2. UNCORRECTED VISION PROBLEMS

This section presents description of the types of vision problems that affect children, the prevalence of vision problems and disparities in vision screening and access to vision care, and evidence on the learning consequences of uncorrected vision problems.

Definitions

The "Children's Vision and Eye Health: A Snapshot of Current National Issues" report by The National Center for Children's Vision and Eye Health (NCCVEH) at Prevent Blindness describes various types of vision disorders that affect children: refractive errors (myopia, hyperopia, and astigmatism), strabismus, and amblyopia.[65] What follows is a brief, abridged description of each of these disorders, taken directly from the NCCVEH report.

Refractive Errors

Refractive errors include myopia, hyperopia, and astigmatism. They occur when light is not focused on the retina, causing blurred vision. Uncorrected refractive errors in infants and preschool-age children are associated with parental concerns about developmental delay, as well as with deficits in cognitive and visual-motor functions that may in turn affect school readiness. In myopia, visual images come to a focus in front of the retina, resulting in defective vision of distant objects. In hyperopia, visual images come to a focus beyond the retina, resulting in defective vision of near objects. Astigmatism is an irregularity in the shape of the cornea or lens that causes blurry vision at all distances.

Amblyopia

In amblyopia (sometimes called "lazy eye"), vision is impaired due to abnormal development of the neural connections between the brain and the eye during early childhood. The primary causes are misalignment of the eyes (strabismus) and high refractive error or unequal refractive error between eyes. Typically, the vision loss affects only one eye, but people with amblyopia are nearly three times more likely than those without amblyopia to develop vision impairment in their better-seeing eye later in life. Early detection of amblyopia is critical; treatment is most successful when started before the age of 7 years, and less effective at older ages. Left untreated or treated too late, amblyopia can lead to permanent vision loss in one or both eyes.

Strabismus

Strabismus is a misalignment of the eyes that can lead to amblyopia. With the eyes oriented in different directions, the brain receives conflicting visual input, interfering with binocular vision development and depth perception. The effect of the eyes' misalignment on a child's appearance may also negatively affect his/her emotional health, social relationships, and self-image.

Prevalence

Estimates of the prevalence of vision problems vary considerably depending on: the types of vision problems included (specific type of vision problem or a range of vision problems); whether these problems are corrected; age group; how the problems were measured (based on report by parent or caregiver, based on eye examination, based on screening, or based on diagnosis information from healthcare records); and demographic and socioeconomic factors (national population, race and ethnicity, poverty status, and vulnerable communities).

Estimates that apply to a range of eye conditions: A comprehensive study on a wide range of eye conditions conducted using 1971-72 National Health and Nutrition Examination found that 22% of children aged 6 to 11 had at least one eye condition identified through ophthalmological examination.[66] This study covered a wide range of eye conditions, including minor ones unlikely to impair function. A more recent study based on 1996-2001 data using nationally representative Medical Expenditure Panel Surveys (MEPS) data found that approximately 7% of children younger than 18 years old living in the U.S. have a diagnosed eye and vision condition.[67] Because this estimate is based on diagnosis information which comes from a healthcare encounter, the authors state that this is likely to be close to prevalence of patients diagnosed, as opposed to the actual occurrence in the general population, and thus can be considered as the lower boundary of the true overall prevalence. The study also found that white children and children living in higher-income families were more likely to have a diagnosed condition, suggesting that there may be underdiagnosis and undertreatment in certain groups, in particular Hispanic children and children living in poverty.

Screening failure rates in underserved communities: Several studies in vulnerable communities indicate a high prevalence of unmet vision needs, based on screening failure rates ranging from 22% to 30%. In vision screenings conducted by Children's Health Fund in public elementary schools in underserved communities, just under 1 out of 4 children failed the screening and required follow-up *(2014 to 2015 data)*.[68] Other vision screenings in schools serving disadvantaged populations have similar screening failure rates. In a study examining school vision screening on preschool through fifth grade children in lower socioeconomic areas in New York City, almost one third (30%) failed the screening and were referred for a comprehensive examination *(1992 to 2002 data)*.[69] In a study of 3 New York City public schools in 1998 -1999, 25% of children screened were referred, based on failure of one or more of the screening tests.[70] In a study in a school district in Los Angeles, 22% of first graders had 1 or 2 ocular disorders.[71] In a screening of students aged 11 to 14 in 4 public intermediate schools located in Washington Heights, Manhattan, 28% had vision of 20/40 or worse in at least one eye. In the majority of cases, follow-up eye examinations confirmed the presence of refractive errors, most of which could be corrected with glasses *(1995-96 data*).[72]

