conduct accurately. Following detection, initial treatment requires removal of risk factors, and spectacle correction. Moderate residual amblyopia is effectively treated with patching or atropine penalisation. Earlier treatment has better results and reduces distress associated with treatment. Although it appears that unilateral amblyopia has an impact, and that screening for and treatment of amblyopia is cost effective, more evidence is needed. There is stronger evidence for the impact and cost effectiveness of detecting and treating bilateral vision impairment.

Expanding the targeted conditions for screening warrants consideration; non-amblyogenic hypermetropia and astigmatism are currently not targets for screening, but there is growing evidence that when left untreated they are associated with reduced developmental and educational outcomes. For myopia, which develops later in childhood, prompt detection and treatment can reduce progression and the likelihood of future ocular pathology. Equity is a particular concern; although screening coverage overall is good, Māori and Pacific whānau are less likely to successfully participate in vision screening, and barriers appear to exist for referral and treatment.

Childhood vision screening can prevent or minimise amblyopia and promote educational outcomes. Improving our current vision screening programme could help us achieve these outcomes for all New Zealand children.

Literature search and selection

We carried out our search in August 2019. Databases and search terms as well as date and language restrictions used are summarised in Appendix I. In the first phase of the selection process, two authors independently reviewed the title and abstract of each of the 2274 unique results, leaving 365 potentially relevant documents. In the second phase of the selection process, two authors independently reviewed the full text of each potentially relevant document using inclusion/exclusion criteria which prioritised systematic reviews, randomised controlled trials and work done within New Zealand. In both phases of the selection process conflicts between authors were resolved by discussion or by input from a third author. Due to the wide range of topics addressed in the questions, we ran a supplemental (unstructured) search for individual questions to capture additional potentially relevant sources. The timeframe did not allow meta-analysis or robust quality checks. The overview of this process and details extracted from included documents are presented in Appendix I.

7.1 Background

7.1.1 What is vision screening intended to identify?

Vision impairment has a substantial impact on how a child interacts with the world, but poor vision may not be apparent to a child or their whānau. Early detection and treatment are important for learning and development[1]. Failure to detect reduced vision can prevent normal development of the visual pathways resulting in amblyopia[2,3]. The most common risk factors for amblyopia are refractive (blurred vision due to uncorrected refractive error), strabismic (unmatched retinal images due to ocular misalignment) and less frequently, deprivation (obstruction of the passage of light to the retina, for example cataract or ptosis)[2]. Amblyopia is less likely to develop, and more amenable to treatment if risk factors are treated promptly[2,4].

Screening programmes can be designed to identify amblyopia and its risk factors, non-amblyogenic treatable vision impairment (such as refractive error alone), and/or non-amblyogenic risk factors for general health (such as retinoblastoma, a rare vision and life-threatening malignancy). Targeted conditions and screening practices vary internationally[5,6], and can depend on availability of eye care for children[7]. Childhood visual impairment meets WHO criteria for population screening because vision impairment is an important health problem, it has an early symptomatic stage during which screening tests are acceptable, and there is acceptable treatment[8]. Although the value of detecting and treating severe bilateral vision impairment is well established, the value of population wide pre-school screening (which predominantly detects unilateral amblyopia, the more common form) is debated[7,9]. Due to the lack of research designed to compare screened to unscreened populations, Cochrane reviews have, to date, concluded that there is insufficient evidence for the effectiveness of childhood vision screening[10,11], while policy statements tend to cite sufficient indirect evidence to recommend universal screening[12].

7.1.2 Current screening practice in New Zealand

Current vision screening in New Zealand (NZ) includes formal vision screening at birth, six weeks, four years and eleven years[13] (Table 7.1). Surveillance questions for parents in the Well Child Tamariki Ora My Health Book are included in Appendix II.

Table 7.1. Vision screening appointments in current Well Child Tamariki Ora schedule

Screening	Age	Health practitioner	Test used
Newborn vision and eye examination	0-7 days	Lead maternity carer (LMC)	External examination, red reflex test, parent questionnaire
Six-week vision examination	6 weeks	General practitioner	External examination, red reflex test
Well Child checks	6 weeks –3 years	Well Child nurse	Review of questions in well child book with parents
B4 School Check (B4SC)	4-5 years	Vision and hearing technician (VHT)	VA test using Parr chart
Year 7 Vision Screening	11-12 years	Vision and hearing technician/school nurse	VA test using Snellen chart

The stated aims of the initial two checks are to detect and refer children with congenital eye abnormalities (newborn) and identify suspected visual impairment (six weeks). The aim of the B4SC is to identify children with amblyopia and those children unable to complete Visual Acuity (VA)

measurement[13]. The Year 7 vision screening is intended to identify any missed functional vision impairment, or newly developed conditions.

VA screening identifies vision impairment due to amblyopia but also due to some non-amblyogenic refractive errors. Hypermetropia and astigmatism tend to be present at birth or develop early in life, but are not always captured by the current VA test whereas myopia tends to develop during the school years. Strabismus is not directly screened for (large angle strabismus will often be detected by whānau, while functionally significant smaller angle strabismus is likely to be detected by decreased VA at the B4SC)[14].

7.1.3 Aims of this report

This brief evidence review attempts to collate evidence about childhood vision screening, as specified through nine questions provided by the Ministry of Health. As for vision screening overall, for many of the questions there is insufficient evidence to make conclusions with certainty, in these cases we have attempted to summarise *available* evidence in a balanced manner. Other groups have conducted more comprehensive evidence reviews addressing similar questions (many including robust quality checks beyond what the timeframe of this rapid review allowed). Of note are the 2004[15], 2011[16] and 2017[17] reports from USA, the 2018 policy statement from the American Academy of Ophthalmology[8], a 2008 report from the UK[18], and a 2010 report from Australia[19].

7.2 Question 1: What is the prevalence of amblyopia in infants and children aged 0-5 years?

We do not know the current prevalence of amblyopia or its risk factors in New Zealand (NZ), but available estimates[20] are presented in Table 7.2. The B4SC is targeted to detect amblyopia, but it also identifies other conditions which cause reduced VA (including non-amblyogenic refractive error, strabismus and pathology), together these conditions were estimated to impact 4.5% of preschool children (study conducted in Auckland)[3].

Table 7.2. Prevalence estimates.

	NZ estimates	Australian estimates	International estimates
Amblyopia	1.8% / 3.5%[20]	1.4% to 3.6%[19]	0.5% to 5.3%[19] *(no bilateral[21] to 3:1[22] unilateral to bilateral)*
Amblyopia risk factors			
Refractive errors		1.0% to 14.7%[19]	0.5% to 34.2%[19]
Strabismus		0.3% to 7.3%[19]	1.0% to 14.7%[19]
Deprivation (cataract)			0.0032% to 0.229%[23] *(~2:1 bilateral to unilateral[24])*

The NZ estimate reports the prevalence of amblyopia within a cohort of 1037 people born in Dunedin in the 1970s. Prevalence for the NZ study is reported for 2 different VA cut-offs: 1) 6/12 or worse in at least one eye or a 2-line difference between eyes, and 2) 6/9 or worse in at least one eye. Australian and international estimates include varying cut-offs.

Although there are no randomised clinical trials (RCTs) designed to compare prevalence between screened and unscreened populations[10,11], indirect evidence suggests screening decreases prevalence, particularly for bilateral amblyopia[21,25]. For example, the prevalence of amblyopia in Denmark fell from 1.78% before population wide screening to 0.44%[21], and the prevalence in Sweden dropped from 3.3% to 0.9%[22,25].

7.2 Summary

Internationally, the prevalence of amblyopia ranges from 0.5 to 5.3%. Estimates from NZ suggest 3.5%.

7.3 Question 2: When is the optimal time(s) to screen for amblyogenic factors?

Early detection and treatment of amblyopia and its risk factors result in the best visual outcomes. Optimal timing and appropriate tests for screening depend on the amblyogenic factors being targeted and the sensitive periods for visual development.

7.3.1 Newborn

Screening for congenital eye conditions should take place as close to birth as possible[19]. Unilateral congenital cataracts are most effectively treated in the first six weeks of life and bilateral cataract within the first ten weeks due to the severity of amblyopia caused by delayed treatment[26]. Additionally, screening early in the neonatal period facilitates the early diagnosis and treatment of retinoblastoma[27].

7.3.2 Preschool

There are no RCTs directly comparing screening for refractive or strabismic amblyopia in different age groups, however there is strong evidence for improved outcomes with amblyopia treatment before 7 years of age[4]. Systematic reviews have reported indirect evidence supporting screening in children aged 3-5 years, to facilitate early treatment. Currently, there is insufficient evidence for, or against screening and testability can be limited in asymptomatic children less than 3 years old[16,17,19]. In a NZ study, Goodman et al[28] found no evidence of benefit from screening children at age two years, as test results were poorly predictive of visual impairment at age four years.

7.3 Summary

There are two key times for vision screening in children to prevent amblyopia: in the neonatal period (as close to birth as possible and during the preschool years (age 3-5 years).

7.4 Question 3: What tests are available to screen for amblyogenic factors in infants and children (0-5 years)?

7.4.1 Newborn

The red reflex test is performed to detect media opacities such as cataract or retinoblastoma[27]. This test can have acceptable sensitivity and specificity when performed by trained specialists[27]. However, in NZ it appears less accurate, with high false positive rates and some cases of congenital cataract may be missed[29,30]. Some of the LMCs conducting these tests have highlighted the need and desire for more training[30,31].

7.4.2 Preschool

Systematic reviews argue methodological variation precludes test recommendation[16-18,32], but guidelines promote certain VA tests and certain auto-refractors and photo screeners[8,33] (which provide automated detection of refractive error, and in some cases strabismus). The Vision in Pre-schoolers (VIP) study directly compared several screening tests and found that the Lea Symbols VA test and two auto-refractors were the most accurate when used as a stand-alone screening tests[34-36] (although VA tests took longer)[34,35]. A 2019 meta-analysis found that two current photo screeners (Spot and Plusoptix) were both accurate for children under the age of 7 years[37]. A 2017 systematic review concluded that a combination of tests is likely to be more effective than any isolated test[17].

In contrast to the Lea Symbols VA test, as well as certain auto-refractors and photo screeners, there is little evidence for the accuracy of the Parr VA test, currently used at the B4SC. There is an ongoing study comparing the accuracy of the Parr VA test to the Lea Symbols VA test and the Spot vision screener, in NZ preschool children.

7.4.3 Comment on innovation

New approaches to vision screening include the use of the infrared reflex[38] and RetCam images[39] as alternatives to the red reflex test, the use of simple cameras for automatic detection of refractive error[40,41], and the use of electronic VA tests[42-44] (including inferring VA from reflexive eye movements[45]). These options are appealing, particularly when they can help prevent common errors made during testing[46] and can improve referral processes. Some of these innovations are being developed[44-46] and tested[39] in NZ.

