CHAPTER 2

REVIEW OF LITERATURE
2.2 Overview on Preschool Vision Screenings

In their review article, Langreze tried to conclude whether the universal vision screening in preschoolers was worthwhile or not. The reason for screening was to primarily prevent amblyopia by identifying its key causes. According to the authors, prevalence of amblyopia ranged from 1 to 5.3%. The need for screening is when the disorder cannot be identified by lay people but can be revealed only by sensitive and specific tests. The recommendation was to use combination of tests rather than a single test as PPV of any single test used in VIP study is low (16%) even though test sensitivity and specificity are 60% and 90% respectively. The authors observed that the prevalence of amblyopia was linked to social strata. All studies published till date have methodological flaws as swotted by various authors. Despite the limitations, the positive effect of screening was apparently consistent in the literature. The author did a comparative study of reports on effectiveness of preschool screening programmes in Britain and Germany respectively. There was lack of uniformity in tests, procedures, treatment age of amblyopia and significant methodological weaknesses resulting in diverging conclusions of the reports. The reviewer emphasized the need for better quality studies to be published and remarked that the discrepancy in evidence base can only be reinforced by clinical experience.26

Ying et al compared the prevalence of amblyopia, strabismus and significant refractive error among African American, American Indian, Asian, Hispanic and non-Hispanic white preschoolers in the VIP study. The prevalence of any VIP targeted vision disorder was 21.4% among the children included with highest in Hispanic children (23.3%) and lowest in American Indian children (17.9%). The prevalence of amblyopia was greatest among Hispanic whites (5.44%) and lowest among Asians (2.98%) while strabismus was highest (4.59%) in non-Hispanic whites and least in Asian children.
The refractive error prevalence was greatest among Hispanics (17.2%) and least among American Indians (11.8%). The statistical analysis revealed no significant difference in the vision disorders among the racial or ethnic groups studied. The authors advocated that although disparities exist in the prevalence of vision disorders across different racial or ethnic groups, providing vision screening and care to preschool children notwithstanding their race was imperative. \textsuperscript{67} Blows et al acclaimed the New South Wales State wide Eyesight Preschooler Screening (StEPS) Programme model to be useful for other jurisdictions in Australia and across the globe to be implemented for prompt referral and optimal treatment of common vision deficits. The authors reported that some children could not be assessed in StEPS and was diagnosed as developmental delay on referral. They stated preschool vision screening desirable to school screening as it is the critical window for mediation as evidence supports vision assessment at 4 year of age as best practice for deterring and treating vision disorders.\textsuperscript{1}

Pascual et al reported visual disorders to be fourth most prevalent disability among children in United States, amblyopia listed as the primary cause affecting 1-4% of preschoolers. Based on the findings in 3869 preschoolers, the study established that unilateral amblyopia was severely dependent with odds ranging from 1.8 for hyperopia 2 to 3 diopter (D) to 4.3 for hyperopia of 4D or greater. Increase in bilateral hypermetropia was associated with increased risk of bilateral amblyopia with odds ranging from 2.8 for bilateral hyperopia of 3 to 4D to 5 for hyperopia 5D or greater. In their study, the risk for unilateral amblyopia was increased when myopia was 2D or more accounting for an odds ratio of 3.9. The study also found that astigmatism of 1D or greater was associated with increased odds of unilateral amblyopia. Bilateral astigmatism > 1 D was associated with bilateral amblyopia. Limitations of the study were that it was not population based, all preschoolers were enrolled from Head Start Programme from low income families and
not all acuities for defining amblyopia were measured with best correction. The study emphasized the need for re-evaluation of guidelines for screening amblyopia using refractive error in general population to provide optimal criteria for identifying children at high risk for amblyopia.\textsuperscript{59} The literature supported significant improvement of vision in amblyopic eyes in more than 75\% of children if early treatment was initiated.\textsuperscript{71-74} Membreno et al reported that early recognition and treatment of amblyopia were extremely cost effective compared to other health care interventions.\textsuperscript{75} Quite a lot of authors emphasized the higher likelihood of visual recovery for earlier detection and treatment of amblyopia preferably younger than 7 years.\textsuperscript{76-81}

Donahue et al reported the prevalence of ARF to be greater than previously suspected which emphasized that high magnitude ARFs increased the likelihood of amblyopia. The evidence based update proposed refractive screening for ARFs to detect astigmatism >2 D, hyperopia > 4 D and anisometropia > 2D in children aged 31-48 months and >1.5 D of astigmatism, anisometropia >1.5 D and hyperopia >3.5 D in children above 49 months in photo screening. The need for identifying visually significant media opacities and manifest strabismus was also mandated by the authors. USPSTF recommended photo screening for children older than 36 months of age.\textsuperscript{82}

Afsari et al determined the age and ethnicity specific prevalence in Australian children of 6 to 72 months. The authors observed anisometropia to be uncommon with interethnic differences. They also quantified the rising risk of amblyopia with increasing spherical equivalent and cylindrical anisometropia and recommended a longitudinal study to assess the temporal relation of these associations. The matter of concern was that anisometropic amblyopia was likely to be detected far along as there was no obvious physical abnormality observed. The authors envisioned to apprise referral policies from the findings of the population based study and reinforced the importance of vision
screening for high refractive errors and anisometropia aimed at prevention of amblyopia in children.\textsuperscript{83}

In a study by Jeong et al, myopic refractive error was as common as hyperopic refractive error in 3-5 year olds in Korea. The authors reported a prevalence of refractive error range from 0.23 to 1.23\% as contrasting to previous study reports of 5-7\%.\textsuperscript{84} Hered et al reinforced the use of visual acuity charts among 4-5 year old children in private practices as it had good PPV for vision loss and questioned the effectiveness of charts in 3 year olds due to higher untestability rates and low PPV. The authors highlighted the need for modification in American Academy of Paediatrics screening policy to initiate visual acuity screening by 4 years of age and substitute photo screening for younger age groups. The study reported amblyopia to be 1-4\% in USA and emphasized the low screening rate (21\% to 36\%) of the children below 6 years of age.\textsuperscript{85}

A study done by Fan et al reported the decrease of anisometropia from 5.16 to 1.58\% over 10 years among preschoolers in Hong Kong\textsuperscript{86} which supported the findings of Jeong et al (0.25 to 0.06\%).\textsuperscript{84} The reason for the decline may be owing to the home screening test employed for early detection and treatment. The limitations of the study were that home screening was conducted by a lay person with chances of methodological flaws. The prevalence value might have been underestimated as there was no information about the false negative children who were referred. The visual acuity cut off was 0.5 which would have failed to detect all vision deficits.\textsuperscript{86}