Refractive errors: Nationally, the prevalence of visual impairment due to uncorrected refractive error is about 18% in the 12 – 17 age group based on 2005 to 2008 National Health and Nutrition Examination Survey (NHANES) data.[73] A study of the 2005-2008 NHANES data further shows that 1 in 4 adolescents (24%) aged 12 to 19 with correctable refractive error were inadequately corrected and this rate was more than 1 in 3 for Mexican American (37%) and black (37%) children, suggesting barriers to accessing vision care.[74] Other studies look at specific types of refractive error. About 4% of children aged 6 months to 6 years and 9% of older children aged 5 to 17 years old have myopia, or nearsightedness. Prevalence of hyperopia, or farsightedness (when nearby objects appear blurry) is 21% among children 6 to 72 months of age and 13% among children aged 5 to 17 years. Between 15% to 28% of children aged 5 to 17 years have astigmatism, depending on the diagnostic threshold used.[75]

Amblyopia and strabismus: Amblyopia is found in about 2% of 6- to 72-month-old children, and strabismus is found in between 2% and 4% of children under the age of 6 years.[76]

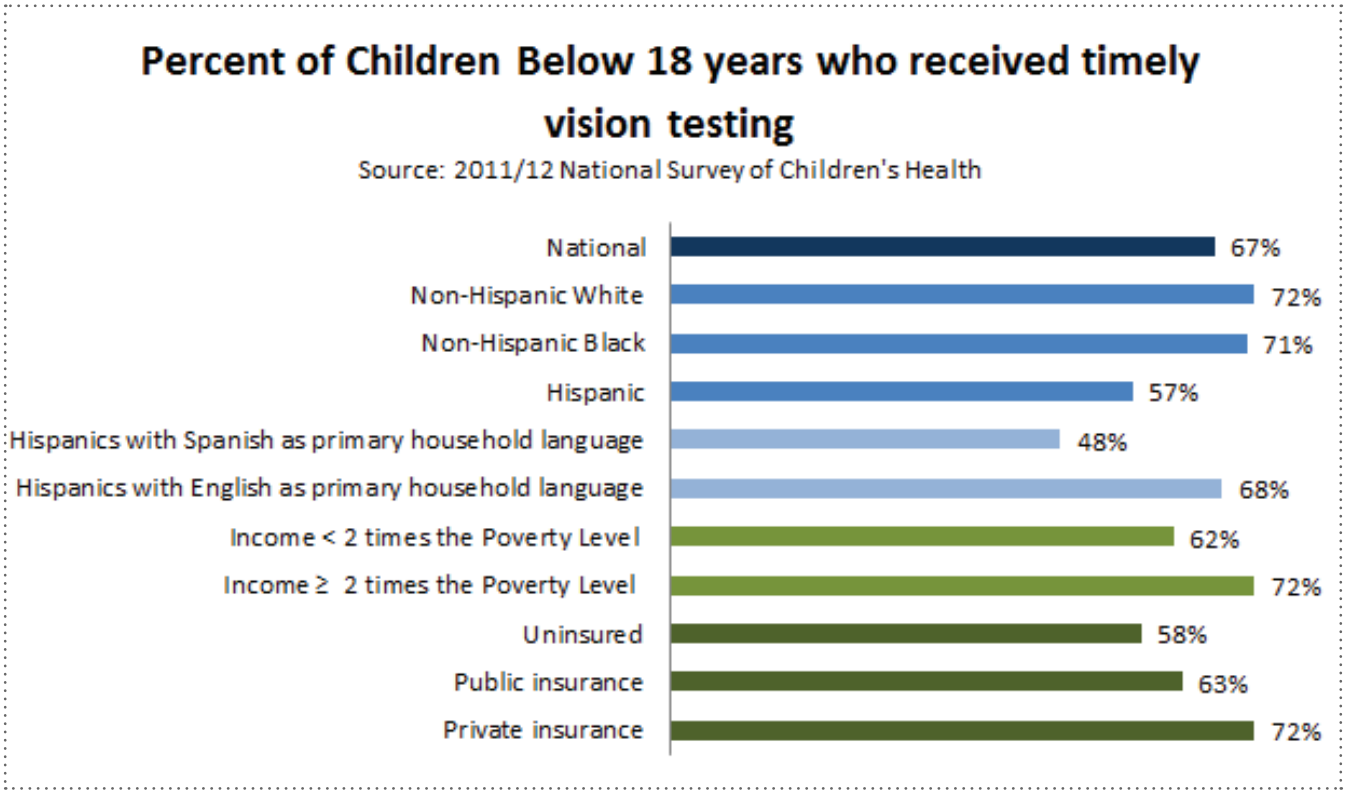
Uncorrected or under corrected vision problems based on parent report: An estimated 2.6% of children aged 17 and under have trouble seeing, even when wearing glasses or contact lenses according to parents, based on 2014 National Health Interview Survey data.[77] This estimate is substantially lower than previously mentioned estimates of uncorrected refractive error in 12 to 17 year olds (18%) and of diagnosed vision and eye conditions in below in children younger than 18 years (7%), indicating the possibility that parents may not always know if their child has a problem seeing. This data also shows disparities by poverty, race, and ethnicity. Children from families below the poverty threshold had a rate 3 times that of the children from families earning more than 4 times the poverty threshold (43.3 vs. 14 per 1000, respectively). Hispanic or Latino children had a rate of 31.6 per 1,000 children, and black children had a rate of 29.8 per 1,000, which are 1.3 times and 1.2 times the rate of 24.4 per 1,000 for white children, respectively.