7.4 Summary

The red reflex at birth, and either a VA screening or automated vision screening (auto-refraction or photo screening) at age 3-5 years, are effective to detect amblyopia and its risk factors.

7.5 Question 4: What interventions are effective for amblyopia and its risk factors?

Treatment of the amblyopia risk factor is the first step of amblyopia treatment, accomplished by surgery and/or providing spectacle correction. Glasses alone are an effective first line of treatment for strabismic and anisometropic amblyopia, with a mean resolution rate of 32% of unilateral[47], and at least 73% of bilateral cases[48].

If amblyopia persists after optical treatment, there is good evidence from several RCTs that patching the stronger eye is effective to improve VA[4,17,49,50]. Atropine drops to blur the stronger eye are equally as effective[51] and can be tolerated moderately better than patching[52] (but can have side effects, such as light sensitivity)[53]. The benefits of both patching and atropine remain over the long-term[53,54]. Although used clinically, there is currently insufficient evidence to establish whether or not these additional treatments are effective for bilateral amblyopia[49] or deprivation amblyopia[55].

7.5.1 Comment on Innovation

Since adherence is often a challenge for conventional treatment[53], more engaging binocular treatment options (based on watching movies and playing games) are the subject of extensive research[56,57]. Currently however, there is insufficient evidence to say whether these treatments are effective[58], and results from recent clinical trials (one based in NZ[56]) are less promising than hoped[56,57].

7.5 Summary

Treatment of amblyopia requires removal of risk factors, and spectacle correction. Patching or atropine drops are both effective for treatment of residual unilateral amblyopia.

7.6 Question 5: What are the long-term impacts of amblyopia?

Bilateral vision impairment is known to impact on children's learning, development and quality of life,[1,17] and if left untreated can result in permanent visual disability due to bilateral amblyopia.[49]

The impact of unilateral vision impairment is less clear[18,59]. Unilateral amblyopia is associated with impairments in grasping, walking, driving and reading[60], increased risk of bilateral vision impairment due to injury or disease in the less-affected eye [59,61] and possible lower academic standing[61] (although a study in NZ did not find differences in education or income measures)[20]. Although population studies tend to show low impact at a group level[20,61], growing evidence points to a more substantial impact[62-64], in particular for individuals interested in pursuits requiring refined VA or stereopsis[64]. Whether these factors translate to a quantifiable decrease in quality of life (or 'utility') requires more research. One study of adults with unilateral amblyopia found, on average, a decrease in utility of 3.7% (using the time trade-off method)[65].

When balanced against the relatively subtle adverse impact of unilateral amblyopia, the impact of penalisation treatment is an important consideration. Although systematic reviews agree that patching can lead to social distress[29,66] and bullying[18], most conclude that rigorous studies are needed to understand the factors involved in these phenomena[16-18,59]. Earlier treatment (to reduce likelihood of patching or atropine at school[18,67]) and innovative binocular treatments (if found to be effective) are likely to reduce the potential adverse impact of treating amblyopia.

7.6 Summary

Bilateral vision impairment negatively impacts a child's quality of life. Although it appears that unilateral amblyopia has an impact on quality of life, more research is needed. Treating amblyopia likely causes some distress, which can be minimised by early treatment.

7.7 Question 6: Should we consider screening for non-amblyogenic vision disorders such as refractive error (myopia, hypermetropia, astigmatism)?

While the B4SC VA screening is effective for detecting amblyopia, early-onset myopia and some vision impairment, it is not targeted to detect hypermetropia or astigmatism. A recent study conducted full eye examinations in a group of 114 mainly Māori and Pacific children who had, 2 years prior, competed the B4SC. At 6 years of age, 3.5% had myopia, 6.1% had hypermetropia and 24.1% had astigmatism. Approximately half of these children with refractive error passed the B4SC (*study in preparation for publication*).

Uncorrected refractive error and reduced visual acuity have been found to impact academic performance[1]. The VIP study found uncorrected hypermetropia is associated with reduced VA and stereoacuity, development of strabismus and amblyopia[68], deficits in attention[69] and reduced preschool early literacy scores[70]. Recent studies report an association between astigmatism and poorer academic readiness in pre-schoolers[71] and with poorer performance on cognitive, language and fine motor tasks[72]. In a longitudinal study, Bruce et al[73] found children with refractive error who were compliant with spectacle wear had improved VA and early literacy compared with those who were non-compliant.

Although the B4SC detects early-onset myopia, most myopia develops in school-aged children[74]. Myopia is critically important because it is a leading cause of distance visual impairment worldwide[75], prevalence is increasing rapidly[75] and more cases are progressing to 'high myopia' which increases the risk of ocular disease including cataract, glaucoma and retinal conditions[76]. There are now treatments to reduce myopia progression[77] and uncorrected myopia is associated with myopia progression[77]; making prompt detection and treatment important to maintaining quality vision and eye health. Correction of moderate myopia has also been shown to improve self-reported visual functioning in children[78].

7.7 Summary

Non-amblyogenic refractive errors are associated with reduced educational outcomes.

Prompt detection and treatment of myopia is likely to reduce progression and the likelihood of future ocular pathology.

7.8 Question 7: Are there any known harms associated with vision screening?

Many NZ children who are referred for further assessment after the B4SC do not have amblyopia. Some of these children have refractive error (which may or may not be amblyogenic), whereas others have normal vision. The proportion of children with normal vision who are referred has been estimated at 31% and 47.4% in Counties-Manukau District Health Board (DHB)[3,79], 56.7% in the Southern DHB and 58.1% in Tairāwhiti DHB[80]. These studies suggest that very few children with amblyopia pass the B4SC vision test[3,80], although none have measured this directly. Suggestions for decreasing the number of unnecessary referrals include changing the referral criteria and/or the screening test[3,79,80].

One downside of over-referral is waste; in the form of time, resource and parental concern. Systematic reviews addressing the potential harms of screening found insufficient evidence linking false positives with negative health outcomes[17,59,81]. Although over-prescription could be a concern[82], so could be under-prescription. As noted in Question 6, correction of non-amblyogenic refractive error can improve academic outcomes, but are not currently targeted by the B4SC. The mismatch between targeted conditions and public perception about a 'pass' means, can result in children who might benefit from glasses being less likely to receive them.

Another potential harm is screening without a process for referral and treatment; concern that NZ children failing the B4SC may not find their way to an eye examination has been raised[80].

7.8 Summary

Clarifying targeted conditions and matching these with appropriate referral cut-offs is important to balance the potential harms of over- and under-referral.

Poor referral processes can prevent children who fail from accessing further assessment or treatment.

7.9 Question 8: What is the cost-effectiveness of vision screening in childhood?

The impact of a condition on quality of life, or 'utility', is required for analysis of cost-effectiveness. From Question 5, we know that an estimate of 3.7%[65] may be reasonable for unilateral amblyopia, but more evidence is needed. Assuming a utility of 1 to 4%, amblyopia treatment appears to be cost effective[83,84]. Cost-effectiveness is more complex when screening is included as part of the analysis due to variability in screening protocol. A UK report addressing this complexity concluded that VA screening at age 3 or 4 years is likely cost-effective if utility of 2% is assumed[18]. A model using similar data suggested this remains true even with a utility of only 1%[85]. However, overall the evidence is weak because of the uncertainty of utility estimates[9,18].

A model of school-based screening later in childhood demonstrated that detection of refractive error and provision of refractive correction is highly cost effective when considered against the expected years lost due to disability associated with bilateral visual impairment[86]. A recent review supports this finding, demonstrating the significant improvement in health utility gained through refractive correction for amblyopia or refractive error[87].

7.9 Summary

There is a lack of evidence around the cost effectiveness of vision screening for unilateral amblyopia, but stronger evidence for the cost effectiveness of detecting bilateral vision impairment and provision of glasses.

7.10 Question 9: What do we know from a Māori and Pacific knowledge basis about vision screening?

There is a paucity of evidence relating to vision screening in Māori and Pacific children. We do know that across NZ, Māori and Pacific children are less likely to participate in the B4SC[88]; 14.0% of Māori and 15.1% of Pacific children did not receive a vision screening in the period 1 July 2011 to 20 June 2015, compared with 9% of European and 8.7% of Asian children (Appendix III). Among screened children, it appears the test further disadvantages these groups; 3.6% of Māori and 2.7% of Pacific children are unable to complete the VA test (compared to 1.9% of European and 1.7% of Asian children – Appendix III). Note that the Parr test is available in English and Te Reo versions, but it is not clear when each is used, or if they have similar sensitivity and specificity.

More generally, whānau of Māori and Pacific ethnicity are overrepresented within areas of high socioeconomic deprivation. Internationally, low income increases the likelihood of a childhood vision disorder, reduces attendance at screening programmes, and poses barriers to diagnosis and appropriate treatment[89].

7.10 Summary

Māori and Pacific whānau are less likely to participate in vision screening, and more likely to be untestable when they do, despite potentially higher likelihood of a vision disorder.

7.11 Summary of evidence for graded recommendations

Overall, the evidence within this rapid review suggests that childhood vision screening can prevent or minimise amblyopia and promote educational outcomes. Quantifying this conclusion facilitates action on a policy level. As such, after completion of the review, we were asked to grade recommendations based on estimated net benefit, and the associated level of certainty. The process through which the grades were generated is outlined in Appendix IV, and the summary is provided in Table 7.3.

Table 7.3. Graded evaluation of vision screening and associated recommendations for policy and practice.

Intervention	Grade	Estimated net benefit	Level of certainty	Recommendation
Newborn vision screening with the red reflex test for congenital eye conditions	B	Moderate	Moderate	We recommend universal birth and 6 week ocular health screen for all newborn babies.
6-month to 3-year vision screening with vision screeners for amblyopia and it's risk factors	I	Moderate	Low	There is currently insufficient evidence to support universal implementation of this screening intervention.
3 to 5-year vision screening with VA tests and/or vision screeners for amblyopia and its risk factors	B	Moderate	Moderate	We recommend universal vision screening between 3 and 5 years of age.
3 to 5-year vision screening with VA tests and vision screeners for non-amblyogenic refractive error	I	Moderate	Low	There is currently insufficient evidence to support universal implementation of this screening intervention.

Grade: A, B, C, D, or I.
Estimated net benefit: substantial, moderate, small, nil or harmful, or insufficient (evidence).
Level of certainty: high, moderate, or low
For more detailed explanation see Supplementary Information - Grade definitions and levels of certainty.