Pan et al reported the referral criteria for 3 to 5 years as a 2 line interocular difference or vision less than 20/40. Their study provided suggestions for redefining normal visual acuity using HOTV Amblyopia Treatment Study protocol for preschool vision screening, clinical care and research. The authors mentioned the influence of
environmental factors and early preschool admissions which may be applicable to other ethnic groups too.\textsuperscript{20} Lan and his colleagues determined the prevalence of refractive errors in Chinese preschoolers. In the 2,480 three to six year olds enrolled, overall prevalence of myopia ($\geq -0.50$ D) was 1%, hyperopia ($\geq +2$ D) was 25.2% and astigmatism ($\geq 1.5$D) was 8.2%.\textsuperscript{66} There was inconsistency in myopia prevalence as reported in Strabismus, Amblyopia and Refractive Error Study (STARS)\textsuperscript{64} and Baltimore Pediatric Eye Disease Study (BPEDS).\textsuperscript{69} The author considered it to be reliant on the stringency of cycloplegic regime used to exclude pseudo myopia in children with dark irises.\textsuperscript{66}

According to Fan and his colleagues, the prevalence of astigmatism $\geq 1.00$ D in 605 Chinese preschoolers (mean age 55.7 months) was 21.1%, predominant being with the rule. The authors stressed that higher astigmatism was related to myopic shift which resulted in longer axial length. They hypothesized that as astigmatism blurred vision, it can lead to the development of myopia. Further research was indispensable on how astigmatism influences myopia development and whether early prescription of astigmatism prevents myopia progression as reported by Fan et al.\textsuperscript{86} Manifest strabismus was observed in 3.3% of white and 2.1% of African American children aged 6 to 71 months in a population based study conducted by Friedman et al.\textsuperscript{87} Repka et al reported structural ocular abnormalities and nystagmus to be present in 2% of preschool-aged children in their population-based study. Vision loss due to these abnormalities was uncommon according to them.\textsuperscript{88} In a study done by Premsenthil et al, the prevalence of visual impairment in preschool children was reported as 5% in the 400 screened. The main cause for visual impairment was found to be refractive errors, myopic astigmatism being the commonest.\textsuperscript{60} According to Chen et al, the prevalence of amblyopia and strabismus in preschool children (36-72 months) in Eastern China were 1.20% and 5.65%, respectively. The main reasons for amblyopia were witnessed to be refractive
errors and strabismus. The prevalence of strabismus had no statistical differences in
gender, but had significance between different age groups in their study.\textsuperscript{61}

STARS determined the prevalence of refractive error in a population based study
of 3009 young Singaporean Chinese children aged 6 to 72 months. Dirani et al reported
lower prevalence of hyperopia in the study population compared to Western kids which
mirrored the early trend of myopia development. Overall prevalence of myopia was 11%
in the study. The authors claimed mounting evidence of higher myopia prevalence in
urban Asian populations attributed to the environmental factors like near work, early
education, socioeconomic status and the outdoor activities.\textsuperscript{6} The prevalence of
Intermittent Exotropia (IXT) was found to be 3.24\% in preschool children of Eastern
China. The authors emphasized that history of hypoxia at birth was a forecaster for IXT.
Pan and colleagues stressed the need to know the epidemiological patterns of IXT for
better detection and clinical care of children.\textsuperscript{63} Griffith et al observed amblyopia (1.37\%),
strabismus (1.76\%), and refractive errors (8.39\%) were the common ocular anomalies in
young children. It was suggested that children who lack access to eye care might be
benefitted from a van based model reaching out to schools.\textsuperscript{62}

In the Australian preschoolers, amblyopia was found to be 1.9\% as reported by
Pai et al. Refractive errors like hyperopia and astigmatism, anisometropia and strabismus
were reported to be the key amblyogenic aspects. According to the authors, the detection
rate of amblyopia in preschool sample was low and advocated the need to develop the
widespread vision screening strategies.\textsuperscript{58} The population based study among preschoolers
by Lu and co -workers reported refractive errors to be the commonest reason for visual
impairment followed by hereditary conditions. As majority of the subjects had curable
conditions, the utmost importance for designing policies to improve the children’s eye
health was emphasized.\textsuperscript{89}
Chia and colleagues perceived 1.2% of strabismus and 0.8% amblyopia in the population based study among children aged 6 to 72 months. Strabismus was associated with astigmatism $\geq 1$ D, family history, lower parental education $\geq 1$D and no statistical significance was observed with maternal age, prematurity or smoking in young Singaporean Chinese.$^{64}$ According to Registrar, the skills for gathering visual input accurately and efficiently owed to basic visual, oculomotor and binocular visual function. Hence, periodic optometric examination was mandatory to identify these disorders early enough to avert persistent visual loss. With the nuances of information technology assimilated into education, an increased demand on visual system for effective learning and information processing was observed. The author reported 20% preschoolers to have visual problems. They highlighted that vision played a major role in the complex learning process as 30-60% of the school day is spent on near tasks, reading and writing. Research also showed that academically and behaviourally at the risk children were bound to have undiagnosed vision disorders. Moreover, the development of normal visual cortex ends by 8 to 10 years and any delay in detection and intervention of the anomaly leads to long-term visual impairment. The sad part highlighted was that only 25 to 30% of the preschool children were screened even in a country like United States (US). Vision screenings only indicated a likely need for extra care and the reasons speculated for negligence of preschool screenings were lack of confidence, poorly skilled screeners, erratic guidelines and accuracy of results.$^{11}$

Braverman et al observed inconsistency in the precision of different screening tests used for refractive error screening in pediatric population. They stressed the need for timely diagnosis of refractive errors in preschoolers to improve their quality of life and the challenge to execute it.$^{81}$ Hartmann et al expressed concern about the lack of scientific data addressing the validity of currently available screening methodologies, the
effectiveness of the programmes, need of follow up and treatment of children identified by screening programmes. Increasing the proportion of preschool children receiving screening was identified as one of the objectives in the area of visual health.\textsuperscript{90}

Kulp et al conducted a multi-center, multidisciplinary, two phase study to determine the performance of vision screening tests in detecting amblyopia, squint, significant refractive error or unanswered reduced vision (≥1 target conditions) in preschoolers. It was implemented through Head Start, a national child development programme in USA More than 99% of children were testable and sensitivities for ≥1 target conditions were compared at set specificities 90% and 94%. Lower sensitivity was observed using Lea symbol charts by nurse and lay screeners compared to Licensed Eye Care Practitioners (LEP) for screening ≥1 target conditions. The preschoolers who were inept to complete the test were twice more likely to have vision disorders than children who passed the tests, therefore further evaluation was mandated for them. Retinomax was one of the best preschool screening tests in the hands of LEP, nurse or lay screeners but the repeatability needed to be tested. Results from the VIP study could guide the progress and execution of more effective screening protocols. Vision screening in preschoolers was of prime importance as they were unable to understand their symptoms or converse it. Future research was recommended to fix the cut off for refractive correction when no amblyopia or strabismus coexists.\textsuperscript{4}