Unmet need for services

According to clinical guidelines, vision screening should occur annually (best practice) or at least once (acceptable minimum standard) between the ages of 3 and 6 years and every 1-2 years after the age of 5.[78,79] Children who fail vision screening should be referred for a comprehensive eye examination performed by an optometrist or ophthalmologist so that they can diagnose and treat eye disorders.[80]

National data show that there is a significant gap between the recommendations of clinical guidelines and the actual vision testing rates among children. According to the 2011 National Survey of Children's Health, 40% of children aged 5 years and below had their vision tested at some point, 83% of children aged 6 to 11 years had their vision tested within the past two years and 67% of all children aged 0 to 17 had their vision tested in a timely way. Moreover, there are disparities by household income and education levels, insurance coverage, race/ethnicity and primary household language.

As shown in the following chart, receipt of vision testing in children aged 17 years and under varies by household income level (62% for children in households with incomes below twice the Federal Poverty Level versus 72% for children in households with incomes at or above twice the Federal Poverty Level), insurance status (58% for children who were uninsured at time of survey and 63% for children with public insurance, such as Medicaid/SCHIP, compared to 72% for children with private health insurance), race/ethnicity (57% for Hispanic children compared to 72% for white children and 71% black children), and primary language spoken in household (48% Hispanic children for whom Spanish is primary household language versus 68% Hispanic children for whom English is the primary household language.[81]



Another estimate of lack of vision testing comes from the 2009–2010 MEPS (Medical Expenditure Panel Survey) data. This survey found that about 78% of children had their vision checked by a doctor or other healthcare provider by the age of 6. This rate is substantially higher than the previously mentioned 40% rate from the 2011 National Survey for Children's Health because the 78% rate is restricted to children aged 5 years at the time of the MEPS survey whereas the 40% rate includes all children 5 years and younger in the NSCH survey. The 2009-2010 MEPS data also shows similar disparities by: race/ethnicity (70% of Hispanic children compared to 81% for white and 81% for black children), poverty level (69% for children in households with incomes below twice the Federal Poverty Level versus 85% for children in households with incomes at or above twice the Federal Poverty Level), and insurance status (39% for children without insurance and 73% of children with public insurance only, compared to 83% for children with private insurance).[82]