To recommend a screening intervention, we needed at least moderate certainty that the answers to three questions were yes; 'Does the condition matter?', 'Are the tests acceptable?', and 'Is there an effective treatment?'. Overall, this was the case for screening newborns for congenital eye conditions using the red reflex test, and screening preschool children for amblyopia and its risk factors with VA tests and/or suitable automated vision screeners. In NZ, we currently complete these two recommended screenings, however, implementation should be improved to achieve these potential benefits. Recommendations for improvement are provided in the next section.

For 6-month to 3-year old screening for amblyopia and its risk factors, we questioned evidence about the accuracy of screening tests, leading to a current conclusion of 'insufficient evidence'. With innovation and continued research, screening tools will continue to improve, and will likely lead to an updated recommendation in the future.

For non-amblyogenic refractive error screening there was insufficient evidence at this time to support universal screening in the 3-5 year old age group. However, refractive error (particularly myopia), becomes increasingly prevalent later in childhood and its correction (with spectacles) improves educational outcomes. We have not sufficiently reviewed the evidence to make a recommendation about the benefits or level of certainty around vision screening for refractive error in school aged children. This needs further consideration and needs to be considered alongside pre-school aged vision screening.

The recommendations for amblyopia screening from 6 months through to 5 years are consistent with the 2017 recommendation from the US Preventive Services Task Force in the USA[12] (note that neither newborn screening, nor screening for non-amblyogenic refractive error were considered by USPSTF).

7.12 Recommendations for further action

Policy and practice

Prevalence and impact

- Regular review of the prevalence and impact of targeted conditions and optimal timing for vision screening.

Screening Protocols

- Improve training for LMCs and VHTs to ensure tests are being carried out correctly across the country.
- Update the B4SC VA test to one with a stronger evidence base.
- Consider adding an auto-refractor or photo screener to the B4SC screening protocol.
- Ensure that referral cut-offs are well-defined and reflect screening goals.
- Regular review of screening protocols to allow integration of innovative tools.
- Reconsider the timing/test selection of the year 7 vision screening, to identify non-amblyogenic refractive errors which become more prevalent later in childhood (> 5 years), particularly myopia.
- Changes should be piloted by LMC/VHTs within sufficiently diverse communities to ensure the testing and protocols are as accurate as possible across NZ.

Systems and barriers

- Ensure screening and referral processes are consistent within and between DHBs.
- Ensure children who are not screened (or had uncompleted rescreens) complete vision screening on school entry.
- Centralise referral pathways and data systems to facilitate the transition between a failed screen and full assessment.
- Increase access to treatment (such as spectacles) by improving subsidies.

Equity

- Ensure the screening tests used are appropriate for all children.
- Consider additional screening (timepoints and/or tests) for children from Māori and Pacific and low socioeconomic whānau.
- Promote diversity of our screeners and health care providers and consider implementing health care models which consider wider social context, such as Meihana90.

Further research

Prevalence and impact

- More data on prevalence of refractive error, visual impairment and amblyopia and its risk factors are needed.
- Investigate the impact of each of these conditions on educational and developmental outcomes, as well as quality of life.
- Prevalence and impact should be investigated across different ethnicities, socio-economic and geographic regions of NZ.

Screening Protocols

- Research comparing current protocol to established VA tests, as well as auto-refractors and photo screeners, including analysis of optimal referral cut-offs.
- Continuation of NZ-based innovation in vision screening assessment tools, and research which enables transition of these tools to population-wide use.
- Accuracy and suitability of tests should be investigated across different ethnicities, socio-economic and geographic regions of NZ.

Systems and barriers

- Evaluate current processes within and between DHBs.
- Research into integration of screening and clinical referral pathways.
- Research into barriers to access to screening, referral and treatment.

Equity

- Research into the specific barriers Māori and Pacific whānau face that prevent them from accessing screening
- Investigate appropriateness of screening tests across ethnicities
- Explore how Māori and Pacific health care models could be translated into more effective vision screening, referral and treatment.

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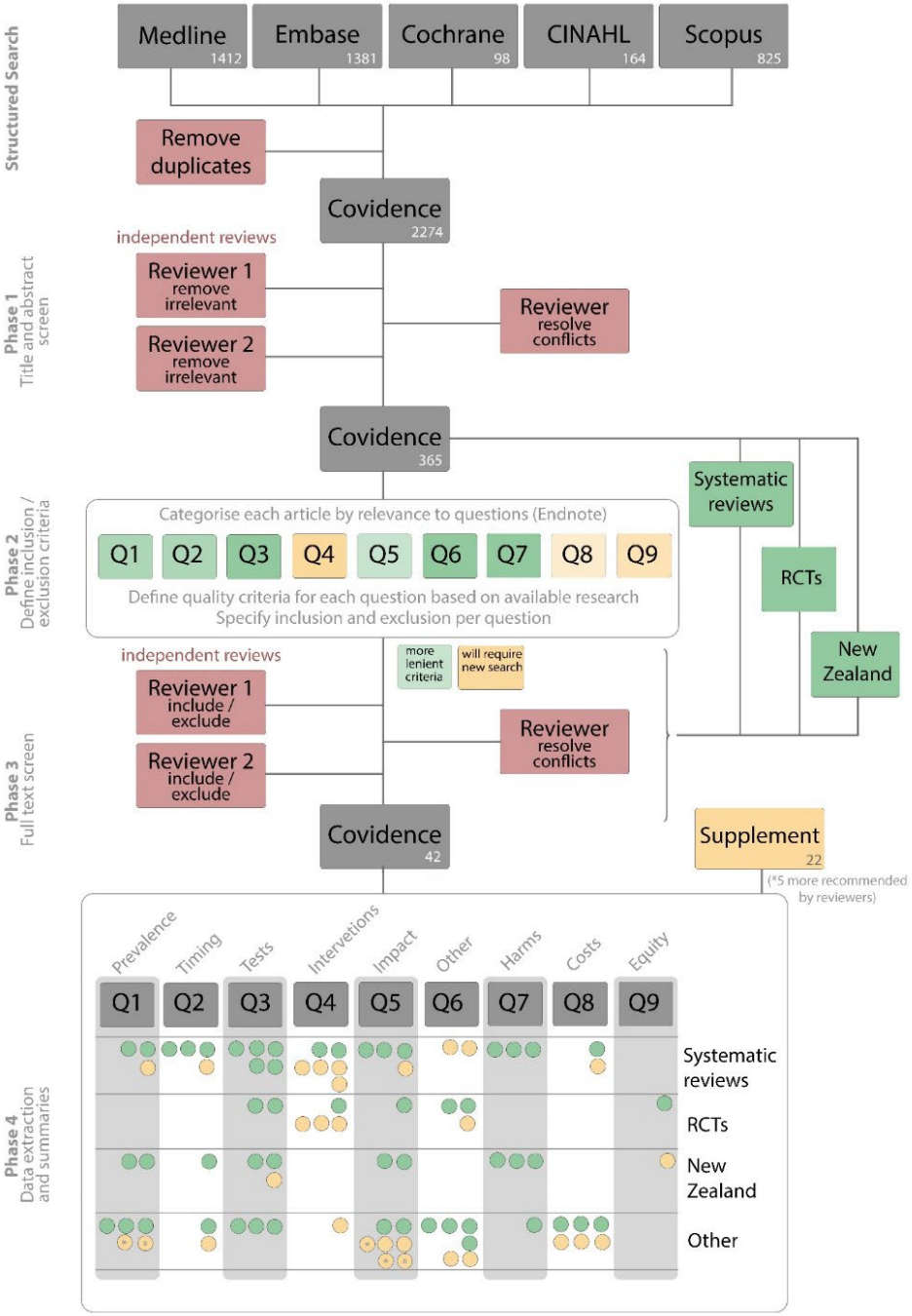
Appendix I: Review methods

Overview

Although we did not have time for a systematic review, we did run a structured search as outlined in the main document. Due to the wide range of topics addressed in the questions, we ran a supplemental (unstructured) search for individual questions to capture available sources. The overview of this process is presented Figure 7.1. Details about included studies presented in the tables, and the search strategy is included after the tables.

Figure 7.1. Overview of literature search methods.
(Covidence is a software developed to facilitate systematic reviews)



Question 1: What is the prevalence of amblyopia in infants and children aged 0-5 years

First author	Year	Type	Location	Age range	Sample size	Targeted conditions	Screening Protocol in area	VA cut off or definition	Reported prevalence	Strengths	Limitations	Comments
Wilson[20]	2013	Prospective, longitudinal birth cohort study	Dunedin, NZ	Multiple measures at different ages	1,037	amblyopia, possible amblyopia and recovered amblyopia	No screening when cohort was 3-5 years old	1) 6/12 VA in at least one eye, or a two-line difference 2) 6/9 VA in at least one eye	1) 1.8% and 2) 3.5%	excellent design and important local data	mostly European and started in the 1970s, so may not be current	key prevalence data from NZ
Langeslag-Smith[3]	2015	Retrospective audit	Auckland, NZ	3-5 year olds	556	amblyopia and its risk factors, refractive error and pathology	universal screening	various cut offs for VA, refractive error and strabismus angle	4.5%	Local data	potential false positives not included in prevalence	
Mathers[19]	2010	Systematic review	International (Australia)	children	NA	amblyopia, refractive error and strabismus	varied	not stated	Listed in table		not an structured meta-analysis	Data from other sources
Powell[10]	2009	Systematic review	International (UK)		0	anisometropic and strabismic amblyopia	NA	NA	NA	rigorous review	no studies met inclusion criteria (RCTs of screened vs unscreened populations)	very specific question with an inconclusive answer
Powell[11]	2005	Systematic review	International (UK)		0	anisometropic and strabismic amblyopia	NA	NA	NA	rigorous review	no studies met inclusion criteria (RCTs of screened vs unscreened populations)	very specific question with an inconclusive answer
Hoeg[21]	2015	population-based cross-sectional study	Denmark	tested in adulthood Group 1: no screening, Group 2: screened	3,826	amblyopia	only for one group	worse than 6/12 VA in at least on eye and at least a 2 line difference between eyes	no screening: 1.78%, Screening: 0.44%	estimated prevalence in screen and unscreened population	not RCT	no one in screened population had bilateral amblyopia

First author	Year	Type	Location	Age range	Sample size	Targeted conditions	Screening Protocol in area	VA cut off or definition	Reported prevalence	Strengths	Limitations	Comments
Thorisdottir[25]	2019	population-based cross-sectional study	Sweden	tested in adulthood Group 1: no screening, Group 2: screened	Group 1: 1500 Group 2: 2626	amblyopia	only for one group	6/9 VA or worse in at least on eye and at least a 2 line difference between eyes	no screening: 3.3%, Screening: 0.9%	estimated prevalence in screen and unscreened population	not RCT	only 2 people in the screening group (out of 23) had bilateral amblyopia
Dikova[22]	2018	Cross-sectional	Bulgaria	4-10 years	1,675	amblyopia	none in country	VA 6/12 or worse in at least one eye	2.5% (73% unilateral, 27% bilateral)	included, and reported on bilateral cases		
Sheeladevi[23]	2016	Systematic meta-analysis	International (UK)	<18 years	24 studies included	childhood cataract	varied	clinical diagnosis of cataract	congenital: 0.63 to 9.74/10,000 childhood: 0.32 to 22.9/10,000	Excellent meta-analysis		
Nagamoto[24]	2015	Questionnaire	Japan	<19 years	521	childhood cataract	not reported	clinical diagnosis of cataract	reported on proportion bilateral (65.8%) and unilateral (34.2%)	study design relied on reporting from facilities		

Question 2: When is the optimal time(s) to screen for amblyogenic factors?