A study was conducted by Yan et al to determine the referral criteria using Plusoptix A09 in spotting amblyopia risk factors. The authors reported the sensitivity of 44.4%, 85.7%, 85% and 55% and specificity of 97.7%, 94.7%, 85.5% and 87.9% for detecting refractive ARF with Plusoptix A09 based on AAPOS. The conclusion from the study was that Plusoptix A09 underestimated hyperopia and overestimated myopia based on spherical equivalent. They recommended a regression equation and a revised criteria
for improving the precision of Plusoptix A09 for screening amblyopia risk factors in large scale. Moreover, the authors deterred from using the instrument for mere strabismus screening.\textsuperscript{54}

Kulp and colleagues performed a secondary analysis on VIP data and evaluated the Receiver Operating Characteristics (ROC) analysis of Non Cycloplegic Retinoscopy (NCR), Retinomax Auto refractor and Sure sight Vision Screener among preschool age group. The definition of significant refractive error as per the VIP study was hyperopia > 3.25 D, myopia > 2.00 D, astigmatism > 1.5 D, anisometropia if interocular difference >1 D for hyperopia, >3.00 D for myopia or >1.5 D for astigmatism. In the 1,1142 children enrolled, significant refractive error ranged from 21 to 26%. The spherical equivalent ranged from -20 D to +16.5 D. The Area Under the Curve (AUC) was excellent for detection of significant refractive error in preschool children. Authors recommended further research to compare sensitivities of screening tests of monocular visual acuity alone with that of combinations of tests to improve refractive error identification in 3-5 year olds.\textsuperscript{57} In a study by Hoeg et al, the prevalence of monocular visual impairment (MVI) was 4.26%, in the Danish National preschool vision screening programme. The examination included visual acuity, squint test and retinal photographs along with an interview. Comprehensive evaluation was done only when referred. Amblyopia was the main cause of MVI. According to the authors, the prevalence of amblyopia decreased by fourfold after initiating the screening programme.\textsuperscript{91}

Schmidt and co-workers compared different preschool vision screening techniques used by LEPs (optometrists and pediatric ophthalmologists) for detecting different target conditions in 2500 preschoolers. The authors reported the accuracy of Lea symbol chart almost equal to NCR and auto refractors in experienced hands while photo screeners were not as precise. Further research on the prevalence of target
conditions and cost efficacy of early screening for exterminating avoidable blindness was specified. Maguire examined the relative prevalence of ocular conditions among children who failed preschool vision screening tests and the impact on measures of screening test performance. When screened for vision problems, preschool children who were untestables were at greater risk of having amblyopia, strabismus, significant refractive error, or unexplained low visual acuity than those who passed the screening test. The ocular problems were at least two times higher for untestables compared to screening passers for modes of screening employed. It was not influenced by the personnel conducting screening. Jost and colleagues underlined the need of appropriate screening for amblyopia as the signs may be subtle, the preschool children may be less co-operative, the consequences can be permanent visual impairment and affected school performance, motor skills, self-image and fine motor skills, posing a grave public health issue. The authors recommended Pediatric Vision Screener for early detection to improve long term visual outcomes of preschoolers. Miller and co-workers compared the effectiveness of different method of screening astigmatism in preschoolers which required a spectacle correction. The prevalence of astigmatism was 33.2% in the sample and non cycloplegic auto refraction proved to be the most accurate screening technique. Visual acuity screening alone could result in over referrals increasing the cost according to the authors. They reiterated the need for other screening techniques and cycloplegia in conditions like strabismus and high hyperopia. According to Kemper et al, vision screening for 3-5 years was recommended for the early detection of amblyopia. In his study among paediatricians, most of them endorsed the importance of preschool vision screenings. The common barriers for service delivery were the chair time and untestability. The authors emphasized the need for financial incentives in ensuring the preschool vision screening in paediatric offices.
Marsh Tootle and co-workers recommended implementation of tests integrating vision and developmental criteria during screening of children of children aged 36 to < 72 months. The panel suggested this to pick up children with neurodevelopmental problems, other motor abnormalities and do direct referral.

In his commentary, Holmes et al underscored the interocular difference and test retest variability in the assessment of visual acuity as it posed an issue close to any postulated threshold. The false positives and false negatives were further exacerbated by test retest variability of different machines and methods as per the authors. Hence he recommended PVS for vision screening other than nurses or lay screeners as it challenged the way amblyopia was defined and treated.\textsuperscript{96} Hess and colleagues reported improvement of visual and stereo acuity in amblyopic subjects treated using binocular paradigms made available as games in iPod or iPad.\textsuperscript{97} A review by Anstice et al correlated visual acuity with quality of life measures and independent living. They found that children needed it for learning and endorsed screening to wipe out enduring visual impairment. In their evidence based update, the authors recommended Lea symbol, HOTV, Tumbling E for preschool children compared to Allen cards, Wright figures and Patti pictures as they lacked standardization. Lea, HOTV and E charts were based on the principles of log MAR chart with equal number of optotypes in each line and standardized progression between lines. All of them had four optotypes and chances of predicting remained the same. Moreover, the charts at shorter working distance (3 meter) improved co-operation and concentration in a child and hence had exceptional repeatability and reliability compared to 6 metre testing distance. Letter matching was possible and could be performed by children as young as 3 years and turned out to be universally testable by 4 years of age. The need to interpret vision measurements in children with caution was emphasized by Anstice and co-workers as overestimation of
visual acuity and under detection of amblyopia occurred if contour interaction was not included in the charts. Another matter of concern was the comparison between charts as visual acuity change reflected may be due to chart design rather than real change in visual function. Future research was suggested to establish age specific limits of normal visual function using common pediatric charts employed in clinical practice and drawing cut off values for normal and abnormal during screening. Ciner et al estimated the associations between stereo acuity and the presence, type and severity of vision disorders in preschool children. It was observed that as the age increased stereo acuity values were better in children without vision disorders. According to the authors, the reduced stereo acuity in a small subset without vision disorders could be attributed to other factors like poor visual attention, large accommodative lags, other undiagnosed cognitive, visual, motor or perception defects. Preschool children who failed stereo acuity test were 5.75 times more likely to have a vision disorder than children who passed the test as per Ciner et al. This study made available the normative data on the probable levels of stereo acuity for children with and without a vision problem using stereo II test which was similar to those reported with randot test designed for preschoolers.
This can be pertinent in detecting and managing vision disorders like amblyopia, strabismus and significant refractive error prevalent in preschool age group. Further research was warranted to determine whether stereopsis testing could be used in monitoring the binocularity improvement, identify cost effective intervention and evaluate treatment efficiency using lenses, patching, surgery or vision therapy.\textsuperscript{99} 