Population-based data on children receiving diagnostic exams and treatment after failed screenings is not easily available.[83] In a study of vision screening of preschool children in pediatric clinics, less than half of those who failed the screening had documentation that they were referred for diagnostic exams.[84] In another study, as many as two-thirds of children who received referrals did not obtain the necessary care.[85] Findings from local studies show various barriers to follow up care, including cost, lack of access to providers, no vision insurance coverage for eye examinations and eyeglasses, parents' lack of awareness about the need for follow up, and inability to contact parents.[86] Findings from these studies coupled with the previously mentioned prevalence estimate of visual impairment due to uncorrected refractive error at about 18% in the 12 – 17 age group[87] and high rates of inadequately corrected refractive error among those with correctable refractive error for Mexican Americans (37%) and black (37%) children provide ample evidence of unmet needs for vision care. [88]

Impact on learning

As described by the American Optometric Association (AOA), good vision is key to doing well in school. As much as 80% of learning occurs via the eyes through visual tasks such as reading, writing, and using computers. In order to effectively read and learn, the AOA states that every child needs the following vision skills:

- "**Visual acuity** — the ability to see clearly in the distance for viewing the chalkboard, at an intermediate distance for the computer, and up close for reading a book.
- **Eye focusing** — the ability to quickly and accurately maintain clear vision as the distance from objects change, such as when looking from the chalkboard to a paper on the desk and back. Eye focusing allows the child to easily maintain clear vision over time like when reading a book or writing a report.
- **Eye tracking** — the ability to keep the eyes on target when looking from one object to another, moving the eyes along a printed page, or following a moving object like a thrown ball.
- **Eye teaming** — the ability to coordinate and use both eyes together when moving the eyes along a printed page, and to be able to judge distances and see depth for class work and sports.
- **Eye-hand coordination** — the ability to use visual information to monitor and direct the hands when drawing a picture or trying to hit a ball.
- **Visual perception** — the ability to organize images on a printed page into letters, words and ideas and to understand and remember what is read."

As the AOA states, undeveloped or poorly developed visual skills make learning difficult and stressful. As a result, children may avoid reading and other near visual work, do the work less efficiently and experience discomfort, fatigue, and a short attention span.

Considerable research on the learning consequences of vision problems has been documented in two literature reviews: i) "Vision and the Achievement Gap Among Urban Minority Youth" by Charles Basch published in 2011 and ii) "Learning-related Vision and Academic Success: A Meta-Analytical Study" by Katherine J. Minton published in 2005. The majority of the research focuses on the impact of vision problems on children's ability to read. What follows is a summary of findings from these literature reviews as well as other sources. Findings are organized by vision problem or vision skills area.

Refractive Errors

Hyperopia: Though children tend not to require correction of low levels of hyperopia as their eyes can self-adjust, several studies show an association between varying levels of uncorrected hyperopia and poor reading performance. Basch's literature review cites studies of elementary school children where hyperopia has been associated with poorer performance on standardized measures of literacy, standardized reading test scores and percentile ranking on the Iowa Test of Basic Skills.[89] A small pilot study cited by Basch's literature reviews compares children with hyperopia and children with ideal vision (emmetropic) and finds that uncorrected hyperopic children, ages 4 to 7 years, perform worse on tests of letter and word recognition, receptive vocabulary, and emergent orthography, despite no difference in selected variables that are known to affect the acquisition of literacy skills (phonological awareness skills, visual cognitive skills, and other family variables known to affect the acquisition of literacy skills).[90] However, this study cautions that it is unclear if the relationship between hyperopia and the poorer progress in emergent literacy is causal and whether the hyperopes will catch up with the emmetropes in time. A larger more recently published study that also compares the literacy skills of 4- and 5-year-old children with uncorrected hyperopia with the skills of emmetropic children similarly concludes that after adjustment for age, race/ethnicity, and parent/caregiver's education, children with significant uncorrected hyperopia perform significantly worse on a Test of Preschool Early Literacy (TOPEL), composed of Print

Knowledge, Definitional Vocabulary, and Phonological Awareness subtests.[91] In an effort to address the methodological limitations of studies that use cross-sectional or case control design that have found associations between uncorrected hyperopia but cannot prove causality, another study took a novel approach of simulating hyperopia in visually normal children (mean age of 10.9) and studying their academic performance under the conditions of normal vision and simulated hyperopia. [92]This study found that simulated hyperopia resulted in poorer performance on reading (rate, accuracy, and comprehension), visual information processing (a child's ability to focus attention, quickly scan, discriminate between and sequentially order visual information) and reading-related eye movement performance. Collectively, these studies point to the need to screen and address significant, uncorrected hyperopia as needed in order to maximize children's ability to read to their potential.

