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## VIEWPOINT

## Towards a national pre-school vision screening programme

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The aim of the study is to examine common approaches to pre-school vision screening, including the current New South Wales model which is known as Statewide Eyesight Preschooler Screening (StEPS) to determine whether the criteria set by the World Health Organization are fulfilled by StEPS, and therefore, whether there is sufficient justification to deploy a similar model nationally. A literature review was conducted to answer four key questions related to vision screening. The authors sought to review (i) the justification for vision screening of a pre-school population; (ii) the principles and best approaches to vision screening such as how, where and who should conduct vision screening; (iii) the conditions that are targeted in vision screening; and (iv) the acceptable pass/fail vision screening criteria. The StEPS vision screening model is an accurate, reliable and economical way of screening for reduced vision at a time when neural plasticity allows improvement in vision following intervention. It fulfils World Health Organization criteria for a successful screening programme. StEPS has very high participation rates compared to other screening methods in Australia due to its unique model whereby screeners utilise early childhood settings to recruit and screen 4-year-old children. Due consideration should be given to deploying the StEPS vision screening model nationally.

Amblyopia describes abnormal visual input in the early years of life secondary to refractive error, strabismus or visual deprivation, resulting in a reversible decrease in visual acuity in one, or less commonly both eyes.<sup>1</sup> Amblyopia and uncorrected refractive error are the most common causes of reduced vision in Australian children.<sup>2</sup> Attebo *et al.* cited amblyopia prevalence rates of 3.2% in Australia<sup>1</sup> and Robaei *et al.* found 10.4% of 12-year-old Australian children had visually significant refractive error.<sup>3</sup>

Amblyopia requires early identification because effective restorative treatment only occurs when children have considerable neural plasticity,<sup>4–8</sup> before becoming entrenched at 8 years of age.<sup>9</sup> Failure to detect reduced vision in young children can result in permanent loss of vision<sup>9</sup> and increased risk of significant vision loss.<sup>10,11</sup> Rahi *et al.*<sup>10</sup> found a 1.2–3.3% 'substantial' lifetime risk of serious vision loss for an individual with amblyopia. Chua and Mitchell determined the risk of significant visual impairment to be nearly three times higher in amblyopes than non-amblyopes.<sup>11</sup> Further, reduced vision may impact on academic achievement levels,<sup>12,13</sup> may lead to reduced quality of life<sup>14</sup> and can exclude people from certain career paths.<sup>15</sup>

Childhood vision screening is known to reduce the incidence and severity of uncorrected refractive error and amblyopia.<sup>16,17</sup> Eibschitz-Tsimhoni *et al.*<sup>16</sup> found amblyopia incidence in screened populations to be 1% compared to 2.6% in a non-screened

population. Garretty<sup>18</sup> found that 92.9% of children who completed treatment following detection on vision screening were ultimately discharged with vision within normal limits for their age.

Currently, a national childhood vision screening approach does not exist in Australia, with considerable variation in regard to screening age, referral criteria and screening personnel between states and territories,<sup>19–25</sup> as evidenced in Table 1. Children living in New South Wales (NSW) are offered vision screening by the Statewide Eyesight Preschool Screening (StEPS) programme, the only universal vision screening programme for children in Australia. StEPS was successfully implemented in 2008, and underwent rigorous review in 2018<sup>24</sup> with the conclusion that StEPS was a 'highly appropriate and effective strategy for guiding young children to early intervention and treatment for childhood ocular conditions' and described it as 'one of the most successful screening programs of its type on an international scale' (p. 6). This report included a cost-effectiveness estimate of approximately AUD \$4 million per year, equating to AUD \$49.21 per child, with predicted economies of scale as more children are screened over ensuing years.<sup>24</sup> It found that '... compared to no screening, the StEPS program ... yielded on average 0.009 additional quality adjusted life years (QALYs) which equates to a cost effectiveness of AUD \$14,386 per QALY gained' (p. 11). The report noted that values of up to AUD \$75 000 per QALY were regarded as the upper threshold in Australia, and therefore concluded that StEPS vision screening was a 'feasible, cost-effective strategy' (p. 91).

Given the ongoing need for efficient and cost-effective childhood vision screening, this paper will propose that a national application of StEPS be considered for the benefit of all Australian children.