First author	Year	Type	Location	Age range	Sample size	Targeted conditions	Screening Protocol used (tests)	Outcome/Recommendation	Comments
Cagini[27]	2017	Primary Cross-sectional	Italy	1-3 days	22,885	Ocular abnormalities	Red reflex	High false positive rate, however useful test for detection of congenital eye disease	Relatively small numbers for a rare condition
Mathers[19]	2010	Systematic review	Australia	Neonatal period	N/A	Congenital abnormalities	Red reflex, external inspection, pupil exam	Recommend screening in neonatal period, inconsistent evidence 6 months to 3 years, Supports vision screening in children 3-5 years	Recommendation in neonatal category based on expert opinion
Chan[26]	2012	Review	International review	0-12 months	N/A	Congenital cataract		Unilateral intervention before 6 weeks gives optimum VA outcome, Bilateral intervention before 10 weeks reduces poor visual outcomes	
Chou[16]	2011	Systematic review	International review (USA)	Strict quality check	N/A			Lack of evidence to support screening in this age group 6 months to 5 years, lower testability in younger children, Supports vision screening in children 3-5 years	
Jonas[17]	2017	Systematic review	International review (USA)	Strict quality check	N/A			Lack of evidence to support screening in this age group, lower testability in younger children	
Goodman[28]	2018	Prospective cohort	NZ	2-4.5 years	355	Reduced visual acuity		Do not support vision screening in this age group, testing at 2 years poorly predictive of vision impairment at 4-5 years	Special population – infants born at risk of neonatal hypoglycaemia (may not be applicable to general population)
Holmes[4]	2011	Meta-analysis of RCTs	USA	3-13 years	996	Unilateral amblyopia	Patching, atropine, Bangerter filters	Amblyopia is more responsive to treatment in children <7 years	

Question 3: What tests are available to screen for amblyogenic factors in infants and children (0-5 years)?

Newborns

First author	Year	Type	Location	Sample size	Instrument	Screener (who?)	Strengths	Weaknesses	Summary
Cagini[27]	2017	Cross-sectional	Italy	22,884	red reflex	neonatologist or paediatrician (trained specifically on red reflex screening)	calculates sensitivity (100%) and specificity (97.7%)	Although sensitivity is reported, not directly measured	suggests that the red reflex is an appropriate test to screen for cataracts and retinoblastoma (when screeners are well trained)
Fry[31]	2005	Survey	Nelson-Tasman, NZ	117	red reflex	NA	excellent uptake within region		suggests that much more training is needed
Hamm[29]	2019	Qualitative	Auckland, NZ	20	red reflex	NA	qualitative work - interviewing families of children with cataracts		some children with cataracts in NZ missed by red reflex test
Raoof[30]	2016	Survey	Auckland, NZ	483	red reflex	NA	large online questionnaire to assess practices and attitudes about the red reflex screening test.		suggests that more training helpful

6 months to 5 years

First author	Year	Type	Location	Age range	Sample size	Instrument	Targeted conditions	Strengths	Weaknesses	Summary
Carlton[18]	2008	Systematic review	International (UK)		NA	many	Amblyopia and its risk factors	Comprehensive summary		Many different tests may be useful, but auto-refraction improved screening efficiency
Chou[16]	2011	Systematic review	International (USA)	1-5 years	NA	many	Impaired visual acuity and amblyopia	Structured review, excellent quality		Several tests have utility to detect vision problems in preschool children, but are generally less effective in toddlers because of testability
Jonas[17]	2017	Systematic review	International (USA)	6 months to 5 years	40 studies, 34,709 subjects	many	amblyopia and its risk factors	used highest quality available evidence with rigorous checks.	could not do quantitative meta-analysis because of heterogeneity of studies	1) insufficient evidence for screening at between 6 months and 3 years 2) Indirect moderate evidence for screening between 3 and 5 years with several different tests

First author	Year	Type	Location	Age range	Sample size	Instrument	Targeted conditions	Strengths	Weaknesses	Summary
Cotter[33]	2015	Guidelines	USA	36 to <72 months	NA	many	amblyopia and its risk factors	Practical recommendations for practice.	Expert panel not systematic review or meta-analysis	Recommend Lea, HOTV, and/or some auto refractors
Wallace[8]	2018	Guidelines	USA	0-6 years	NA	many	many	Recommendations for practice. Weakness: Expert panel not systematic review or meta-analysis	not a systematic review, between review and guidelines	Recommend Red reflex (from birth), Lea, HOTV or Sloan letters
Schmucker[81]	2009	Systematic Review	International (Germany)	0-6 years	2 studies met inclusion criteria	many	amblyopia	rigorous inclusion/exclusion	too few studies met criteria to perform meta-analysis	Concludes there is not sufficiently rigorous definitions and protocols to compare screening tests between studies.
Zhang[37]	2019	Systematic Review	International (China/USA)	All ages (but we report sub-analysis of children <7 years)	21 studies including 5022 subjects	Spot and Plusoptix Vision Screeners	amblyopia and its risk factors	completed a meta-analysis to calculate sensitivity (Spot=91.7%, Plusoptix=90.2%) and specificity (Spot=82.6%, Plusoptix 93.0%)	many variables within included papers, and there were not enough children under 3 to evaluate the 6 month-3 year age range.	Suggests that both Spot and Plusoptix Vision Screeners are effective for detecting amblyopia in children under 7 years of age
VIP Group[34] **(Schmidt)**	2004	RCT	USA	3-5 years	2588	compared many tests	Three groups defined by clinical relevance	Excellent RCT, allowed direct comparison of many screening tests (Lea test 89% specificity at 90% sensitivity)		excellent evidence for use of Lea, Retinomax and SureSight
VIP Group[35]	2005	RCT	USA	3-5 years	2588	compared many tests	four groups: (amblyopia, strabismus, refractive error, and reduced VA	excellent RCT, allowed direct comparison of many screening tests (Lea 85% sensitivity at 94% specificity)		excellent evidence for use of Lea, Retinomax and SureSight
Anstice[79]	2012	Retrospective audit	Auckland, NZ	3-5 year olds	131	uncrowded Parr	amblyopia and its risk factors, refractive error and pathology	local data	retrospective and do not know about children who passed, or did not attend follow up appointments	report positive predictive value of 47.4% (many false positive referrals)
Langeslag-Smith[3]	2015	Retrospective audit	Auckland, NZ	3-5 year olds	556	crowded Parr	amblyopia and its risk factors, refractive error and pathology	local data	retrospective and do not know about children who passed, or did not attend follow up appointments	report positive predictive value of 31% (many false positive referrals)

First author	Year	Type	Location	Age range	Sample size	Instrument	Targeted conditions	Strengths	Weaknesses	Summary
Muller[80]	2019	Retrospective audit	Gisborne and South Island, NZ	4 year olds	116	Parr	amblyopia and its risk factors refractive error and pathology	local data, estimated sensitivity from 54.7%-94.7% and specificity at 93.8% to 95.7%	retrospective and do not know about children who passed, or did not attend follow up appointments	estimate positive predictive value between 29.5 and 51.1% (many false positive referrals)

Examples of innovative tools (across all ages)

First author	Year	Location	Age range	Sample size	Instrument	Reference instrument	Targeted conditions	Who conducted the test	Outcome	Summary
Duret[38]	2019	UK	infants to 13 years	200	infrared reflex using prototype device (smartphone with co-axil IR-emitting diode and IR camera)	Red reflex with ophthalmoscope	neonate and childhood cataract	medical students (IR and R), and experienced midwives (R)	better outcome for IR than red reflex	suggests infrared light and cameras may be improve currently used Red reflex test
Simkin[39]	2019	Auckland, NZ	Infants	346	Retcam images reviewed by ophthalmologist	NA	ocular abnormalities, including retinal haemorrhages.	technician took images, paediatric ophthalmologist graded all images	primarily reported prevalence of ocular anomalies	suggests the red reflex exam has problems, and more comprehensive options feasible
Peterseim[41]	2018	USA	6 months to 7 years	206	GO Check Kids Vision Screener' smartphone app photo screener	Full eye exam	amblyopia and amblyogenic risk factors	medical students	Sensitivity 76%, specific 67%	suggests automated screening for amblyopia risk factors improves testability
Sangi[45]	2015	Auckland, NZ	2-year-olds	5	optokinetic nystagmus test using video (not eye trackers)	manual detection of optokinetic nystagmus	none	researcher	Sensitivity 89%, specificity 99% (compared to manual detection	suggests measuring an ocular reflex to moving targets may be a feasible option to explore
Aslam[42]	2016	UK	4-16 years	112	tablet VA test using Landolt "C" (gamified)	EDTRS VA chart	none - just interested in comparing VA measures across range of conditions	automated (child completed the test alone in a booth)	Agreement with reference tests +/- 0.208 logMAR	suggests childhood self-assessment is feasible
Hamm[44]	2018	Auckland, NZ	5-12 years	121	tablet VA system using TAO symbols	full eye exam/EVA system	amblyopia and amblyogenic risk factors	researcher	Agreement with reference test: TAO Regular =0.14 logMAR, TAO Vanishing = 0.15, Parr = 0.15 logMAR	suggest a different VA test may be an improvement over currently used PARR test

First author	Year	Location	Age range	Sample size	Instrument	Reference instrument	Targeted conditions	Who conducted the test	Outcome	Summary
Hamm[91]	2019	Auckland, NZ	7-year-olds	33	tablet VA test with distance tracking	NA	none	lay screener	tests at 150cm or closer should account for test distance to test	suggests tracking distance with webcam is feasible and important if testing at or closer than 150cm
Bani[40]	2013	India	adults	138	consumer digital camera with 10x optical zoom, images taken and graded	existing diagnosis	amblyopia and amblyogenic risk factors	researcher/ clinician	sensitivity 86%, specificity 85%	suggests consumer grade equipment can function as a photo screener

Question 4: What interventions are effective for amblyopia and its risk factors?