In their review article, Jordan et al evaluated the effectiveness of hyperopic spectacle prescription compared with no intervention for the prevention of strabismus in infants and children. None of the studies reported the presence of amblyopia, stere acuity or quality of life in the children as per the review.\textsuperscript{100} Cowen et al measured the magnitude, type and central tendency of astigmatism found in a country wide population of Canadian preschoolers of mean age 48.1 months. 369 of the 1179 children were referred to eye care practitioners and with the rule astigmatism was the most prevalent. As spectacle prescription guidelines had not been well established for preschoolers, it had to be undertaken with caution considering the emmetropisation of children. The sample had 1.25 D as 95\textsuperscript{th} percentile calculated from the study and suggested astigmatism prescription for the critical levels that fall outside the population norms in clinical practice.\textsuperscript{101} A study by Miller et al designed and validated a hybrid screening programme to detect the need for prescription glasses in native American preschool children with high prevalence of astigmatism and recommended it for vision screening. Hybrid Screening Programme Referral criteria was to refer if 2.25 D of corneal astigmatism, refractive astigmatism \( \geq 1.50 \) D if noted in either eye or the children was unable to read 3 out of 5 letters of 20/63 size with either eye in two attempts.\textsuperscript{102} 

Hall and colleagues commented on the unacceptable delays between detection and diagnosis of vision deficits in under 5s due to various factors like ignorance, prejudice or carelessness. They suggested the need for history taking, inspection of eyes
and recognition of abnormal visual behaviour in children too young to co-operate for
vision tests.\textsuperscript{103} Hopkins et al looked over the purpose of children’s vision screenings and
the guidelines available in literature. The authors highlighted the requirement of valid,
reliable test batteries for detection and cost effectiveness of the screenings. The review
pointed out amblyopia and its risk factors, refractive errors and ocular pathologies to be
commonly encountered in clinical practice. It was questionable on the ideal age for
screening children for amblyopia as some literature supported early treatment while
others contradicted reporting that age of treatment initiation does not affect the final
visual outcome.\textsuperscript{69} The most vital feature of a screening battery is the equilibrium between
sensitivity, specificity and time efficacy. As the number of tests increased, extra time
would be spent. There was a lot of research gaps to be addressed as to when the children
have to be screened, conditions to be targeted, screening personnel and protocols to be
employed which are pertinent across the globe. The review established that there was no
universally agreed strategy for children’s vision screening either in Australia or
globally.\textsuperscript{17} Several real and perceived barriers were reported which impeded successful
screening programs resulting in low rates of screening. Inadequate training, insurance,
co-operation level and chair time were the obstacles listed by primary eye care providers.
Children who were unco-operative were usually not referred resulting in undue delay in
diagnosis and intervention of amblyopia.\textsuperscript{10, 104, 105} Mehavar\text{an et al reported the utilization
pattern and challenges of preschool vision program and observed the unmet requirements
of refractive correction in Los Angeles. In the University of Los Angeles vision
screening of 12,088 children, 850 (7.5\%) were prescribed glasses which was massive.
The authors stressed the need to find out the barriers to access of eye care and formulate
a way out to tackle the issue.\textsuperscript{56}
Ying et al observed that, when the specificity was set at 94%, the tests which help in accurate detection of amblyopia were NCR (88%), for strabismus was MTI photo screener (65%), significant refractive error was NCR (74%) and reduced visual acuity was Lea Symbol chart (48%) in the VIP study group. The screening tests varied extensively in sensitivity, when specificity was fixed differently in 2588 children aged 3 to 5 years.\textsuperscript{106} Kemper and co-workers emphasized that for elimination of amblyopia, timely after care of children who failed preschool vision screening was desirable. It was observed that only half of the children turned up for follow up. Barriers reported were dearth of insurance coverage, inconvenience of follow-up, petite family revenue, minorities and lack of awareness on the benefits of prompt intervention. The need for designing ways to overcome the barricades to follow up was highlighted to tackle the issue by various authors.\textsuperscript{107,108}

\textbf{2.3 Research gaps and recommendations}

Hartmann and colleagues highlighted the National Centre for Children’s Vision and Eye Health’s (NCCVEH) and USPSTF recommendation to increase the vision screening of children aged 36 months to less than 72 months. The authors emphasized utmost need for an integrated data system to safeguard the vision screening results, appropriate referral, monitoring of untestable children and follow up care with optometrists and ophthalmologists for diagnosis and management aspects. Currently, there was lack of communication and synchronization of services which led to duplication of vision screening efforts in US as reported by Hartmann et al. The panel recommended the integration of vision care data with other child health data following national guidelines for uniform data collection and stressed the need of vigorous data system with regards to data entry, monitoring and reclamation of information. The need of data entry from different levels like educational, community, public health and
primary eye care settings, summary of diagnosis, treatment recommendations and liberty of families to review the information without amendment was also highlighted in the review. PVS was endorsed by many associations even though there was dearth of reliable data on the percentage of children who received screening and its effect on eye health. Hence, NCCVEH commended on the vision screening system to be assimilated with immunization and Electronic Health Records. The most important aspect would be the enhancement of population level surveillance of health of children’s vision. The utmost need of optometrists and ophthalmologists to take leadership roles in this realm had been stressed by Hartmann and his colleagues.¹³

Marsh Tootle et al reported that PVS was influenced by positive attitudes and should target multiple aspects like high testability and validity of tests used, highlighting the fact that children with amblyopia may be asymptomatic.¹⁰⁹ Cotter et al recommended screening children between 36 to 72 months for visual disorders using suggested methods in educational, community or public health settings. The article emphasized on the best practices reinforced by evidence and the need for standardizing the screening programmes.⁹ The authors reported adequate evidence on improved visual outcomes due to early intervention in amblyopia ⁷⁹, ⁸⁰, ¹⁰⁶ which was the drive for research into realistic screening programmes. Roch et al⁸⁰ and Atkinson et al¹⁰⁴ commented that significant refractive correction was linked to child development and enhancement of school readiness indicating early intervention. Cotter and colleagues attributed the success of amblyopia treatment on child’s age with children younger than 7 years likely to have added improvement.⁹ This was supported by Holmes et al emphasizing the necessity of preschool screening.¹¹⁰

Supporting research specified vision screening as the first step in spotting vision deficits and serves as a noteworthy public health initiative contingent to accuracy and
reliability of the methodology employed. According to Registrar, adequate propagation of vision screening into the community requires education of people and community partnership is the future and cornerstone of an efficient and methodical preschool screening process. According to Hartmann et al, visual disorders amidst preschoolers are common. However, screening was rare. When they reviewed literature, the authors observed successful screening of 3-year-olds as 80% and 4-year-olds as 94%. The evidence supported the effectiveness of screening at age 4 to reduce amblyopia prevalence. The endorsements proposed by the Preschool Child Task Force, America are the need for development of new and superior methods for vision screening, certification programmes for individuals involved in preschool vision screenings for reliable results, recognize and overcome obstacles and improved communications between professionals involved in eye care delivery. The report concluded suggesting the need for thorough review in all aspects of vision screening to take forward the dream of universal preschool screening. Marsh Tootle and colleagues featured PVS by practitioners as a public health urgency. Increasing the quality and accountability at national, state, local and provider levels and the requirement for optometrists and ophthalmologists to take up leadership positions in the evolution and implementation of this endeavour was highlighted in the review.