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**Table 1** Patterns of pre-school screening in Australian states and territories and internationally

State/Territory OR country	Screening personnel	Screening location	Cut-off referral	Referral follow-up/data collection/quality control
South Australia <sup>19</sup>	Child and family nurses	Community health centre	Not specified	Not publicly available
Tasmania <sup>20</sup>	Child and family health nurses	Community health centre	<6/9 in either eye or unequal acuity	Not publicly available
ACT <sup>21</sup>	Child and family nurses	Community health centre	<6/9 in either eye	Not publicly available
Queensland <sup>22</sup>	Nil pre-school – performed in schools aged at least 5 years			
Western Australia <sup>23</sup>	Community health staff	Community health centre	Not specified	Not publicly available
NSW <sup>24</sup>	Trained staff	Pre-school/day care setting	6/9-3 in either eye	Published data available
Victoria <sup>25</sup>	Child and family nurses	Community health centre	3/5-3 in either eye (equivalent to 6/10-3). Nota bene single rather than crowded optotypes are presented	Not publicly available
NT	No details of formal programme available on internet (as of 9 March 2022)			
New Zealand <sup>26,27,28</sup>	Vision and hearing technician/school nurse	Not supplied	6/12 Nota bene screening is performed with an unvalidated test (Parr chart) and at an atypical test distance of 4 m <sup>28</sup>	Published data available
UK <sup>27</sup>	Trained staff and orthoptists	Not supplied	6/9.5 – various test types used	Not supplied
USA <sup>27,29</sup> – 34 states provide vision screening guidelines, 15 of which require pre-school vision screening of at least some children	Personnel is variable, often nurses and trained staff	Not supplied	6/9 – various test types used	Not supplied

## Database Search and Literature Review

Key issues related to childhood vision screening (of children >3 years of age) including the optimal timeframe for screening, appropriate screening locations, test types and personnel, target conditions, and vision screening criteria were explored in a database search using the term 'vision screening'. The National Library of Medicine (PubMed), Web of Science and ProQuest Central were searched to identify peer-reviewed papers, published after 2000, applicable to the Australian context. Relevant publications such as the 2009 National Children's Vision Screening Project (NCVSP)<sup>30</sup> and the Evaluation of the NSW State-wide Eyesight Preschooler Screening Program (StEPS)<sup>24</sup> were also included.

### Optimal timeframe for childhood vision screening

To determine the optimal timeframe for childhood vision screening, there is a need to balance the urgency of identifying conditions that

may affect visual development with the challenge of examining visual acuity in young children. Studies have shown that children can reliably participate in vision screening. Leone *et al.*<sup>31</sup> found visual acuity testability rates of 93% and 95% in 4 and 4.5-year-old children respectively, when an age appropriate, adult equivalent vision test that incorporated a matching technique (to assist the child's participation) was used. This Australian study concluded that reduced vision could be reliably detected in 4-year-old children, aligning with international findings.<sup>17,32</sup> Support for vision screening of children aged 3–5 years was also evident in the reported outcomes of the National Children's Vision Screening Project (NCVSP)<sup>30</sup> and the US Preventative Services Task Force (USPSTF) Recommendations Statement.<sup>33</sup> Various other studies also noted that screening this age group left sufficient time for treatment to reverse vision loss.<sup>4–9</sup>

Deferring vision screening until a child is older poses risk. For example, if vision screening occurs at school entry, children are generally 5 years old and if they fail screening may be 6 years old before beginning treatment.<sup>30</sup> The optimal period in which to

restore visual development is up to 8 years old.<sup>4–9</sup> Visual gains are known to be more challenging to achieve the closer the child is to the threshold of 8 years, and unfortunately, children with delayed detection of reduced visual acuity may be left with a visual acuity deficit for life.<sup>1,9</sup> Without vision screening prior to school entry, some children are starting school with unidentified vision problems, including significant uncorrected refractive error, which may impact on early literacy levels.<sup>11–13,30</sup> Therefore, vision screening is recommended in pre-school children aged 4 years, such as in the StEPS screening model.