First author	Year	Type	Location	Age range	n	Amblyopia type	Intervention	Outcome	Strengths	Weaknesses	Adverse effects
Asper[47]	2018	Systematic review (invited)	International (Australia)	3-17 years	29 studies (20 used for effect size calculation)	anisometropia, strabismus and combined	glasses (optical treatment or refractive adaptation)	Glasses alone works to improve VA	Could complete quantitative meta-analysis	first round of screening not independent	none reported
Clarke[50]	2003	RCT	UK	3-5 years	177	anisometropia, strabismus and combined	1) glasses + patching, 2) glasses alone, 3) no treatment	Glasses + patching, then glasses alone are best if VA starts worse that 6/9	Compared 3 groups from screening through to treatment	only followed up for short time (because cross over design)	none reported
Jonas[17]	2017	Systematic review	International (USA)	6 months - 5 years	2 RCTs, 240 participants	anisometropia, strabismus and combined	patching	Patching works to improve VA (mean 1-2 lines)	Rigorous overview		none reported
Holmes[4]	2011	Systematic review	International (USA)	3 to 13 years	4 RCTs	unilateral amblyopia	patching	VA improvements higher in children less than 7 than in children older than 7 (1-5 lines)	Meta-analysis on age as a factor for effectiveness of treatment		none reported
Taylor[49]	2012	Cochrane systematic review	International (UK)	any age	0 RCTs found	bilateral amblyopia	glasses and patching	Not enough evidence	Rigorous methodology	insufficient evidence for bilateral amblyopia (no RCTs)	NA
PEDIG[51]	2002	RCT	USA	3-7 years	419	anisometropia, strabismus and combined	either patching or atropine	Patching and atropine are equally effective (1-3 lines)	Direct comparison of patching to atropine		reports of mild skin irritation (patching) and light sensitivity (atropine)
PEDIG[52]	2003	RCT follow up	USA	3-7 years	364 of 419 completed questionnaire	anisometropia, strabismus and combined	either patching or atropine	Although atropine and patching were both tolerated well, patching performed worse overall and on all 3 subscales	Direct comparison of patching to atropine	questionnaire measures have flaws (ie limited to questions asked)	patching had higher scores than patching for adverse effects compliance, and social stigma

First author	Year	Type	Location	Age range	n	Amblyopia type	Intervention	Outcome	Strengths	Weaknesses	Adverse effects
Repka[54]	2014	RCT follow up	USA	15 years	147 participants took part in this follow up	anisometropia, strabismus and combined	either patching or atropine	Gains from original treatment were maintained in both groups	Long-time follow up on 2002 PEDIG study		not noted
Antonio-Santos[55]	2014	Cochrane systematic review	International (USA and UK)	any age	0 RCTs found	stimulus deprivation amblyopia	patching or atropine	not enough evidence	Rigorous methodology	Insufficient evidence for stimulus deprivation amblyopia (no RCTs)	NA

Question 5: What are the long-term impacts of amblyopia?

Impact of bilateral amblyopia

First author	Year	Type	Location	Targeted conditions	Outcome/Recommendation	Strength	Weakness
Jonas[17]	2017	Systematic review	International (USA)		Without treatment vision loss can become irreversible		Not primary topic of review
Hopkins[1]	2019	Invited review	International (Australia)	Visual acuity, refractive error	Association between both visual acuity and refractive error and academic performance	Convenient summary	Not systematic, may have bias
Taylor[49]	2012	Cochrane review	International (USA and UK)	Unilateral and bilateral refractive amblyopia	Poor improvement in VA when non-compliant with refractive correction	Rigorous methodology	Not about impact directly

Impact of unilateral amblyopia

First author	Year	Type	Age range	n	Location	Setting	Outcome/Recommendation	Strength	Weakness
Carlton[18]	2008	Systematic review	Children and adults	NA	International (UK)		Lack of paediatric specific data on QoL with amblyopia	Comprehensive	No quality check
Solebo[59]	2015	Systematic review	4-5 years	NA	International (UK)			Comprehensive	No quality check
Grant[60]	2011	Review	Children and adults	NA	International (UK)	Lab-based	Unilateral amblyopia associated with impairments in reaching, grasping, driving and reading	Compiles lots of primary studies	Study selection may be biased
Wilson[20]	2013	Prospective longitudinal Population-based survey	Adults followed up from childhood	1,037	New Zealand (Dunedin)	Clinical	No evidence of poorer motor development, lower self esteem or reduced adult SES in participants with amblyopia	Generalizable metrics (Child: motor control, Teen: stress, Adult: SES)	Measures may be insensitive to vision specific loss
van de Graaf[65]	2010	Utility Estimation for amblyopia (TTO and SC)	Adult	135	The Netherlands	Clinical		Asked participants to quantify impact of amblyopic vision loss	Large gap between TTO results (3.5%) and SC results (0.0006%)
Chua[61]	2004	Prospective longitudinal Population-based survey	Adults	3654	Australia (Blue Mountains)	Clinical	Amblyopia did not affect occupation but fewer completed university degrees, increased risk bilateral visual impairment	Used generalizable factors	Measures may be insensitive to vision specific loss

First author	Year	Type	Age range	n	Location	Setting	Outcome/Recommendation	Strength	Weakness
Webber[64]	2018	Invited review	All ages	NA	International (Australia)		Amblyopia results in poorer outcomes on tests of skills required for everyday tasks and which relate to childhood academic performance	Convenient summary	Not systematic, may have bias
Birch[62]	2019	Cross-sectional	3-7 years	110	USA	Lab-based	Amblyopia associated with lower self-perception and reduced physical competence		Lab-based, not population
Birch[63]	2019	Cross-sectional	8-13 years	81	USA	Lab-based	Amblyopia associated with lower self-perception, slower reading speed and reduced motor skills		Lab-based, not population

Impact of unilateral amblyopia treatment

First author	Year	Type	Location	Strength	Weakness
Jonas[17]	2017	Systematic review	International (USA)		
Solebo[59]	2015	Systematic review	International (UK)	Comprehensive	No quality check
Carlton[18]	2008	Systematic review	International (UK)	Comprehensive	No quality check
Hrisos[66]	2004	RCT follow up	USA	Compared 3 groups from screening through to treatment	Did not get data from all participants (81% of surveys returned)
Hamm[29]	2019	Qualitative	NZ	Parents reflected on treatment experience	Subjective experience, did not try to quantify Convenient sample
Williams[67]	2006	Commentary	UK	Reflection by authors of ALSPAC study (RCT) – so used in the context of that RCT	Type: Commentary does not meet inclusion criteria

Question 6: Should we consider screening for non-amblyogenic vision disorders such as refractive error (myopia, hypermetropia, astigmatism)?

First author	Year	Type	Location	Age range	Sample size	Participant details	Targeted conditions	Cut-offs (definition)	Measure of impact	Outcome/Recommendation
Hopkins[1]	2019	Invited review	International (Australia)	School age	N/A		Visual acuity, refractive error		Academic performance	Association between both visual acuity and refractive error and academic performance
Kulp[68]	2014	RCT (VIP)	USA	3-5 years	4040	Low income	Hyperopia and strabismus/amblyopia	>+3.25	Strabismus, Amblyopia	Children with hyperopia higher prevalence amblyopia and strabismus
Kulp[69]	2017	RCT (VIP)	USA	4-5 years	493	Low income	Hyperopia	≥+3.00	Attention	Hyperopia associated with reduced attention scores
Orlansky[71]	2015	Cohort study	USA	3-5 years	122	Low income	Astigmatism	≥0.50	Academic readiness	Astigmatism associated with lower scores for tests of academic readiness
Harvey[72]	2018	Cohort study	USA	12-35 months	26	Recruited from well child screening failures	Astigmatism (moderate to high)	>2.00	Cognitive and language tasks	Astigmatism associated with poorer performance on cognitive, language and fine motor tasks
Bruce[73]	2018	Longitudinal study nested within birth cohort study	UK	4-5 years	801		Refractive error correction	Hyperopia ≥+1.00 Myopia ≤-0.50 Astigmatism ≥1.00	VA, Literacy	Children adherent to spectacle wear greater improvements in VA and improved early literacy
Kulp[70]	2016	RCT (VIP)	USA	4-5 years	492	Low income	Hyperopia	≥+2.00	Early literacy	Hyperopia ≥+4 or ≥+3 to ≤+6 with reduced near VA or reduced stereo acuity associated with reduced early literacy
Esteso[78]	2007	Cohort study	Mexico	12 years	88		Myopia	≤-1.25	Self-reported visual functioning	Improvements in self-reported functioning with spectacle correction

Question 7: Are there any known harms associated with vision screening?

First author	Year	Type	Location	Age range	Sample size	Targeted conditions	Screening method	Cut-offs (definition referral)	Cut-offs for eye exam	Outcome/Recommendation
Anstice[79]	2012	Retrospective audit	New Zealand	4-5 years	3273	Amblyopia	VA Parr chart	6/12 or worse either eye, or 6/6 one eye 6/9	Presence of ocular condition including refractive error (non-amblyogenic)	
Langeslag-Smith[3]	2015	Retrospective audit	New Zealand	4-5 years	5572	Amblyopia	VA Parr chart	6/12 or worse either eye, or 6/6 one eye 6/9 other eye	Presence of ocular condition including refractive error (non-amblyogenic)	High rate of false positives
Muller[80]	2019	Retrospective audit	New Zealand	4-5years	2344	Amblyopia	VA Parr chart	6/12 or worse either eye, or 6/6 one eye 6/9 other eye	Presence of ocular condition including refractive error (non-amblyogenic)	High rate of false positives
Donahue[82]	2004	Retrospective audit	USA	1-5 years	102,508	Amblyogenic factors	MTI Photoscreener		Amblyopia risk factors	Spectacles prescribed for 19.5% of false positive referrals from screening (no amblyogenic factors)
Schmucker[81]	2009	Systematic review	International (Germany)	<6 years	N/A					No adverse effect of false positive screenings found
Solebo[59]	2015	Systematic review	International (UK)	4-5 years	N/A					No adverse effect of false positive screenings found
Jonas[17]	2017	Systematic review	International (USA)	6 months-5 years	N/A					High false positive rates in studies with low prevalence

Question 8: What is the cost-effectiveness of vision screening in childhood?