According to Moseley and Fielder, there is ongoing debate on the best age for preschool vision screening. They emphasized the need of refractive screening along with visual acuity assessment for preventing the missing of amblyopia during screenings at the earliest age possible. The prevalence of amblyopia was almost half in those screened at 37 months to those not screened. The need to develop preschool vision screening strategies and design policies for childhood eye health was recommended by many authors. Added research on prevalence of the disorders and cost efficacy of early
vision screening was emphasized by Schmidt et al.\textsuperscript{40} The barriers to eye care and the necessity to tackle it was stressed by Mehavaran et al. to meet the requisite of uncorrected refractive errors in preschoolers.\textsuperscript{56} Leone et al reported preschool screening to lower the prevalence of amblyopia when children were assessed at 7.5 or 8 years. They pinpointed the scantiness of population based studies to estimate the pertinence of the standardized visual acuity tests in preschools. Testability rates of vision with HOTV were 80\% and above from 36 months and was associated with age. The authors gave emphasis to the testability aspect as it helped in developing recommendations for preschool vision screening protocols. The higher testability of East Asian children in STARS was owing to early learning strategies than ethnicity according to the authors. According to the authors, role of education, pre training and their effects was to be studied in a preschool setting.\textsuperscript{14} The influence of environmental factors like near work, early education, socioeconomic status and the outdoor activities on increased myopia among preschoolers should been investigated according to Dirani et al.\textsuperscript{64} Trajer et al observed that the testability of vision and refraction was high in the preschool aged Chinese Singaporeans which threw light on the feasibility of the programme.\textsuperscript{112} According to Solebo et al, children with unilateral vision impairment might not be aware of the problem and only a proper screening could enable timely diagnosis and management. Due to scantiness of research on the real life effect of the disorder, the burden of amblyopia was unclear.\textsuperscript{113, 114} This dearth of data was due to reliability of a self-reported quality of life in children and lack of robust instruments.\textsuperscript{114} According to Awan et al, the outcomes of amblyopia treatment showed wide variation between and among countries.\textsuperscript{115} Furthermore, evidence base was lacking on the pathway needed for children who fail screening, monitoring, cost effectiveness and public acceptability. The paramount advantage of timely management (before 6 years) was seen in children with
severe amblyopia and who were at the threat of bilateral visual impairment in later life.\textsuperscript{116-118} 

The UK National Screening Committee (NSC) had revised its childhood screening policy and recommended to undertake 4-5 year olds with visual acuity worse than 0.2 log MAR for referral.\textsuperscript{114} Moreover, the requirement for standardization of the screening programme was reported to be crucial for quality assurance and best outcomes.\textsuperscript{113} Rahi and co-workers reported that within 1 year of losing vision in the better eye, 31\% of adults showed improvement in their amblyopic eye and the likelihood of improvement was higher in those who underwent amblyopia therapy. In the population based study, Rahi et al explored the risk, causes, and outcomes of visual impairment owing to vision loss in the non amblyopic eye. They reported the life time threat of vision loss for an amblyope to be 1.2 to 3.3\%. Hence, the effective treatment of amblyopia in childhood assisted as a valued approach against debilitating vision loss far along in life besides enhanced vision in the amblyopic eye.\textsuperscript{117} Solebo and colleagues reported that India did not have a national programme for the vision screening of preschoolers. They recommended the need for country specific estimates of the prevalence and incidence of amblyopia that would benefit service planning and calculation of cost effectiveness. The authors highlighted that population level preventive tactics were rare and long term assessments of outcomes after treatment and appraisal of quality of life of the preschool age group has to be assessed in future.\textsuperscript{114} 

According to Su et al, lack of awareness of parents of children who failed vision screening was the main barrier to follow up care. Hence, there was a need to devise strategies on educating them on the significance of timely assessment for their children.\textsuperscript{118} A review article by Alley reported tremendous inconsistency in the PVS techniques and rates. The main aim for endorsing PVS by different organizations was the
detection of amblyopia and its risk factors. The recommendation was to refer any child who was untestable after 2 attempts, demonstration of any ocular anomaly or visual acuity less than 20/40 in either eye or 2 line difference in the visual acuity. A vision screening one time at least between 3 to 5 years was mandated by USPSTF. More studies were suggested to determine optimal age to screening, screening methods and screening intervals. Literature supported the enhanced visual results of amblyopia treatment if initiated during preschool age. It was reported that amblyopia usually developed by the age of three which indicated the need for preschool screening. The results of Colburn and co-workers stated the significance of timely screening and spectacle correction of hypermetropia (>+3.50 D) to reduce the risk of amblyopia. The authors observed greater depth of amblyopia with higher anisometropia.

Instrument based screenings could be an alternative to traditional screening in 3 to 5 year olds as per AAO,AAPOS and AAP but the viable option is still the charts owing to cost effectivity. The recommendation of photo screeners for 6 months to 3 years has to be elective and above 5 years, visual acuity charts are cost effective and efficacious. The objective of all these is to eliminate preventable childhood visual impairment. The demerits with the instruments was that it checks the risk factors and not the actual disease and reporting of parameters differ within them which makes comparisons challenging. Alley emphasized the underreporting of amblyopia using the guidelines of AAPOS. In the review, Alley summarized by indorsing PVS, the need for efforts to guarantee that children are benefitted and heading for elimination of lifetime visual impairment.