## Pre-school vision screening approaches

### Test type

Visual acuity should be tested at 3 or 6 m with crowded optotypes, that is letters or pictures surrounded by other images or 'bars'. This is known to provide a direct measure of visual function and will reliably identify amblyopia and/or reduced vision.<sup>34,35</sup> Crowded optotypes are more sensitive for amblyopia detection than single optotypes.<sup>36</sup> It is critical that a pre-school vision screening programme uses crowded optotypes in the assessment of vision<sup>17,35</sup> as is the case with StEPS.<sup>24</sup>

### Location of testing

There is no doubt that for vision screening to be accessed consideration of children and their families should be a priority. In the StEPS model vision screening is conducted in pre-schools, day care centres, family day care and community health centres across NSW, including rural and remote locations. The StEPS evaluation reported that between 2009 and 2016, 96.4% of 4-year-olds living in NSW ( $n = 719\,686$ ) were offered vision screening, of which 84% of families consented to their children undergoing screening.<sup>24</sup> In an earlier publication, Blows *et al.*<sup>37</sup> reported StEPS screening rates amongst Aboriginal children to be consistent with the estimated proportion of Aboriginal children residing in NSW. This had an additional benefit of closing the gap between Indigenous and non-Indigenous health and well-being outcomes, provided that adequate follow-up and treatment were available.

Taking vision screening to children, as occurs in the StEPS vision screening model, results in higher participation rates than other models<sup>24,30</sup> and is therefore recommended.

### Vision screening staff

As a matter of principle, vision screening should not be performed by a person or group who can gain benefit from the outcome of screening such as may occur if the screeners are also potential treating practitioners. For this reason, optometrists and ophthalmologists should not hold a primary role in screening.

Childhood vision screening must be conducted by trained and experienced screeners who strictly adhere to mandated screening guidelines. It is known that visual acuity testing can be reliably performed by adequately trained personnel.<sup>18,24,30</sup> In Australia and internationally, vision screening has been performed by nurses, orthoptists and trained lay people.<sup>17,26,27,29,38</sup> In the StEPS model, screening is performed by nurses and lay people specifically trained by orthoptists, a method which has been shown to yield results of comparable quality to screening programme delivered by orthoptists themselves.<sup>18</sup> In the StEPS model, orthoptists in some local health districts (LHDs) provide secondary screening

which has resulted in a lower rate of high priority referrals (–1.9%).<sup>24</sup> Garretty also found secondary screening by orthoptists reduced false positives in the UK.<sup>18</sup> Similarly, significantly lower referral rates were observed in StEPS when orthoptists provided secondary screening for children who were unable to be screened due to physical or developmental issues (–0.8% for routine referral and –3.9% for borderline passes).<sup>24</sup> In developing a national approach, it is recommended that selection of suitable staff should parallel the StEPS approach.

## Target conditions

Pre-school vision screening is intended to identify children who have reduced vision caused by conditions such as refractive error, amblyopia or ocular pathology at a time when intervention may result in visual gains.<sup>4–9</sup> Such conditions are generally not detectable through parental surveillance alone and/or may only become apparent when vision is tested monocularly.<sup>30</sup>

The Evaluation of the NSW StEPS Program<sup>24</sup> identified refractive error followed by amblyopia as the most common conditions to be diagnosed following a failed StEPS screen. Over a 3-year period (September 2013–December 2016), 36.1% of high priority referrals and 22.3% of routine referrals required glasses, 12.9% of high priority referrals and 3.1% of routine referrals were diagnosed with amblyopia, and 1.6% and 0.8% respectively were diagnosed with ocular pathology including cataract, glaucoma, optic nerve disorder, corneal pathology, nystagmus and ptosis. In all, 72.7% of children referred from StEPS received some form of eye care, including 65.8% who had not previously sought treatment.<sup>24</sup> In 2014, Blows *et al.*<sup>37</sup> studied the outcomes from StEPS screening for two LHDs from July 2010 to June 2011 and found similar (but higher) rates of diagnosis for amblyopia and refractive error, and that over 90% of those referred required treatment or further review. This is strong evidence that the StEPS model, which offers screening to over 95% of the 4-year-old population in NSW, is effective in identifying the target conditions.

## Vision screening criteria

Typical visual acuity in 4-year-old children is considered to be around 6/9.5 when tested using gold standard methods.<sup>34</sup> Many vision screening programmes consider visual acuity of less than 6/12 in one or both eyes to be indicative of a true positive

**Table 2** Summary of StEPS pass/fail visual acuity criteria

Visual acuity standard in one or both eyes	Outcome from vision screening
6/9 or better	Pass – no referral
6/9-1 or 6/9-2	Borderline pass – parents notified and advised to recheck vision in 12 months
6/9-3 to 6/18	Fail with a referral provided to a diagnostic service (low priority)
<6/18 or presence of obvious abnormality	Fail with a referral provided to a diagnostic service (high priority)
StEPS, Statewide Eyesight Preschooler Screening.	