First author	Year	Type	Location	Strength	Weakness
Carlton[18]	2008	Systematic Review to cost-utility analysis	UK	Includes screening through to treatment	
Rein[85]	2012	Model (assumed gain from treatment to be 0.99/1%)	USA	Includes screening through to treatment	
Baltussen[86]	2009	Model	The Netherlands	Includes screening through to treatment	Does not consider preschool age group
van de Graaf[65]	2010	Utility study	The Netherlands	Uses TTO and SG to estimate utility	
Membreno[84]	2002	Cost-utility analysis (assumed utility gain from treatment to be 3%)	USA	Includes surgical intervention. Still cost effective	Does not consider the costs of screening
Konig[83]	2004	Cost-utility analysis (Assumed utility of unilateral vision impairment at 0.96/4%)	Germany	Starting treatment at 3 years old (so relevant to screening)	Does not consider the costs of screening
Malvankar-Mehta[87]	2018	Systematic review of cost to families of glasses	Canada	Discusses all amblyogenic factors (deprivation and strabismus are the most costly)	Does not consider factors outside costs of glasses
Harstall[9]	2012	Government report	Canada	Cost effectiveness analysis of preschool screening	Insufficient data

Question 9: What do we know from a Māori and Pacific knowledge basis about vision screening?

First author	Year	Type	Location	Age range	Sample size	Subject specifics	Ethnicity	Socio-economic status	Targeted conditions	Screening Protocol used (tests)	Outcome/Recommendation
Majeed[89]	2008	RCT	UK	7 years old	8,271	ALSPAC cohort	88.9% White, 1.8% non-White	wide range of parental social class scores	amblyopia and refractive error	full eye exam	Prevalence of eye conditions higher in the lower SES groups. However, children from lower socioeconomic status groups were less likely to see an eye care specialist or to use screening services.
Gibb[88]	2019	Observational study	NZ	3-5 year olds	252,273	National level NZ data, linked with birth stats, so can calculate who is missing screening	reflects NZ demographics	reflects NZ demographics	amblyopia and its risk factors	Parr VA test	System further disadvantaging groups who need the most support

Search strategy

Scopus: 825

(TITLE-ABS-KEY ("vision screening" OR "visual screen*" OR "vision screen*" OR "population vision screen*" OR "red eye reflex" OR "red reflex" OR "infra-red reflex")
AND
TITLE-ABS-KEY ("visual acuity" OR "vision disorders" OR amblyop* OR amblyopia OR strab* OR strabismus OR astigmatism OR hyperopia OR "lazy eye" OR "distance perception" OR ptosis OR rop OR "deprivation amblyop*" OR refract* OR "refractive error")
AND
TITLE-ABS-KEY (child OR children OR infant OR preschool OR pre-school OR newborn OR paediatric OR kindergarten))
AND
PUBYEAR > 2003 AND (LIMIT-TO (LANGUAGE , "English"))

Cochrane Reviews: 98

(TITLE-ABS-KEY ("vision screening" OR "visual screen*" OR "vision screen*" OR "population vision screen*" OR "red eye reflex" OR "red reflex" OR "infra-red reflex")
AND
TITLE-ABS-KEY ("visual acuity" OR "vision disorders" OR amblyop* OR amblyopia OR strab* OR strabismus OR astigmatism OR hyperopia OR "lazy eye" OR "distance perception" OR ptosis OR rop OR "deprivation amblyop* " OR refract* OR "refractive error")
AND
TITLE-ABS-KEY (child OR children OR infant OR preschool OR pre-school OR newborn OR paediatric OR kindergarten))
AND
PUBYEAR > 2004
Reviews: 3
Trials: 101

CINAHL Plus 164

Search ID#	Search Terms	Search Options	Actions
S5	S1 AND S2 AND S3	**Limiters** - Publication Year: 2004-2019 **Search modes** - Find all my search terms	View Results (164)
S4	S1 AND S2 AND S3	**Search modes** - Find all my search terms	View Results (186)
S3	(MM "Vision Screening") OR (MH "Vision Tests") OR "red eye reflex" OR "red reflex"	**Search modes** - Find all my search terms	View Results (2,185)
S2	(MM "Amblyopia") OR (MH "Eye Abnormalities") OR (MM "Refractive Errors") OR (MM "Cataract") OR (MM "Astigmatism") OR (MM "Myopia") OR (MM "Hyperopia") OR "ptosis" OR "strab*" OR anisometropia OR "ocular motility" OR "lazy eye" OR "deprivation amblyopia"	**Search modes** - Find all my search terms	View Results (9,128)
S1	(MH "Infant") OR (MH "Child")	**Search modes** - Find all my search terms	View Results (476,272)

Medline/Ovid: 1412

# ▲	Searches	Results	Type
1	Vision Screening/	2132	Advanced
2	Vision Tests/	10030	Advanced
3	Mass Screening/	98420	Advanced
4	(visual adj2 screen*).ti,ab,kw,kf.	1119	Advanced
5	(vision adj2 screen*).ti,ab,kw,kf.	1264	Advanced
6	((ocular or opthalmic or eye) adj2 screen*).ti,ab,kw,kf.	878	Advanced
7	(red reflex or redreflex or infrared reflex or infra-red reflex or ir-reflex).ti,ab,kw,kf.	216	Advanced
8	or/1-7	111883	Advanced
9	Visual Acuity/	71226	Advanced
10	Vision Disorders/	26436	Advanced
11	Refraction, Ocular/	12893	Advanced
12	Amblyopia/	6529	Advanced
13	exp Strabismus/	15604	Advanced
14	Astigmatism/	6843	Advanced
15	Myopia/	16127	Advanced
16	anisometropia/ or hyperopia/	3821	Advanced
17	ocular motility disorders/	3670	Advanced
18	(refracti* or amblyop* or strabism* or myopi* or astigmat* or anisometrop* or hyperop* or hypermetrop*).ti,ab,kw,kf.	81033	Advanced
19	((vision or visual) adj2 (disorder* or acuity)).ti,ab,kw,kf.	62961	Advanced
20	(lazy adj3 eye*).ti,ab,kw,kf.	56	Advanced
21	distance perception/	2800	Advanced
22	((depth or distance) adj2 (perception* or perceive*)).ti,ab,kw,kf.	2963	Advanced
23	ptosis.ti,ab,kw,kf.	8711	Advanced
24	((eye or eyes or ocular) adj2 abnormal*).ti,ab,kw,kf.	4844	Advanced
25	(ROP or retinopathy of prematurity or retinoblastoma).ti,ab,kw,kf.	23196	Advanced
26	(cataract or cataracts or deprivation amblyop* or visual deprivation).ti,ab,kw,kf.	54989	Advanced
27	or/9-26	261670	Advanced
28	child, preschool/ or exp infant/	1518159	Advanced
29	(infant or infants or newborn* or new-born* or neonate? or neo-nate? or child or children or toddler* or pediatric* or paediatric* or kindergarten* or pre-school* or preschool*).ti,ab,kw,kf.	1734241	Advanced
30	28 or 29	2380181	Advanced
31	8 and 27 and 30	3388	Advanced
32	limit 31 to (english language and "humans only (removes records about animals)")	2818	Advanced
33	limit 32 to yr="2004 -Current"	1412	Advanced

Embase 1980 to current/Ovid: 1381

# ▲	Searches	Results	Type
1	mass screening/	48652	Advanced
2	vision test/	7607	Advanced
3	(vision adj2 screen*).ti,ab,kw.	1492	Advanced
4	(visual adj2 screen*).ti,ab,kw.	1332	Advanced
5	((ocular or opthalmic or eye) adj2 screen*).ti,ab,kw.	1287	Advanced
6	(red reflex or redreflex or infrared reflex or infra-red reflex or ir-reflex).ti,ab,kw.	256	Advanced
7	or/1-6	58829	Advanced
8	exp amblyopia/	8664	Advanced
9	amblyop*.ti,ab,kw.	7688	Advanced
10	myopia/	21649	Advanced
11	(lazy adj3 eye*).ti,ab,kw.	77	Advanced
12	exp strabismus/	20498	Advanced
13	(strabism* or squint* or refracti* or myopi* or astigmat* or anisometrop* or hyperop* or hypermetrop* or ammetropi*).ti,ab,kw.	74284	Advanced
14	((vision or visual) adj2 (disorder* or acuity)).ti,ab,kw.	79508	Advanced
15	(ptosis or cataract* or (deprivation adj3 amblyop*) or (visual adj3 deprivation)).ti,ab,kw.	72515	Advanced
16	(ROP or retinopathy of prematurity or retinoblastoma).ti,ab,kw.	27579	Advanced
17	or/8-16	230987	Advanced
18	exp child/	2323578	Advanced
19	exp infant/	882024	Advanced
20	(infant or infants or newborn* or new-born or neonate* or new-nate* or child or children or toddler* or pediatric* or paediatric* or kindergarten or pre-school or preschool*).ti,ab,kw.	1995174	Advanced
21	or/18-20	2880582	Advanced
22	7 and 17 and 21	2426	Advanced
23	limit 22 to (english language and "humans only (removes records about animals)")	2044	Advanced
24	limit 23 to yr="2004 -Current"	1381	Advanced

Total = 3880
First remove duplicates (exact) – left with 2304 (will be more duplicates)
Loaded into Covidence.org more refs removed – now = 2274

Appendix II Surveillance questions for parents included in Well Child Tamariki Ora my health book

24-48 hours assessment

- close relative with eye tumour at birth or during infancy or close relative with
- congenital eye malformation
- rubella (German measles), contact with rubella, or other congenital infection
- such as CMV or toxoplasmosis during pregnancy
- prematurity – less than 32 weeks or birth weight less than 1250 g
- eye malformations (absent red reflex, bulging eye, abnormal pupil), failure to fix
- or follow, or abnormal eye movements
- newborn seizures, encephalopathy, or metabolic disease
- trauma to eye or conjunctivitis that worsens or doesn't resolve

LMC final assessment

Can your baby see well? Do they…

- close their eyes against a bright light?
- stare at people's faces when they are up close?
- turn towards light?
- smile at you without being touched or spoken to?

4-6 weeks assessment

Can your baby see well? Do they…

- close their eyes against a bright light?
- stare at people's faces when they are up close?
- turn towards light?
- smile at you without being touched or spoken to?

8-10 weeks assessment

Can your baby see well? Do they…

- close their eyes against a bright light?
- stare at people's faces when they are up close?
- turn towards light?
- smile at you without being touched or spoken to?

3-4 months assessment

Can your baby see well? Do they…

- close their eyes against a bright light?
- stare at people's faces when they are up close?
- turn towards light?
- smile at you without being touched or spoken to?
- look at their own fingers?

5-7 months assessment

Can your baby see well? Do they…

- follow a slow-moving, bright-coloured object with their eyes?
- reach out for toys and other things?
- hold them firmly and look closely at them?