A study conducted by Silbert and colleagues reported a set of risk factors that had to be detected by PVS. The AAPOS defined criteria for amblyopia risk factors were anisometropia >1.5 D (either spherical or cylindrical), any manifest strabismus,
hyperopia >3.5 D in any meridian, myopia >3D in any meridian, astigmatism >1.5 D in regular and >1.0 in oblique axis, ptosis <1mm and media opacity >1.0 mm and recommended complete eye examination if any of the above mentioned conditions were observed in a preschooler. Of the total 521 data used for analysis, AAPOS referral criteria had 85% sensitivity, 95% specificity, 5% false positive rate and 15% false negative rate for amblyopia likelihood. According to the authors, the study had rigid cut offs which led to the under detection of children at risk for amblyopia and suggested to adjust the formulas to minimize the false positives and negatives. There was selection bias observed in the study as the study population consisted of children who failed vision screening and therefore the prevalence of the disease was high. Instrument-based screening might not be influenced by the conduct of children, as compared to other screening tests. AAP, AOA and AAPOS encouraged further research of photo screening and other screening methods to explicate the validity, worth and cost efficacy for detection of amblyogenic factors to eradicate avoidable childhood visual impairment.

Clausen and co-workers developed an educational program to improve the worth and productivity of pediatric vision screening using Lea and HOTV optotypes. The purpose of the study was to ascertain the effectiveness of this program. Video education in the office and provision of adhesive patches was found to be useful. According to Chang et al, early identification of vision disorders has farfetched returns in the health and wellbeing of children and photoscreeners could be of public health significance to assist early preschool screening. Nathan et al determined the impact of different referral criteria for Plusoptix in identifying ARFs. The authors reported manufacturer’s criteria showing high sensitivity (100%) but low specificity (37%) demanding modification using Arthur criteria which displayed improved specificity (76%) while sustaining the sensitivity (89%). According to Lattore et al, the prevalence of refractive error was 6.2% in preschoolers. The screening was performed by school teachers and specificity
was 95.8%. Refractive error was considered when myopia ≥ -1.00D, hyperopia > 3.00D and astigmatism < 1.50 D. The findings from the study posed a striking public health issue as in low income countries, entry to education of children with disabilities was around 10% according to WHO. Future research was warranted on the sustainability, appropriate tests required and the economic impacts resulting from early vision screening. In their retrospective cohort study, Lowry et al. assessed cost-effectively competent referral norms for auto refraction based preschool vision-screening program. The authors proposed a modelled referral criteria to reduce the cost and let more vulnerable children to be covered with the same economic resources. A study conducted by Jost and colleagues reported the under referring of affected children and over referring of the normals in automated preschool vision screenings, which posed a grave public health issue. Hence he recommended Pediatric Vision Screener for rapid and accurate estimation of risk factors. The consequences of delayed detection and treatment of ARFs may lead to long-lasting visual impairment and upsets education, motor skills, social development and self-esteem according to the authors.

Chen et al observed the prevalence of strabismus and amblyopia to be 5.65% and 1.2% in preschool children of Eastern China. Amblyopia caused by refractive error was reported to be 85.29% which contradicted to studies done in Australia and Britain and consistent with STARS and Multi Ethnic Pediatric Eye Disease Study (MEPEDS). Moreover, exotropia was most commonly seen in STARS contrary to MEPEDS and BPEDS. This highlighted the ethnic and genetic role in the risk factors which warranted further research. The limitation of the study was the non-inclusion of vision deprivation amblyopia. Langer Smith et al. reported that PPV of preschool vision screening in South Auckland, New Zealand was low. This resulted in substantial burden on the health care system and the eye departments. The authors recommended the necessity to relax
the referral criteria to unilateral visual acuity worse than 6/12 from 6/9. This revision was found to improve PPV without affecting NPV with a reduced cost. Further research on the cut off for refractive correction when strabismus or amblyopia do not co-exist was recommended by Kulp et al. Ross et al stated the need for modifications in the mobile follow up of preschoolers, reassessment of the economic aspects and approval for implementation in communities across the nation.

Plusoptix with modified Arthur referral criteria could be a highly precise screening device detecting amblyopia risk factors without missing children with moderate/severe amblyopia according to Silverstein et al. Bruce and co-workers demonstrated a significant association between decreased visual acuity and early literacy in the 11,186 children screened. 8.7% of children had reduced vision and there was 2% reduction in literacy score for every line of vision decline. This study stressed the need for vision screening programme at national level for 4-5 year olds as it had far fetching implications on the childrens’ educational, health and societal outcomes. Research was warranted to determine the impact of treatment on educational accomplishment.

In the study by Burgmeier et al, 45% of amblyopic children had impaired visual-auditory speech perception. According to the authors, early childhood was the period for the development of effective visual auditory fusion. Therefore, if amblyopia was not treated early enough, it might have impact on the perception of sound in addition to visual acuity reduction. Webber et al stated that home treatment aimed at repetitive binocular involvement with IPOD games resulted in improved Fine Motor Skill (FMS) scores. In their study, FMS scores were found to be worse in amblyopes compared to controls and the better baseline visual acuity correlated well with the improvement in FMS scores post treatment. The authors testified the maintenance of functions even after 3 months of cessation of therapy. A study by Colmain et al reported the outcomes of
a large cohort from an orthoptic delivered preschool vision screening. In the 4365 children screened, 523 (11.9%) failed vision test. The children from better socioeconomic group had an odds ratio of 1.4 in passing the visual screening test compared to those from the most deprived socioeconomic group. The study threw light on the provision of health care and resource management for the future. Rewri et al demonstrated the usefulness of preschool vision screening programme and endorsed the need for implementation of such a programme in India. Overall validity of screening 3 to 8 year children by school teachers was good according to the authors with better performance in children aged above 5 years. Vision cut off value selected for the study was 6/12 for better cost effectivity.

In the review by Sanchez and co-workers, photo screening devices were an assorted group of instruments used for early screening of refractive errors and amblyopia. The challenge was the reports generated by each of these instruments which made the comparisons between them almost impossible. Hence, added research on the clinical utility of the device was acclaimed. Casas et al devised a protocol with visual acuity measurement using Lea charts, ocular alignment, motility tests and stereo acuity with TNO random-dot test in 4 to 5 year old children to validate a preschool based amblyopia screening population. The screening protocol model showed high sensitivity (89.3%) and specificity (93.1%) in detecting high risk amblyopia and was recommended for amblyopia screening at schools. In a study conducted by Pan and colleagues, reduced visual acuity (VA) was observed in 3.7% in the worse eye and 1.6% in the better eye of 3 to 6 year old children in China. Presenting VA of worse than 0.30 log MAR, for either better or worse eyes was considered as reduced VA. In their population based study, they had examined 5667 children and refractive error was the predominant cause of vision reduction (66.8%). The proportion of reduced vision caused by refractive
factors were 95.2% which highlighted the need for screening and correction of errors in this age group. Moreover, authors underlined the ethnic, geographical and environmental role in the vision impairment variations globally. Hence, a pressing requisite for the implementation of preschool screening programmes and need for investigating its cost effectiveness in future studies was endorsed in China.  