Myopia: Evidence of the association between uncorrected myopia and lower academic performance is provided by a randomized controlled trial study that finds the provision of free glasses to Chinese children in rural western China with myopia improves their performance on mathematics testing to a statistically significant degree. Furthermore, the effect on performance was larger for children in classrooms where blackboards were used more regularly.[93] The authors concluded that the effect of myopia on classroom learning is not well understood and they were not able to find other randomized controlled trials to examine the impact of correcting myopia on school performance.

Astigmatism: A study of pre-kindergarten children in a Head Start program found that children with astigmatism performed consistently lower than their peers without astigmatism in the areas of language and literacy, physical health, and development and communication, though a causal relationship could not be established.[94] These findings point to the need for research to explore the causal mechanism underlying the association between astigmatism and academic readiness. To understand the impact of uncorrected astigmatism on reading, another study looked at the effect of induced astigmatic refractive error in young adults on a selection of standardized clinical measures of reading performance. This study found that induced astigmatic blur resulted in poor word recognition and slow reading rate.[95]

Amblyopia

Several studies looked at the impact of amblyopia on reading and motor skills. A study investigating reading and associated eye movements in school-age children found that amblyopic children read more slowly compared with non-amblyopic children with treated strabismus and normal controls.[96] Another study looked at the impact of amblyopia on children's ability to perform a range of standardized age-appropriate tasks that assess motor skills needed in practical, everyday tasks and found that children with amblyopia perform more poorly, particularly on manual dexterity tasks that require speed and accuracy.[97]

Visual motor integration

Both Basch's and Minton's literature reviews cite studies finding that low visual perception and/or visual motor integration was associated with low reading achievement. For example, a study cited by Basch's review on students in kindergarten through third grade finds that visual motor integration skills are significantly related to academic performance (as measured by teachers' ratings of children's ability in reading, math, spelling and writing).[98] Another study that compared children with normal visual integration and children with low visual integration found that low visual integration group made significantly more errors in educational activities that require accurate placement of letters and numbers on a page.[99] However, in contrast, a recently published study that looks at how visual motor skills relate to reading achievement when taking into account precursor and reading-related skills finds that the contribution of visual motor integration skills to reading achievement reduces when language-based skills are taken into account.[100]

This study's authors state that prior research on visual-motor performance and reading ability have produced mixed findings, partly because some studies have not taken into account known predictors of early reading skills, particularly language-related predictors.

Tracking

Minton's literature review "Learning-related Vision and Academic Success: A Meta-Analytical Study" concludes that the studies included in the literature review find low tracking skills are associated with low reading achievement. Basch's literature review cites studies showing that the stability of binocular control, which is essential for tracking, is associated with reading and with spelling skills. Another study cited by Basch finds suggests that tracking skills are a risk factor for low levels of reading ability in adolescents.

Other visual skills

Both the literature reviews by Basch and Minton cite studies that find associations between low levels of other visual skills (convergence, stereoacuity, accommodation/focusing), and reading.

Conclusions

Key points:

- Uncorrected vision problems and low rates of timely vision testing are highly prevalent among children from poor families, black children, Hispanic children, uninsured children, and children on public insurance.
- Good vision is key to doing well in school because as much as 80% of learning occurs through visual tasks such as reading, writing, and using computers. Studies provide ample evidence showing that uncorrected vision problems and the lack of certain visual skills undermine a child's ability to read, an ability which is critical to academic achievement.
- These findings clearly underscore the importance of early vision screening and comprehensive vision examinations for children who fail vision screening so that vision problems don't undermine a child's academic readiness and performance.