9-12 months assessment

Can your baby see well? Do they…

- pick up small things like bits of fluff from the floor?
- follow the movement of a dangling ball in all directions?
- look for dropped toys?
- watch what people are doing near them?
- tilt their head sideways to look at things?
- have a lazy eye, 'cross' eye or squint (when both eyes don't look straight at you most of the time)?

15-18 months assessment

Can your child see well? Do they…

- pick up small objects with their finger and thumb?
- point to interesting things (like birds)?
- watch everything that is going on around them?
- search with their hands rather than their eyes?
- bring objects up close to their eye?
- have a lazy eye, 'cross' eye or squint (when both eyes don't look straight at you)?

2-3 years assessment

Can your child see well? Do they…

- recognise small details in picture books?
- hold objects really close to look at them?
- have a lazy eye, 'cross' eye or squint (when both eyes don't look straight at you)?

B4 School Check

Can your child see well? Do they…

- point to interesting things (like birds)?
- run into things – high or low?
- bring objects close to their eyes to look at them?
- tilt their head in an unusual way to look at things?
- have a lazy eye, 'cross' eye or squint (when both eyes don't look straight at you)?

Appendix III: B4 School Check vision outcomes for the period 1 July 2011 to 30 June 2015

Acknowledgements

As part of the review process, the authors were able to obtain vision screening data from the B4 School Check recorded in Stats NZ Integrated Data Infrastructure (IDI). This was possible thanks to Nick Bowden, Jesse Kokaua, Barry Milne, and Rick Audas who carried out this work very quickly.

Disclaimer

The results in this paper are not official statistics. They have been created for research purposes from the Integrated Data Infrastructure (IDI), managed by Statistics New Zealand. The opinions, findings, recommendations, and conclusions expressed in this paper are those of the author(s), not Statistics NZ or the University of Otago. Access to the anonymised data used in this study was provided by Statistics NZ under the security and confidentiality provisions of the Statistics Act 1975. Only people authorised by the Statistics Act 1975 are allowed to see data about a particular person, household, business, or organisation, and the results in this report, paper have been confidentialised to protect these groups from identification and to keep their data safe.

Careful consideration has been given to the privacy, security, and confidentiality issues associated with using administrative and survey data in the IDI. Further detail can be found in the Privacy impact assessment for the Integrated Data Infrastructure available from www.stats.govt.nz. The results are based in part on tax data supplied by Inland Revenue to Statistics NZ under the Tax Administration Act 1994. This tax data must be used only for statistical purposes, and no individual information may be published or disclosed in any other form, or provided to Inland Revenue for administrative or regulatory purposes. Any person who has had access to the unit-record data has certified that they have been shown, have read, and have understood section 81 of the Tax Administration Act 1994, which relates to secrecy. Any discussion of data limitations or weaknesses is in the context of using the IDI for statistical purposes, and is not related to the data's ability to support Inland Revenue's core operational requirements.

Background

Current B4SC vision screening comprises a visual acuity screening using the Parr Chart which is performed by lay screeners in a community setting. There are three possible outcomes of screening; "Pass", "Rescreen" or "Refer". Additionally, families may decline the screening or may be unable to be contacted or scheduled for screening.

Methods:

Data were sourced from the Statistics New Zealand Integrated Data Infrastructure (IDI)including data from 1 July 2011 to 30 June 2015. The eligible population and B4SC coverage were determined using methods developed previously (Gibb).

Children unable to complete vision screening were identified by finding those children with a B4SC vision screening outcome of "Referred" or "Rescreened" for whom there was no vision measurement recorded.

Results:

B4SC Vision screening coverage

Vision screening coverage was high and completed screenings increased from 2011 to 2015 (Table 1). Children from whānau identifying as Māori or Pacific had reduced proportions of completed screenings. Specifically, more Māori (14.0%) and Pacific (15.1%) children compared with European (9%) and Asian (8.7%) children did not receive a vision screening. Māori and Pacific children were more likely to miss the vision check despite partially completing the B4SC, and Pacific families had a higher prevalence of declined screenings than other ethnicities (Table 2).

Table 1. Coverage of B4SC by year

	2011/12	2012/13	2013/14	2014/15	Combined
B4SC Coverage	88.7	90.0	91.8	92.9	90.8
Full B4Sc coverage	76.2	79.5	84.2	85.7	81.4
Vision Coverage	86.8	88.7	90.7	91.8	89.5

Table 2. B4SC Coverage for the 2011-2015 period by ethnicity, NZDep quintile and DHB.

	Children receiving vision B4SC (n)	Children receiving vision B4SC (%)	Children completing part B4SC but not vision (n)	Children completing part B4SC but not vision (%)	Declined vision (n)	Declined vision (%)
Overall	**225,714**	**89.5**	**3,411**	**1.5**	**3,438**	**1.5**
Sex						
Male	116,151	89.5	1,743	1.5	1,755	1.5
Female	109,566	89.5	1,668	1.5	1,680	1.5
Ethnicity						
Māori	68,889	86.0	1,395	2.0	1,272	1.8
Pacific	37,218	84.9	669	1.8	1,221	3.3
Asian	30,879	91.3	336	1.1	462	1.5
European	169,473	91.0	2,376	1.4	1,893	1.1
NZDep						
Q1	41,565	92.4	519	1.2	408	1.0
Q2	40,854	91.4	498	1.2	480	1.2
Q3	41,727	90.3	564	1.3	516	1.2
Q4	44,064	89.5	699	1.6	684	1.6
Q5	56,541	86.4	1,113	1.9	1,320	2.3
DHB Regions						
Auckland	20,664	88.1	309	1.5	882	4.3
Bay of Plenty	11,364	92.8	45	0.4	33	0.3
Canterbury	23,586	92.5	822	3.4	483	2.0
Capital and Coast	12,126	80.4	303	2.4	12	0.1
Counties Manukau	30,585	90.1	237	0.8	855	2.8
Hawke's Bay	8,739	92.7	288	3.2	33	0.4
Hutt Valley	7,317	85.4	141	1.9	12	0.2
Lakes	6,279	93.8	81	1.3	27	0.4
MidCentral	8,325	87.9	39	0.5	42	0.5
Nelson Marlborough	6,504	91.2	12	0.2	27	0.4
Northland	7,869	80.9	81	1.0	153	1.9
South Canterbury	2,679	96.4	36	1.3	9	0.3
Southern	14,040	92.6	180	1.3	72	0.5
Tairawhiti	2,883	89.9	51	1.7	6	0.2
Taranaki	5,949	87.1	93	1.5	48	0.8
Waikato	21,285	93.9	156	0.7	144	0.7
Wairarapa	2,019	89.6	24	1.2	S	S
Waitemata	28,122	90.0	264	0.9	510	1.8
West Coast	1,461	85.3	15	1.0	9	0.6
Whanganui	3,048	86.9	225	6.9	51	1.7

Children referred or identified for rescreening

Overall 6.8% of children were referred for further assessment and 4.2% were awaiting rescreening.

Table 3. Children classified as rescreen or refer from B4SC by ethnicity, NZDep quintile and DHB

	Rescreen (n)	Rescreen (%)	Referred (n)	Referred (%)
Overall	**9,531**	**4.2**	**15,318**	**6.8**
Sex				
Male	5,061	4.4	7,935	6.8
Female	4,470	4.1	7,383	6.7
Ethnicity				
Māori	3,558	5.2	5,022	7.3
Pacific	1,905	5.1	3,057	8.2
Asian	1,113	3.6	2,628	8.5
European	6,528	3.9	10,152	6.0
NZDep				
Q1	1,554	3.7	2,271	5.5
Q2	1,449	3.5	2,430	5.9
Q3	1,623	3.9	2,661	6.4
Q4	1,842	4.2	3,099	7.0
Q5	3,009	5.3	4,797	8.5
DHB Regions				
Auckland	1,089	5.3	1,566	7.6
Bay of Plenty	597	5.3	546	4.8
Canterbury	1,746	7.4	1,557	6.6
Capital and Coast	1,014	8.4	909	7.5
Counties Manukau	903	3.0	3,150	10.3
Hawke's Bay	207	2.4	876	10.0
Hutt Valley	243	3.3	639	8.7
Lakes	174	2.8	699	11.1
MidCentral	489	5.9	837	10.1
Nelson Marlborough	126	1.9	93	1.4
Northland	597	7.6	372	4.7
South Canterbury	84	3.1	249	9.3
Southern	120	0.9	846	6.0
Tairawhiti	78	2.7	186	6.5
Taranaki	84	1.4	645	10.8
Waikato	579	2.7	420	2.0
Wairarapa	216	10.7	195	9.7
Waitemata	783	2.8	1,275	4.5
West Coast	99	6.8	81	5.5
Whanganui	255	8.4	132	4.3

Children unable to complete vision screening

Of all children who had an outcome of "Referred" or "Rescreened" overall 20.5% did not have a vision measurement recorded. Inability to complete vision screening increased with increasing NZDep Quintile (1.26% Quintile 1 to 3.68% Quintile 5) and children of Māori ethnicity were less likely to achieve a vision measurement (3.59% unable) than other ethnicities. Considerable variation is recorded between DHBs.

Table 4. Children with no VA measurement compared to Referred or Rescreen outcome and total number screened by ethnicity, NZDep quintile and DHB

	No VA recorded for refer/rescreen (n)	Number of refer/rescreen (n)	No VA recorded % of refer/rescreen	Total screened (n)	No VA recorded % of total screened
Overall	**5,091**	**24,849**	**20.5**	**225,714**	**2.26**
Sex					
Male	2,964	12,996	22.8	116,151	2.55
Female	2,127	11,853	17.9	109,566	1.94
Ethnicity					
Māori	2,475	8,580	28.8	68,889	3.59
Pacific	993	4,962	20.0	37,218	2.67
Asian	525	3,741	14.0	30,879	1.70
European	3,258	16,680	19.5	169,473	1.92
NZDep					
Q1	522	3,825	13.6	41,565	1.26
Q2	567	3,879	14.6	40,854	1.39
Q3	819	4,284	19.1	41,727	1.96
Q4	1,062	4,941	21.5	44,064	2.41
Q5	2,079	7,806	26.6	56,541	3.68
DHB Regions					
Auckland	219	2,652	8.3	20,664	1.06
Bay of Plenty	261	1,143	22.8	11,364	2.30
Canterbury	624	3,306	18.9	23,586	2.65
Capital and Coast	405	1,920	21.1	12,126	3.34
Counties Manukau	573	4,056	14.1	30,585	1.87
Hawke's Bay	456	1,086	42.0	8,739	5.22
Hutt Valley	177	879	20.1	7,317	2.42
Lakes	273	873	31.3	6,279	4.35
MidCentral	174	1,326	13.1	8,325	2.09
Nelson Marlborough	84	219	38.4	6,504	1.29
Northland	363	966	37.6	7,869	4.61
South Canterbury	42	330	12.7	2,679	1.57
Southern	99	966	10.2	14,040	0.71
Tairawhiti	72	264	27.3	2,883	2.50
Taranaki	102	729	14.0	5,949	1.71
Waikato	549	996	55.1	21,285	2.58
Wairarapa	51	411	12.4	2,019	2.53
Waitemata	276	2,055	13.4	28,122	0.98
West Coast	54	180	30.0	1,461	3.70
Whanganui	207	387	53.5	3,048	6.79

Appendix IV: Process of estimating graded recommendations

The search and selection strategy for this review were structured to address the questions provided by the Ministry of Health in the short time frame provided. After completion of the review, authors were asked to provide grades for recommendations within the review. Compliance with this request required compromise, as a new search and analysis with this new aim was not feasible. Within this context, to limit our bias in estimating graded recommendations, we used a semi-structured approach, outlined below.