2.4 Summary

Schmucker et al reported that population based preschool vision screening programmes could not be sufficiently assessed from the literature currently available. The methodological weaknesses in the published studies cannot be used to state the non efficacy of preschool vision screening programmes. It rather specified that these programmes had not been tested rigorously. The prevalence of amblyopia across studies justified vision screening of under six. The studies conducted till date suffer from methodological weakness as the children who did not participate in the study were ignored. Yet, clinicians across the globe recommend early treatment for amblyopia. Short term benefits of treatment were reported to be improved quality of life while long term were reduction in the chances of visual impairment later in life due to a disease in the better eye.  

The need for developing screening protocols, cut offs for screening and policy making for combating childhood blindness at preschool age have been emphasized in literature.
REVIEW OF LITERATURE

A systemic search of research articles was conducted to form a dataset for the authors to work on. The search was conducted by reviewing citations and sourcing articles in search engines and databases such as PubMed, Google Scholar, Embase, Scopus, Science direct, Hinari, Medline, Web of Science, CINAHL and Global Health to find out relevant articles published in English language. Extra references identified through the literature cited in the designated articles were also incorporated. The published literature was searched using key words and MeSH terms including preverbal children, preschool children, toddlers, vision screening, preschool, amblyopia screening, visual deficit, visual impairment, prevalence, refractive error, vision, charts, depth perception and photo refractor. The search results were polished and around 200 articles were identified from 1981 to 2016. Articles from other languages were referred if the abstracts were available in English language. Database was collected from peer reviewed case series, review, scientific articles and non-scientific papers. More credibility was given to scientific articles, especially those in higher hierarchy of evidence. All manuscripts considered relevant to the subject were included. In the end, we narrowed down to original research articles and reviews only. Their titles and abstracts were assessed and the full texts were downloaded and reviewed.

There was no consensus universally regarding the vision screening protocols for 3 to 6 year old children.17

2.1 Screening tests

Visual acuity charts

Khandekar et al reported that vision screening programmes in 3-6 year olds was cost effective. According to them, log MAR charts with Lea symbol would be more
useful for screening 3-6 year olds. The authors highlighted the paucity of literature on preschool vision screening in India. In their systematic review, Schmucker and colleagues found that the diagnostic accuracy of preschool vision screening tests could only be sufficiently investigated establishing age related values defining amblyopia, refractive errors and other binocular vision problems and suggested a longitudinal study design to fill in these research gaps. A study by Williams et al. observed early treatment for amblyopia to be more effective which supported the preschool vision screening. They reported mean visual acuity in the worse eye was better for children who had been treated for amblyopia compared to children in the control group. Lim et al reported the feasibility of undertaking visual acuity screening at 4 to 4.5 year olds. They had screened 82.7% of the children with Snellen chart and 91.6% with Frisby stereo test. Hered and coworkers observed Lea symbol to have a testability of 92% while HOTV displayed 85% in 3 year olds even though time taken for screening was almost similar. Vision in Preschoolers study group found that 3 to 5 year old children can be screened using either HOTV or Lea symbols and HOTV might be slightly more difficult than Lea symbols. According to them, 99% of the children were able to complete the tests. Lea symbol distance chart could be successfully used in 95.9% of preschoolers for detecting visual disorders according to Bertuzzi et al and for amblyopia detection as reported by Graf and colleagues. Bertuzzi and colleagues reported the sensitivity, specificity, positive likelihood ratio (PLR) and negative likelihood ratio (NLR) of crowded Lea symbol to detect amblyogenic risk factors to be 0.96, 0.83, 5.7 and 0.05 respectively. Becker et al observed that every child older than 30 months can be assessed with Lea symbols and an interocular difference of less than 2 lines is not an amblyopia suspect. They reported that Lea symbol showed higher applicability compared to Landlot C in children aged 21 to 93 months. A study by Cyert et al
compared the testability and threshold levels of crowded HOTV and Lea Symbol charts in children aged 3 to 3.5 years. The monocular visual acuity measured with both charts were high and crowded HOTV was on average 0.25 log MAR (2.5 lines) better than Lea symbols. Adhikari and co workers performed vision screening of 3 to 7 year olds with the help of certified medical assistants and found HOTV having 80% sensitivity and 90% specificity in Nepal. Therefore, the authors recommended preschool screening with HOTV to be effective in developing countries. Moganeswari et al reported that Lea and HOTV visual acuity charts showed good repeatability and validity to detect visual acuity ≤ 0.2 log MAR compared to E chart among preschool children in India. Omar et al observed that lea symbol chart showed higher sensitivity (97.5%) when compared to Sheridian Gardiner (57.1%) in preschool children. VIP study group indicated the sensitivity, specificity, positive likelihood ratio and negative likelihood ratio to be 0.61, 0.90, 6.1 and 0.43 with crowded lea symbol chart while for the crowded HOTV test, the values estimated were 0.54, 0.89, 4.9 and 0.52 respectively. Sanker et al observed Tumbling E chart to be comparable with Lea in assessing visual acuity of preschoolers, especially in 5 to 6 year olds. They recommended Lea chart for 3 to 4 year children over the E chart. The sensitivity of visual acuity charts in the preschool age group ranged from 61% to 97.5% as reported in literature. VIP study group compared the visual acuity performance using Lea and HOTV optotypes. 99% of children were screened successfully and Lea was easier to administer for 3 to 5 year olds in comparison to HOTV.

**Stereo acuity charts**

In their study, Schmidt and colleagues observed that 75% of children aged 3 years were able to perform the stereo acuity tests. According to them, testability with stereo smile test was greater than Randot E and Randot Preschool test. The authors
suggested two stereo test procedures to increase the testability of young preschoolers.\textsuperscript{42} Randot E stereo acuity had a sensitivity and specificity of 0.42 and 0.90 as per the VIP study\textsuperscript{40} group while Chang et al reported the values to be 0.20 and 0.98 for amblyopia detection.\textsuperscript{43} Leat et al reported that there was good repeatability for Frisby stereotest in young kids.\textsuperscript{44} In a study conducted by Farvardin et al, the sensitivity of TNO, Titmus and Randot test were 55.5\%, 48.4\% and 44.4 \% in a screening set up. They underscored the fact that stereo tests employed were diverse across studies.\textsuperscript{45} According to Ohlsson et al, the sensitivities of Randot E, Titmus and TNO stereo test for the detection of amblyopia were 36\%, 38 \% and 46 \%.\textsuperscript{30} Schmidt et al reported 47\% sensitivity and 90\% specificity for Randot E test in screening refractive risk factors.\textsuperscript{46} Randot preschool stereoacuity test was reported to be the most unfailing in sensing ocular conditions compared to Lang II and Stereosmile II test in a study by Afsari and coworkers.\textsuperscript{47} The stereo acuity charts showed good repeatability with poor diagnostic validity in the study by Diana et al.\textsuperscript{38}