(or failed vision screen) in a 4-year-old population.<sup>4,18,24,28,30</sup> StEPS uses slightly stricter criteria which are summarised in Table 2. The main point of difference between StEPS criteria and other vision screening programmes is that categories exist for failed vision screening including low or high priority referrals and borderline passes.

The StEPS approach of prioritising certain referrals was supported in the 10-year StEPS evaluation.<sup>24</sup> Of the 564 068 4-year-old children screened 9.4% ( $n = 53\ 169$ ) failed screening and were subsequently referred to an ophthalmologist or optometrist. The rate of false positives in this review was reported as 'negligible' and was often attributed to children having developmental or physical issues which prevented full participation. From September 2013 to December 2016, nearly 80% of the high priority referrals required intervention or follow-up, some of which resulted in significant diagnoses such as cataracts, glaucoma and optic nerve disorders.<sup>24</sup>

The suitability of criteria chosen to define a pass or fail from vision screening is foundational to the success of a vision screening programme.<sup>39</sup> Langeslag-Smith *et al.*<sup>28</sup> assessed the efficacy of the New Zealand vision screening programme (B4 School Check) in 2015. They found that changing the fail criteria from 6/9 to 6/12 reduced false positives without affecting the negative predictive value. Therefore a cut off of either 6/9-3 or 6/12 may be considered appropriate.

## World Health Organization Criteria for Screening

The StEPS programme aligns with the World Health Organization (WHO) criteria for a successful screening programme.<sup>39</sup>

First, WHO states that the condition being screened for should be an important health problem.<sup>39</sup> Amblyopia and uncorrected refractive error are the most common causes of reduced vision in Australian children and occur in approximately 3% and 10% respectively of unscreened Sydney children.<sup>1-3</sup>

Second, there should be a latent/symptomatic period, the condition should be well understood and there should be an accepted treatment.<sup>39</sup> Four-year-old children who have reduced vision can be effectively treated if identified in a timely manner.<sup>4-8,18</sup> Failure to detect reduced vision in a period of neural plasticity risks reduced vision for life<sup>9</sup> and significantly higher risk of severe visual impairment later.<sup>10,11</sup>

Third, there should be a suitable test with a high level of accuracy that is acceptable to the population.<sup>39</sup> The distance visual acuity test with crowding effect, used in the StEPS vision screening programme, is the gold standard for investigating the presence of reduced vision and amblyopia in a 4-year-old population.<sup>17,31,32,35,36</sup> It accurately identifies children with reduced vision with negligible false positives when performed by well trained and experienced screeners.<sup>18,24</sup> The StEPS screening programme has high participation rates, evidenced by 84% of parents who provided consent for vision screening,<sup>24,37</sup> and completion rates approaching 90%.<sup>24,37</sup>

Fourth, WHO states that there should be an agreed policy on whom to treat as patients and facilities for diagnosis and treatment.<sup>39</sup> The current StEPS criteria refer children who return vision of 6/9-3 or worse on an age-appropriate gold standard visual acuity test.<sup>24,37</sup> Other findings in the literature also suggest

that a cut off of 6/12 may also be considered appropriate.<sup>28</sup> Referral pathways are provided to the parents of children who fail StEPS screening and LHD coordinators must follow-up on the outcome of further testing.

Fifth, it is essential that screening is cost effective.<sup>39</sup> There is a benefit to quality of life by identifying and treating reduced vision,<sup>4-8</sup> and reducing the burden that blindness imposes on an individual and society.<sup>10,11</sup> StEPS has been found to be cost-effective and an appropriate use of available resources in a report commissioned by NSW Health.<sup>24</sup>

Sixth, screening should be a continuing process in the target population.<sup>39</sup> StEPS is offered to all eligible 4-year-old NSW children, including remote, rural and Aboriginal and Torres Strait Islander populations.<sup>24,37</sup>

## Conclusion

StEPS has been shown to be an accurate, reliable and economical way of screening Australian children for reduced vision. StEPS fulfils mandated WHO criteria for an acceptable screening programme. The StEPS model is unique in that children are actively recruited for vision screening via their pre-school or day care setting, and vision screeners routinely attend these settings to screen vision. This has resulted in very high participation rates as compared to other models. Thousands of NSW children have received treatment to reverse vision loss which may have remained unidentified. Serious consideration should be given to deploying a model such as StEPS as a national pre-school vision screening programme.

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