Identifying key screening interventions

First, we established which screening interventions justified specific recommendations. Decisions were based on current screening practice and evidence gathered while answering the questions provided by the Ministry of Health. The age, targeted conditions, test and treatments considered for each screening intervention are listed in Table 7.X. Note that currently in NZ the specific VA test used (Parr) differs from those most used in the literature (Lea or HOTV), and we do not use automated vision screeners.

Table 7.4. Screening interventions for graded recommendations.

Age	Targeted conditions	Tests used most in literature	Treatments
Newborns	Congenital eye conditions	Red reflex	Cataract removal surgery and amblyopia treatment
6 month to 3-year	Amblyopia and its risk factors	vision screener	Spectacle correction and amblyopia treatment
3 to 5-year	Amblyopia and its risk factors	VA test and/or vision screener	Spectacle correction and amblyopia treatment
3 to 5-year	Non-amblyogenic refractive error	VA test and vision screener	Spectacle correction

Generating estimates of benefit and certainty

To estimate the net benefit for each the screening interventions outlined in Table 7.X, we considered how the questions provided by the Ministry of Health could be rephrased such that answering ‘yes’ reflected a benefit (Figure 7.2). Note that questions 2 (timing of screening) and 6 (targeted conditions) were used to delineate between screening interventions rather than to estimate net benefit. For each screening intervention, there was very little evidence for cost-effectiveness or impact for Māori and Pacific children (questions 8 and 9, respectively) so these were not included in the estimates of net benefit.

The remaining rephrased questions fit into three categories: 1) does the condition matter (blue), 2) are the screening tools acceptable (green) and 3) is there an effective treatment (yellow). We then reviewed the evidence from the rapid review to answer each of the re-phrased questions as either ‘no’, ‘maybe’ or ‘yes’, and estimated the associated level of certainty as ‘low’, ‘medium’, or ‘high’. We plotted estimated benefit (position on x-axis) and level of certainty (‘small’, ‘medium’ or ‘large’ dots reflecting ‘low’ ‘medium’ and ‘high’ certainty, respectively) for each rephrased question. Estimating benefit and certainty in this way is imprecise, however, making the process transparent allows key concepts and current debates to be highlighted. From these plots, we estimated overall net benefit and level of certainty for each of the four candidate screening interventions, described below.

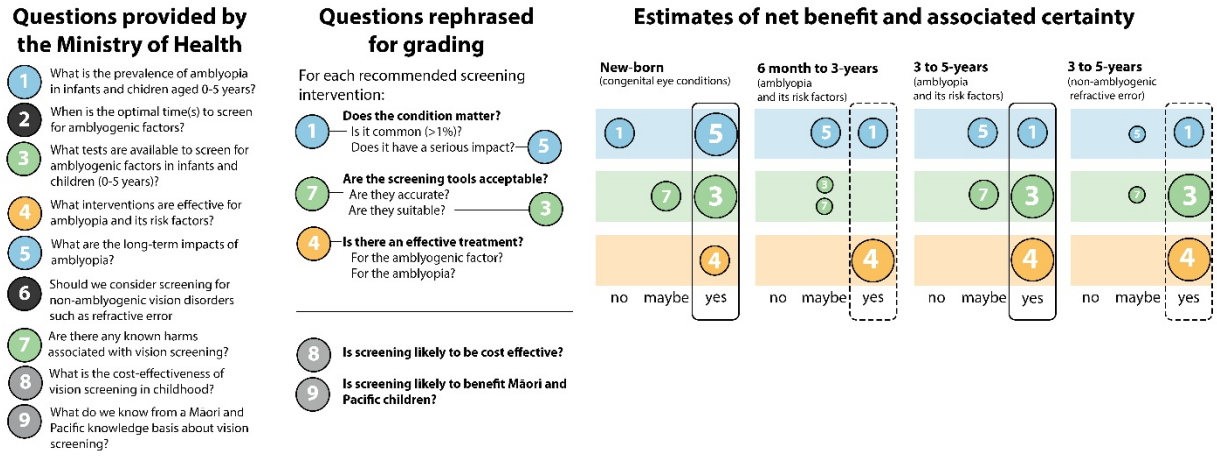


Figure 7.2. Relationship between rapid review questions and net benefit and associated certainty estimates. Justification for the position and size of each dot in the 'estimates of net benefit and associated certainty' section are summarised below.

Summary of estimated benefit and associated certainty

We estimated that screening newborns for congenital eye conditions with the red reflex test has a moderate net benefit, with moderate certainty.

Does the condition matter? Although the prevalence of these conditions is low (medium certainty), the impact is high due to the sight and life-threatening nature of congenital cataract and retinoblastoma, respectively (high certainty).

Are the tests acceptable? The red reflex test is non-invasive (high certainty), and acceptably accurate if performed by trained professionals (to detect severe congenital conditions such as cataract and retinoblastoma - medium certainty).

Is there an effective treatment? Although there is a current lack of research regarding patching and atropine to treat deprivation amblyopia, this is balanced by the well-established effectiveness of cataract removal surgery (together, medium certainty).

Grade B – All newborns should be screened for congenital eye conditions with the red reflex test.

We estimated that screening 3 to 5-year old children for amblyopia and its risk factors with VA tests and/or vision screeners has a moderate net benefit with moderate certainty.

Does the condition matter? Although debate exists about the impact (moderate impact, with medium certainty), the condition is relatively common (medium certainty), such that even a minor impact is likely beneficial at scale.

Are the tests acceptable? Lea symbols VA tests and certain vision screeners are suitable for children of this age (high certainty) and are sufficiently accurate with enough training, and appropriate referral criteria (medium certainly).

Is there an effective treatment? Treatment is well established to be effective (high certainty).
Grade B – All 3 to 5-year old children should be screened for amblyopia and its risk factors with VA tests and/or vision screeners.

We estimated that screening for amblyopia and its risk factors in younger children (6 months to 3-years) has moderate benefit but low certainty.

Does the condition matter and are there effective treatments? Prevalence, impact and treatment are similar to that in preschool children, suggesting moderate benefit.

Are the tests acceptable? Current screening tests are less accurate at this age, and fewer toddlers are able to complete the tests than pre-school children, therefore, currently we only have medium certainty that test are acceptable. Due to question about acceptable screening tests, overall, certainty that the benefits of screening at this age would be realised, was low.

Grade I – There is currently insufficient evidence to say whether or not 6 month to 3 year old children should be screened for amblyopia and its risk factors.

We estimated that screening for non-amblyogenic refractive error in 3 to 5-year old children has moderate benefit, but low certainty.

Is there an effective treatment? Treatment is well established and effective (high certainty).

Does the condition matter? Although debate exists about impact, there is growing evidence that non-amblyogenic refractive errors at least as impactful as unilateral amblyopia (however certainty remains relatively low).

Are the tests acceptable? Tests for VA and automated assessment of refractive error are acceptable, however, there is currently insufficient evidence about the accuracy of VA tests/vision screeners to detect non-amblyogenic refractive error in preschool children.

Overall, certainty that the benefits of screening for non-amblyogenic refractive error at this age would be realised was low.

Grade I – There is currently insufficient evidence to say whether or not 3 to 5-year old children should be screened for non-amblyogenic refractive errors.

Supplementary Information - Grade definitions and levels of certainty

Table S1. Grade definitions for screening tools and interventions

Adapted with permission from the U.S. Preventive Services Task Force 2012.[i]

Grade	Definition	Recommendation for policy and practice
A	• The authors recommend this screening tool/intervention. • There is high certainty that the net benefit is substantial.	• This screening tool/intervention should be offered or provided.
B	• The authors recommend the screening tool/intervention. • There is high certainty that the net benefit is moderate, or there is moderate certainty that the net benefit is moderate to substantial.	• This screening tool/intervention should be offered or provided.
C	• The authors recommend selectively offering or providing this screening tool/intervention to patients based on professional judgment and patient preferences. • There is at least moderate certainty that the net benefit is small.	• This screening tool/intervention should be provided for selected patients depending on individual circumstances.
D	• The authors recommend against this screening tool/intervention. • There is moderate or high certainty that the screening tool/ intervention has no net benefit or that the harms outweigh the benefits.	• The authors discourage the use of this screening tool/intervention.
I	• The authors conclude that the current evidence is insufficient to assess the balance of benefits and harms of the screening tool/intervention. • Evidence is lacking, of poor quality, or conflicting, and the balance of benefits and harms cannot be determined.	• If the screening tool/intervention is offered, patients should understand the uncertainty about the balance of benefits and harms.

Table S2. Levels of certainty regarding net benefit

Adapted with permission from the U.S. Preventive Services Task Force 2012 [1].

Level Of Certainty	Description
High	• The available evidence usually includes consistent results from well-designed, well-conducted studies in representative populations. • These studies assess the effects of the preventive service on health outcomes. • This conclusion is therefore unlikely to be strongly affected by the results of future studies.
Moderate	• The available evidence is sufficient to determine the effects of the preventive service on health outcomes, but confidence in the estimate is constrained by such factors as: – the number, size, or quality of individual studies; – inconsistency of findings across studies; – limited generalizability of findings to routine practice; – lack of coherence in the chain of evidence. • As more information becomes available, the magnitude or direction of the observed effect could change, and this change may be large enough to alter the conclusion(s).
Low	• The available evidence is insufficient to assess effects on health outcomes, because of: – the limited number and/or size of studies; – important flaws in study design and/or methods; – inconsistency of findings across individual studies; – gaps in the chain of evidence; – findings not generalizable to routine practice; – lack of information on important health outcomes. • More information may allow estimation of effects on health outcomes.

[i] https://www.uspreventiveservicestaskforce.org/Page/Name/grade-definitions