**Plusoptix Photo screeners**

A study done by Matta et al found out the sensitivity, specificity, false positive and false negative rates of Plusoptix S04 for amblyogenic risk factors (ARF) in 3 to 5 year old children to be 99\%, 82\%, 18\% and 1.2\% respectively. In their study, the authors vouched for cost effective testing with the tool in screening set ups.\textsuperscript{48} According to Matta, Medical Technological Innovations (MTI) and Plusoptix photo screeners were effective in community based vision screening programmes. The authors witnessed Plusoptix to have greater sensitivity and specificity for ARFs.\textsuperscript{49,50}

According to Silbert et al, Plusoptix A09 revealed a sensitivity of 98\% and a specificity of 88\% in children aged < 1 to 17 years for screening amblyogenic risk
The Plusoptix A09 was found to have 89% sensitivity and 80% specificity for identifying ARF in a study by Silbert et al and reported it to be a dependable screening device. Plusoptix A09 demonstrated the sensitivity, specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of 94%, 89%, 11% and 6% for sensing ARF by lay screeners and commended on the massive implications in community eye care. Plusoptix A09 showed a sensitivity of 94.9% and specificity of 67.5% for spotting refractive amblyopia risk factors and 40.7% and 98.3% for strabismus detection in children aged 2 to 14 years in China. Singman and colleagues reported that Plusoptix S04 and A09 achieved comparable results when used by lay screeners in the same study group. They observed 85% sensitivity, 94% specificity, 15% false positive rate and 6% false negative rate in detecting amblyopia risk factors for Plusoptix S04. The Plusoptix A09 demonstrated a sensitivity of 92%, specificity of 88%, false positive rate of 11%, and false negative rate of 8%. 


### Table 2.1

Recent studies from the literature showing the prevalence of the vision deficits in pre school children across the globe. There is wide variation in the screening tests used and the diagnostic conditions.

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Screening tests</th>
<th>Age and sample size</th>
<th>Diagnostic condition</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rewri et al (J Ophthalmic Vis Res 2016)</td>
<td>India</td>
<td>Snellen charts</td>
<td>3 to 8 years n = 6004</td>
<td>Reduced visual acuity</td>
<td>8.04%</td>
</tr>
<tr>
<td>Mehavaran et al (J AAPOS 2016)</td>
<td>USA</td>
<td>Retinomax 3</td>
<td>3 to 5 years n=12,088</td>
<td>Refractive error</td>
<td>7.5%</td>
</tr>
<tr>
<td>Kulp et al (Invest Ophthalmol Vis Sci 2014)</td>
<td>USA</td>
<td>NCR, Retinomax, Suresight</td>
<td>3 to 5 years n=11142</td>
<td>Refractive error</td>
<td>21 -26%</td>
</tr>
<tr>
<td>Pai et al (Ophthalmology 2012)</td>
<td>Australia</td>
<td>Electronic Visual acuity System</td>
<td>30 to 72 months n=1422</td>
<td>Amblyopia</td>
<td>1.9%</td>
</tr>
<tr>
<td>Pascual et al (Ophthalmology 2014)</td>
<td>USA</td>
<td>HOTV, cover test</td>
<td>3 to 5 years n=3869</td>
<td>Amblyopia</td>
<td>7.7%</td>
</tr>
<tr>
<td>Premsenthil et al (BMC Ophthalmol 2013)</td>
<td>Malaysia</td>
<td>Sheridan Gardiner, Lang test</td>
<td>4 to 6 years n=400</td>
<td>Visual impairment</td>
<td>5%</td>
</tr>
<tr>
<td>Chen et al (Br J Ophthalmol 2016)</td>
<td>China</td>
<td>ETDRS, cover tests, Auto refractor</td>
<td>36 to 72 months n=5862</td>
<td>Refractive error</td>
<td>1.20%</td>
</tr>
<tr>
<td>Griffith et al (Am J Ophthalmol 2016)</td>
<td>USA</td>
<td>Vision, stereo acuity, ocular alignment</td>
<td>2 to 6 years n=63841</td>
<td>Refractive error</td>
<td>8.39%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Amblyopia</td>
<td>1.37%</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Strabismus</td>
<td>1.76%</td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Screening tests</td>
<td>Age and sample size</td>
<td>Diagnostic condition</td>
<td>Prevalence</td>
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<tr>
<td>Pan et al 63 (Optom Vis Sci 2016)</td>
<td>China</td>
<td>HOTV test stereo acuity, ocular alignment</td>
<td>3 to 6 years n=5831</td>
<td>Intermittent Divergent Squint</td>
<td>3.24%</td>
</tr>
<tr>
<td>Lattorre et al 16 (GlobHealth Action 2014)</td>
<td>Peru</td>
<td>E charts</td>
<td>3 to 5 years n=204</td>
<td>Refractive error</td>
<td>6.2%</td>
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<tr>
<td>Chia et al 64 (Ophthalmic Epidemiol. 2013)</td>
<td>Singapore</td>
<td>Sheridan Gardener, cover test</td>
<td>6 to 72 months n=3009</td>
<td>Strabismus</td>
<td>1.2%</td>
</tr>
<tr>
<td></td>
<td>Singapore</td>
<td>Vision assessment, ocular motility tests</td>
<td>6 to 72 months n=3990</td>
<td>Myopia</td>
<td>11%</td>
</tr>
<tr>
<td>Dirani et al 65 (Invest Ophthalmol Vis Sci 2010)</td>
<td>China</td>
<td>E chart, ocular alignment</td>
<td>3 to 6 years n=2480</td>
<td>Myopia</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>USA</td>
<td>HOTV, cover test</td>
<td>3 to 5 years n=4040</td>
<td>Any vision disorder</td>
<td>21.4%</td>
</tr>
<tr>
<td>Al Rowaily et al 68 (Saudi Journal Ophthalmol 2010)</td>
<td>Saudi Arabia</td>
<td>Snellen, cover uncover test, non cycloplegic retinoscopy, power refractor</td>
<td>4 to 6 years n=1319</td>
<td>Refractive error</td>
<td>4.5%</td>
</tr>
<tr>
<td>Giordana et al 69 (Ophthalmology 2009)</td>
<td>USA</td>
<td>Vision assessment, ocular motility tests</td>
<td>6 to 71 months n=2298</td>
<td>Refractive error</td>
<td>5.1%</td>
</tr>
<tr>
<td>Busic et al 70 (Croat Med J. 2016)</td>
<td>Croatia</td>
<td>Lea symbol chart</td>
<td>48 to 54 months n=15648</td>
<td>Amblyopia</td>
<td>8.08%</td>
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</tbody>
</table>